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COFFEE QUALITY, LAND USE, AND PROCESSING IN THE CAJAMARCA REGION OF PERU

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COFFEE QUALITY, LAND USE, AND PROCESSING IN THE CAJAMARCA REGION OF PERU

by

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Procedures used for defining coffee quality include a variety of activities ranging from physical measurements, hedonic sensory evaluations, and valuation of recognized extrinsic attributes. The physical measurements of coffee quality evaluate intrinsic attributes through a set of formal coffee grading and analysis standards, in addition to human sensory activities which conduct formal cupping protocol standards and formal tasting competitions. Extrinsic qualities include attributes such as branding and aesthetics, in addition to sets of ethical qualities established to further differentiate value beyond intrinsic and hedonic qualities. The promotion and standardization of coffee quality expectations directly impact activities taken by coffee producers. Achieving established quality expectations require coffee producers to adapt certain land-use practices and post-harvest processes activities which significantly impact their livelihoods. This thesis will examine how coffee quality is interpreted, standardized, and implemented within the coffee supply chain and will further investigate environmental and economic trade-offs quality standards impose on land-use and post-harvest processing activities.

The thesis will approach defining coffee quality through a collection of three distinct categories; intrinsic, hedonic, and extrinsic quality. This examination aims to

demonstrate how these categories of coffee quality impact decisions made in the daily activities of coffee farming communities. A descriptive account will be presented to demonstrate activities relating to land-use and post-harvest processing methods within three separate smallholder coffee farming communities in the Cajamarca Region of Peru. Observations were made to show a variety of economic and environmental tradeoffs for achieving quality standards driven by current market demands.

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CHAPER ONE: INTRODUCTION

Problem Statement

The promotion and standardization of coffee quality expectations directly impact activities taken by coffee producers. Achieving established quality expectations require coffee producers to adopt certain land-use practices and post-harvest processing activities which significantly impact their livelihoods. Farm management strategies have focused attention on maximizing yield potential through the incorporation of a land use strategy known as technification, where optimal sun-exposure and agricultural chemical inputs often result in removal of forested areas and weakened wildlife biodiversity throughout coffee growing areas. Increasing demands for specialty coffee involving fully washed processing techniques have presented challenges for coffee producers to successfully manage natural resource usage. Achieving coffee quality standards set by retailers, roasters, and professional coffee tasters have imposed environmental and social trade-offs which have not been heavily researched by the coffee industry. These conditions raise concerns within the coffee industry as research institutions have predicted by the year 2050, half of all suitable land for coffee production will no longer be suitable for coffee production (Bunn, Läderach, Jimenez, Montagnon, & Schilling, 2015), while global coffee consumption rates will have doubled or even tripled within the same time frame (Killeen, 2016). This thesis will examine how coffee quality is interpreted, standardized, and implemented within the coffee supply chain and will further investigate environmental and economic trade-offs quality standards have imposed on land-use and processing activities, focusing on site observations conducted among three coffee producing areas in the Cajamarca Region of northern Peru.

Research Objectives

The main objective of this study is to examine how coffee quality is defined, interpreted, standardized, and implemented within the coffee supply chain and to further investigate environmental and economic trade-offs quality standards impose on land-use and post-harvest processing activities through providing a descriptive account of smallholder coffee producer communities located in the Cajamarca Region of Peru.

Significance of Study

Further understanding of the environmental and economic trade-offs smallholder coffee farmers manage as a response to achieving quality requirements set forth by industry standards will raise awareness within consumer markets and supply chain actors to consider the socio-economic and environmental costs which result from intrinsic and hedonic qualities, while also presenting opportunities for strengthening the extrinsic values placed on coffee.

The question remains if cup quality, connection to appellation, and ethical considerations (e.g., equitable trade and environmental health) are driving consumer choice. If this is the case, is the coffee industry's message of sustainability delivering on these aspects? Regardless of intentions behind decisions consumers make during the process of purchasing coffee, defining the role of coffee quality is essential to better understanding preferences and perceptions of consumers. With a more thorough understanding of the facets of coffee quality which exist throughout the coffee supply chain, decisions made by retailers, roasters, and importers who provide coffee quality options to the end coffee consumer will better guide decisions taken for supporting efforts towards improving equitable trade, environmental health, and cup flavor quality.

Limitations and Assumptions of the Study

Considering the sheer scope of human variation and the innate subjective nature of how quality is perceived and understood, in addition to the field of sensory science being relatively young (Griffiths, 2015), limitations of this study involve a lack of well researched and applicable empirical evidence conducted and applied to how perception and preferences of specialty coffee impact socio-economic and environmental conditions within coffee growing communities. During the research conducted in Peru, I confronted difficulties choosing measurable indicators for providing data towards how selective harvesting might influence intrinsic qualities.

Indicators involving how coffee producers determine ripeness was my initial focus. The assumption was made that selective harvesting was the primary human activity which primarily determined quality potential of a coffee bean. Yet, limitations for answering these questions were presented in the fact that harvesting patterns and frequency change throughout the picking season, such that when there is more ripe coffee cherry to harvest, daily activities are adjusted. I visited these farms over a period of three weeks in the later part of May and early June of 2016. During the time spent in Peru, most of the coffee harvest season in the region of Cajamarca had just begun. Observations of selective harvesting behaviors were difficult to compare, since there was very little ripe coffee to harvest during the research period. Limitations of this study also came from changing elevations between each site location. As elevation increased, the maturation of coffee development slowed, whereas lower elevations had faster maturation cycles. This was evident when observing the increased amount of activities involving processing and harvesting at lower elevations, while sites located at higher elevations had not begun harvesting activities. Additionally, my presence as a research student and observer likely impacted their demonstration of processing and harvesting techniques.

Research Methods

Methods used for the examination of intrinsic, hedonic, and extrinsic qualities involved a literature review of research articles and data addressing development of intrinsic quality standards in coffee commodity markets and the physical actions which take place throughout coffee harvesting and processing which directly impact quality level outcomes. Further literature was reviewed to provide understanding for the basic physiology of flavor and how biological functions influence perception and preference of flavor. Included in the literature review further address variation between age, sex, and cultural groups and how these factors impact preference and perception of taste. Discussion continues with an exploration of how hedonic qualities are measured through a variety of coffee industry techniques, including formalized tasting evaluation and coffee competitions, both performed by professionally trained coffee tasters.

To evaluate the effectiveness of these evaluations, a coffee tasting exercise was conducted in Lincoln, Nebraska and approved by the University of Nebraska Institutional Review Board (Appendix A.1) to further explore possible preference variations and tasting bias presented through formalized coffee tasting evaluations and competitions. Non-coffee professional coffee drinkers were invited to participate in a tasting event where they were given a form to rate their preferences between coffee selections. Drawing from the literature review regarding how age impacts perception and preference of tastes, I collected data to perform a crosstabulation between two age groups and two roast level categories. Findings from the Chi-Square test showed a significant relationship between preference of dark roast among older adults (Appendix G). The scope of this tasting exercise was limited, producing further questions regarding perception and preference among non-professional coffee drinkers and how these two categories of consumers may differ when assigning positive coffee quality attributes.

The third quality reviewed address extrinsic qualities of coffee including the ethics, brand, and suitability of coffee products. The extrinsic quality of coffee is also valued through ethical attributes. In Chapter 2, discussion addressing extrinsic qualities examine two areas which seek to guarantee equitable trade and support environmentally sustainable practices. Additional extrinsic qualities which impact purchasing decisions are researched, including branding and personal suitability regarding consumer cost, aesthetic appeal, and accessibility. The three categories of quality (intrinsic, hedonic, extrinsic) are evaluated as factors which ultimately influence production.

To further explore how categories of quality impact land-use and post-harvest processing activities of coffee producers, I present research approved by the University of Nebraska Institutional Review Board (Appendix A.2) which aimed to provide a thorough understanding of the challenges coffee producers face and the decisions which are made in response to coffee market conditions. Research concentrated efforts on exploring topics addressing farm management activities and how coffee farmers connect with global supply chain markets. Further aim for research address how market relationships are determined through ascribing intrinsic, hedonic, and extrinsic qualities to coffee, and explore impacts on land-use and post-harvest processing activities.

The methods used for gathering descriptive information in the Cajamarca Region of Peru were conducted through personal interviews, questionnaires, and personal participation within selective picking and post-harvest processing activities (Appendix B). I spent several weeks residing as a guest within each farmer community household. The goal was to gain a local perspective on factors influencing harvesting, processing, and land management decisions of producers, and to note possible significant variation between coffee producer situations and how market access may influence farm management and processing activities. Many of these factors were highlighted in casual conversation which otherwise may not have been acknowledged by non-participant forms of investigation.

To measure variation between coffee quality outcomes of each coffee producer visited, I collected information on selective harvesting practices as an indicator of quality production. Conducting this measurement required random sampling of coffee harvested by coffee producers within each location. The quantity of each sample collected measured either one kilogram or 500 grams, depending upon the available quantities and situation of the moment. For each sample collected, maturation levels of each coffee cherry were recorded to provide a measurement for the range of ripeness each coffee producer accepted during their selective harvesting activities. Additional measurement collected involved separation of harvested coffee cherry defects through water floatation, measuring the percentage of defects (floaters) and the percentage of non-defects (sinkers). Additional indicators involved observation of land-use management strategies utilized on each coffee farm, particularly examining attributes of each coffee farming system and how each site employed attributes of technified and traditional land-use practices. Interview questions presented to coffee producers within Cajamarca, Peru addressed additional factors which impact quality production. These post-harvest processing steps include activities involving the de-pulping, fermentation, washing, drying, and storage of coffee.

CHAPTER TWO: LITERATURE REVIEW

History of Coffee and its Trade

Coffea Arabica, a wild coffee plant species indigenous to the western forested areas of Ethiopia, has been claimed by several historians to be discovered around AD 850 (Clifford, 2012). Myths about the discovery of coffee involve a goatherder named Kaldi who while tending to his flock, noticed his goats eating cherries and soon after observed their increasingly energized behavior. The goatherder decided to bring back these cherries to his village to share his new discovery. One of the earliest sources for the goatherder origin story came from a document written by Antoine Faustus Nairon, author of one of the first printed treatises regarding coffee, authored in 1671 titled, *De Saluberrimá Cahue seu Café nuncupata Discursus* (Weinberg & Bealer, 2001). Several additional origin stories have been told throughout history, many of which connect berry consumption by animals and the resulting observation by humans. The origin stories of coffee follow a formulaic set of events, recalling specifics to a moment in time which occurred well over eight hundred years prior to the time the story was documented. Regardless of its origin, the beverage and its economic and environmental impact has found its way into almost every community on the planet in modern times.

Coffee has played a defining role in the creation of agricultural landscapes across the world. Over 70 countries produce and export coffee for economic prosperity. It is no surprise the commodity which is known to be traded as one of the most valuable agricultural commodities in the world has become referred to as 'black gold'. Assessing coffee quality is necessary for establishing its value and has played a role in the expansion of coffee production and history of its trade. The evaluation of coffee quality attributes has resulted in complex and varied systems of standardization unique to national and regional coffee producing and consuming areas. With coffee being grown, processed, and exported by over 70 counties and consumed by almost every nation in the world, variation in assessment and interpretation of quality becomes as diverse as each of the cultures in which it is produced or consumed.

Coffee began its path out of Ethiopia through trade by the Turkish empire, which began shortly after their occupation of Yemen in 1536 (Pendergrast, 2010). A significant expansion of trade continued with involvement by the Dutch, who began coffee cultivation in Ceylon by 1658. This widened its presence across the East Indies throughout much of the 17th century (Pendergrast, 2010). As the Dutch began serving an increasing demand in Europe through its cultivation across southeast Asia, coffee plants were brought to Europe which led to its voyage across the Atlantic Ocean to the New World. Coffee was first brought to the colony of Dutch Guinea in South America in the early 18th century. Most of the coffee seen today is known to have originated from the Typica coffee variety, originally transported to the French colony of Martinique in 1723 by a French naval officer named Gabriel Mathieu de Clieu (Pendergrast, 2010).

When considering how colonization has accelerated the genetic flow of coffee around the world within a relatively short period of time, the natural ecological processes and adaptation abilities for coffee within unique environments (rainfall patterns, elevations, soil types, and cultural activities) began shaping agricultural management strategies, harvesting and processing techniques, and coffee brewing practices. Most of these areas had already established trade routes and information channels, yet remained relatively distinct in their cultural and environmental atmospheres. The expansion of foreign botanical species introduced new agricultural experimentation with Robusta and Arabica coffee varietals, facing unforeseen agricultural challenges, such as native pests, disease, and varied climatic conditions.

The two main commercially viable cultivated species disseminated out of Ethiopia are *Coffea arabica* (Arabica) and *Coffea canephora* (Robusta). Although additional coffee species such as *Coffea liberica* have been identified, these species have not found a strong market presence. Both Arabica and Robusta varieties were found to be able to adapt to a wide variation of climatic conditions throughout subtropical landscapes. Additionally, these coffee species offered sufficient yield and acceptable tastes for consumer markets during its initial expansion into the New World. Both Arabica and Robusta species have physiological attributes catering to specific elevations and climate patterns. Robusta is a hardy coffee species, flourishing in lower elevations and withstanding warmer temperatures, while providing both greater resistance to pests and disease than its neighboring Arabica species. Arabica is better suited to higher elevations and cooler climates, causing for longer maturation times for fruit development. Although these conditions often deliver lower yields, the biochemical complexities developed within the fruit allow for greater cup quality potential. The division between Arabica and Robusta throughout the historical expansion of coffee production around the world play an important role in the development of coffee qualities, first being introduced on the attributes of price and function where quality was determined by the suitability to individual economic and geographic conditions. Branding added aesthetic qualities, in addition to the added benefits of caffeine as a source for energy. With these quality attributes as the driving force behind a growing market, Robusta served the market and the demand well. When flavor became of concern, the addition of milk, sugar, chicory, and other additives helped curb what some consumers perceive as harsh bitter flavors from lower grade Robusta. The use of Robusta continues its popularity in several current coffee consuming markets. Regardless of how some coffee markets negatively perceive the taste qualities of Robusta coffee, preference for Robusta coffee might indicate habituation. Although the initial consumption of Robusta might have delivered an unpleasant sensation, repeated exposure to certain flavors, whether naturally unpleasant or otherwise, will normalize. These markets generally reside in Asia, Europe, and within many nations where coffee consumption could be based more on economic attributes.

Robusta in Java, due to climatic conditions, set the stage for development of the wet-hulling process. In Ethiopia, it is common to see drying beds used for a part of the coffee drying process, whereas in Central and South America, much of the coffee is dried on cement patios. The cultivation and processing of coffee has changed significantly within the past several hundred years, and has increasingly changed within the past few decades, likely due to the ease of access to market and technical information. The question might be asked if seeking higher quality coffees which cater to differentiated specialty coffee markets is economically, socially, and environmentally sustainable.

During the mid to late 20th century, the coffee industry began to slowly define coffee quality with a hyper-focus on cup quality, which reached beyond the traditional focus currently in the mindset of consumers during the 1950s, where other quality attributes such as convenience and price played a more important role in the decision-making process of consumers.

Coffee quality control departments seek to define physical attributes of coffee in an objective manner by measuring aspects which develop standards for purchasing raw coffee harvests from producers. These physical attributes include a list of factors such as; the size of the seed, color, smell, moisture level, density, uniformity, consistency, and amount and type of defects found in a sample. The reason such attributes are measured is to provide both the producer and consumer guidelines for price discovery. Physical attributes often influence the hedonic value of a given coffee sample. For example, if a selection of severe insect damaged coffee seeds were prepared separately for roasting and consumption, the flavor evaluation would likely result in lower hedonic responses by coffee professionals. On the other hand, there are situations where a defect becomes a desired trait, such as what is known as the "peaberry", resulting from a cherry developing only one seed rather than the standard formation of two seeds. Peaberries are physically small coffee seeds passing through screens well below what is often considered standard size for higher quality lots. At one point in history, these smaller seeds were collected, roasted, and evaluated by professional coffee cuppers and were given favorable flavor attributes. Since this discovery, the defect has become a valuable attribute with limited supply due to infrequent genetic mutation.

Coffee tasting measures the hedonic value of a coffee selection for a variety of consumer markets. The third category of quality encompasses a range of subjective measures which cater to individual interpretations often determined by ascribing value to the ethics, aesthetics, and personal suitability, such as location, price, convenience, and physical necessity.

Valuation of these qualities are typically assessed on a regular basis at each step throughout the coffee supply chain, from producer to coffee consumer. The various categories of quality discussed in this thesis will include the physical attributes, hedonic responses, and extrinsic cues.

Assessments made throughout the supply chain by consumers, retailers, roasters, importers, exporters, and coffee producers all create quality expectations which ultimately impact land-use management strategies and adoption of farm post-harvest processing decisions (i.e., coffee drying times, washing activities, selective harvesting guidelines, sorting defects). This thesis aims to review how coffee quality is interpreted, standardized, and implemented within the coffee supply chain and investigate impacts these categories of quality have on land-use, natural resources, and post-harvest processing practices.

I will present a descriptive account of three smallholder coffee farmer communities in the Cajamarca Region of Peru. The discussion will begin by consideration for how coffee quality is defined across three distinct categories; intrinsic, hedonic and extrinsic qualities. Each category will be addressed separate sections for exploring the definition and influence each quality category plays within the coffee industry.

INTRINSIC COFFEE QUALITY

The inherent worth of an item is often described as the intrinsic value in which an object carries. A visual observation of the raw seed of a coffee cherry prior to roasting shows little value to the end coffee drinker. The coffee seed carries hidden value which has yet to be developed to a useable product. The intrinsic qualities of coffee consist of its genetic makeup, while being further defined by how the fruit matured through its ripening stages to final cultivation. The following section will explore the development of physical coffee standards and the determinants of these qualities.

Development of Physical Coffee Standards

Agricultural commodities are typically dependent upon the formation of standardization to help facilitate valuation of a product and the trading of those goods between producers and buyers. Among the physical quality categories which help guide and determine the valuation of coffee, measurable attributes typically concentrate on moisture content, water activity, density, shape, color, physical defects, bean size, and odor. This collection of physical measurements provides the basis for many of the coffee grading systems in use today. In addition, advancements in technology have allowed for an adoption of tools for measuring molecular aromatic compounds and identifiable genetic information determining physical coffee qualities. Although physical qualities were historically based on a more condensed list of attributes than mentioned above, technological capabilities for advanced measurements (such as solid phase micro-extraction and gas chromatography) have outpaced the current ability of the coffee industry to apply such tools within commercial applications for quality improvement.

In addition to physical quality attributes that are quantifiable through objective instrumental measurement, coffee retains intrinsic physical molecular chemical structures which are influenced by the selection of plant species and varietal selections, in addition to processing and storage conditions. These actions impact physical qualities prior to the final roasting stage. The value and interpretation of intrinsic attributes are typically made through taste evaluations, and more recently identifiable with laboratory equipment such as solid phase micro-extraction and gas chromatography. These most recent techniques for evaluation where the lexicon of aromatic and taste compounds have yet to complete develop a cohesive and shared definition within the international coffee industry. Efforts to create a shared lexicon through developing standardized sensory analysis protocol for tasting brewed coffee are evident within the Specialty Coffee Association (SCA). The SCA collaborated with the World Coffee Research organization to develop a coffee lexicon and flavor wheel to better identify and communicate flavor attributes. The variation of preference, perception, and experience of professional tasters continue to raise concern for successfully implementing such standardization.

In 1881, the New York Coffee Exchange was formed, dramatically shifting how coffee was traded (Daviron & Ponte, 2005). Prior to the exchange, coffee was most often auctioned in lots, without any formalized or specific grading standard. Formation of the Coffee Exchange brought about defining nine grading levels, based primarily on the number of defects present in a sample, yet these grades were constantly being adjusted, responding to supply challenges and changing market demands (Daviron & Ponte, 2005). Due to its historical activity of trade across multiple international boundaries which have continued for centuries, standardization of grading systems primarily remains within national boundaries and has yet to become unified on an international level. Attempts have been made to organize international standards, but the variation of market demands and expectations remain to fluctuate, therefore creating fluid definitions for coffee grades.

Technological advancements in machinery used within post-harvest processing continue to improve the removal of defects from harvests which had once depended on belt driven assembly coffee sorting lines traditionally employed by manual labor. These advancements have increased a processor's ability to clean and sort coffee at a much faster pace, at a much lower cost. These advancements have influenced the supply chain's abilities to define, select, mix, and present specifically desired quality levels. Interestingly, the attributes of a certain grading profile are often developed by private entities which present internal expectations and profiles to match their specific market requirements.

In addition to advancements at the farm and processing level, advanced logistics for reducing transportation time and costs have greatly improved supply chain conditions for delivering consistency and uniformity of physical coffee quality attributes.

The history of coffee cultivation rested mainly in the hands of larger plantation operations where centralized estate management decisions guided processing activities. It was not until the late 1850s when coffee became largely cultivated by independent smallholder families (Daviron & Ponte, 2005). The shift in production from estate to smallholder producers first began in Costa Rica around this time, where farmers harvested and delivered coffee cherries to regional collection stations (Daviron & Ponte, 2005). By the 1930s, coffee production in Colombia became the first country to incorporate post-harvest processing stages on independent smallholder farms (Daviron & Ponte, 2005). Changes from estate to smallholder production increased the likelihood of variation of intrinsic and hedonic quality attributes between farming operations.

Determinants of Intrinsic Coffee Qualities

It is often said within the specialty coffee industry that you can easily make an amazing coffee taste terrible, but you cannot make a terrible coffee taste good. Each action taken from seed stock selection to final coffee cherry selection will determine final product quality and price. Immediately below, I will outline activities from crop planning to the final stages of post-harvest processing activities, providing discussion on how these steps influence intrinsic coffee qualities. The discussion will first address environmental suitability for commercially viable coffee species and varieties, followed by an examination of steps within coffee processing methods responsible for impacting quality.

Species and Varietal Selection

Environmental conditions primarily determine the best suited coffee species and variety selection for a coffee producing landscape. These conditions will be the first set of determinants to establishing potential for cup quality. Elevation, soil types, land use, and other geographic attributes offer producers a set of guidelines for choosing the proper varietal for their landscape. The richness of information available for determining what is the best choice for varietal selection not only rests in potential for successful fruit maturation, but the focus in which the producer has for a product. Decisions can be guided by a variety of influences, such as optimization of yield, inclusion of forest canopy, or desire for achieving specialty market differentials for higher hedonic cup qualities.

The variation in physical qualities are typically achievable by most varieties. For example, most varieties are capable of homogeneous screen size, moisture content, and water activity. On the other hand, certain varietals are more prone to disease and insect damage, therefore increasing the likelihood of higher defect counts in the finished product. Robusta has more resistance to insect damage due to its increased caffeine content which acts as a natural insecticide, whereas Arabica generally has lesser caffeine content, lacking a natural defense mechanism which favors Robusta. When further considering hedonic quality potential for these coffee species, there are significant differences in the outcomes, which are further discussed below. Considering Robusta production as capable of achieving higher yields in addition to facing less insect damage, the decision to select Robusta for cultivation over Arabica can often be quite appealing if it were not for the importance of markets demanding specific flavor profiles.

Planting and Husbandry

Coffee is generally capable of growing in areas which maintain minimum temperatures of at least 0°C to 10°C and an annual rainfall between 1200 mm to 2000 mm, depending upon the selection of Robusta or Arabica species (Illy & Viani, 2005). Germination of the coffee seed often takes one month, thereafter transferred to nurseries for the next 6 to 12 months prior to transplanting into the field (Illy & Viani, 2005). Coffee takes several years before bearing fruit. The flowering stage is extremely important as successful fruit development depends on the proper fertilization of these flowers, typically conducted mainly through pollination carried by wind (Wintgens et al., 2004). Flowering is a major concern expressed by coffee producers (Fig. 1), often mentioning heavy winds or excessive rainfall can remove flowers from the branch severely reducing yield potential.

Figure 1. Coffee flowering

Including the flowering stage, the average time for coffee fruit to mature typically takes 7-9 months for Arabica, and 9-11 months for Robusta (Illy & Viani, 2005). Like most agricultural products, coffee involves seed selection and grafting techniques for improved root systems and fruit production. The proper soil selection and fertilization, rainfall, and topographical and atmospheric considerations all play important roles in the decision farmers make in the cultivation and husbandry of coffee. The wealth of literature and information addressing various applications of each of these roles is beyond the scope of this examination. It is important to note that although many of these decisions may appear to be in the hands of the coffee producer, external influences outside of their own farming systems may often impose governmental policy which requires mandated agricultural practices, or persuade farmers to implement certain farming practices through financial incentives. Private interests from the coffee supply chain are stakeholders in the success of farmers, often seeking situations where producers can produce sufficient amounts of a specific type of product quality.

Harvesting: Mechanical, Stripping. & Selective

Regardless of producer intentions or access to technical assistance to maximize their desired production goals, decisions on how the harvesting selection of fruit throughout the picking season is a crucial step in achieving physical qualities.

Harvesting coffee cherries is the first processing step following cultivation. Optimal timing for the collection of coffee cherries is an essential decision producers face, influenced by a variety of factors including; percentage of ripe fruit, weather conditions, financial markets, labor availability, and personal financial situations. Each one of these factors may delay or expedite harvest times, impacting amount of ripe coffee cherries collected. If the producer is asked to meet certain financial obligations or confront favorable market conditions which increase demand for product, the producer may sacrifice optimal maturation levels and settle for higher percentages of under ripe coffee. On the other hand, if the weather is unfavorable during peak harvest time, delays may cause for greater percentages of overripe fruits, causing a change in potential quality. The following harvesting strategies are the most common methods for cherry collection, presenting various techniques which favor efficiency, yield, and quality, quite often driven by financial means and topographic conditions of the coffee farm.

Mechanical Harvesting

The strategy in which harvesting is conducted is guided by a set of factors including the suitability of landscape which may allow for mechanical harvesting. In areas with excessive slope, producers will be restricted to harvesting by hand labor. In both cases, the producer requires access to either sufficient capital to invest in mechanical harvesting equipment or manual labor. Consideration for access to an affordable and dependable labor pool will also be necessary. These conditions vary greatly between estate plantations to smallholder producers. Regardless of farm size, economic condition, and environmental determinants for botanical coffee variety selection, international markets must be favorable enough to incentivize farmers to exert the physical effort and financial investment to collect, process, and delivery cherries during harvest time.

Mechanical strip picking is the least labor intensive harvesting technique with the highest capital investment, with the lowest discriminating selection. Due to the relatively flat landscape needed for operation of mechanical harvesters, it is more common to find such practices in areas lower in elevation, such as the case in Brazil. The initial percentage of under-ripe, overripe, and defective cherries tend to be higher with mechanical harvesting. Farms which invest in mechanical harvesting equipment are likely to have the means for investing in the proper sorting and drying equipment to achieve production expectation qualities.

Stripping

Stripping coffee from the branch is similar to mechanical harvesting in that the method does not consider ripeness as a determining factor for picking. Although this is done primarily by hand, there are hand held tools which mimic similar mechanical harvesting techniques which shake fruit off the branches onto plastic tarps and are then collected into bags (Wintgens et al., 2004). Strip picking is practiced in areas where achieving volume expectations drive producers more so than physical quality grades, such as in Brazil and most Robusta producers (Wintgens et al., 2004). Although labor is required, there is very little skill needed, therefore the labor pool is typically paid very little wage due to lack of specialization and knowledge for determining ripeness.

Selective Harvesting

The third form of harvesting is done by hand, using selective strategies for picking ripened fruit. Selective harvesting demands greater investment in a higher skilled labor pool and requires greater time investment throughout the season. Depending on the intensity and selective strategies, a single coffee plant can be harvested up to 10 times within one season (Wintgens et al., 2004). The fruit is typically placed in a bucket or basket which is carried by the picker. Selective harvesting is a generalized term for such practices, but the variation of selection is increasingly specific as demand for higher quality coffees have strengthened within global specialty coffee markets.

Selective harvesting promotes the collection of fruit which has achieved proper maturation. Fruit maturity often correlates to the potential complexity of flavors within the bean. Selective harvesting often achieves higher quality coffees through minimizing variation of ripeness, yet costs involved regarding the amount of labor needed to achieve proper selection may outweigh potential premiums which could be received for higher quality.

The definition of ripeness may not equate to the definition of what is acceptable for harvest, nor might the spectrum of ripeness have a definitive range or condition for cherry selection. Research conducted throughout the Cajamarca Region of Peru demonstrate color and condition of fruit having a wide range of acceptance. The color of coffee cherries ranged from light greenish-yellow to almost chocolate-purple. An additional attribute mentioned for determining harvest selection was the ability for coffee cherries to produce juice when squeezed by hand. The range of ripeness selected during harvest may also be influenced by how well coffee producers are connected to differentiated markets seeking higher end specialty coffee qualities. In addition, access to credit and capital for investment allow producers to take greater risk for seeking the sale of quality over quantity, therefore reducing the range of ripeness based on the level of income a producer obtains.

Post-Harvest Processing Methods: Fruit, Pulp, Parchment, & Seed-Dried

As recently as 2015, the international association of coffee professionals known as the Specialty Coffee Association (SCA) introduced refined terminology to replace traditional nomenclature for defining a set of common coffee processing methods used throughout most coffee producing countries. This standardization is an attempt to clarify processing methods used for preparing coffee to a shelf stable condition in raw seed form, prepared for final delivery to roasting operations. Traditionally, these categories of processing are termed as the following (Will, 2017):

- Natural Processed, Dry-processed (Fruit-Dried)
- Pulp Natural, Honey-Processed (Pulp-Dried)
- Semi-Washed, Mechanically Demucilaged (Parchment-Dried)
- Washed, Fully Washed, Wet-Processed (Parchment-Dried)
- Wet Hulled (Seed-Dried)

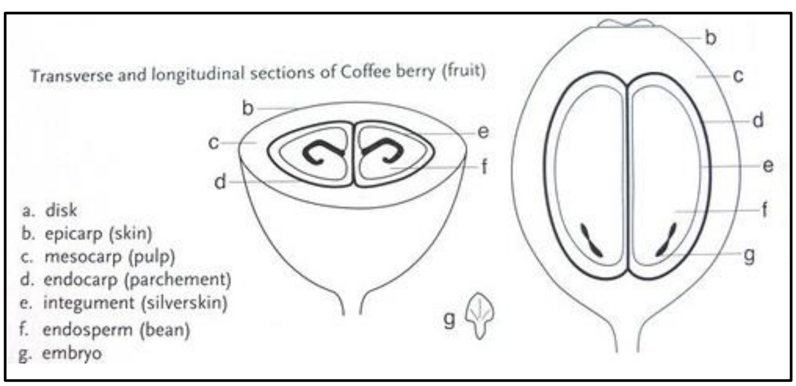


Figure 2. Coffee cherry anatomy (Wintgens et al., 2004).

Before final delivery of raw green coffee, each processing method requires removal of the outer layer of cherry pulp and an inner shell layer of parchment (Fig. 2). With an exception of natural processed (fruit-dried) coffee, the first step following harvest for all other processing techniques is known as depulping (Fig. 3). Removal of mucilage begins as coffee passes through machinery which squeezes and pulls the fruit skin and pulp from the inner parchment seed casing (Wintgens et al., 2004). Removal of the sticky mucilage bound to the seed can also be forcibly removed by mechanically scrubbing, or through naturally occurring microbial fermentation processes.

Figure 3. Motor-driven coffee pulper and tank

Decisions as to which processing method is used is determined by several factors, including access to sufficient water resources, capital for adequate processing equipment, and current market demand for a defined flavor profile from a specific growing region.

Washed coffee processing is utilized in areas with limited access to water, likely due to the demands presented by the coffee market. The water usage differs dramatically between the most common methods used for processing (Fig. 4). As shown below, traditional washing of coffee for the removal of mucilage uses larger amounts of water for the separation of defects, fermentation, and cleaning of parchment. Improved wet-mills generally imply recycling of water or use of mechanical demucilaging. Ecological wet mills specifically utilize mechanical demucilagers, where the fermentation stage may also be bypassed for conserving greater amounts of water. Pulp natural and natural processed coffees do not require washing or fermentation, therefore require little to no water (SCAA, 2017). In Chapter 3, observations in Peru show coffee producers continuing to choose to traditionally wash coffee, even to the point of sacrificing minimal drinking water resources within their community.

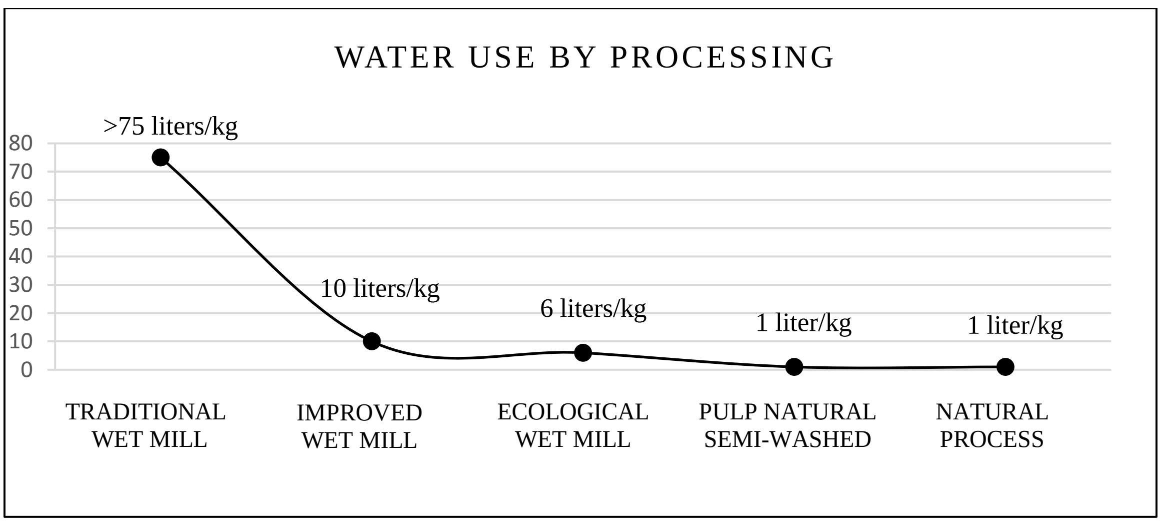


Figure 4. Water use by processing method. Adapted from (SCAA, 2017)

The drying stage of coffee processing follows the removal of mucilage. Understanding necessary environmental conditions and providing adequate space for drying coffee influence decisions on which drying method best suites an operation. The following section will examine each major processing method used, providing historical accounts to these techniques and highlighting actions within the process responsible for determining intrinsic coffee cup qualities. After each processing variation is described, I will briefly review a variety of drying techniques which are shared throughout all coffee processing methods.

Fruit-Dried

Natural processed coffee is the most basic processing method. Directly after harvesting coffee cherry fruit, producers will separate sticks, leaves, and other matter from cherries through winnowing and sifting with the use of screens, often followed by placement of cherries in water to further separate by density (Wintgens et al., 2004). In the example below from a coffee farm visit in Kenya (Fig. 4), when coffee picking is complete, harvesters return to the sorting area near the main processing center. They place all collected cherries, leaves, unripe cherries, and foreign matter on cement patios to begin sorting. Once it has been separated, the leaves, unripe cherries, and foreign matter is taken to a secondary screening area and added to a designated pile of lower quality coffee. The quality level (known as *m'buni*) is considered a poor-quality selection which are comprised of under-ripe and over-ripe cherries harvested from the coffee tree, or cherries which have been collected from the ground.

Figure 5. Secondary screen sorting of leaves, unripe cherries, and foreign matter

Floating coffee cherries are of lower quality, separated into lower quality lots. The fruit is placed on cement patios or raised beds to be dried to a moisture content of approximately 12 percent to avoid mold development during storage. This is one of few internationally recognized standard measurements. The target of 12% moisture content is used as a measurable intrinsic quality standard buyers use when collecting coffees and determining price paid to producers. Higher moisture levels change the physical weight of coffee being sold to collection agents, therefore often influencing prices paid to coffee producers. If coffee is delivered at a higher moisture content, producers will often receive a discounted price for insufficiently dried coffee. Once coffee has reached the proper moisture level, the raisin-like covered cherry is then hulled, polished, and stored for final delivery. These steps remove the dried fruit skin, parchment shell, and layer of silver-skin from the coffee seed.

The impact on intrinsic coffee quality rests on the timing and consideration for how coffee fruit is dried. During the drying phase, microbial fermentation within the cherry produces ethanol, acetic, lactic, butyric, and propionic acids (Will, 2017). The organic acids produced during fermentation cause rancid, sour, vinegar, and bitter flavors in the coffee (Will, 2017). Prolonged drying due to lack of full sun may also lead to spoilage and the development of ochratoxin A, a food-contaminating mycotoxin commonly found areas where grains are stored in moist storage conditions (Will, 2017).

If fruit-dried, natural processing is handled with care, potential for achieving competitive specialty coffee prices are possible, yet for many farmers the process may pose too much of a financial risk. Historically, choosing to use natural processing techniques were driven by environmental constraints. In Ethiopia, fruit-dried coffee was the traditional practice, mainly due to the minimal access to water within their arid environment. This method is often risky for the farmer as over-fermentation can easily occur, producing low quality flavors. On the other hand, with the introduction of using raised beds and better management strategies of drying cherry, natural processed coffees can result in unique and often rare fruit flavors in which specialty coffee buyers are willing to pay higher differentials.

Specialty grade natural processed coffees started in Ethiopia, gaining significant attention from high-end specialty coffee buyers beginning in the early 2000s. Prior to this recent recognition for fruit-dried coffees, parchment-dried washed coffees were the preferred method for producers from 1960-2000, and continues to be the dominant practice today. The introduction of fully washed, parchment-dried coffees were likely brought on by market developments showing a growing demand for cleaner coffee favors, in addition to the producer facing lower production losses throughout post-harvest processing stages. In response to the popularity and low-risk, natural processed coffees were generally ignored as a desired flavor profile by specialty coffee buyers. Regardless of specialty coffee preference for primarily washed coffees, coffee markets continued to demand natural fruit-dried coffees which were produced in the eastern Harari Region of Ethiopia where the access to sufficient amounts of water caused producers to use natural processed, fruit-drying methods.

Boot (2007) mentions the natural sun-dried process is most often chosen as the most practical method for processing in areas where there is limited access to water, which is typically seen in countries such as Brazil and Ethiopia. Coffee professionals give credit to a producer in Ethiopia by the name of Abdullah Bagersh for revitalizing interest in natural processed coffee. President of the Specialty Coffee Association of America, Peter Giuliano wrote a brief explanation regarding the processing methods in which Abdullah Bagersh popularized in 2007. Giuliano explains:

> Once upon a time, Abdullah Bagersh, talented and dedicated coffee miller and exporter, created a coffee he called "Misty Valley" at a small washing station in the Gedeo zone near Yirgacheffe called Idido. One of the things that made this coffee special was its unusual, extremely meticulous take on the Ethiopian Natural process, creating the first Grade 1 Natural in anyone's memory. It has rightfully taken the super-specialty coffee world by storm the past few years. This year, Abdullah executed his signature super-meticulous natural prep at other washing stations besides Idido. One of them was Biloya, and I had the privilege of tasting it in Ethiopia in

> January, both as part of a contest and open outcry auction, and in Abdullah's tasting room. The coffee is magnificent in the same way Idido Misty Valley is, although it has a much different flavor profile (2007, para. 1).

Following the growing popularity for fruit-dried Ethiopian coffees, Central America soon followed, adopting the processing technique after discovering the competitive differentials this processing was receiving from coffee buyers. Biloya coffee from Bagersh in Ethiopia became highly sought after in specialty coffee markets, driving green coffee prices well above standard. Mark Prince, coffee professional and owner of a popular coffee industry website mentioned a buyer could acquire fourteen ounces of roasted Biloya special natural processed coffee for $25.00 following the 2007 coffee harvest of Ethiopia (2007).

Prior to 2005, Panama rarely considered natural processing as a method for obtaining exceptional cup quality. Within a decade, natural processing techniques and varietals uncommon in most coffee growing nations are now seen in Panama fetching abnormally high auction prices. In 2014, coffee produced by Willem Boot named, "La Mula Natural CAC" from the Portrerillas Arriba region of Panama, received $107.86 per pound from the Best of Panama 2014 Auction (Stoneworks Specialty Coffee Auction, 2014).

Setting the stage for producers to follow in the footsteps of these auction winners could mislead producers into taking extraordinary risks during production, and most of these risks have undefined results. Author Martinez-Torres writes in her book *Organic Coffee*, "The drawback of this method is that the fermentation gives a sour flavor to the beans, which then bring a lower price" (Martinez-Torres, 2006, p. 25). She further explains how this process is used by coffee farmers in Chiapas, Mexico for their own consumption, and for coffee picked on the final harvesting pass (Martinez-Torres, 2006). On the other hand, if the process is carefully handled to avoid over fermentation and undesirable processing defects, a unique and highly sought after coffee can be produced. Willem Boot, owner of a small plantation in Panama specializing in natural processed coffee states, "the sun-dried process produces the remarkable natural coffee flavor, which ranges in taste from pungent and harsh to intensely sweet and fruity" (2007). Natural processing coffees are inherently risky for farmers due to the ease of over-fermentation and rotting. Professional author specializing in the coffee industry explains, "Wet process is the most desirable process, not because of the acidity or cup profile, because it is the least likely to result in defective coffee" (Hoffman, 2010). Fruit-dried coffees use no water in the process, have significant fruit flavor, yet are easily susceptible to mold and processing. The environmental impacts of natural processed coffees are extremely low, especially when considering the minimal water consumption. Illy and Viani explain:

> The natural process is the only one that does not attack the environment, since it does not require the use of water and does not produce solid and liquid resides rich in organic substances…the natural process is, therefore, environmentally friendly by definition (p. 95).

Balancing risk with the economic gains for selecting this processing method can be an arduous task, having to take into consideration a list of variables which relate to a producer's accessibility to differentiated specialty markets and resources for investing proper drying tools and specific technical knowledge for preparation to avoid spoilage or fermentation difficulties. What was once considered a processing technique left to lower quality lots has now gained the attention of specialty coffee producers throughout the world. The benefits of adapting this processing method have generally resulted in increasing the coffee quality and price for estate run plantations or well-connected producers who have direct market access for their production.

Pulp-Dried

The pulped-natural processing method adds an additional step beyond natural processing. Cherries are passed through a de-pulper which removes the outer skin and fruit surrounding the parchment layer of the coffee seed. There is very little water used in this process, allowing for a varying amount of sticky mucilage to remain. The process is relatively new, commencing in Brazil during the early 1990s. The processing method was found to be an effective manner for separating unripe cherries from ripe selections which were commonly mixed during mechanical harvesting and strip picking (Wintgens & others, 2004). The drying of mucilage on the outer layer of parchment impacts the intrinsic flavor of coffee, adding taste characteristics which share similar taste qualities to naturally processed coffees. There are many benefits to the development of unique intrinsic quality when using this processing method. Coffee producers have found this process to add unique fruit flavor attributes to otherwise common profiles. Coffee buyers have also found pulp-dried coffees to blend well with either washed or natural coffees in the roasting process, providing greater flexibility in application (Wintgens & others, 2004).

With popularity gaining in the application of pulped-natural coffees beyond its use in Brazil, coffee professionals involved with quality control and marketing within coffee producing countries have further supported differentiation of pulped-natural coffees by marketing this process by calling it “honey-processed”. Although it shares similar processing methods to pulped-natural coffees, honey-processed coffees further distinguish and categorize between amounts of mucilage left on the outer parchment surface. Three of the most common levels of honey-processed coffees are known as yellow, red, and black honey. The major difference is depth of fruit flavor, achieved by adjusting drying times and calibration of the pulping equipment. Yellow honey has the fastest drying time of about eight days, where coffee receives ample amounts of sunshine, giving the coffee a light-yellow color by the time it has reached its proper finished moisture level, and typically has the most significant amount of mucilage removed. Red honey takes longer to dry, and usually developed during cloud cover, often taking about twelve days to finish drying. During the pulping stage, a greater percentage of mucilage is typically left on the parchment. Black honey takes a little over a week for drying. The coffee is often covered by a black plastic tarp while constantly turned on raised African-style beds. Black honey typically has the most complex body and flavor profile. Due to the higher percentage of mucilage remaining on the outer parchment shell, spoilage and undesirable flavors to fruit-dried processing may occur, making it the most laborious and risky process of the three processing variations.

Parchment-Dried

Parchment-dried, fully-washed coffee processing is the most common method used for Arabica coffee production. Fruit-dried, natural-processing was the original method used for preparing coffee due to its ease of production and minimal water consumption. In the case of parchment-dried, fully-washed coffees, many of the same steps are followed as pulped-natural processing. Variation occurs through how the outer mucilage is removed from parchment.

The coffee industry has focused significant research in the methods which are taken to remove mucilage as this step has been recognized as a significant factor in changing final coffee flavors. Mucilage is typically removed through a natural dry-fermentation process. Once coffee is pulped of its skin and fruit, the sticky parchment covered in mucilage remains in a pile often housed in cement storage tanks submerged under water or without water for a period varying anywhere between 6 to 72 hours (Medina, 2017). Much of this time variation is caused by environmental temperatures, which often correlate to elevation. As elevation increases, ambient temperature decreases, extending fermentation times and labor hours. The impact of fermentation has been heavily debated, suggesting a significant impact on cup quality, yet more research is needed to fully understand how fermentation specifically change intrinsic qualities (Wintgens et al., 2004).

Time allocated to fermentation is influenced by a variety of factors including producer desires to match or develop a specific coffee quality or meet production volume demands during peak harvest. Facilities may become limited in their capacity for processing incoming collected cherry or have available labor on hand to monitor and process coffee during the day, pressuring operations to shorten fermentation times to speed up production. The variation of these determinants is seen most widely between estate run plantations or vertically integrated processing centers that are staffed and coordinated to handle expected volumes.

For many smallholder producers, a common method for determining when coffee fermentation has completed is typically conducted by placing a long wooden handle or paddle into a pile of dry fermented coffee. When the wooden stick forms a solid hole in the pile without collapsing, the fermentation is considered complete. This practice is found throughout several countries in South and Central America where dry fermentation is popular. Other techniques may include monitoring of pH of mucilage surrounding freshly pulped coffee parchment using pH monitoring devices. In research conducted in Peru, I monitored a freshly pulped pile of coffee parchment covered with mucilage, where a maintained average level of approximately 5.4 pH acidity was observed (Fig. 6). After 13 hours of fermentation, the liquid surrounding the mucilage on the parchment increased to a pH level of 4.35. The increase nearing 4.0 pH demonstrate acceptable fermentation levels.

Figure 6. *Monitoring fermentation with Pinpoint pH Monitor American Marine Inc.*

If pH levels continue to increase, coffee may become over-fermented, acquiring unfavorable notes and taints including sour beans and stinker beans. These defects can typically result from multiple contaminations caused by bacteria and molds gathered throughout these longer fermentation times (Illy & Viani, 2005).

Where ample water is present, fermentation may be conducted by submerging freshly pulped coffee under water at the beginning of fermentation. The wet fermentation process allows for homogeneous results, yet extends fermentation times. Coffee professionals consider washed coffees as providing a cleaner and more consistent flavor than sun-dried or pulped natural processes (Boot, 2007).

The amount of fresh water required to properly rinse coffee after the dry or wet fermentation process demonstrate an environmental concern as many areas utilize limited water resources to achieve desired demands made by collection stations and exporting agencies. According to a group of coffee experts working in Central America, the traditional wet-milling process uses 35-60 liters of water to produce one pound of dry parchment, which equates to approximately one million gallons of water over the course of a typical harvest season (Kline, 2013). Questions addressing irrigation, water use rights, and additional agricultural management practices may be considered in addition to the amount of water used, as some areas where coffee is grown have confronted issues accessing clean drinkable water.

Although natural fermentation is commonly used for improving intrinsic cup qualities, mechanical removal of mucilage through friction and scrubbing has gained attention for its significant reduction in water consumption and its speed of production (Arce, et al., 2009). Mechanical removal speeds up production significantly through bypassing fermentation. Rather than delaying the start of final drying times, cleaned wet parchment can be immediately prepared for sun or mechanical drying. The use of mechanical removal of mucilage can reduce consumption of water to about 36 liters of water per 100 lbs. of green coffee, which is a reduction of approximately 90% in water usage for processing (Arce, et al., 2009).

The first machinery used for ecologically minded removal of mucilage was introduced in the early 1960s known as the Raoeng pulper (Wintgens et al., 2004). Debate continues between specialty coffee industry professionals to the value which dry and wet fermentation add to intrinsic qualities of coffee. Some argue without allowing coffee to experience fermentation times, cup quality potential remains mediocre and more frequently impacted by defects from the harsh mechanical handling of seeds if machinery is not kept calibrated properly (Wintgens et al., 2004). The hedonic qualities which result from microbial interaction during the time following de-pulping of coffee cherry have been favored by professional cuppers and coffee buyers. Preferences developed by conducting hundreds of professional cupping sessions within dozens of producing origins have provided the coffee industry with clear guidance for assuming this processing step adds important value to coffee. Regardless of the increased monetary value attributed to fully washed and fermented coffee, consideration for environmental costs may rarely weigh consideration against premiums received for higher hedonic cup quality.

Seed-Dried (Wet-Hulled)

While most of the coffee processing practices share three similar techniques, seed-dried processing is less widely practiced. Indonesia is well known for this method, also described as wet-hulled, and more regionally known as *Giling Basash*. The climate in Indonesia during harvest is typically wet and humid with significant cloud cover. These climatic conditions make it difficult for producers to quickly dry coffee. In comparison to other coffee growing countries where drying coffee may be achieved within 20 days, many parts of Indonesia reach 30 days or longer (Owen, n.d.). Wet hulling coffee is a processing method prepared by harvesting, pulping, and de-mucilaging coffee beans in a similar manner to fully washed coffee processing, but the drying of coffee parchment is unique. Most coffee producers in Indonesia pick their own red cherries and pulp them at home, leave it in a bucket overnight for fermentation, and wash it clean with water in a pan the following morning. Coffee is typically put into a bag for delivery and taken to a hulling station where parchment is removed. What differentiates this process is an unusually expedited removal (or wet-hulling) of parchment prior to the coffee seed reaching a moisture level sufficient for proper storage prior to export. While the parchment is still wet, producers spread it across a plastic tarp for a few hours until it reaches 50% moisture content, thereafter selling to a middleman at local markets (Owen, n.d.). Once the coffee has been delivered to a wet-hulling site, parchment is removed, exposing the raw green coffee seed where moisture content typically rests above 25-30%. At this stage, coffee will be laid out once again on cement patios for several more days, brining moisture levels closer to 20 percent. During this time, coffee seeds are exposed directly to rainfall, human activities, and other contaminants. Thereafter, the coffee is collected in burlap sacks and taken to a final export warehouse station for further drying and final defect sorting. Seed-dried coffee is also used for lower grade Robusta qualities found throughout Vietnam and other countries with similar lower quality grades, due to the very low production costs, ease of processing, and higher commodity volumes, fetching minimal prices within the market.

Wet hulling adds several distinct intrinsic characteristics to coffee. Although these attributes are sought after by a set of demographics and regional markets, many professional specialty coffee drinkers have a negative response to these qualities, describing such flavors as showing mustiness or earthiness (Davids, 2015). There has been pressure for producers from specialty coffee buying professionals to suggest better manage cherry selection practices and improve methods for post-harvest processing to help develop cleaner flavor profiles for their consumer markets.

Additionally, it may be argued that if a wet-hulled coffee from Indonesia was placed on a tasting table next to a lower quality washed Central American coffee, the coffee from Indonesia would be considered defective due to its earthy characteristic. In comparison, Indonesian coffees have higher percentages of physical defects, many of which are caused by wet-hulling machinery damaging the softer wet coffee bean causing them to be crushed, broken, and chipped. With this being a common situation, the physical standard grading system in Indonesia emphasize cup flavor profiles rather than defect count, as most other standard grading systems typically follow.

In the scenario where a producer traditionally using wet hulling attempts to modify or adopt dry hulling processing, the problem then relates to varietal and elevation constraints, where Indonesia is limited to lower elevations and lower quality Arabica varietal selections. With such constraints, dry hulling coffee in Indonesia typically produce similar taste qualities as an average Central American coffee. Indonesia generally will receive higher premiums for coffee regardless of cup quality. This means a buyer would have less reason to buy similar fully-washed, dry-hulled coffees from Indonesia for a higher price, and rather opt to purchase a similar cup quality from Central America for a much more competitive, lower price. Perhaps the only attribute which would help differentiate this coffee is would be extrinsic qualities, which will be addressed in the following Chapter. Given the challenges and lack of incentives for pursuing alternative production methods, Indonesia is likely to continue their processing traditions.

Drying and Storage

One of the most significant activities during post-harvest processing that establishes cup quality is the drying stage. As mentioned in several of the processing methods, coffee seeds share an international exportation standard for achieving a moisture content of 10% to 12% to retain safe storage of raw green coffee. To describe each drying method and condition for most of the processing methods described above is well beyond the scope of this thesis. In short, the following techniques listed represent general methods for drying coffee, often shared amongst most coffee producing origins. Benefits to each of these techniques are quite often measured regarding the responses of climatic conditions, economic situations, and cultural tradition. For example, many producers have adopted the use of raised drying beds, traditionally first used in parts of Africa, typically made of a wooden frame and a fine mesh base for holding wet parchment well above the ground. This technique allows air to flow underneath the bed of drying coffee, while also allowing the sun to dry. The parchment is moved by hand, turning often to help maintain consistency in drying. Producers from all over the world have started to adopt this method, although smallholder farmers in many parts of the world remain with traditional practices, due to lack of technical training, access to capital, desire to minimize risk through experimentation, or a combination of such factors. Many producers simply use plastic tarps which are placed over the ground for drying parchment. At the end of the day, coffee is collected into large sacks, stored inside of a room for protection from the elements, and placed back outside the next morning for further drying. As producers gain greater access to capital for further investments, cement drying patios are often constructed and used quite frequently in Central and South America. As plantation size, capital investment, and volume increase, the use of mechanical drying is often employed. With mechanical drying, farms achieve consistent and faster drying times, although many specialty coffee producers and buyers have observed a loss of cup quality due to this method of drying.

Roasting

One of the final processing steps which impact intrinsic qualities of coffee is the transformation of raw green coffee into a dissolvable material through the process of roasting. Roasting is typically conducted within the country of consumption. Coffee roasting is quite complex, chemically transforming most of the organic material within raw green coffee into a completely different form. Interestingly, the amount of influence intrinsic qualities retained and presented within the final roasted product impact final taste attributes, demonstrating why such concentration on farm management and post-harvest processing techniques are important. As with drying methods, the conversation of roasting is complex. Likely the most important attributes given to coffee would simply be explained by how much influence the roasting presents within the flavor profile. The darker a coffee is roasted, the more roast character is present, either masking defects, unique attributes, and origin characteristics of a coffee. Lighter roasted coffees retain more organic matter, whereby retaining greater amounts of the intrinsic qualities defined by the processing technique. Darker roasted coffees develop and break down organic compounds, slowly homogenizing qualities to similar roast characteristics.

HEDONIC COFFEE QUALITY

Coffee cherries have very little resemblance to what we see in the café or what we taste at home in our cup. Chapter one presented a brief review on how coffee arrives to the point of consumption along with actions taken place defining intrinsic characteristics. The characteristics and composition of a coffee bean is the result of a complex process transforming the physical nature of coffee into an almost unrecognizable finished product from when it began. Although intrinsic qualities are present, value of those attributes have not yet been defined beyond its physical properties. In short, although coffee may appear to fit into a standard grade, hedonic quality will significantly impact the final market value. Tasting evaluation begins prior to shipment from the coffee's origin. Tasting most often occurs at quality control labs located near towns where final milling and preparation for exportation are conducted. At this initial evaluation, local coffee professionals who are familiar with coffee attributes from the region evaluate incoming lots from surrounding coffee producers. The sensory analysis of its liquor is recorded and given a cupping score often calibrated to a tasting grading system. Thereafter, coffee buyers who often work for importation or roasting companies in coffee consuming nations will visit facilities in the country of origin to choose which coffee lots they are interested in purchasing, or have the raw green coffee samples mailed to their importation or roasting facility. The choice for purchasing a coffee lot is typically agreed upon after this analysis. Purchasing contracts are negotiated for these coffee lots and prepared for export to be shipped to the buyer's warehouse abroad. Thereafter, the final stages of processing occur through the form of roasting. At this stage, a significant hedonic impact is determined, where the roaster develops the final coffee flavor profile by choosing a roasting profile which can transform a raw coffee into various flavors. Significant moisture and organic matter is lost, transformed, and developed into a newly package form. Through this process, coffee can result in a myriad of roast profiles most commonly described as light, medium, or dark. How to communicate and define the color spectrum of roast level identification has been under long debate. Generally, lighter roast profiles retain flavors relating to intrinsic organic material present in the coffee bean, whereas a medium roast balances these flavors through what is known as the

Maillard reaction. Darker roasts tend to cover up unique organic intrinsic qualities, which can either hide the flavors of common defects, or mask the positive attributes of acidity found in lighter roasts. These preferences for roast levels becomes a significant determination for coffee. As each roasting operation has the capacity to select several roast levels for each coffee type, they often have developed a certain flavor profile and expectation for their consumer base. To better understand the preferences and perceptions of coffee consumers, a roaster will more likely be able to cater to the needs of their customer base if they have a better understanding of the preferences and perceptions of their consumers. A basic review of the physiological aspects of flavor will provide a foundation for further discussion on how hedonic qualities and perceptions are established.

In the following section, I will examine basic physiology of flavor, and variation within human populations regarding perception and preferences of flavor. Discussion will lead into examining tasting evaluation activities conducted within the coffee industry used for determining the value of coffee flavor attributes. Finally, analysis will focus on standardized cupping calibrations and coffee competitions arguing how preference and perception of the professional pool of coffee tasters impact coffee farm management strategies and post-harvest processing decisions.

Physiology of Flavor

The International Standards Organization defines flavor as, "…a complex combination of the olfactory, gustatory and trigeminal sensations perceived during tasting. The flavor may be influenced by tactile, thermal, painful and/or kinaesthetic effects" (Delwiche, 2004, p. 137). Oral stimulation by food is often considered one of the most complex and rich multimodal sensory experiences a person can have (Breslin, 2013). The gustation system utilizes both reception and transduction mechanisms which function in the delivery of taste. These functions provide the body a service for evaluating food items to be consumed which is argued to have evolved as a protection mechanism against hazardous substances and to identify nutritionally valuable items (Cappuccio & Petracco, 2005). The process of transduction is the foundation for how the human body interprets tastes. It begins in the oral cavity, presenting molecules which are responding to taste qualities, transforming into electrical signals carrying information to the brain. The result of these processes shapes our perception of a given flavor sensation (Cappuccio & Petracco, 2005). Taste receptor cells are present in the oral cavity, found as single cells or combined in structures within densely layered receptors, known as taste buds, often varying to nearly 5000 buds on the human tongue (Cappuccio & Petracco, 2005).

The olfactory system is an important physiological system for the interpretation and perception of flavor. Combination of both gustatory and olfactory experiences develop sensations which are contingent upon the proper function of each system. Olfaction is the physiological system which informs us about the chemical compositions of our surrounding environment, while receptor genes are responsible for transduction of information given by molecular compounds. These physiological functions construct the ability for humans to recognize approximately 2,000 to 100,000 odors (Cappuccio & Petracco, 2005). The trigeminal system serves somatosensory sensations relating to textual experiences of a certain combination of olfactory and gustatory attributes during the consumption of an item, which help the body define if the substance is an acceptable item to ingest (Cappuccio & Petracco, 2005).

Variation of Perception and Preference of Flavor

Sensory science is a complex and rather recent scientific discipline which investigates how humans perceive food and beverages (Griffiths, 2015). When addressing the physiological variation within our global population, variables which impact preference and perception of food choices are plentiful. Research shows evidence demonstrating ability to perceive flavor diminishes with age, resulting in a noticeable impact on preference. Furthermore, one's biological sex tends to influence ability for flavor recognition. In addition to physiological functions, environmental conditions impact physiological capacity (i.e. smoking, diet, exercise, work) in addition to socioeconomic variables (i.e. access to diverse food choices, economic constraints, and life, living conditions, education, and early childhood). In the following section, we will address how age, sex, and the culture impact the perception and preference of flavor.

Aging

Although some attributes of the human existence improve with age, research suggests abilities to perceive tastes and flavor recognition diminish. Age is a widely agreed upon variable for impacting the ability for flavor recognition. The volumes of research available provide conclusive evidence demonstrating that age is not a factor which is necessarily bound to cultural or environmental conditions. The research available is widely measurable due partially on an ability to control experimentation with quantifiable, discrete measurements. This section will address the early developmental years of humans, addressing an evolutionary and genetic influence on the function and ability of taste at early age, with further discussion on environmental impacts which begin the variation of abilities between and within populations.

Childhood

The early developmental years of the human life are a critical time for acquiring attributes in relation to flavor and preference. Children are biologically primed to accept sweet, salty, and savory flavors which are often paired with higher energy density (Ventura & Worobey, 2013). With the gathering of food experiences into adulthood, tendencies for developing preferences for bitter and sour flavors increase due to positive and supportive social environments, in addition to ease of access to certain food choices, among other environmental and social factors (Ventura & Worobey, 2013). Research provides evidence suggesting biological and genetic influences on taste are identified by a set of genes responsible for the perception of sweet, umami, and bitter tastes, particularly TAS2R38 allele known to be responsible for such taste perceptions (Ventura & Worobey, 2013).

An article addressing the development of food preferences during early developmental stages have shown interesting data gathered from both formula-fed infants and breast-fed infants. The study researched how formula and human milk impacted early development of food preferences of children. Human milk is not only sweet, but provides flavors that are dynamic in flavor, often reflecting the diet and lifestyle choices of the mother, whereas formula is constant, static in its flavor profile (Ventura & Worobey, 2013). Variation within different formulas result in preferences of infants depending on the tendency of the formula flavor, thereby influencing preference of the child later on in life (Ventura & Worobey, 2013). The research conducted concentrates on parental influence over the child's consumption habits, arguing some measurements become counter-intuitive. When a parent restricts sweet, energy dense, and fatty foods from a child and then provides free access to these restricted foods, children tend to have higher consumption rates of these foods as opposed to the non-restricted choices (Ventura & Worobey, 2013). The article provides an interesting study between formula-fed infants and breast-fed infants, reporting results which show human milk provides taste experiences more dynamic in flavor often reflecting diet and lifestyle choices of the mother, whereas baby formula is constant and static in its flavor profile, limiting exposure to unique flavor combinations for infants (Ventura & Worobey, 2013).

Adulthood

Research suggests a significant percentage of elderly confront complications of diminishing olfactory abilities with age. In a study addressing populations in the United States, approximately half of the population between 65 to 80 years of age experience significant olfactory loss while nearly three quarters experience loss over of age of 80 (Doty & Kamath, 2014). This section addresses the influence of age on olfactory abilities, providing explanation for likely causes for diminishing functions. In relation to the influence of genetics on the likelihood of olfactory dysfunctions, Doty and Kamath (2014) point to research which state:

> Persons over the age of 70 who are homozygous for the allele of the val66met polymorphism of brain derived neurotropic factor (BDNF) exhibit a somewhat greater 5-year decline in odor identification performance than persons heterozygous for this allele (v/m) or homozygous for the met allele (m/m) (p. 8).

In addition to the role in which genetics impacts olfaction, multiple physiological changes due to age are well studied. Research demonstrates importance of a non-neural process responsible for loss of olfactory function in aging adults which is explained as a decline in the size and number of patent formation of the cribriform plate which, "…can lead to a pinching off or elimination of olfactory receptor cell axons that enter into the brain from the olfactory epithelium" (Doty & Kamath, 2014, p. 9). Additional information review changes in the olfactory bulb, the central brain regions involved with olfactory processing, and changes in the olfactory neuroepithelium. Research shows an increasing dysfunction for aging populations in properly identifying odors. These impairments increase when 80-97 years of age is reached, impacting 62.5% of the total elder population (Boesveldt, Lindau, McClintock, Hummel, & Lundström, 2011). As olfactory abilities are directly related to perception of flavor, this impairment greatly impacts preferences.

Research has shown a variation of sensory abilities between human populations, specifically in relation to sex, age, experience, and education, although contrasting results have been found when comparing the olfactory and gustatory abilities of biological sex cross-culturally, yet age seems to have similar universal results. Studies show age diminishes gustation and olfactory abilities, in addition to several studies showing younger women with higher education demonstrating overall better sensory abilities. There are several reports showing women being able to recognize flavors more accurately, while younger subjects display higher sensitivity in test results (Ahne, Erras, Hummel, & Kobal, 2000). On the other hand, in a study conducted with Japanese subjects, no gender difference was reported (Kaneda, et al., 2000).

Biological Sex

Throughout much of the research and articles dedicated to the physiology of flavor, it is well argued biological sex shows differentiation when measuring ability. Possible arguments for this ability often relate to an evolutionary response which strengthens the ability for women to sense bitter flavors, heightening awareness for possible toxic foods, thereby selecting genetic attributes which favor reproductive success. As research suggests, "at the time when fetal toxin sensitivity is greatest, women's sensitivity to bitter compounds is greater, perceived bitterness intensity is higher, and more foods taste bitter to them relative to before pregnancy" (Breslin, 2013, p. 415).

Research suggests women have a better perception of bitter stimuli than men (Ahne, Erras, Hummel, & Kobal, 2000). Some possible explanation for this preference could result from the fact that men have larger salivary glands than women, leading to altered taste perception, variable taste receptor sites, and possible variation in hormonal status (Ahne, Erras, Hummel, & Kobal, 2000). In the research conducted, perception of sweetness was again easy for most ages and both sexes to identify, where both bitter and sour were often confused (Ahne, Erras, Hummel, & Kobal, 2000).

It is important to not only distinguish age, geographic, and cultural backgrounds of participants in these studies, but include additional factors which may influence preference such as the temperature, color, and atmosphere in which the food item is consumed, including tools, including vessels, or words which are associated during the foods or beverages being tested. While addressing the multitude of influences on how perception of flavor is interpreted in foods, it is important to recognize the complexities of how chemosensory organs utilize a combination of these sensations to interpret foods. Temperature, texture, color and sight of medium, odor, and perhaps even sound, greatly influence individual definition and hedonistic value of flavor and experience (Delwiche, 2004).

Cultural Influence

The research discussed in the following sections will demonstrate evidence showing how both evolutionary adaptive measures, environmental factors, and cultural influences which shape preferences and perceptions of flavor. In addition to understanding variation between the sexes and age generations, the following sections will argue research which concludes higher levels of education may display greater capacity for odor and flavor recognition, as it may be misleading in the overall capacity for such abilities.

An interesting phenomenon presented in this research states, “odors that typically induce sweet tastes appear to be related to previous instances of co-exposure with a sweet taste, such as might naturally occur during eating” (Auvray & Spence, 2008, p. 1018). An example which was further provided lends continued discussion for cross-cultural analysis of food preferences. The paper provides an example which describe how odors of vanilla, strawberry, and mint induce perception of sweetness in most western countries where these are most often paired with sucrose based dishes, whereas non-western participants do not describe the same odors as sweet, leading the researchers to speculate the probability that these odors were not paired as frequently with sweetness in their food culture (Auvray & Spence, 2008). This research supports insight for cross cultural comparisons of the immense plasticity of human perception and preference for a variety of flavors.

Culture regularly influences consumption of ingredients, spices, and food stuffs, shaping our preferences and preferences for certain taste and flavor combinations. Research conducted between Japanese and German women titled, *Differences in Perception of Everyday Odors: A Japanese-German Cross-cultural Study* conclude, "…a positive relationship was found between pleasantness and judgment of stimuli as edible, suggesting that culture-specific experiences—particularly of foods—may significantly influence odor perception" (Ayabe-Kanamura, et al., 1998, p. 31). In addition, the study shows significant differences found between the two populations on all accounts (1998, p. 31).

Research has also shown the level of language capacity and semantic memory ability for naming and labeling odors can impact the ability to identify flavor (Thorngate, 1997). Argument can be made for questioning the validity of using education as a measurement of sensory abilities. A person may be able to smell as well as another person who has gained the intellectual capacity to provide detailed descriptions to a sensorial experience. It does not mean that the person who is unable to provide detailed descriptions are less capable in smelling the same aromatic chemical compounds. This measurement is only an exercise in proper identification, not necessarily olfactory capabilities. On the other hand, professional tasting experience or relation to a field which requires utility of olfactory and gustatory experience increases ability for recognition. Such evidence can be seen with experts matching descriptions to wines better than non-experts (Thorngate, 1997).

Professional Taste: Measuring Hedonic Qualities of Coffee

Professional coffee tasters are given the responsibility to accurately and fairly place hedonic value on a given coffee sample. The evaluation can be difficult for even the most highly trained coffee tasting professional. It should be acknowledged that not all professional coffee tasters recognize how their physiological, cultural, or environmental attributes impact their perception. To be cognitive of these conditions could help lessen subjectivity during tasting evaluations. Questions may arise to how confident tests may be for controlling substantial variables, while also designing and implementing research without culturally bias and limited environmental influences. A question worth addressing would be if accuracy of industry standard tasting evaluations are adequate measurements for determining useful market demands, assuming such that the purpose behind assigning value to hedonic attributes is for establishing benchmark qualities considered desirable by a coffee consuming audience, not necessarily by a specific set of professionally calibrated coffee tasters.

Coffee Cupping

To further improve communication between supply chain actors within the coffee industry, a general standardization and set guidelines have been created to support recognition for common defects and positive attributes found in coffee. The most common tasting protocol is known as cupping, a formalized tasting evaluation which uses a standardized format to evaluate the aroma and taste characteristics of coffee (Lingle, 2003). The Specialty Coffee Association and the Coffee Quality Institute were the first organizations to formalize cupping protocol through establishing a certification process for testing professional tasters. Certification involves a variety of knowledge and skill based exercises to evaluate abilities of a professional coffee taster. During the process, tasters learn how to become calibrated in their scoring of quality attributes. Although a formalized evaluation has been utilized in quality control exportation and importation facilities for decades, the practice has recently been introduced into retail and consumer markets as a vehicle for customer engagement and education.

The coffee lexicon has developed a much wider range of descriptors within the past few decades. With this evolution of cupping out of quality control labs and into consumer markets, greater attention is being paid to finite differences between coffee aroma and taste qualities by this wider audience. Increased consumer awareness has driven roasters and cafes to seek out more unique aromatic and defined flavor attributes, helping roasters, cafes, and coffee producers further differentiate their coffee offerings.

With increased attention to unique attributes, preferences for distinct coffee profiles have gained popularity in certain specialty markets. On the other hand, preferences seem to have become noticeably homogenized within high-end specialty coffee tasting professional communities, while the wider coffee consuming population has often yet had the opportunity to adopt similar preferences, or simply do not agree with their preferences.

Even though professional tasters tend to choose specific taste profiles, preferences and descriptions of coffee flavors often vary depending on the level of professional tasting experience, age, sex, and cultural background.

Cup of Excellence

Beginning in 1999, The Cup of Excellence competition has held coffee judging events in eleven countries, which has provided a venue for discovering quality coffees from areas previously unrecognized or unknown within the specialty coffee industry (Alliance for Coffee Excellence, n.d.). The intention of the program is to harness greater attention to farmers who invest in improved quality production. Following the international cupping, an online auction takes place where coffee buyers bid on their favorite coffees. Prices which are paid to producers through this platform have made historical records, with average prices earning 4.5 times higher than the International Coffee Organization (ICO) composite price (Wilson & others, 2014). Organizers select a group of approximately twenty to thirty professional coffee tasters from a variety of consuming countries (i.e., Australia, Germany, Norway, Japan, United States) and provides in-country expenses and logistics for each jury guest within each country of coffee origin. This occurs within 8 to 10 different coffee producing countries on an annual basis since the onset of the Cup of Excellence competition. Tasters evaluate on average between 40 to 50 coffees during a five-day cupping session, vetting each sample and calibrating scores between the entire group after each cupping session (Fig. 7).

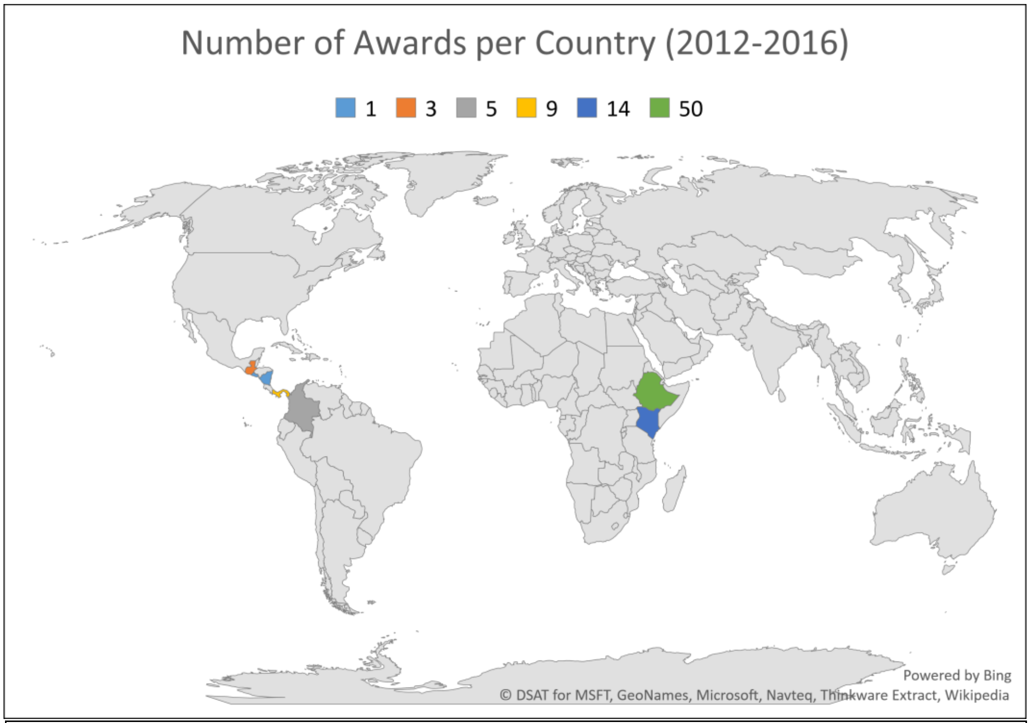
Figure 7. Judges calibration for the Cup of Excellence

I have participated as one of the international cupping jury members seven times over the last seven years. Throughout these tasting experiences, I have noticed trends which I argue would indicate cultural preference for certain cup profiles in addition to a taster's age and cupping experience. The interpretation of hedonic quality attributes within international jury member culture groups often show preference for certain cup profiles, in addition to the economic value within these international consumer markets. A great deal of weight is put on trusting palates of professional tasters even though average consumers may not necessarily agree or prefer the same qualities in which a professional taster prefer. The question should be asked, are judges serving as representatives of their coffee consuming markets, or merely looking to evaluate what they perceive as positive hedonic and extrinsic quality attributes?

The Good Food Awards

To further examine an observable homogenized preference within specialty coffee tasters, I gathered results from The Good Food Awards, an annual event held in San Francisco established to recognize sustainable production and excellent flavor, distinguishing winners by selecting coffees presenting, "…exemplary flavor – sweet, clean, well developed body, balanced acidity and phenomenal aromatics" (Good Food Awards, 2017), in addition to meeting social or environmental certification standards for eligibility. Between 2012 to 2017, the competition has given awards to seven different coffee producing countries. Considering over 70 nations produce coffee, the list of awarded countries appears limited.

Out of the total 86 winning coffees, 50 awards were given to coffees from Ethiopia, 14 from Kenya, 9 from Panama (all of which are Gesha varietals from estate owned farms), 5 from Colombia, 3 from Guatemala, one from Nicaragua, one from El Salvador, and 3 blended selections containing Ethiopia coffees in combination with another origin (Fig. 8). Results heavily favor cup quality attributes which are found primarily in Ethiopia. Some of the data describing post-harvest processing techniques used for each coffee were difficult to obtain. Most of these coffees were either washed (parchment-dried) or natural (fruit-dried) during post-harvest processing.



Country	**Total**	**Notes:**
El Salvador	1	Details unavailable
Nicaragua	1	Estate Farm
Ethiopia Blends	3	w/ Nicaragua, w/ Kenya, w/ Panama
Guatemala	3	2 of 3 Geisha varietal
Colombia	5	4 out of 5 are from Estate Farms
Panama	9	All Geisha varietal from Estate Farms
Kenya	14	Details unavailable
Ethiopia	50	Details unavailable

Figure 8. Good Food Awards winning coffee origins (2012-17)

Although this is a rather short collection of results, it could present an interesting trend which establishes preference for a familiar set of combined flavor attributes shared among the panel of judges. The judges for this event were seasoned coffee professionals, ranging between 25 to 50 years of age balanced between male and female judges. Additionally, most of the judges lived within the State of California and share a similar level of professional coffee industry experience. I spoke with a judge who participated in the 2017 Good Food Awards to ask about their interpretation of this trend. The judge mentioned many of the roasters had submitted a disproportionate amount of Ethiopia and

Panama *Geisha* variety selections, suggesting awareness by roasting companies of prior winning coffee selections in addition to strategically limiting their risk and optimizing chances for matching established winning flavor profiles historically represented by these selections. The path for discovering coffees that do not fit into established taste attributes will likely not widen unless there is a shift in strategy for diversifying expectations within the specialty coffee market place.

Do professional tasters represent or seek to best serve preferences of the public, or is there a different goal in mind measuring what cup quality should be? If a random set of coffee drinking consumers were asked to taste a variety of coffees in a different location in the United States, would they end up with the same outcome of preferences? If so, could we assume intrinsic qualities for geographic origins, post-harvest processing methods, and coffee varietals which are indeed representative of positive hedonic responses, and perhaps not completely guided by extrinsic attributes? If trends are not similar, would this suggest professional coffee tasters have collectively developed a shared expectation and definition for what is considered valuable, while consumers who are not experienced in recognizing coffee flavor characteristics, attribute negative responses to the same attributes and place less value on the same hedonic responses? If other extrinsic attributes of coffee selections are removed from the tasting evaluation (i.e., removing labels, retail bags, and avoiding open discussion between participants) would coffee drinkers agree with the professional coffee taster results?

Age and Preference: A Coffee Tasting Experience

To further research how preferences might vary within a small population of coffee drinkers, a previous event which was conducted prior my thesis development provides insight to how preferences may be influenced by age. A coffee tasting event was arranged in Lincoln, Nebraska to evaluate the general preference of coffee drinkers. After this event was complete, resulting data appeared to display a trend where age influenced preference. No additional information was collected regarding sex, level of education, or additional socio-economic factors.

Methods and Protocol

The participant size received during this experience was limited for gathering conclusive results, but preliminary observations show trends which suggest preference is possibly influenced by the age of the participant. There was a gathering of 38 participants in a room lined with tables which presented 21 coffees. These coffees were brewed and contained in identical air pots labelled with numbers 1 through 21. Age of the participants were recorded under categories using the following age ranges; (0-20yrs.), (21-39yrs.), (40-51yrs.), and (52-70yrs). Of the participating group, 22 of the 38 coffee drinkers were between the ages of (21-39), leaving very little data for analysis of the other remaining age groups.

Measurements indicated on the questionnaire addressed overall preference for a selected coffee, perception of strength of brew, age group of participants, how participants regularly prepare their coffee (i.e., plain, with cream, with sugar, with cream and sugar), frequency of drinks consumed, and location most often consuming coffee beverages. No further personal information was collected, and the process for selecting participants were taken by random responses with no qualifying or disqualifying conditions. Although it was an informal event, to avoid environmental and social influence on preference, I requested no one discuss coffee experiences verbally and to record their preferences by filling out a written questionnaire (Appendix F).

All brewed coffees were prepared using the same brewing method and measurements. All coffees were placed in identical coffee carafes with no labels or identification, placed on tables distributed randomly throughout the room in numerical order. Each taster was given a clipboard and a sheet for recording taste preferences. Questions included general level of preference from Bad to Excellent on a scale of 1 to 5, including their preference level for the perceived strength of brew. I chose a hedonic preference test using a simple point scale (1=bad, 5=excellent) for measurement. Providing a more detailed scale for an untrained tasting panel may have led to confusion (Cappuccio & Petracco, 2005). I included one set of coffee samples within the 21 offered coffee samples which were brewed identically and placed in two positions on the table, cup 5 and cup 12, to investigate the level of accuracy for each participant in scoring perception and preference.

Descriptive Review

The data presented discusses each age group category and the top three selections chosen by the majority. For the age group including adults 20 years and younger, the three highest scored coffees were from El Salvador (Table 1) with a lighter roast profile, presenting a mild, clean cup profile. This age group selected both Cup 5 (El Salvador) and Cup 12 (El Salvador), coffees which were the only two identical coffees out of the 21 samples on the table. These two samples were two out of the top three scored coffees for their age group.

The age group consisting of adults between the ages of 21 to 39 years of age chose all Ethiopia origins for their top three favorite coffees. The top scoring coffee was an Ethiopia natural processed coffee with a light roast profile, presenting distinct fruity flavors with a pleasant acidity. The second favorite coffee was another Ethiopia fruit-dried, natural processed light roast coffee with similar characteristics as the first selection. The third coffee selected was also a lighter roasted Ethiopia coffee which was a parchment-dried, fully washed processed coffee, presenting citric lemon acidity, light body and a floral aroma. All three of these coffees were lighter roast profiles which typically allow for presence of innate organic acids showcasing fruit acidity and medium body attributes.

The third age group included adults between 40 to 51 years of age. The top three scoring coffees were Cup 12 (El Salvador), followed by Cup 20 (Dark Roast Blend). The third favorite coffee selected was Cup 9 (Dark Roast Blend). The top three represent dark roasted coffees where roast attributes begin to take over intrinsic characteristics of coffee, demonstrating less presence of organic acids in the cup flavor profile with balanced flavors.

Our fourth age group ranged from 52 to 70 years of age. The top favorite coffee selected was Cup 2 (Dark Roast Blend). The second favorite selection was Cup 3 (Dark Roast Blend), presenting a similar roast level and taste quality. The third favorite was identified as Cup 20 (Dark Roast Blend). All top three preferences were dark roasted blends which presented roast character often described as smoke, sulfur, lower acidity, with stronger astringency and bitterness. These attributes are developed when roasting continues well into the Maillard reaction, where sugars are broken down in the organic chemical structure of the coffee seed and becomes browned, typically resulting from hotter and longer roasting times.

Table 1. List of coffee samples for tasting

Table Placement	Coffee	Roast Level
Cup 1	Mexico	dark
Cup 2	Dark Roast Blend (a)	dark
Cup 3	Dark Roast Blend (b)	dark
Cup 4	Kenya	light
Cup 5	El Salvador (a)	light
Cup 6	Dark Roast Blend (c)	dark
Cup 7	Dark Roast Blend (d)	dark
Cup 8	Ethiopia Washed (a)	light
Cup 9	Dark Roast Blend (e)	dark
Cup 10	Ethiopia Washed (b)	light
Cup 11	Light Roast Blend	light
Cup 12	El Salvador (a)	light
Cup 13	El Salvador (b)	light
Cup 14	Guatemala	light
Cup 15	Ethiopia Washed (c)	light
Cup 16	Ethiopia Natural (a)	light
Cup 17	Nicaragua	dark
Cup 18	Costa Rica	light
Cup 19	Dark Roast Blend (f)	dark
Cup 20	Dark Roast Blend (g)	dark
Cup 21	Ethiopia Natural (b)	light

Coffee Tasting Data Analysis

To further explore the data collected, I ran a crosstabulation on IBM SPSS Statistics for Windows software to perform a Pearson Chi-Square test to find the statistical level of significance from the data collected (IBM Corporation, 2010). To perform this test, I arranged data for reclassification of age groups through combining all ages under 40 to be defined as young, while all participants of age 40 and over defined as old. This age cut off point was determined by my experience through serving coffee and the general knowledge of physiological changes which occur in middle-aged adulthood, in addition to the literature reviewed during research. A reduction in the classification of the 21 coffees were grouped into two separate categories, both light and dark. These were determined through my experience as a professional roaster and as licensed Q-grader by the Coffee Quality Institute, where I determined intrinsic and hedonic characteristics of each coffee sample.

The final adjustment performed to the data set addressed the scaling from (1 to 5) points for participant responses. Due to the description of the number choice (3) as being average, it did not accurately reflect whether the participant preferred the sample or not. Therefore, I did not include responses which chose (3) as their selection. This limited the data selection even further, yet the strength of preference communicated by the respondent increased, since scores recorded were now grouped into either “no” which reflect scores of (1-bad) or (2-acceptable), and group “yes” recording scores of (4-good) or (5-excellent). In addition, I calculated the percentages of “dislike” responses for each participant. I thought it was important to measure not only what each taster liked, but also how often the participant disliked each sample. This allowed me to accurately measure preference for a general category such as roast level. The rationale behind calculating percentages of dislikes helped include data from tasters which might have alternative ways of expressing preference. There were some participants that did not score coffees above (3), but they did respond in a manner that showed they disliked certain samples less than others, resulting in a preference as “less un-pleasant”. These regroupings allowed for conducting the Pearson Chi-Square test. The data used for this test is given in Appendix G.

Table 2. Chi-Square: Do adults age 40 and over prefer dark roast?

AGE * ROAST Crosstabulation

			ROAST		Total
			.00	1.00	
AGE	1.00	Count	25	7	32
		Expected Count	21.1	10.9	32.0
	2.00	Count	2	7	9
		Expected Count	5.9	3.1	9.0
Total		Count	27	14	41
		Expected Count	27.0	14.0	41.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.762[a]	1	.002		
Continuity Correction[b]	7.435	1	.006		
Likelihood Ratio	9.489	1	.002		
Fisher's Exact Test				.004	.004
Linear-by-Linear Association	9.524	1	.002		
N of Valid Cases	41				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.07.

b. Computed only for a 2x2 table

Source; IBM, SPSS Statistics for Windows, 2015

Chi-Square Results for Age and Preference

Table 2 represents the crosstabulation showing a relationship between participants (n = 41), age group (1 = young, 2 = old) and coffee roast level (0 = light, 1 = dark) using a chi-square test. Out of the younger age group (n = 32), 25 preferred lighter roast samples, whereas seven tasters preferred dark roast samples. Of the older group (n = 9), two counts are given for light roast and seven counts are given for dark roast. The relationship between the two groups displayed a Pearson Chi-Square level of .002

(Asymp. Sig) and Likelihood Ratio level of .002 (Asymp, Sig), which indicated these variables as showing a relationship with statistical significance.

Accuracy of Taste Recognition in Relation to Age

An additional question considered were if younger tasters were more accurate in flavor recognition than older tasters. In this experiment, Cup 5 and Cup 12 were identical. Out of the 41 respondents, 18 tasters responded with similar preferences (i.e., scored similar preferences rating for both cup 5 and cup 12). Younger tasters had a higher percentage of similar responses. Older tasters had higher percentage of different responses. I performed a Chi-square test to evaluate this assumption.

Table 3. Chi-Square results for tasting accuracy and age

	Similar Response	Different Response	Total
Young	15	17	32
Old	3	6	9
Total	18	23	41

The Chi-Square is 0.523. The *p*-value is .469555. This result is *not* significant at $p < .05$.

Chi-Square Results for Accuracy of Taste in Relation to Age

The results of the Chi-Square test showed no significant difference between old and young tasters accurately identifying samples. The finding does not support my hypothesis, although this may lend reason to the small sample size given for consideration. Regardless, the observation showed that more than 50% of the total tasting group including both young and old tasters did not similarly prefer the identical coffees, Cup 5 and Cup 12. This lends question to the overall validity of how accurate general tastings with non-expert coffee drinkers may result in consistent data. Due to the small sample size and number of events, this experiment may serve as an example for further research methods and questioning.

Discussion of Coffee Preference and Perception in Relation to Age

Results of the coffee tasting experience reflect similar research which demonstrate change of preference and perception due to advancement of age. Coffee is often an acquired taste throughout early adulthood. Preference for coffee taste profiles are likely to be partially socially constructed. In regards to research addressing innate and learned human behavior in flavor and taste choices, Breslin describes much of the human capacity for accepting bitter, sour, and acidic flavors as having a strong physiological and evolutionary correlation in regards to an innate preference for fruits which present a wide range of acids and sourness, along with natural sugars, all which served as a guide to ingesting necessary amounts of vitamin C fruits (2013).

To further address the influence of social behavior over perception and preference of flavor, in addition to age related diminishing abilities, research presume older more established groups of consumers are those which invest in "higher priced" and "pure coffee" (Geel, Kinnear, & De Kock, 2005). Although this cultural practice perhaps exists in South Africa where this research was conducted, to assume older populations outside of the given geographical area and cultural context of South Africa share similar definitions of pure coffee, while also sharing a similar desire to spend greater amounts of money on coffee, presents a strong ethnocentric view within conducting their research. The limited income group were affiliated and described as the "coffee-blend lovers" noting mostly students and domestic workers typically behaving with greater price-sensitive consumption patterns, looking for lower priced coffee options (Geel, Kinnear, & De Kock, 2005). This would be an interesting comparison to the United States where consumer behavior may be quite the opposite, showing younger millennial coffee drinkers preferring more expensive, lighter roasted coffees with eccentric coffee flavor profiles, exhibiting slightly bitter, acidic, and sometimes sour flavor attributes, rather than lower grade coffees which are described within this article.

Geel et al. (2005) establishes an approach in describing two cues which guide preference, both intrinsic and extrinsic in form. As described in the article, intrinsic values refer to the appearance, taste and smell, while extrinsic qualities refer to price, brand, in addition to personal and situational variables (Geel, Kinnear, & De Kock, 2005). The last two variables mentioned were not given further exploration within the article, but I would also argue the idea of the locale and ease of access to a certain coffee, or any food item for that matter, would likely increase preferences.

Certain organic acids in coffee have bitter, sour, and salty taste attributes, which may be less recognizable and less desirable with older age, yet preference for and the ability to perceive sweetness is not greatly diminished across age, sex, or cultural constraints, demonstrating at least one universal connection; humans prefer things that tastes sweet. These results show both the age and sex of humans have a strong impact on perception, intensity, and preference of certain flavor combinations. The body of literature and research conclusively show how perception of flavor diminish with age, resulting in a significant impact on preference. Evolutionary mechanisms in relation to differentiation in abilities between males and females clearly show olfactory and gustation to be stronger for females, suggesting differences are due to physiological systems catering to rearing of offspring.

Creating a Demand for Flavor: The Impact on Producers

Research involving taste preference provide market research for product development in the food and beverage industries. Recognizing the outcome of such market preferences also help explore how agricultural landscapes are shaped, allowing to gain further insight on how both domestic and international economic policy may be driven by consumer demand. Recognizing variables which influence perception and develop preference for certain food and beverage items benefit market research for product development in the food and beverage industries.

The perception and resulting developed preferences of flavors will impact directions agricultural landscapes are utilized. Coffee consumption in China is growing quickly as younger generations are drawn away from the previous generations of traditional tea drinkers. The move away from tea towards coffee is arguably due to both social status and the heightened sensorial experiences. Change in consumption is argued to be driven by popularity in westernized societies. Roberio Silva, the executive director of the International Coffee Organization, states consumption of coffee will increase by almost 25% in the next five years as consumption patterns in societies like India, China and Latin America continue to be westernize (Bariyo, 2015). This will severely impact decisions landowners make regarding how coffee producing countries utilize landscapes. The prediction is compounded with research stating half of the land currently used for coffee production will no longer be suitable by the year 2050 due to climate change (Bunn, Läderach, Jimenez, Montagnon, & Schilling, 2015). Researchers state, "Zones that currently have climates better suited for Arabica will migrate upwards by about 500 meters in elevation. In these zones the up-slope migration will be gradual, but will likely have negative ecosystem impacts" (Bunn, Läderach, Jimenez, Montagnon, & Schilling, 2015, p. 1).

In addition to coffee, rising demand for palm oil on the international market raises concern for loss of biodiversity and deforestation in areas where countries are incentivized to invest in increasing export yields, such as Malaysia and Indonesia. As trends within the marketplace show manufacturers switching from hydrogenated fats to trans acid-free substitutes, the use of palm oil as a viable alternative is increasingly being used for production of shortenings and margarines, serving as a raw material for production of solid-fats which are high in palmitic acid (44%) and crystallizes in the β' form (Nor Aini, et al., 2007). The demand for palm oil drives agricultural expansion into forested areas, both creating massive deforestation while dramatically increasing loss of biodiversity and extinction of many wildlife animals. Researchers state, "…during the period 1990–2005, at least 56% of oil palm expansion in Indonesia may be attributed to the conversion of primary, secondary, or plantation forests" (Koh & Wilcove, 2008, p. 1).

When flavor preferences gain demand and popularity within a market, those coffee producers with access to market information may find an advantage for modifying farm management and post-harvest processing methods to adapt to these newly defined flavor preferences. On the other hand, many of these flavor profiles present greater risk in production for the farmer. Such risks often include seed selection for varietals which are in demand, such as the Geisha varietal which is more prone to disease or insect damage with lower fruit yield potential and longer maturation times. Activities may also include greater labor investment including increased accuracy on selective harvesting ripe cherries, time spent on calibration of processing equipment, and longer drying times. In addition, many of the farmers are given no guarantee the resulting raw coffee product will achieve sufficient positive scores or responses from specialty coffee buyers once their coffee arrives to the cupping table for analysis.

EXTRINSIC COFFEE QUALITY

In this section, I will address the external attributes of coffee and how value is ascribed to these qualities within the coffee industry. Both intrinsic and hedonic qualities of coffee heavily influence customer response and consumer behavior as the product is tested by the individual. These qualities may hold greater value than another quality category depending on the motivation of the consumer. Extrinsic coffee qualities often offer the first impression on the consumer. Such qualities as packaging, familiarity to brand, location and cost of coffee, including conversation with the person who might be selling the coffee, all fall into extrinsic qualities encompassing several areas including ethics, branding, and consumer suitability. These qualities are extremely important as they are the initial influence on a buyer to invest their time into further experiencing flavors which are suggested through labeling, ethical claims, or even the smell of coffee prior to brewing.

Category of Ethics

Foundational arguments for sustainable coffee can be linked to the sustainable agriculture movement and discussion regarding global food security. These discussions lend to further analysis toward population growth and its impact on finite resources, such as clean fresh water, rich top soils for agricultural production, and fossil fuel for a growing global consumption of energy. Although signs of a slowing global population growth have been confirmed by some researchers, these environmental and social stresses remain contentiously debated and unresolved.

Controversial themes within human population growth include debate regarding causes of over population, biological and social mechanisms in which societies regain sustainable populations, impacts of population growth on the depletion of natural resources, and scholastic propositions to solutions by specifically addressing food production while exploring other methods of managing population growth.

The Green Revolution presented significant advancement in agricultural production beginning in the late 1960's, spearhead by the leadership of Norman Borlaug. Borlaug announced during his Noble Peace Prize speech how Malthus had signaled the dangers of population pressure on global resources a century and a half prior (Borlaug, 2014). Although Borlaug focused his work on increasing capacity for world food production to curb world hunger, his approach never ignored the core issue of over-population as a pressing cause to world hunger and the stress imposed on the environment.

The following excerpt from Borlaug's Noble Peace Prize Speech explains how his work may be done in vein unless issues of over-population are considered. Borlaug explains:

> The green revolution has won a temporary success in man's war against hunger and deprivation; it has given man a breathing space. If fully implemented, the revolution can provide sufficient food for sustenance during the next three decades. But the frightening power of human

> reproduction must also be curbed; otherwise the success of the green revolution will be ephemeral only. (2014, para. 91).

Although the green revolution had increased the possibilities of food production well beyond the scope of what Malthus thought was possible in the late 18th century, questions remain as to whether the quality of the food produced in lieu of the green revolution is providing adequate nutrition to curb catastrophic disease and famine.

The Green Revolution significantly increased agricultural production, yet greater access and distribution of food to those most in need remained problematic. Although the Green Revolution increased the intake of macro-nutrient sufficiency for many populations, a case study has found in South Asia where although cereal production has quadrupled in production since 1970, micro-nutrient deficiency has declined by 20% (Graham, et al., 2007). Zinc deficiency alone is responsible for over 450,000 deaths a year, with approximately 40% of the world's population suffering from some form of micronutrient deficiencies (Welch & Graham, 2002).

As noted in his historical noble peace prize speech, Borlaug addresses Malthus as having historical insight on the issues of over population, yet also makes a clear statement that Malthus could not foresee man's ability and potential for increasing food production, nor the urban migration that was to take place in the late 20th century. Although Borlaug makes a clear case, it is argued Malthusianism can be applied in broader and less specific terms in relation to social-economics, applying a seemingly simple concept, perhaps, that human population will continue to increase with better medicine, more food, and greater comforts. On the other hand, William Godwin's argument where population will regulate itself by diverting desires to more intellectual concerns could still be interpreted in a sense this “intellectual” advancement of humankind may be the socially accepted measures of contraception and family planning taken by societies where communities are not strictly bound to traditional religious moral leadership but rather intellectual and rational individual freedom of choice expressed through modern democratic societies (Godwin, 2013).

In addition to population pressures, climate change poses additional production threats to smallholder coffee producers. As environmental factors force migration of coffee production to higher elevations due to increasing temperatures within most coffee producing areas, current coffee varieties will no long suit the necessary quality and yield expectations to remain economically viable. By the year 2050, half of all suitable land for coffee production will no longer be suitable for coffee production (Bunn, Läderach, Jimenez, Montagnon, & Schilling, 2015) while global coffee consumption rates will have doubled in the same time (Killeen, 2016). One of the suggested leading adaptation strategies for coffee production proposes strengthening agronomic research for breeding climate resistant Arabica varietals. Several development strategies have been proposed to mitigate the impact of climate change within the coffee industry, yet should smallholder coffee producers consider further investments to intensify their production by seeking new hybrids, or perhaps diversify their production and landscape to incorporate alternative cash crops?

One of the main foci within the specialty coffee industry has been to support economic sustainability within the supply chain by promoting a belief that higher cup quality leads to higher prices for coffee producers. This is a logical assumption to make given the free market economic framework in which consuming nations participate. On the other hand, results from several coffee tasting competitions often show winning coffees originate from estate owned farms, as seen in the results given from the Good Food Award winners who live in Panama. Of those winning coffees, all nine coffees from Panama were awarded to estate owned farms that cultivated a single varietal known as Geisha (Good Food Awards, 2017). This may suggest conditions remain unfavorable for smallholder farmers who are at a competitive disadvantage who are likely unable to take greater production risks with experimentation or have less access to technical support and minimal direct connection to specialty coffee markets. These issues remain at the forefront of the specialty coffee industry. In the Specialty Coffee Chronicle, Executive Director of the Specialty Coffee Association Ric Rhinehart states:

> …we are faced with the need to assess the sustainability of specialty coffee. That is, even if a coffee results in a great tasting beverage, if it does so at the cost of the dignity, value or well-being of the people and land involved, it cannot truly be a specialty coffee (2017, p. 4).

The coffee trade has a complex history filled with economic, social, and environmental issues which have engaged the interests of consumers. Coffee consumers are gaining access to extensive amounts of information regarding their product. The story behind a specific coffee offering helps further differentiate its value by partnering with the intrinsic and hedonic qualities. Information given by coffee roasters to customers often address socio-economic and environmental issues involved in the production of coffee. The methods in which this information is presented typically entail information posted on roasted bags of coffee, detailed stories on websites, or even arranging personal visits from the producer to roasting facilities or cafes to celebrate and highlight their business relationships. Coffee roasters within the United States often deliver their commitments to ethical production through purchasing certified coffees through a third-party organization or perhaps implement their own company purchasing guidelines which may involve a formal verification structure, or an informal set of guidelines or practices for adherence.

As explained above, the value of sustainability as an extrinsic quality attribute to coffee adds an important role in the coffee trade. The International Trade Centre reported 8% of all green coffee exported by 2009 had carried a form or certification or credible sustainability claim, and with current trends, the global coffee trade should reach 20-25% by 2015 (Pierrot, 2011). Historically, the coffee trade carries similar ethical burdens as most other agricultural commodities, having established their presence in the world through centuries of exploitation of economically marginalized communities. Additionally, technification of landscapes have minimized biodiversity and decreased smallholder food security strategies by limiting land-use for inclusion of nutritionally valuable food staples. An increase in agrochemical runoff, waste water discharged into rivers and streams often used for drinking water, increased deforestation rates, and soil depletion remain ongoing consequences to production of coffee.

Additional environmental issues surrounding the impact of technified management practices show approximately 10-12% of global greenhouse gas (GHG) emissions are directly attributed to agriculture (Killian, 2013). Research regarding the total carbon footprint of Costa Rican coffees ranged from 4.82 – 7.15 kg CO_{2e} per kilogram of green coffee, reflecting differences mainly contributing to the variation of fertilizer use at farm level (Killian, 2013). These levels of carbon emission produced throughout the coffee supply chain are well within the classification of "very high intensity", ranging > 5 kg CO_{2e} per kg (Killian, 2013). The carbon emission classification is determined by the Publicly Available Standard 2050 (PAS 2050), a methodology created in collaboration with the British government and the British Standard Institute for calculating GHG emissions (Killian, 2013). The following diagram (Fig. 9) shows the distribution of carbon footprint throughout the coffee supply chain with 45% of the total footprint contributed by coffee consumption, whereas 31% is produced at the farm and central mill (Killian, 2013).

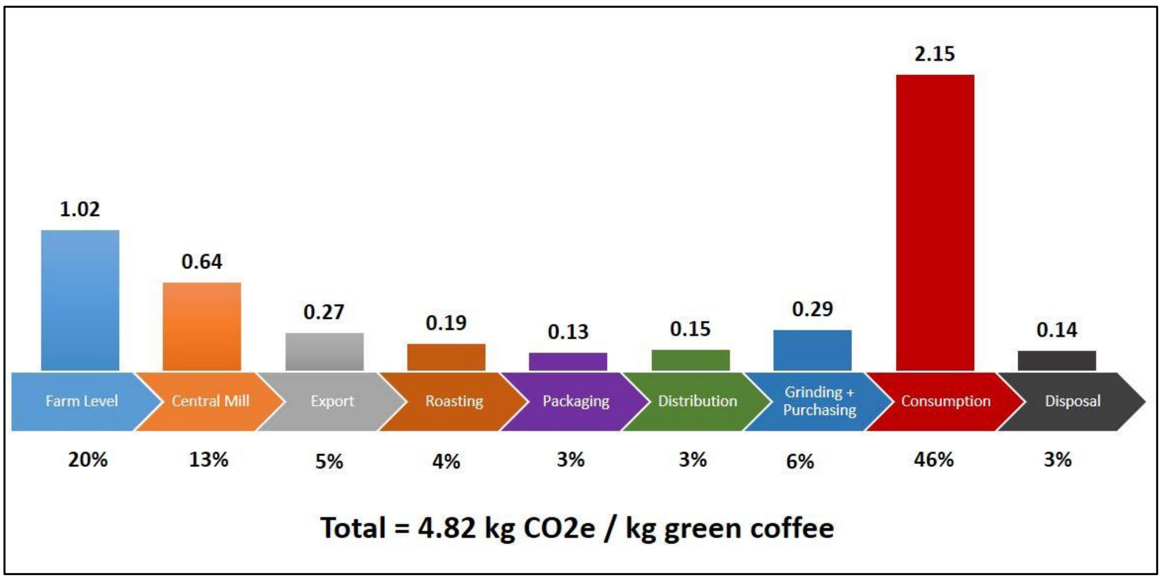


Figure 9. Carbon footprint of Costa Rican supply chain. Adapted from (Killian, 2013)

The measurement of carbon footprints within the coffee supply chain has provided an indicator for consuming markets to help measure their environmental impact while also providing an opportunity to invest in reducing or even neutralizing their coffee carbon footprint through investments in carbon credit schemes or adopting mitigation strategies throughout the supply chain (Killian, 2013). Consumers have shown a desire to invest in purchasing decisions which can help them rest assured they are not contributing to negative environmental and social consequences, yet the impact of the preparation of coffee beverages may often be overlooked as the major carbon footprint. Certifications and private businesses have implemented strategies to cater to these ethical concerns by developing extrinsic qualities for their coffee inventories, most often concentrating on farm level and origin certifications. With more research and public awareness, the growth of certifications for cafe service practices and transportation methods may become a valuable area for further investments.

Certifications within coffee often address two distinct areas, to guarantee equitable trade and support environmentally sustainable practices. Organic, Fair Trade, RFA, UTZ, 4C, Bird Friendly, Shade Grown, Direct Trade and Relationship-Coffee Models are several of the leading certifications and practices currently available for coffee consumers.

The growing demand for certified coffees has been fueled by consumer awareness in combination with leadership within the coffee supply chain and business entities. Several companies have ethically driven mission statements set forth by individuals who are deeply committed to improving socio-economic and environmental conditions. With a growing number of business owners sharing similar visions and mission statements, in addition to those companies who recognize the growing financial opportunity in marketing ‘sustainable’ consumption, certification has become an effective tool for differentiating coffees within the coffee market.

In addition to achieving sustainable production practices, an additional purpose behind certification is to guarantee consumers coffee they purchase meet a certain set of ethical standards. As stated in the International Trade Centre Coffee Exporter’s Guide:

> Roasters buying certified coffee benefit from the guarantee provided by the certificate and by using the logo and related information on their retail packaging. Certification protects both buyer and supplier, often also resulting in better marketing opportunities because there is a specific demand for certified products (Hilten, Fisher, & Wheeler, 2011, p. 53).

Can sustainability be achieved through certification? Certifications are a tool to measure individual commitments towards practicing guidelines and production methods which ideally cater to management systems which focus on environmental and socio-economic improvements. Achieving a wider landscape of sustainable coffee production across economic, social, and political lines presents a much greater challenge which will likely need to incorporate a much wider net of collaboration between farmers, community members, government agencies, buyers, and consumers.

Certification is often achieved by well-organized and financially capable farming units to handle necessary commitments and activities required to maintain certification. Although certifications add extrinsic value to coffee, measuring impact toward sustainability through the application of certification platforms have struggled to report an accurate measurement of success, especially under consideration that the playing field for becoming certified tends to cater to groups which might already practice sustainable production, leaving many of the marginalized smallholder producers behind. A technical paper issued by The International Trade Centre (ITC) suggest smaller African producers face some of the greatest needs yet lack groundwork for implementing certification guidelines. This causes many of the certification bodies to concentrate work with producers better equipped to achieve certification standards. The (ITC) states:

> Most of the certification bodies find it understandably difficult to operate there and have focused more on quickly developing supplies from producers that are often more capable and better financed, such as those in many parts of Latin America (Pierrot, 2011, p. 12).

Certification has a long list of challenges, but it has become a necessary marketing tool for communicating commitments from both producer and consumer that ethics is a quality attribute that carries substantial economic value.

The use of the phrase “direct trade” has become a common label within the coffee industry, helping roasters differentiate coffee selections with intention of building more transparent and long-term commitments with producers who cultivated these specific coffees. Although original intentions for the trading model were to have a tailored approach to each coffee supply chain, the term has become a watered-down marketing term with very little meaning. Geoff Watts, a pioneer of the terminology and implementation of the direct trade model explains:

> At its most simple I’d define it this way: A proactive and mutually beneficial collaboration between coffee farmers and coffee roasters aimed at increasing the quality, value, and consistency of coffees produced, where the farmer and the roaster are committed to working together transparently and long-term. While we have our own set of metrics to determine which coffees qualify, it was never the intention that it would become yet another certification system that could be outsourced or commoditized. In some ways it shouldn’t be, as it was originally designed as a sort of “anti-cert” in response to what I saw as some of the flaws in

> certification systems that are necessarily generalized so that they can be applied universally across a whole range of contexts, countries, and products. This was meant to be a tailor-made and highly specific approach to working with coffee farmers so that we could both realize our individual and mutual goals regarding coffee quality and profitability. The whole point was that there WAS no certification that worked equally well for every roaster, farmer or farmer group. We weren't trying to create that, and I'm not sure such a thing could exist given the staggering and profound differences between producing countries, individual farmers, and individual companies. We wanted something that could take into account those differences and be relevant and effective across many individual contexts while still leading to the same place—improved quality, full transparency, full traceability, and genuine sustainability (Stark, 2012, para. 22).

Although there is a baseline set of shared principles offered by a few select coffee roasters, there is no formal approach or responsibility for achieving environmentally sustainable practices, or even a requirement for conducting proper research for accurately determining what steps might be taken to achieve such goals. Although there are benefits to tailored trade relationships, there are no requirements which establish that the person visiting coffee farms are adequately trained to measure proper indicators necessary to make informed decisions on environmental, economic, or social situations. Producers could provide unfit labor conditions, pollute waterways, deforest areas within protection zones, or misuse agrochemical inputs without any form of regulation or verification expected by direct trade coffee buyers. These direct relationships may also not consider how personal trade relationships may impact regional social networks beyond the group in which is involved in trade relations, leaving regional economic concerns and policy for coffee communities out of this trade paradigm.

Direct trade models have since progressed into a more generalized definition of trade. Most recently, such trade practices have been recognized as the Relationship Coffee Model (RCM), where collaboration between smallholder growers, roasters, buyers, and importers work to establish long term commitments for providing higher-quality cup profiles (Hernandez-Aguilera, et al., 2015). Hernandez-Aguilera, et al., (2015) suggest overall impacts of the RCM model contribute to integration of smallholder producers into global coffee markets, while also generating measurable socioeconomic benefits showing increased access to credit and the integration of more environmentally-friendly resource management practices for those who participated in RCM (Hernandez-Aguilera, et al., 2015).

Category of Brand

Branding of a company enterprise is one of the more recognizable extrinsic attribute to coffee, where aesthetics immediately impact decisions made by the end consumer. Consistency of brand across regional or international areas become an important competitive attribute for success, where brand recognition provides a sense where less risk is taken by the consumer, allowing expectations for familiarity to assist in the purchasing.

Initially, the geographic location of coffee will impact the intrinsic and hedonic qualities of a coffee through its interaction with specific soils, elevations, and climatic conditions. The geographic name of a coffee provides customers to determine product value through recognition towards past experiences with a coffee from a similar area, even if actual content within the coffee bag have little to no connection to the consumer's previous purchases of a similar coffee. For example, if a coffee from Guatemala is consumed and enjoyed, the use of its geographic location becomes a label of reference for consumer preferences. On the other hand, the variation of intrinsic and hedonic qualities within a geographic location can be tremendous.

Category of Suitability

Suitability of a coffee selection involves extrinsic qualities such as price, location, convenience, and service experience. Price is a leading factor for a wide audience, particularly for consumers who do not feel the need to attach greater value beyond its utility as a hot beverage with caffeine. With simple expectations, simple pricing typically follows.

The extrinsic value of a suitable price can also establish quality expectations for the consumer. If a customer limits the amount of cost, they also manage expectation for quality, and with habitual perception of a certain quality grade, a person accepts this level of expense for the level of quality as sufficient.

Location and convenience add another level of extrinsic values, all contributing to further individual cost-benefit analysis decisions. Finally, the type of customer service ties into suitability – friendliness, speed of service, environmental décor, knowledge of product and ability to understand individual needs, all factor into the extrinsic value of coffee.

CHAPTER THREE: COFFEE IN THE CAJAMARCA REGION OF PERU

The rise in global demand for coffee has stimulated a significant transformation of land use in Peru. Coffee has been an export commodity since 1880, after almost a century of cultivation being introduced in 1742 (Fox, 2015). Today, approximately two million people make a livelihood within the coffee industry with 85% of the producers cultivating coffee on less than five hectares of land (Fox, 2015). Although a major transition to coffee production from other cash crops have been introduced, many of these contemporary agricultural landscapes and agroforestry practices have been in used for generations (Rice, 2008). Clarke Erickson writes:

> …landscapes were built over temporally long scales, starting with systematic burning, forest and grassland management, and dispersal of plants and animals by hunting and gathering peoples 12,000 years ago in the Americas and hundreds of thousands of years ago in other parts of the world (2006, p. 350).

An estimated population of 30 million people from the Inca Empire inhabited the area of Peru prior to the arrival of the Spanish in 1530. Researchers suggest they cultivated approximately seventy crop species, utilizing principles of agroforestry, such as the intentional planting and harvesting of tree species for fuel, in addition to controlling soil erosion (Chepstow-Lusty & Jonsson, 2000).

The landscape of Peru has continued to change dramatically prior to and following the Inca Empire. Before AD 1100, the Andes showed signs of major soil erosion and deforestation, in addition to evidence suggesting strategic agroforestry management practices such as the planting of trees to provide renewable source of wood for fuel and construction, in addition to soil erosion control (Chepstow-Lusty & Jonsson, 2000). Chepstow-Lusty, Bennett, Switsur, and Kendall state, "Improved terracing and irrigation technology correspond with a series of kingdoms and chiefdoms leading to the rise of the Inca c. AD 1290-1537" (1996, p. 832). The Inca successfully managed agricultural production to support over 30 million people primarily through agroecological intensification of arable landscapes (Chepstow-Lusty & Jonsson, 2000).

Regardless of either agricultural management technique, Peruvian coffee farmers face challenges accessing credit, financial support, or technical assistance to invest their time in either technified or intensified agroecological strategies. Rice states;

> The Peruvian coffee sector has received little aid, with many grower communities essentially abandoned to fend for themselves in remote, difficult regions characterized by broken terrain, heavy rainfall, and poor infrastructure. Most growers in both countries are peasant producers with a risk-averse philosophy and admirable pluck and perseverance when it comes to producing coffee (2008, p. 215).

This reality within the coffee sector of Peru has created a diverse patchwork of land-use management, with both modern and traditional agricultural landscapes existing side by side. Coffee is not the primary source of total farm income for most of Peruvian smallholder coffee farmers, as many of the farmers benefit from the coca trade and other secondary goods (Rice, 2008). Recent reports estimated production of 90,000 certified organic hectares of coffee in Peru, leading the world in organic coffee exports (Brown, 2015). Agroforestry practices in Peru are evident, reporting an average of 135 individual shade trees per hectare (Rice, 2008). Researchers suggest traditional forms of agricultural management have not been a question of choice, but rather lack of access to credit and support from the government, as an USDA representative suggest, "…many smallholders produce organic, shade-grown coffee simply because they do not have access or capital for fertilizers, pesticides and herbicides" (Brown, 2015, para. 7). The lack of technification has been blamed for the outbreak of leaf rust spreading throughout Peru, impacting 30-40% of the coffee crop in 2013 (Brown, 2015).

Researchers also question if the lack of technification has supported conservation of biodiversity, environmental health, while maintaining cultural traditions and community activities. When quantifying success purely on conditions of measuring economic growth, conclusions often support technification as a viable strategy for achieving regional economic gains. Technification has rarely proven to deliver long term economic prosperity towards smallholder livelihoods. On the contrary, access to natural resources, increased pollution, and risky loans provided to smallholder producers for technification of their coffeelands often create additional challenges for coffee producer communities.

Land Use Strategies: Traditional to Technified

Currently, well over 3.1 million hectares of land in northern Latin American countries have turned to coffee production (Souza, 2008). Brazil alone produces most of the coffee harvested in the world, covering approximately 27,000 km^2 of the country's land (Souza, 2008). The agricultural landscapes created for coffee production are diverse, falling along a wide spectrum of agricultural management practices, from highly diversified traditional agricultural landscapes to very specialized production.

Forces for the broad spectrum of coffee land-use incorporate traditional ecological practices derived from a variety of traditional methods, along with modern technologies stemming from the Green Revolution, where an emphasis on efficiency for obtaining higher yield introduced the implementation of chemical fertilizers, pesticides, herbicides, in addition to the removal of tree canopy.

Removal of primary and secondary forests remain a common practice as international coffee commodity markets continue to drive demand. Such intensification for cultivation incentivizes producers to remove forested areas to provide greater agricultural expansion.

Shifting cultivation is capable of supporting populations for extensive periods of time when patches of cleared forest are permitted to rest with sufficient fallow periods, allowing for restoration of soil fertility and conservation of biodiversity. In modern agriculture, practice of shifting cultivation often lack sufficient periods of fallow, leading toward unsustainable conditions. Impacts of excessive removal of timber for firewood, an introduction of inappropriate crops, and an overgrazing of livestock lead shifting cultivation to an unsustainable management system (Gliessman, 2014). In addition to the uncontrolled use of slash and burn to meet demands for extensive cash crop production, it creates conditions that often lead to invasion of noxious weeds, complicating traditional agricultural methods once known to be sustainable (Gliessman, 2014).

Technified coffee management seeks optimization of coffee yields, often entailing removal of forested areas for greater sun exposure and the implementation of irrigation systems along with inputs of agricultural chemicals for pest and disease control (Rice, 1999). In contrast, coffee producers have also retained traditional forms of intensified agricultural practices, catering to ecologically driven decisions aiming to retain biodiversity and capture benefits from the multitude of ecosystem services present within their landscapes. These systems of production, from traditional rustic forms of coffee landscapes to technified industrial agriculture, are often practiced side by side within coffee production.

Although many traditional management practices have been shared and knowledge has been passed down through kinship relations and social networks within regional communities for generations, the modernization of communications and an increasing intimate involvement of international development organizations has changed the frequency and content of knowledge sharing within producer communities. In addition, the interests from vertically integrated supply chain commodity groups seek to protect and improve agricultural investment interests by heavily influencing and disseminating practices within supplier communities to optimize yields, driving change to landscape management and processing methods to meet economic goals. The manner information is typically transferred throughout agricultural smallholder communities is through the involvement of local farmer leaders who have demonstrated respect from their community, while also demonstrating initiative to seek economic prosperity and implementation of new ideas which facilitate and support shared interests of the government, business, or economic institutions who have vested interest in the success of these farming communities.

Suitable Landscapes for Coffee Production

Coffee cultivation is typically found within countries where land, rainfall, high-altitude lands, and an inexpensive labor pool are plentiful. There is a range of suitable environmental conditions in which coffee can be grown for commercial purposes. These areas for growth typically fall between the Tropic of Cancer and the Tropic of Capricorn, with altitudes ranging from sea level to greater than 2500 meters above sea level. Altitude greatly impacts quality, therefore most of the production for higher quality Arabica cultivation occurs between 1200-2200 meters above sea level, while lower quality Robusta cultivation typically ranges between sea level to 1200 meters above sea level (Wintgens et al., 2004).

The specialty coffee market is viable for a limited group of growers who have significantly differentiated their products by appealing to niche markets that have created a demand for rare appellations and unique storylines. On the other hand, the historical value of coffee has been a continual challenge for most smallholder coffee producers who remain marginalized within the coffee industry. For example, in 1977, coffee reached an all-time high of $3.39 and a record low of $0.43 in 2001 (Fig. 10) where the price currently rests near $1.50 per pound (Trading Economics, 2017).

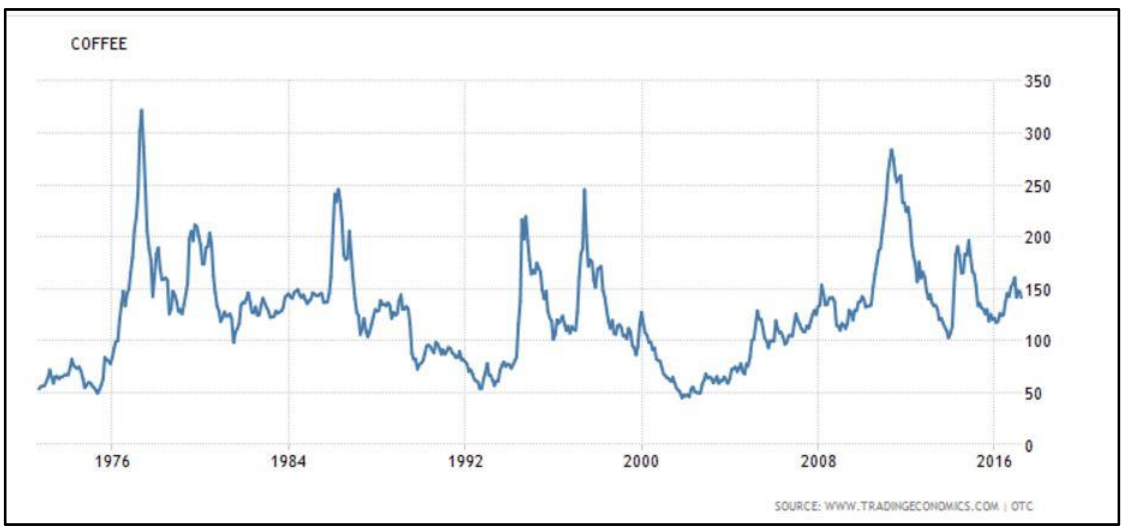


Figure 10. Historical coffee prices (1972-2017) Source: (Trading Economics, 2017).

One coffee plant produces enough coffee cherry in a single year to produce one pound of roasted coffee. The planting density is determined by several factors including soil fertility, species and varietal of coffee, and cultivation methods (Wintgens et al., 2004). For higher grown Arabica coffee produced in equatorial zones average between 2,500 to 3,000 trees per hectare, and in lower elevations recommend planting density of 1,100 to 1,600 trees per hectare (Wintgens et al., 2004).

Most areas of Latin America prior to colonization practiced forms of agricultural intensification. With the inclusion of coffee as a commodity cash crop, producers have introduced new strategies of management techniques in addition to retaining several traditional practices. The impact on social and physical landscapes within coffee growing nations are often attributed to the degree in which they have been positioned for successfully exporting production, in addition to land-use practices and willingness or capacity for adaption to modern technified practices, or the retention of traditional methods (Rice, 2008).

With modern intensified agricultural coffee landscapes, traditional shifting cultivation activities are utilized for clearing land yet fallow periods are shrinking as access to land is stressed by increasing populations. This exclusion of rest from production increases stress upon coffee fields beyond the ability for these parcels to revitalize soil qualities for sustainable productive agriculture, creating scenarios calling for additional inputs of chemical fertilization, pesticide, fungicide and herbicidal solutions. In addition, modern management practices seek yield optimization, often entailing forest removal for greater sun exposure and the implementation of irrigation systems, in addition to inputs of agricultural chemicals for control of pest and disease outbreaks (Rice, 1999). In contrast, many coffee producers have retained traditional forms of agricultural practices, following agroforestry practices where utilization of shade tree regimes and other similar ecologically driven decisions retain biodiversity and capture benefits of ecosystem services.

Labor requirements vary significantly as to the type of cultivation implemented. Wintgens et al., (2004) write:

> …extensive methods of cultivation of coffee (with shade trees, without irrigation, irregular pruning, low levels of agrochemical inputs and low yielding) will require less labor than intensive cultivation (no shade trees, with irrigation, regular pruning, high levels of agrochemical inputs and high yields) (p. 188).

The costs of production and return on investments between technified and traditional cultivation is a conversation that should be further addressed, as the foundation is strictly viewed in terms of an international market economy. For example, technified cultivation presents an ideology which maximizes yields for an optimization of profits. As discussed earlier, if activities such as subsistence farming and livestock production take up land which otherwise could be used for coffee production, this central goal of optimization is compromised (Perfecto & Vandermeer, 2015). Typically, measuring costs of production are recorded by consideration for the costs of chemical inputs, seed stock, labor investment, and other tools necessary for modernized production. The technified economic approach often excludes analysis of the costs and benefits of natural ecosystem services and overall landscape health which may provide financial benefits through improving environmental qualities and healthier and more productive labor pool.

Perfecto and colleagues provide an excellent financial comparison addressing three coffee landscape strategies which fall within the continuum. They write,

> Modern farms out produced semi-modern (a combination that includes some shade reduction, a change to new coffee varieties, and at least some use of agrochemicals) and traditional farms, with yields of 1397, 953, and 317 kg/ha, respectively. However, the levels of production had considerably different costs as well; in absolute terms, the cost (in us dollars) of production for a hectare of modern, semi-modern, and traditional coffee was $1,738.94, $1,092.00, and $269.47, respectively. The cost to produce 1 kg of coffee was thus $1.24 for modern coffee, $1.14 for semi-modern coffee, and $0.85 for traditional coffee. Traditional production devotes 2% of its expenditures to chemical inputs, whereas semi-modern and modern production spend 19% and 25% on chemical inputs, respectively. In addition, non-harvest labor accounts for the single largest cost in modernized systems because it entails an array of intense cultivation practices such as standardized pruning, fertilization and insecticide, fungicide, and nematocide applications to individual plants (1996, p. 599).

Perfecto and Vandermeer further discuss defining landscape in a way which describes the combination of considerations within conservation of biodiversity, retention and understanding of ecosystem services, and needs for producing a livelihood (2015).

Challenges behind transitional efforts from intensified cultivation to agroforestry practices are heavily influenced by international markets and low commodity prices, leading to increased farm sizes, as smallholder producers are unable to remain competitive (Bezner-Kerr, et al., 2012). Latin American countries continue to see deforestation in response to the expansion of industrial agriculture since the 1950s. Even though empirical evidence suggests agroecological systems generate similar yields, and even strengthen yields in developing nations, commodity payment systems offering subsidies encourage the implementation of larger mono-cultural production strategies (Bezner-Kerr, et al., 2012).

Traditional Farming Practices in Coffee

Landscapes managed through the incorporation of traditional land-use practices often provide multiple benefits through supporting ecosystem services, in addition to promoting the sustainability of social, economic, and environmental health. Recently, the study of agroecology and agroforestry have become central for understanding how food systems interact with ecology. Agroecology is defined by contemporary scholars as “the integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions” (Francis, et al., 2003, p. 100). The application of agroecology to researching coffee landscapes in Peru has contributed a holistic insight similar to an anthropological perspective, with greater attention to the ecosystem services and how these factors may influence economic and social outcomes within coffee producing communities.

Ecological functions provided by shade coverage include services such as supplying organic matter to fields, foliage coverage, nitrogen fixation for retaining healthy soil composition, protection from winds during coffee flowering, climate resistance, temperature and humidity regulation, weed suppression, bee migration, increased pollination rates (Perfecto & Vandermeer, 2015), carbon sequestration, drought resistance, as well as weed and biological pest control (Tscharntke, et al., 2011). Patches of forested landscapes within coffee cultivation also provides for biological corridors and pathways for wildlife migration (Chazdon, et al., 2009).

Social aspects of agroforestry management may benefit from the incorporation of intercropping, crop rotation, and planting of root vegetable and fruit trees within and surrounding fields of coffee production. With the wide diversity of nutritional food resources, smallholder coffee farmers are less likely to depend on a single cash crop for purchasing food staples. Additionally, incorporation of tree canopy layers and regular pruning of these shade trees provide fiber for construction and wood for fuel, both regularly supplying additional income. Evidence further suggests that the incorporation of shade tree and agroforestry production produce similar yields as those landscapes which have been technified (Bezner-Kerr, et al., 2012), and without costs of chemical inputs, lower financial investments in irrigation systems, and less labor applied to minimal pruning strategies (Wintgens et al., 2004) although yields may not be optimized, the financial return on minimal investment can equate to long term economic stability.

Lines of credit are often risky due to high interest rates compounded with volatile market prices. If producers have access to credit, they are often given with intention of supplying technical packages promoting modernization with chemical inputs and technified assistance, rather than offering programs relating to integration of agroforestry management practices (Perfecto & Vandermeer, 2015).

Regarding cultural aspects, agroforestry practices can provide recreational, spiritual, and aesthetic value (Chazdon, et al., 2009). Although benefits of shade coverage are evident to ecologists, significant challenges persist for producers to adopt or retain traditional agroforestry management practices due to recognizing the economic, social, and environmental benefits, in addition to pressures from organizations which support application of technical packages which are often driven by profitable intentions from agricultural chemical entities or governments which require export quotas to meet conditions for loan repayments. The balance between traditional and technified forms of coffee production are vast, even within land-use practices which incorporate tree canopy coverage. In the following picture (Fig. 11), a spectrum of canopy coverage range from what is known as “rustic” shade to “shaded monoculture” in addition to “unshaded monoculture” (Moguel, 1999).

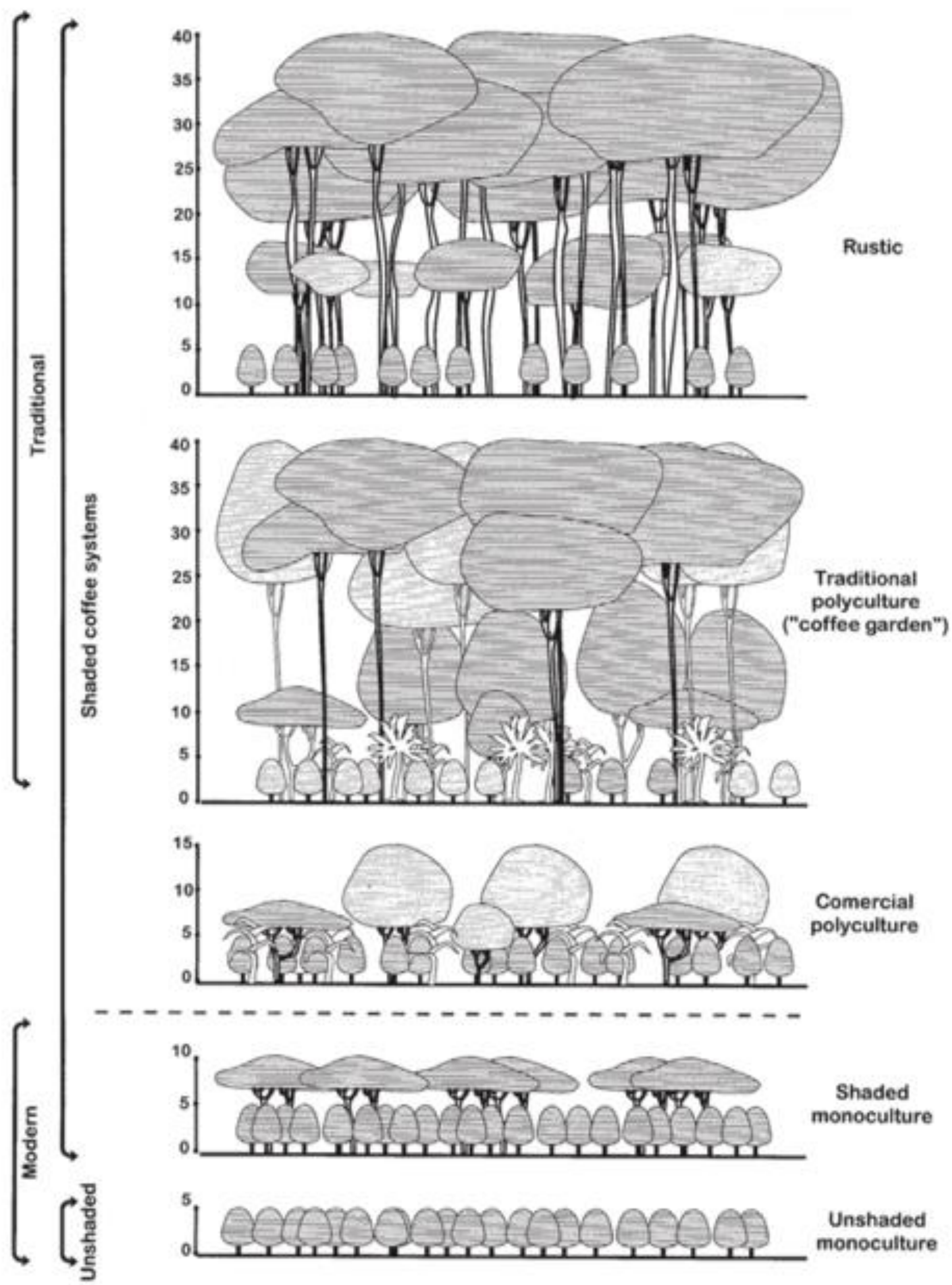


Figure 11. Spectrum of coffee landscapes (Moguel, 1999).

Technified Farming Practices in Coffee

The term often used by development agencies and local institutions to specifically indicate the application of technical and industrial ideologies to agriculture is described as technified agriculture (Perfecto, et al., 1996). The primary goal of industrial agriculture is to generate profit by employing the most efficient manner of production. Perfecto and Vandermeer suggest,

> …if we assume that, in the capitalist system, society's prime purpose is to make sure that production happens for the sake of profit in all spheres of human activity, it is obvious that we must make all products tradable. If some activities are unmarketable, or produce an unmarketable product, they represent a barrier to this central goal (2015, p. 18).

Fitting within this application of an industrialized philosophy to agriculture, traditional land management practices are viewed as inefficient, lacking maximization of yield potential (Perfecto & Vandermeer, 2015). Technification of agricultural landscapes ultimately aim to optimize yield potential in a manner which depend on chemical inputs and technical assistance. Patches of forested areas are sometimes retained, but quite often lack sufficient interconnectivity across a landscape for supporting a healthy ecosystem (Fig. 12). Reliance on high-yielding varieties, an increase of chemical inputs, higher planting densities, and tree canopy removal for greater sun exposure to maximizing photosynthesis, are often attributes to these technified packages (Perfecto, Rice, Greenberg, & der Voort, 1996).

Figure 12. Technified hillside coffee landscape in Brazil

The push to modernize coffee production was a combination of capitalist philosophies, efficient land-use through densely planted parcels, contributing to a serious threat from coffee leaf rust (*Hemileia vastatrix*), a fungal disease which spread throughout coffee regions (Rice & Ward, 1996).

Several examples regarding coffee technification present political and economic initiatives by national governments to modernize agricultural production. An article by Perfecto and Vandermeer (2015) discuss USAID coffee intensification programs launched in Costa Rica in response to an increased pressure for generating exports to service outstanding World Bank debts. During the implementation of these initiatives, shade trees were removed and higher yielding varietals were introduced, resulting in one of the highest deforestation rates in the world at that time. Thereafter, intensification spread throughout the Americas contributing to a significant loss of biodiversity as a direct consequence to these ecological changes.

Deforestation and the drive for agricultural intensification exists well beyond landscapes of Latin America. Researchers argue massive deforestation in parts of Indonesia during the 1990s was driven by incentives introduced by government programs which provided land access and resources to clear forests for intensive sun-grown coffee plantations as a direct response to national policies supported by international development banks (Dietsch, Philpott, Rice, Greenberg, & Bichier, 2004). Many of the decisions which drive implementation of technification are often held by political leaders and economists basing initiatives on assumptions that rarely reflect immediate interests of smallholder coffee producers or realities which exist within the global market. Dietsch and others write:

> Plans to intensify production assume coffee-price and job stability, yet prices of overproduced export crops are volatile. In general, green revolution intensification benefits consumers via lower prices, but farmers have experienced increased costs and reduced prices for crops (2004, p. 625).

More affordable food items for those facing malnutrition are beneficial to these populations, but as these communities become further dependent on production of cash crops, adopting technologies which promote further yield optimization may result in driving down the value of these crops due to an oversupply, perpetuating the supply and demand conundrum of agriculture.

Coffee Harvesting and Processing in the Cajamarca Region of Peru

I spent several weeks residing as a guest within each farmer community household in three separate communities within the Cajamarca region of Peru. The goal was to gain a local perspective on factors influencing harvesting, processing, and land management decisions of producers, and to note variation between coffee producer situations. Many of these factors were highlighted in casual conversation which otherwise may not have been acknowledged by non-participant forms of investigation. The methods used for gathering descriptive information was conducted through personal interviews, questionnaires, and personal participation within selective picking and post-harvest processing activities (Appendix B).

The case studies present in this research aim to provide a thorough understanding of challenges smallholder producers face and decisions which are made in response to these challenges. My further research concentrates efforts on exploring topics addressing access to natural resources, access to credit, and how coffee farmers connect with global supply chain markets and buyers, in addition to how these relationships determine land-use. The intention for including coffee quality related information rest in how quality control decisions impact utilization of natural resources. Coffee must reach an export grade to receive international market prices for coffee.

There are general observations on how landscapes are managed, although most information describes daily activities with intention of constructing an understanding of the daily activities which impact decisions regarding land-use practices. During each site visit I attempted to collect harvested samples from workers who were picking coffee in the field. Due to the early harvest season, there was little uniform ripeness on most of the coffee plants. Time of year, elevation, and varietal selections within a field should be taken into consideration. Exploration of the ecophysiology of coffee growth and fruit production is beyond the scope of this research, but knowledge of basic principles influencing maturation is necessary for understanding expectations for the selective harvesting of coffee cherries. An unequal ripening of fruit is generally a consequence of environment and varietal interactions with sporadic rainfall occurring mostly during bud development, being one of the most uncontrolled factors causing multiple blossoming periods (DaMatta, Ronchi, Maestri, & Barros, 2007). Gathering variables which impact selective harvesting is a time-consuming task with several limitations. The goal for this collection of selective picking during the early harvesting season was to gain a better understanding of how coffee pickers determine ripeness and selection.

In addition to recording levels of maturation, I measured the percentage of high quality and lower quality cherries, categorizing into two main levels. The first category is described as floaters. These are coffee cherries lacking sufficient density, often reflecting damage from insect infestation, plant disease, or attributed to over-ripeness. Floaters are typically separated by water floatation and sold as lower quality, secondary coffee. The cherries which sink to the bottom are known as sinkers. These fruits have achieved proper density, signaling the first attribute to unharmed fruit. The challenge remains for separation of under-ripe cherries which also sink with ripe cherries. Depending upon each coffee producer’s decisions on separation and processing techniques, several additional levels of quality can be produced. In general, most farmers separate into either a primary higher quality level or the secondary lower quality level.

Selective harvesting is the first step taken by the producer in defining the outcome of annual yield and quality. I measured this activity starting with the question addressing how coffee farmers define what is ripe and when it is proper to harvest a cherry. Coffee producers within three sites responded to a variety of questions regarding the categorical description of color and maturation levels within the cycle of coffee cherry development.

Prior to collecting data from the three sites visited, I spent several days with a coffee producer in San Ignacio, Peru. The time spent with this producer was constructed as a calibration session to become more familiar with regional coffee processing methods prior to beginning further site visits. The intention of this visit was to establish a baseline for color and maturation category descriptions of maturation. My contact in San Ignacio assisted in recording the weights, sizes, and degree of brix for each maturation level within each of these categories. The producer helped establish priorities and a fuller understanding of regional environmental conditions and agronomic practices within the region of Cajamarca. During this attempt to catalog maturation information, it became clear I would be confronted with multiple varietals within each coffee parcel, further complicating selection practices and decisions. On the other hand, a broad categorical recognition for each maturation level was found for a list of specific varietals during my visit in San Ignacio, Peru.

Classification of Fruit Maturation Levels in San Ignacio

The first step to identifying how maturation levels are determined by coffee producers involved an exercise and interview with a coffee producer in San Ignacio, Peru. The producer and I collected the widest range of cherry maturation levels found on his farm and brought them back to the house to categorize by color, from under-ripe to over-ripe. I recorded the size, weight, color, and the Brix degrees for each cherry selected. Although the measurement of the Brix degrees within coffee harvesting is a relatively new practice for some coffee producers, the application of this measurement has been used within the wine industry to determine maturation of grapes and guide optimal harvesting times. The Brix degree for coffee fruit is said to be the best indicator for optimal selective harvesting apart from color, measuring the soluble solids in the mucilage, where one Brix degree equals one gram of sucrose in 100 milliliters of water. (Folmer, 2017).

The purpose of this interview was to establish reference points for coffee producers to explain what the range of acceptable harvest selections are within these categories. The intention was to identify the range of variation between each location and producer to discover if harvesting standards varied, and if so, to what extent this variation occurred. One observation made while measuring size and Brix degree was although the color may be the same, when the cherry is larger, it typically has lower Brix degree.

The sorting exercise resulted in 10 classifications from under-ripe to overripe as described during an interview conducted with a coffee producer in San Ignacio, Peru (Fig. 13). The tan coffee parchment at the top of the photograph is a representation of coffee after fruit has been removed using the washed-processing method.

Figure 13. Classification of coffee fruit maturation, San Ignacio, Peru

This experience helped define regional terminology for maturation levels, yet each producer gave slightly different terms and ranges for each maturation level, presenting difficulties for accurately defining and comparing maturation levels and selective harvesting practices between each site location.

The comparison between three locations are provided below, presenting three diverse land-use strategies between technification and traditional farm management practices, in addition to diverse post-harvest processing strategies.

Confidentiality

To maintain confidentiality of each participating coffee farmer interviewed during my research, I have coded each location as Site 1, Site 2a, 2b, 2c, and Site 3. To display a general distance from each site location, the map provided below (Fig. 14) shows a general distance between the farm and milling station located Jaén, Peru. It is important to understand the transportation difficulties each community face in addition to the time necessary for delivery. Further details regarding delivery to Jaén are addressed within each section below.

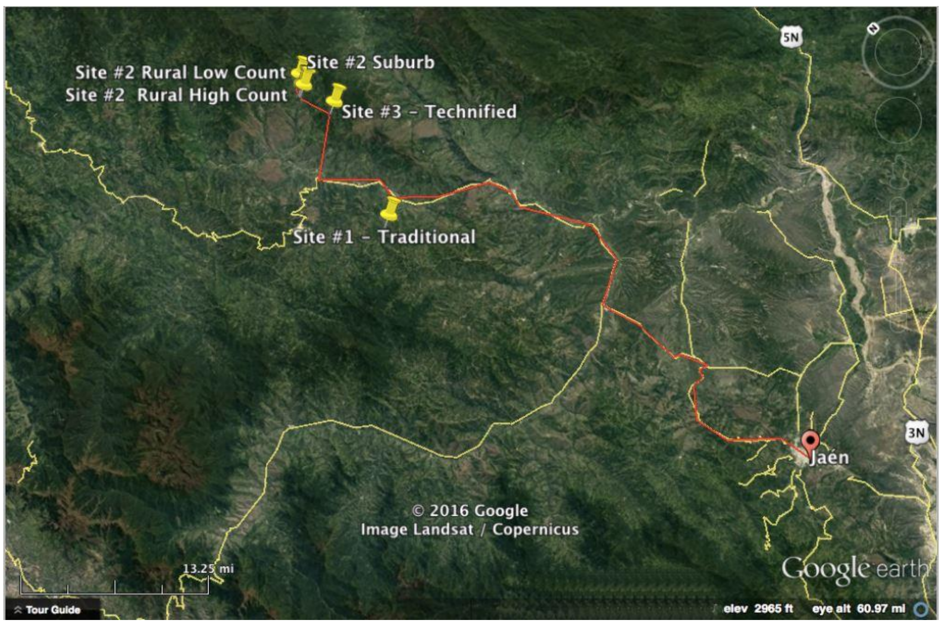


Figure 14. Jaén to Site 1-3 (Google Earth, 2017)

Site 1

Site 1 is located on the ridge of a mountain resting 1400 meters above sea level. The community was supplementing traditional subsistence farming practices with coffee production. I was given the opportunity to observe coffee harvesting and processing methods during the three-day visit. I spent several days with one farmer who was considered a community leader and owner of one of the only markets in the area. His house was the central receiving location for producers in the area where they store their dried coffee parchment prior to delivery to the central milling station located in Jaén, Cajamarca.

During the time of my visit, each house had a plastic tarp placed in front of their house by the side of the road with coffee parchment in the process of drying. Once coffee is harvested, it was most often brought back to the producer's home where processing was finished off through drying though direct exposure to the sun. Depending on cloud cover and general weather conditions, the drying process took between 10 to 25 days. The producer harvested coffee at a location approximately 5.8 kilometers from his home. The site of his coffee cultivation was centered around the processing area where an older adobe two story structure is located. Most of his coffee was harvested near 1355 meters above sea level. The house (Fig. 15) was used for storing processing equipment and served as a day camp for serving meals to the hired labor during harvest season. The house was his childhood home, but the family has since relocated and built homes for each of the siblings, and his parents have relocated to another home. Five years ago, he moved from this location up the mountain to where he currently lives today. There was no electricity available in the area, as it is very remote, which could have influenced his permanent relocation towards the top of the mountain closer to the road and electrical grid.

Figure 15. Field house for coffee storage, processing, and meals

Very little water is available in the area to process coffee using traditional washing techniques. The water and fermentation tank used on this farm was small in comparison to other washing tanks in the area, likely in response to the lack of available water for processing. There is a small water tube from the mountain side which trickled fresh water into a cement holding tank measuring 4 feet long, 4 feet wide, by 4 feet deep, and covered by a metal corrugated sheet. In front of the holding tank located at the bottom was a drain tube measuring two inches used for discharging water into a lower cement holding tank. The drainage area was normally used to collect dirty discharged water, but he was using the smaller cement drainage area (Fig. 16) to scrub coffee parchment by foot. The larger tank was usually not full of water. The processing consisted of placing freshly fermented and sticky parchment into a large mesh bag. The coffee mucilage was removed manually by the producer scrubbing coffee by foot, with a few gallons of water slowly added from the larger tank. This action continued until the coffee parchment was clean from the sticky mucilage, which took several water rinses. Techniques used for mucilage removal usually do not employ this method of processing. This was most likely a sign of an adaptive response to the lack of water in the area, in addition to the farmer meeting local demands for selling washed coffee to exportation facilities.

Figure 16. Modified use of cement washing tank, scrubbing in discharge channel

Water scarcity was explained as a result to the use of water by coffee producers located at higher elevations, processing coffee using water for larger quantities, leaving little water resources for lower elevations. The producer also mentioned they were experiencing drought conditions during the year.

With the severe lack of access to adequate water sources, the producer was unable to utilize water for the separation of coffee defects from higher quality coffee cherry. Without employing density separation to float-out the defects in water, it likely caused a greater percentage of defects in the final product. The dry mill located in Jaén, Cajamarca employ a quality control department staffed with coffee professionals to analyze and count defects, resulting in an established grade which in turn receive a standard price. Higher percentages of defects in coffee samples delivered to the central mill typically reflect lower payments paid to producers.

The lack of water also impacted harvesting decisions. The producer explained even though coffee cherries were ripe and ready to be harvested, without sufficient water for processing they could not wash the coffee properly. This created yield loss on the trees due to rotting, in addition to creating an advantageous environment for pest and disease infestation.

There was no wastewater management in place on most farms in the area. It is estimated at least 85% of the coffee mills worldwide do not use water-efficient practices (Hicks, 2016). Wastewater is discharged, following through a shallow dug channel measuring 3 inches deep and 8 inches across. The channel was constructed with the intention to divert the highly acidic water out of the coffee growing area to the side of the mountain where no coffee is grown. He explained this action was taken because wastewater from the processing of coffee carried microbial organisms unhealthy for coffee plant growth. Using the Pinpoint pH Monitoring device, the discharged water from his washing tank measured between 3.8 to 4.2 pH. After scrubbing with minimal amounts of water, he took coffee to an area where the wet coffee was placed onto a black tarp for drying. He took a screen to separate coffee from foreign matter consisting mainly of pulped cherries and other defects. Due to rainy weather, he regularly put the black tarp back inside the old house, reserving the second floor for placing coffee which was in the finishing drying stages.

There was significant coffee cultivation at higher elevations, which impact the water quality and quantity prior to arrival to Site 1. This restricted the quantity available for homes located in Site 1. Houses which did not have water storage units on their property borrowed water from their neighbors. Children were often seen fetching water from neighbors. One child mentioned his father was not able to wash their harvested coffee because of a shortage of water.

For further understanding of the coffee landscape through the experience of harvesting coffee, I spent a day harvesting coffee with producers and hired labor. There was a heavy presence of insects in the field, including gnats and small insects which left a rash-like bite under most of the worker's clothing. Working with a product which produced a sweet juice often ending up on clothes, hands, neck, arms, and ears, attracted insects adding a physical challenge while harvesting coffee cherries.

Most of the coffee landscape was covered in two layers of tree canopy strata, including a diversity of leguminous shade trees and fruit trees such as banana, plantain, mandarin, and cacao. The canopy understory consisted of a wide selection of fruits and vegetables interplanted within the coffee parcel. The shade allowed for frequent breaks from the direct sunlight and heat. The coffee trees harvested in the field were about six to seven years of age with sizeable stature reaching seven to eight feet tall, where shade was often provided by the coffee plants themselves.

With frequent rains switching to frequent sun during the harvest season, humidity remained well above 50% for most of the season, averaging temperatures of 70 degrees Fahrenheit. The day I spent coffee harvesting, I was joined by one adult male, a six-year old boy, a fourteen-year old boy, and one younger girl of about thirteen years of age. They were listening to a radio while whistling and laughing. They started picking coffee around 9:00 A.M. Two hours later, one of the boys announced to the adult male, "*2 latas*", referring to how many he had picked that morning. The spatial movement for picking coffee was done in horizontal fashion, facing uphill. All coffee cherries other than fully under-ripe green fruit were selected for harvesting. The producer explained that any cherry which had an ability to produce juice was considered harvestable. There were no further methods or strategies expressed by the adult male. I observed multiple directions of picking on an individual plant, but the producer tended to stay on one branch until all cherries were removed, except for the green under-ripe cherries.

During our harvesting of coffee, the producer talked about the lack of funds to experiment and issues regarding water lacking in the area. He explained children in the area often harvest coffee because they need to pay for their school fees and food. The families are poor and need financial sustainability. They lack access to water, technical support, and credit. The producer demonstrated to have plenty of diverse foods available in the coffee growing area, supported through traditional methods of farming practices with coffee serving as the understory, and a canopy existing of multiple native species, in addition to fruit and leguminous trees.

Many coffee producers surrounding Site 1 practice a mixture of rustic shade coverage to moderately technified land-use. The removal of trees by slash and burn methods was observed on a facing mountain slope across from the site location which I was visiting. There were cleared patches of forest for production of coffee, corn, and similar subsistence crops. It was apparent the shortage of water was a driving factor behind decisions relating to processing and harvesting strategies. The retention of tree canopy and inclusion of a wide diversity of fruit and vegetable production within and surrounding coffee production provided a level of food security within households.

In addition to water shortages, an infestation by the coffee berry borer, *Hypothenemus hampei* had been responsible for damaging fruit on the coffee plant prior to harvest.

Additionally, *Hemileia vastatrix*, a fungus responsible for causing coffee leaf rust (Folmer, 2017) was mentioned to be a severe problem due to the devastation to the entire coffee plant. The producer explained how five years prior he had harvested an average of 18,000 kilograms on an annual basis. After coffee leaf rust hit the area, he was only able to harvest 300 kilograms. There were more coffee berry borer infestations during the 2016 season than the prior year, and the producer expressed his concerns of witnessing continued signs of this problem worsening.

The farmer brought up climate change as a major cause to this outbreak. He mentioned the year prior had received more rain and less sun, which produced better fruit while lessening the infestation of the coffee berry borer. For 2016, the producer explained they experienced less rain. The producer ended the conversation mentioning a shortage of water which they had been facing for the past eight years.

Site 1: Floaters, Sinkers, and Percentage of Maturation Levels

The following three charts provide information outlining maturation levels harvested in addition to the amount of floater and sinker percentages. These samples were collected from a single producer in site 1, from multiple days (Fig. 17-19).

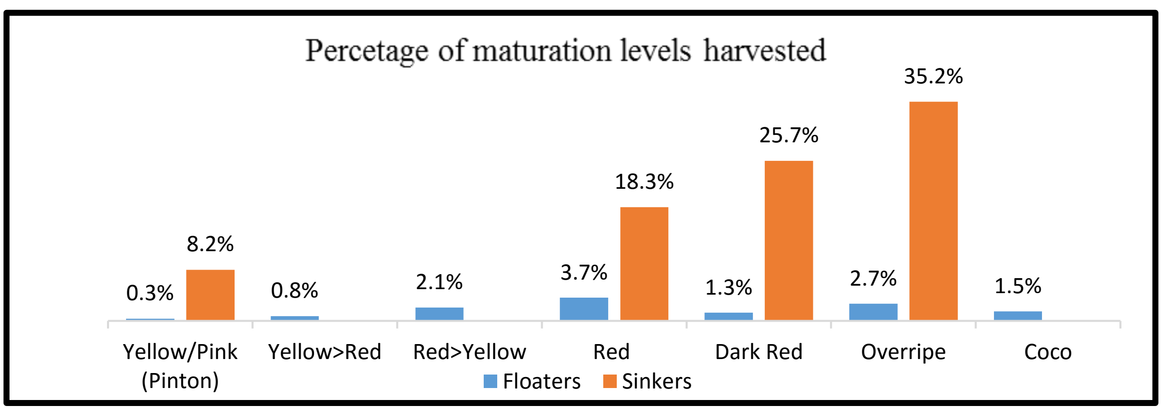


Figure 17. Site 1 (5/26) Floaters 12.6%, Sinkers 87.4%

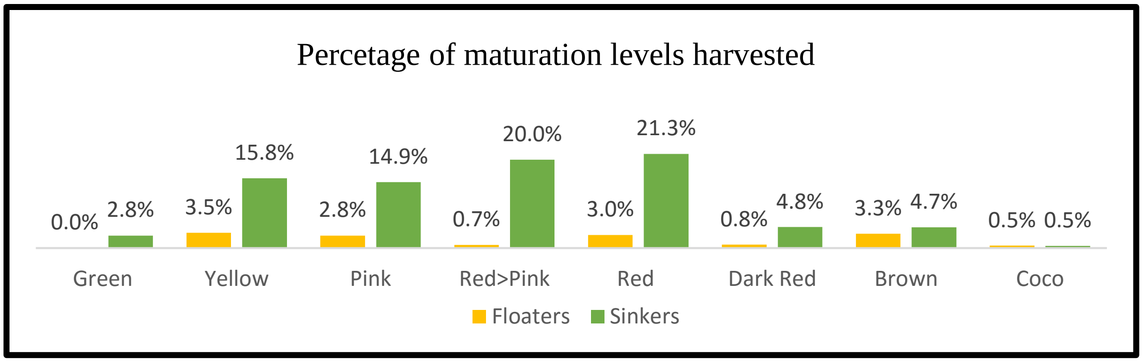


Figure 18. Site 1 (5/28) sample (a) Floaters 14.6%, Sinkers 85.4%

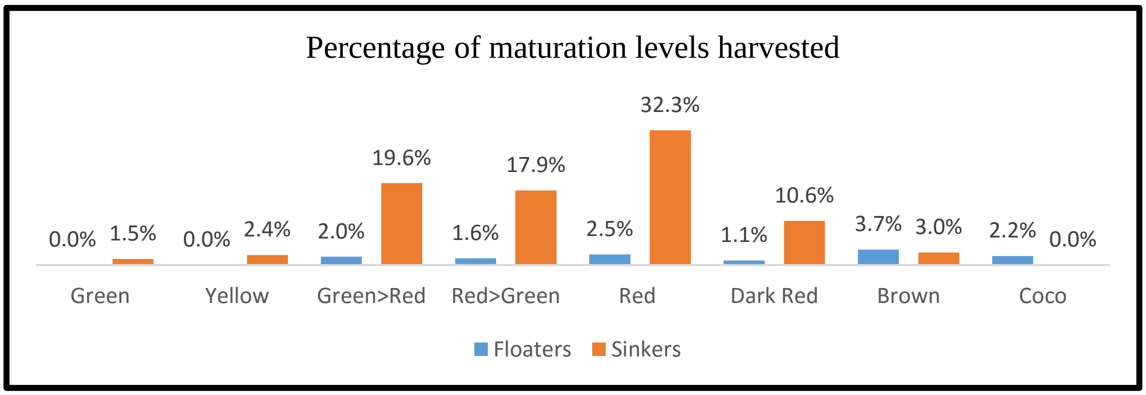


Figure 19. Site 1 (5/28) sample (b) Floaters 12.8%, Sinkers 87.2%

An overall observation for the initial findings may suggest the producer harvested an entire range of coffee maturation but maintained higher percentages of cherries between categories closely resembling ripe red. The above figure shows a higher percentage of harvested Green > Red, measuring 19.6% of overall harvested sample (Fig. 19), whereas in (Fig. 17) from a different harvesting day and sample, the percentage of under-ripe color categories did not equate to greater than 11.4% when considering all categories less mature than red. Overall, the percentage of floaters maintained a range between 12.6% to 14.6 for all samples collected within site 1 (Fig. 17-19).

Site 2 (2a, 2b, and 2c)

Site 2 was within the same network of coffee suppliers for a dry mill company in Jaén, Peru. Measuring in a straight line using satellite imagery, Site 2 is located approximately fourteen miles from Site 1. Considering mountainous conditions, it took several hours by car to arrive. Upon entering Site 2, I was introduced to an additional coffee extensionist from the coffee mill in Jaén. The town has a population of approximately 1,350 people. Several small markets inside the homes surrounding the center of town offered soda, chips, and small household goods for residents. One or two trucks and a few cars arrived and departed daily. The town was considered remote by those living in Jaén, often difficult to access due to a washed-out bridge (Fig. 20) several miles down the mountain from the area of Site 2. The washed-out bridge added extra cost and time for delivering coffee to Jaén where it is prepared prior to final exportation. It took us approximately twenty minutes to cross the river using a floatation device and a cable system. Not only was this time consuming, but somewhat dangerous.

Figure 20. River crossing on the route to Site 2

The coffee representative came to assist my visit in addition to hosting visits with farmers in the community to discuss and promote a program managed by Olam Peru, a coffee exporting company located in Jaén. The coffee producers had chosen to participate by adopting agricultural management practices which were required for certification within their environmentally focused program.

The content of information given to members addressed proper use of agrochemicals through providing a piece of paper which listed banned products. The extension agent asked farmers to sign an agreement that verified banned products were not being applied. Site 2 had an organized coffee farmer group to achieve community participation in the certification effort.

Producers in this region faced several issues impacting yields. Most common responses given during the visit addressed the presence of coffee leaf rust which had devastated yields and quality for the last three years. With plant disease making a sizable impact in the area, the increase of herbicides showed a threat to possible non-compliance to the required certification process implemented through Olam. The outreach efforts conducted by both Olam and coffee producer groups demonstrated action towards addressing environmental health concerns in the area, yet little research or empirical evidence had been collected for measuring the effectiveness of these extension efforts within Site 2.

In stark contrast to Site 1, there was no shortage of water resources for coffee processing throughout Site 2 locations. Due to the availability of water, washing coffee was done with several more stages in larger volume tanks. A commonly heard conversation addressed the need for greater funding and access to chemical fertilization and a desire for more soil testing analysis in the area. Most of the farms in this area ranged between intensified traditional polyculture to partially shaded technified monoculture, with a variety of farms practicing highly skilled applications and principles of traditional agroforestry. Several have applied a mixture of both technified and traditional management, sometimes with unintentional negative consequences. Densely planted eucalyptus trees used for shade coverage within coffee parcels were common in this area, although such density has led to poor coffee cultivation caused by depleted soil health. Responses currently taken to soil depletion were to invest in chemical fertilization. Options considering alternative shade tree management and design were not present in the general narrative throughout my site visits, although research suggests the removal of eucalyptus and replanting of native species may provide long term solutions to soil and plant health, in addition to consistent productivity.

Site 2 coffee producers utilized traditional de-pulpers, both manual and motor driven, typically attached to small cement tanks near either their home or coffee parcel processing area. Producers demonstrated awareness for a demand for higher quality coffees, yet methods used to achieve coffee quality vary greatly within the community. Some producers were investing in solar drying, while others were concentrating efforts on soil quality and proper fertilization. Several producers were interested in planting higher quality varieties for coffee cultivation, while others harvested patches of random varietals and maturation levels.

Each farmer expressed a unique perception of what will increase quality and their personal financial situation, yet there was evidence which showed a lack of information on how quality post-harvest processing impacted coffee quality. Monitoring harvest selection and processing steps, time, and technique were not conducted with specific guidelines. Observations of collected coffee cherries which had not been de-pulped for greater than an entire day were seen mixed with freshly harvested cherries and de-pulped together. Delayment of the coffee de-pulping process may increase the risk of spoilage caused by microbial development, temperature fluctuation and oxidation of coffee fruit encompassing the seed.

As seen in other coffee producing countries, actions taken to strengthen quality control can be implemented through investments in centralized wet and dry milling station where cherry can be received and processed utilizing guidelines developed and implemented collectively by producer groups or cooperatives. Although these measures could be desired by communities, limited access to credit or other political and social situations may complicate such investments.

Site 2a

The first visit within Site 2 was located near the edge of downtown. The producer's home was a small two-story adobe home with a metal roof, with most of his coffee processing activities done in the front yard and storage area on the second story level of his home. The producer had lived in Site 2a for the past five years. He moved from Jaén to grow coffee, where he had established approximately 2.5 hectares of coffee production located aside his home. The producer explained difficulties with labor shortages in the area which had impacted his ability to find pickers willing to harvest coffee for the wage he was able to provide. He picked an average of four to five full 5-gallon buckets of coffee cherry within an average day of harvesting. Farmers typically receive $1.50 per bucket, although this wage fluctuated depending on the relationship in which a coffee picker had with the owner of a coffee parcel. In this case, he was the owner and picker, therefore receiving slightly more income for his coffee. He used an average sized washing station and stored his drying coffee on the second floor of his house.

Site 2b

The second visit within Site 2 was conducted with a producer located near the entrance of town. The distance between his home and his coffee parcel was approximately a 30-minute walk down the main road. They harvested coffee near a house used for storing field maintenance and processing equipment, which also served as a kitchen for daily lunches. These arrangements were similar to those seen during Site 1. The grandmother of the coffee producer walked to the coffee parcel to cook meals for her sons and their hired labor. Her schedule typically involved leaving the main house by 9:00 A.M. to start preparing mid-day meals. Most of the people in the area did not live next to their coffee parcels. Some families walked several hours from town to where they have property. Post-harvest processing most often occurred nearby coffee harvesting areas, including cleared patio areas for drying wet coffee parchment. Although drying typically occurred near harvesting areas, families often relocated coffee to their homes located in town, protecting from theft while also allowing family members to care for properly drying by members who stayed near home throughout the day. The location of Site 2b also served as a distribution point readily positioned next to the main road where trucks could easily accept coffee for delivery to Jaén.

The first noticeable issue regarding land-use in Site 2b entailed densely planted eucalyptus trees within the coffee parcel (Fig. 21). This producer had requested additional funds for fertilizer due to poor soil quality, which had been applied amongst densely planted eucalyptus trees and coffee plants. Research conducted by Chepstow-Lusty & Jonsson (2000) suggest several disadvantages come when planting eucalyptus for shade tree management. Primarily, the amount of water consumed by eucalyptus is significant, in addition to the level of toxic compounds present in the foliage preventing germination of understory plant species which help to maintain proper nutrient levels in the soil. The evidence provided by Chepstow-Lusty & Jonsson suggest poor soil quality could be related to having high densely planted eucalyptus in his fields. Chepstow-Lusty & Jonsson (2000) also state in their research eucalyptus monocultures increase the amount of pest damage.

Figure 21. Densely planted eucalyptus trees in a coffee parcel, Site 2b

Rather than implementing a fertilization regiment, consideration for the evaluation of possible benefits for removing eucalyptus trees might be beneficial to coffee production. Chepstow-Lusty & Jonsson (2000) suggest replacing eucalyptus with Aliso, a native tree species that is known for its rapid growth, ability for nitrogen fixation, wood and traditional medicinal applications.

Following the observations of land-use, an additional area of interest within Site 2b involved variations of coffee processing, including the cement washing tank and drying area. Upon our arrival, the coffee washing tank was full of harvested coffee cherries, picked the day prior, being left in the tank of water overnight. In Peru, standard practice for cherry processing typically occurred directly after harvesting the same day. The possibility of over-fermentation of coffee likely occurred if cherries were not pulped within several hours after picking. The producer explained the reason why this occurred was due to early rains the prior evening, making conditions for processing too difficult, resulting in the delay. The producer expressed that this was not a normal practice to hold cherry in the tank for that amount of time. This variation in processing demonstrated yet another impact rainfall had on coffee quality.

In addition to the producer and myself, there were three additional relatives harvesting coffee. Two of the men went to the side of the mountain to harvest coffee. Makeshift plastic skirts were used to protect from insects and coffee fruit liquids that occurred during the harvesting of cherries. Additionally, the steep slope and longer branches contributed difficulties during harvest. Within this coffee parcel, the producer and workers averaged one hour to harvest a five-gallon bucket of coffee cherries. The time of year was also considered, as the harvesting season had not yet reached the height of the season, leaving much of the branches with minimal fruit load.

In addition to early harvest conditions, the coffee parcel was plagued with coffee leaf rust. The producer mentioned the plant disease mostly impacted the coffee varietal *Caturra amarillo*, a single coffee variety. Most of the varietals planted in their parcel was identified as *Catimor*, a highly resistant varietal to coffee rust which often remained healthy.

The group continued to harvest coffee past 4:00 P.M. Near the washing tank, they had collected four full bags and three partial bags of harvested coffee cherry. Some were harvested that day while several bags remained from the day's prior harvest.

The coffee picked was manually hand-cranked as opposed to motor-driven, which most producers in the area utilized. The group harvested 39 five-gallon buckets of cherry. It took an average of two minutes to hand crank one full five-gallon bucket of coffee, with a total time spent of one and a half hours of de-pulping by hand. For each four batches of hand-cranked coffee completed, the older man switched with another family member to share the workload.

One of the five-gallon buckets of cherries being de-pulped was harvested the day before. The resulting pulped coffee parchment was noticeably different by sight and smell. It was apparent fermentation had begun, as the parchment had developed a pink hue tone. The coffee harvested from the day prior was hand cranked and mixed with recently harvested coffee from the current day. This mixture of older picked coffee with freshly picked coffee was an action which likely caused a reduction in quality. Once their coffee was combined with multiple harvests from the area, this lack of consistency may not have been recognizable after it was homogenized at the coffee mill in Jaén.

The first harvest of the season for Site 2 was on the 25th of April, which started one week prior to my arrival. The producer planned to finish the second harvest of the season the following day. They would then need to wait between 20 days to a month before commencing the third harvest of the crop year. The producer predicted the third harvest would take 20 days to harvest. He would then break for 20 additional days to start the fourth harvest. Finally, after waiting another 20 days, they would begin the fifth and final harvest which consisted of very small quantities of low quality cherry.

Post-harvest coffee de-pulping started at 4:15 P.M. The last bucket was finished by 5:48 P.M. After having been asked to participate, I hand cranked the last full bucket of coffee cherry. The cranking took continual effort in motion, but did not require heavy resistance and was relatively easy to turn, although extremely repetitive. After completed, they took a bucket of water and rinsed the de-pulper. We returned to the main house at 6:00 P.M. in Site 2 to eat dinner. During dinner conversation, the producer discussed needs for further investment in drying beds. He said he currently had 500 bags of fertilizer, but required 1,500 bags of fertilizer to sufficiently supply his coffee fields.

Site 2c

The third farm visited in Site 2c was positioned at an elevation of 1479 meters above sea level, resting two hundred meters from the previous farm visit, slightly lower in elevation reaching 1401 meters. The farm implemented solar dryers which few in the area incorporated as a quality management practice. Solar dryers help to regulate drying times of the coffee during post harvesting stages by protecting it from damaging elements. Most of the farms in the area used plastic tarps which were placed above bare ground, exposing freshly pulped parchment to several detrimental factors. The benefit of using tarps resided in the initial low investment, yet practices are also dictated by local customs and market considerations for the level of quality in demand (International Coffee Organization, 2006).

Challenges come with the wet coffee parchment having direct exposure to rainfall and other foreign matter, such as livestock, pets, and other possible contaminates ranging from tractors, motorcycles, cars, including wastewater run-off liquids or solids which may contact coffee tarps, as they are typically placed near residences (Fig. 22). Throughout my travels I had witnessed trucks, pets, and children stepping on coffee with no protective barrier between coffee and contaminates which often comingled with drying parchment.

Figure 22. Coffee drying on tarps, Site 2b

Although many of these activities would not fully absorb through the protective outer parchment layer of the coffee seed, many of these contaminates had potential to spoil coffee, particularly rainfall. With tarps, producers must pay further attention to the storage of parchment due to possible unexpected rainfall. During coffee harvest season, irregular rainfall often occurred in the mountains during the coffee harvest season making it difficult for parchment to reach proper moisture levels. Moisture content typically rests between 12% to 14% moisture content in the seed. Producers face possible damage due to inconsistent drying and molding of coffee when using tarps, which could also lead to the formation of ochratoxin A (Poltronieri & Rossi, 2016), a mycotoxin produced by fungal species, which have been identified as potentially carcinogenic to humans (Mateo, 2007).

The third producer visit at Site 2 implemented an alternative method for drying coffee parchment. Rather than using tarps placed on the ground, the producer dedicated space located under the rooftops of many of the buildings and structures on his property. Coffee parchment is stored on secondary levels of their housing areas, each batch tagged with a lot number to record succession of drying times, helping to identify proper rotation of batches as they reach necessary moisture levels. Site 2c has three main drying areas, all utilizing rooftop solar-drying storage areas with corrugated sheets made of clear heavy fiberglass (Fig. 23). This allows sunlight and heat to help assist in the drying of coffee. During rainy days, this protection from the rain allows the producer to keep drying coffee parchment, whereas if it were on a tarp on the ground outside exposed directly to the elements, such daily collection at the end of the day is required to avoid mold and other forms of damage created by moisture. The producer explained the slower drying process was beneficial to creating improved cup qualities.

Figure 23. Rooftop drying area, Site 2c

This practice is often seen in Colombia and other coffee producing areas, which shares similar traditional storage activities applied to corn and other grains. This drying strategy could prolong or shorten drying times depending on cloud cover, although some concerns should be considered regarding possible detrimental impacts of drying too rapidly. Shortened drying times may add taste attributes described as woody characteristics, which is often a result of removing too much organic matter out of the coffee seed, resulting in a poor cup quality profile.

During the farm tour, we visited with a small group of eight to ten workers sitting on the ground next to the coffee plants picking coffee with plastic skirts wrapped around their bodies. The coffee plants were approximately two to three feet tall, appearing to be shorter and younger than average aged coffee plants. This was the first year of harvest for the plants in this section of the producer's coffee parcel. The workers picking coffee explained all coffee cherries should be harvested except green under-ripe cherries. We crossed a road to another parcel of the producer's land which consisted of two-year old plants already twice as tall as the previously visited coffee parcel. These plants were identified by the producer as *Catimor amarillo*, located at 1444 meters above sea level. The producer intercropped a variety of food staples including corn, guava trees, plantains, and yucca.

When asked about other possible challenges confronting coffee production in Site 2, they mentioned some issues with coffee leaf rust and the coffee borer insect, yet the impact does not appear to be as damaging on this farm compared to the neighboring farm located only two hundred meters apart. The producer's farm appeared well managed, utilizing agroforestry practices with an inclusion of innovative quality control techniques.

Site 2: Floaters, Sinkers, and Percentage of Maturation Levels

The following charts provide information outlining maturation levels harvested in addition to the amount of floater and sinker percentages of samples collected during visits to Site 2. The chart measures percentages of floaters from Site 2a (Fig. 24) where lower percentages of floaters per sample are collected.

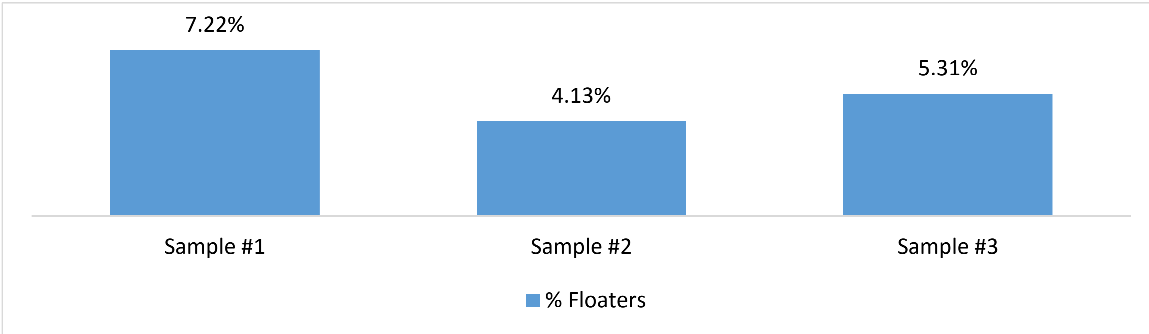


Figure 24. Site 2a, samples 1-3, displaying percentage of floaters

Figure 25 demonstrates selected coffee cherry maturation levels collected from Site 2a Sample 4. The results show 15.63% of the sample harvested at the under-ripe green and pink color, 21.47% of pink/red, and 47.74% red. The distribution shows a wide spectrum of acceptable maturation levels.

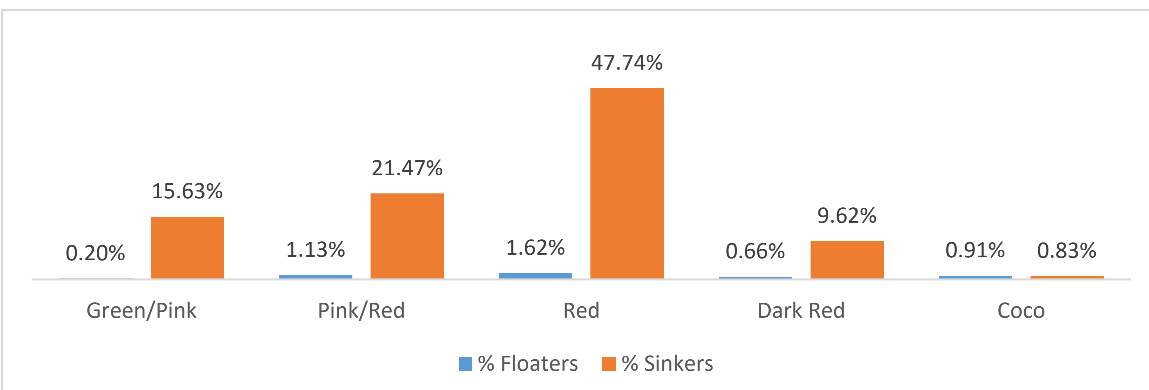


Figure 25. Site 2a, sample 4

The percentage of floaters and sinkers are displayed in Figure 24, representing each maturation level. The sample percentage weight of sinkers totaled 95.48% while the total percentage of floaters equaled 4.52%.

An increase in floater percentage is evident when addressing the results listed in Figure 26 for Site 2b. Floater percentages ranged from 16.03-17.83% between all four samples collected. Maturation levels shown in Figure 27 demonstrate an even distribution of maturation selection percentages from under-ripe to overripe, with lower percentages of red than from Site 2a collected samples.

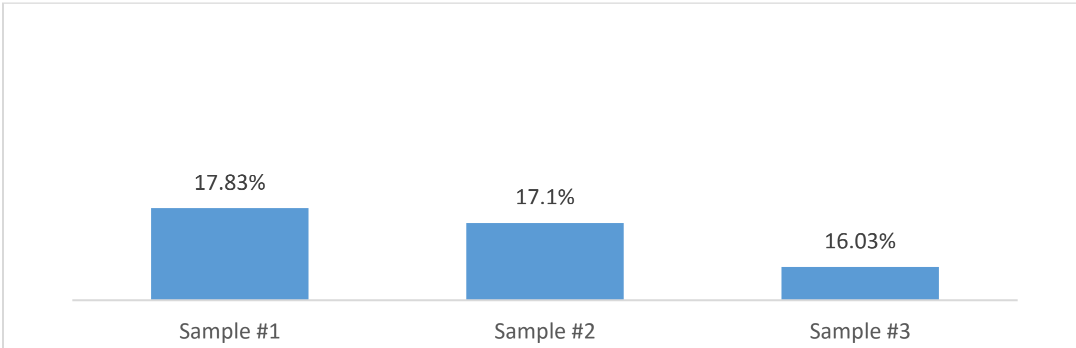


Figure 26. Site 2b, samples 1-3, percentage of floaters

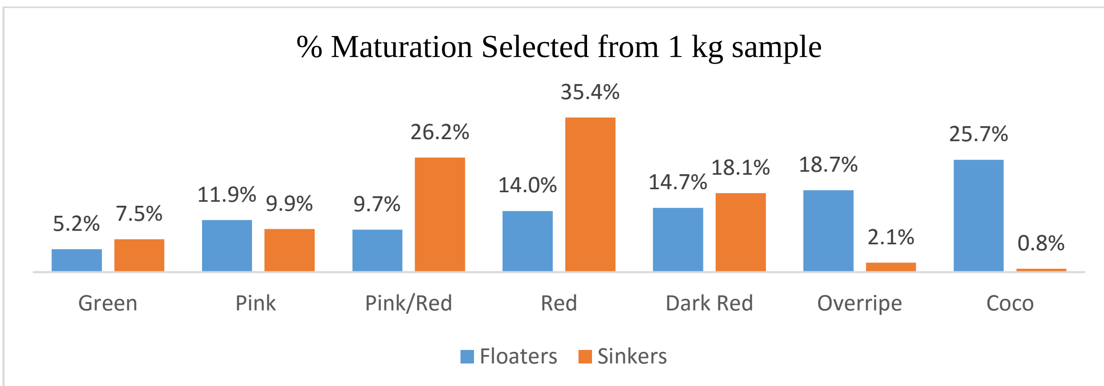


Figure 27. Site 2b, sample 2, percentage of floaters 17% and sinkers 83%

Figure 28 represents a sample taken from Site 2c Sample 1. The overall percentage of floaters from the collected sample measured 8.31%, where the remaining sinkers totaled 91.7%. The chart shows very little percentage of floaters across maturation with tighter distribution of selection between Red (42.6%), Dark Red (14.4%), and Brown (19.65%).

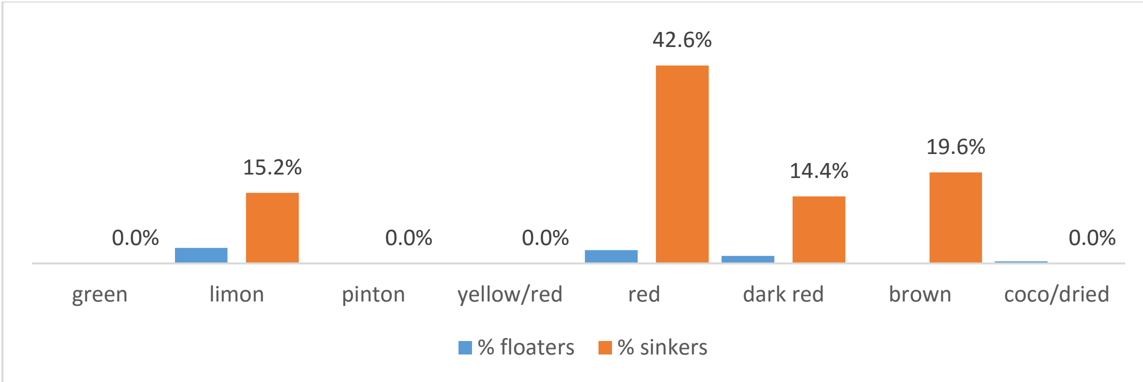


Figure 28. Site 2c, sample 1, maturation levels

Site 3

Site 3 is located approximately three miles from Site 2. Due to mountainous terrain and poorly constructed roads, actual travel time between Site 2 and Site 3 took several hours.

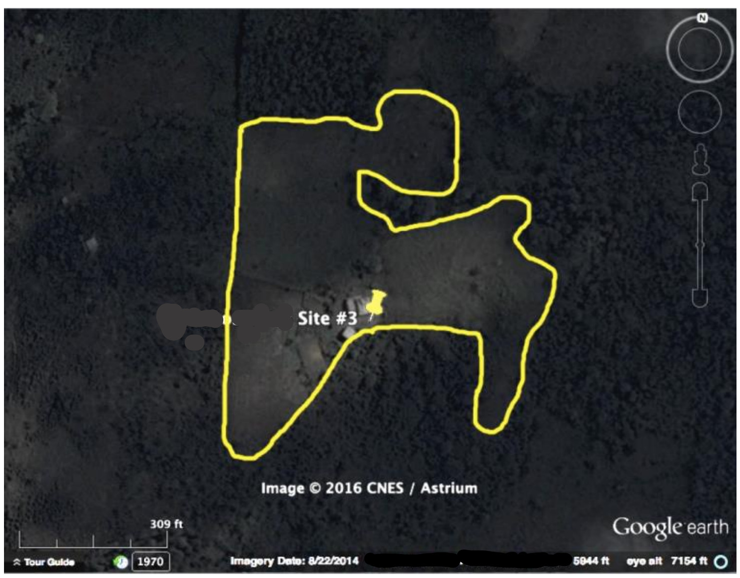


Figure 29. Cleared land for coffee cultivation, Site 3 (Google Earth, 2014)

Evidence of technified landscape management is shown in the area, specifically at higher elevations in Site 3 nearing 1,828 meters above sea level. Upon entering the area surrounding Site 3, hillsides of recently deforested patches were evident (Fig. 29). The coffee parcel and home of the producer was located approximately fifteen-minutes from the center of town, accessible only by foot or horseback. Unlike previous visits, the producer's home served as the center for hosting migratory labor during harvest season, conducting post-harvest processing, and related coffee activities. The producer lived with his wife and two young adult sons in an adobe two-story home. There was plentiful access to water for all coffee cultivation necessities. Although electricity was available within the general area, it was frequently out of service. The producer owed 20 hectares, with five allocated to his eldest son. Ten to twelve hectares of land were under coffee cultivation. The producer harvested approximately 2,400 pounds of parchment on an annual basis. He mentioned the amount was rather low as much of the coffee plants were too young for optimal production. The producer raised cattle on the land prior to coffee cultivation. Only one head of cattle remained on his property. The producer and his sons were in the process of preparing their coffee fields. They had been in the process of weeding and removing all organic matter from the ground surface surrounding the coffee plants. Most of the area surrounding the main house appeared recently planted with the *Catimor* coffee varietal. Site 3 showed signs of stumped trees and recently cleared undergrowth which allowed much of the soil surface exposure to direct sunlight. Deforestation and the practice of shifting cultivation with various burn patterns and intensity for clearing land was evident in the coffee parcel, in addition to several of the surrounding coffee fields.

There was noticeable evidence of prior contact and involvement with technical assistance programs addressing sustainable agricultural practices. Signs were strategically posted around the producer's processing area and household which identified each area for its usage and addressed restriction of certain activities (Fig. 30).

The signs were posted from a prior involvement with an exporter agency which required the producer to adhere to certain practices, including improvement of coffee processing methods, social welfare of migrant labor, and environmental health issues.

Figure 30. "Hunting and logging prohibited" posted near household

Current management practices showed evidence of recent removal of tree coverage. There was little evidence of any incorporation of mulching between coffee plants. The coffee producer chose to establish *Catimor* as the main coffee varietal within his coffee parcel. This varietal is known for higher yields and greater resistance to damage caused by the coffee borer insect. This varietal also tends to withstand coffee leaf rust more than most other Arabica varietals. It is widely accepted within the coffee that the *Catimor* varietal struggles to deliver higher quality cup profiles, making it difficult for producers to receive premiums based on the value of taste qualities.

Balancing consideration for achieving desired coffee qualities along with the challenges facing increased risk for cultivating varietals more susceptible to pest and disease are some of the most challenging trade-offs coffee producers consider when exploring production of specialty grade coffee. With less access to differentiated markets and limited technical resources, consideration for *Catimor* often become the least risky investment, providing the greatest yield potential.

Evidence demonstrated general application of an intensified approach to coffee cultivation during the visit to Site 3. The producer mentioned his neighbors were transitioning to similar management strategies, turning lightly forested pasture into full sun coffee production. The coffee producer offered reasoning behind the removal of tree canopy due to conditions presented by higher altitude cultivation, demanding less percentage of shade cover due to cooler temperatures and longer maturation times. Very little soil conservational practices such as terracing, intercropping, construction of live or dead soil barriers, or crop covers were implemented on his farm or throughout the immediate surrounding landscape. The photograph below demonstrates the property line between Site 3 on the right, and a neighboring parcel on the left (Fig. 31) which has yet to be transformed into full sun coffee cultivation.

Figure 31. Property line between neighboring fields, Site 3 on the right

The producer used a combination of methods for drying coffee parchment. Most of the coffee was dried using tarps placed directly upon the ground. In addition to this drying practice, he had constructed a raised platform with a solid rooftop for drying his higher quality selected coffee lots. He also reserved space for additional coffee drying and storage on the second level of his house. He discussed desire for constructing facilities similarly found during my visit with the producer from Site 2c (Fig. 23). He quoted the local price equivalent to $10.00 per clear fiberglass corrugated sheet. The producer estimated he would need more than 100 sheets to build a properly sized drying space, mentioning this investment was well outside of his current budget. When I showed him a photo of a similar solar drying unit made of more affordable materials including bamboo and plastic transparent tarps, he claimed stronger winds from the mountainside would destroy such structures. His reasoning seemed valid given the current positioning of the coffee parcel along a vast hillside where the absence of trees would likely not protect the structure from stronger winds.

With higher elevations of 1800 meters above sea level at Site 3, drying times were estimated between 13 to 40 days depending on the drying method used. The producer mentioned he could sell wet parchment at any given moisture percentage, but a penalty came with a reduction in payments at the receiving mill in Jaén. To receive full payment for his coffee, his obligation to the milling station in Jaén required coffee to be delivered at a moisture content between 12 to 14 percent. The producer explained there was little financial incentive for delivering higher quality coffees as premiums paid for cleaner coffee and proper moisture levels rarely outweighed the labor and time investment needed for such production.

Due to higher elevation, speed of coffee cherry maturation was slower. Since Site 3 rested 400 meters above the elevation of Site 2, very little coffee was ready for harvesting during the site visit. This early harvest reflected through the percentage of floaters collected from samples taken from Site 3, in addition to a wide maturation selection (Fig. 32). The producer mentioned it would be one more month before he began the regular harvest season. He typically harvested three times over the annual coffee season.

The producer constructed a waste water management system consisting of three separate pits to help properly adjust discharged water from the washing tanks. Typically, water is discharged at approximately 4.0 pH which can cause significant pollution for downstream waterways. This was the only water management system witnessed during my visit to Peru. Although the producer mentioned many producers in the area have constructed similar systems, I was unable to make the extra site visits to verify. Water from the tanks ran into two pits for cleaning. The first tank measured 1.5 meters deep, and the second pit measured equal in size, located slightly downhill from the first pit. Once the first pit was full of discharged wastewater, remaining wastewater entered the next treatment tank for further catchment.

During this time of the year, they performed maintenance on equipment, including calibration for the coffee depulper and repairs on coffee washing tanks. The migrant labor for picking coffee typically arrived in late June and stayed until August. The producer mentioned migratory labor typically came from the Cutervo Province of Cajamarca. The producer expected migrant workers to arrive the following Sunday for early harvesting. Migrant laborers received *5 Soles* ($1.46) for collection of one full five-gallon bucket of coffee cherries, which took approximately one hour to harvest. The producer required the work of ten to fifteen people during peak harvest season. Hired labor remained on the farm for approximately one month and remained longer if desired, which would also include food and housing in addition to the wage paid for harvesting. The producer claimed he had never had any labor disputes or issues with hired labor.

Once the coffee was ready for delivery to the central dry mill in Jaén, the producer had each bag carried by mule or by hand to the road in Site 3, approximately a 15-minute hike down the mountain to the center of town. Thereafter, small pickup trucks were used to deliver his coffee to Jaén for payment. The producer normally delivered his coffee to Jaén one full sack at a time. The producer's travel time to Jaén took two and a half hours by truck. Once coffee was received by the dry mill in Jaén, the dry coffee parchment received a quality analysis to measure moisture content and defect count. Upon arrival to the dry mill in Jaén, coffee quality analysis took approximately one to two hours for each producer. Depending on the amount of work the quality control lab had scheduled for their day, receiving payment may have taken until the following day. The producer must wait in Jaén to receive payment which was normally issued by check and cashed at local banks. If the producer delivers coffee which was not fully dried, the mill would discount the rate and finish off drying on patios near the mill. The producer mentioned the range of payment for one full bag fluctuated from 340 *Soles* ($99.00 USD) for a higher quality cup profile, to 290 *Soles* ($85.00) for lower qualities.

The producer in Site 3 had the storage capacity for holding up to two hundred finished sacks of coffee in his household, almost two-thirds of his annual harvest expectations. With average production, he currently harvested approximately three hundred sacks of coffee parchment on an annual basis. The reason for storing finished sacks at his farm allowed him to remove sacks as needed, delivering to the dry mill when the market was favorable, and saving the coffee during times when the market was low. When the market was favorable, he explained that the dry mill in Jaén become overwhelmed with coffee deliveries and the mill was then forced to stop receiving coffee, making it a challenge for farmers to receive favorable prices.

Site 3: Floaters, Sinkers, and Percentage of Maturation Levels

The following chart (Fig. 32) provides information outlining the maturation levels harvested in addition to the amount of floater and sinker percentages of the samples collected from Site 3. Initial observations drawn from this presented data showed higher percentages of sinker maturation levels collected between Red (26.3%), Dark Red

(41.1%) and Purple (13.9%). The overall percentage of floaters present at Site 3 was similarly found in the previous Site 2b Sample 2 which measured overall floaters at 17.1% (Fig. 27).

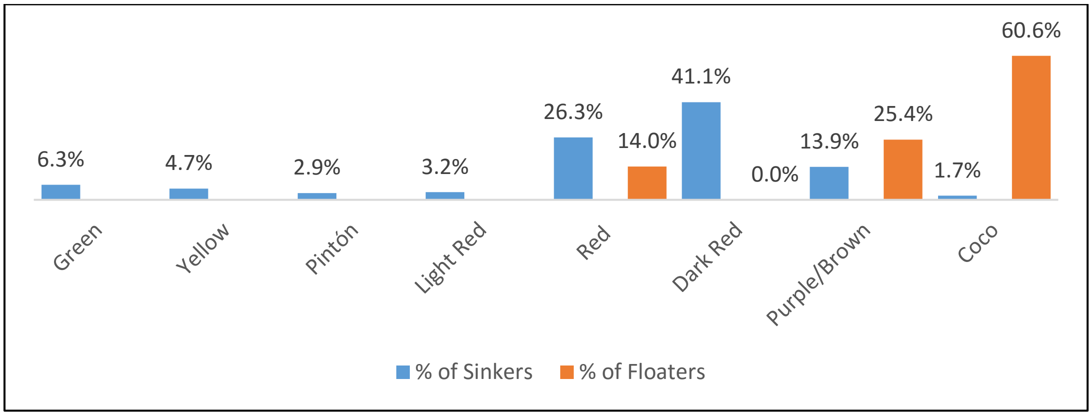


Figure 32. Site 3 Maturation distribution of sinkers 84.7% and floaters 16.5%

The producer at Site 3 was awaiting the beginning of his harvest. There were very few cherries ready for harvesting during the time of my visit. The above data represents a general view of harvesting maturation and selection patterns reflected during early harvest (Fig. 32). His attention to selective practices could have been influenced by my presence, rather than conducting normal operations in which he would have followed on a regular day during this period of the season.

CHAPTER FOUR: ANALYSIS OF COLOR, BRIX, AND MOISTURE

Observations of the selective harvesting conducted during my three site visits demonstrate the effectiveness of harvesting decisions made by farmers during early harvesting season. Measurement of harvested coffee cherries may further indicate percentage of defects selected during harvest, in addition to demonstrating possible cause contributing to defects, such as insect damage or plant disease. Measuring the percentages of cherries harvested within maturation levels also reflect what coffee producers consider to be an economically acceptable practice to harvest fruit at these given times. Several personal accounts during the interviews expressed if coffee cherries extract liquid by squeezing the fruit, regardless of color, it was ready for picking. This statement reflected such practices within the samples gathered, where many of these selections showed a wider range of maturation levels.

The samples measured in the previous section were gathered from random harvested basket samples of either 500 grams or one kilogram of cherry prior to de-pulping. There were two measurements carried out during the visits. I measured the weight of coffee cherries which floated in a container of water, and the weight of cherries which sank to the bottom. The placement of fruit into water measured density, which was the first indicator for exportable non-damaged coffee. If coffee cherries floated, they were immediately separated into a lower quality pile and collected for lower quality markets.

In several personal communications during my visits, producers explained price differences received for certain quality levels. For those cherries with higher density, they would sink to the bottom of the tank of water and were considered clean coffee, worth approximately 360 Soles per 120 lbs. of dry coffee parchment. For secondary quality, farmers received around 290 Soles per 120 lbs. sack of dry coffee parchment. Cherries which floated (*decarte*) are considered the lowest quality and received approximately 240 Soles per 120 lbs. of parchment. These prices fluctuated with changing market demands, but general observations made were the price differences between primary coffee quality and lower coffee quality, with a price difference of roughly 80 Soles per 120 lbs. sack, equivalent to roughly $25.00 per 120 lbs. of coffee. Additional financial evaluation on cost of production and time allocation for producers investing in homogenized higher quality lots would be an area for further investigation. Due to this small difference in price, the farmer mentioned a lack of financial incentivization to produce higher quality lots, therefore little investments have been made to improve coffee qualities.

Further questions came to mind after reviewing the data gathered from all sites. With selective harvesting practices, coffee samples that have more floaters in the overripe category may signal late harvesting practices or perhaps a wider variation of coffee varietals and elevation within a coffee parcel. If samples have more floaters from the red maturation category, it may signify problems reflecting insect damage due to coffee borer insects which consume the inside of the seed and fruit, causing lighter density. Measuring density in addition to the percentages of maturation selected may help indicate several issues, yet assumptions should involve a range of variables, including the economic, environmental, and individual habits of each coffee producer, as variation within selective harvesting practices often range drastically between neighboring farms.

In the figure below, an overall comparison between sites show the percentage of floaters and sinkers within each Site sample (Fig. 33). The highest percentage was seen at Site 2b Sample 1, followed by all the additional samples collected from the same producer. This was the same site which expressed concern with soil health and densely populated eucalyptus trees. Additionally, the producer from Site 2b did not have a motor-driven de-pulper. The producer used a piece of bamboo to spread out wet parchment on his tarps and combined cherries from harvested coffees over several days which likely caused uneven pH levels during fermentation. The lowest percentage of floaters was found in Sample 2 collected from Site 2a, with the same producer receiving low percentages of floaters measuring 7.22 percent.

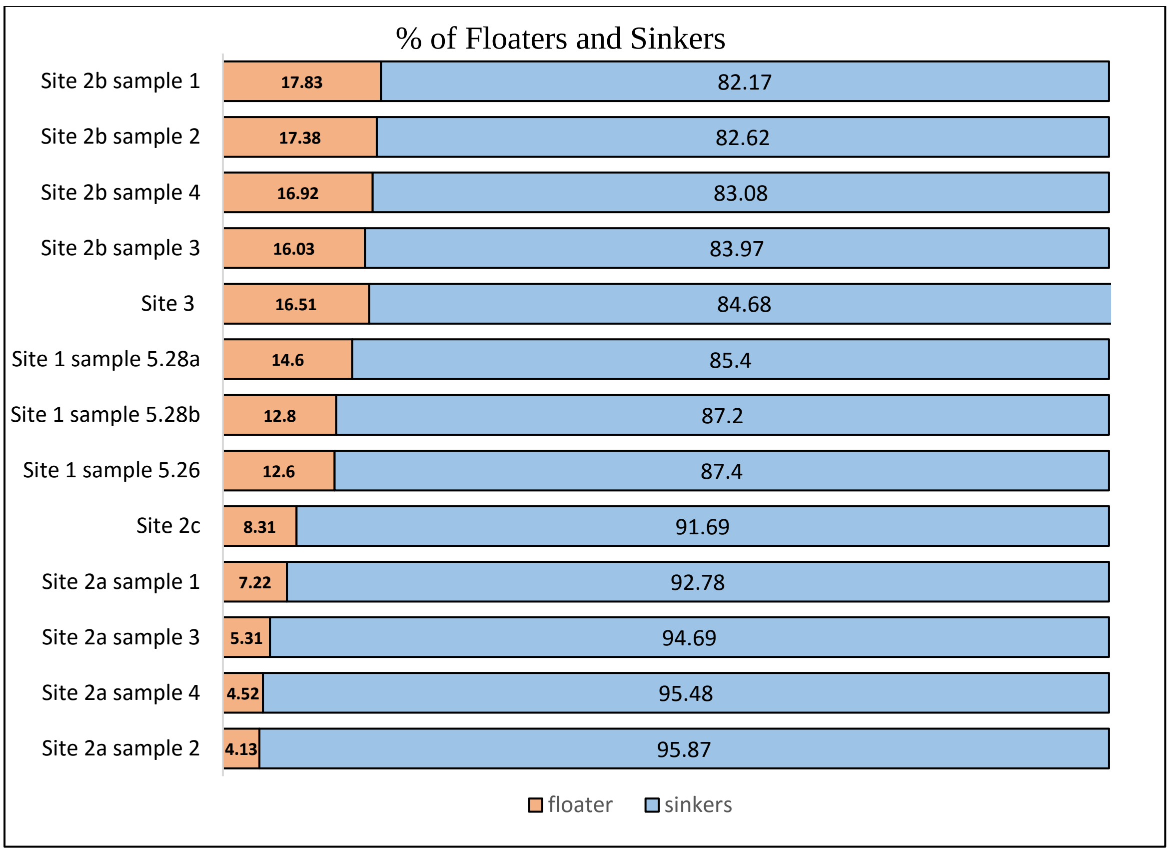


Figure 33. Percentage of floaters and defects within each site visit

Access to greater financial means for this producer may reflect greater capital investment and interest in driving quality within his production, perhaps best represented by his investment in a motor-driven de-pulper. His drying techniques utilized the second story of his household, with greater involvement in the techniques and tools used for post-harvest processing. The producer from Site 2a did not have multiple workers harvesting coffee. He was the only person to harvest his coffee. He also moved to this area with the intention of starting a coffee farm five years prior. Many of these observations are assumptions which may suggest motivational differences behind coffee production, or various levels of technical knowledge regarding coffee processing.

Maturation Level Comparison Between Sites

In this section I address various levels of cherry ripeness and percentages of defective and non-defective harvested cherries within each maturation category. Sinkers most often represent higher quality, dense, and healthy cherry selections. The percentages of proper maturation levels during harvest will impact financial gains throughout the harvest season. Although I visited this area during the earlier harvests, the resulting observations have shown some level of variation between sites. Throughout this section I will address results gathered from each site visit sample and present observations to demonstrate possible cause behind harvesting variations. The samples collected were minimal, therefore the conclusions made are speculative, presented as a pilot study which may serve to engage further research.

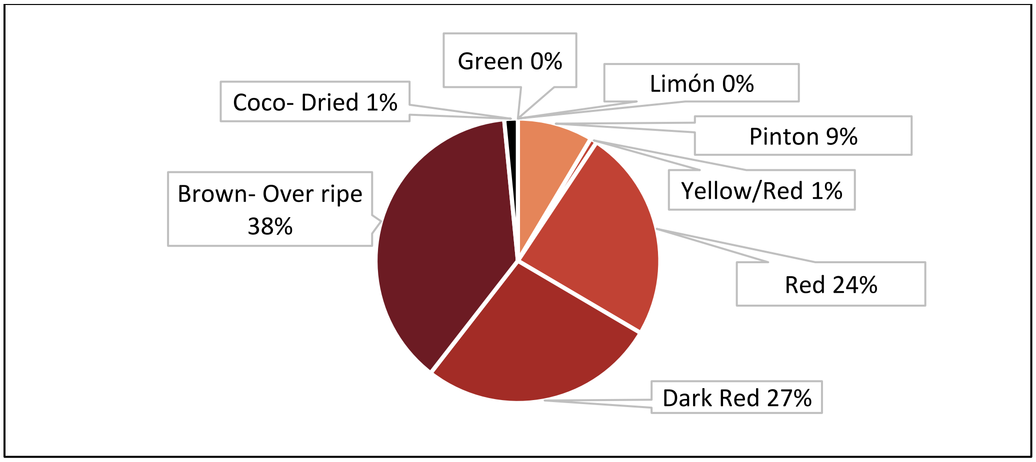


Figure 34. Site 1 (5/26) percentages of coffee within each maturation level

The samples provided below are presented in chronological order of site visits. The analysis was conducted in this fashion to support a descriptive approach reflecting an experience between each site visit and to add context to possible observed variation. The first sample was from Site 1 shown in (Fig. 33). The absense of green, limon, and only 9% pinton maturation levels demonstrated efforts towards selective harvesting to avoid under-developed maturation levels. Unripe cherries often sink, while most insect damaged coffees tend to float. The coffee farmer did not express much concern with insect damage within his site. He had incorporated traditional polycultural shade management on his farm, which included a wide selection of fruit trees and vegetables throughout his coffee garden. The increased percentage of harvested maturation colors between Brown-Overripe (38%) and Dark Red (27%) maturation categories presented an interesting result. The cause behind maturation levels were likely caused by a situation explained by the farmer, stating he had waited for my arrival to demonstrate the de-pulping of coffee. Due to my late arrival, he had allowed this batch of ripe harvested cherry to sit for almost a day. The coffee cherries continued to ripen after harvesting.

Since the coffee had sat for an unusual period of time, this likely would have altered the visual maturation category results.

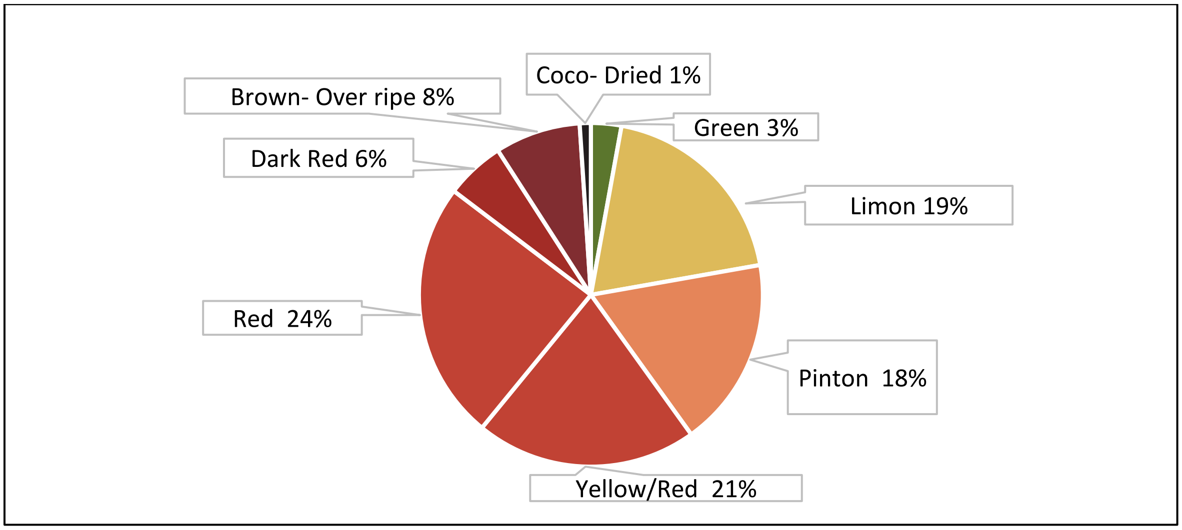


Figure 35. Site 1 sample 5-28a percentage of coffee within each maturation level

The charts displaying information from Site 1 Sample 5-28a (Fig. 35) and Site 1 Sample 5-28b (Fig. 36) are from the same day but different harvesting times. Site 1 Sample 5-28a was harvested during the morning hours, while Site 1 Sample 5-28b was collected in the afternoon (Fig. 36). Both samples were collected with the help of neighboring family members. A general comparion shows approximately 75 percent of both harvests would be within light to dark red matuation categories, while around 25 percent fell into either overripe or underripe selections. There were very small percentages of severely underripe green coffees in both samples, although the sample collected in the morning, Site 1 Sample 5-28a showed higher percentages of mostly underripe “limon” maturation category.

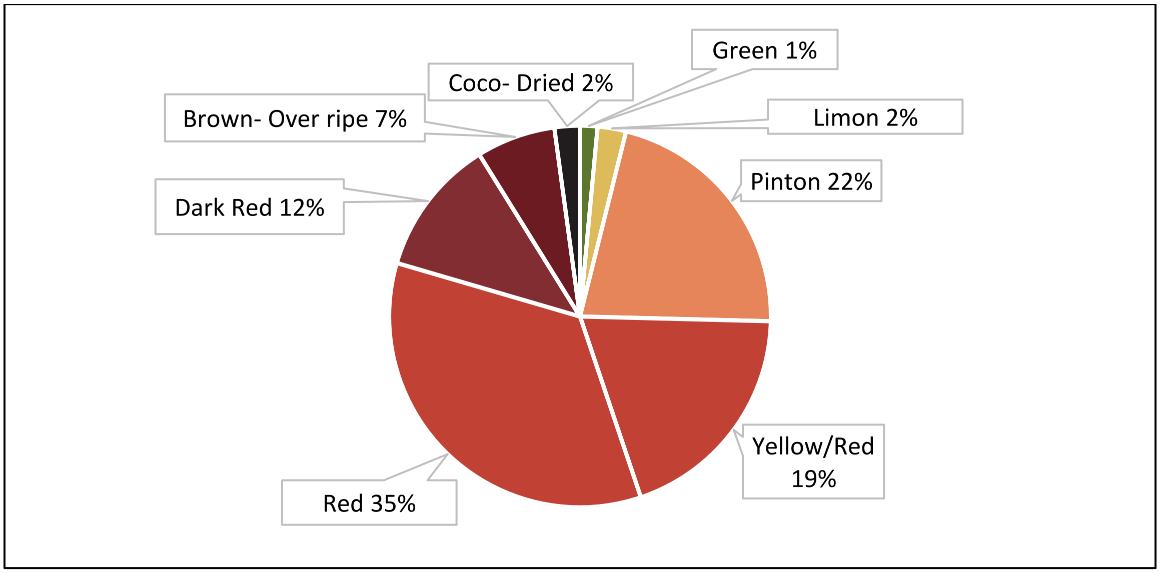


Figure 36. Site 1 Sample 5-28b percentage of coffee within each maturation level

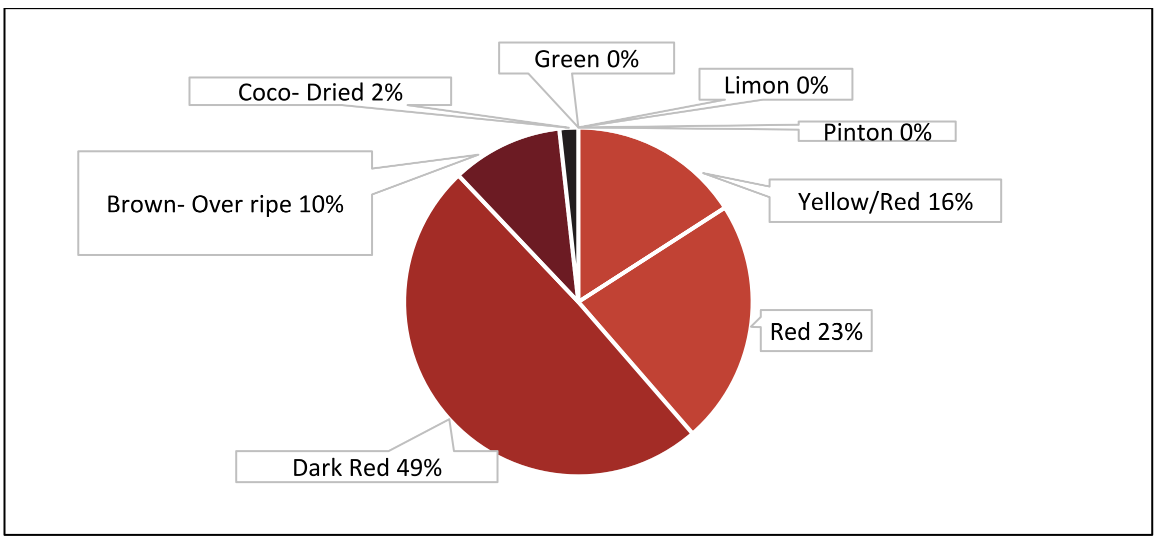


Figure 37. Site 2a, sample 4, percentage of coffee within each maturation level

The second site visit entailed three visits beginning with Site 2a Sample 4. The sample taken showed no percentage of unripe or underripe cherry selection (Fig. 37). This selection of sinkers within the ripe maturation levels suggested a hightened attention to selective harvesting practices. The reasoning behind this homogenized selection of ripeness could demonstrate the positive results which come from individual selection practices. The farmer was the only person involved in harvesting coffee on his farm. He had no hired labor or family members joining him in the field. Additionally, my presense in the field throughout the morning could have unintentionally influenced his harvesting habits.

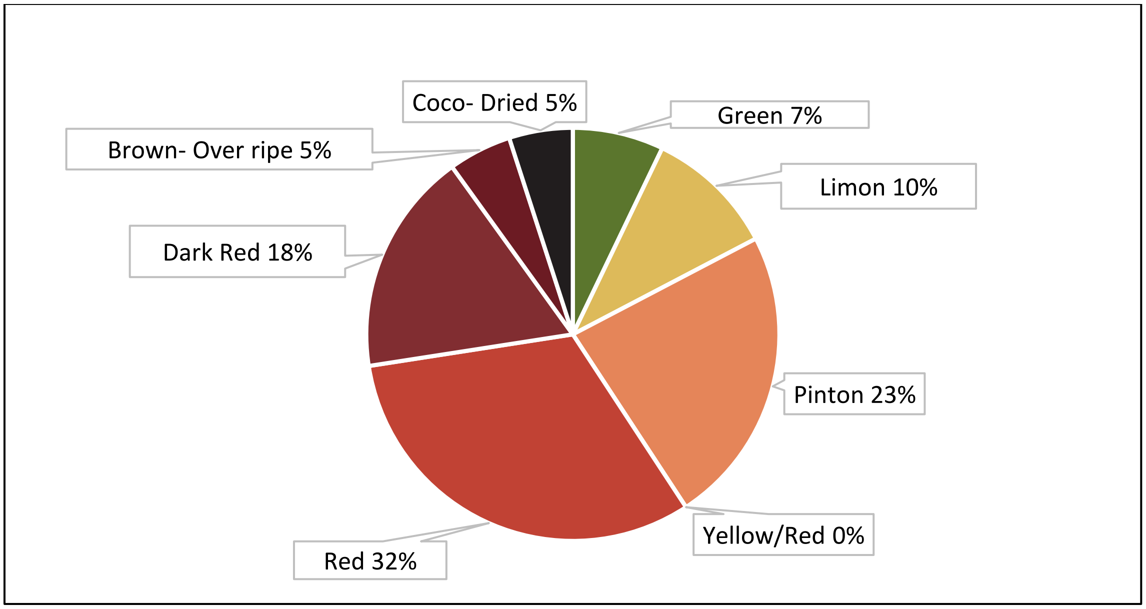


Figure 38. Site 2b, sample 2, percentage of coffee within each maturation level

Site 2b Sample 2 (Fig. 38) demonstrated a much wider distribution of maturation percentage than Site 2a and Site 1. Seven percent of all sinker cherries were catagorized as green unripe cherry. Additionally, there was a presence of all categories of maturation levels. Nearly 50 percent of the coffee cherry selection fell outside of what may be considered within an ideal ripe range. Approximately 23 percent of Site 2b Sample 2 fell into the nearly ripe pinton level of maturation. On this farm, the elder son was not present and there were several extended family members harvesting coffee during my visit. This site was suffering from soil qualiy issues in addition to heavily shaded areas by eucalyptus. The plants appeared to be lacking general plant health with signs of insect infestation. This observation was also confirmed by the amount of insect damage found in the samples which also result in increased percentage of floaters (Fig. 38).

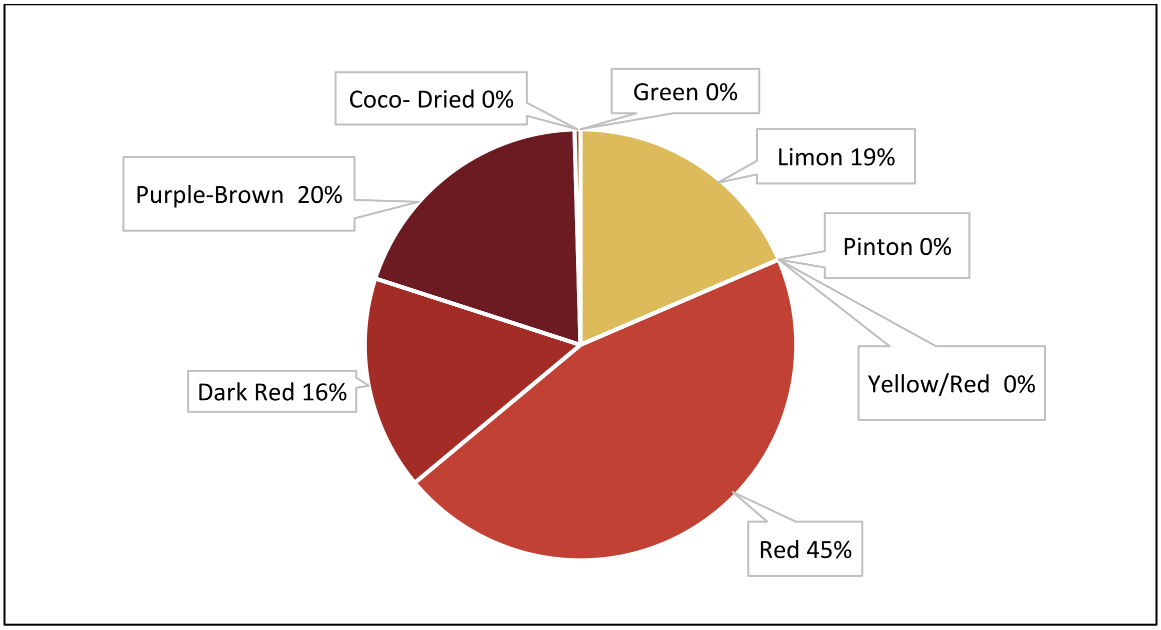


Figure 39. Site 2c, sample 1, percentage of coffee within each maturation level

The absense of green and coco-dried maturation levels of cherry ripeness within Site 2c Sample 1 likely demonstrated some effort towards managed selective harvesting practices (Fig. 39). Unripe coffee cherries sink, therefore having no sign of green unripe cherries in this sample may have suggested selective harvesting techniques were intentially avoiding these undesired levels of selection. Although most coco-dried coffees tend to float due to a lack of organic matter remaining within the seed or cherry pulp, over-ripe coffees will often sink. With no sign of this ripeness in the sample, it again demonstrated the assumption of an intenional avoidance of these lower coffee maturation qualities.

The geographic proximity between Site 2b Sample 2 (Fig. 38) from Site 2c (Fig. 39) being approximately 200 meters apart suggested although soil qualities and topographic conditions may differ, general environmental attributes shared similar pressures. The wider distribution of maturation selections from Site 2b may point to a lack of access to technical support, soil quality, access to sufficient capital for coffee pulping equipment, or perhaps a lack of general concern and lack of motivation to produce higher quality coffee.

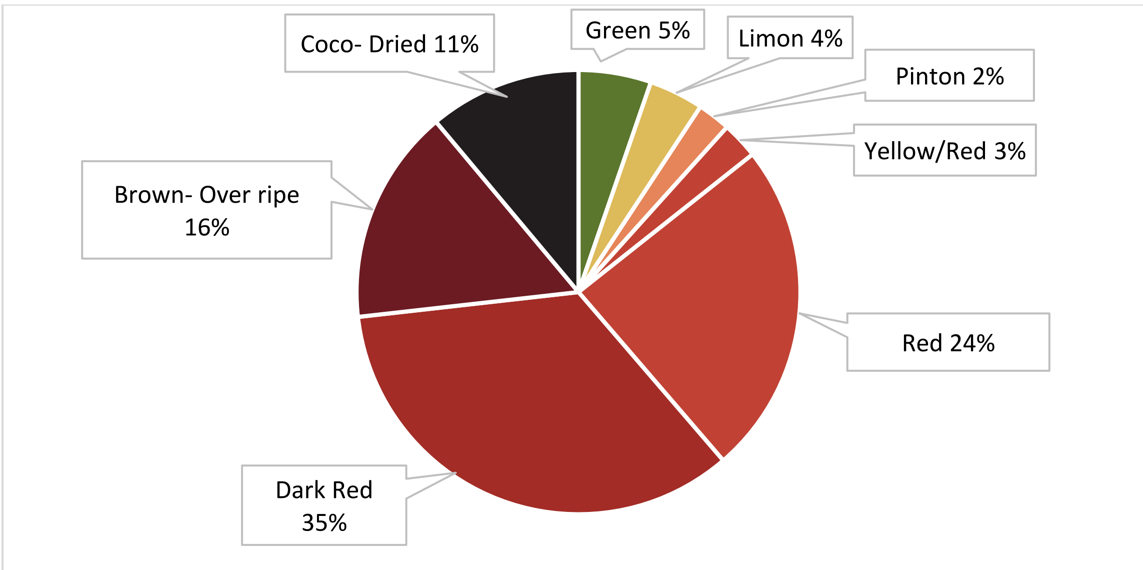


Figure 40. Site 3 percentage of coffee within maturation levels

The pie chart addressing Site 3 (Fig. 40) reflects a possible relationship to how elevation may have slowed maturation processes. The producer expressed his concern for his smaller percentage of available ripe cherry for harvesting during my visit. During this time of year at 1,800 meters above sea level, the harvest had yet to officially begin, offering a small amount of ripening cherries. The variation of maturation was also likely influenced by my presence and request to monitor selective harvesting practices. The producer was willing to participate in the study of selective harvesting, but the selection availabe on his farm could have influenced percentages as shown in Figure 40. Higher percentages of dried cherry pods could have been a sign of early crop harvesting, due to the possibility that the farmer does not find spending the time picking only smaller selections of ripe cherry valuable during the early harvest, therefore allowing for the first ripe coffees to be left on the tree. He had not hired labor for harvesting until later in the season when cherries reached ripeness. The lack of labor likely caused less time dedicated to selection during the very early harvesting season.

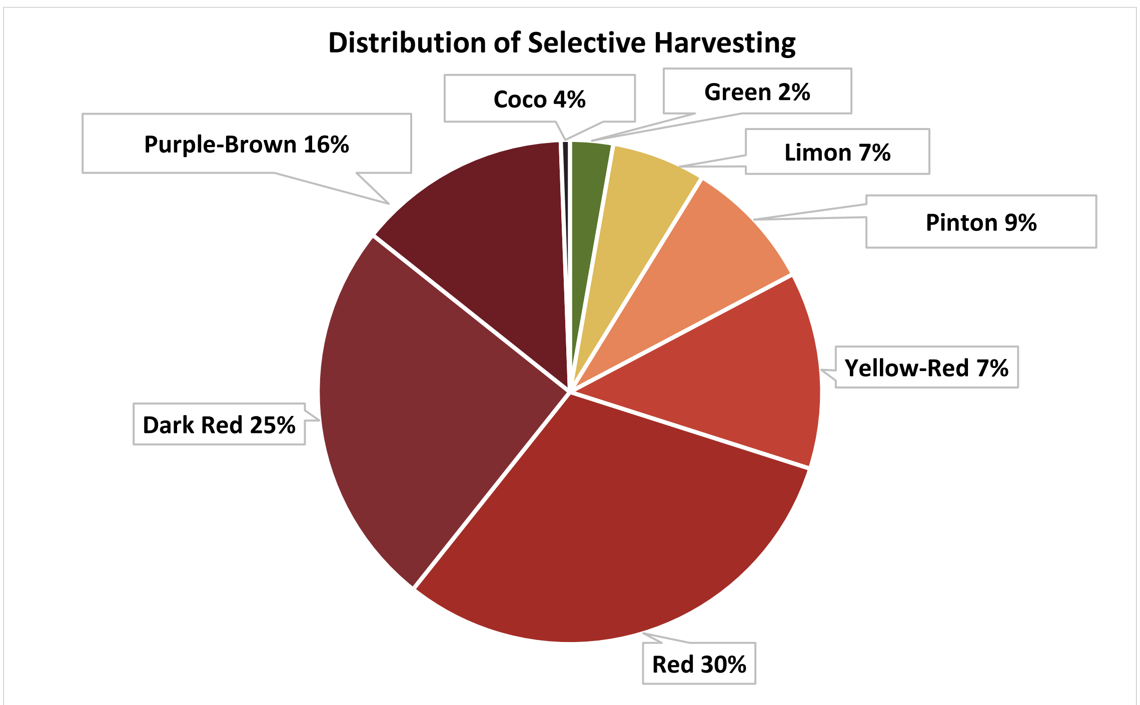


Figure 41. Overall percentage of maturation levels collected from all sites

Figure 41 presents the total combined samples from all site samples collected, representing the overall percentage for each category of maturation selected during early harvest. The information provided within the selective harvesting data set (Appendix E) indicates approximately thirty percent of all cherries selected were considered optimal maturation levels (Red), whereas very ripe (Dark Red) provided twenty-five percent of the total sample selection. The distribution of maturation reflected an overall picture of the regional average selection which could be found after many of these coffee lots are combined at the exporting mill. Coffee provided by smallholder producers are normally combined into larger homogenized coffee lots after being delivered to Jaén for final milling. To improve the overall intrinsic coffee quality, addressing the selective harvesting practices within each coffee cultivating community would merit further research for improving harvest potential.

Measuring Brix and Classification of Maturation Levels

Using the Brix scale for determining optimal selection for coffee harvesting is a relatively new practice for coffee producers. The application of this measurement has been used within the wine industry to determine the potential of alcohol development in relation to the maturation of grapes, which in turn guide optimal harvesting times.

The Brix degree for coffee fruit has been regarded as one of the best indicators for optimal selective harvesting apart from color (Folmer, 2017). The Brix degree is determined by sampling the soluble solids in the mucilage of coffee cherries, measuring the total amount of sugar components within the fruit. The level of sugar is used as a general indicator for ripeness, where one Brix degree equals one gram of sucrose in 100 milliliters of water.

The purpose of incorporating the degree of Brix measurement with each harvesting site was to establish a reference point for coffee producer to help explain what the range of acceptable harvest selections were within defined maturation ranges. The intention was to identify the range of variation between each location and producer to discover if harvesting standards varied, and to what extent these variations occurred. Several observations were made while measuring the physical size and Brix degree of each individual harvested cherry from various coffee varieties.

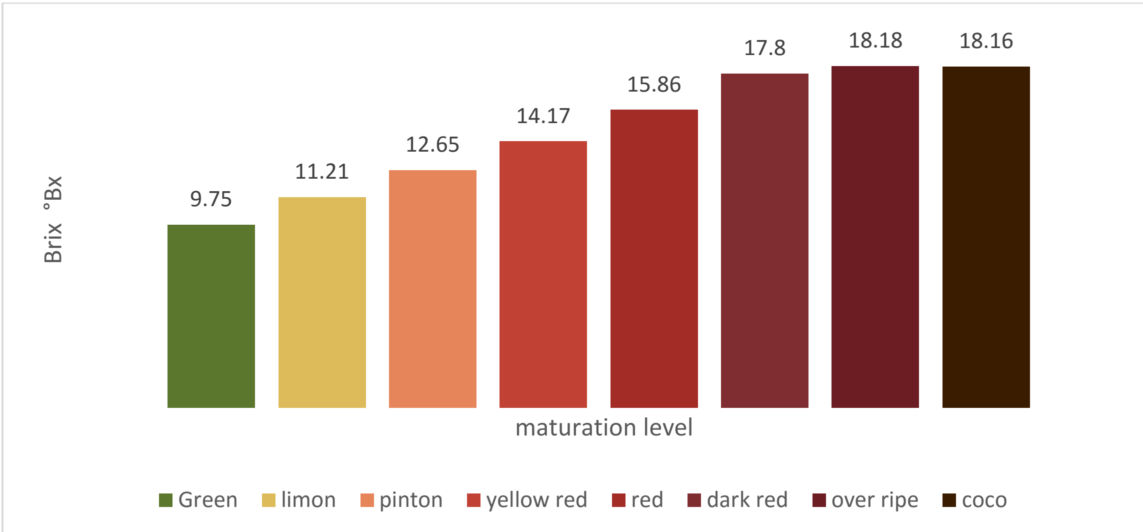


Figure 42. Overall sample average of Brix (°Bx) for maturation level

As shown above (Fig. 42), the degree of Brix (°Bx) increased as the maturation colors changed from green to coco. The level of Brix for ripe coffee cherries averaged between 15 °Bx to 18 °Bx, whereas under-ripe cherries averaged 10 °Bx to 12 °Bx. The percentage of selected cherries within each level of ripeness and the degree of Brix within each maturation category provide an overview of selective harvesting practices, although consideration for differences between coffee varieties and environmental factors will dramatically alter the results and benefits for using such indicators as a tool for making improvements in selective harvesting practices.

After several collected samples from the *Catimor* coffee varietal, it was apparent the amount of liquid present, level of Brix, and physical volume of the *Catimor* coffee variety were higher than all other varieties intermixed within the sample sets (Fig. 43).

Maturation level = 6 (Red)				
Site 2 (2a) Caturra	sample 1	sample 2	sample 3	sample 4
Weight (g)	1.50	2.00	2.1	2.00
Length (mm)	1.80	1.80	2	1.90
Width (mm)	1.30	1.50	1.5	1.50
Brix (°Bx)	9.75	12.75	12	14.50
Maturation level = 6 (Red)				
Site 2 (2a) Catimor	sample 1	sample 2	sample 3	sample 4
Weight (g)	3.20	2.50	2.90	2.80
Length (mm)	2.00	2.00	2.00	2.10
Width (mm)	1.80	1.60	1.60	1.60
Brix (°Bx)	19.75	25.00	25.20	23.25

Figure 43. Coffee cherry comparisons between Caturra and Catimor varieties.

Although there was an increase of liquid, cherry size, and higher degree of Brix measured, the typical cup taste profile for *Catimor* is usually not favorable when in comparison to other varietals, such as *Caturra*, where professional coffee tasters often favor this varietal over *Catimor* flavor profiles.

Drying Techniques and Measurement

As explained in the previous section outlining post-harvest coffee processing stages, drying freshly pulped coffee cherries to an acceptable moisture percentage for safe and stable storage is one of the most important steps taken throughout the entire processing from planting of the initial seed to brewing the final coffee beverage. Drying techniques are usually interconnected and determined by the local environmental conditions, as the risk and opportunity for completing proper drying techniques are dependent on daily weather conditions. The risks are reduced when facilities have infrastructure to help regulate the process, yet most independent smallholder coffee producers within the Region of Cajamarca do not have sufficient financial capacity for such investments.

Although several producers have dedicated further resources to establishing raised drying beds or allocated space under clear panel rooftops, smallholders observed within the area most often used tarps placed directly on the ground, spreading freshly pulped coffee cherry evenly across the surface of the tarp. Thereafter, producers occasionally turned the coffee by walking across the tarp with a rake to help mix coffee to achieve consistent drying throughout the batch. At the end of each day, coffee on tarps were collected and placed within large plastic sacks and kept under shelter overnight. The next morning, coffee was once again spread out on tarps and continued drying in the same manner.

Producers in all three site locations gave similar estimates for drying times, all basing estimates upon three general environmental conditions; full sun, partly cloudy, and rain. Variation of the above conditions changed drying times and altered methods in response to such variables as; daily temperature, percentage of direct sunlight, strength of wind, frequency and amount of rainfall, and relative humidity.

Producer interviews conducted within Site 1 and Site 2a demonstrated similar responses to the average time taken for properly drying coffee parchment to deliverable moisture percentage. Site 1 stated his coffee typically takes three days to dry with full, strong sun exposure, five to seven days for full cloud cover, and 15 to 20 days with cloud cover and rain. The coffee producer at Site 2a stated his coffee took three to four days with full sun, and up to 20 days with rainfall. The traditional farmer knowledge gained from experience demonstrated a commonality shared throughout the region, particularly in relation to the time frame associated with using tarps for drying.

Although most smallholder producers used tarps, an increasing variety of drying methods are being implemented throughout the region. The most common variation for drying coffee was the use of parabolic solar drying structures. These are similar in structure to a greenhouse, lined with raised drying beds sheltered by a clear plastic tarp and framed using bamboo or wooden poles, leaving open ends for increased air ventilation (Fig. 44).

Figure 44. Coffee on raised beds inside parabolic solar drying structures

Parabolic solar drying structures are useful for protecting the coffee from rainfall, in addition to capturing extra solar energy helping shorten overall drying time. The raised beds allow for additional airflow underneath the coffee to aid in consistent drying throughout the drying coffee batches.

During my initial visit with the producer in San Ignacio, I gathered moisture readings from a variety of batches at different drying stages within the producer's parabolic solar dryer. The figure below (Fig. 45) shows the physical appearance of coffee parchment and coffee seed with different moisture content and drying times. The cleanliness of the coffee seed and the thickness of the protective parchment shell were observed by the producer as attributes determining proper moisture content. As shown in Figure 45, the desired 12 percent moisture content was achieved within seven days. Although this time frame was slower than estimates given by producers using full sun exposure on tarps in other areas, the risk for added moisture from rainfall was avoided.

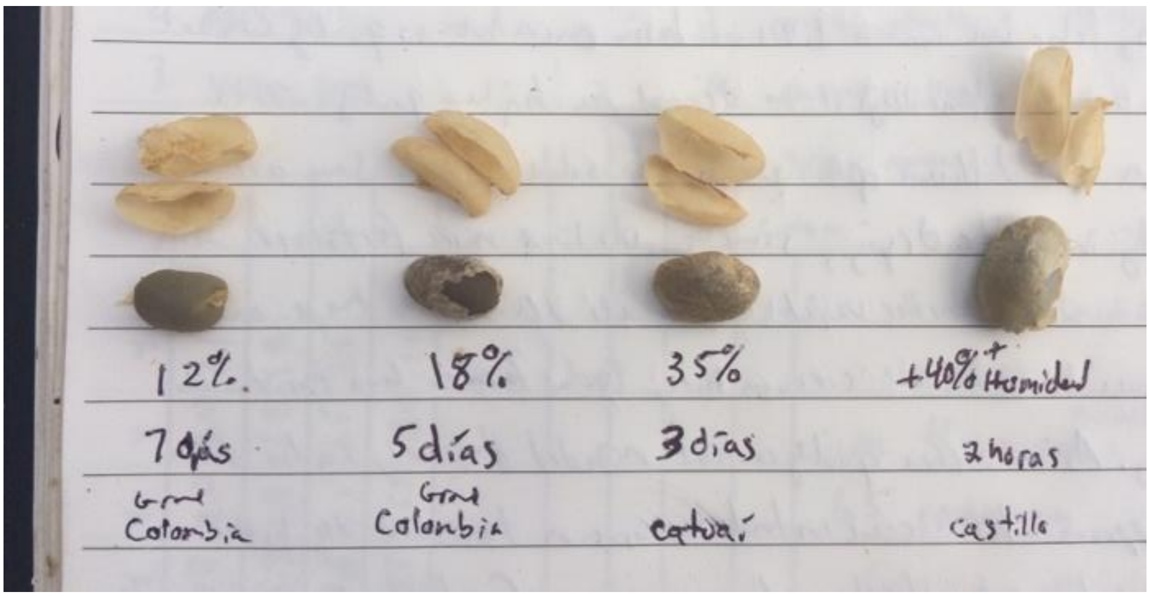


Figure 45. Moisture percentage of coffee parchment over seven days of drying

Determining Moisture Content

The importance of accurately identifying moisture content for coffee parchment directly reflect prices received by the producer from final buying agents, cooperatives, or exportation warehouses where payments are issued. The final moisture content for coffee should reach a level of 12 percent to protect from further damage due to mold or bacteria (Guatz, 2008). The international standardization of moisture content has also established market expectations for price delivery. For each percentage point deviated from the standard, one pound of water is added or subtracted for each one hundred pounds of coffee (Guatz, 2008). The purchase of a standard full container of coffee weighing roughly 42,300 lbs. at an average price of $2.00 per pound could potentially cost the buyer or seller roughly $846.00 for each percentage point of moisture deviated from the standard.

There are several techniques used in the field for determining moisture content. These methods typically involve direct observations on the condition of coffee including brittleness of parchment, color of seed, and hardness of bean (Guatz, 2008). Analysis of coffee parchment is typically determined through the traditional physical senses of the coffee producer using a combination of sight, touch, smell, and sound. In addition to the human senses, digital moisture meters are often used in the field, dry mill, and quality control labs when financial means are available.

Throughout all site visits in Peru, I carried a portable coffee moisture meter to evaluate accuracy of the producer's physical senses for identifying moisture content of drying parchment (Fig. 46). The portable moisture meter was initially calibrated with the Olam Agro Peru quality control lab moisture meter located in Jaén.

Figure 46. AgtraTronix 08150 handheld coffee moisture meter

The first sample was measured from drying parchment available at Site 2a. The producer guessed 18 percent moisture content, mentioning the coffee needed one more full day of drying before it was complete. After his analysis, I took three random samples from drying parchment located from the same proximity, resulting in an average of 18.2 percent moisture content. An additional sample taken from a recently processed coffee from Site 2a by the same producer was not as accurate as his first prediction. The producer guessed 20 percent moisture content whereas the handheld coffee moisture meter read three samples averaging 26 percent moisture content. For measuring moisture, the producer first used his teeth to measure hardness of coffee parchment, then rolled coffee parchment in his hands to feel the level of brittleness, followed by bringing the coffee to his nose to smell. With the knowledge of these sensory conditions of coffee, he accurately judged moisture content within a few percentage points. This observation was similar within each site visit, yet the accuracy of judgement below 18 percent moisture was not analyzed and would serve for further investigation due to the financial importance to coffee producers.

CHAPTER FIVE: SUMMARY & CONCLUSION

The three site visits represented points along a continuum of coffee processing and landscapes within the Region of Cajamarca in Peru. These observations provided insight to the environmental, social, political, and economic challenges facing producers, demonstrating a variety of situations which impact decisions for inclusion of various land-use and post-harvest processing strategies.

Site 1 faced limited access to sufficient water resources for delivering fully washed coffee using traditional processing techniques, demonstrating unique adaptive strategies for delivering the necessary washed coffee profiles international markets continue to demand. The producer in Site 1 heavily incorporated a diversity of native tree species and food items throughout his coffee parcel, securing food options and diversifying additional income opportunities beyond coffee.

Site 2 involved three visits within the same community area, demonstrating various processing and land-use strategies by each individual family farm. The first visit to Site 2a demonstrated harvesting practices which produced average amounts of defects in the samples gathered. Site 2b expressed verbal concerns regarding soil health, in addition to presenting issues with higher insect damage and lower yields. The coffee parcel which was suffering from poor soil was densely populated with eucalyptus. Research suggests this may inadvertently have led to poor coffee yields caused by soil nutrient depletion. In addition to issues of poor soil quality, they did not have access or ownership to a motor-driven de-pulper, nor did they invest in using a rake for spreading wet parchment across black plastic tarps for drying coffee.

Successful implementation of drying techniques at the third site visit in Site 2 demonstrated a producer's ability and willingness to experiment with technologies for improving quality and drying times by adoption of new methods, helping improve drying times and consistency for final coffee parchment delivery. The coffee parcel was located very near the second location, but with significantly different post-harvest practices and conditions. The de-pulping station was covered by a free-standing roof, a cement floor, in addition to a motor-driven de-pulper. The second floor of each of the housing units within Site 2c were all used for dry storage.

In Site 3, an example of technified production at higher elevations demonstrated evidence of prior technical outreach and certification involvement, yet practices showed physical evidence of mass clearing of field using slash and burn techniques. Although shifting cultivation has been employed for agricultural production in this area for centuries, the frequency and expansive implementation of this practice has grown to become a tool for cash crop market based production and expansion.

Through these case studies, an attempt was made to demonstrate how access to natural resources, credit, and an intimate connection to the international commodity coffee and buyers impacted landscape use and environmental health throughout the Region of Cajamarca.

Coffee quality related information included in the case studies reflected several decisions impacting the use of natural resources for delivering quality exportation standards. The descriptive account of smallholder coffee producers in Peru offered insight on the complexities involved for organizing independent producers for supplying higher quality coffees when employing consistent quality control methods throughout harvesting and processing activities. The demand of specialty coffee industry markets through promoting higher quality coffees often stem from a desire to help farmers capture more of the economic value of their product, while also asking for a product that has pleasant hedonic taste qualities.

The consumer framework in which many specialty coffee professionals reside consider the livelihood of coffee producers as an important determination for purchasing coffee. The definition of ‘livelihood’ often rests primarily in the measurement of economic success and financial security for producers and supply chain actors within the specialty coffee industry. Although this is a very logical and necessary measurement for increased standards of living, obtaining economic success often comes with environmental costs often ignored when equating the quality of life standards of a community. The distribution of economic success within a coffee growing community may also be further considered when discussing sustainability.

Currently, most green coffee purchasing decisions are driven primarily by intrinsic and hedonic cup flavor qualities prior to consideration for the extrinsic qualities. Although cup quality is essential for competition within the coffee market, questions remain if the impact of promoting quality coffee production as the best vehicle for achieving higher prices may end up causing unintentional negative environmental and socio-economic consequences.

Further Investigations

Considerations for further research which were not possible to conduct during time in Peru include the monitoring of selective harvest practices throughout the entire harvest season. Extended research would provide further evidence for the selective harvesting practices, allowing further insight on how defect percentages due to ripeness or maturation of coffee plants change throughout the season. With more ripeness produced during the peak of harvest, more labor may or may not be available which would also influence selective harvesting results. In addition, the level of care by the harvesters may also be influenced by family necessity or level of attention by farm management.

Further research could also focus attention on what is primarily driving consumer demand for specific coffee processing methods such as natural, pulped, and mechanically de-mucilaged coffees profiles, and what the possible impact increasing demands for specific processing methods may have on coffee producing landscapes and economies. If export demands in Peru changed to semi-washed, honey, or natural-processed coffee, farmers might begin to invest in alternative processing methods, resulting in lower water consumption throughout post-harvest processing stages.

Conclusion

Flavor preferences have shaped the political, economic, agricultural, and cultural landscapes of our world. Preferences are both innate and acquired, determined through variation from environmental, physiological, social, and economic situations. This research paper has provided an outline for how perception and preference of flavor can vary within populations, including basic information provided for better understanding the physiology of flavor, and the impacts perception has upon the agricultural landscapes of coffee. The question remains, would an increase in global demand for average coffee quality that incorporates traditional agroecological land-use practices result in the reduction of water usage and pollution while increasing access to food security and sufficient economic success for smallholder coffee producers in the Region of Cajamarca, Peru? How does specialty coffee improve the lives of producers when the amount of investment may be greater than the cost of production, included inflated risks and time allocation to these tasks which require greater physical work and mental investment at the producer level?

Throughout this paper, I have outlined categories of coffee quality and how these attributes influence decisions producers make toward land-use and coffee processing methods. The first quality category addressed intrinsic attributes, outlining activities from crop planning to final stages of post-harvest processing activities. The section further addressed environmental suitability for commercially viable coffee species and varieties, followed by an examination of steps within coffee processing methods that demonstrated impacts on intrinsic quality.

Following the review of intrinsic value, I addressed the role in which hedonic qualities were attributed to coffee and the development of standards establishing final market value. To further explore how we ascribe hedonic qualities to coffee, a brief examination on the physiology of flavor was presented, helping establish a deeper understanding to the complexities and variation of preference and perceptions within human populations. The purpose for introducing this discussion was to shed light on how the evaluation of positive hedonic attributes may be determined more-so through leadership by professional coffee tasters, branding, and other social influences. The literature review on how sex, age, and cross-cultural variables impact preference lends further discussion on the merits of what quality coffee entails. As coffee competitions demonstrate, professional coffee tasters and roasters have gravitated to certain habitual preferences within niche specialty markets, showing in some cases what is considered unfavorable coffee qualities, such as Robusta, are considered pleasing within some consuming markets, such as Italy and many international nations. The argument could be made that the reason they do not enjoy Arabica coffee is because they have not been exposed to these qualities attributes prior, and if they had, they would prefer Arabica. If this is the case, the coffee industry will need to consider the impacts of climate change and the future availability of landscapes suitable for the necessary volume and quality of coffee production. It is important to recognize the preferences of emerging markets that are further investing their preferences towards fully washed Arabica coffees. The promotion of higher coffee qualities may further challenge situations by influencing coffee markets to increase production of a commodity which may exacerbate the challenging environmental and socio-economic issues at hand.

The coffee tasting event provided further supporting data that followed research demonstrating how age influenced flavor perceptions and preferences. The results of this tasting showed age as a factor, where younger generations preferred coffees lighter in roast profile with more present acidity and other innate intrinsic coffee qualities, where aging generations preferred darker roasted blends that had less innate intrinsic cup qualities, lower perceived acidity and a smoother body. The results of the tasting also reflected preferences found by the winning coffees from the Good Food Awards. Further discussion argued whether such competitions represented positive hedonic qualities for the average coffee consumer, or if such judgements only serviced a niche group of coffee professionals or a specific socio-economic demographic.

The following section addressed extrinsic qualities, the final category which represented the external attributes which are placed on a coffee product, rather than defined by the actual physical coffee. In this section, I addressed the value of ethics placed on coffee and the impact these decisions had on purchasing coffee by the consumer. The section reviewed impacts of certifications and alternative trade models which addressed improving socio-economic and environmental conditions throughout the coffee supply chain. These attempts were shown to be driven by an audience which demonstrated a growing demand for information on how their coffee is grown, processed, and traded with the intention of supporting sustainable and Fair Trade products. The section concluded with a review of additional external factors such as price, location, and service that influence the final market value.

After presenting a thorough review of how coffee quality is defined and marketed, Chapter 3 introduced how qualities impacted decisions made by producers at farm level, specifically regarding land-use strategies and post-harvest practicing decisions. A descriptive account was given of research conducted in the Cajamarca Region of Peru where I spent several weeks within coffee growing communities observing general harvesting practices and land-use strategies. Throughout each site visit, I concentrated on comparing selective harvesting samples by measuring the percentage of maturation levels harvested within each coffee parcel, in addition to recording samples of the percentage of defects within each sample. Focus was placed on the measurement of one indicator of quality and how this differed for each coffee producer. General observations on land-use were also recorded, helping demonstrate variation between traditional farming to technified farming strategies.

Global specialty coffee market demands have a profound influence on how coffee growing communities respond. From the beginning of its journey out of Africa into the hands of communities around the globe, it has become a staple product, and the demand for its presence is not subsiding. The future of coffee appears to be as complex as its past, perhaps facing even greater challenges in the decades ahead.

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APPENDIX A.1 - IRB APPROVAL #17058 - COFFEE TASTING

University of Nebraska Lincoln

Official Approval Letter for IRB project #17058 - New Project Form

April 3, 2017

Jonathan Ferguson
Department of Anthropology
2245 S 11th St Lincoln, NE 68502

Raymond Hames
Department of Anthropology
OLDH 837, UNL, 68588-0368

IRB Number: 20170417058EP
Project ID: 17058
Project Title: Coffee Tasting: Does a Person's Age Impact Preference?

Dear Jonathan:

This letter is to officially notify you of the approval of your project by the Institutional Review Board (IRB) for the Protection of Human Subjects. It is the Board's opinion that you have provided adequate safeguards for the rights and welfare of the participants in this study based on the information provided. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46).

o Review conducted using expedited review categories 5 & 7 at 45 CFR 46.110
o Date of Approval: 04/03/2017
o Date of Expedited review: 03/24/2017
o Date of Acceptance of Revisions: N/A
o Funding (Grant congruency, OSP Project/Form ID and Funding Sponsor Award Number, if applicable): N/A
o Consent waiver: Yes, waiver of consent at 45 CFR 46.116(d)(1-4)
o Review of specific regulatory criteria (contingent on funding source): 45 CFR 46
o Subpart B, C or D review: N/A

You are authorized to implement this study as of the Date of Final Approval: 04/03/2017. This approval is Valid Until: 04/02/2018.

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:
* Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
* Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
* Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
* Any breach in confidentiality or compromise in data privacy related to the subject or others; or
* Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

For projects which continue beyond one year from the starting date, the IRB will request continuing review and update of the research project. Your study will be due for continuing review as indicated above. The investigator must also advise the Board when this study is finished or discontinued by completing the enclosed Protocol Final Report form and returning it to the Institutional Review Board.

If you have any questions, please contact the IRB office at 402-472-6965.

Sincerely,

Rachel Wenzl, CIP
for the IRB

Full Accreditation

University of Nebraska-Lincoln Office of Research and Economic Development
nugrant.unl.edu

NUgrant

APPENDIX A.2 - IRB APPROVAL #16136 – RESEARCH IN PERU

Nebraska Lincoln

Official Approval Letter for IRB project #16136 - New Project Form

May 13, 2016

Jonathan Ferguson
Department of Anthropology
2245 S 11th St Lincoln, NE 68502

Raymond Hames
Department of Anthropology
OLDH 837, UNL, 68588-0368

IRB Number: 20160516136 EX
Project ID: 16136
Project Title: Factors influencing selective harvesting techniques and post-harvest coffee processing activities within coffee grower groups near Jaen, Peru.

Dear Jonathan:

This letter is to officially notify you of the certification of exemption of your project. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46) and has been classified as exempt.

You are authorized to implement this study as of the Date of Exemption Determination: 05/13/2016.

o Review conducted using exempt category 2 at 45 CFR 46.101
o Date of Exemption: 5/13/2016
o Funding: N/A

1. The stamped and approved form(s) have been uploaded to NUgrant. Please use the stamped form(s) to make copies to distribute to participants. If changes need to be made, please submit the revised form(s) to the IRB for approval prior to use.

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:
* Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
* Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
* Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
* Any breach in confidentiality or compromise in data privacy related to the subject or others; or
* Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

This project should be conducted in full accordance with all applicable sections of the IRB Guidelines and you should notify the IRB immediately of any proposed changes that may affect the exempt status of your research project. You should report any unanticipated problems involving risks to the participants or others to the Board.

If you have any questions, please contact the IRB office at 402-472-6965.

Sincerely,

Becky R. Freeman

Becky R. Freeman, CIP
for the IRB

Full Accreditation — Association for the Accreditation of Human Research Protection Programs, Inc.

University of Nebraska-Lincoln Office of Research and Economic Development
nugrant.unl.edu

NUgrant

IRB# 20160516136 EX
Date Approved: 05/13/2016
Valid Until: 05/14/2021

Participant Informed Consent Form

University of Nebraska Lincoln

DEPARTMENT OF ANTHROPOLOGY

IRB #16136

Title:
Factors influencing selective harvesting techniques and post-harvest coffee processing activities within coffee grower groups near Jaen, Peru.

Purpose:
This research project will aim to measure variables regarding coffee processing activities which may factor into processing losses and/or improvement of quality of brewed coffee. You are invited to participate in this study because you are involved with selective harvesting techniques and post-harvest coffee processing activities near Jaen, Peru.

Procedures:
You will be asked to participate in an interview of questions regarding selective harvesting techniques and post-harvest coffee processing activities. Interviews will last 15 to 30 minutes, conducted at harvesting and coffee processing sites.

Benefits:
There are no direct benefits to you as a research participant.

Risks and/or Discomforts:
There are no known risks or discomforts associated with this research.

Confidentiality:
Any information obtained during this study which could identify you will be kept strictly confidential. The data will be maintained in a secured computer, encrypted, and password protected. A coding system will replace connections to information given by informants. Participants will be identified during data collection by one or more of the following identifications; photo, audio, written or video of person, stating name and location of farming operations. The data will be coded by linking names to an encrypted numerical coding system. Information will be destroyed once research is complete, or 8-12 months following collection. Identifiable records and data will be kept 8 to 12 months. Unidentifiable records may be kept for 2 years. Data and results may be reported at conferences, journals, in a thesis, in a dissertation, and to the funding agency, and back to the project site, in aggregate form.

Opportunity to Ask Questions:
You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may contact the investigator(s) at the phone numbers below. Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 to voice concerns about the research or if you have any questions about your rights as a research participant.

Freedom to Withdraw:
Participation in this study is voluntary. You can refuse to participate or withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln, or in any other way receive a penalty or loss of benefits to which you are otherwise entitled.

Consent, Right to Receive a Copy:
You are voluntarily making a decision whether or not to participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Signature of Participant:

______________________________ Signature of Research Participant

______________________ Date

Name and Phone number of investigator(s)

Jonathan Elliott Ferguson, Graduate Student, Principal Investigator — Office: USA +1(402) 817-9991
Principal Investigator contact information while conducting research in Peru — **Contact: +51 (1)7160720 M: +51 990813863**

Raymond Hames, Ph.D., Secondary Investigator — Office: USA +1(402) 472-2411

IRB# 20160516136 EX
Date Approved: 05/13/2016
Valid Until: 05/14/2021

Participante Formulario de Consentimiento Inforn

University of Nebraska Lincoln

DEPARTMENT OF ANTHROPOLOGY

IRB #16136

Título:
Factores que influyen en la recolección selectiva y el procesamiento de café después de la cosecha dentro de los grupos de productores de café cerca de Jaén, Perú.

Propósito:
Este proyecto de investigación tendrá como objetivo medir las variables relativas a las actividades de procesamiento de café que puede tener en cuenta en las pérdidas de transformación y / o mejora de la calidad del café preparado. Usted está invitado a participar en este estudio porque usted está involucrado con las técnicas de recolección selectiva y actividades de procesamiento de café después de la cosecha cerca de Jaén, Perú.

Procedimientos:
Se le pedirá a participar en una entrevista de preguntas en relación con las técnicas de recolección selectiva y actividades de procesamiento de café después de la cosecha. Las entrevistas tendrán una duración de 15 a 30 minutos, realizadas en los sitios de procesamiento de cosecha y café.

Beneficios:
No hay beneficios directos para usted como participante del estudio.

Riesgos y / o molestias:
No existen riesgos conocidos o molestias asociadas con esta investigación.

Confidencialidad:
Cualquier información obtenida durante este estudio que podría identificarlo se mantendrá estrictamente confidencial. Los datos se mantendrán en una computadora segura y encriptada, y protegidos con contraseña. Un sistema de codificación reemplazará conexiones a la información dada por los informantes. Se identificarán los participantes durante la reunión de datos por una o más de las siguientes identificaciones; foto, audio, vídeo o por escrito de la persona, indicando el nombre y la ubicación de la finca. Los datos se codificarán mediante la vinculación de nombres a un sistema de códigos numéricos cifrada. La información será destruida una vez que se haya completado la investigación o 8-12 meses después de la recogida. Registros de identificación y los datos se mantendrán 8 a 12 meses. Registros no identificables pueden mantenerse durante 2 años. Los datos y los resultados podrán presentarse en conferencias, revistas, en una tesis, en una disertación, y al organismo de financiación, y de vuelta al sitio del proyecto, de manera agregada.

Oportunidad de hacer preguntas:
Usted puede hacer cualquier pregunta relacionada con esta investigación y tener esas preguntas contestadas antes de aceptar participar o durante el studio o puede comunicarse con el investigador(es) a los números indicados a continuación. Por favor, póngase en contacto con la Universidad de Nebraska - Lincoln Junta de Revisión Institucional al (402) 472-6965 para expresar sus preocupaciones sobre la investigación, o si tiene alguna pregunta sobre sus derechos como participante en la investigación.

Libertad para retirar:
La participación en este estudio es voluntaria. Puede negarse a participar o retirarse en cualquier momento sin dañar su relación con los investigadores o con la Universidad de Nebraska-Lincoln sin recibir sanción o pérdida de beneficios a los que tiene derecho.

Consentimiento, derecho a recibir una copia:
Usted está tomando una decisión voluntaria sobre si desea o no participar en este estudio de investigación. Su firma certifica que usted ha decidido participar y ha leído y comprendido la información presentada. Se le dará una copia de este formulario de consentimiento.

Firma del Participante:

_______________________________ Firma de la Participante

_______________________ Fecha

Nombre y Número de teléfono del investigador(s)

Jonathan Elliott Ferguson, Estudiante de tercer ciclo, Investigador Principal — Oficina EEUU +1(402) 817-9991
Información de contacto principal investigador mientras que la realización de investigaciones en Perú — **Contacto +51 (1)7160720 M: +51 990813863**

Raymond Hames, Ph.D., Investigador Secundaria — Oficina EEUU +1(402) 472-2411

APPENDIX B: COFFEE PRODUCER QUESTIONNAIRE

The following interview questions were verbally asked and directed to farmworkers involved with coffee harvest and processing activities in Cajamarca, Peru.

Coffee Processing Techniques

There are several processing methods available to choose from; natural, washed, or semi-washed.

- What are some of the reasons one process method is chosen over another? (If more than one coffee process is chosen, what are some reasons for variations?)
- Do environmental conditions such as altitude, temperature, rainfall, drought, and other weather events impact processing activities? If so, how?

Ripeness and Selective Harvesting

- How is ripeness determined?
- How do you know when a coffee cherry is ready to be harvested?
- What are some factors that determine when coffee is harvested?
- What are some of the most difficult decisions to make while harvesting coffee?
- Do environmental conditions such as altitude, temperature, rainfall, drought, and other weather events impact processing activities? If so, how?

De-Pulping Process

- Does time from field to de-pulping impact defect count or processing losses?
- What amount of pulp is removed and how is this determined?
- What are some of the most difficult challenges faced in the de-pulping process?
- Do environmental conditions such as altitude, temperature, rainfall, drought, and other weather events impact processing activities? If so, how?

Fermentation

- How do you know when the fermentation process is completed?
- What are some factors that determine when coffee has completed this process?
- What are some of the most difficult decisions to make during the fermentation process?
- Do environmental conditions such as altitude, temperature, rainfall, drought, and other weather events impact processing activities? If so, how?

Washing Process

- What are some of the most difficult decisions to make during the washing process?
- What are some factors that determine when coffee has completed the process?

- Do environmental conditions such as altitude, temperature, rainfall, drought, and other weather events impact processing activities? If so, how?

Drying Stage

- Does altitude, temperature, and weather impact decisions? If so, how?
- What are some of the most significant challenges during the drying stage?
- What are some factors that determine when coffee has completed this process?
- How do you know when the drying process is completed?

On Farm Storage of Coffee Product

- Where is the coffee parchment stored after it has completed the drying stage?
- How is it stored?
- How long is it stored for?
- What are the major concerns during storage?

The following interview questions will be verbally asked and directed to Olam Agro Peru staff involved with coffee warehousing activities and quality control processes in Jaén, Peru.

Delivery to Warehouse

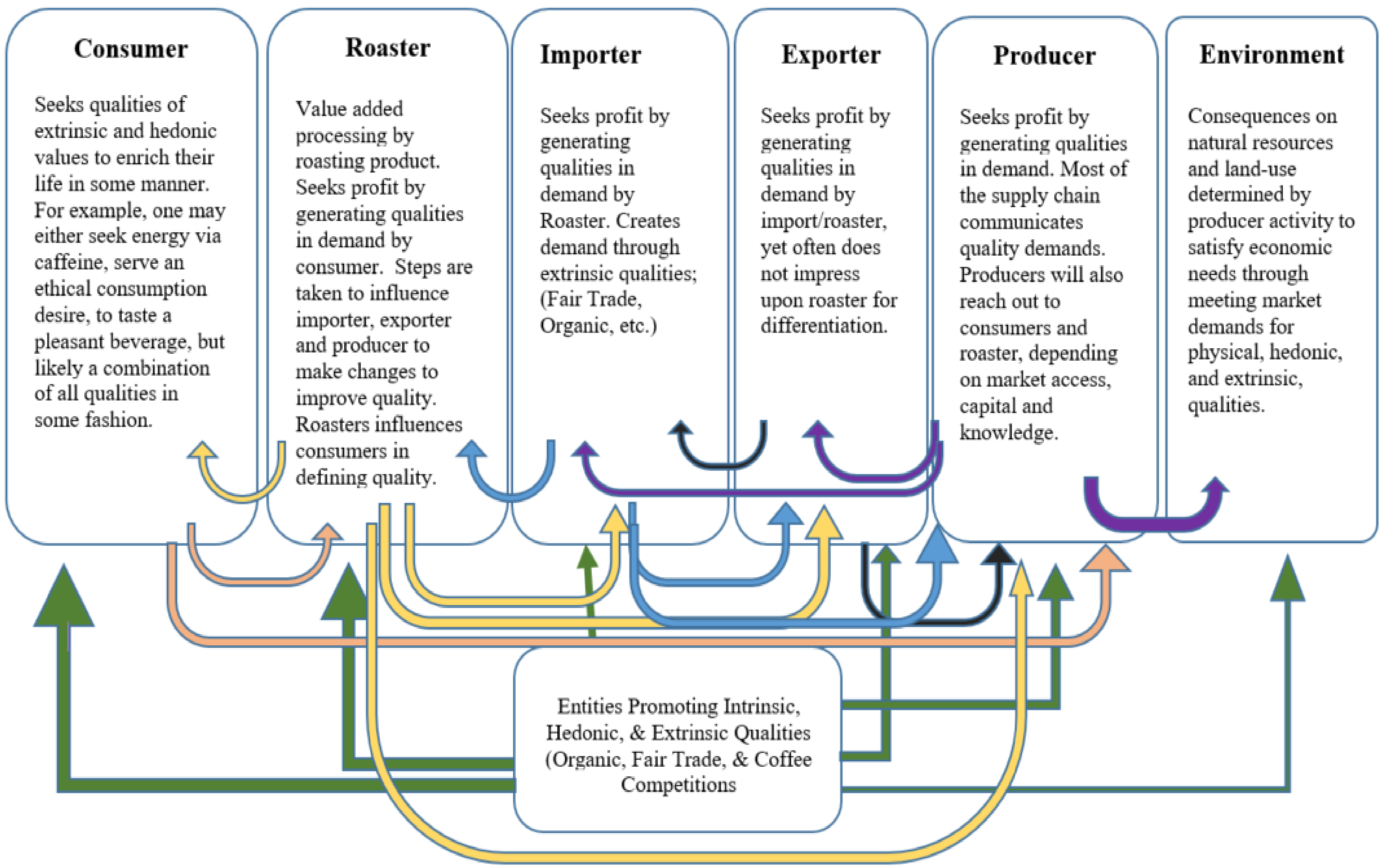
- Do transportation times from farm to warehouse impact cup quality or impact product loss? If so, how?
- Do environmental conditions such as altitude, temperature, rainfall, drought, and other weather events impact processing activities? If so, how?

Dry Mill, Quality Control Lab, and Warehouse Storage Facility

- What are the factors that add to quality or processing loss at the dry mill?
- Which are the most common processing defects identifiable through tasting coffees?
- How do visual or taste defects impact value of a submitted coffee harvest?
    - Do you use the Specialty Coffee Association of America tasting form?

APPENDIX C: COFFEE PRODUCTION FLOW CHART: INDICATORS

APPENDIX D: COFFEE SUPPLY CHAIN: FLOW CHART



APPENDIX E: SELECTIVE HARVESTING DATA SET

MATURATION LEVELS:		GREEN			LIMON			PINTON			YELLOW-RED		
Site	Total Grams	Float	Sink	Sink%	Float	Sink	Sink%	Float	Sink	Sink%	Float	Sink	Sink%
Site 1 (5-28a)	500	0.0	14.2	2.8	17.3	78.9	15.8	14.2	74.6	14.9	3.4	100.1	20.0
Site 1 (5-28b)	500	0.0	7.4	1.5	0.0	12.1	2.4	9.9	98.0	19.6	8.1	89.4	17.9
Site 1 (5-26)	1000	0.0	0.0	0.0	0.0	0.0	0.0	3.5	83.1	8.2	7.7	0.0	0.0
Site 2 (2b) sample 1	1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2b) sample 2	838	8.9	63.0	7.5	20.3	82.6	9.9	16.6	219.9	26.2	0.0	0.0	0.0
Site 2 (2b) sample 3	1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2c) sample 1	996	0.0	0.0	0.0	33.6	151.0	16.5	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2a) sample 1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2a) sample 2	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2a) sample 3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2a) sample 4	1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	156.3	15.6
Site 3 (Technified)	1012	0.0	53.3	6.3	0.0	40.1	4.7	0.0	24.2	2.9	0.0	27.0	3.2
	7846.4		137.9			364.7			499.8			372.8	
Total Weights of Maturation			146.8			435.9			544			394	

APPENDIX E: SELECTIVE HARVESTING DATA SET

MATURATION LEVELS:	RED			DARK RED			BROWN/ OVER RIPE			COCO -DRIED		
Site	Float	Sink	Sink%	Float	Sink	Sink%	Float	Sink	Sink%	Float	Sink	Sink%
Site 1 (5-28a)	14.8	106.5	21.3	3.9	23.8	4.8	16.4	23.6	4.7	2.7	2.5	0.5
Site 1 (5-28b)	12.7	161.3	32.3	5.3	53.0	10.6	18.6	15.0	3.0	10.8	0.0	0.0
Site 1 (5-26)	59.3	185.0	18.3	13.2	260.3	25.7	27.7	356.2	35.2	15.6	0.0	0.0
Site 2 (2b) sample 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2b) sample 2	23.9	296.7	35.4	25.1	151.5	18.1	32.0	18.0	2.2	43.9	6.4	0.8
Site 2 (2b) sample 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2c) sample 1	28.8	423.8	46.4	16.0	143.8	15.7	0.0	195.0	21.3	4.4	0.0	0.0
Site 2 (2a) sample 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2a) sample 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2a) sample 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 (2a) sample 4	11.3	214.7	21.5	16.2	474.4	47.7	6.6	96.2	9.6	9.1	8.3	0.8
Site 3 (Technified)	22.6	222.7	26.3	0.0	347.9	41.1	40.8	117.3	13.9	97.5	14.3	1.7
TOTALS		1610.7			1454.7			821.3			31.5	
Total Weights of Maturation		1784.1			1534.4			963.4			215.5	

APPENDIX E: SELECTIVE HARVESTING DATA SET

	TOTALS				
Site	Total Float (g)	Total Sink (g)	Total Float%	Total Sink%	Total (g)
Site 1 (5-28A)	72.7	424.2	14.6	85.4	497
Site 1 (5-28B)	65.4	436.2	12.8	87.2	502
Site 1 (5-26)	127.0	884.6	12.6	87.4	1012
Site 2 (2b) sample 1	178.3	821.7	17.8	82.2	1000
Site 2 (2b) sample 2	170.7	838.1	17.1	83.1	1009
Site 2 (2b) sample 3	160.3	839.7	16.0	84.0	1000
Site 2 (2c) sample 1	82.8	913.6	8.3	91.7	996
Site 2 (2a) sample 1	72.2	0.0	7.2	92.8	0
Site 2 (2a) sample 2	41.3	0.0	4.1	95.9	0
Site 2 (2a) sample 3	53.1	0.0	5.3	94.7	0
Site 2 (2a) sample 4	45.2	949.9	4.5	95.5	995
Site 3 (Technified)	165.1	846.8	16.5	84.7	1012
TOTALS	1234.1	6954.8			7695.4

Percentage of overall harvested maturation levels	
green	2%
limon	7%
pinton	9%
red	30%
dark red	25%
purple brown	16%
coco	4%

APPENDIX F: MATURATION LEVELS AND DEGREE OF BRIX

Maturation Levels (1-8)	1	1	1	1	2	2	2	2	3	3	3	3
Site 1 - Catuai Amarillo					12.00	10.50	10.50	11.75	15.00	13.25	14.25	12.00
Site 1 - Pachi											12.50	
Site 1 - Mundo Novo			6.00			12.00	10.75	10.50	13.00	11.25	10.00	12.00
Site 2 - (2a) Caturra					12.50	11.00		9.75	10.00	9.50	9.50	
Site 2 - (2a) Catimor			11.50		11.25	11.25	13.75		15.00	16.50	14.25	10.25
Site 2 - (2a) National					9.00			7.00	12.00			8.00
Site 2 - Caturra Amarillo		8.00	11.50	9.25	9.50	17.25	11.75	14.75	13.00	19.50	20.25	13.75
Site 2 - (2c) Pachi					9.50				10.00	10.25	12.00	11.00
Site 3 - Caturra Rojo					11.25	7.50	11.50	9.50	10.75	12.00	13.00	
Site 3 - Pachi			12.00			10.50		10.50	11.25	10.25		10.75
Site 3 - Caturra Amarillo			10.00		12.50	11.50	12.50	12.75	15.00	14.00	13.00	13.50
Brix (°Bx) average				9.75				11.21				12.56
Ripeness Level	1				2				3			

APPENDIX F: MATURATION LEVELS AND DEGREE OF BRIX

Maturation Levels (1-8)	4	4	4	4	5	5	5	5	6	6	6	6
Site 1 - Catuai Amarillo	13.25	12.25	13.75	11.75	13.25	13.25	22.00	13.50	18.75	15.25	19.25	24.00
Site 1 - Pachi		12.00	12.00			12.00	14.00	14.00	12.75	19.00	18.00	18.25
Site 1 - Mundo Novo	15.00	14.00	16.25	18.00	15.50	17.25	18.00	17.50	20.00	18.75	19.75	17.50
Site 2 - (2a) Caturra	9.50	12.00	11.50	9.00	11.75	11.25	9.25		9.75	12.75	12	14.50
Site 2 - (2a) Catimor	17.50	18.00	18.75	16.25	16.25	15.00	17.50	16.75	19.75	25.00	25.20	23.25
Site 2 - (2a) National		1.40	16.25	14.00	18.00	14.75	15.00	16.50	18.00	20.50	21	20.00
Site 2 - Caturra Amarillo	21.50	19.25	21.50	21.00	23.50	25.00						
Site 2 - (2c) Pachi	11.75	12.00	15.00	11.50		17.00	15.75	16.50	20.00	15.75	16.50	22.50
Site 3 - Caturra Rojo	13.50	15.25	15.25	12.75	11.25	12.75	14.00	13.25	12.00	12.75	12.75	12
Site 3 - Pachi	10.75	13.50	14.00	14.00	16.75	15.00	13.75	14.25	17.50	14.50		
Site 3 - Caturra Amarillo	13.00	16.25	16.75	15.75	18.00	18.25	21.00	21.75				
Brix (°Bx) average				14.31				15.9				17.62
Ripeness Level	4				5				6			

APPENDIX F: MATURATION LEVELS AND DEGREE OF BRIX

Maturation Levels (1-8)	7	7	7	7	8	8	8	8
Site 1 - Catuai Amarillo	19.25	10.00						
Site 1 - Pachi	19.00	21.00	20.00	19.00				
Site 1 - Mundo Novo	20.00	19.75						
Site 2 - (2a) Caturra	17.50	17.25	12.50	12.25	16	14	20	17
Site 2 - (2a) Catimor	32.00	24.00	25.00	22.00	19			
Site 2 - (2a) National								
Site 2 - Caturra Amarillo								
Site 2 - (2c) Pachi	20.00							
Site 3 - Caturra Rojo	13.75	13.5	13			23		
Site 3 - Pachi								
Site 3 - Caturra Amarillo								
Brix (°Bx) average				18.54				18.17
Ripeness Level	7				8			

APPENDIX G: COFFEE TASTING SHEET

TASTER CODE # ________

ROUND ONE

Date of Birth Range:	(X)
1996 and later	
1977 to 1995	
1965 to 1976	
1946 to 1964	
1945 and before	

Which best describes your coffee drinking?	(X)
once in a while	
one cup per day	
multiple cups per day	
obsessed with drinking	
cupper (able to score)	

Typically, I drink coffee…	(X)
Black (nothing added)	
w/ cream only	
w/ sugar only	
w/ cream and sugar	

Where do you most often drink coffee?	(X)
at home	
way to work	
work, office, etc.	
hobby, everywhere	

COFFEE #1

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #2

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #3

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #4

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #5

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #6

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #7

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #8

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #9

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #10

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #11

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

COFFEE #12

	BAD	ACCEPTABLE	AVERAGE	GOOD	EXCELLENT
How do you rate this coffee overall?					
	VERY WEAK	LITTLE WEAK	GOOD	LITTLE STRONG	VERY STRONG
How is the strength?					

which number was my favorite coffee, why?

COMMENTS

APPENDIX H: COFFEE TASTING AGE & ROAST CROSSTABULATION

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
AGE * ROAST	41	100.0%	0	0.0%	41	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.762[a]	1	.002		
Continuity Correction[b]	7.435	1	.006		
Likelihood Ratio	9.489	1	.002		
Fisher's Exact Test				.004	.004
Linear-by-Linear Association	9.524	1	.002		
N of Valid Cases	41				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.07.

b. Computed only for a 2x2 table

AGE * ROAST Crosstabulation

			ROAST		Total
			.00	1.00	
AGE	1.00	Count	25	7	32
		Expected Count	21.1	10.9	32.0
	2.00	Count	2	7	9
		Expected Count	5.9	3.1	9.0
Total		Count	27	14	41
		Expected Count	27.0	14.0	41.0

(IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.)

APPENDIX I: COFFEE TASTING DATA SET

APPENDIX I: COFFEE TASTING DATA SET

Light =0 Dark=1	Cup 1	Cup 2	Cup 3	Cup 4	Cup 5	Cup 6	Cup 7	Cup 8	Cup 9	Cup 10	Cup 11	Cup 12	Cup 13	Cup 14	Cup 15	Cup 16	Cup 17	Cup 18	Cup 19	Cup 20	Cup 21
TASTERS A=young B=old	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0
A1			yes		yes		yes	no	no	no	yes	no		no	no	no			no	no	no
A2		no	no	no	no	no	no	no	yes		no	yes	no	yes	yes		yes	yes		no	
A3		yes				no	no	yes		no		yes	yes			yes					
A4		yes		yes	no	no	no	yes		yes	no				no		no	yes			yes
A5		no	yes	yes	yes	yes		yes	yes		no	yes	yes		yes	yes	yes				yes
A6			no	no	no	yes	no		yes	no	no	yes		yes	yes	yes		no		yes	yes
A7		no			no	no	no	yes		yes			yes		yes	yes	no	yes	no	no	yes
A8		no	yes	yes	yes	no		yes		yes	yes	yes	yes	yes		yes	no	yes	no	no	yes
A9		no	no		yes	no		yes		yes	yes	yes	no	no	no	yes	no				yes
A10			yes	no		yes	yes	no	yes	no	no	yes	yes		yes	yes	no		yes	yes	yes
A11		yes	no	no			no	no		yes	no		--	--	--	--	--	--	--	--	--
A12		yes	yes	yes	yes	no	no	no	yes	yes		yes	--	--	--	--	--	--	--	--	--
A13	no	no	no	no	no	yes			yes	no	no		no	no	no	no		no	yes	yes	no
A14	no	yes		no	no	yes	no	yes			yes	yes	yes		yes	yes	yes		no		
A15	no	yes		yes	no			yes	yes		no	--	yes	yes	yes		no	yes	no		

APPENDIX I: COFFEE TASTING DATA SET

Light =0 Dark=1	Cup 1	Cup 2	Cup 3	Cup 4	Cup 5	Cup 6	Cup 7	Cup 8	Cup 9	Cup 10	Cup 11	Cup 12	Cup 13	Cup 14	Cup 15	Cup 16	Cup 17	Cup 18	Cup 19	Cup 20	Cup 21
TASTERS A=young B=old	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0
A16	no		no	yes	yes	no	no		no	yes	yes		yes	yes	yes	yes	no	yes	no	no	yes
A17	no	no		yes		no	no	yes	no			no		no	no	yes	no	no	no	no	yes
A18	no	no	no	yes		no	no	yes		yes	no					yes	no	yes		yes	yes
A19	no			yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		yes	yes	yes	yes
A20	no	no		no	no		no	no	no	no	yes		--	--	--	--	--	--	--	--	--
A21	no		no	yes	no	no	no	no	yes	yes		yes	--	--	--	--	--	--	--	--	--
A22	no		no	no		no	no	no		no	no			no	no	no	no		no	no	no
A23	no	no	no			yes	no	no			no			yes		yes	yes		yes		yes
A24	yes	no		no		no	no	no			yes	yes	yes	yes	yes					no	no
A25	yes		yes	no		yes	no	yes	no		no		no	yes		no		no	yes	yes	no
A26	yes	no	yes			no	no	yes		yes	yes		yes		no	yes			no		yes
A27	yes		yes		yes			yes		yes	yes				no		yes		no		yes
A28	yes			no	yes	yes	no	yes	yes	yes		no	yes	yes						yes	yes
A29	yes	yes	yes	yes	yes		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
A30	yes		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
A31	yes	no	no	yes	yes	no	no			yes	yes	yes	yes	yes	yes	yes		yes	no	no	yes
A32	yes		yes	yes	yes	no	no	yes		yes		yes	yes	yes	yes	yes		yes			yes

APPENDIX I: COFFEE TASTING DATA SET

Light =0 Dark=1	Cup 1	Cup 2	Cup 3	Cup 4	Cup 5	Cup 6	Cup 7	Cup 8	Cup 9	Cup 10	Cup 11	Cup 12	Cup 13	Cup 14	Cup 15	Cup 16	Cup 17	Cup 18	Cup 19	Cup 20	Cup 21
TASTERS A=young B=old	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0
B1		yes	no	no	no		no	no		no	no	yes	no		no	no	no	no		yes	no
B2		yes	yes	no	yes	no	no	no	no	yes		yes	yes	yes		yes	no		no	no	
B3			no	yes	no					no	yes	yes	yes		yes	yes	yes				
B4	no		yes	no	no	yes		yes	yes		no	no	no	no					yes	yes	no
B5	no	no				yes	yes	no	yes	yes		yes	no			yes	yes	yes	yes	yes	no
B6	no	yes		yes	yes	yes	yes		yes	no		yes	yes	yes	no		yes			yes	yes
B7	no	no	no	no		yes	no	yes		no		no	--	--	--	--	--	--	--	--	--
B8	yes	yes	yes	yes	yes	yes	no	yes	yes	no	no	no	yes	yes		yes	yes	yes	yes	yes	yes
B9	yes		yes	no		no	no	yes	no		no	yes	--	--	--	--	--	--	--	--	--

APPENDIX I: COFFEE TASTING DATA SET

TASTERS A=young B=old	Yes for Dark	Yes for Light	No for Dark	No for Light	% of light samples liked (13)	% dark samples liked (8)	% light disliked	% dark disliked	Preference
A1	2	2	3	7	15%	25%	54%	38%	dark
A2	1	5	5	5	38%	13%	38%	63%	light
A3	1	4	2	1	31%	13%	8%	25%	light
A4	1	3	2	4	23%	13%	31%	25%	light
A5	3	9	1	1	69%	38%	8%	13%	light
A6	3	5	2	5	38%	38%	38%	25%	dark
A7	0	7	4	2	54%	0%	15%	50%	light
A8	1	11	4	1	85%	13%	8%	50%	light
A9	0	7	3	3	54%	0%	23%	38%	light
A10	6	5	0	5	38%	75%	38%	0%	dark
A11	1	1	2	3	8%	13%	23%	25%	light
A12	3	4	2	1	31%	38%	8%	25%	dark
A13	4	0	3	10	0%	50%	77%	38%	dark
A14	2	7	3	2	54%	25%	15%	38%	light
A15	2	6	1	3	46%	25%	23%	13%	light
A16	0	10	7	1	77%	0%	8%	88%	light
A17	0	4	7	5	31%	0%	38%	88%	light
A18	1	6	5	2	46%	13%	15%	63%	light
A19	4	12	2	0	92%	50%	0%	25%	light
A20	0	1	4	4	8%	0%	31%	50%	light

APPENDIX I: COFFEE TASTING DATA SET

TASTERS A=young B=old	Yes for Dark	Yes for Light	No for Dark	No for Light	% of light samples liked (13)	% dark samples liked (8)	% light disliked	% dark disliked	Preference
A21	1	3	4	2	23%	13%	15%	50%	light
A22	0	0	6	9	0%	0%	69%	75%	light
A23	2	4	4	2	31%	25%	15%	50%	light
A24	1	5	4	3	38%	13%	23%	50%	light
A25	5	2	2	6	15%	63%	46%	25%	dark
A26	2	6	4	1	46%	25%	8%	50%	light
A27	2	5	1	1	38%	25%	8%	13%	light
A28	4	6	1	2	46%	50%	15%	13%	dark
A29	7	13	0	0	100%	88%	0%	0%	light
A30	7	13	0	0	100%	88%	0%	0%	light
A31	1	11	6	0	85%	13%	0%	75%	light
A32	2	11	2	0	85%	25%	0%	25%	light
B1	2	1	2	11	8%	25%	85%	25%	dark
B2	2	6	5	2	46%	25%	15%	63%	light
B3	0	7	1	2	54%	0%	15%	13%	light
B4	5	1	1	7	8%	63%	54%	13%	dark
B5	5	5	2	3	38%	63%	23%	25%	dark
B6	5	7	1	2	54%	63%	15%	13%	dark
B7	1	1	4	3	8%	13%	23%	50%	dark
B8	7	9	1	3	69%	88%	23%	13%	dark
B9	2	2	3	2	15%	25%	15%	38%	dark

APPENDIX J: TASTING ACCURACY AND AGE DATA

AGE 0=young 1=old	Response: 1= similar 0= different	Cup 5 yes= like no=dislike x= Average	Cup 12 yes= like no=dislike x= Average
0	0	yes	no
0	1	yes	yes
0	1	yes	yes
0	1	yes	yes
0	1	x	x
0	1	yes	yes
0	1	x	x
0	1	yes	yes
0	1	x	x
0	1	x	x
0	1	x	x
0	1	x	x
0	1	yes	yes
0	1	yes	yes
0	1	yes	yes
0	1	yes	yes
0	0	no	yes
0	0	x	yes
0	0	no	x
0	0	no	yes
0	0	no	x
0	0	x	yes
0	0	no	x
0	0	no	yes
0	0	no	x
0	0	yes	x
0	0	x	no
0	0	no	x
0	0	no	yes
0	0	x	yes
0	0	yes	x
0	0	yes	no
1	1	yes	yes
1	1	no	no
1	1	yes	yes
1	0	no	yes
1	0	no	yes
1	0	x	yes
1	0	x	no
1	0	yes	no
1	0	x	yes