SPREAD 2008 ECO-PROCESS RESEARCH REPORT

The effect of pulping machine type and wet processing system on the cost of production and quality of specialty coffee in Rwanda

Introduction:

Rwanda was an unknown specialty coffee origin with no functional washing stations in the country until 2003. Today, Rwanda is a 'sought-after' specialty coffee origin with 120 functional washing stations throughout its coffee regions producing, processing, and exporting an estimated 5,000 tons of specialty coffee in 2008. The Rwandan National Coffee Strategy promotes an increase from 5,000 tons in 2008 to over 15,000 tons of specialty coffee exports by 2011. In order to reach this goal, the coffee sector is expected to increase the number of coffee washing stations (CWS) to 250 by 2011.

The Rwandan Specialty Coffee sector was initiated through USAID support to the National Coffee Board, OCIR-Café in 2000. From 2002 to 2006, the USAID projects, PEARL and ADAR, working with OCIR-Café, assisted private and cooperative entrepreneurs to construct CWS, execute quality protocols, establish quality control cupping laboratories, and link them directly to Specialty Coffee Companies in the US, Europe and Japan.

The pulping technology used from 2002 to 2006 in Rwanda was the disc pulping machines based upon McKinnon Company designs created for Africa in the early 1900s. This is largely due to the fact that USAID projects in 2002 looked to Kenya and Burundi for processing methodology and did not consider newer technologies from South America. These machines and technology use large volumes of water to pulp the coffee, which is then fermented. After fermentation this system requires that even higher amounts of water are again utilized to wash the fermented sugars off the wet parchment. Approximately 10 liters of water is used for every 1 kilogram of parchment coffee. These waters are highly charged with pollutants and must be treated in order to render it harmless to the environment. This presents an additional expense to the CWS owner and a threat to the environment.

More recently, South American coffee machinery companies, Penagos and Pinhalense, have developed improved technology that eliminates the high-volume water use of the disc pulping system through mechanically removing the mucilage after rasp pulping the cherries. Coffee

produced in this manner can be placed directly on the drying tables eliminating the costly steps involved in fermentation and washing. There are additional savings in capital investments for CWS construction since fermentation tanks, water channels, and water tanks are no longer needed.

However, many specialty coffee buyers feel as if coffee produced by fermentation and washing is of higher quality. In fact, some coffee buyers will avoid operations not using the old, traditional methods. Therefore, in 2008 a series of experiments were conducted in Rwanda to provide scientific evidence on the effect of the newer technologies on the quality of the coffee produced. Furthermore, these experiments assessed the effect of each system on the environment and the cost of production so that any quality effects can be evaluated within the context of both their economic and environmental values.

The major and sole goal for these experiments was to produce objective, scientific information for Rwandan CWS owners and potential investors so that they can make the most informed decision on the choice of equipment and processing systems for their business models. It is important to emphasize that these experiments were not intended to compare one machine 'brand' or 'mark' over another; they were intended to determine the effects of processing systems on the quality of coffee resulting from them and their effects on the environment and cost of production.

Partners

The following were the collaborators in this research; Faculty of Agriculture at the National University of Rwanda, the Norman Borlaug Institute for International Agriculture, OCIR-Café, Technoserve, BrazAfric, Penagos, Pinhalense, the Maraba Coffee Cooperative, Volcafe Specialty Coffee, Intelligentsia Coffee and Counter Culture Coffee.

Specific objectives:

The research comprised of three specific goals or experiments; **Experiment 1:** Investigate the effect of three pulping machine types (Naicof Company single disc pulping machine, Penagos Ecologic Wet Coffee Unit UCBE 500M, and Pinhalense Ecological Wet Mill ECO-1SV) and wet processing on the amount of fuel used, amount of water, processing time, and quality of

specialty coffee in Rwanda. **Experiment 2:** Compare the cost of production and quality of specialty coffee processed using Naicof machine with that processed with the Penagos Pulping machine set at full and partial removal of mucilage followed by soaking. **Experiment 3:** Compare the cost of production and quality of specialty coffee processed using Naicof machine with that processed with the Pinhalense Pulping machine set at full and partial removal of mucilage followed by soaking. The descriptions of the three pulping machines investigated are presented in Annex A.

Materials and Methods

Experimental design and description of treatments and variables

The experiments were conducted at the SOVU CWS of the Maraba Coffee Cooperative located at Sovu, HUYE, which is nine kilometers from Butare Town directly on the paved road to Cyangugu. The Sovu station is a McKinnon equipment-based mini-CWS designed to process 50 tons of parchment coffee per harvest season using a Naicof Company single disc pulping machine with a 3.5HP diesel motor. The station possesses three large fermentation tanks and nine small ones for research purposes, storehouse, water tanks, and a gas generator-powered auxiliary electrical system.

Experiment 1 was composed of the five treatments; (T1) Pulping with Naicof Single Disc pulping machine and fermentation system as commonly used throughout Rwanda. This was considered the control for the experiment. (T2) Pulping with Penagos Eco Logic UCBE 500M machine utilizing the full-mucilage removal function of the pulper, and directly transferring the parchment from machine to sorting table without soaking. (T3) Pulping with Pinhalense Ecological Wet Mill ECO-1SV machine without soaking wet parchment. (T4) Pulping with Penagos Eco Logic UCBE 500M machine followed by soaking the wet parchment overnight. (T5) Pulping with Pinhalense Ecological Wet Mill ECO-1SV machine followed by soaking the wet parchment overnight.

Experiment 2 was composed of the following treatments; (T1) Pulping with Naicof Single Disc machine followed by dry fermentation and soaking, (T2) Pulping with Penagos Eco Logic UCBE 500M machine with full mucilage removal followed by direct drying of the beans, (T3) Pulping with Penagos Eco Logic UCBE 500M machine with partial mucilage removal followed by

directly drying the beans, (T4) Pulping with Penagos machine with partial mucilage removal followed by dry fermentation, (T5) Pulping with Penagos Eco Logic UCBE 500M with full mucilage removal followed by soaking.

Experiment 3 also contained five treatments; (T1) Pulping with Naicof Single Disc machine followed by dry fermentation and soaking, (T2) Pulping with Pinhalense Ecological Wet Mill ECO-1SV machine with full mucilage removal followed by directly drying the beans, (T3) Pulping with Pinhalense Ecological Wet Mill ECO-1SV machine with partial mucilage removal followed by directly drying the beans, (T4) Pulping with Pinhalense Ecological Wet Mill ECO-1SV machine with partial mucilage removal followed by dry fermentation of the beans, and (T5) Pulping with Pinhalense Ecological Wet Mill ECO-1SV machine with full mucilage removal followed by soaking.

Variables measured

For all experiments, the following variables were measured after applying the above treatments were cost of production factors such as amount of fuel used in liters per ton, amount of water used in liters per ton, and processing time in hours per ton. Also the following coffee quality factors were measured; sweetness, acidity, flavor, body, finish, and percentage score.

Statistical Analysis

Analysis of variance (ANOVA) was performed using the general linear model (GLM), and the significance of the differences among treatments for each measured factor was established by t-test (LSD) mean separation method. All statistical analyses were performed with SAS version 9.0 software (SAS 2002).

Results and Discussion

Experiment 1:

Analysis of variance indicated significant differences in the cost of product among the different pulping machines (Table 1). Wide and significant variations in the costs of production attributes were observed among the pulping machines (Table 1). The Naicof Single Disc pulping machine consumed less fuel (0.73 L/Ton), followed by the Pinhalense Ecological Wet Mill ECO-1SV machine (1.37 L/Ton), while the Penagos Eco Logic UCBE 500M machine utilized the most

amount of fuel (1.92 L/Ton). However, the Naicof Single Disc pulping machine required the largest volume of water (20,599 L/Ton), whereas Penagos Eco Logic UCBE 500M machine utilized the least amount of water (227 L/Ton) even where soaking was done (840 L/Ton). The Penagos Eco Logic UCBE 500M and Pinhalense Ecological Wet Mill ECO-1SV systems took less processing time, 1.6 and 1.3 hours/ton, respectively, compared to the Naicof Single Disc pulping machine (40.7 hours/ton) which requires fermenting and washing the fermented sugars off the wet parchment before the coffee beans can be dried. These results support earlier assumptions that the new technologies would save costs in the amount of water and time required to complete coffee processing if translated into monetary terms.

As regards to cupping quality variables the Penagos Eco Logic UCBE 500M system, without soaking the beans prior to drying, consistently yielded the best results for all characteristics. However, it was not significantly different from the Pinhalense Ecological Wet Mill ECO-1SV, except for the finish variable. Both systems, Penagos Eco Logic UCBE 500M and Pinhalense Ecological Wet Mill ECO-1SV, were significantly better than the Naicof Single Disc pulping system for flavor, finish, cupper points, and percent cupping score.

Soaking the wet parchment after pulping with either the Penagos Eco Logic UCBE 500M or the Pinhalense Ecological Wet Mill ECO-1SV machine seemed to add no extra benefit in cupping quality since the soaked coffee beans pulped with either machine are not significantly better in quality than those not soaked (Table 1).

Experiment 2:

This experiment was conducted to test the effect of partial mucilage removal using the Penagos Eco Logic UCBE 500M machine followed by some fermentation on the quality of coffee. This study would shade some light on the belief by many specialty coffee buyers that coffee produced by fermentation and washing is of higher quality. These treatments have been discussed in the industry but little information is available for CWS to make any meaningful decisions. Results presented in Table 2 show significant differences between the Naicof Single Disc and Penagos Eco Logic UCBE 500M pulping systems in terms of fuel and amount of water consumed, with the Naicof Single Disc pulper using less fuel than the Penagos Eco Logic UCBE 500M pulper set at either full of partial mucilage removal. However, the Penagos Eco Logic UCBE 500M pulping system, with and/or without dry fermentation and soaking, consumes much less water than the

Naicof Single Disc pulper. As regards to coffee cupping quality, full or partial mucilage removal with the Penagos Eco Logic UCBE 500M pulper followed by fermentation produced as good a product as the Naicof Single Disc pulper in terms of coffee sweetness, acidity, flavor, body, and percent cupping score. Therefore, these results seem to lessen the importance of fermentation as a critical activity in coffee processing.

Experiment 3:

Similar treatments and variables, as in experiment 2, were utilized in this experiment but instead of the Penagos Eco Logic UCBE 500M pulper, the Pinhalense Ecological Wet Mill ECO-1SV system was used. Results from this study are presented in table 3, and they indicate that full or partial mucilage removal with the Pinhalense Ecological Wet Mill ECO-1SV pulping system with and/or without fermentation did not significantly differ from the Naicof Single Disc pulping system in terms of coffee sweetness, flavor, body, and finish, all of which are important coffee quality traits. However, as earlier mentioned the Pinhalense Ecological Wet Mill ECO-1SV pulper with or without fermentation significantly conserved more water than the Naicof Single Disc pulping system.

Table 1: Mean separation from experiment 1 data showing the effect of different pulping machine types and wet processing system on quality and cost of production of specialty coffee in Rwanda.

		Processing Cost Attributes			Quality Factors						
Treatments	**Treatment Name**	**Fuel (L/Ton)**	**Total Water (L/Ton)**	**Processing time (Hrs/Ton)**	**Sweetness**	**Acidity**	**Flavor**	**Body**	**Finish**	**Cupper points**	**Cupping Score**
T1	A1/1905/SOVU/EP1/T1	0.73^{c}	20,599^{a}	40.7^{a}	6.6^{bc}	6.7^{b}	6.6^{b}	6.7^{b}	6.5^{c}	6.5^{c}	79.7^{c}
T2	A1/1905/SOVU/EP1/T2	1.92^{a}	227^{d}	1.6^{c}	7.3^{a}	7.2^{a}	7.2^{a}	7.1^{a}	7.1^{a}	7.0^{ab}	82.7^{a}
T3	A1/1905/SOVU/EP1/T3	1.37^{b}	1,744^{bc}	1.0^{c}	7.1^{ab}	7.0^{ab}	7.0^{a}	7.0^{ab}	6.8b^{c}	6.9^{ab}	81.6^{ab}
T4	A1/1905/SOVU/EP1/T2-S	1.92^{a}	840^{cd}	11.6^{b}	7.0^{ab}	7.0^{ab}	7.1^{a}	7.1^{a}	7.0^{ab}	7.1^{a}	82.2^{ab}
T5	A1/1905/SOVU/EP1/T3-S	1.37^{b}	2,203^{b}	11.0^{b}	6.8^{bc}	6.9^{b}	6.9^{a}	7.1^{a}	6.9^{ab}	6.8^{b}	81.^{4b}
LSD		**0.40**	**1,290**	**0.7**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**1.3**

Table 2: Mean separation from experiment 2 data showing the effect of Penagos pulping machine type and wet processing system on quality and cost of production of specialty coffee in Rwanda.

		Processing Cost Attributes			Quality Factors						
Treatment	**Treatment Names**	**Fuel (L/Ton)**	**Total Water (L/Ton)**	**Labor (Manhrs/Ton)**	**Sweetness**	**Acidity**	**Flavor**	**Body**	**Finish**	**Cupper points**	**Cupping Score**
T1	A1/0606/SOVU/EP2/T1	0.44^{b}	22,594^{a}	117.8^{b}	7.3^{a}	7.3^{a}	7.2^{a}	7.2^{a}	7.1^{a}	7.0^{a}	83.1^{a}
T2	A1/0606/SOVU/EP2/T2-F	1.98^{a}	150^{b}	478.2^{a}	7.0^{ab}	7.2^{a}	6.7^{b}	6.9^{ab}	6.9^{a}	6.8^{ab}	81.5^{a}
T3	A1/0606/SOVU/EP2/T2-P	2.01^{a}	188^{b}	455.2^{a}	6.8^{ab}	7.0^{a}	6.8^{ab}	6.7^{b}	6.8^{a}	6.7^{ab}	80.8^{a}
T4	A1/0606/SOVU/EP2/T2-P/DF	2.01^{a}	5,920^{b}	368.2^{a}	6.9^{ab}	7.1^{a}	6.9^{ab}	7.0^{ab}	7.0^{a}	6.7^{ab}	81.9^{a}
T5	A1/0606/SOVU/EP2/T2-F/S	1.98^{a}	523^{b}	351.9^{a}	6.7^{b}	7.0^{a}	6.8^{ab}	6.9^{ab}	6.7^{a}	6.5^{b}	80.9^{a}

LSD	**0.26**	**6,704**	**159.4**	**0.5**	**0.6**	**0.5**	**0.4**	**0.4**	**0.4**	**2.3**

Table 3: Mean separation from experiment 3 data showing the effect of Pinhalense pulping machine type and wet processing system on quality and cost of production of specialty coffee in Rwanda.

		Processing Cost Attributes		Quality Factors						
Treatments	**Treatment Names**	**Fuel (L/Ton)**	**Total Water (L/Ton)**	**Sweetness**	**Acidity**	**Flavor**	**Body**	**Finish**	**Cupper points**	**Cupping Score**
T1	A1/0506/SOVU/EP3/T1	0.46^{b}	$29,307^{a}$	6.5^{b}	6.8^{b}	7.0^{ab}	6.8^{a}	6.7^{a}	6.5^{a}	80.2^{b}
T2	A1/0506/SOVU/EP3/T3-F	0.89^{ab}	$1,460^{bc}$	7.2^{a}	7.6^{a}	7.4^{a}	7.0^{a}	7.1^{a}	6.8^{a}	83.0^{a}
T3	A1/0506/SOVU/EP3/T3-P	1.31^{a}	859^{c}	6.9^{ab}	7.1^{ab}	6.7^{b}	6.7^{a}	7.0^{a}	7.0^{a}	81.3^{ab}
T4	A1/0506/SOVU/EP3/T3-P/DF	1.31^{a}	$6,047^{b}$	6.8^{ab}	6.9^{b}	6.7^{b}	6.9^{a}	6.8^{a}	6.6^{a}	80.6^{ab}
T5	A1/0506/SOVU/EP3/T3-F/S	0.89^{ab}	$1,704^{bc}$	7.1^{ab}	7.2^{ab}	7.1^{ab}	7.0^{a}	6.9^{a}	6.9^{a}	82.0^{ab}
LSD		**0.45**	**4,861**	**0.6**	**0.6**	**0.7**	**0.5**	**0.5**	**0.6**	**2.4**

Annex A: Description of the Pulping Machines

Naicof Company single disc pulping machine: Processes an estimated 1000kg of cherries into A1 and A2 grades wet parchment, using an onboard 3.5hp diesel motor, which consumes 1L of fuel per hour. The estimated rate of water consumption is 10L per 1kg cherries for mechanical operation alone. Actual consumption for water-fed procedure is far greater.

Penagos Ecologic Wet Coffee Unit UCBE 500M: System designed to process 500kg cherries per hour, consuming 0.2L of water per 1kg cherries, to yield zero-, partial-, or full-mucilage removed, washed parchment coffee prepared for sorting and drying. Mucilage removal setting allows for variable partial removal. The unit is powered by a self-contained, Intek Pro 8HP gasoline engine and is equipped with a pulp and mucilage mixing and conveying delivery system. Processed parchment is produced in a single grade. A small amount of pulp and parchment is separated as 'second grade' and can be sorted.

Pinhalense Ecological Wet Mill ECO-1SV: System equipped with DC-3X Pulper, DMP-0X Mucilage Remover, and Immature Green Cherry Separator. It is specified with a processing capacity between 1500 and 1800kg of cherries per hour, using 3.5L water per 1kg cherries to produce washed parchment coffee. Zero-, partial-, or full-mucilage removal is possible. No onboard power source is included, so Sovu installed an Igea 13KVA diesel generator, provided by BrazAfric. Parchment is not density-graded into separate lots.