2016 Belgravia Fermentation Experiments Results - White Paper

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Diverse scientific studies from several authors[1] have shown that fermentation in washed coffee is a key factor for flavor development and, along with *terroir* and genetics, are perhaps the three factors that most influence the way that a washed coffee tastes after roasted. Wine and beer, to name a few drinks that are usually compared with coffee, also use fermentation to develop flavors. Yet fermentation in beer and wine only have in common with coffee the chemical, microbial process. While in beer and wine fermentation is used to produce alcohols – and hence flavors, in washed coffee fermentation of the fruit (mucilage) is conducted mainly for the easy removal of mucilage from the parchment when put in contact with water and agitation, stopping the fermentation process and preventing any alcohols to be produced in the seed inside the parchment. How and for how long a producer ferments coffee can affect the final cup quality – sometimes positively but sometimes negatively. Unfortunately, how fermentation plays a part in flavor development is something that has not been sufficiently studied.

Around 2006 we started questioning why all producers in Colombia always fermented for 12 to 14 hours, irrespective of the altitude and microclimate present at the farm. When questioned about this common practice, producers always replied: "that's what the *tecnico* told me", or, "that's how it's always been done here". As the answers didn't make much sense, we started asking producers to extend their fermentation times to 18 hours and sometimes even 24 hours. The results were usually cleaner, sweeter and more defined cup profiles and, as a consequence, higher cup scores. These empirical results confirm the role of fermentation in flavor development – or perhaps, in flavor clarity. Despite the fact that extended fermentation times posed some challenges to producers, especially when doing 24-hour fermentations, as two activities coincided at the same time: pulping and washing coffee. Yet the increase in cup quality at a marginally low cost was sufficient to motivate the most committed producers to find ways to deal with the challenges. Now it is common practice among producers in Colombia to ferment for 24 hours or longer.

Ten years later, we set out to experiment with different fermentation techniques to better understand the effects that different techniques might have on coffee quality and flavor development.

The Experiment

For this experiment we used coffee harvested and processed at our own innovation farm, Finca Belgravia, located at 1910 masl in Popayan, Cauca (Colombia), with an annual median temperature of 17 degrees Celsius, a maximum of 28 degrees Celsius and minimum of 10 degrees Celsius, a median annual humidity of 87.0% and annual average rainfall of 2040 mm.

[1] Among the scientific studies reviewed for this white paper are the following:

- Puerta Q., G.I. Factores, procesos y controles en la fermentación del café . Avances Técnicos Cenicafé No. 422, December 2010, 12 pages.
- B.T. Iamanaka, A.A. Teixeira, A.R.R. Teixeira, M.V. Copetti, N. Bragagnolo, M.H. Taniwaki, The mycobiota of coffee beans and its influence on the coffee beverage, Food Research International, Volume 62, August 2014, Pages 353-358;
- L. Wei, M. Wai Cheong, P. Curran, B.Yu, S. Quan Liu. Coffee fermentation and flavor – An intricate and delicate relationship. Food Chemistry, Volume 185, 15 October 2015, Pages 182-191
- Gonzalez-Rios, O., Suarez-Quiroz, M. L., Boulanger, R., Barel, M., Guyot, B., Guiraud, J.-P., et al. (2007a). Impact of "ecological" post-harvest processing on coffee aroma: II. Roasted coffee. Journal of Food Composition and Analysis, 20(3–4), 297–307.

The Caravela team at Belgravia harvested two distinct coffee varieties planted at the farm and experimented with three different fermentation techniques. The varieties were Bourbon and Colombia (a rust resistant variety between Caturra and H. Timor developed by Cenicafé and released to producers in 1983), each offering a different "genetic profile" but both grown at the same altitude, soil and microclimate. It is important to mention that the seeds of both varieties were purchased in 2008 from Cenicafé and are therefore verified seeds, which were germinated and later planted at the farm at the same time, in September 2009.

The fermentation techniques in these experiments were as follows:

1. **"Dry" fermentation**: coffee is pulped, and the parchment with mucilage is allowed to rest for a period of 24 hours in a plastic tank, with local yeast and bacteria helping break down the sugars present in the mucilage. Samples are identified with an S, which stand for *seco*, or dry in English. This is the technique how coffee is generally processed at Belgravia.
2. **"Wet" fermentation**: same as 1 above, but clean water was added to the mass after pulping, effectively submerging the mucilage-covered seeds in water during the fermentation stage for a period of 24 hours. Samples are identified with an A, which stands for *agua* or water in English.
3. **"Covered" fermentation**: same as 1 above, but the plastic tank is covered with a lid during the fermentation process. This allowed any heat built up from the fermentation process to be held inside the tank rather than being released into the atmosphere. The tank has a small opening to allow oxygen to enter. Samples are identified with an T, which stands for *tapado* or covered in English.

For the experiment, 2.5 kg of coffee cherry from these two varieties were manually selectively harvested in June 2016 over a nine-day period ensuring only ripe cherries were included. Before pulping, cherries were floated in water to remove any lower density beans, and then pulped on the same day of harvest, around 5 PM. The fermentation stage was done at the farm on plastic buckets.

This resulted in six different samples per day for nine days of harvesting equaling 54 total separate samples. After washing, each lot was dried in a covered drying patio with 100% shade during the first 7 days, then 7-10 days in semi-shade conditions and the final 3-5 days with full sun exposure. All samples were dried to a target moisture of 10.5% and measured for water activity (PAw) to make sure that they all measured below 0.60. Once in parchment, each sample weighed approximately 500 gr and when milled approximately 400 gr of green exportable grade green.

These samples were sent out in August 2016 to each of Caravela's sales offices in North America, Europe and Australia. Several blind cupping sessions were then held in August and September 2016 in 7 different cities with customers and intrigued coffee professionals using standard SCAA (now SCA) roasting and cupping procedures. Each sample was given a coded number and was cupped blind. The participants were not aware of the processing technique or variety when cupping. Participants were asked to score each coffee and provide flavor descriptions of each sample.

Sample Coding

The following are the codes that were assigned to the six different combinations of variety and technique:

- BAM: Bourbon fermented with water
- CAM: Colombia fermented with water
- BSM: Bourbon dry fermentation
- CSM: Colombia dry fermentation
- BTM: Bourbon covered fermentation
- CTM: Colombia covered fermentation

Items for Consideration

When looking at the results of the experiment it is important to keep a few things in mind.

1. Cuppings were executed across the globe, so local preferences can skew results.
2. Roasting of each sample was subject to the skill-set of that roaster. Every effort was made to keep the samples consistent within a given locale.
3. Participants were coffee professionals and enthusiasts with very diverse levels of coffee cupping experience and not all were Q-Graders or cupping was their main area of expertise. This diversity could potentially skew the cupping results. We calculated both the median and the averages removing the outliers (max and min).
4. North America had a total of thirty participant cuppers in five different venues, from San Francisco to Chapel Hill. Europe had seven participants in one venue, and Australia fourteen, also in one single venue. In total fifty-one coffee professionals participated.

Quantitative Results

In order to analyze which fermentation technique is best, we analyzed the median and average cupping scores, as well as the variance, maximum and minimum scores and the spread between maximum and minimum scores. Below is the statistical analysis of the 6 samples.

TABLE 1
Statistical Analysis of Cupping Results

	BAM	BSM	BTM	CAM	CSM	CTM
Spread (max – min)	15.25	15.00	27.25	22.25	17.50	9.50
Variance	4.22	4.00	7.86	5.48	4.74	2.36
Standard Deviation	2.05	2.00	2.80	2.34	2.18	1.54
Median	85.13	85.38	85.00	84.38	84.00	84.00
Average (min, max removed)	85.28	85.39	85.12	84.11	84.05	84.14
Confidence (95%)	0.41	0.40	0.56	0.46	0.43	0.30

For all fermentation techniques studied, the Bourbon variety scored on average 1.0-1.4 points higher than the Colombia variety, with median scores between 85.00 and 85.38.

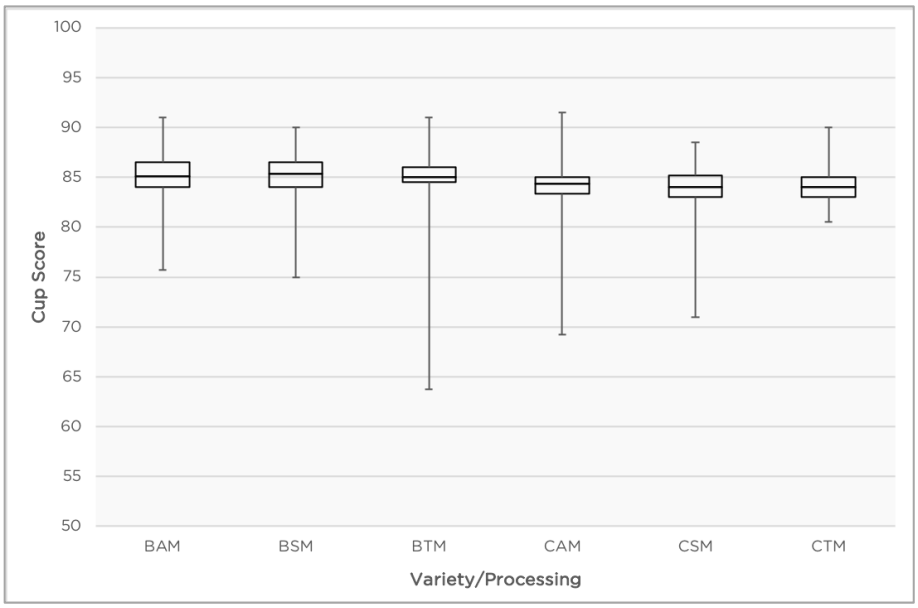
Within the Bourbon variety, the technique of covering the coffee during fermentation scored the lowest (85.12), but not statistically lower than the other two methods which had average scores of 85.28 and 85.39 for the wet and dry fermentations, respectively. The wet technique had the highest high and the highest low, with a tight spread between high and low, but not really much different results than the dry technique.

The Colombia variety had a median score ranging between 84.0-84.38 amongst the three techniques, therefore there were no statistically valid differences between any of the techniques studies. However, the covered Colombia technique had a much lower spread than the other two techniques and the highest low of the three processes for this variety.

To present the statistical results in a graphical way, we have used a Box-and-Whisker graph, seen in Graph 1 below. This is a very practical way of showing statistical data from different data sets. A Box-and-Whisker plot graphically shows five statistics for each data set:

- A minimum value – the smallest value in the data set
- Second quartile – the value below which the lower 25% of the data are contained
- Median value – the middle number in a range of numbers
- Third quartile – the value above which the upper 25% of the data are contained
- Maximum value – the largest value in the data set

GRAPH 1
Graphical Statistical Analysis of Cupping Results (Box-and-Whisker Graphs)



As seen in the graph above, there weren't any huge quantitative differences between processes within the same variety. Given these results, it is difficult to quantitatively discern which technique is best for cup quality. Interestingly, the wet technique had one of the tightest score range and the highest score for the Bourbon samples, which could indicate that using water as the fermentation medium for Bourbon could result in more consistent and higher scoring coffees. However, for the Colombia samples, the covered process seemed to be a safer technique for this variety as it had a tighter range and the second-best score and the highest low score.

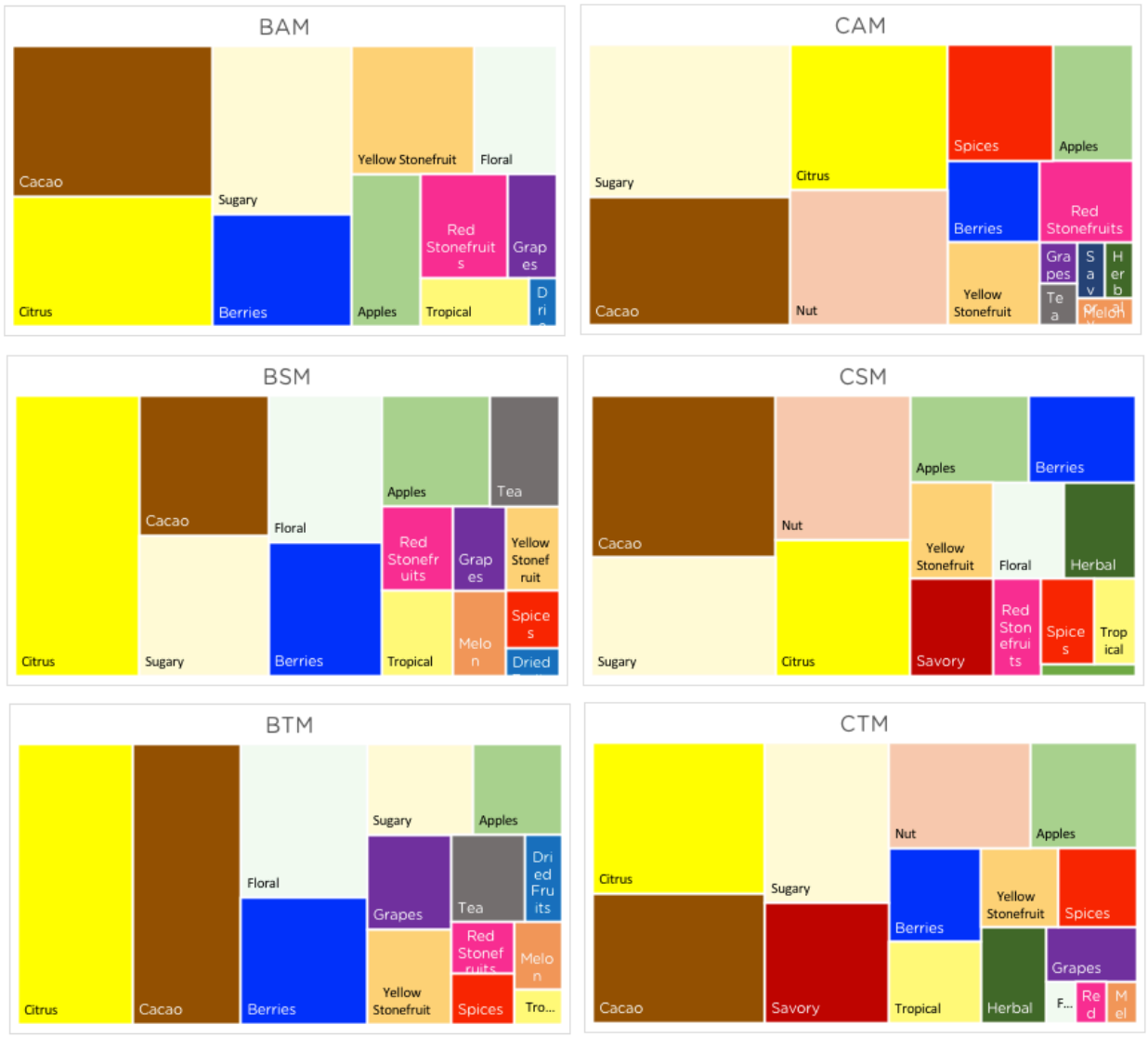
Qualitative Results

We also looked at the qualitative results within the cupping notes to determine any major differences between processing techniques and varieties. In order to analyze qualitative differences, we graphed the flavor descriptors of each processing/variety of all the cuppers using tree maps graphs. These graphs are commonly used to display quantities for each category via area size, with the whole graph representing a total of 100%. Therefore, each individual area represents the weight of each category over 100%.

To construct the graph, we tallied all the descriptors used by cuppers. Some cuppers used more descriptors than others, and also some samples had more descriptors than others.

Therefore, all samples did not have the same total number of descriptors. The minimum number of total descriptors was 95 and the maximum was 133. Regardless of this disparity in total number of descriptors, the graphs do show which samples had more defined flavors, together with complexity of flavors. We did not tally taste descriptors (e.g., “bright acidity”, “good body”, “clean”, “juicy”), only flavor descriptors. And whenever possible, we grouped similar flavors into the same category (using the Counter Culture Coffee Flavor Wheel descriptors) to keep the graphs easier to read. For example, descriptors such as milk chocolate, cacao, cacao nibs, where all grouped in the general “Cacao” category.

GRAPH 2
Tree Maps of Cupping Descriptors per Variety/Process



Observing the graphs above, coffees processed using the wet technique had more defined flavors, with 3 very dominant flavors which weigh about half of the total, plus 2 additional flavors which complete roughly 75% of the total weight, along with 6-9 additional descriptors which seem to add some complexity, for a total of 11 and 14 descriptors, the lowest number of descriptors of all samples. This is consistent with the quantitative data which shows more

consistency and a tighter range in flavors, which could lead to higher cup scores among cuppers.

The dry technique shows 2 dominant flavors but when adding the 3 subsequent flavors the total is less than 70% in both varieties, with 9 additional flavor descriptors, for a total of 14 flavor descriptors. In the covered technique, the results are different for each variety, with the covered technique being quite defined for the Bourbon samples, with the top-5 flavors representing 71% of the total, whilst this technique in the Colombia variety was much less defined, with the top-5 flavors representing only 64% of the total. Based on the results of this experiment and given the disparity in results between varieties with this technique, it seems like the covered technique would not be recommended as results could vary depending on variety.

It is interesting to observe that “Cacao”, “Sugary” and “Citrus” are the flavor descriptors common to all six samples, independent of variety and technique. These seem to be the “basic flavors”, which are probably imparted by *terroir* since that is what all six samples have in common. But there are other flavors that are most likely related to variety, irrespective of fermentation technique, such as “Berry” and “Floral” flavors observed in all 3 Bourbon samples, and the “Nutty” and hardly any “Floral” flavors observed in the Colombia variety samples. In addition, there are other flavors that seem to be highlighted by fermentation technique. Given this, fermentation technique seems to add or subtract flavors and complexity to the cup. A good example of “flavor subtracting” is how the Colombia variety processed by the “Wet” method does not show “Savory” flavors and less “Herbal” notes.

When comparing the results of the quantitative analysis versus the qualitative analysis, it seems that qualitative analysis is more useful to determine which processing technique is best for each variety.

Final Thoughts

While these results have no scientific backing, statistically don’t show any major differences in cup quality between the different processes, and are just merely "experimental", the results help Caravela, coffee producers, and green coffee buyers to understand how much impact a fermentation technique can have on coffee quality. We can now begin asking more in-depth questions about fermentation when engaging producers. As well, we can share this data with producers to empower them to implement techniques to obtain better results with their cup quality at a marginal cost.

Caravela will continue to undertake experiments like this one with the aim of generating further knowledge so that coffee producers can adopt practices that have been tried and tested experimentally. For future studies, a greater number of participants as well as more repetitions with the same cuppers will allow us to analyze the results with more statistical batteries and hopefully provide us with more scientific results.

Acknowledgments

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