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BEVERAGE + PROCESS

Abstract

5 individual 150G coffee steep tests to determine effect of grind, roast, temperature, and ingredient ratio on cold brew coffee

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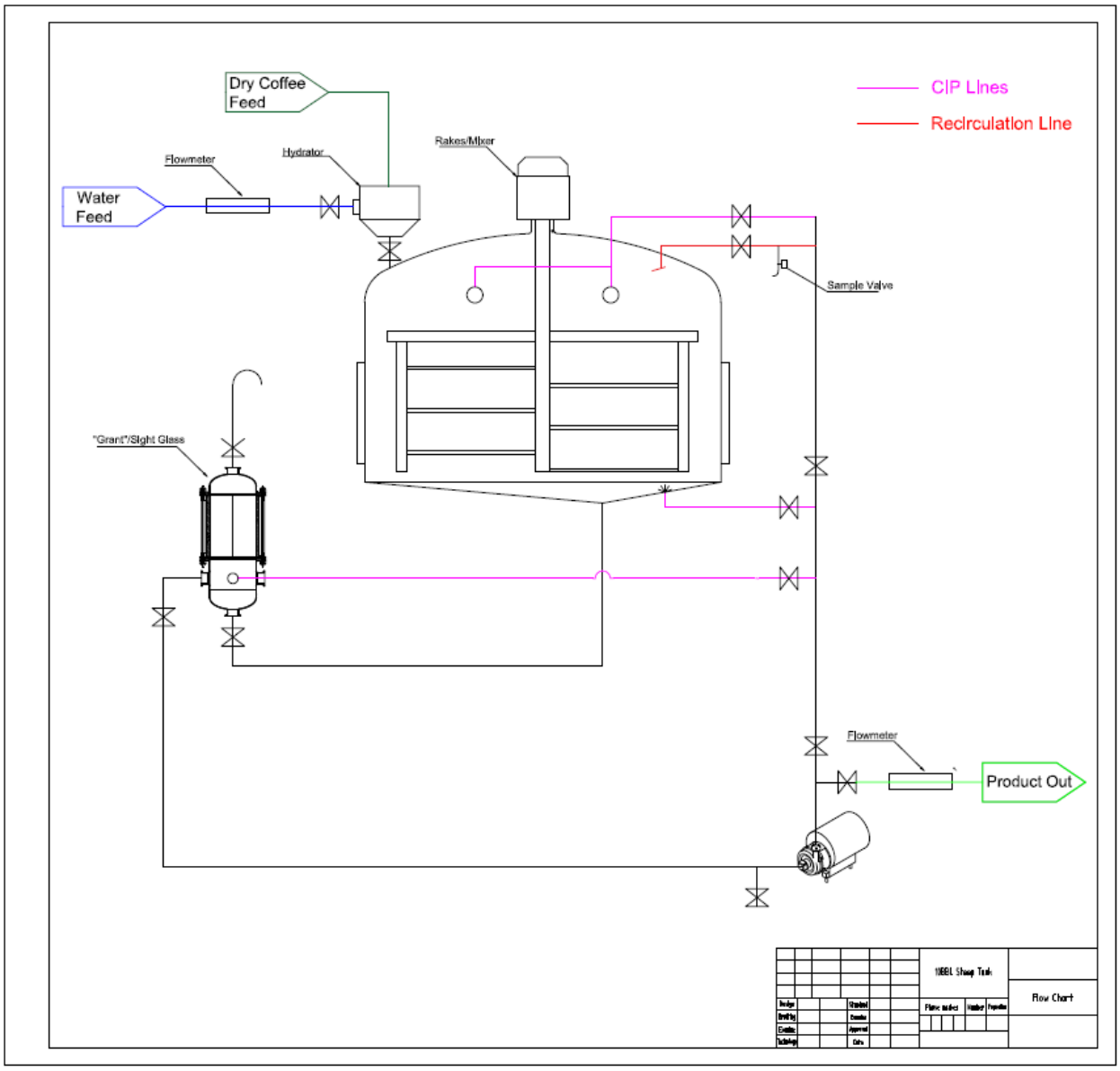
Preface

Five different coffee trials were performed on a Deutsche Beverage and Technology 150G steeping vessel. The purpose being to better understand how certain variables affect final product as well as verify scalability of Deutsche equipment to smaller, benchtop cold brew equipment.

The steep tank is made of 304 stainless steel and includes: a 450-micron v-wire false bottom floor, mixing rakes and plow with adjustable speed and direction, recirculation with distribution plate, flowmeter for precise water addition, temperature transmitter for steep temperature, recirculation "grant" vessel for clarity checks, coffee hydrator, SPX centrifugal pump, and complete CIP ability with sanitary spray balls. Also on the vessel, but not utilized for these trials are spray nozzles for hot or cold water sparging or "re-wetting" of the coffee grounds.



Trial Constants

All five tests kept the following potential variables constant. Any of these could change the outcome of the cold brew coffee, and potential users of Deutsche coffee steep tanks are encouraged to adjust these variables to fine tune a specific recipe.

Constants	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Steep Time	180min	180min	180min	180min	180min
Total Coffee lbs	194 lbs	194 lbs	*155 lbs	*155 lbs	124 lbs
Total Water gal	150 gal	150 gal	*120 gal	*120 gal	150 gal
Agitation	Yes	Yes	Yes	Yes	Yes
Recirculation	Yes	Yes	Yes	Yes	Yes

*Table A - *Dosing was originally intended to stay constant, see below report for reason of change. Ratio of 6.5:1 still constant at new loading for trials 3 and 4*

- ***Steep Time*** has a large effect on brix and extraction percentage, but based on previous trials and industry research, there is a sharp drop off after an initial time window. For a production schedule, additional steeping time is not warranted for the slight gain in extraction. We expect this fall-off to occur after the 2-hour mark. A 3-hour steep time was determined to be able to plot a brix over time chart to prove more time does not warrant the additional extraction.
- ***Agitation*** is not common in bench top or smaller scale cold brew equipment. On previous Deutsche equipment tests we have found too much agitation can cause clarity and over extraction which can lead to bitterness. For these four tests, the vessel was agitated at our slowest mixer speed for 15 seconds on, 45 seconds off for a total of five minutes. This agitation also occurred at the same time as a recirculation step noted below. We then allowed the vessel to steep undisturbed for 25 minutes and repeated throughout the 3-hour steep.
- ***Recirculation*** is also uncommon in smaller systems and a benefit of a Deutsche steep tank. There is promising opportunity to speed up extraction times with an added recirculation step. To prevent over-extraction, for these four tests, we did a five-minute recirculation during the agitation step. And allowed the bed to steep undisturbed for 25 minutes.

Trial Variables

For these specific tests, we chose to see how temperature, grind size, roast, and ingredient ratio affect final product. The base trial, trial 1, used medium ground coffee (500-800 micron), a medium roast, at ambient temperatures. Ambient temperature for trial 1 was 54F. Trial 2 increased grind size to a coarse grind but kept ambient temperature and medium roast constant. Trial 3 used a dark roast, while holding the other 2 trial variables constant. Trial 4 was selected to determine the effect of increased temperature. The grind size and roast were kept constant, but steeping temperature was increased to 110 degrees F. And lastly, trial 5 was performed to determine effects of a higher water to coffee ratio. The ambient temperature in trial 5 was slightly elevated compared to trials 1-3. This was due to time constraints of the testing date.

Variables	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Steep Temperature	Ambient	Ambient	Ambient	120F	*Ambient
Roast (light, med, dark)	med	med	dark	med	med
Grind Size (med = 900-1000 micron, coarse = >1000 micron)	med	coarse	med	med	med
Water:Coffee Ratio	6.5:1	6.5:1	6.5:1	6.5:1	10:1

*Table B - *Trial Constants *Slightly increased due to time and resource constraints*

Coffee

We used 100% arabica beans, ground approximately 3 weeks prior to the start of the tests. Using fresher coffee and/or changing the origin and type of the bean can also significantly affect final outcomes. We encourage users of Deutsche steep tanks to use the best and freshest ingredients for best results, but also to try different beans and origins to see how it effects your product.

The medium roast, medium grind coffee had an Agtron Colorimeter of 45 and average grind of 920 micron. The medium roast coarse grind had the same color spec but with an average micron of 1200 for the grind. The dark roast color was 35 with a grind of 1000 micron.

Trial Method

The definitions of cold brew coffee and concentrate may differ depending on the source. For this document, we consider “concentrate” any final product above a final brix reading of 1.6, and “cold brew coffee” any coffee that was steeped below 130F. The base trial 1 variables were chosen for common ambient or slightly chilled steeping temperatures. The aggressive water:coffee ratio was chosen to try and achieve maximum concentrate values. The original dosing amount was determined to obtain maximum yield/batch for our steeping equipment.

194 lbs of medium ground, medium roast coffee, was weighed into 5-gallon buckets. A water holding tank, with carbon filtered ambient water, was connected through a centrifugal pump and a sanitary hose to the inlet flowmeter mounted on the coffee steeping skid. The mixing rakes inside the steep tank were started at a 50% speed to assist with initial mixing and setting of the coffee bed. Water was pumped into the tank, through the hydrator, at ~20 GPM until it rose slightly above the false bottom floor of the vessel. At this point, coffee buckets were dumped into the hydrator until all water – 150G and coffee – 194 lbs were inside the vessel. The mixer continued to run at 50% speed until the coffee was fully hydrated and the bed inside the tank was evenly distributed (9 minutes total).

The coffee steeped undisturbed for 25 minutes before the mixer was started at a roughly 4 RPM setting for 15 seconds on, 45 seconds off. At the same time, we turned on the steep tank pump and allowed the mixture to recirculate at a minimum rate for 5 minutes. The pump speed was determined by the rate of filtration through the coffee bed (~24% on the VFD). At the end of the five minutes, a sample was pulled from the top of the coffee bed. This process was repeated every block of 30 minutes for 3 hours. At the end of the 3-hour sample period, the coffee was allowed to transfer out, with a final sample being pulled after 50 Gallons was yielded. No filtration of the coffee was performed. Results of the trial are shown in the chart below.

The tank was emptied and cleaned prior to each trial, which all followed the same parameters and constants listed above. All 7 samples per trial were pulled and tested in house using a handheld refractometer and pH strips. No noticeable difference in pH was determined for any of the samples or trials based on our testing using pH strips. All strips signified a weak acid with pH close to 6. All brix readings from the refractometer were verified by minimum 2 persons, and the average was taken if any discrepancies between the readings.

The final sample from each trial were sent to a lab to verify brix, TDS, and pH, as well as provide a caffeine sample. Lab results for each trial are shown under each trial description below, with a full summary of results in the results and conclusions section of this report.

Trial 1 – Base

After the initial dosing of coffee and water, the fill level inside the tank was roughly a 24” bed height or 96% full. The max operational bed height is 25” (distance from false bottom flow to spray ball). This can be considered the maximum loading of this vessel. With this loading, the initial mix in looked slightly muddier and clumpier than usual, but we were cautious of over mixing to prevent over extraction and a reduction in filterability.

During the initial recirculation and mixing step at 00:25, we did notice any pump speed above 24% emptied the grant, signaling issues flowing through the grain bed. This is attributed to the full loading of the vessel, the aggressive water:coffee ratio, and the grind size of the coffee. We were able to recirculate, although not at full strength and obtained a brix reading of 3 from our sample at 00:30.

The remaining samples all followed the same pattern with difficulty recirculating, but we were always able to complete the step without any plugging and obtain satisfying brix results. During the final transfer or yield capture, the system did stop flowing after roughly 75 gallons of yield. It required increased mixing and use of a manual rake to loosen up the stuck bed. After this manual mixing, there was a rush of coffee flow until a final yield of 112 gallons was achieved. See the chart below for lab results of trial 1.

Picture 1 – Notice Loading Level and Dry Bed

Brix	Brix User Manual	3.90	%
Caffeine	AOAC 980.14 (Caffeine)	1629.68	ppm
pH	pH	5.57	--
Total Solids	Total Solids – AOAC 930.15	3.28	%

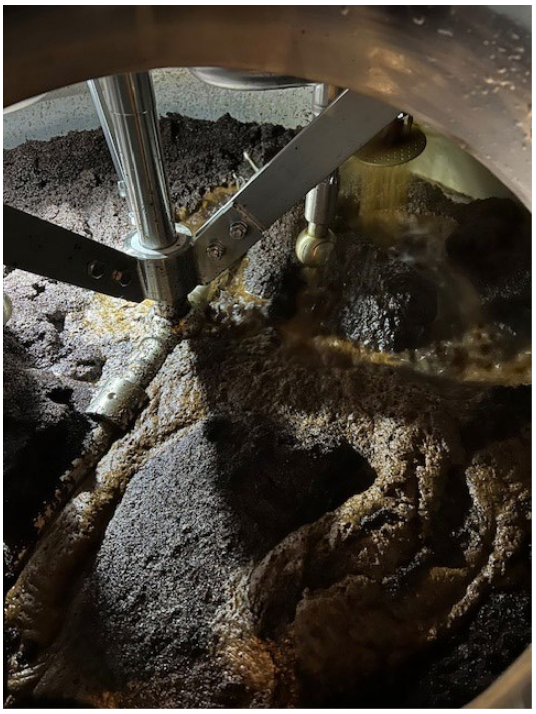
Table C – Trial 1 Lab Data

Trial 2 – Coarse Grind

We decided to keep the original dose volume the same for this trial because we wanted to see if coarse grounds would increase the ease of recirculation and transfer. After the initial mix-in, the tank was again filled with a 96% fill volume.

The initial recirculation and mixing step resulted in a more fluidized bed, and the sample pulled resulted in a brix of 2.6. The pump recirculation speed was increased to 25% for the recirculation step. Future recirculation periods resulted in *slightly* increased filterability and flow, but still required operator attention like trial 1.

During the last transfer, we lost flow through the bed after roughly 80 gallons of yield. Flow was better than the previous trial, but the coarseness of the grind did not make a significant difference in the filterability of the coffee bed. *Because of the flow issues, we decided to reduce the total dosing of the equipment in the remainder of the tests by 20% but kept the water:coffee ratio consistent.



Picture 2 – During Recirculation and Mixing, Notice High Level

Brix	Brix User Manual	3.80	%
Caffeine	AOAC 980.14 (Caffeine)	1627.96	ppm
pH	pH	5.58	--
Total Solids	Total Solids – AOAC 930.15	3.25	%

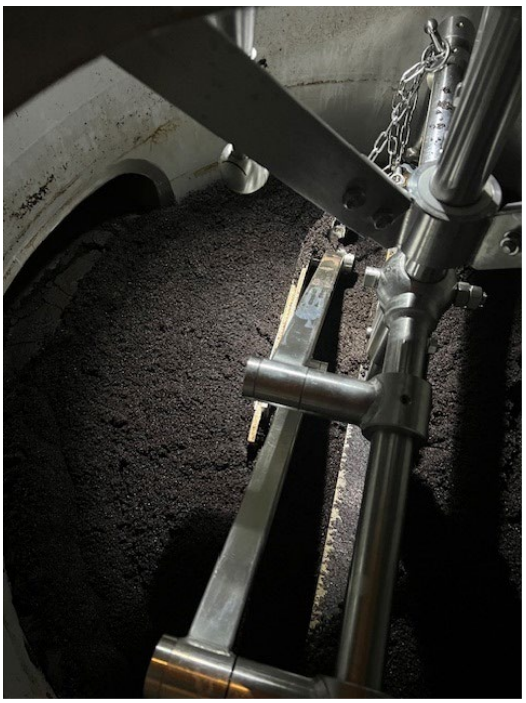
Table D – Trial 2 Lab Data

Trial 3 – Dark Roast

For this trial, the water:coffee ratio was kept at 6.5:1, however; due to filtration and flow limitations of the previous 2 trials, the total dosing was reduced by 20% to 120G of water and 155 lbs of coffee. The resultant bed was about 4" below the spray balls or about 84% full. Initial mix in created a more fluidized bed compared to trial 1, likely because of the decreased dosing.

The initial brix reading of 2.1 was the lowest of any trial so far, but there was a steady increase of readings all the way up until the 2:00 mark. The dark roast coffee, while still considered a medium grind for these tests, did have a slightly increased ground size of 1000 micron compared to the medium roast.

The final transfer still saw challenges and required some manual mixing. Once the initial rush of fluid started, it was a smooth transfer the rest of the way.



Picture 3 – After Transfer Was Completed

Brix	Brix User Manual	4.00	%
Caffeine	AOAC 980.14 (Caffeine)	2194.33	ppm
pH	pH	5.77	--
Total Solids	Total Solids - AOAC 930.15	3.42	%

Table E – Trial 3 Lab Data

Trial 4 – 110F Steep

A "strike" water dose of 120F was used to obtain a steep temperature of 110F. No preheating of the steep vessel occurred which was roughly 65 degrees at the start of mixing in. The dry coffee was also at 65 degrees. After the initial mixing and steep, the coffee bed was noticeably foamier, possibly a result of the higher temperature.

The first brix reading was 3.6, the highest result of all the trials. The highest brix reading obtained was 4.7, but the last few samples were the least consistent.

Once again there was some initial trouble obtaining good transfer flow, but like trial 3, after an initial manual mixing, there were no issues throughout the remainder of the transfer.

Brix	Brix User Manual	4.00	%
Caffeine	AOAC 980.14 (Caffeine)	1855.22	ppm
pH	pH	5.49	--
Total Solids	Total Solids - AOAC 930.15	3.37	%

Table F – Trial 4 Lab Data

Trial 5 – Water:Coffee Ratio

Our water holding tank had some residual heat leftover from trial 4 and was at 76 degrees at the time of the trial. Due to time constraints and limited building water feed rates we had to continue with the test. We reduced the water:coffee ratio to 10:1 which we expect to reduce the overall brix value. The slightly elevated temperature of 76F may lead to a slight increase in brix.

Image 4 – Initial Dosing of Coffee through Hydrator

We did increase the volume for this test because of the reduced water:coffee ratio. The full volume was ~3 inches below the spray balls after the initial mix. The first brix reading after the initial 30-minute steep was 2.3, the second lowest of any test so far. The trend of a ~0.5 brix boost from the second steep test continued with a result of 2.9. The bed was the most fluidized of any test so far. Even so, we needed an initial manual mix to start the rush of coffee during the transfer. This test yielded 125 gallons for the highest extraction percentage of 21%.

Image 5 – 1 Hour into the Steep. Notice Liquid Level

Brix	Brix User Manual	2.80	%
Caffeine	AOAC 980.14 (Caffeine)	1106.76	ppm
pH	pH	5.59	--
Total Solids	Total Solids - AOAC 930.15	2.30	%

Table G – Trial 5 Lab Data

Results Summary

All concentration curves followed a similar pattern. The initial brix reading after only 30 minutes was substantial, followed by ~0.5 brix increases per 30 minute sample period for the following 2-3 tests. All tests after the 2-hour mark only increased on average of 0.1 brix per sampling period. All trials plateaued around the 1.5-2-hour mark, making a convincing case to reduce steep times in favor of faster production ability. Ratio had the single largest impacts on final brix, as expected.

The chart below represents brix data pulled immediately after each sample was taken in the field with a handheld refractometer. Compared to the lab data of the final samples, these readings are consistently higher than true brix by 5-10% across the board. The trending of the data is a still a good reference for determining optimum steep time.

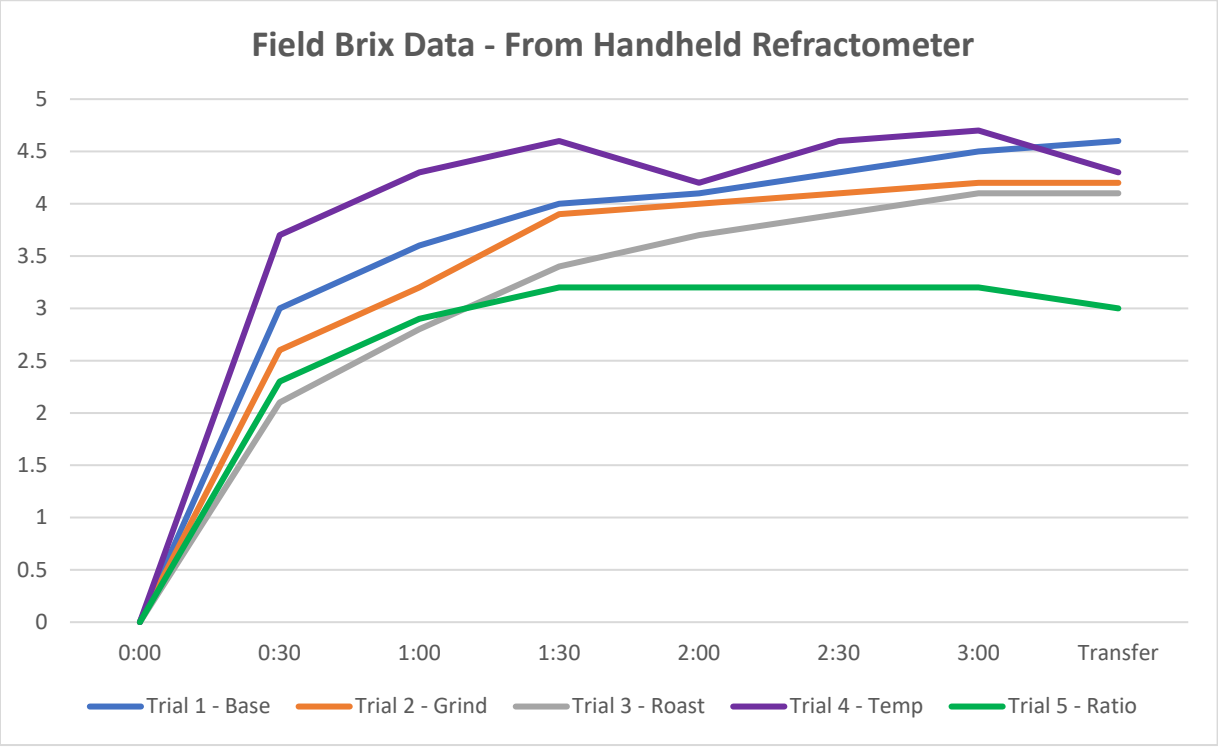


Chart 1 – Field Brix Data

Extraction % was determined with the lab Total Dissolved Solids (TDS) result using this standard formula: EXT % = 8.314 * Yield Volume (gal) * TDS / 100 / Coffee Dose (lbs). Target extraction % ranges are 17-20%. The low results in trial 1-3 are probably due to the aggressive water:coffee ratio that is consistent between those trials. By increasing temperature in trial 4, but keeping the ratio steady, the extraction % increased significantly. An interesting component is that brix for trial 4 was not higher than any of the previous trials, even with increased temperature. Only the TDS in relation to brix increased, leading to the higher extraction %. Trial 5 had the highest extraction %, likely due to the lower water:coffee ratio resulting in increased yield due to easier transfer.

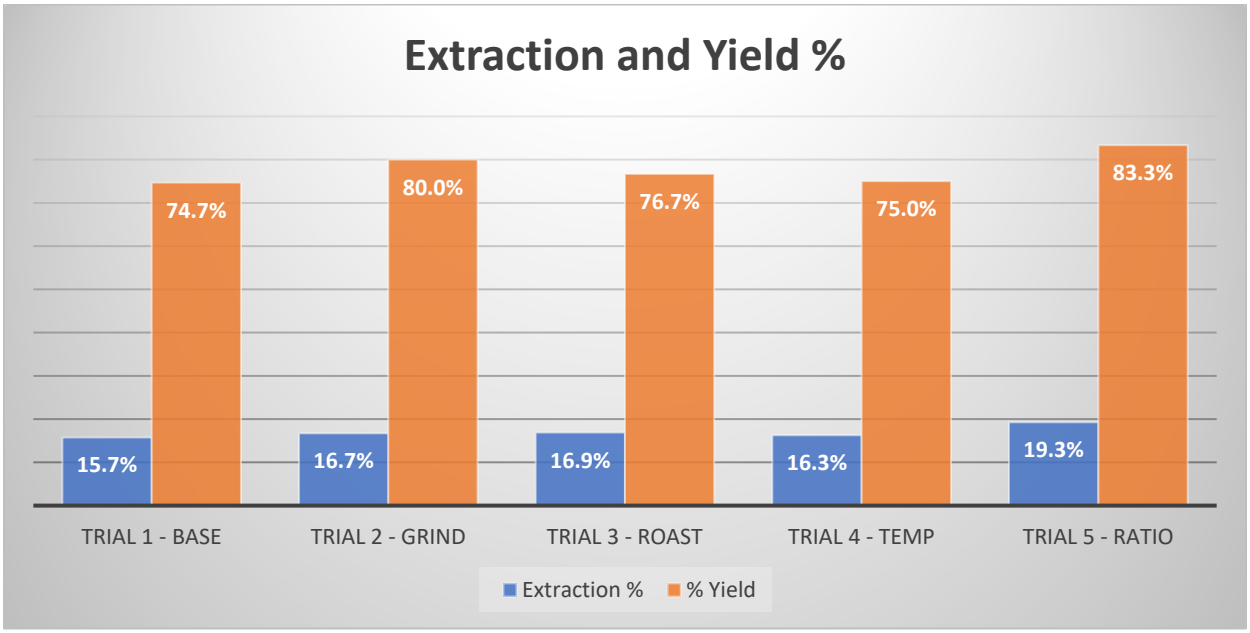


Chart 2 – Extraction % and % Yield

Complete lab data is summarized in bar chart 3 below. These were compiled using the final transfer sample of each of the five trials. In theory, this should be the product leaving our steep equipment prior to any filtration, post processing, or storage and should also be the maximum extract result for the given parameters.

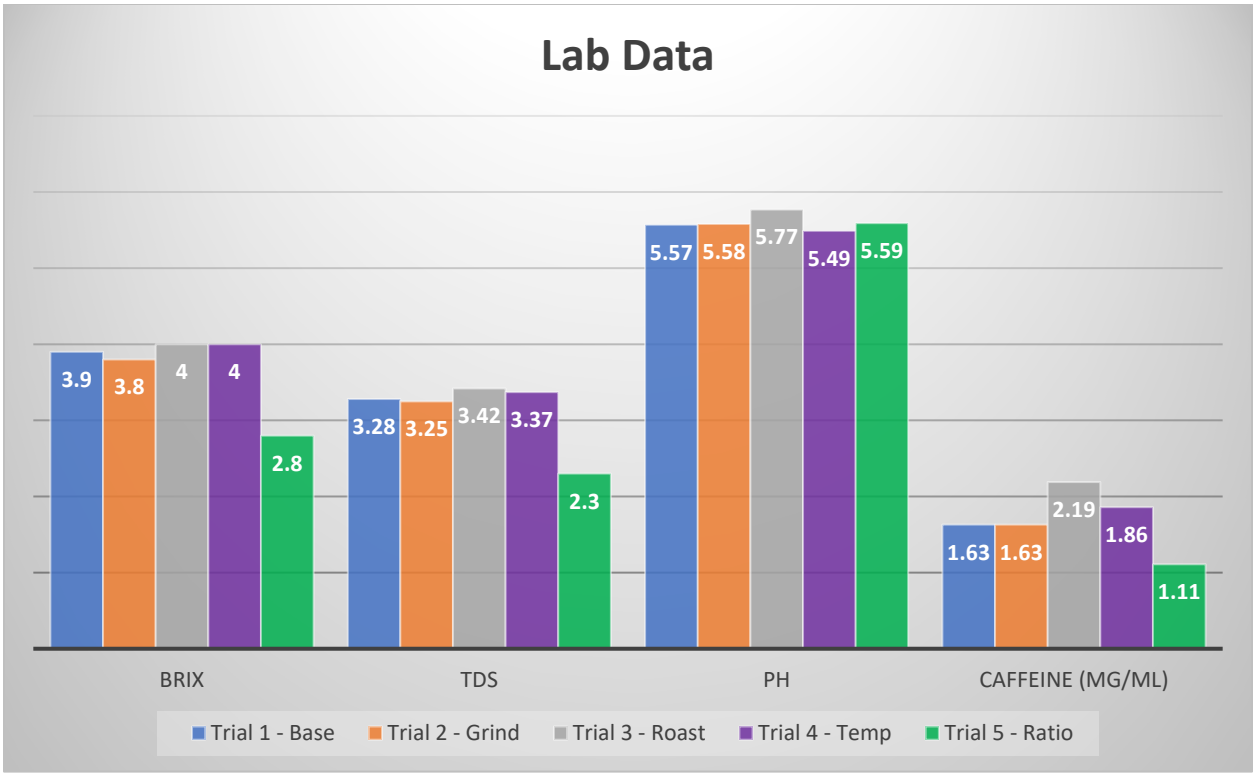


Chart 3 – Lab Data

Again, brix was consistent among the first 4 trials, which was also noted in our field testing. It was interesting to see that the increased steep temperature of 110F, from the base trial of 57F did not lead to a difference in brix result but did lead to a significant increase in TDS as opposed to trials 1-3. The lab data also verified ratio of ingredients as the single greatest factor on brix. Roast and grind had negligible effect on final product brix.

TDS only had minor discrepancies in trials 1 and 2. It did trend up slightly for trial 3 and 4, with roast surprisingly with the highest TDS result. Trial 5 result was expected with less coffee solids in solution in the steep tank.

PH was also steady and in range of expected values. Typical cold brew is within 5-6 pH. Dark roast had the most basic result, with temperature not surprisingly having the most acidic result.

Caffeine, shown in mg/ml, showed differentiation, especially trials 3-5. Dark roast led to the highest caffeine concentration. This is surprising because it goes against light roast “green” beans having the most extractable caffeine content. Temperature also increased the overall caffeine content of the final product.

Conclusions and Recommendations

The purpose of the trials was to determine how basic recipe parameters can affect a final cold brew product, specifically in the quest to obtain a maximum concentration and extraction % from our equipment, while maintaining caffeine and other qualities expected in cold brew.

The biggest factor for brix pick-up in cold brew from these trials was the ratio of ingredients. A 10:1 lbs water to lbs coffee ratio versus the base case of 6.5:1 resulted in a final brix 1.5 lower than any of the other trials. However, the 10:1 ratio also resulted in the highest extraction % because it was the easiest batch to fully transfer all the liquid solution inside the vessel.

There could be a benefit to choosing a different roast level in search of a precise caffeine spec. However, we encourage more testing. The higher caffeine content is likely most effected by the quality and origin of the bean itself.

We advise increasing temperature for higher TDS and extraction % if that is a key performance indicator of your process. There was no noticeable difference in brix result with our different temperature trials. You may need to balance higher TDS and extraction % with increased acidity, as well as higher caffeine concentrations – which may be preferred.

Each trial gave us some flow issues during the final transfer. The biggest factors for flow constraints on our equipment were determined to be total loading of the vessel, the water:coffee ratio, and the grind size. The easiest trials to operate were Trial 2 and Trial 5. On trials 3 through 5, after the initial raking of the tank to loosen the bottom bed, no further agitation or manual mixing was required, likely due to the reduced total recipe dosing volumes. Fine tuning the ratio will lead to higher yield, and higher extraction %.

A recommendation is to always use a coarse grind >1200 micron. The field and lab results do not warrant reducing the grind size to try and obtain higher brix, TDS, or caffeine level. A second recommendation is the more aggressive the water:coffee ratio, the less loading in the vessel.

On smaller 150G and 300G systems, manually mixing the bed with a plow or hoe is not difficult and can lead to very high yields at high ratios and dosing, but at production system volumes of 500G or higher, this becomes more difficult. For production systems, we would recommend slowly stepping up the ratio and total loading until transfer rates and flow are hindered. If you do encounter a flow problem, spraying water through the underlet nozzles can help free up any stuck grounds and give the initial “rush” of flow to start the transfer process. Underlet nozzles are on all Deutsche steep tanks and if plumbed to a water vessel and pump, can be used to help unstick any beds in the steep tank.

The trials did not use the sparge nozzles that are included in every Deutsche steep tank. There is potential to modify your recipe to utilize a sparge step – either during a recirculation or a second “wetting” of the grounds to increase your total yield or concentrate. The nozzles help distribute an even spray of water over the entire bed, and may allow you to cut back on mixing, which can disturb the filter bed and make transferring more challenging. We encourage users to experiment utilizing the sparge nozzles at different temperatures to achieve desired results.