Patrick Watson

Team Second

MCEN 4151

11/10/2023

Espresso!

Purpose

The purpose of this report is to show the beauty behind pulling a shot of espresso. Making espresso in the morning has turned into art that many people throughout the world have turned to get their caffeine fix in the morning. The dedication to the setup of pulling the shot has become incredibly time consuming and meticulous just to maintain uniformity and repeatability. Making coffee in the morning has essentially turned into a chemistry lab procedure.

Context

To start the morning, espresso has made it easier to jumpstart myself to get into work or school work. My most prolific memory of espresso was when I came into work early and decided to make coffee. I found my boss making espresso. I reached over and ground enough beans to make myself coffee. My boss didn't tell me that he swapped the beans for his own. The look on his face when I ground his personal stash of beans by accident was horrifying. He let out a loud "Nooooo!" Frankly it was terrifying because I had just ruined my boss's espresso routine that morning and might have been in fear for my life by the look that he gave me. He was okay with it when he got past his grievance phase and even let me make the espresso for myself. My personal procedure for espresso is as follows. Starting by heating the brew head and portafilter, for the Flair 58 lever press, on the electric kettle for 30 minutes with water that is boiling at 203 degrees Fahrenheit. This prevents the metal parts from sapping heat away from the water that will be run through the fine espresso grinds. After the parts have been heated, measuring the correct proportions of beans for the grind step is critical. 18 grams is ideal for most people, I tend to grind ~18.4 grams. Grind size is critical for ensuring good taste. Too fine the coffee tastes bitter and to coarse will taste sour. Sour tasting coffee is awful and leaning towards bitter (finer) is best. Using my DF64P grinder, with high uniformity SSP burrs, I ground the 18.4 grams of espresso beans from Sweet Bloom in Denver. After grinding, even distribution of espresso grinds in the portafilter is vital. If unevenly dispersed, the result is an under extracted shot and will taste awful. After distribution comes tamping of the grinds into a densely packed puck. The portafilter with grinds is then placed into the heated brew head and hot water, from the kettle, is placed into the brew head. Pulling down on the lever until the pressure dial reads 3 bar for 5~7 seconds helps draw water into the espresso grinds for a pre-infusion. Then for the duration of the pull the lever is forced down to produce 9 bars of pressure. Total brew time is around 40 seconds. The size of the espresso grinds and how densely packed they are providing resistance as the water mixes and passes through to the cup underneath. I did this 9 times in one afternoon while trying to capture the espresso pull. You better believe that I didn't do all of this to just waste espresso. I drank it all, except for the last one. I did not feel well after.

Description

Capturing the texture and feel of the espresso during the pull is very complicated. The camera must be very close to maintain a good depth of field and the focus must be perfect. This is considered macro photography, and I was not using a macro lens. The most frequent user error was the depth of field being focused on the center but losing a lot of detail on the edges. Capturing the crema during the shot pull is vital to showing the flow physics. The crema essentially acts to show the direction of flow and provides contrast over the espresso. The total collected mass of espresso was 36 grams over 40 seconds of brew time. Using equation 1 we get the average mass flow rate.

$$\bar{\dot{m}} = \frac{m}{t} \qquad \textit{eqn. 1}$$

$$\bar{\dot{V}} = \frac{\bar{\dot{m}}}{\rho_{water}} \qquad \textit{eqn. 2}$$

This means that the total mass flow rate is 0.9 grams per second or 9e-4 kilograms per second for SI. Utilizing the density of water at 160 degrees Fahrenheit (about the temperature of the espresso) and equation 2, the volumetric flow rate is 9.026E-7 cubic meters per second. As gravity pulls on the espresso as it breaks the surface tension to create a stream, the stream will "neck down." What is happening is that the stream's average velocity is increasing in the axial direction of gravity. As velocity increases, conservation of mass says that the cross-sectional area will decrease to maintain constant flow rate. Because the crema and espresso offer contrasting colors, we can see the streams turbulence composition. We can say with certainty that it is laminar flow. Ideally the frame rate should be higher to resolve the photo in time better, but 4k video recording was prioritized to better resolve the flow physics. Also, a reduction in ISO would have increased image clarity and richness. Lighting was critical and was handled by 2 120Volt 60Hz 400 Lumen 2700k lightbulbs. The lightbulbs were placed above and then white paper was used to try and diffuser/bounce the light into the frame.

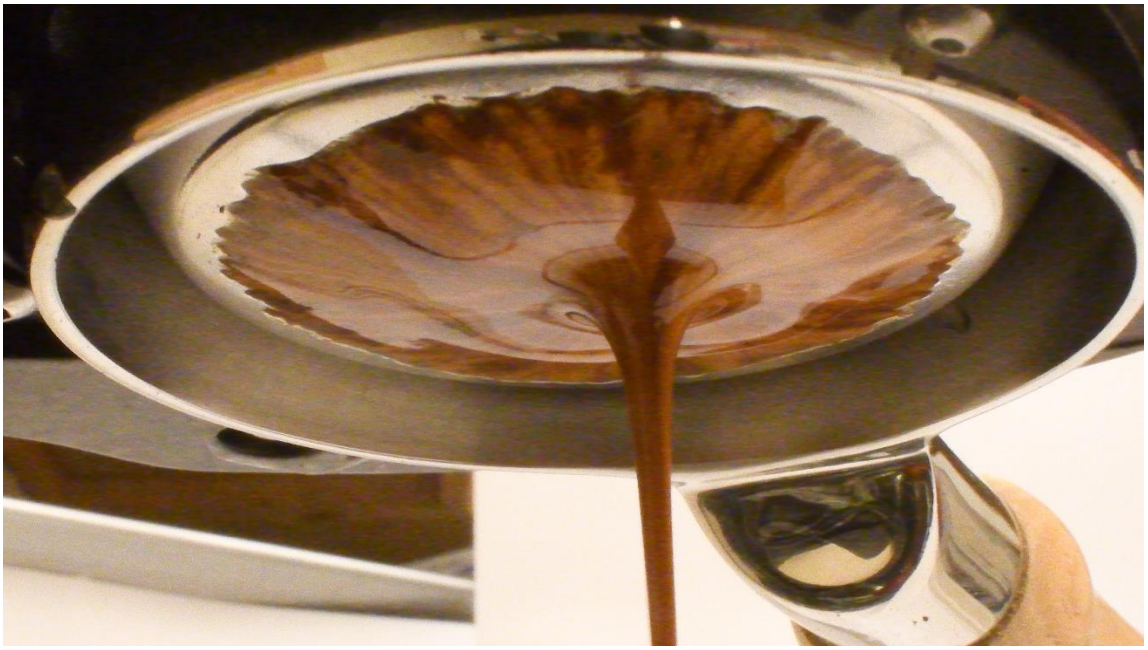

Figure 1: Unedited Photo.

Figure 2: edited photo to show off the deep rich colors and texture of espresso.

Camera	Nikon D7500
Focal Length	18mm
ISO	1250
FPS	30
Image Size (Pixels)	3840 x 2160

Table 1: Camera Specs

Conclusion

This project has been a lesson in patience and setup. Lighting has been critical for making sure that the flow and texture is captured. After many tries, the video was captured while being spatially resolved and mostly time resolved.

References

Hertzberg, Jean. “Overview 4 - Photography C: Lenses - Focal Length.” *Flow Visualization*, 25 July 2023, www.flowvis.org/Flow%20Vis%20Guide/overview-4-photography-3-lenses/.

“Dive into Anything.” *Reddit*, www.reddit.com/r/espresso. Accessed 11 Nov. 2023.