Development and Optimization of a "Hop Free" Beer

A Major Qualifying Project Report
submitted to the Faculty of Worcester Polytechnic Institute
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
in the field of Chemical Engineering.

Submitted on May 10th, 2020

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Abstract

The beer industry is diverse and has grown through experimentation. This project, completed in conjunction with Purgatory Brewing Co. of Northbridge, Ma, explored the use of hops as a preservative and flavor additive in beer. Hops are vital in modern beer recipes, but their strong taste can be off-putting to some. This report examines the feasibility of alternatives to hops that maintain similar preservative properties and provide desirable flavors. Following the completion of the brewing process, samples were subjected to spoiling tests to analyze their preservative capabilities. Due to the COVID-19 pandemic, chemical analysis of the samples were unable to be completed. The completed objectives as well as the incomplete data analysis procedures have all been outlined in this proposal.

Acknowledgments

We would like to thank the following people for their contributions to this project:

- Professor Stephen Kmiotek for his guidance and support throughout this project.
- Brian Distefano and Kevin Mulvehill for sponsoring our project and participating in our taste tests.
- The other Purgatory Beer MQP groups for collaborating with us and assisting us in learning experimental methods.
- Marissa Capua for teaching us how to homebrew and assisting us in making our Industry Based Juniper Raspberry beer recipe.

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1. Introduction

The brewing industry has developed greatly over many years, and the widespread popularity of craft brewing has contributed to a large part of this growth. Craft brewers are continually creating unique beer recipes, which are brewed in relatively small batches using different flavor profiles and brewing techniques [4]. The growth of the craft industry has reached 24% volume of the total U.S. beer market in 2018, consisting of over 7,000 operating breweries [14]. Nearly all craft breweries can be categorized as microbreweries, defined as a brewery with an output of less than 15,000 barrels of beer a year [10].

Hops are one of the basic ingredients found in nearly all beers. They have been used in beers for centuries as an ingredient that provides preservative properties and adds flavor [2]. Hops contain alpha acids, which give beer it's classic bitterness to balance out sweeter flavors from the grains [12]. Before hops became an essential ingredient for brewing, another type of beer was common. Called a gruit, this type of beer used a mixture of herbs and spices instead of hops to add balance and depth to the flavor [1]. Some of the ingredients used in gruit beers included heather flowers, spruce tips, borage, bog myrtle, sage, rosemary, and juniper.

For this project we worked with Purgatory Beer Co., a local microbrewery owned and operated by Brian DiStefano and Kevin Mulvehill. We used inspiration from gruit beer ingredients to create a modern hopless beer. Our objectives included developing new flavor profiles without bitterness from hops while simultaneously maintaining preservation properties. We aimed to provide Purgatory Brewing Co. with a chemical data analysis of different hop alternatives and beer flavors in order to create a quality hopless beer recipe. Due to the unprecedented circumstances arising from the COVID-19 pandemic, all experimentation and data collection was conducted remotely to the best of our ability after March 6th, 2020 following government mandates. This proposal contains information and data collected throughout the course of the year, as well as an overview of the procedures that were scheduled to be completed on campus after March 6th.

Prior to the mandated shutdown of WPI, our group completed the initial flavor matrix and brewing portion of the project. The first step began narrowing down flavoring combinations by infusing flavors into an existing flavorless beer and qualitatively eliminating the disliked combinations. We then brewed batches of the top three flavor combinations. For each batch, we created a matrix of samples using differing amounts of hop alternative and flavoring in order to determine the best ratio of hop alternative to flavor in our recipe. After the brewing process, we performed spoil tests on our beers to compare the preservative quality of the hop alternatives to that of traditionally brewed beer. The following objectives were unable to be completed due to the rapid spread of the pandemic and subsequent shutdown of the WPI campus. A Gas Chromatography-Mass Spectroscopy (GC-MS) device, would have been used to test samples of each hop alternative and flavor as well as each beer sample we brewed. Following the collection of GC-MS chemical composition data, our group would have objectively determined and ranked the best beers to find evidence of correlation between the data and our qualitative ratings.

2. Background

Craft brewing is a large and expanding market that has established itself independently from the traditional market of mass produced beers. By making beer in small batches, brewers are able to hone in on different flavor compositions and utilize complex brewing techniques that are not seen in large batch beers. Our group has worked with local brewery Purgatory Beer Co. to develop beer recipes created with nontraditional ingredients for unique flavors. The long-established base recipe for beer contains 4 main ingredients: water, grains, yeast, and hops. We looked into removing hops and experimenting with different flavor and preservation alternatives. Beers incorporate hops as a way to counteract the sweetness of the grains, add spicy, citrusy, herbal or even floral aromas, and introduce a bitter taste to the flavor profile. There are thousands of different hop varieties and each adds their own twist to the final brewed product. Additionally, hops are very important in the preservation of beer. It is found that through the process of brewing, hops impart different alpha and beta acids into the beer. The alpha acids are responsible for the bitter flavors of the hops while the beta acids have been found to slow down beer spoiling due to bacteria. The antiseptic properties in the beta acids of hops helped spread the consumption of hopped beer, as the product is able to be transported large distances without spoiling. Evidence of hop use in beer dates back as early as the 9th century and grew to be a widely popular practice by the 16th century [3]. During this time, gruit beers and hop flavored beers were in direct competition with each other, with hops eventually succeeding as the preferred flavorant.

Taking inspiration from gruit beers, we chose 6 different replacements for hops and started developing recipes based around them. The most promising of the hop replacements we found were heather flower, rosemary, juniper berries, yarrow, coriander, and sage, due to their historical use in gruit beers and other hopless beer alternatives. When choosing these replacements we took into account the ingredients preservative abilities and found that many of our alternatives contain a variety of different antiseptic, anti-inflammatory, and antimicrobial properties. In a 2014 study, heather extracts were tested for in-vitro antibacterial activity on 30 pathogenic bacterial strains of *Escherichia coli, Enterococcus faecalis* and *Proteus vulgaris.* This study found that heather extracts showed significant antibacterial activity on all tested strains [13]. In a 2005 study juniper oils were tested against bacterial species, yeast-like fungi, yeast, and dermatophyte species. The study found that the oil showed good antibacterial activity against 14 out of the 16 bacteria strains. Additionally, the juniper oil showed much stronger antifungal properties against the yeasts, yeast-like fungi and dermatophytes [6]. In a 2017 study, yarrow from India was studied for its antimicrobial properties against multiple bacteria strains including *Escherichia coli* and *Salmonella typhimurium*. Yarrow exhibited antimicrobial properties against all nine tested bacteria strains but with varying magnitudes ranging from low to moderate strength [11]. Researchers in a 2017 study tested the antibacterial activity of rosemary oils against standard strain and clinical strains of *Escherichia coli*. It was found that rosemary essential oil is active against all of the clinical strains from *Escherichia coli,* including efficacy

against strains that showed antibiotic resistance to Ampicillin, Piperacillin, and Ticarcillin [7]. Another proposed hop alternative (Coriandrum Sativum or coriander) has been found in essential oil form to be effective against a wide range of foodborne and clinically relevant gram-positive and gram-negative bacteria such as *Escherichia coli* , several Pseudomonas species, *B. gladioli*, *X. campestris,* and more. However, sources are not conclusive in determining if coriander is more effective at inhibiting bacterial growth in thicker cell wall gram positive or thin cell wall gram negative bacteria [8]. Finally, one of sages' components, *Salvia fructicosa*, was shown to exhibit antibacterial properties. A 1997 study used the essential oil of *Salvia fructicosa* to test its antibacterial properties. The study concluded that it had both antiviral and antibacterial properties [9]. With these studies in mind, our group could devise experimental flavor matrices that included a wide range of hop alternatives.

3. Methodology

The goal of this project was to develop a new beer recipe for Purgatory Beer Co. using different combinations and concentrations of hop alternatives and fruits. Additionally, this project was aimed to chemically analyze the flavors, aroma, and chemical structure present when using different combinations of hop alternatives and fruits in the same beer base. Similarly we looked to analyze the preservative properties of our hop replacements in the newly developed recipes. The following are objectives that were created to assist in the completion of these goals:

1. Produce preliminary flavor matrix samples to determine the sponsor's initial flavor preferences with different combinations of hop alternatives and fruits using Coors Light as a base beer. Review qualitative results to create a targeted secondary flavor matrix. From secondary results, determine best flavor combinations to homebrew.
2. Determine sponsor's optimal flavor ratio in homebrewed beer samples by adjusting hop alternative and fruit concentrations of the highest rated beers from the flavor test in Objective 1.
3. Analyze preservative properties of the varying hop replacements compared to traditionally brewed beer through extensive spoil testing.
4. Analyze all the hop alternatives and fruit flavors using GC-MS analysis to determine correlation between chemical structure and flavors.

3.1 Objective 1: Determine Primary Flavor Combinations of Hop Alternatives and Fruit using Coors Light

To narrow down our flavor profiles, we first performed tests with Coors Light to simulate beer samples we would later brew. We completed objective 1 using six hop alternatives; Juniper, Heather tips, Sage, Coriander, Rosemary, and Yarrow.

3.1.1 Determining Combination Trials to Test

We began testing with combinations of standard concentration of the hop alternative with a fruit pairing. The hop alternative and fruit pairings were determined through research of historically well-paired flavor combinations. All trials included one hop alternative and one fruit flavor combination. A single flavor combination could consist of a single fruit/spice ingredient or a mixture of 2 or more ingredients.

3.1.2 Dry Hopping Procedure

After determining the hop alternative and fruit pairings to make samples of, we ran trials with Coors Light as the base beer. We chose Coors Light due to its plain taste and low level of hops, to better understand how the hop alternatives and fruit influenced overall beer flavor. To test this, we began by acquiring ingredients outlined in the preliminary flavor matrix. Each hop alternative was purchased online. Sage, juniper berries, rosemary, and yarrow were purchased

online at Monterey Bay Spice Company. Heather tips were purchased online at Yakima Valley Hops. Coriander was purchased at Patel Brothers. Our methodology for dry hopping was as follows:

1. Fill half of an empty tea bag with hop alternative
2. Fill other half of bag with desired fruit
3. Fully immerse tea bag in the beer
4. Allow the beer and the teabag to sit for 15 minutes so the displaced carbonation can escape
5. Seal the jars and refrigerate for 5-8 days to maximize flavor expression

3.1.3 Taste Testing

Following the designated period of time, a taste test was performed to qualitatively analyze each beer sample. We brought our first round of samples to be tested by the owner of Purgatory Brewing. He tasted each sample and provided positive and negative feedback on the particular flavor and texture aspects. The team narrowed the matrix down to three hop alternatives and three fruit combinations based on his recommendations.

3.1.4 Dry Hopping Retest

After determining the hop alternatives and fruit combinations, the team prepared a second round of dry hopping using Coors Light. We utilized the procedure outlined in section 3.1.2, altering only Step 1 where the quantity of hop alternative in each sample increased from a half tea bag to a full tea bag. We conducted a secondary sample test with the sponsor to receive further feedback and determine the flavors which would be brewed to complete Objective 2.

3.2 Objective 2: Determine the Sponsor's Optimal Hop Alternative and Fruit Flavor

The next phase of this project was to brew batches of beer samples. We brewed these samples using our top three hop/flavor combinations, determined by reviewing the top scoring samples from the results of Objective 1. For each beer we used different quantities of both the hop alternatives and fruit combinations. We distributed beer into masons jars with twistable lids and added tea bags with specified hop and fruit ratios.

3.3 Objective 3: Spoil Testing

This test was utilized to determine the preservative qualities of each hop alternative used in our brewed beers. Samples of each of our brewed beers were opened and placed both inside and outside the refrigerator to be observed everyday. Changes in the samples were recorded and pictures were taken for visual purposes. The samples placed inside the refrigerator were poured into glass cups to mimic opened beer in a bottle that was unfinished. Most of the samples placed outside the refrigerator were poured into red solo cups to mimic a beer left out after a night of alcohol consumption. Due to the circumstances caused by the pandemic, the ability to use one

kind of cup to hold all samples in one area was limited. As a result some of the samples left outside the refrigerator were put into glass cups. These spoil tests ran for 2 weeks, to ensure the beers had ample time to develop notable spoiling characteristics including smell, bacteria growth, and mold. The beers were observed daily in order to track the progress of the spoiling.

3.4 Objective 4: Analyze the Beer Flavors Using Gas Chromatography-Mass Spectroscopy (GC-MS)

In order for the GC-MS to run properly, our samples would have had to be prepared in a specific way to render the beer compatible with the machine. Specifically, the organic constituents of the beer would have had to be extracted into an organic solvent and all water removed, using salt for dehydration. In a centrifuge tube, we would have added the salt, water, and dichloromethane as our solvent. We then would have poured the beer down the side of the tube slowly to prevent emulsification. After, we would have capped the centrifuge tubes and placed them in a centrifuge in Goddard Hall for 70 minutes at 10% power. Once the 70 minutes were complete we would have transferred the liquid layer of the centrifuge tubes to GC-MS vials with auto sampler tops and analyzed the samples in the Goddard Hall GC-MS.

4. Results and Discussion

4.1 Flavor Matrix

Our first flavor matrix partially took inspiration from well known combinations of fruit flavors in alcoholic drinks, which were matched to the best of our ability to the flavor profiles of our various hop alternatives. We also devised less traditional combinations in hopes of finding other interesting flavor profiles that could work in our beer. Based on our research, we drafted a preliminary matrix pairing each hop alternative with 2-3 flavor combinations as seen in Table 1 below.

Hop Alternative	Flavor Combination 1	Flavor Combination 2	Flavor Combination 3
Rosemary	Grapefruit and Pear (RGP)	Grape and Strawberry (RGS)	-
Sage	Lemon and Honey (SHL)	Cranberry, Lemon, and Lime (SCLL)	Blackberry (SB)
Coriander	Pomegranate, Apple, and Cinnamon (CCPA)	Papaya and Mango (CPM)	Grapefruit, Cranberry and Nutmeg (CGCN)
Heather	Banana and Apple (HBA)	Orange and Honey (HOH)	-
Yarrow	Honey and Lemon (YHL)	Apple and Orange (YAO)	-
Juniper	Raspberry (JR)	Mango and Strawberry (JMS)	Lemon and Raspberry (JLR)

Table 1: *Flavor Matrix for the first round of taste tests*

After developing this flavor matrix, we dry hopped the hops and flavor combinations into our base Coors Lite beer and allowed them to infuse for a week. Upon completion of the samples, our group along with the sponsor tasted the variety of flavor combinations and provided constructive comments about each specific beer to use moving forward. Feedback and comments on each beer from this test can be found in Appendix A.1.

Many of the samples were given negative reviews, allowing the team to quickly eliminate various hops and flavoring combinations. Additionally, positive feedback allowed our team to narrow down our flavor options to Juniper Rasberry, Heather Orange Honey, and Sage Honey Lemon which are highlighted in Appendix A.1.

The second round of taste testing only utilized the hops present in the best reviewed beers from the preliminary round. We began by focusing on understanding the individual flavors of the highly rated hop alternatives. This was achieved by boiling the hops in water to create a "tea". To explore a larger variety of flavor combinations for each hop alternative, we paired each alternative with new or altered flavor combinations. We used the same dry hopping technique as the first round of taste testing and the flavor matrix can be found below in Table 2.

Hop Alternative	Flavor Combination 1	Flavor Combination 2	Flavor Combination 3	Tea
Heather	Raspberry (HR)	Orange and Honey (HOH)	Lemon and Honey (HLH)	Heather Tea (H_{Tea})
Sage	Raspberry (SR)	Orange and Honey (SOH)	Lemon and Honey (SLH)	Sage Tea (S_{Tea})
Juniper	Raspberry (JR)	Orange and Honey (JOH)	Lemon and Honey (JLH)	Juniper Tea (J_{Tea})

Table 2: *Flavor Matrix for the second round of taste tests*

4.2 Homebrewing

While testing the flavor matrices with Purgatory Beer Co. to determine the best flavors for future brewing, our group had the opportunity to gain experience in basic homebrewing procedure and technique from WPI alumna Marissa Capua. Together, we created a beer recipe containing juniper berry, one of our proposed hop replacements. We brewed this beer using ingredients found in many of our sponsor's beer recipes, such as 2-row grain. The recipe and the procedure we followed to brew this beer can be found in Appendix B, and will be referred to as Industry Based Juniper Beer in this paper.

4.3 Taste Testing

The second round of tests with our sponsor included tasting the hop replacement teas, the dry hopped samples from Table 2, and the juniper raspberry beers we had brewed with Marissa C. Our sponsor's feedback for this round of taste tests can be found below in Appendix A.2.The top three flavor combinations from the second test would then be brewed in the next step. The top three combinations were Juniper Raspberry, Juniper Orange Honey, and Heather Lemon Honey. With three unique flavor combinations to brew, our group aimed to determine the best ratio of hop alternative to fruit flavoring for each. The matrix found in Table 3 lists the proportions for each sample of flavor combination we brewed.

Juniper Raspberry (JR)			Juniper Orange Honey (JOH)				Heather Lemon Honey (HLH)			
	Juniper (g)	Raspberry (g)		Juniper (g)	Orange (oz)	Honey (tsp)		Heather (g)	Lemon (oz)	Honey (tsp)
1	0	11.35	1	0	0.5	1/4	1	0	0.03	1/8
2	0.35	17.11	2	0.58	0.25	1/2	2	0.0425	0.06	-
3	0.7	22.88	3	1.06	0.5	3/4	3	0.0875	0.03	1/4
4	0.89	11.56	4	0	0.25	1/4	4	0.145	0.06	-
5	1.24	17.03	5	0.58	0.5	1/2	5	0.18	0.03	1/8
6	1.4	22.67	6	1.06	0.25	3/4	6	0.2225	0.06	-
7	0.53	11.42	7	0	0.5	1/4	7	0.265	0.03	1/4
			8	0.58	0.25	1/2	8	0.31	0.06	-
			9	1.06	0.5	3/4	9	0.35	0.03	1/8
							10	0.3975	0.06	-

Table 3: *Proportions of hop alternative to flavor for each batch of beer. The amounts of hop alternatives are the amounts that were used to dry hop.*

Each beer was named and numbered in a standard format, beginning with the initials of the flavor combination followed by sample number. For example, the Juniper Raspberry beer numbered 1 in the table is named JR-1. For all the Juniper Raspberry beers 2 oz of crushed juniper berries were initially added to each boil. The mass of juniper berries found in Table 3 refer to the dry hopped amount added during the second fermentation step along with the raspberries. The raspberries were added after the first fermentation to avoid a large increase in alcohol percentage caused by the fermentation of the raspberries. The Juniper Orange Honey beers had 2 oz of crushed juniper berries added to the boil as well as the amounts of orange peel indicated in Table 3. Like the Juniper Raspberry beers, the mass of juniper berries indicated in Table 3 were dry hopped into each sample during secondary fermentation. The Heather Lemon Honey beers contained 0.25 oz of heather tips during the boil and the values found in Table 3 indicate the amount of lemon. One of the two batches of this beer didn't have enough water to yield 5 samples of 1 cup like the other beers and instead yielded 5 samples of ½ cup each. Because the sample started out so small, the liquid was nearly impossible to separate from the dead yeast between fermentations. Because of this, all samples containing 0.06 oz of lemon were discarded and did not undergo a second fermentation. In the remaining HLH beers, the honey

was also added right before the second fermentation along with the additional amounts of heather tips found in Table 3. Pictures of the beers during the fermentation process can be found in Appendix C.

4.4 Spoil Testing

A spoil test was performed over the course of two weeks to directly compare the preservative qualities of juniper and heather to that of hops. Half of the beer samples were opened and placed inside of a refrigerator, and the other half were opened and left to stand at room temperature. After 2 weeks open at ambient temperature, nearly all beers had experienced notable changes. A small mass appeared in the Bud Light 4 days into the test, the first sample to exhibit characteristics of spoiling. The mass in the Bud Light had grown big enough to be photographed by Day 5, and can be seen as two circles connected together as seen in Figure 1 below. On Day 6, the mass had grown to nearly half the size of the beer in the glass, shown in Figure 2 below.

Figure 1: *Bud Light left unopened at room temperature for 5 days.*

Figure 2: *Bud Light left unopened at room temperature for 6 days.*

In the following days, the mass continued to grow to nearly the size of all the beer in the glass. Additionally, a small spot of white mold appeared and began to grow on the surface of the

beer. By Day 9, a circle of mold had formed on the surface around spots of white mold. The growth of the white mold on the mass can be seen in Figures 3 and 4 below.

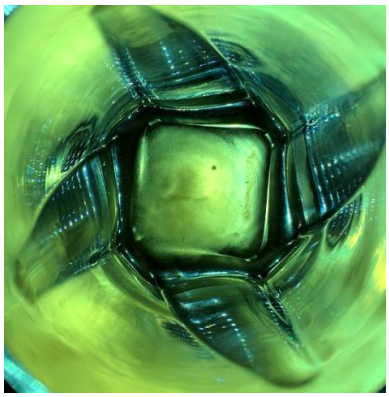

Figure 3: *Bud Light left unopened at room temperature for 7 days.*

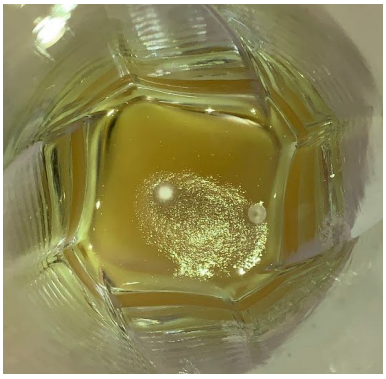

Figure 4: *Bud Light left unopened at room temperature or 9 days.*

The next day black mold had formed on the surface of the beer where the white mold circle had been the day before and had expanded to cover a larger surface area. An image of this is shown below in Figure 5. Black mold continued to grow and spread on the surface of the beer for the remainder of the testing period. By the final day of the test the surface was almost entirely covered in black mold along with a singular spot of white mold near the center. This is shown in Figure 6.

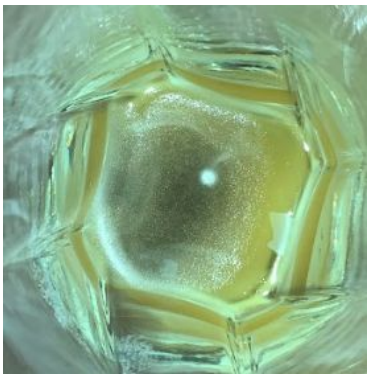

Figure 5: *Bud Light left unopened at room temperature for 10 days.*

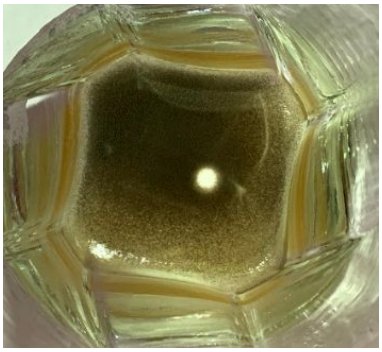

Figure 6: *Bud Light left unopened at room temperature for 14 days.*

The Industry Based Juniper Raspberry beer was the second sample at room temperatures outside to show signs of spoilage. Unlike the Bud Light, the Industry Based Juniper Raspberry did not develop mold or any visible indication of spoiling. This beer developed an abnormal smell on Day 5, one day after mold was observed in Bud Light. We noted small black specks at the bottom of the Industry Based Juniper Raspberry, however the same black specks were present in the other Juniper Raspberry as well as Juniper Orange Honey beers. We concluded that the black specks were remnants of the crushed juniper berries not captured in the filtering process we performed prior to bottling. After Day 5, the abnormal smell continued to grow stronger up to the conclusion of the test.

The remaining samples tested at room temperature behaved similarly during the 2 week period. For the majority of the spoil test, visual and olfactory changes could not be detected. On Day 10, a number of beer samples had thickened: JR-1, JR-4, JR-7, HLH-2, HLH-3, and HLH-5. These samples had a consistency similar to that of the thick malt extract used to brew them. HLH-3 was the most viscous sample, mimicking the consistency of molasses. The remnants of the beer shifted slowly after placing the cup sideways. The gradual shift of the beer created noticeable ripples seen in Figure 7, and did not lose its shape even after the cup was righted.

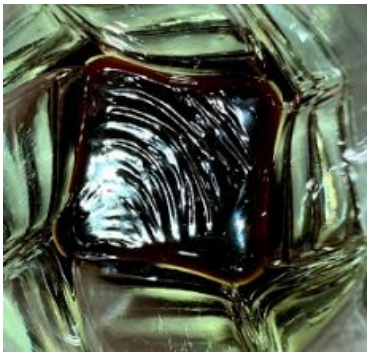

Figure 7: *HLH-3 left unopened at room temperature for 10 days.*

The viscosity of the beers continued to increase for the rest of the spoil test. HLH-3 was nearly solid on Day 12, showing no movement when the cup was tipped on its side as well as upside down. The next day JR-1 exhibited these same near solid properties. On the last day of testing, all of the beer samples were mixed with a knife. The aforementioned beers that became more viscous over the course of the 2-week test were difficult to mix. The contents of all of these samples had to be scraped off the knife on the side of the cup and were left in a large clump after mixing. JR-3 had also become slightly thicker during this test, but remained mostly liquid and did not get stuck to the knife after mixing. Pictures of each beer after mixing on the last day can be found in Appendix D.29. We predict that the thickening of the beers is not a result of spoilage, rather a result of insufficient water used during the initial brewing process. The water in the beer samples likely evaporated to varying degrees during the spoil test. The inconsistencies between samples can be attributed to the different amounts of water used during each batch of brewing, as the batches were individualized based on the recipe outlined in the final flavor matrix.

The remaining samples tested at room temperature not discussed in the above sections showed no signs of thickening or spoilage during the two week spoil test. Pictures of each beer sample every day can be found in Appendix D.

Identical samples were concurrently opened and placed in a refrigerator during the same 2 week period. Unlike the Bud Light at room temperature, the open Bud Light in the refrigerator showed no signs of spoilage during the 2 week period. Similarly, the Industry Based Juniper Raspberry inside the refrigerator showed no signs of spoilage. The black specks attributed to unfiltered crushed juniper berries were present in this sample as well. On Day 8, a thin clear layer appeared on the surface of the sample, which was unable to be captured on camera. We concluded that the clear layer was not a sign of spoilage after receiving advice from Marissa Capua and referencing information obtained from BeerAdvocate [5]. The clear layer likely originated from juniper berry based oils settling at the top. Furthermore, a taste test confirmed that this oil layer does not affect the taste of the beer.

As with the room temperature samples, the rest of the juniper beer in the refrigerator also had varying amounts of black specks in them. JR-2 contained these specks, as well as a layer of darker mass that had been present from the beginning of the spoil test. This was most likely dead yeast that wasn't properly removed during the filtration process. JR-2 showed no other visual changes or changes in smell, indicating that there was no spoilage during the test period.

A few samples in the refrigerator exhibited thickening as well. On Day 12, HLH-4 and HLH-5 were first observed to thicken. Over the next two days, the viscosity of HLH-4 grew to the point that the sample was very difficult to mix on the last day of the testing period. The beer stuck to the knife used to mix the sample in a sticky thick mass. HLH-5 was also thick when mixed on Day 14, but significantly less so than HLH-4. HLH-3 was mostly liquid with slight thickness, and did not stick to the knife or clump up after being mixed. Pictures of all three of these beers after being mixed can be found in Appendix D.30. The thickening of the refrigerated beers is also attributed to the evaporation of water from the sample and not spoilage of the beer.

Following the completion of the initial spoil test, the thickened samples were discarded and all remaining samples in liquid form were kept in the same conditions to observe any further significant changes. After 2 more days, all of the beers we brewed from the final flavor matrix had thickened except the Industry Based Juniper Raspberry and the Bud Light. We brewed beer from the final flavor matrix in exceptionally small batches, due to the number of unique samples needed. We hypothesize that the amounts of water used in this unconventional brewing process was insufficient for the beers to retain liquid over a two week period. After acknowledging that the lack of water affected all final flavor matrix samples to some degree, it is reasonable that the Industry Based Juniper Raspberry and Bud Light lasted the longest. After observing these beers for another week, we noticed that the liquid level of the Industry Based Juniper Raspberry beer had decreased significantly more than the liquid level of the Bud Light. A picture of the two side by side can be seen below in Figure 8.

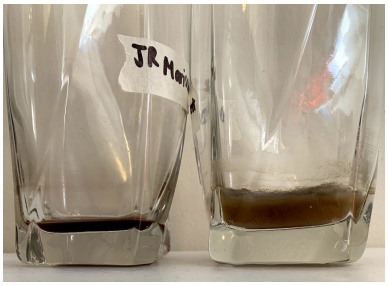

Figure 8: *Industry Based Juniper Raspberry (left) and Bud Light (right) left unopened at room temperature for 3 weeks.*

As can be seen in Figure 8, the liquid level of the Industry Based Juniper Raspberry beer is much lower than that of the Bud Light, despite samples starting at the same liquid height at the beginning of the spoil test. We predict this difference is due to the independent rates of evaporation in the two beers. As can seen here the layer of mold on the top of the Bud Light is fairly thick and covers the whole surface of the beer. We theorized that the rate of evaporation is

slower, as the liquid is not directly interacting with the air. On the other hand, the Industry Based Juniper Raspberry beer evaporated relatively faster with no physical barrier covering the surface of the liquid.

4.5 Project Interruption

The beer taste test yielded qualitative information about our beers. For quantitative information, we had planned to analyze GC-MS data of each individual beer sample. In doing so, we hoped to obtain insight on the compounds present in our beers and compare flavor variations at a molecular level. This data would allow us to understand more about the flavors that worked well, as well as the ones that did not. Furthermore, we aimed to identify compounds commonly found in the disliked beers to inform our sponsor of flavors and compounds to avoid in future brews.

In addition our team planned to participate in another round of taste testing with our sponsor. This final taste test would have aimed to determine the sponsor's preferred hop alternative to flavor ratio for each flavor combination: Juniper Raspberry, Juniper Orange Honey, and Juniper Lemon Honey as well as an overall best beer. Ideally, we would have worked with our sponsor to refine our best sample's recipe and brewing procedure to scale to an industrial batch size. Due to the COVID-19 pandemic and government recommended safety precautions, we were not able to try the final samples with our sponsor. This prevented us from working directly with the brewery to create an industrial hop free beer recipe, but we hope our sponsor can utilize what we learned for his future endeavors creating new beers.

5. Conclusions

The primary goal of this project was to create a unique hop-less beer recipe using different combinations of hop alternatives and fruit flavors. Based on preliminary results from a qualitative taste test done by our sponsor, we could create better recipes to taste with a smaller sample size of flavors. We found that Coriander, Rosemary, and Yarrow did not make flavors of beers that our sponsor was interested in, which quickly eliminated these flavors in the first round of testing. The three most positive flavors contained the hop alternatives Juniper, Heather tips and Sage. With this information, we created a new set of samples to be tested and rated by our sponsor. The secondary taste test eliminated sage entirely as a hop alternative for brewing, and three best combinations, Juniper Raspberry, Juniper Orange Honey and Heather Lemon Honey would continue in the next step of the project.

We decided to use each of the preliminary hop alternatives due to evidence of strong preservative properties, which would be necessary to replace hops in a beer recipe. After determining the two best hop alternatives, their ability to preserve beer was tested by performing a spoil test. At the end of the spoil test, the control sample of industrial beer containing traditional hops was shown to have spoiled the fastest. This could have been due to many different factors including brewing method, shelf life, and storage of this beer. However, based on this test, our data supports the claim that hop replacements could be used in future brewing.

The recipe we found that we like the best was for the Industry Based Juniper Raspberry beer. This was brewed under the supervision of Marissa Capua, whose knowledge of beer making ensured our product was high quality and rated well in taste tests.

6. Recommendations

For future tests, we believe several factors from our project can be modified in order to ensure the best possible results. Even after consultation with Marissa Capua, our team struggled with the homebrewing aspect of this project. We had limited resources directly affecting the amount of ingredients we were able to add to our batches. Given the size of the pots available to brew in, we weren't able to add as much water as would normally be added to a boil. Additionally, choosing to brew with a viscous malt extract rather than malt grains led to a darker and thicker beer than expected. This malt extract had a very strong, sweet smell and flavor that overpowered that of the ingredients being tested. When brewing with Marissa, she used a crystalized malt extract and had equipment to brew with an ample amount of water. We would recommend using a crystalized malt over malt extract, and obtaining equipment to fit the needs of the brewing process. Additionally, we recommend using a lid during the boil, especially with smaller pots, to prevent excessive evaporation and minimize temperature changes that may occur, which is an important factor in the boil. It would also be wise to focus on one or two batches at a time so you can be diligent in timing the brewing steps and preventing major temperature fluctuation.

Given the time constraints of this project, we were only able to test a few different proportions of flavor to hop alternative. In order to expand on our work, another team could test more flavor combination ratios to determine the best product possible. The brewing process is very time consuming, so we would recommend focusing on one flavor combination and adjusting the amount of the specific ingredients.

If more ideal circumstances were available, we would make several changes to our spoil testing. First, we would perform the test in a controlled laboratory environment, where the room temperature is well controlled and outside contamination can be minimized. Ideally, the same type of cup would be used to hold all samples of beer both in and out of the refrigerator. Preferably, the cups would be clear glass, to mimic the storage material of a glass beer bottle and to be able to observe the beer from all angles. Furthermore, it would be best to start the spoil test right after the brewing process ends to determine its shelf life. A control beer for the spoil test should contain hops and have a similar shelf life to the beer(s) being tested for consistency. This can be done by purchasing an industrially produced beer or brewing your own beer with hops at the same time as the hopless beer(s). It is also important to have the same amount of liquid in all samples such that they evaporate an equal amount over the course of the test. If the samples do evaporate at different rates, it will indicate that the ingredients in the beer are contributing to a faster evaporation and is not a result of the amount of liquid present at the start of the test.

Another way to build off of this project is to recreate the Industry Based Juniper Raspberry beer into a "sour", a type of beer characterized by fruit flavors and tart taste. During the second taste test, our sponsor mentioned that the sample reminded him of a sour and that it could be a good direction to go in if time permitted. He recommended using lactose to sour the beer.

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Appendices

Appendix A: Flavor Matrices

A.1- Taste Test 1

Flavor Combination + Hop Alternative	Comments from Sponsor
JLR	Very lemony, not very junipery-good, (could make into a sour)
JMS	Needs more juniper, smell mango, taste little strawberry
JR	REALLY GOOD, needs more juniper
CCPA	Not good, tastes like air freshener
CPM	Not a fan, tastes like soap
CGCN	Ok
YHL	Tastes like grapefruit
YAO	Ok, not a lot going on
HBA	Tastes like tea: only apple really comes through
HOH	Good taste
SB	Not terrible
SHL	Nice, very lemony
SCLL	Too much lemon
RGS	Ok: tastes like juice box, has different texture than others
RGP	Can only taste pear

Table 4: *Taste Test 1 feedback. Those highlighted in green are the three best samples.*

A.2- Taste Test 2

Flavor Combination + Hop Alternative	Comments from Sponsor
H_{Tea}	Nice taste, smells like earl grey tea
J_{Tea}	Not bad, tastes like Vic's secret hop but not bitter, smells like air freshener
S_{Tea}	**Gross**, HORRIBLE, tastes like Christmas
HLH	Not bad, lemony, boozy taste: like lemon, tastes like chardonnay
HOH	Smells good, sweet, watery aftertaste, ok
HR	Nice, raspberry is good
SLH	Did not taste
SOH	Did not taste
SR	Not good, sage is not good
JLH	Not bad, little too sweet
JOH	Smells delicious, smooth, good, orange acid balances sweet
JR	Smells like a sour, tastes like a sour, GOOD

Table 5: *Taste Test 2 feedback. Those highlighted in green are the three best samples.*

Appendix B: Industry Based Juniper Raspberry Recipe

Industry Based Juniper Raspberry Gruit Ale
These are instructions for a 5 gallon batch using the brew-in-a-bag, all-grain method.

Equipment

- Brew kettle
- Thermometer
- Large mesh bag
- Clips
- Large spoon or mash paddle
- Auto siphon
- Plastic tubing
- Bottling bucket
- Fermentation bucket
- Lid for fermenter
- 3-piece airlock
- Filter
- Sanitizer
- Large bucket or Rubbermaid bin for sanitizing solution
- Outdoor propane burner
- Propane tank
- Long Lighter
- Hydrometer
- Cylinder
- Spring-loaded bottling wand
- 2 cases of 22 oz. brown bottles
- Bottle caps
- Bottle capper

Ingredients

- 6 lb 2-Row
- 2 lb White Wheat
- 0.75 lb Flaked White Wheat
- 0.5 lb Caramel/Crystal 40
- 1 oz Juniper Berries (crushed, boil @ 15 min)
- 3 lb Raspberries (puree & pasteurize before addition)
- Wyeast American Wheat 1010
- Priming Sugar

Procedure

Brew Day

- Preparing your sanitizing solution - 1 oz of Star San for every 5 gallons of water.
- Add 4 gallons (mash thickness ~1.75 qt/lb) of spring water to brew kettle. Heat to 158°F.
- Add mesh bag of grains and steep at 149°F for 60 min.
- Mash out at 168°F for 10 min.
- Transfer wort and grain bag from kettle to bottling bucket. Open spigot slightly and let wort drain slowly back into kettle.
- Heat 3.75 gal sparge water to 175°F. Add sparge water and let drain into kettle. Kettle full/pre-boil volume: _____ gal (Target: 6.5 gal)
- Boil for 60 minutes. Add juniper berries @ 15 min.
- Turn off heat and begin cold crash. Cool to 75-80°F.
- Transfer wort through filter and into fermentation bucket.
- Record final volume: _____ gal
- Take a gravity reading. Original Gravity: _____ (Target OG: 1.052)
- Take a temperature reading, then pitch yeast. Temperature: _____°F (Target: 65-72°F)

- Close fermentation bucket with sanitized lid. Fill airlock with sanitizer and add to lid.

Fermentation

- Store fermentation bucket in a dark place with a consistent temperature. Fermentation target temperature range: 65°F-72°F
- Allow 7-10 days for primary fermentation. Check for consistent gravity readings. Primary Final Gravity: _____ (Target FG: 1.012)
- Add pureed raspberries to sanitized glass carboy. Transfer beer to carboy and circulate. Take a gravity reading. Secondary Original Gravity: _____. Seal with stopper and airlock.
- Allow 1-2 weeks for secondary fermentation.
- Take a final gravity reading. Secondary Final Gravity: _____

Packaging

- Sanitize 2 cases of 22 oz. brown glass bottles, caps, bottle capper, plastic tubing, bottling wand, and auto siphon.
- Prepare priming sugar solution.
- Add priming sugar solution to sanitized bottling bucket, then carefully transfer beer from glass carboy to bottling bucket, using sanitized auto siphon and filter. Avoid pulling trub from carboy, and avoid splashing.
- Fill bottles with beer, leaving approximately 1 inch of space at top. Place caps on top and use bottle capper to seal.
- Store filled bottles at room temperature in a dark place for about 2 weeks to allow for bottle conditioning/carbonation.
- After 2 weeks have passed, place one bottle in the fridge to chill. Once chilled, taste test. If it tastes too flat, give it another few days. If you are satisfied with the level of carbonation, then place the rest of the bottles in the fridge--they are done.

Appendix C: Fermentation Pictures

Juniper Raspberry

Figure 9: *Fermentation of JR.*

Juniper Orange Honey

Figure 10: *Fermentation of JOH.*

Heather Lemon Honey

Figure 11: *Fermentation of HLH.*

Figure 12: *Dead yeast clumps surface of JR.*

Appendix D: Spoil Test Pictures

D.1- *Day 0 Room Temperature:*

Bud Light:

Figure 13: *Bud Light left unopened outside the refrigerator for 0 days.*

Heather Lemon Honey:

Figure 14: *Heather Lemon Honey left unopened outside the refrigerator for 0 days.*

Juniper Raspberry:

Figure 15: *Juniper Raspberry left unopened outside the refrigerator for 0 days.*

Juniper Orange Honey:

Figure 16: *Juniper Orange Honey left unopened outside the refrigerator for 0 days.*

Industry Based Juniper Raspberry:

Figure 17: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 0 days.*

D.2- ***Day 0 Refrigerated:***

Bud Light:

Figure 18: *Bud Light left unopened inside the refrigerator for 0 days.*

Heather Lemon Honey:

Figure 19: *Heather Lemon Honey left unopened inside the refrigerator for 0 days.*

Juniper Raspberry:

Figure 20: *Juniper Raspberry left unopened inside the refrigerator for 0 days.*

Juniper Orange Honey:

Figure 21: *Juniper Orange Honey left unopened inside the refrigerator for 0 days.*

Industry Based Juniper Raspberry:

Figure 22: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 0 days.*

D.3- ***Day 1 Room Temperature:***

Bud Light:

Figure 23: *Bud Light left unopened outside the refrigerator for 1 day.*

Heather Lemon Honey:

Figure 24: *Heather Lemon Honey left unopened outside the refrigerator for 1 day.*

Juniper Raspberry:

Figure 25: *Juniper Raspberry left unopened outside the refrigerator for 1 day.*

Juniper Orange Honey:

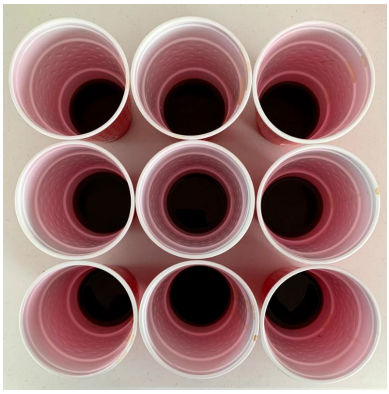

Figure 26: *Juniper Orange Honey left unopened outside the refrigerator for 1 day.*

Industry Based Juniper Raspberry:

Figure 27: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 1 day.*

D.4- ***Day 1 Refrigerated:***

Bud Light:

Figure 28: *Bud Light left unopened inside the refrigerator for 1 day.*

Heather Lemon Honey:

Figure 29: *Heather Lemon Honey left unopened inside the refrigerator for 1 day.*

Juniper Raspberry:

Figure 30: *Juniper Raspberry left unopened inside the refrigerator for 1 day.*

Juniper Orange Honey:

Figure 31: *Juniper Orange Honey left unopened inside the refrigerator for 1 day.*

Industry Based Juniper Raspberry:

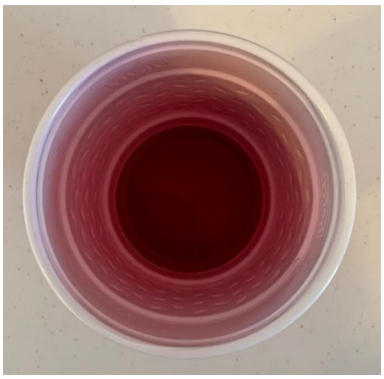

Figure 32: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 1 day.*

D.5- *Day 2 Room Temperature:*

Bud Light:

Figure 33: *Bud Light left unopened outside the refrigerator for 2 days.*

Heather Lemon Honey:

Figure 34: *Heather Lemon Honey left unopened outside the refrigerator for 2 days.*

Juniper Raspberry:

Figure 35: *Juniper Raspberry left unopened outside the refrigerator for 2 days.*

Juniper Orange Honey:

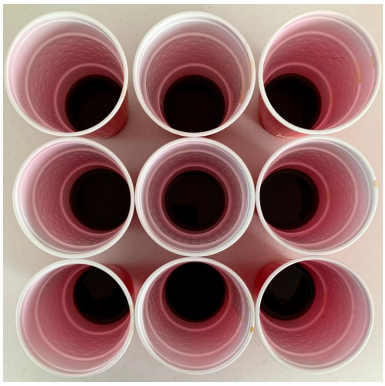

Figure 36: *Juniper Orange Honey left unopened outside the refrigerator for 2 days.*

Industry Based Juniper Raspberry:

Figure 37: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 2 days.*

D.6- *Day 2 Refrigerated:*

Bud Light:

Figure 38: *Bud Light left unopened inside the refrigerator for 2 days.*

Heather Lemon Honey:

Figure 39: *Heather Lemon Honey left unopened inside the refrigerator for 2 days.*

Juniper Raspberry:

Figure 40: *Juniper Raspberry left unopened inside the refrigerator for 2 days.*

Juniper Orange Honey:

Figure 41: *Juniper Orange Honey left unopened inside the refrigerator for 2 days.*

Industry Based Juniper Raspberry:

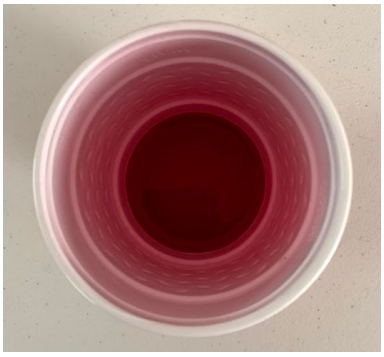

Figure 42: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 2 days.*

D.7- *Day 3 Room Temperature:*

Bud Light:

Figure 43: *Bud Light left unopened outside the refrigerator for 3 days.*

Heather Lemon Honey:

Figure 44: *Heather Lemon Honey left unopened outside the refrigerator for 3 days.*

Juniper Raspberry:

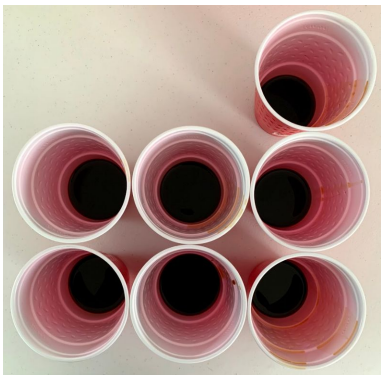

Figure 45: *Juniper Raspberry left unopened outside the refrigerator for 3 days.*

Juniper Orange Honey:

Figure 46: *Juniper Orange Honey left unopened outside the refrigerator for 3 days.*

Industry Based Juniper Raspberry:

Figure 47: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 3 days.*

D.8- ***Day 3 Refrigerated:***

Bud Light:

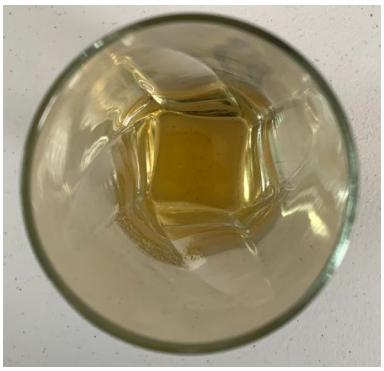

Figure 48: *Bud Light left unopened inside the refrigerator for 3 days.*

Heather Lemon Honey:

Figure 49: *Heather Lemon Honey left unopened inside the refrigerator for 3 days.*

Juniper Raspberry:

Figure 50: *Juniper Raspberry left unopened inside the refrigerator for 3 days.*

Juniper Orange Honey:

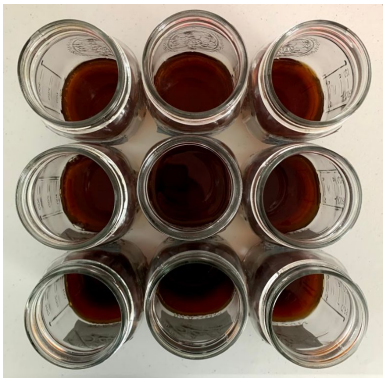

Figure 51: *Juniper Orange Honey left unopened inside the refrigerator for 3 days.*

Industry Based Juniper Raspberry:

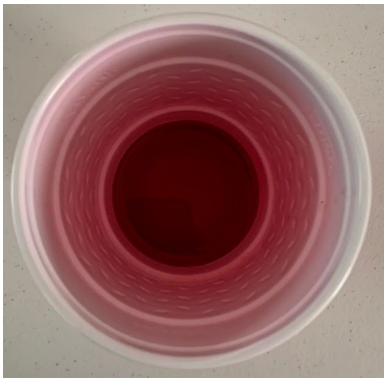

Figure 52: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 3 days.*

D.9- ***Day 4 Room Temperature:***

Bud Light:

Figure 53: *Bud Light left unopened outside the refrigerator for 4 days.*

Heather Lemon Honey:

Figure 54: *Heather Lemon Honey left unopened outside the refrigerator for 4 days.*

Juniper Raspberry:

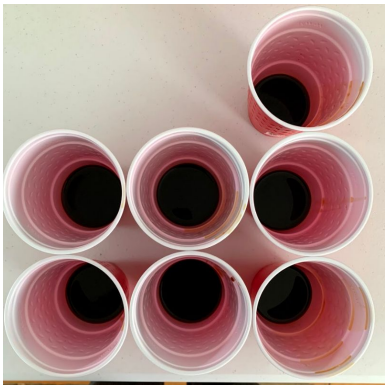

Figure 55: *Juniper Raspberry left unopened outside the refrigerator for 4 days.*

Juniper Orange Honey:

Figure 56: *Juniper Orange Honey left unopened outside the refrigerator for 4 days.*

Industry Based Juniper Raspberry:

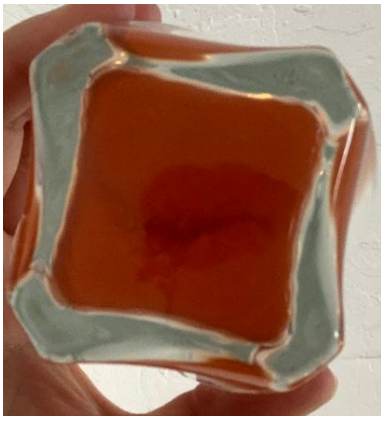

Figure 57: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 4 days.*

D.10- ***Day 4 Refrigerated:***

Bud Light:

Figure 58: *Bud Light left unopened inside the refrigerator for 4 days.*

Heather Lemon Honey:

Figure 59: *Heather Lemon Honey left unopened inside the refrigerator for 4 days.*

Juniper Raspberry:

Figure 60: *Juniper Raspberry left unopened inside the refrigerator for 4 days.*

Juniper Orange Honey:

Figure 61: *Juniper Orange Honey left unopened inside the refrigerator for 4 days.*

Industry Based Juniper Raspberry:

Figure 62: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 4 days.*

D.11- ***Day 5 Room Temperature:***

Heather Lemon Honey:

Figure 63: *Heather Lemon Honey left unopened outside the refrigerator for 5 days.*

Juniper Raspberry:

Figure 64: *Juniper Raspberry left unopened outside the refrigerator for 5 days.*

Juniper Orange Honey:

Figure 65: *Juniper Orange Honey left unopened outside the refrigerator for 5 days.*

Industry Based Juniper Raspberry:

Figure 66: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 5 days.*

D.12- ***Day 5 Refrigerated:***

Bud Light:

Figure 67: *Bud Light left unopened inside the refrigerator for 5 days.*

Heather Lemon Honey:

Figure 68: *Heather Lemon Honey left unopened inside the refrigerator for 5 days.*

Juniper Raspberry 1:

Figure 69: *JR-1 left unopened inside the refrigerator for 5 days.*

Juniper Raspberry 2:

Figure 70: *JR-2 left unopened inside the refrigerator for 5 days.*

Juniper Raspberry 3:

Figure 71: *JR-3 left unopened inside the refrigerator for 5 days.*

Juniper Raspberry 4:

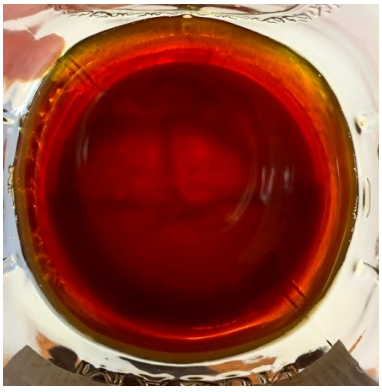

Figure 72: *JR-4 left unopened inside the refrigerator for 5 days.*

Juniper Raspberry 5:

Figure 73: *JR-5 left unopened inside the refrigerator for 5 days.*

Juniper Raspberry 6:

Figure 74: *JR-6 left unopened inside the refrigerator for 5 days.*

Juniper Raspberry 7:

Figure 75: *JR-7 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 1:

Figure 76: *JOH-1 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 2:

Figure 77: *JOH-2 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 3:

Figure 78: *JOH-3 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 4:

Figure 79: *JOH-4 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 5:

Figure 80: *JOH-5 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 6:

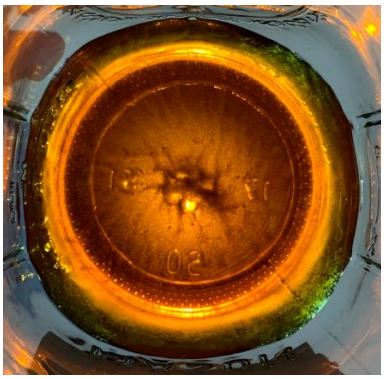

Figure 81: *JOH-6 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 7:

Figure 82: *JOH-7 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 8:

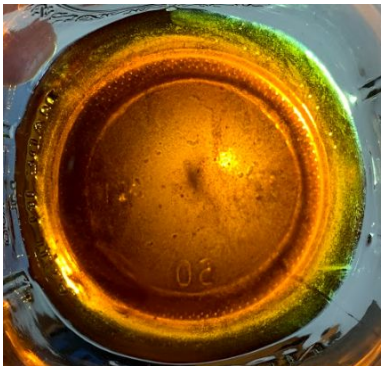

Figure 83: *JOH-8 left unopened inside the refrigerator for 5 days.*

Juniper Orange Honey 9:

Figure 84: *JOH-9 left unopened inside the refrigerator for 5 days.*

Industry Based Juniper Raspberry:

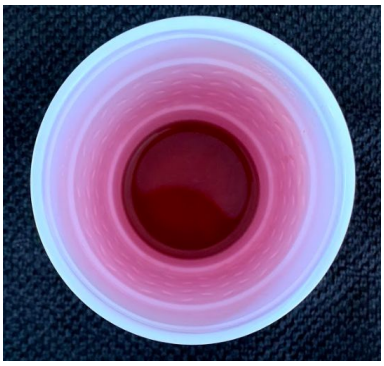

Figure 85: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 5 days.*

D.13- *Day 6 Room Temperature:*

Heather Lemon Honey:

Figure 86: *Heather Lemon Honey left unopened outside the refrigerator for 6 days.*

Heather Lemon Honey 1:

Figure 87: *HLH-1 left unopened outside the refrigerator for 6 days.*

Heather Lemon Honey 2:

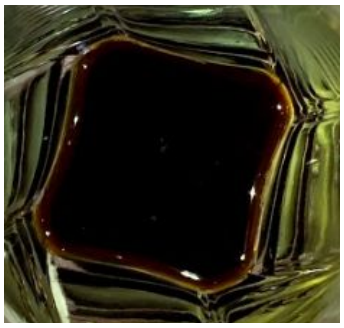

Figure 88: *HLH-2 left unopened outside the refrigerator for 6 days.*

Heather Lemon Honey 4:

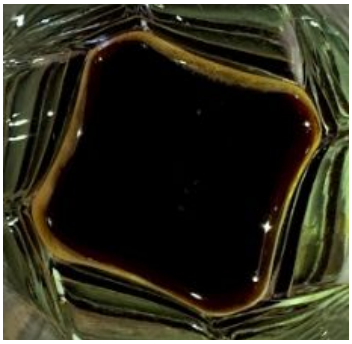

Figure 89: *HLH-4 left unopened outside the refrigerator for 6 days.*

Heather Lemon Honey 5:

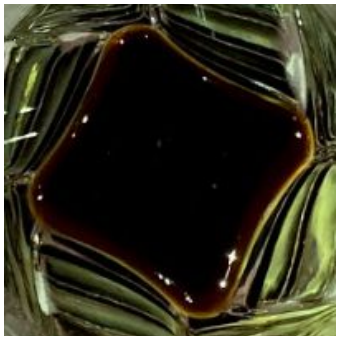

Figure 90: *HLH-5 left unopened outside the refrigerator for 6 days.*

Juniper Raspberry:

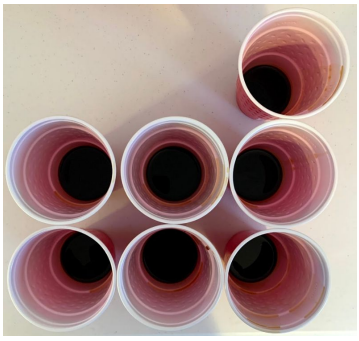

Figure 91: *Juniper Raspberry left unopened outside the refrigerator for 6 days.*

Juniper Raspberry 1:

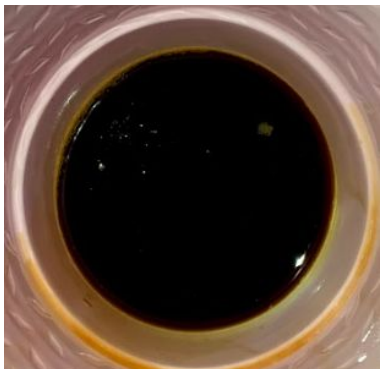

Figure 92: *JR-1 left unopened outside the refrigerator for 6 days.*

Juniper Raspberry 3:

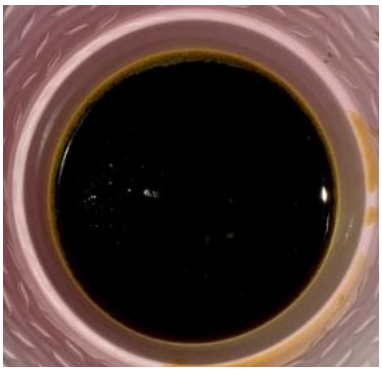

Figure 93: *JR-3 left unopened outside the refrigerator for 6 days.*

Juniper Orange Honey:

Figure 94: *Juniper Orange Honey left unopened outside the refrigerator for 6 days.*

Industry Based Juniper Raspberry:

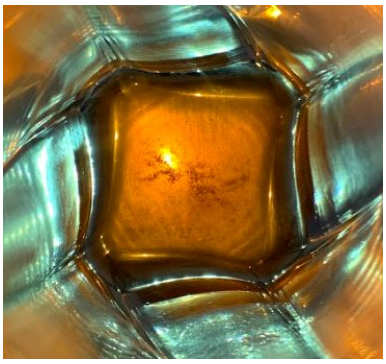

Figure 95: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 6 days.*

D.14- ***Day 6 Refrigerated:***

Bud Light:

Figure 96: *Bud Light left unopened inside the refrigerator for 6 days.*

Heather Lemon Honey:

Figure 97: *Heather Lemon Honey left unopened inside the refrigerator for 6 days.*

Heather Lemon Honey 1:

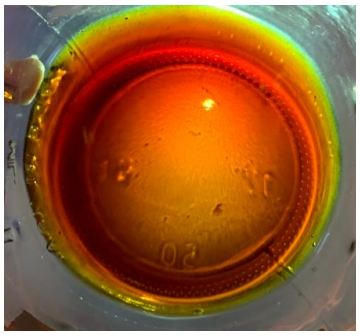

Figure 98: *HLH-1 left unopened inside the refrigerator for 6 days.*

Juniper Raspberry 1:

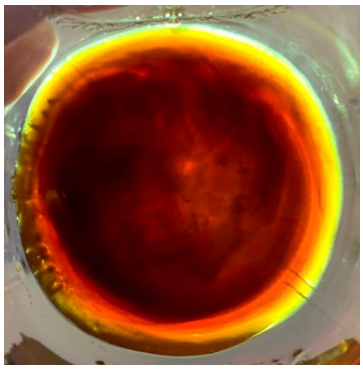

Figure 99: *JR-1 left unopened inside the refrigerator for 6 days.*

Juniper Raspberry 2:

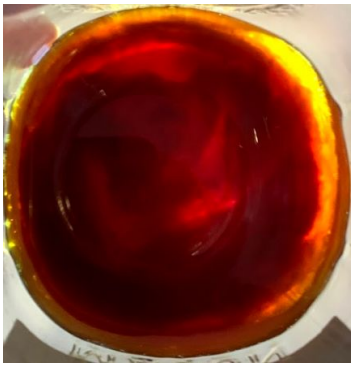

Figure 100: *JR-2 left unopened inside the refrigerator for 6 days.*

Juniper Raspberry 3:

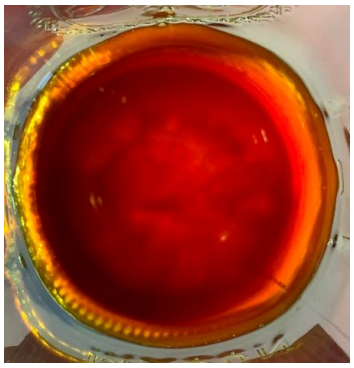

Figure 101: *JR-3 left unopened inside the refrigerator for 6 days.*

Juniper Raspberry 4:

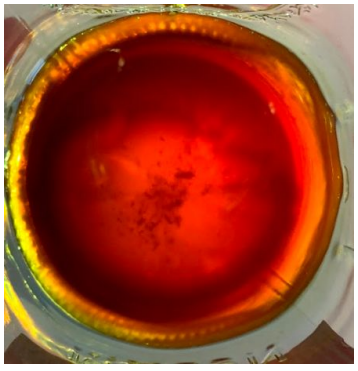

Figure 102: *JR-4 left unopened inside the refrigerator for 6 days.*

Juniper Raspberry 5:

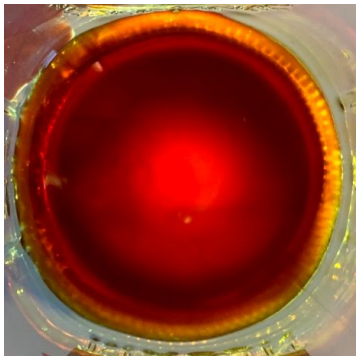

Figure 103: *JR-5 left unopened inside the refrigerator for 6 days.*

Juniper Raspberry 6:

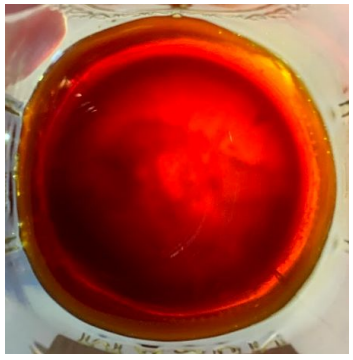

Figure 104: *JR-6 left unopened inside the refrigerator for 6 days.*

Juniper Raspberry 7:

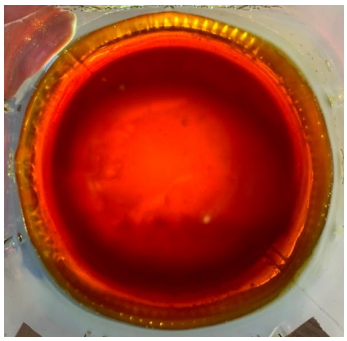

Figure 105: *JR-7 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 1:

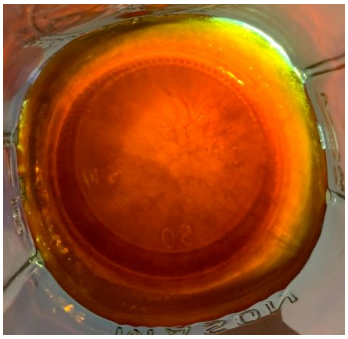

Figure 106: *JOH-1 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 2:

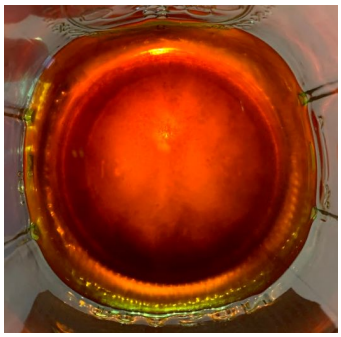

Figure 107: *JOH-2 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 3:

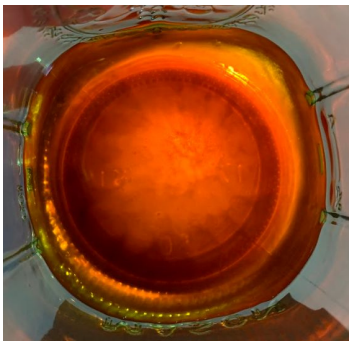

Figure 108: *JOH-3 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 4:

Figure 109: *JOH-4 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 5:

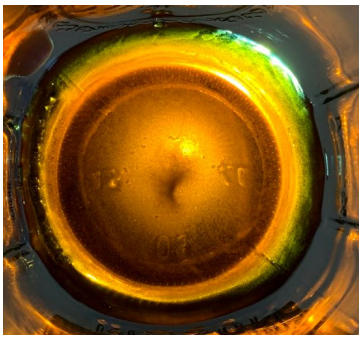

Figure 110: *JOH-5 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 6:

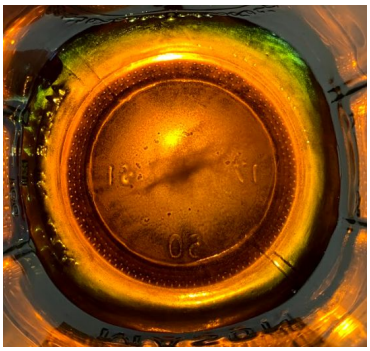

Figure 111: *JOH-6 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 7:

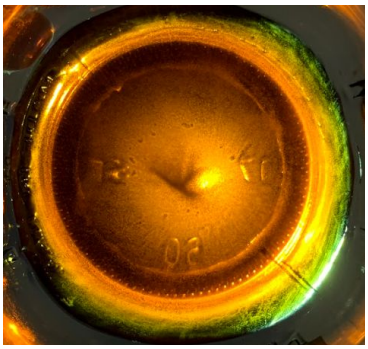

Figure 112: *JOH-7 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 8:

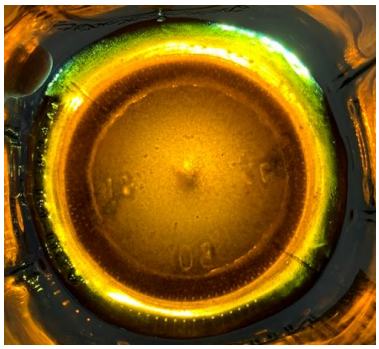

Figure 113: *JOH-8 left unopened inside the refrigerator for 6 days.*

Juniper Orange Honey 9:

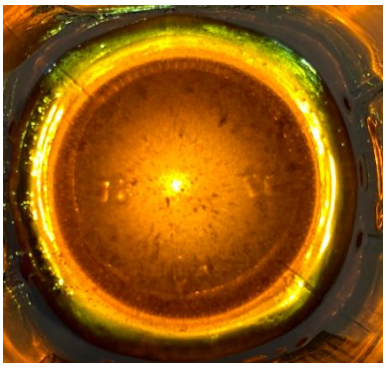

Figure 114: *JOH-9 left unopened inside the refrigerator for 6 days.*

Industry Based Juniper Raspberry:

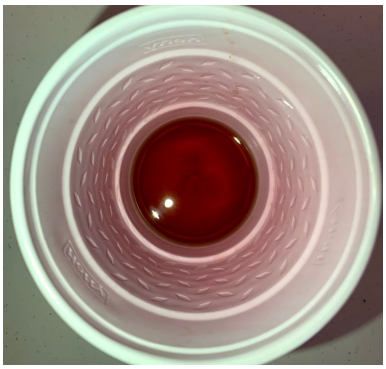

Figure 115: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 6 days.*

D.15- *Day 7 Room Temperature:*

Heather Lemon Honey 1:

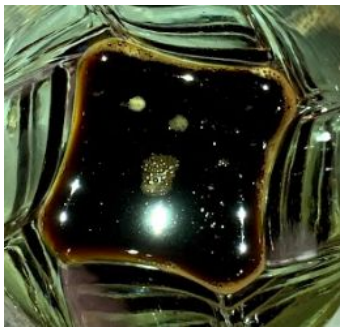

Figure 116: *HLH-1 left unopened outside the refrigerator for 7 days.*

Heather Lemon Honey 2:

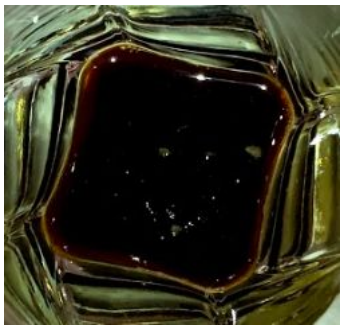

Figure 117: *HLH-2 left unopened outside the refrigerator for 7 days.*

Heather Lemon Honey 3:

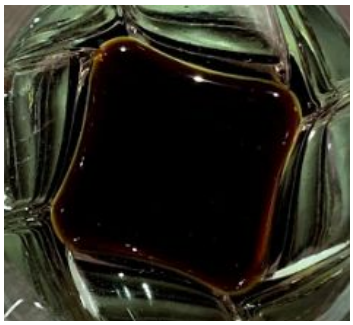

Figure 118: *HLH-3 left unopened outside the refrigerator for 7 days.*

Heather Lemon Honey 4:

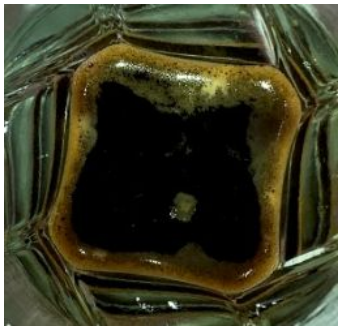

Figure 119: *HLH-4 left unopened outside the refrigerator for 7 days.*

Heather Lemon Honey 5:

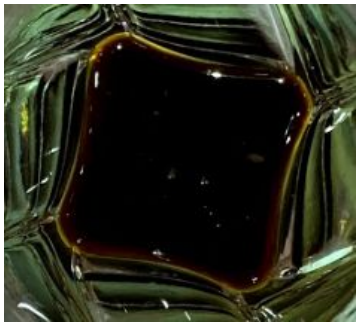

Figure 120: *HLH-5 left unopened outside the refrigerator for 7 days.*

Juniper Raspberry 1:

Figure 121: *JR-1 left unopened outside the refrigerator for 7 days.*

Juniper Raspberry 2:

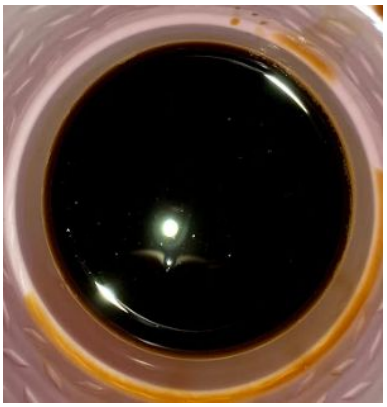

Figure 122: *JR-2 left unopened outside the refrigerator for 7 days.*

Juniper Raspberry 3:

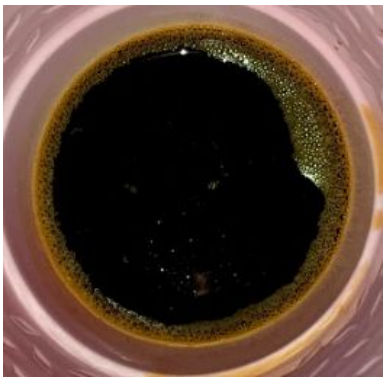

Figure 123: *JR-3 left unopened outside the refrigerator for 7 days.*

Juniper Raspberry 4:

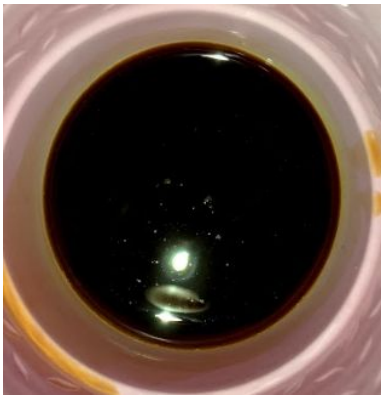

Figure 124: *JR-4 left unopened outside the refrigerator for 7 days.*

Juniper Raspberry 5:

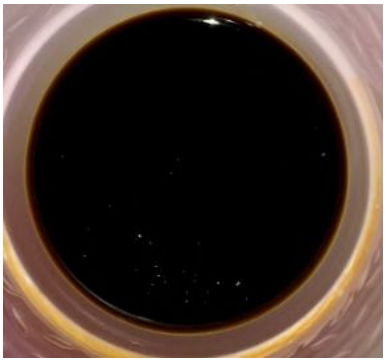

Figure 125: *JR-5 left unopened outside the refrigerator for 7 days.*

Juniper Raspberry 6:

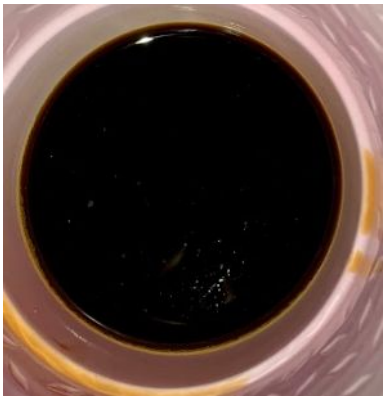

Figure 126: *JR-6 left unopened outside the refrigerator for 7 days.*

Juniper Raspberry 7:

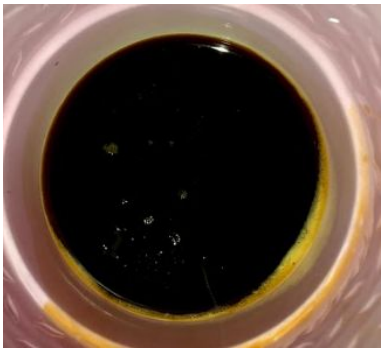

Figure 127: *JR-7 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 1:

Figure 128: *JOH-1 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 2:

Figure 129: *JOH-2 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 3:

Figure 130: *JOH-3 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 4:

Figure 131: *JOH-4 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 5:

Figure 132: *JOH-5 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 6:

Figure 133: *JOH-6 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 7:

Figure 134: *JOH-7 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 8:

Figure 135: *JOH-8 left unopened outside the refrigerator for 7 days.*

Juniper Orange Honey 9:

Figure 136: *JOH-9 left unopened outside the refrigerator for 7 days.*

Industry Based Juniper Raspberry:

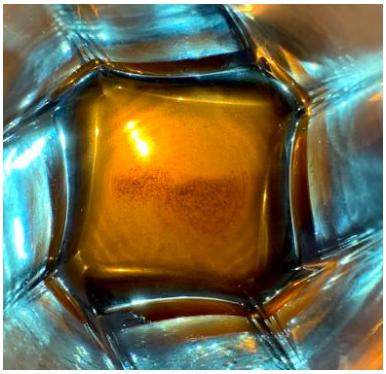

Figure 137: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 7 days.*

D.16- ***Day 7 Refrigerated:***

Bud Light:

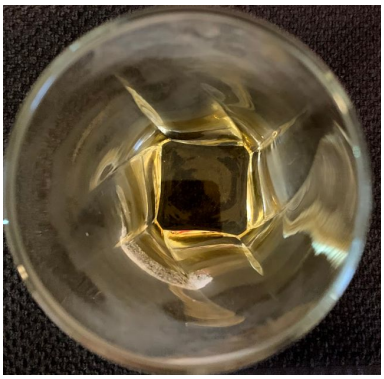

Figure 138: *Bud Light left unopened inside the refrigerator for 7 days.*

Heather Lemon Honey 1:

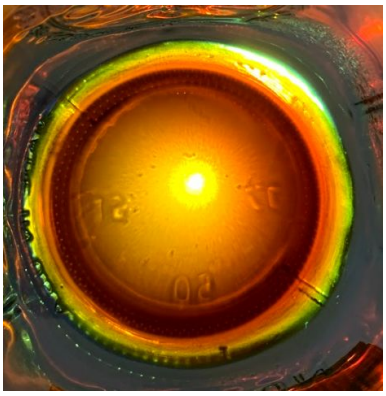

Figure 139: *HLH-1 left unopened inside the refrigerator for 7 days.*

Heather Lemon Honey 2:

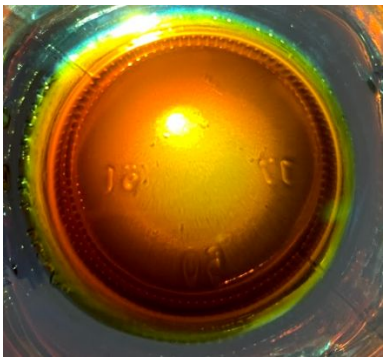

Figure #140: *HLH-2 left unopened inside the refrigerator for 7 days.*

Heather Lemon Honey 3:

Figure 141: *HLH-3 left unopened inside the refrigerator for 7 days.*

Heather Lemon Honey 4:

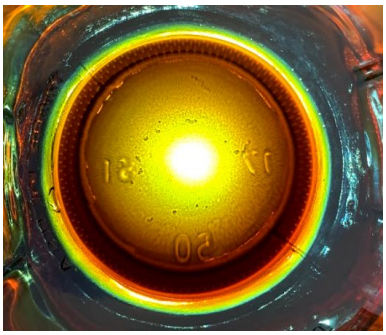

Figure 142: *HLH-4 left unopened inside the refrigerator for 7 days.*

Heather Lemon Honey 5:

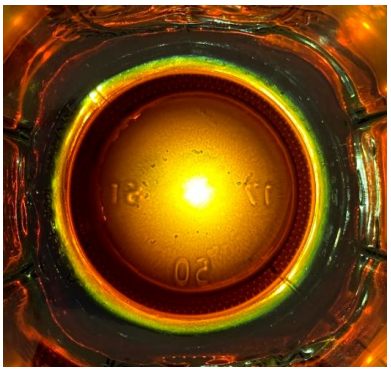

Figure 143: *HLH-5 left unopened inside the refrigerator for 7 days.*

Juniper Raspberry 1:

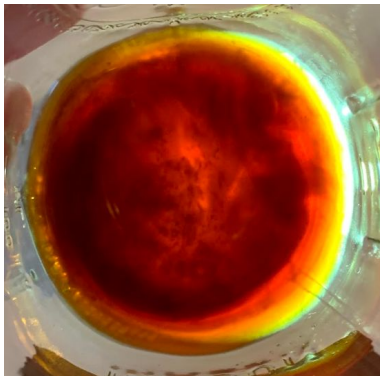

Figure 144: *JR-1 left unopened inside the refrigerator for 7 days.*

Juniper Raspberry 2:

Figure 145: *JR-2 left unopened inside the refrigerator for 7 days.*

Juniper Raspberry 3:

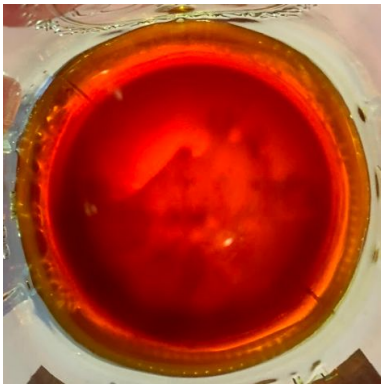

Figure 146: *JR-3 left unopened inside the refrigerator for 7 days.*

Juniper Raspberry 4:

Figure 147: *JR-4 left unopened inside the refrigerator for 7 days.*

Juniper Raspberry 5:

Figure 148: *JR-5 left unopened inside the refrigerator for 7 days.*

Juniper Raspberry 6:

Figure 149: *JR-6 left unopened inside the refrigerator for 7 days.*

Juniper Raspberry 7:

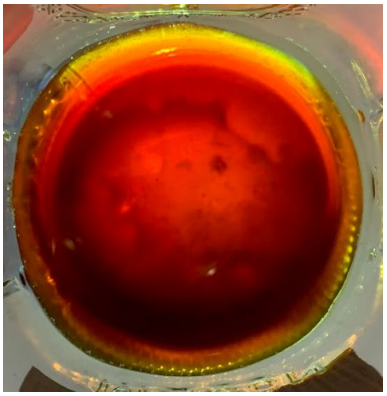

Figure 150: *JR-7 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 1:

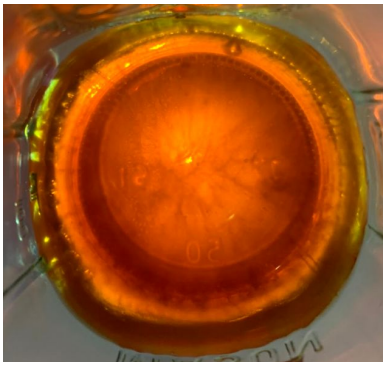

Figure 151: *JOH-1 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 2:

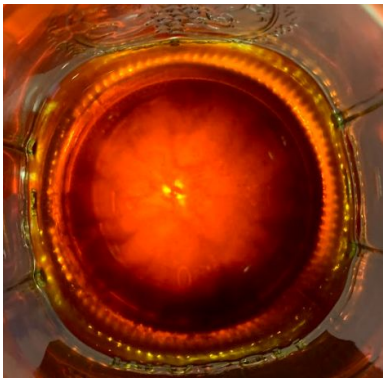

Figure 152: *JOH-2 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 3:

Figure 153: *JOH-3 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 4:

Figure 154: *JOH-4 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 5:

Figure 155: *JOH-5 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 6:

Figure 156: *JOH-6 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 7:

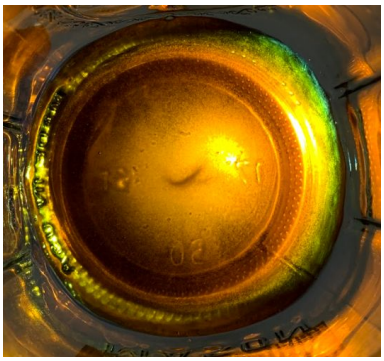

Figure 157: *JOH-7 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 8:

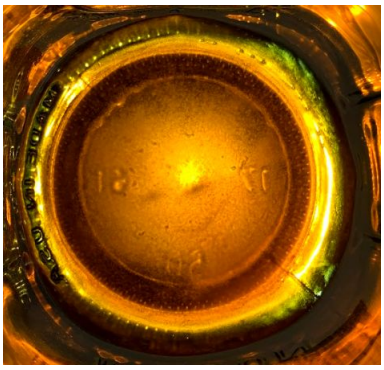

Figure 158: *JOH-8 left unopened inside the refrigerator for 7 days.*

Juniper Orange Honey 9:

Figure 159: *JOH-9 left unopened inside the refrigerator for 7 days.*

Industry Based Juniper Raspberry:

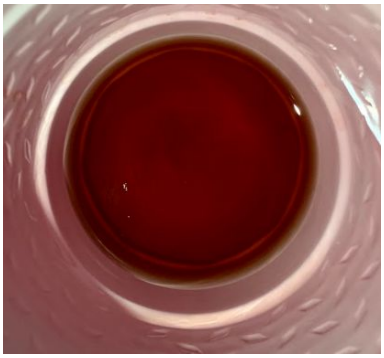

Figure 160: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 7 days.*

D.17- ***Day 8 Room Temperature:***

Bud Light:

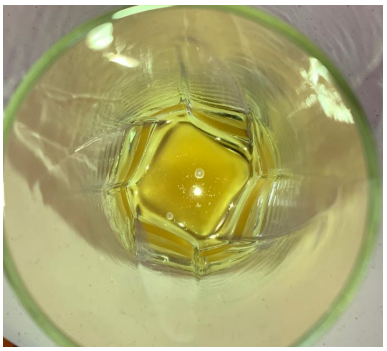

Figure 161: *Bud Light left unopened outside the refrigerator for 8 days.*

Heather Lemon Honey 1:

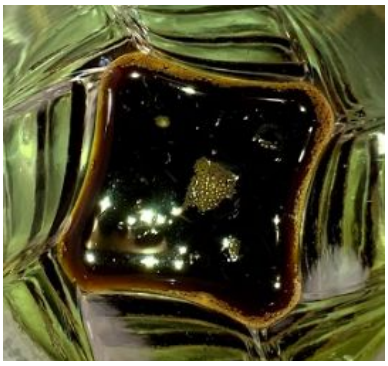

Figure 162: *HLH-1 left unopened outside the refrigerator for 8 days.*

Heather Lemon Honey 2:

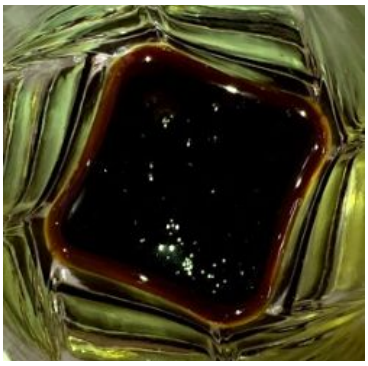

Figure 163: *HLH-2 left unopened outside the refrigerator for 8 days.*

Heather Lemon Honey 3:

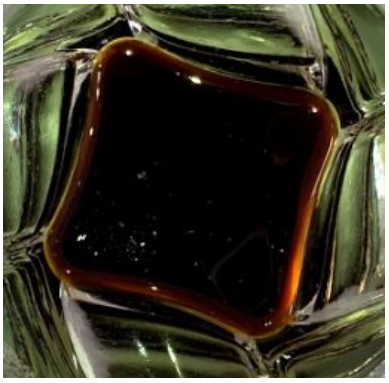

Figure 164: *HLH-3 left unopened outside the refrigerator for 8 days.*

Heather Lemon Honey 4:

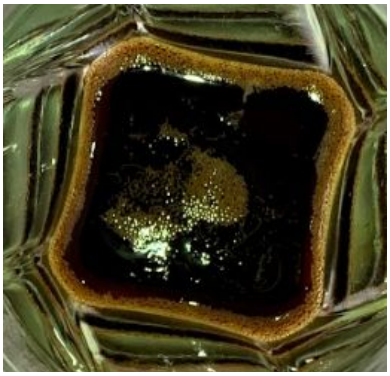

Figure 165: *HLH-4 left unopened outside the refrigerator for 8 days.*

Heather Lemon Honey 5:

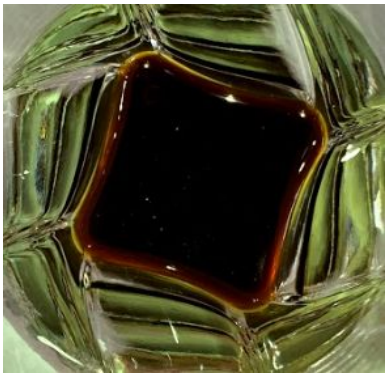

Figure 166: *HLH-5 left unopened outside the refrigerator for 8 days.*

Juniper Raspberry 1:

Figure 167: *JR-1 left unopened outside the refrigerator for 8 days.*

Juniper Raspberry 2:

Figure 168: *JR-2 left unopened outside the refrigerator for 8 days.*

Juniper Raspberry 3:

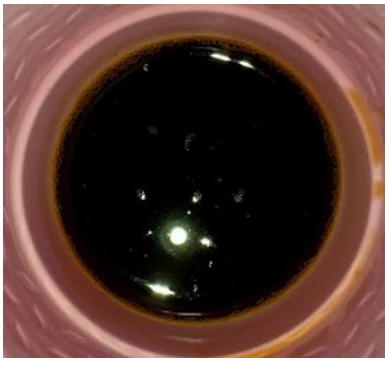

Figure 169: *JR-3 left unopened outside the refrigerator for 8 days.*

Juniper Raspberry 4:

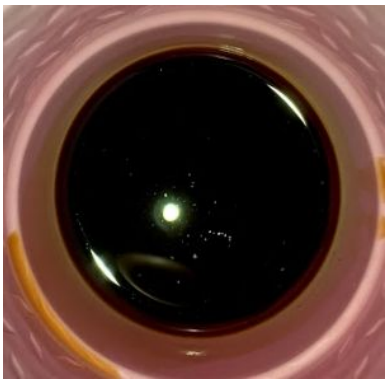

Figure 170: *JR-4 left unopened outside the refrigerator for 8 days.*

Juniper Raspberry 5:

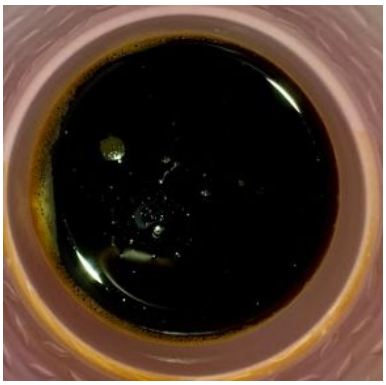

Figure 171: *JR-5 left unopened outside the refrigerator for 8 days.*

Juniper Raspberry 6:

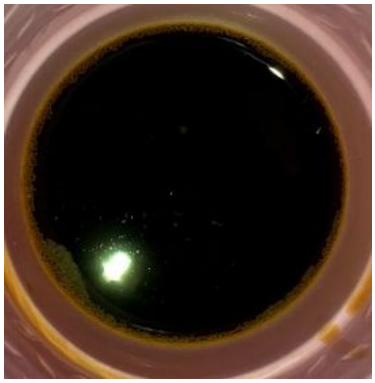

Figure 172: *JR-6 left unopened outside the refrigerator for 8 days.*

Juniper Raspberry 7:

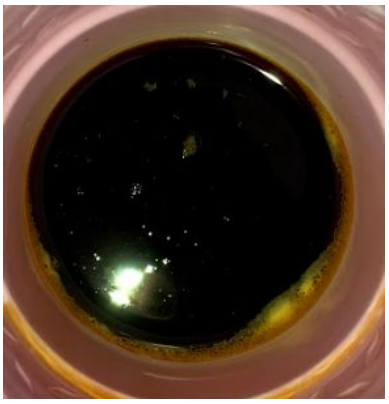

Figure 173: *JR-7 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey:

Figure 174: *Juniper Orange Honey left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 1:

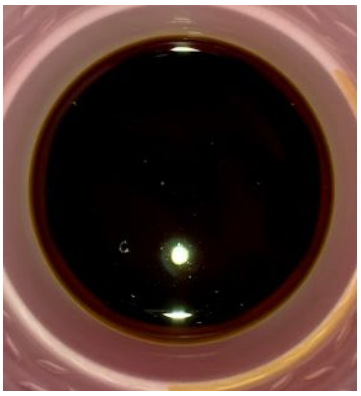

Figure 175: *JOH-1 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 3:

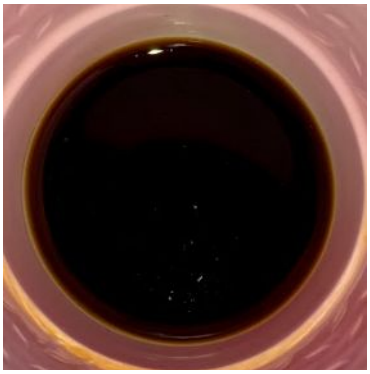

Figure 176: *JOH-3 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 4:

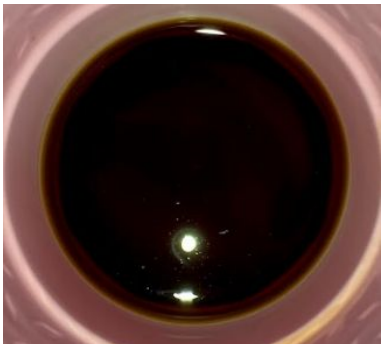

Figure 177: *JOH-4 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 5:

Figure 178: *JOH-5 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 6:

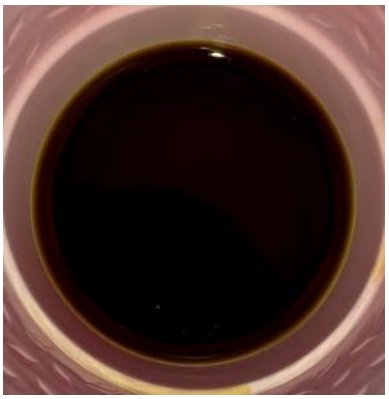

Figure 179: *JOH-6 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 7:

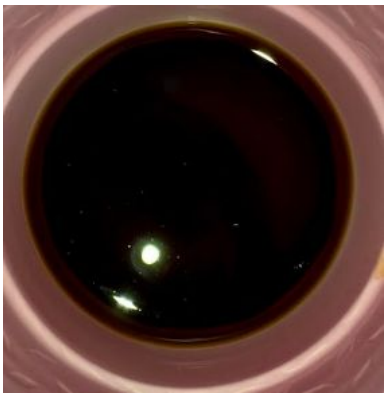

Figure 180: *JOH-7 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 8:

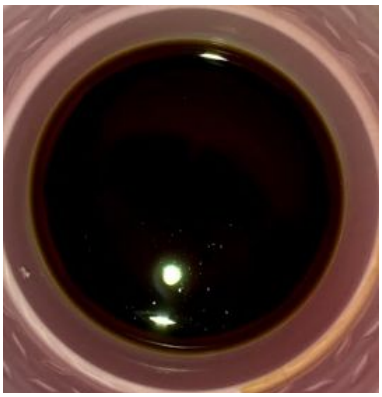

Figure 181: *JOH-8 left unopened outside the refrigerator for 8 days.*

Juniper Orange Honey 9:

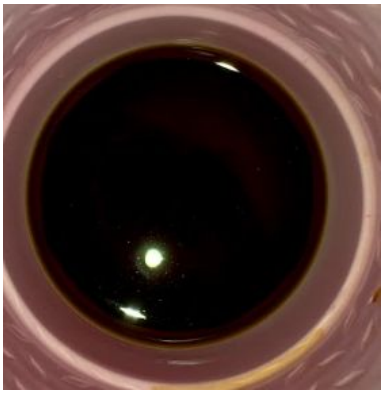

Figure 182: *JOH-9 left unopened outside the refrigerator for 8 days.*

Industry Based Juniper Raspberry:

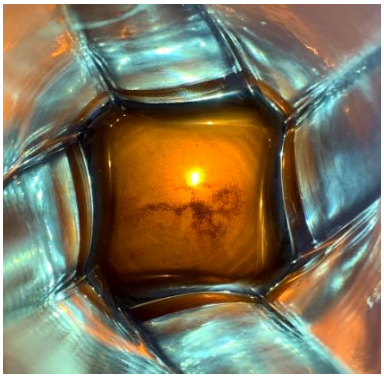

Figure 183: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 8 days.*

D.18- ***Day 8 Refrigerated:***

Bud Light:

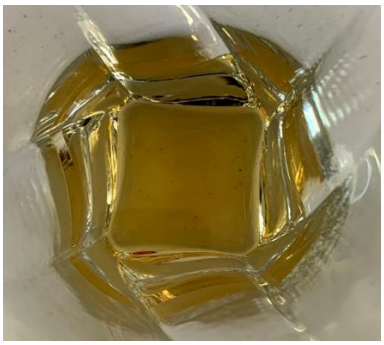

Figure 184: *Bud Light left unopened inside the refrigerator for 8 days.*

Heather Lemon Honey 1:

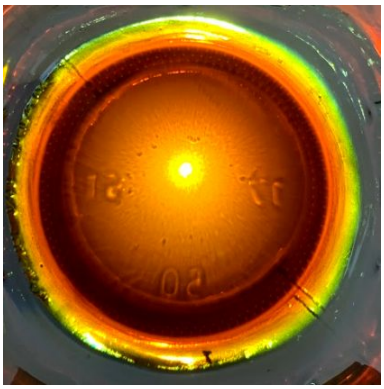

Figure 185: *HLH-1 left unopened inside the refrigerator for 8 days.*

Heather Lemon Honey 2:

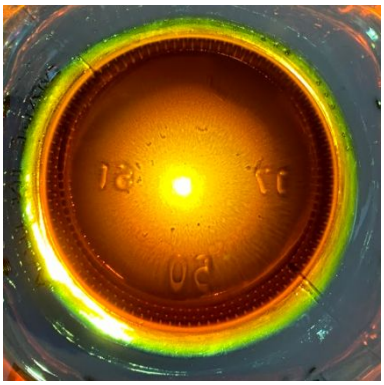

Figure 186: *HLH-2 left unopened inside the refrigerator for 8 days.*

Heather Lemon Honey 3:

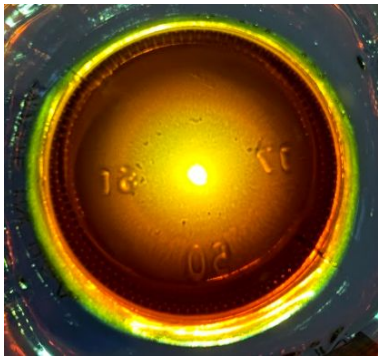

Figure 187: *HLH-3 left unopened inside the refrigerator for 8 days.*

Heather Lemon Honey 4:

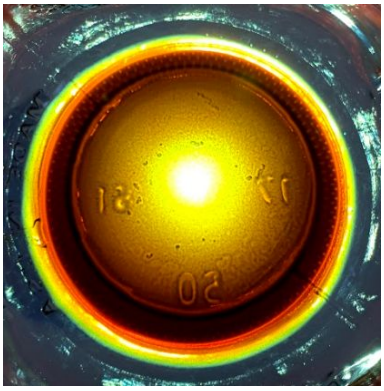

Figure 188: *HLH-4 left unopened inside the refrigerator for 8 days.*

Heather Lemon Honey 5:

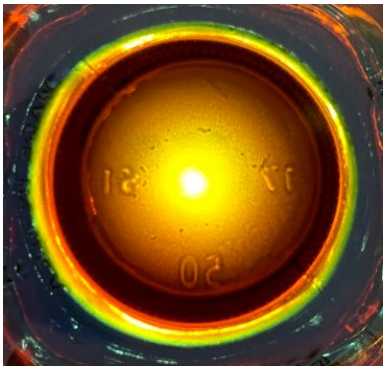

Figure 189: *HLH-5 left unopened inside the refrigerator for 8 days.*

Juniper Raspberry 1:

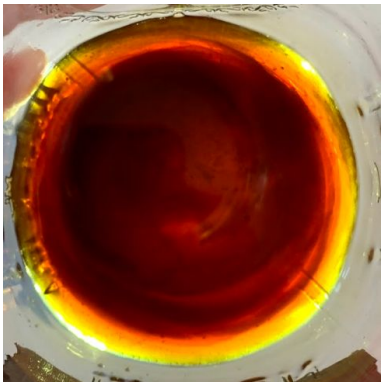

Figure 190: *JR-1 left unopened inside the refrigerator for 8 days.*

Juniper Raspberry 2:

Figure 191: *JR-2 left unopened inside the refrigerator for 8 days.*

Juniper Raspberry 3:

Figure 192: *JR-3 left unopened inside the refrigerator for 8 days.*

Juniper Raspberry 4:

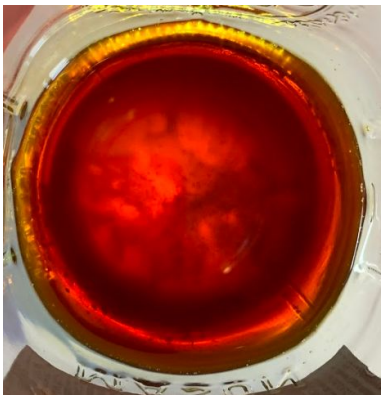

Figure 193: *JR-4 left unopened inside the refrigerator for 8 days.*

Juniper Raspberry 5:

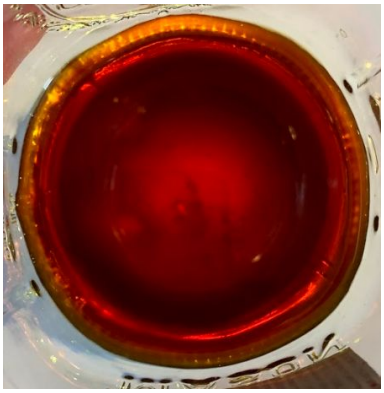

Figure 194: *JR-5 left unopened inside the refrigerator for 8 days.*

Juniper Raspberry 6:

Figure 195: *JR-6 left unopened inside the refrigerator for 8 days.*

Juniper Raspberry 7:

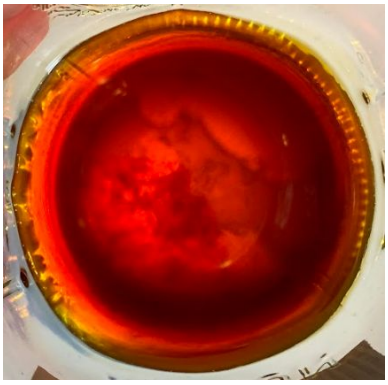

Figure 196: *JR-7 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 1:

Figure 197: *JOH-1 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 2:

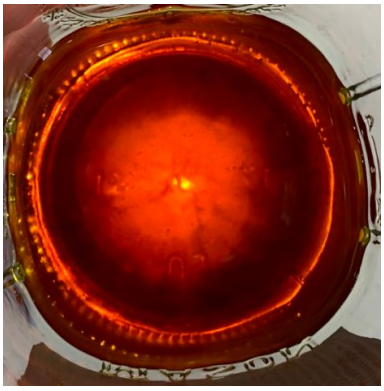

Figure 198: *JOH-2 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 3:

Figure 199: *JOH-3 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 4:

Figure 200: *JOH-4 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 5:

Figure 201: *JOH-5 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 6:

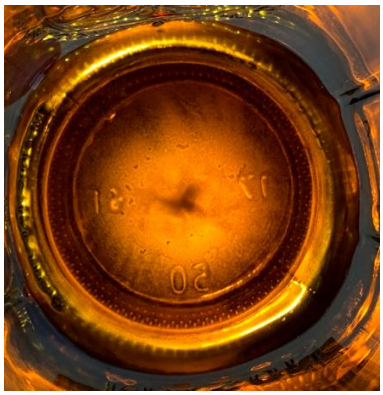

Figure 202: *JOH-6 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 7:

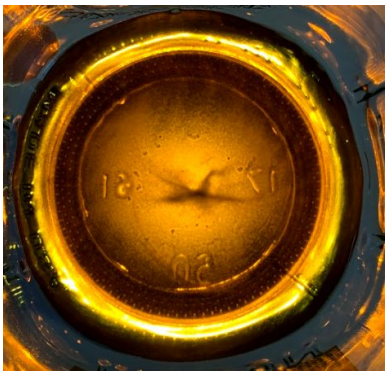

Figure 203: *JOH-7 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 8:

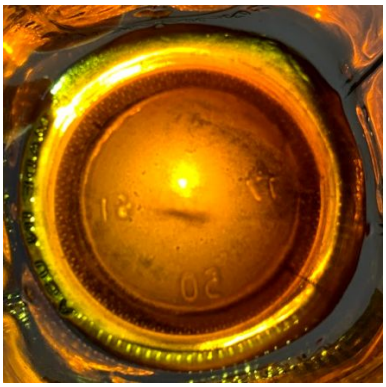

Figure 204: *JOH-8 left unopened inside the refrigerator for 8 days.*

Juniper Orange Honey 9:

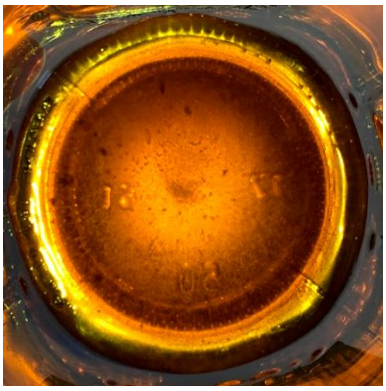

Figure 205: *JOH-9 left unopened inside the refrigerator for 8 days.*

Industry Based Juniper Raspberry:

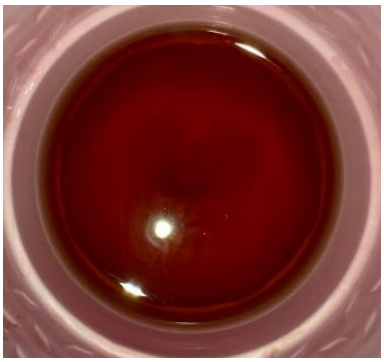

Figure 206: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 8 days.*

D.19- ***Day 9 Room Temperature:***

Heather Lemon Honey 1:

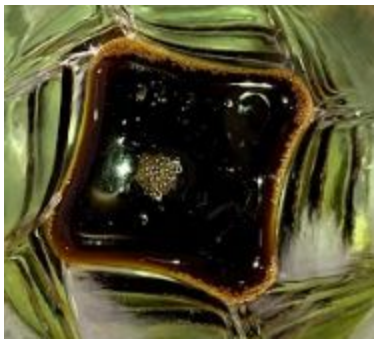

Figure 207: *HLH-1 left unopened outside the refrigerator for 9 days.*

Heather Lemon Honey 2:

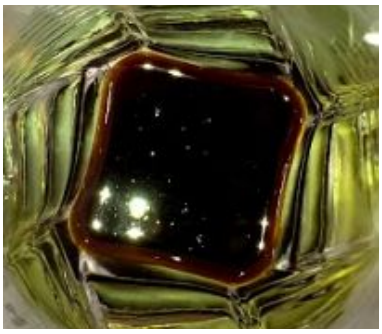

Figure 208: *HLH-2 left unopened outside the refrigerator for 9 days.*

Heather Lemon Honey 3:

Figure 209: *HLH-3 left unopened outside the refrigerator for 9 days.*

Heather Lemon Honey 4:

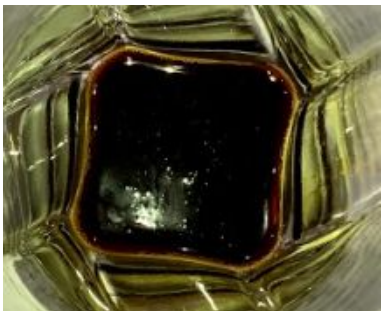

Figure 210: *HLH-4 left unopened outside the refrigerator for 9 days.*

Heather Lemon Honey 5:

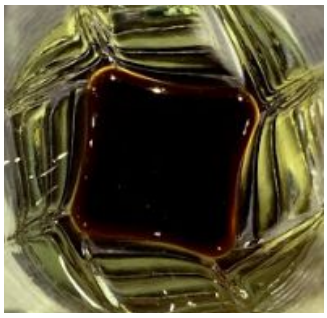

Figure 211: *HLH-5 left unopened outside the refrigerator for 9 days.*

Juniper Raspberry 1:

Figure 212: *JR-1 left unopened outside the refrigerator for 9 days.*

Juniper Raspberry 2:

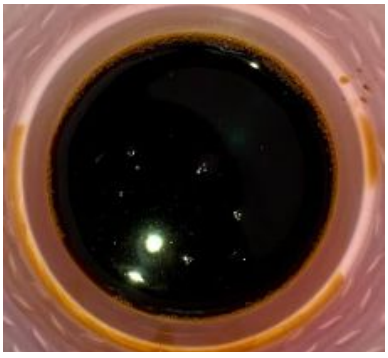

Figure 213: *JR-2 left unopened outside the refrigerator for 9 days.*

Juniper Raspberry 3:

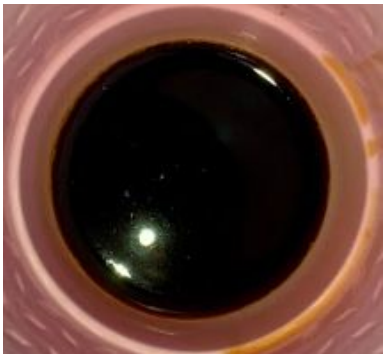

Figure 214: *JR-3 left unopened outside the refrigerator for 9 days.*

Juniper Raspberry 4:

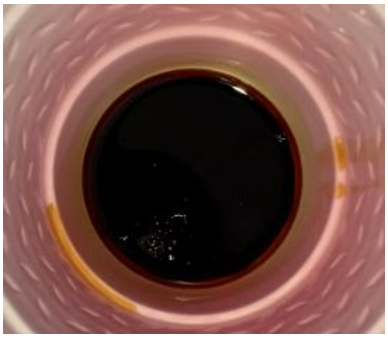

Figure 215: *JR-4 left unopened outside the refrigerator for 9 days.*

Juniper Raspberry 5:

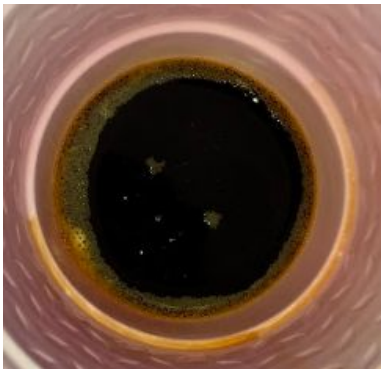

Figure 216: *JR-5 left unopened outside the refrigerator for 9 days.*

Juniper Raspberry 6:

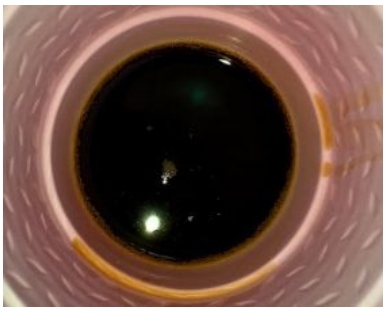

Figure 217: *JR-6 left unopened outside the refrigerator for 9 days.*

Juniper Raspberry 7:

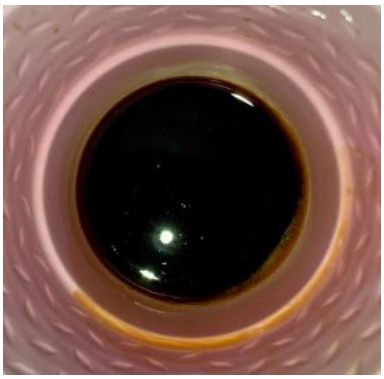

Figure 218: *JR-7 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 1:

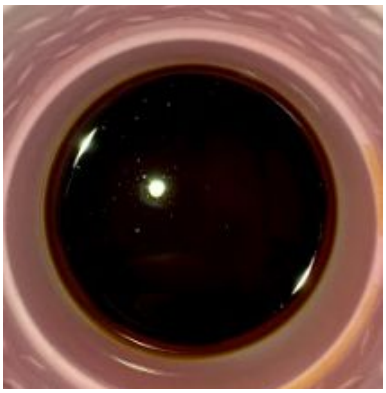

Figure 219: *JOH-1 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 2:

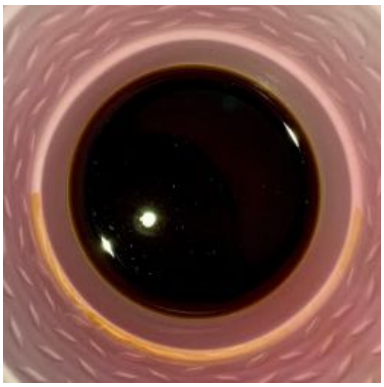

Figure 220: *JOH-2 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 3:

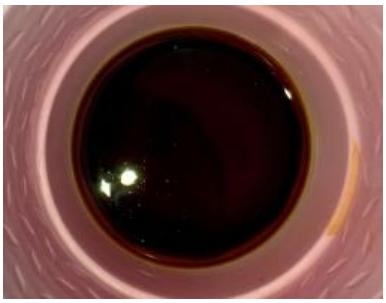

Figure 221: *JOH-3 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 4:

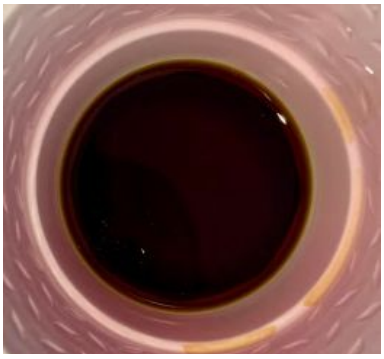

Figure 222: *JOH-4 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 5:

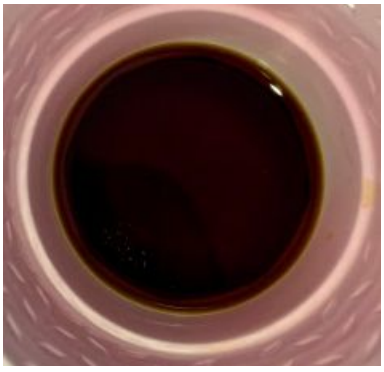

Figure 223: *JOH-5 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 6:

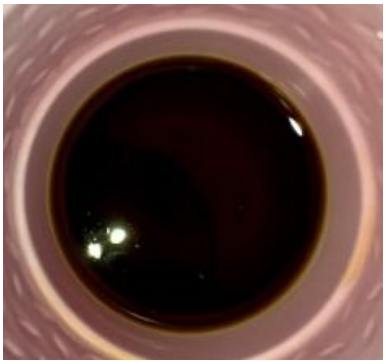

Figure 224: *JOH-6 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 7:

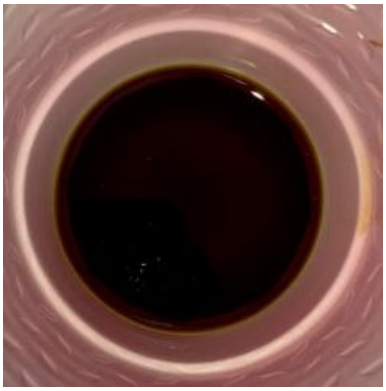

Figure 225: *JOH-7 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 8:

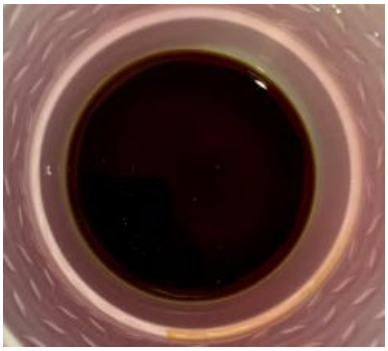

Figure 226: *JOH-8 left unopened outside the refrigerator for 9 days.*

Juniper Orange Honey 9:

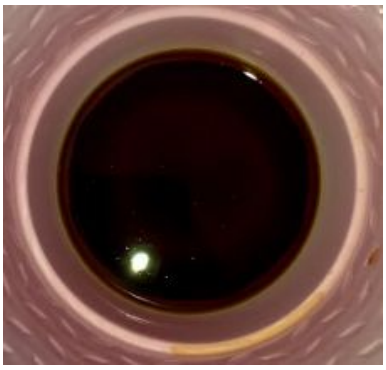

Figure 227: *JOH-9 left unopened outside the refrigerator for 9 days.*

Industry Based Juniper Raspberry:

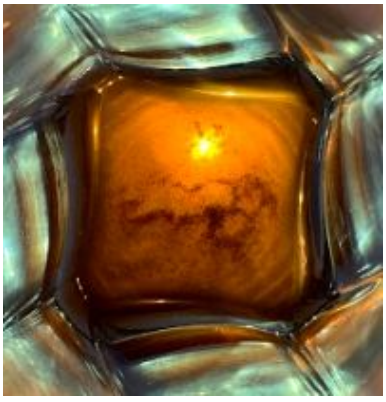

Figure 228: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 9 days.*

D.20- ***Day 9 Refrigerated:***

Bud Light:

Figure 229: *Bud Light left unopened inside the refrigerator for 9 days.*

Heather Lemon Honey 1:

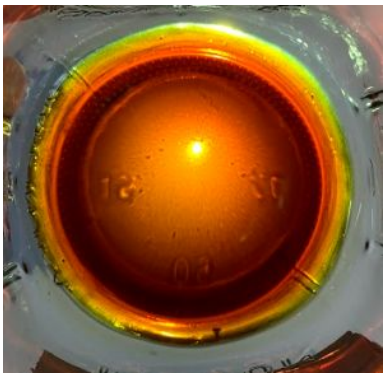

Figure 230: *HLH-1 left unopened inside the refrigerator for 9 days.*

Heather Lemon Honey 2:

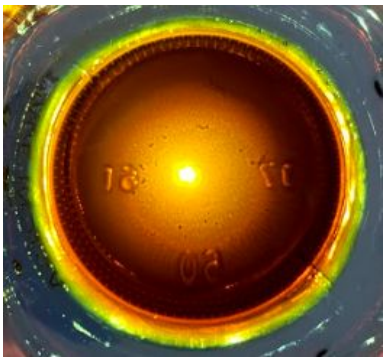

Figure 231: *HLH-2 left unopened inside the refrigerator for 9 days.*

Heather Lemon Honey 3:

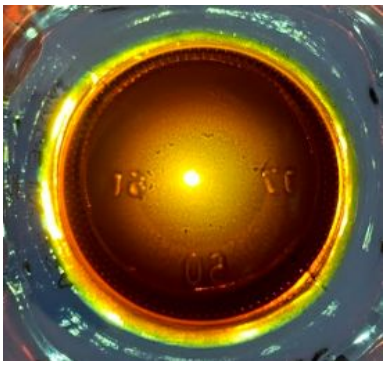

Figure 232: *HLH-3 left unopened inside the refrigerator for 9 days.*

Heather Lemon Honey 4:

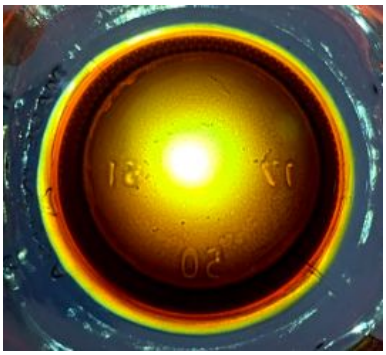

Figure 233: *HLH-4 left unopened inside the refrigerator for 9 days.*

Heather Lemon Honey 5:

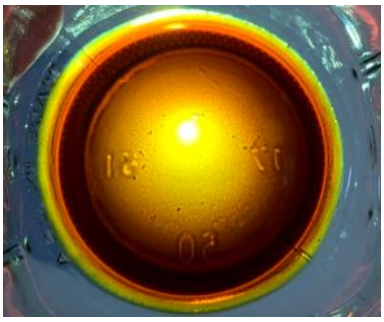

Figure 234: *HLH-5 left unopened inside the refrigerator for 9 days.*

Juniper Raspberry 1:

Figure 235: *JR-1 left unopened inside the refrigerator for 9 days.*

Juniper Raspberry 2:

Figure 236: *JR-2 left unopened inside the refrigerator for 9 days.*

Juniper Raspberry 3:

Figure 237: *JR-3 left unopened inside the refrigerator for 9 days.*

Juniper Raspberry 4:

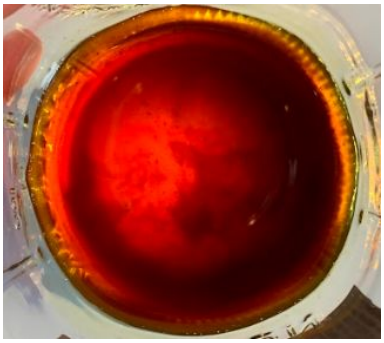

Figure 238: *JR-4 left unopened inside the refrigerator for 9 days.*

Juniper Raspberry 5:

Figure 239: *JR-5 left unopened inside the refrigerator for 9 days.*

Juniper Raspberry 6:

Figure 240: *JR-6 left unopened inside the refrigerator for 9 days.*

Juniper Raspberry 7:

Figure 241: *JR-7 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 1:

Figure 242: *JOH-1 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 2:

Figure 243: *JOH-2 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 3:

Figure 244: *JOH-3 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 4:

Figure 245: *JOH-4 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 5:

Figure 246: *JOH-5 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 6:

Figure 247: *JOH-6 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 7:

Figure 248: *JOH-7 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 8:

Figure 249: *JOH-8 left unopened inside the refrigerator for 9 days.*

Juniper Orange Honey 9:

Figure 250: *JOH-9 left unopened inside the refrigerator for 9 days.*

Industry Based Juniper Raspberry:

Figure 251: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 9 days.*

D.21- ***Day 10 Room Temperature:***

Heather Lemon Honey 1:

Figure 252: *HLH-1 left unopened outside the refrigerator for 10 days.*

Heather Lemon Honey 2:

Figure 253: *HLH-2 left unopened outside the refrigerator for 10 days.*

Heather Lemon Honey 4:

Figure 254: *HLH-4 left unopened outside the refrigerator for 10 days.*

Heather Lemon Honey 5:

Figure 255: *HLH-5 left unopened outside the refrigerator for 10 days.*

Juniper Raspberry 1:

Figure 256: *JR-1 left unopened outside the refrigerator for 10 days.*

Juniper Raspberry 2:

Figure 257: *JR-2 left unopened outside the refrigerator for 10 days.*

Juniper Raspberry 3:

Figure 258: *JR-3 left unopened outside the refrigerator for 10 days.*

Juniper Raspberry 4:

Figure 259: *JR-4 left unopened outside the refrigerator for 10 days.*

Juniper Raspberry 5:

Figure 260: *JR-5 left unopened outside the refrigerator for 10 days.*

Juniper Raspberry 6:

Figure 261: *JR-6 left unopened outside the refrigerator for 10 days.*

Juniper Raspberry 7:

Figure 262: *JR-7 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 1:

Figure 263: *JOH-1 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 2:

Figure 264: *JOH-2 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 3:

Figure 265: *JOH-3 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 4:

Figure 266: *JOH-4 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 5:

Figure 267: *JOH-5 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 6:

Figure 268: *JOH-6 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 7:

Figure 269: *JOH-7 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 8:

Figure 270: *JOH-8 left unopened outside the refrigerator for 10 days.*

Juniper Orange Honey 9:

Figure 271: *JOH-9 left unopened outside the refrigerator for 10 days.*

Industry Based Juniper Raspberry:

Figure #272: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 10 days.*

D.22- ***Day 10 Refrigerated:***

Bud Light:

Figure 273: *Bud Light left unopened inside the refrigerator for 10 days.*

Heather Lemon Honey 1:

Figure 274: *HLH-1 left unopened inside the refrigerator for 10 days.*

Heather Lemon Honey 2:

Figure 275: *HLH-2 left unopened inside the refrigerator for 10 days.*

Heather Lemon Honey 3:

Figure 276: *HLH-3 left unopened inside the refrigerator for 10 days.*

Heather Lemon Honey 4:

Figure 277: *HLH-4 left unopened inside the refrigerator for 10 days.*

Heather Lemon Honey 5:

Figure 278: *HLH-5 left unopened inside the refrigerator for 10 days.*

Juniper Raspberry 1:

Figure 279: *JR-1 left unopened inside the refrigerator for 10 days.*

Juniper Raspberry 2:

Figure 280: *JR-2 left unopened inside the refrigerator for 10 days.*

Juniper Raspberry 3:

Figure 281: *JR-3 left unopened inside the refrigerator for 10 days.*

Juniper Raspberry 4:

Figure 282: *JR-4 left unopened inside the refrigerator for 10 days.*

Juniper Raspberry 5:

Figure 283: *JR-5 left unopened inside the refrigerator for 10 days.*

Juniper Raspberry 6:

Figure 284: *JR-6 left unopened inside the refrigerator for 10 days.*

Juniper Raspberry 7:

Figure 285: *JR-7 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 1:

Figure 286: *JOH-1 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 2:

Figure 287: *JOH-2 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 3:

Figure 288: *JOH-3 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 4:

Figure 289: *JOH-4 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 5:

Figure 290: *JOH-5 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 6:

Figure 291: *JOH-6 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 7:

Figure 292: *JOH-7 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 8:

Figure 293: *JOH-8 left unopened inside the refrigerator for 10 days.*

Juniper Orange Honey 9:

Figure 294: *JOH-9 left unopened inside the refrigerator for 10 days.*

Industry Based Juniper Raspberry:

Figure 295: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 10 days.*

D.23- ***Day 11 Room Temperature:***

Bud Light:

Figure 296: *Bud Light left unopened outside the refrigerator for 11 days.*

Heather Lemon Honey 1:

Figure 297: *HLH-1 left unopened outside the refrigerator for 11 days.*

Heather Lemon Honey 2:

Figure 298: *HLH-2 left unopened outside the refrigerator for 11 days.*

Heather Lemon Honey 3:

Figure 299: *HLH-3 left unopened outside the refrigerator for 11 days.*

Heather Lemon Honey 4:

Figure 300: *HLH-4 left unopened outside the refrigerator for 11 days.*

Heather Lemon Honey 5:

Figure 301: *HLH-5 left unopened outside the refrigerator for 11 days.*

Juniper Raspberry 1:

Figure 302: *JR-1 left unopened outside the refrigerator for 11 days.*

Juniper Raspberry 2:

Figure 303: *JR-2 left unopened outside the refrigerator for 11 days.*

Juniper Raspberry 3:

Figure 304: *JR-3 left unopened outside the refrigerator for 11 days.*

Juniper Raspberry 4:

Figure 305: *JR-4 left unopened outside the refrigerator for 11 days.*

Juniper Raspberry 5:

Figure 306: *JR-5 left unopened outside the refrigerator for 11 days.*

Juniper Raspberry 6:

Figure 307: *JR-6 left unopened outside the refrigerator for 11 days.*

Juniper Raspberry 7:

Figure 308: *JR-7 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 1:

Figure 309: *JOH-1 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 2:

Figure 310: *JOH-2 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 3:

Figure 311: *JOH-3 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 4:

Figure 312: *JOH-4 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 5:

Figure 313: *JOH-5 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 6:

Figure 314: *JOH-6 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 7:

Figure 315: *JOH-7 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 8:

Figure 316: *JOH-8 left unopened outside the refrigerator for 11 days.*

Juniper Orange Honey 9:

Figure 317: *JOH-9 left unopened outside the refrigerator for 11 days.*

Industry Based Juniper Raspberry:

Figure 318: *Industry Based Juniper Rasberry left unopened outside the refrigerator for 11 days.*

D.24- ***Day 11 Refrigerated:***

Bud Light:

Figure 319: *Bud Light left unopened inside the refrigerator for 11 days.*

Heather Lemon Honey 1:

Figure 320: *HLH-1 left unopened inside the refrigerator for 11 days.*

Heather Lemon Honey 2:

Figure 321: *HLH-2 left unopened inside the refrigerator for 11 days.*

Heather Lemon Honey 3:

Figure 322: *HLH-3 left unopened inside the refrigerator for 11 days.*

Heather Lemon Honey 4:

Figure 323: *HLH-4 left unopened inside the refrigerator for 11 days.*

Heather Lemon Honey 5:

Figure 324: *HLH-5 left unopened inside the refrigerator for 11 days.*

Juniper Raspberry 1:

Figure 325: *JR-1 left unopened inside the refrigerator for 11 days.*

Juniper Raspberry 2:

Figure 326: *JR-2 left unopened inside the refrigerator for 11 days.*

Juniper Raspberry 3:

Figure 327: *JR-3 left unopened inside the refrigerator for 11 days.*

Juniper Raspberry 4:

Figure 328: *JR-4 left unopened inside the refrigerator for 11 days.*

Juniper Raspberry 5:

Figure 329: *JR-5 left unopened inside the refrigerator for 11 days.*

Juniper Raspberry 6:

Figure 330: *JR-6 left unopened inside the refrigerator for 11 days.*

Juniper Raspberry 7:

Figure 331: *JR-7 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 1:

Figure 332: *JOH-1 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 2:

Figure 333: *JOH-2 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 3:

Figure 334: *JOH-3 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 4:

Figure 335: *JOH-4 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 5:

Figure 336: *JOH-5 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 6:

Figure 337: *JOH-6 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 7:

Figure 338: *JOH-7 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 8:

Figure 339: *JOH-8 left unopened inside the refrigerator for 11 days.*

Juniper Orange Honey 9:

Figure 340: *JOH-9 left unopened inside the refrigerator for 11 days.*

Industry Based Juniper Raspberry:

Figure 341: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 11 days.*

D.25- ***Day 12 Room Temperature:***

Bud Light:

Figure 342: *Bud Light left unopened outside the refrigerator for 12 days.*

Heather Lemon Honey 1:

Figure 343: *HLH-1 left unopened outside the refrigerator for 12 days.*

Heather Lemon Honey 2:

Figure 344: *HLH-2 left unopened outside the refrigerator for 12 days.*

Heather Lemon Honey 3:

Figure 345: *HLH- left unopened outside the refrigerator for 12 days.*

Heather Lemon Honey 4:

Figure 346: *HLH-4 left unopened outside the refrigerator for 12 days.*

Heather Lemon Honey 5:

Figure 347: *HLH-5 left unopened outside the refrigerator for 12 days.*

Juniper Raspberry 1:

Figure 348: *JR-1 left unopened outside the refrigerator for 12 days.*

Juniper Raspberry 2:

Figure 349: *JR-2 left unopened outside the refrigerator for 12 days.*

Juniper Raspberry 3:

Figure 350: *JR-3 left unopened outside the refrigerator for 12 days.*

Juniper Raspberry 4:

Figure 351: *JR-4 left unopened outside the refrigerator for 12 days.*

Juniper Raspberry 5:

Figure 352: *JR-5 left unopened outside the refrigerator for 12 days.*

Juniper Raspberry 6:

Figure 353: *JR-6 left unopened outside the refrigerator for 12 days.*

Juniper Raspberry 7:

Figure 354: *JR-7 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 1:

Figure 355: *JOH-1 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 2:

Figure 356: *JOH-2 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 3:

Figure 357: *JOH-3 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 4:

Figure 358: *JOH-4 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 5:

Figure 359: *JOH-5 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 6:

Figure 360: *JOH-6 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 7:

Figure 361: *JOH-7 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 8:

Figure 362: *JOH-8 left unopened outside the refrigerator for 12 days.*

Juniper Orange Honey 9:

Figure 363: *JOH-9 left unopened outside the refrigerator for 12 days.*

Industry Based Juniper Raspberry:

Figure 364: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 12 days.*

D.26- ***Day 12 Refrigerated:***

Bud Light:

Figure 365: *Bud Light left unopened inside the refrigerator for 12 days.*

Heather Lemon Honey 1:

Figure 366: *HLH-1 left unopened inside the refrigerator for 12 days.*

Heather Lemon Honey 2:

Figure 367: *HLH-2 left unopened inside the refrigerator for 12 days.*

Heather Lemon Honey 3:

Figure 368: *HLH-3 left unopened inside the refrigerator for 12 days.*

Heather Lemon Honey 4:

Figure 369: *HLH-4 left unopened inside the refrigerator for 12 days.*

Heather Lemon Honey 5:

Figure 370: *HLH-5 left unopened inside the refrigerator for 12 days.*

Juniper Raspberry 1:

Figure 371: *JR-1 left unopened inside the refrigerator for 12 days.*

Juniper Raspberry 2:

Figure 372: *JR-2 left unopened inside the refrigerator for 12 days.*

Juniper Raspberry 3:

Figure 373: *JR-3 left unopened inside the refrigerator for 12 days.*

Juniper Raspberry 4:

Figure 374: *JR-4 left unopened inside the refrigerator for 12 days.*

Juniper Raspberry 5:

Figure 375: *JR-5 left unopened inside the refrigerator for 12 days.*

Juniper Raspberry 6:

Figure 376: *JR-6 left unopened inside the refrigerator for 12 days.*

Juniper Raspberry 7:

Figure 377: *JR-7 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 1:

Figure 378: *JOH-1 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 2:

Figure 379: *JOH-2 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 3:

Figure 380: *JOH-3 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 4:

Figure 381: *JOH-4 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 5:

Figure 382: *JOH-5 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 6:

Figure 383: *JOH-6 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 7:

Figure 384: *JOH-7 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 8:

Figure 385: *JOH-18 left unopened inside the refrigerator for 12 days.*

Juniper Orange Honey 9:

Figure 386: *JOH-9 left unopened inside the refrigerator for 12 days.*

Industry Based Juniper Raspberry:

Figure 387: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 12 days.*

D.27- ***Day 13 Room Temperature:***

Bud Light:

Figure 388: *Bud Light left unopened outside the refrigerator for 13 days.*

Heather Lemon Honey 1:

Figure 389: *HLH-1 left unopened outside the refrigerator for 13 days.*

Heather Lemon Honey 2:

Figure 390: *HLH-2 left unopened outside the refrigerator for 13 days.*

Heather Lemon Honey 3:

Figure 391: *HLH-3 left unopened outside the refrigerator for 13 days.*

Heather Lemon Honey 4:

Figure 392: *HLH-4 left unopened outside the refrigerator for 13 days.*

Heather Lemon Honey 5:

Figure 393: *HLH-5 left unopened outside the refrigerator for 13 days.*

Juniper Raspberry 1:

Figure 394: *JR-1 left unopened outside the refrigerator for 13 days.*

Juniper Raspberry 2:

Figure 395: *JR-2 left unopened outside the refrigerator for 13 days.*

Juniper Raspberry 3:

Figure 396: *JR-3 left unopened outside the refrigerator for 13 days.*

Juniper Raspberry 4:

Figure 397: *JR-4 left unopened outside the refrigerator for 13 days.*

Juniper Raspberry 5:

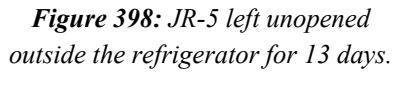

Figure 398: *JR-5 left unopened outside the refrigerator for 13 days.*

Juniper Raspberry 6:

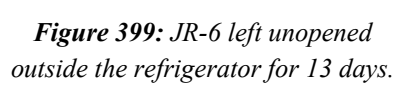

Figure 399: *JR-6 left unopened outside the refrigerator for 13 days.*

Juniper Raspberry 7:

Figure 400: *JR-7 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 1:

Figure 401: *JOH-1 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 2:

Figure 402: *JOH-2 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 3:

Figure 403: *JOH-3 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 4:

Figure 404: *JOH-4 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 5:

Figure 405: *JOH-5 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 6:

Figure 406: *JOH-6 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 7:

Figure 407: *JOH-7 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 8:

Figure 408: *JOH-8 left unopened outside the refrigerator for 13 days.*

Juniper Orange Honey 9:

Figure 409: *JOH-9 left unopened outside the refrigerator for 13 days.*

Industry Based Juniper Raspberry:

Figure 410: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 13 days.*

D.28- ***Day 13 Refrigerated:***

Bud Light:

Figure 411: *Bud Light left unopened inside the refrigerator for 13 days.*

Heather Lemon Honey 1:

Figure 412: *HLH-1 left unopened inside the refrigerator for 13 days.*

Heather Lemon Honey 2:

Figure 413: *HLH-2 left unopened inside the refrigerator for 13 days.*

Heather Lemon Honey 3:

Figure 414: *HLH-3 left unopened inside the refrigerator for 13 days.*

Heather Lemon Honey 4:

Figure 415: *HLH-4 left unopened inside the refrigerator for 13 days.*

Heather Lemon Honey 5:

Figure 416: *HLH-5 left unopened inside the refrigerator for 13 days.*

Juniper Raspberry 1:

Figure 417: *JR-1 left unopened inside the refrigerator for 13 days.*

Juniper Raspberry 2:

Figure 418: *JR-2 left unopened inside the refrigerator for 13 days.*

Juniper Raspberry 3:

Figure 419: *JR-3 left unopened inside the refrigerator for 13 days.*

Juniper Raspberry 4:

Figure 420: *JR-4 left unopened inside the refrigerator for 13 days.*

Juniper Raspberry 5:

Figure 421: *JR-5 left unopened inside the refrigerator for 13 days.*

Juniper Raspberry 6:

Figure 422: *JR-6 left unopened inside the refrigerator for 13 days.*

Juniper Raspberry 7:

Figure 423: *JR-7 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 1:

Figure 424: *JOH-1 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 2:

Figure 425: *JOH-2 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 3:

Figure 426: *JOH-3 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 4:

Figure 427: *JOH-4 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 5:

Figure 428: *JOH-5 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 6:

Figure 429: *JOH-6 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 7:

Figure 430: *JOH-7 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 8:

Figure 431: *JOH-8 left unopened inside the refrigerator for 13 days.*

Juniper Orange Honey 9:

Figure 432: *JOH-9 left unopened inside the refrigerator for 13 days.*

Industry Based Juniper Raspberry:

Figure 433: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 13 days.*

D.29- ***Day 14 Room Temperature:***

Heather Lemon Honey 1:

Figure 434: *HLH-1 left unopened outside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 2:

Figure 435: *HLH-2 left unopened outside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 3:

Figure 436: *HLH-3 left unopened outside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 4:

Figure 437: *HLH-4 left unopened outside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 5:

Figure 438: *HLH-5 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Raspberry 1:

Figure 439: *JR-1 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Raspberry 2:

Figure 440: *JR-2 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Raspberry 3:

Figure 441: *JR-3 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Raspberry 4:

Figure 442: *JR-4 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Raspberry 5:

Figure 443: *JR-5 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Raspberry 6:

Figure 444: *JR-6 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Raspberry 7:

Figure 445: *JR-7 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 1:

Figure 446: *JOH-1 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 2:

Figure 447: *JOH-2 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 3:

Figure 448: *JOH-3 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 4:

Figure 449: *JOH-4 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 5:

Figure 450: *JOH-5 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 6:

Figure 451: *JOH-6 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 7:

Figure 452: *JOH-7 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 8:

Figure 453: *JOH-8 left unopened outside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 9:

Figure 454: *JOH-9 left unopened outside the refrigerator for 14 days after mixing.*

Industry Based Juniper Raspberry:

Figure 455: *Industry Based Juniper Raspberry left unopened outside the refrigerator for 14 days after mixing.*

D.30- ***Day 14 Refrigerated:***

Bud Light:

Figure 456: *Bud Light left unopened inside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 1:

Figure 457: *HLH-1 left unopened inside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 2:

Figure 458: *HLH-2 left unopened inside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 3:

Figure 459: *HLH-3 left unopened inside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 4:

Figure 460: *HLH-4 left unopened inside the refrigerator for 14 days after mixing.*

Heather Lemon Honey 5:

Figure 461: *HLH-5 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Raspberry 1:

Figure 462: *JR-1 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Raspberry 2:

Figure 463: *JR-2 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Raspberry 3:

Figure 464: *JR-3 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Raspberry 4:

Figure 465: *JR-4 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Raspberry 5:

Figure 466: *JR-5 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Raspberry 6:

Figure 467: *JR-6 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Raspberry 7:

Figure 468: *JR-7 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 1:

Figure 469: *JOH-1 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 2:

Figure 470: *JOH-2 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 3:

Figure 471: *JOH-3 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 4:

Figure 472: *JOH-4 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 5:

Figure 473: *JOH-5 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 6:

Figure 474: *JOH-6 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 7:

Figure 475: *JOH-7 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 8:

Figure 476: *JOH-8 left unopened inside the refrigerator for 14 days after mixing.*

Juniper Orange Honey 9:

Figure 477: *JOH-9 left unopened inside the refrigerator for 14 days after mixing.*

Industry Based Juniper Raspberry:

Figure 478: *Industry Based Juniper Raspberry left unopened inside the refrigerator for 14 days after mixing.*