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Analytical Study of Craft Breweries in Central Spain

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Acknowledgments

Thank you to the breweries who opened their doors to me during uncertain times and welcomed me with open hearts and a cold beer. I couldn't have done any of this without their collaboration and I hope it helps the sector to learn more about processes and growth happening now! Also, a huge thank you to my husband Daniel for constantly reminding me to set up interviews and driving me all over Spain to talk to brewers. I wouldn't have been able to see so many amazing projects if he wasn't here to back me up. Thank you to my internship tutor Daniel for connecting me with brewers and convincing them to take place in this study!

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ABSTRACT

This analytical study of breweries consists of a compilation and analysis of data from an interview conducted with 10 different breweries throughout central Spain, including Madrid, Toledo and Segovia. The questions focused on 4 main categories: equipment, methods, raw materials and global vision of the brewery. It aims to overview the practices of the craft beer sector in a specific region. This study is a continuation of the work done by Alvaro Mayordomo Martínez, completed in 2020 in Cataluña and Valencia. This continuation aims to give the sector back information about equipment and practices with the goal of providing points of improvement, trends and strengths in central Spain breweries.

RESUMEN

Este estudio analítico de cervecerías consiste en una recopilación y análisis de datos que provienen de unas entrevistas realizadas en diez cervecerías localizadas en el centro de España, que incluye Madrid, Toledo y Segovia. Las preguntas se enfocan en cuatro categorías principales: equipos, metodología, materia prima y visión global de la cervecería. El estudio intenta dar una visión de las tendencias en el sector cervecero artesanal en una región específica. Este estudio es una continuación del trabajo realizado por Álvaro Mayordomo Martínez, terminado en 2020 en Cataluña y Valencia. Esta continuación ambiciona devolver al sector información útil a nivel de equipos y metodologías y tiene el objetivo de proveer puntos de mejora, tendencias y puntos fuertes en cervecerías de centro España.

INTRODUCTION

Beer culture and consumption across the world is expanding every year and yet university level studies of craft breweries do not match up. Studies nowadays focus on craft beer's socioeconomic impact, its environmental impact and even craft beer tourism but very few are concerned with how all this beer is being made. We study tasting the product but what really went into that product? The beer sector in Spain, if we discount the year 2020 due to the Coronavirus pandemic's complete dismantling of businesses across the world, has achieved consistent growth in sales, consumption and exportation since 2013. Production in the Community of Madrid by craft brewers (no association with the "big six" macrobrewery corporates of Spain) was about 37.700 hectoliters! (Ministerio de Agricultura, Pesca y Alimentación & Cerveceros de España, 2020) This considers that central Spain is 22% of the market share in the beer industry.

The question of how all this craft beer is made still stands. We know very little about methodology of individual craft breweries. The joy and struggle of the craft beer industry is that brewers come from all different walks of life. Some started young in other breweries, some went to other countries to learn about beer and others started in garages or kitchens and turned their passion into a business! The idea of gathering data about small scale equipment and methods is lackluster to big corporations because setting it next to their production data makes the rest look null. The importance of learning about the craft sector and improving it is left to those within it. Many microbreweries started with plenty of help from other craft brewers. Gathering knowledge within universities, maintaining visibility and sharing it back to production teams is one small part in the big picture that is growing this interesting and engaging sector!

OBJECTIVE

The objective of the following study is to gather data from different microbreweries across central Spain, including the regional areas of Madrid, Toledo and Segovia. Within this area, as of 2020, there are currently 38 craft brewers associated with AECAI (1), which includes nomadic brewers as well. Nomadic brewers could not be included in this study due to not having personal equipment. The four overview areas of the study included equipment, methodology, raw materials and global vision of the factory. Equipment will focus on capacities, machinery, origins, and yield overall. Methodology focuses on processes and median time of key brewing steps. Raw materials focus on the use of hops, yeast, and water. Global vision looks into annual production, the evolution of breweries opening in the region, beer styles and future designs of the breweries.

MATERIAL AND METHODS

The method that was taken to complete this study was the realization of an interview with 10 different craft breweries across the specified region. The only material necessary was the planned questionnaire of around 100 questions and a recording device. The questions were an adapted and actualized version of Mayordomo's previous study (3). The interview was conducted on site at the breweries in all but one case, which was completed via video call. The data was collected and grouped according to each section into a series of 102 graphs. All data collected was explicitly presented anonymously and the participants will remain as such throughout the entirety of the study.

The two most important graphs that were utilized to correctly weigh data were overall yield (Graph 1.1) and annual production (Graph 4.2). Two breweries did not know their yield and the median yield of the other eight given was applied to their production when weighing data. This was used in several cases where it was deemed necessary to accurately display data based on current liter production of the brewery. This method also did not take into account the year 2020 as the Coronavirus pandemic took away many months of production.

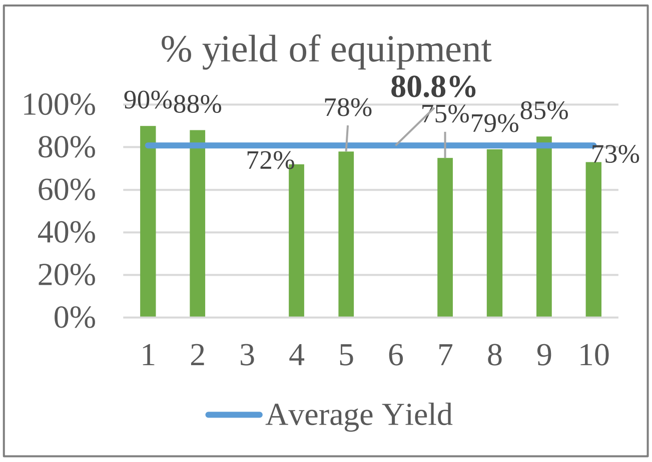
RESULTS

The total hectoliter coverage of this study was 11.100 hL and using data from the 2019 Socioeconomic Report of the Beer Sector in Spain (3), the calculated coverage of this report in central Spain is around 30% of all craft beer produced in the year 2019.

1. Equipment

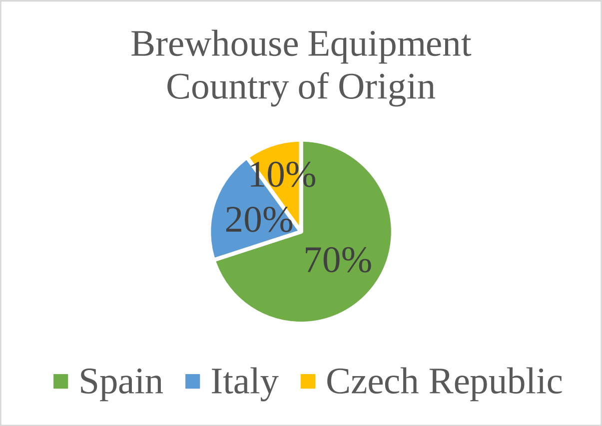
General Information

As previously stated in the Methods section, the yield of each brewery was utilized to maintain significance in the graphic outcomes of the data. This is displayed in Graph 1.1 to the right. The average yield was 80.8% and this average was applied to the annual production of the two breweries that did not provide yield. Brewers were also asked for a personal opinion of this yield on a scale of 1-5, with 5 being very satisfactory and 1 being not satisfactory (Graph 1.2). All of the brewers were somewhere between 2 and 5, with the average coming in at 3.75. The acquisition of the brewhouse equipment was mainly purchased new, with a few fermenters or other bits being second hand and only two brewhouses were purchased second hand (Graph 1.3).



Graph 1.1 Yield of equipment in brewhouse

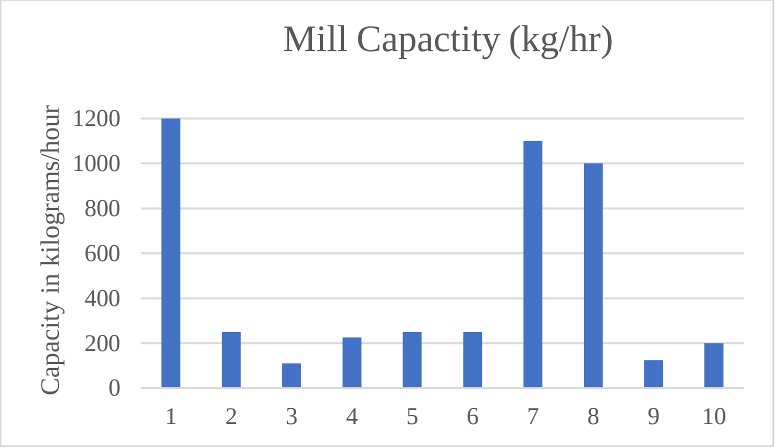
The significant majority of brewhouses are still on their first equipment in the factory (Graph 1.4) and the discussion of this data will touch on similarities across Spain. The origin of the brewhouses was mostly from Spain with a few coming from Italy and one from the Czech Republic, visible in Graph 1.5 to the right. Some of the Spanish equipment takes into account own design and the use of Boris designs as well. Some come from Toledo and others from Almeria.



Graph 1.5 Brewhouse Equipment Country of Origin

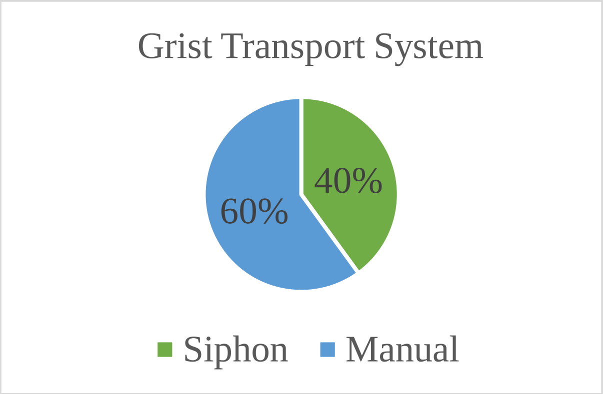
Mill

Mills were widely available in breweries across the Madrid region, with every factory having its own (Graph 1.6). The capacity of those mills varied greatly (Graph 1.7 below).



Graph 1.7 Mill Capacity in Kilograms per Hour

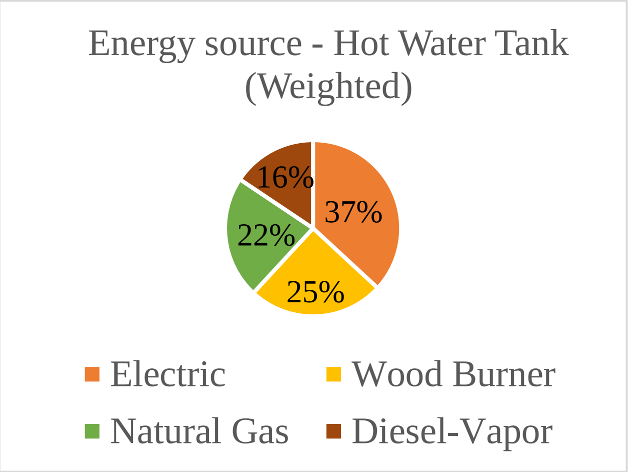
The maximum capacity was 20 kilograms a minute, or 1200 kilograms per hour while the smallest mills only ran at 125kg/hr. A slow mill also did not correlate with less yearly brewing. One of the fastest mills was a 3 roller, but the rest were all 2 roller mills (Graph 1.8), and many of these mills were of the German brand Sommer Haferboy®.



Graph 1.9 Grist Transport System (Siphon or Manual)

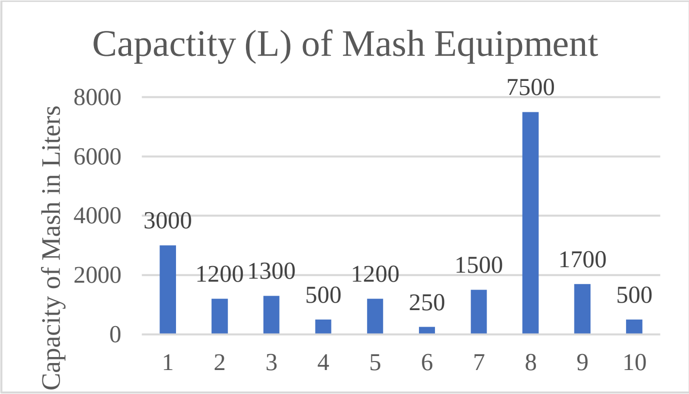
Of the 10 breweries, 4 had siphons (Graph 1.9 to the right) and this did correlate with yearly production, as those that had automatic grist transport systems were all well over the weighted production average of 900hL annually (Graph 4.2).

Mash

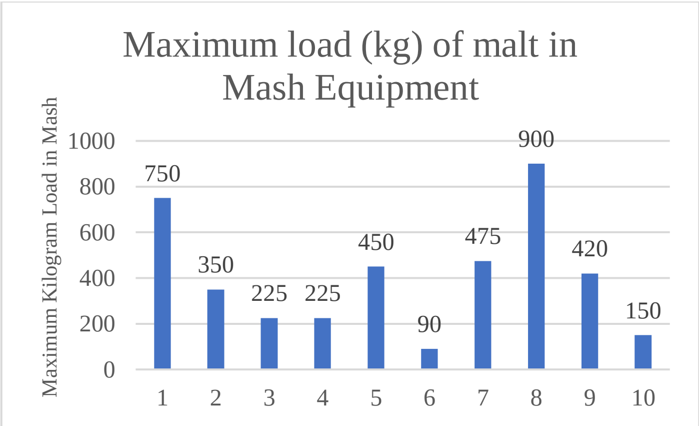


*Graph 1.11 Energy source of the Hot Water Tank (**Weighted** by size of tanks)*

The first step in the mash process is hot water. Every brewery had a hot water tank present in its equipment and the capacity of the tanks is shown in Graph 1.10. The sizes varied greatly and the energy source is also taken into account (Graph 1.11 right). The energy source is weighted for liter capacity of the water tanks, as the largest tank is heated by a direct wood burner and more of the smaller tanks receive heating from electric sources. Graph 1.51 in the discussion section will further explain the relationship of tank size to energy source. The mash tun versus lauter tank in the brewhouse also varied significantly. More breweries had mash tuns than lauters, but it was close to even (Graph 1.12). The capacity and maximum kilogram load can be found in Graphs 1.13 and 1.14 below.



Graph 1.13 Capacity on Liters of Mash Equipment



Graph 1.14 Maximum load in Kilograms of malt in Mash or Lauter

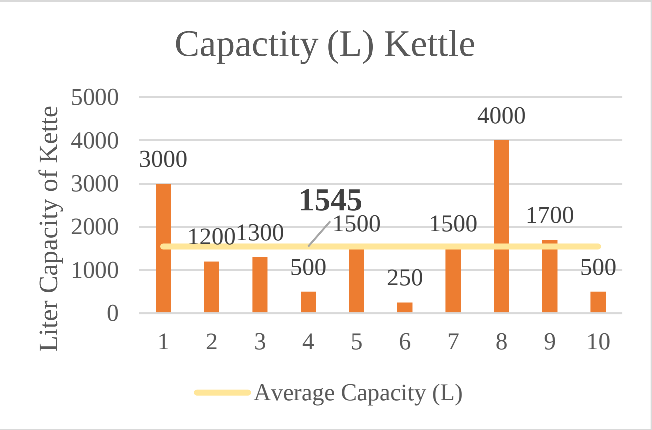
The two graphs above should correlate, considering capacity of the mash equipment would assume that the more liters available, the more malt can be utilized at once, but this is not always the case. This could be dependent on brewers not attempting any higher density beers or just personal preference. The largest lauter of all ten is 7500 liters and while 900 kilograms is its maximum now, this number is only the maximum that has been put in up until today, with the assumption that it very well could fit a significant amount more. The largest lauter is also designed to do very high-density brews with a dilution plan, similar to those in the macrobrewing industry and is likely the only one of its kind in Spain at the microbrewery level. Some of these brew houses, although bigger than others, are very different in design and must take into account other issues like filtering when overloading the mash. The filtration diameter was also measured in meters and this could affect the filter bed depending on surface area available (Graph 1.15) and all the filter orifices were circular (Graph 1.17).

The mash energy source is majority vapor and electricity (Graph 1.16) when weighted against the annual hectoliter production that passes through the mash equipment. Wood burner and direct flame were much less significant after weighting the data for production. Other important pieces that go into the mash equipment are buffers and the pump. Very few brewhouses are utilizing a buffer tank, only 20% (Graph 1.18), which is surprising considering the ease of filtration that it could bring, especially to larger mash tuns. All the pumps associated with the mash to kettle movement did have speed settings (Graph 1.19), which is very important for facilitated filtration of the sweet wort. A one-speed pump could significantly slow transfer to a kettle if the malt content is high or other, harder to filter malts are used. It could go so fast that solids get pulled through with the wort or it could collapse the filtration bed.

Kettle

The majority of kettle recipients were separate from the lauter or mash tun (Graph 1.20). The capacity varied greatly, the with average capacity being 1545 liters (Graph 1.21 below).

The kettle is, in all but one case, the same size as the mash or lauter. The largest lauter still has the largest kettle but it is 3500 liters smaller in size. As stated earlier this is because of dilution plans and the possibility to split boils. Therefore, this average capacity calculation is less skewed than the mash tank capacity would be and is included in the graph. Half of the breweries are near average for boiling capacity.

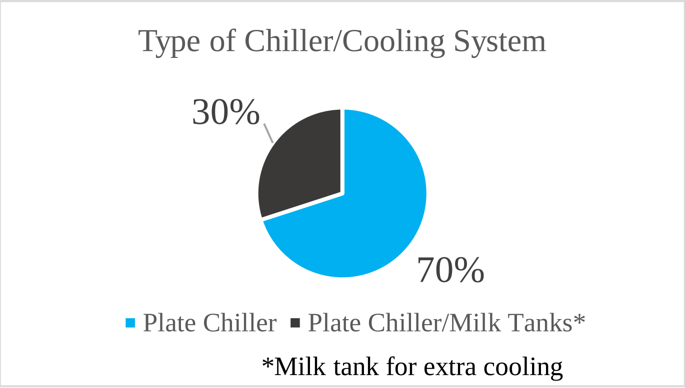


Graph 1.21 Capacity in Liters of Kettle and Average Capacity

The energy source of the kettle is similar to the mash energy source (Graph 1.22) but takes into consideration that vapor for heating one of the kettles comes directly from a diesel vapor generator instead of the vapor from a hot liquor tank. Evaporation in the kettle is also included and is within a realistic range for evaporation (Graph 1.23). The lowest point on the graph, 3.5%, is due to a condenser attached to a kettle, keeping the evaporation much lower than normal. The whirlpool was also taken into account about its placement, whether it was in or separate from the kettle or if there was no whirlpool in the brewery at all. The amount of separate and same vessel whirlpools was the same, while still being a majority against breweries that have no whirlpool (Graph 1.24).

Cooling

The chilling system for post-boil was, in all cases, a heat exchange with a simple plate chiller first, but 30% of breweries utilized a two-step method and had milk tanks or refrigeration tanks for extra chilling after heat exchange (Graph 1.25 to the right). Of all the cooling methods, only 10% utilized glycol water instead of



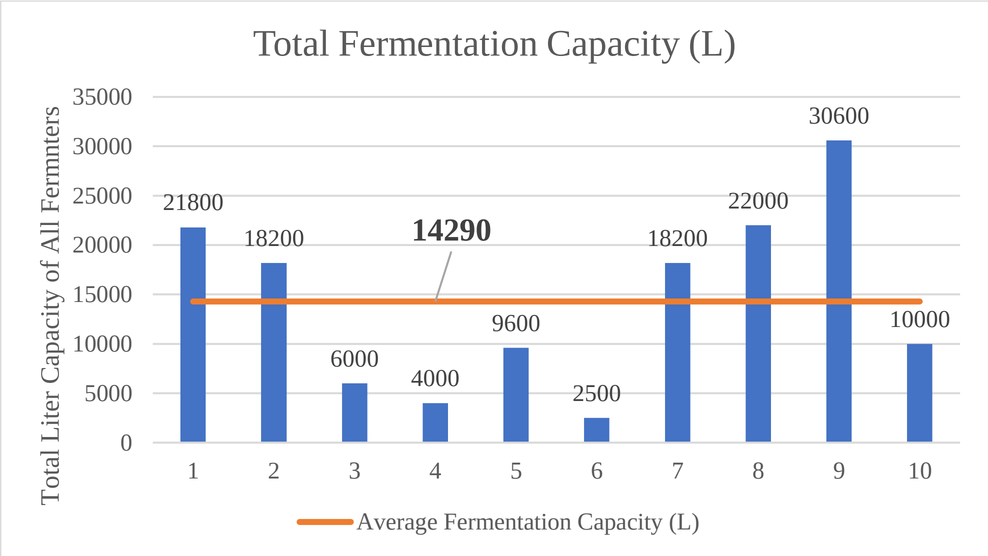
Graph 1.25 Type of Chiller/Cooling System for Boiled Wort

simply tap water (Graph 1.26) and this was done in a two-step process with a refrigeration tank. All of the breweries have a plan for reuse of coolant water, whether it be used continuously for chilling, for cleaning or directly goes back to brewing (Graph 1.27), though within the interview questions its exact use was not specified.

Oxygenation of the wort was done through three main techniques, spraying into the fermenter, line or oxygenation stone. Half of the breweries rely on air and spraying while the other half use pure oxygen via line or stone (Graphs 1.28 & 1.29).

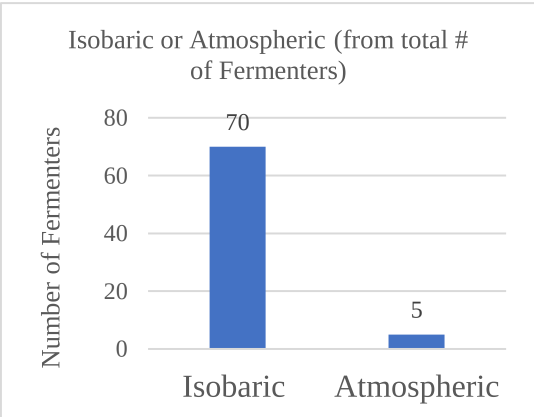
Fermentation

Fermentation equipment focused mainly on the fermentation capacity and overall average capacity of the factories. While the number of fermenters is interesting to see (Graph 1.30), it doesn't give us much information in regards to how much beer can actually be fermenting or stored at once. The graph below, Graph 1.31, gives us the total liter capacity for each factory and an average overall.



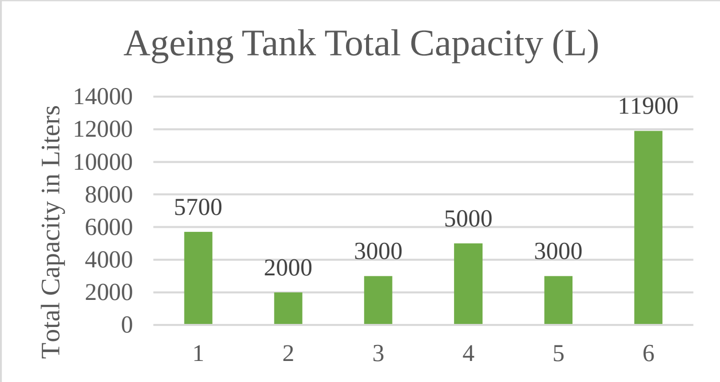
Graph 1.31 Total Fermentation Capacity in Liters for Entire Brewery and Average Overall

The average overall was about 14.300 liters total across all the breweries. Some were significantly different from this average, with one brewery even doubling it and others were less than half the average. All of the fermenters represented are cylindroconical (Graph 1.32) and Graph 1.33 to the right shows that the vast majority of these fermenters are isobaric as well when considering this from the total number of fermenters across all breweries, which was 75 total.



Graph 1.33 Isobaric or Atmospheric Fermenters from total # of Fermenters (75)

Ageing tanks were taken into account separately from fermenters, although some old fermenters were used specifically for ageing. The total number of ageing tanks in each brewery is much less than fermenters, only 18 total (Graph 1.34). The total capacity of these tanks is shown below (Graph 1.35). Four breweries did not have any tanks that were specifically for ageing.



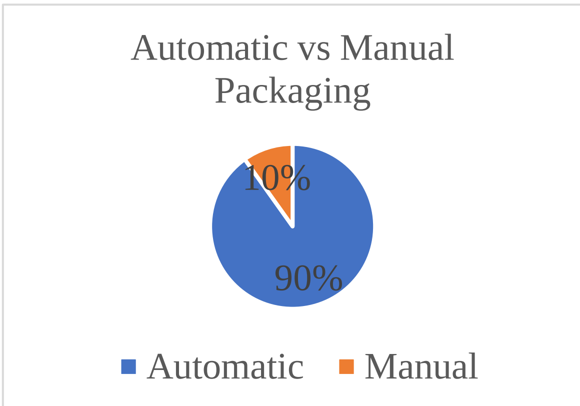
Graph 1.35 Ageing Tanks Total Capacity in Liters

The type of ageing tanks is represented over the total number of tanks (Graph 1.36), which is a majority of horizontal bright tanks. Weighting the type of tanks against capacity didn't affect the data significantly. The connection between all the tanks is truly a majority of hoses, with any fixed tubing only being represented between the mash and kettle deposits. None of the factories had fixed tubing to the fermenters or ageing tanks, as hoses were used (Graph 1.37).

The pumps that move the beer around the factory and clean were also counted to give a total count of pumps in the brewery (Graph 1.38). Some breweries were playing with fire, only having 1 fixed or mobile pump in the whole factory, without a backup. From the total count of pumps, 28 between all breweries, the vast majority have variable speed and the rest were one speed (Graph 1.39), with one even being an adapted pool pump used for cleaning!

Bottling/Canning

All data for the packaging machines in the following results were bottling machines unless specific cases were that the factory only had a canning machine, which was the case for 2 breweries (Graph 1.45). All the breweries had some form of packaging machine, automatic or manual. The Graph 1.40 to the right shows the weighted percentages of automatic vs manual packaging machines, because while more than 10% of machines were manual, the annual liters bottled or canned was significantly less.

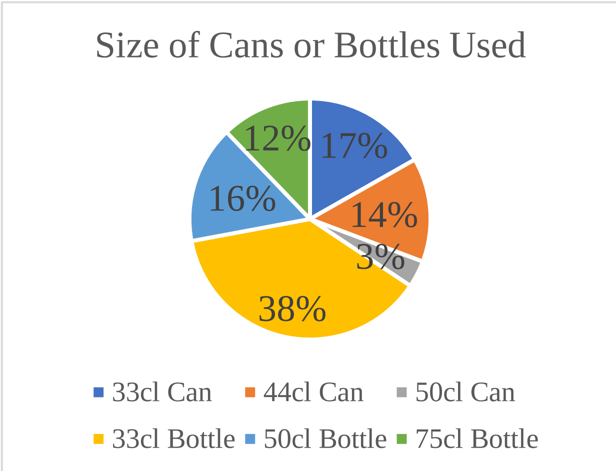


*Graph 1.40 Automatic vs Manual Packaging (**Corrected** for hL Production)*

The capacity of the primary packaging machine (Graph 1.41) varied greatly, with one bottler going as far as bottling 4000 bottles an hour, which is not impossible. It has 12 injectors and is continuous but it is an outlier when compared to the average, landing almost 2 standard deviations away from the average 1458 bottles or cans per hour. The origin of the packaging machines varies greatly, with the majority coming from Germany and Italy (Graph 1.42) and a couple, specifically canning machines, came from England and the USA as their craft canning cultures are more advanced than here.

While the majority of brew house equipment is still the first in the brewery, this is not the case with bottling and canning machines. 70% of factories had a different bottling machine at the start of the brewery and have since upgraded (Graph 1.43). The vast majority of these machines are isobaric (Graph 1.44) and the graph is corrected to account of hL production of the breweries. The one brewery still using atmospheric bottling was in the process of obtaining an isobaric bottling system but the new data didn't make it into this study.

As previously stated, 20% of the breweries are can-only and this graph also reflects that 50% are bottle only (Graph 1.45). The other 30% actually have both machines and one of them is a two-in-one machine adapted specifically to the size and needs of the factory. A wide range of bottle and can sizes are used across all of these breweries, with the most popular sizes being the classic 33cl bottle and 50 cl bottles and the 33cl can (Graph 1.46 to the right). This graph weights answers based on annual liters of each brewery and divides the liters by number of separate types of packaging used in the factory. While the 33cl bottle has more percent than all three of the popular can sizes put together, it is very possible that actual packaging rate of each deposit could skew this graph as kegs were also not weighted in this scenario.

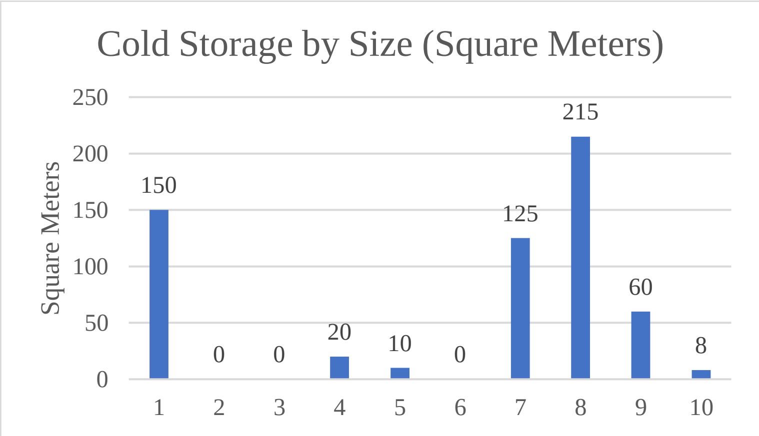


Graph 1.46 Size of Cans or Bottles Used Overall, Weighted by Liter Production

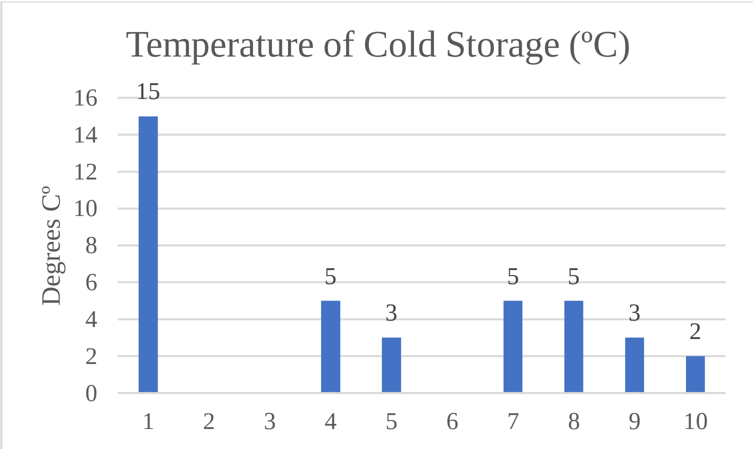
Kegs were also discussed, counting the number of answers for each type of kegs but similarly to bottles and cans, not taking into account percentage of use for each as many breweries used multiple types of kegs (Graph 1.47). The majority keg used in central Spain is still the nonreusable, plastic KeyKeg® and Polykeg®. This also means that about half of breweries do not require CO_2 lines for draft taps as compressed air is sufficient to push the beer out of the interior bag (Graph 1.48).

Storage

Cold storage of kegs, bottles, cans, hops and whatever else fits was measured in square meters. Some of these cold storages are warehouse big and possibly a bit too warm to be called cold storage while others are hermetically sealed off rooms sitting at the temperature of a refrigerator. The graphs below, Graph 1.49 and Graph 1.50, show storage size and temperature.



Graph 1.49 Cold Storage by Size in Square Meters



Graph 1.50 Temperature of Cold Storage in ºC

Cold storage would have to be something separate from a general warehouse or storage unit and it must have a temperature control. It is important to note that the three breweries without any square meters of cold storage equate to the 0 temperatures in the graph on the right. There are no cold storages set at 0ºC in this study!

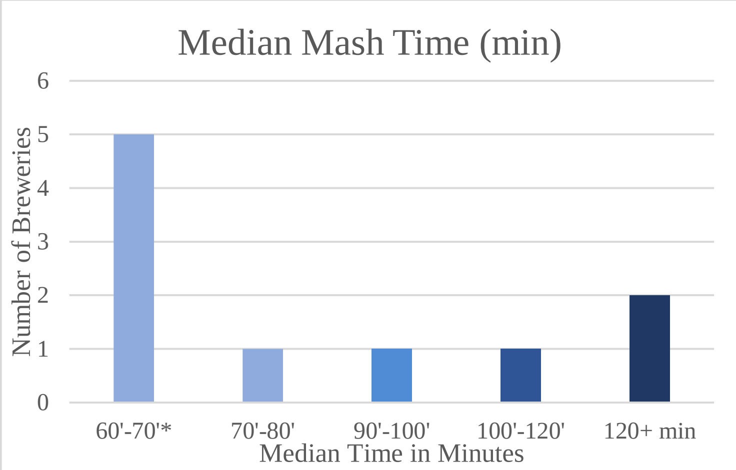
2. Methodology

Mash

Starting a correct mash should always kick off with a well milled grain. Too much flour in the grist and the mash will end up pasty, making filtration a disaster. Grain that hasn't been milled enough can lower sugar yields, causing density to come out lower than previously expected. An easy fix to knowing if a mill is doing its job correctly is to analyze the grist with sieves. Unfortunately, this is not the case for 90% of breweries in the region (Graph 2.1). This test can also be used to check that the mill is working properly and assure it is set at a correct speed or the opening to the rollers is the right size. The investment is small as well, simply with a set of sieves and a balance to weigh each level a brewery can solve one of the biggest problems that lowers yield!

pH rectification, depending on the malt or water in the brewery, could be more or less necessary from one brew to the next. 80% of breweries used some form of pH rectification (Graph 2.2) but frequency was not discussed as this is dependent on too many individual factors. The most popular product for rectification of pH was phosphoric acid, while lactic acid and ascorbic acid were used infrequently. Many brewers commented that phosphoric acid use was not notable in the final product.

Mash time and methods were variable, with median mash time being anywhere from 60 minutes all the up to more than two hours (Graph 2.4 to the right, *3 of 5 in the 60–70-minute mash time correspond to <10hL equipment). It is important to note that deposit size does not correlate to shorter or longer mash times, though it was interesting to note some of the smaller tanks had shorter times.

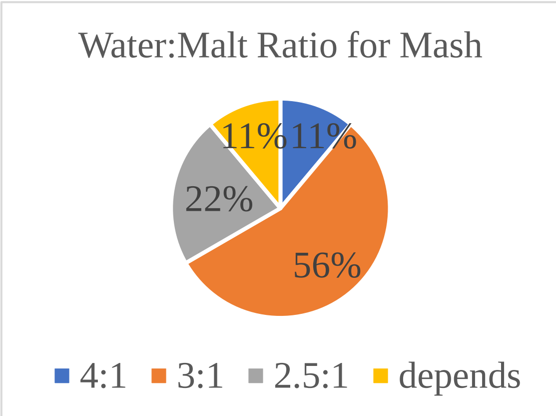


Graph 2.4 Mash Time in Minutes (Average)

Temperature scaling in the mash was utilized by 70% of breweries, and one of those breweries does so with various, controlled additions of hot water instead of heating directly with the deposit (Graph 2.5). All of the breweries utilize a mash out (Graph 2.6). Many of these set-ups allow for automatic agitation of the mash, 80%, while 20% are manually mixing with a shovel or rake (Graph 2.7). All of the brewers said that they believe the temperature maintains well throughout the mash, which is a positive outlook for the equipment as lost heat can be costly (Graph 2.8).

Many breweries are using the typical 3:1 water to malt ratio while others used more or less water and some said it completely depends on the recipe (Graph 2.9 to the right).

Application of the iodine test was also discussed and many, 70% to be exact, said they do not apply it currently (Graph 2.10). Of this 70%, some said that they used to use iodine testing but do not anymore now that they know their equipment and others said they specifically wouldn't ever use it. The brewers that are consistently using it change recipes often or have variable outcomes with their brewhouse.

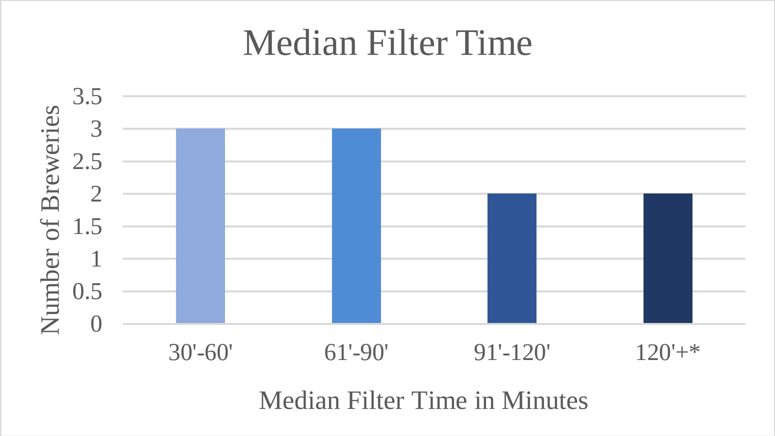


Graph 2.9 Water : Malt Ratio for Mash

Filtration

Filtration methodology depended on a few things, including recirculation time, use of sparging and time to pass a filter to the kettle. Recirculation time had 50% of responses between 5 to 10 minutes, with the maximum time being 20 minutes (Graph 2.12). All brewers utilized a sparging method to wash the grain bed (Graph 2.14). The filter time was extremely variable, with median times running from 30 minutes up to over two hours

(Graph 2.13 below, *one filter can do 10hL in 40 minutes but has the largest lauter). This was not dependent on size of the brew house, as some of the smaller tanks had slower pumps or backed up often. One system even does the whole filtering process via gravity.



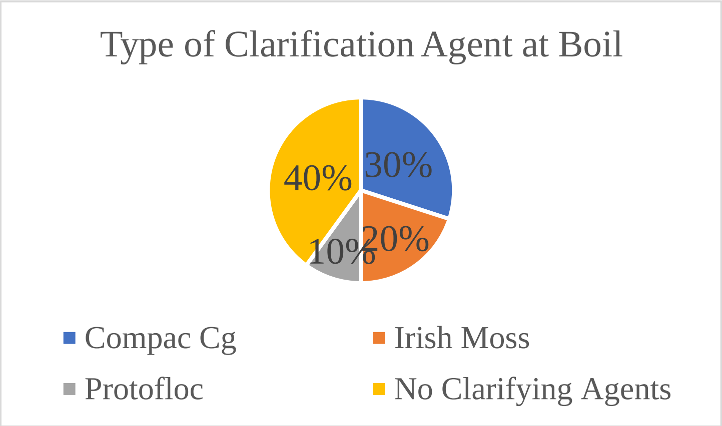
Graph 2.13 Median Filter Time (From Mash to Kettle)

The spent grain that was removed after filtering was in all cases repurposed for other uses and the most popular use was animal feed (Graph 2.15). Other interesting uses included use in a bread shop, plant compost and even insect feed!

Kettle

Boil methods included time, products used, analysis of the boil and whirlpool time was considered if it was used at the end of the boil. Median boil time was mostly between 60 and 69 minutes, with half of all answers landing in that range (Graph 2.16). Boil is usually recommended to be around 60 minutes to assure maximum alpha acid utilization in the hops. Style depending, a longer boil can also stave off DMS compounds in the wort, assuring the removal of such defects in the final product. Boil over problems in the equipment were also taken into consideration, with 30% having regular overboil issues and another 30% answering that they sometimes have issues (Graph 2.17). As of now, none of the breweries are using antifoam agents (Graph 2.19).

Many breweries carefully watch pH throughout the process, including in the kettle, with 70% analyzing pH at or after boil (Graph 2.18). Clarification agent use at boil is also a popular method of stabilization of the final product. 60% of breweries are using some clarification agent (Graph 2.20 to the right). Some of the products being used are Compac Cg and Irish moss, which are both seaweed compounds. Protofloc is a flocculation agent that helps crash out solids in the boiled wort. 40% of breweries are sticking to natural clarification of the boiled wort, letting the kettle do the work.

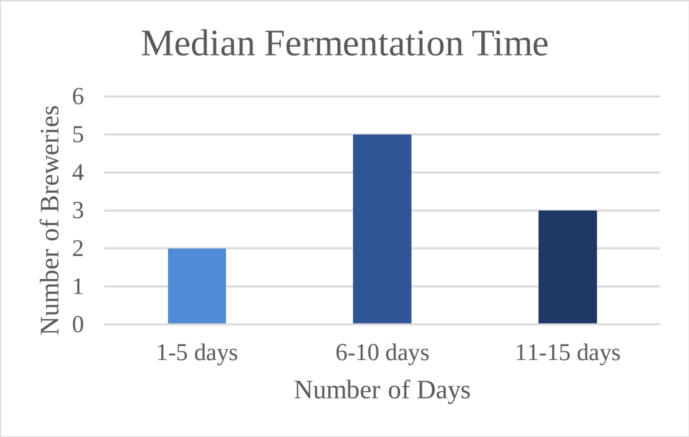


Graph 2.20 Type of Clarification Agent at Boil

Median whirlpool time was variable, with times being anywhere from about 11 minutes up to more than 30 minutes (Graph 2.21). Two of the breweries, as mentioned before in Graph 1.24, do not have a whirlpool and are reflected as zero minutes of whirlpool. One of the breweries did not answer this question (N/A) but does have a whirlpool.

Fermentation

The methods of fermentation focused on fermenting and ageing time, stabilization methods including clarification and filtration and also carbonation at the end of the process. The median fermentation time had 50% of participants with a median time between 6 to 10 days (Graph 2.22 to the right). For ale fermentation, this is on par with an average fermentation that isn't a quick yeast. Those that had higher median fermentation times could be because lager fermentation was factored into the median when coming up with an answer.

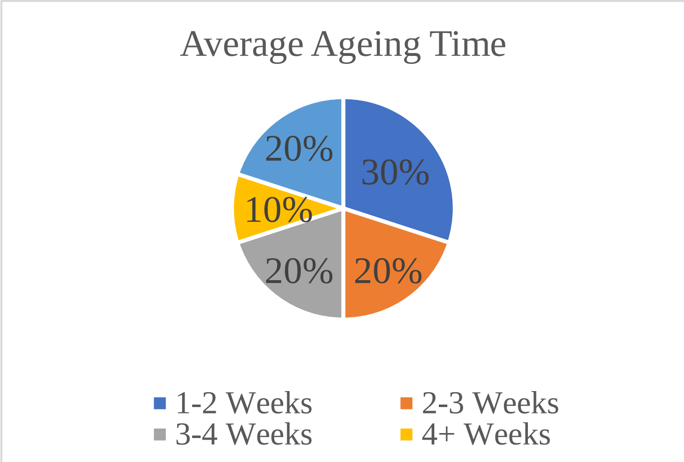


Graph 2.22 Median Fermentation Time in Minutes

Graph 2.23 explains that 60% of the breweries regularly use nutrients to improve yeast performance, which could explain a majority of fermentations being close to an accepted average for ale fermentation. Post-treatment of the finished beer was dependent on a few factors, including style and even audience of the beer. Filtration post fermentation (Graph 2.24) found that half of all breweries are not filtering at all but the other half, in some cases are. Some said it depended on the client, others said only their lager is filtered. This specific trend will be debated further in the Discussion section. Other methods of stabilization post-fermentation were less common, with only 20% of breweries using other methods. The other method shown in Graph 2.25 was Vicant, an antioxidant product that is added to beer usually a day before bottling the final product and its goal is to stave off any oxidation compounds in the bottle, can or keg.

The post fermentation clarification of craft beers is commonly achieved through a cold crash but this study found that 20% of breweries were using a cold crash and clarifying agents to improve beer clarity (Graph 2.28). Frequency of use was not specified.

Another important type of fermentation represented, while significantly less notable, is wooden barrel fermentation. In Graph 2.26, we observe that only 10% of breweries are attempting barrel fermentation and when we see the actual number of hectoliters compared to other styles (Graph 4.5), we can see the production rate is extremely low. Only 16 hectoliters a year are produced compared to 5000 hL of traditional ales, which isn't surprising considering the space and cleaning regime that goes into having wooden barrels in a brewery. Average ageing time varied greatly across all breweries, with a relatively even split between all the different ranges of weeks (Graph 2.27 to the right). Barrel fermentation was not accounted for in this average aging time as production was too low, it is too variable and can last years.



Graph 2.27 Average Ageing Time

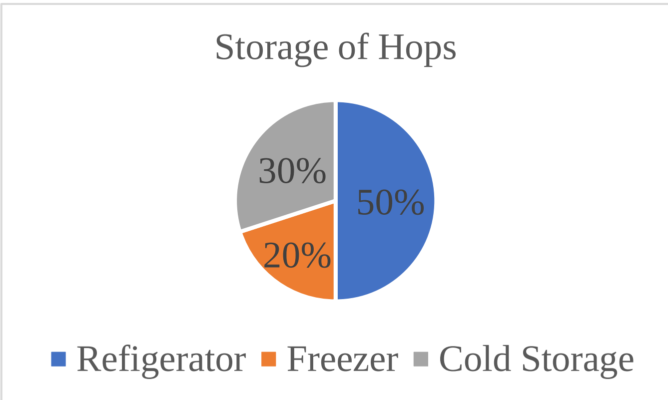
Carbonation, whether it be a spunding method toward the end of fermentation or forced, was weighted by number of liters carbonated in each way (Graph 2.29). Some breweries said they partake in both spunding and forced carbonation, so each answer was separately weighted by total liters annual and divided by number of types of carbonation realized. The most common answer was forced carbonation, by hooking up CO_2 to an isobaric fermenter and raising the pressure (47%).

3. Raw Materials

Hops

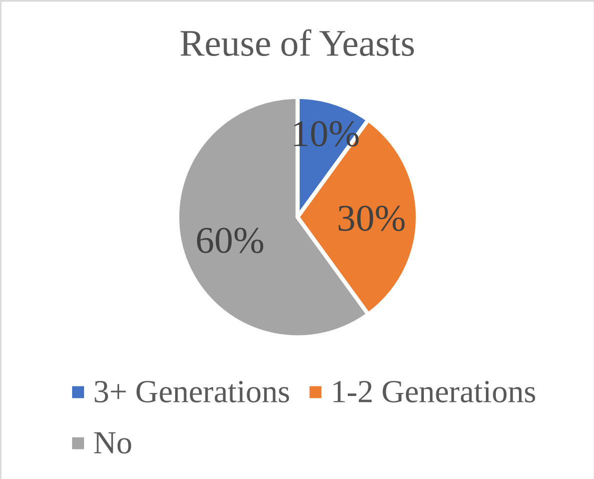
The goal of hops, whether they are bittering or aromatic, is to give our finished product character. Many brewers in central Spain are sticking to pellet as the main form of hops (Graph 3.1) and we can see a few use cryo hops as another, newer form. None of these brewers are currently using dried, whole hop flowers and while some said that they have tried using flower in the past, they didn't get the desired outcome that comes from pellet. Some did say they are trying out different advanced hop products like resins, oils and extracts. In Graph 3.2, we see that 30% say they are actively trying advanced hop products while 10% test products sometimes.

Storage of hops is important for shelf life and conservation of resins in the pellet. Truly, the colder the better when it comes to hops. Around 50% of hop storage in central Spain is in temperature-controlled refrigerators (Graph 3.3 to the right). Usually this is sufficient for long term storage but the 20% using a freezer could find that their hop aromas are still as fresh as the day a bag of pellet is opened, even many months after being opened. As we previously saw the temperature of cold storages, this can also be an appropriate, controlled place, as long as temperatures stay at or below 5ºC.



Graph 3.3 Storage of Hops

Yeast

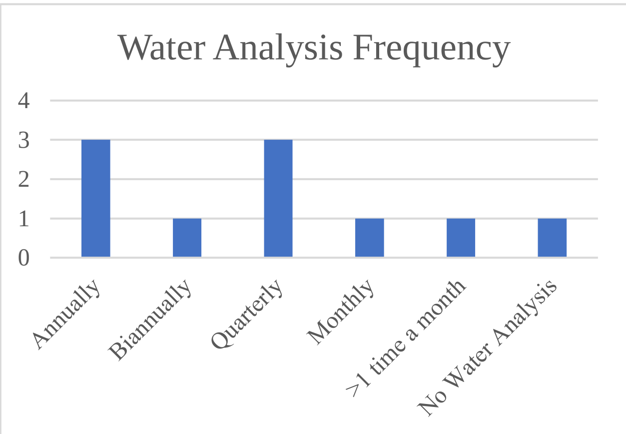


Graph 3.5 Reuse of Yeasts and for How Many Generations

The goal of studying yeast was to find breweries that are actively reusing or even starting cultures. Less than half of all breweries are actively using starters (Graph 3.4) while the majority are pitching dry yeast directly into the fermenter. Graph 3.7 explains that 70% of fabrication is done only by dry yeast and the other 30% use both dry and liquid yeast, but we do not know the frequency at which liquid yeast is actually being used. 60% of brewers are discarding yeast after one use, while 30% reuse their yeast 1-2 generations and 10% use it for 3 or more generations (Graph 3.5 above). Typically, it is recommended to not reuse yeast more than 3 generations unless you have lab equipment adept to check viability and count yeast cells. As this is still the craft beer sector and no macrobreweries were included, it is not surprising to see that none of these participants are actively using their own yeast cultures (Graph 3.6). The infrastructure to do so isn't here yet in the craft sector of Madrid.

Water

Origin of brewing water has to be pondered in this study, especially considering tap water is not the same if it comes from different parts of central Spain. While 100% of brewers in the study apply only tap water to their beer recipes (Graph 3.8), treatments of that water changed depending on location. Graph 3.9 shows the count of different water treatments used by the breweries. It was taken into account that the breweries with locations directly in and around Madrid did not have to filter or treat the water with anything other than salts, which is more personal preference for adapting water to different styles. Also, it is notable that of the two who applied no treatment one brewer is located in Madrid while the other was in the Sierra where the water is well water, not city treated water. Those that had to apply filters or osmosis, along with salt additions, were all located in either Toledo or Segovia.

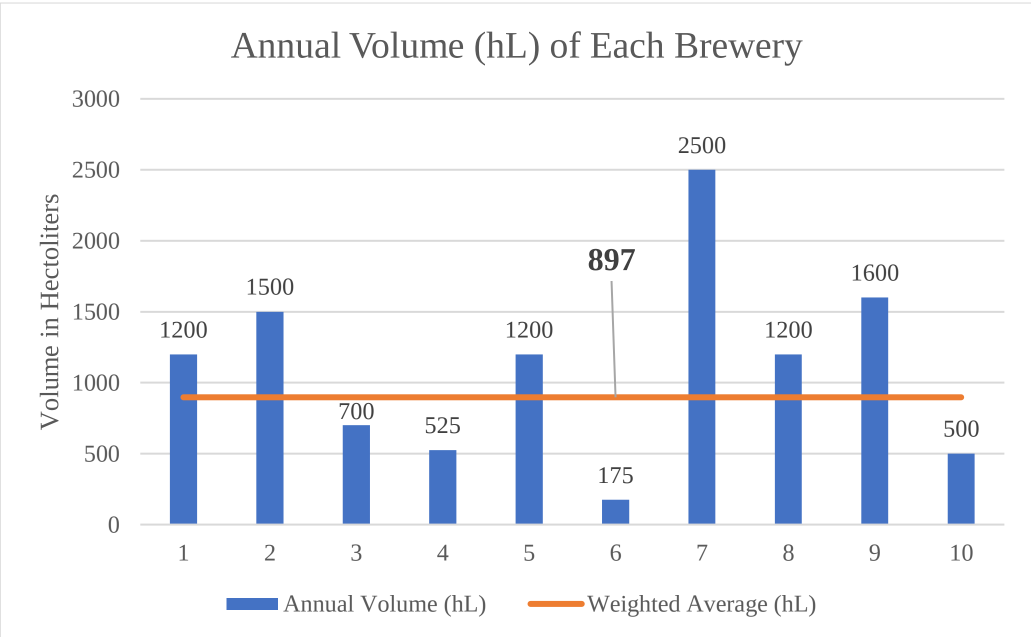


Graph 3.10 Water Analysis Frequency

Water analysis frequency did not depend on location, with breweries in Madrid analyzing water annually, others quarterly and some even monthly. Frequency of analysis (Graph 3.10 to the right) depended on two factors: personal opinion of water quality and trusting the accuracy of reports done by city halls. Some city halls make finding their water reports difficult or do not analyze water with enough regularity to become useful to brewers. This is why timing of personally ordered water analysis varied greatly. Some brewers said the water always comes out exactly the same every time they have had an expert come and others said their water varies significantly. Figuring out how often to analyze water would depend on outcomes of previous tests and deciding if more should be done to adjust water composition for individual breweries. Many breweries are ordering labs to take samples and test their water, around 67% (Graph 3.11), which is an expected majority considering many craft breweries do not have the lab equipment to analyze all the contents of their brewing water.

4. Global Vision

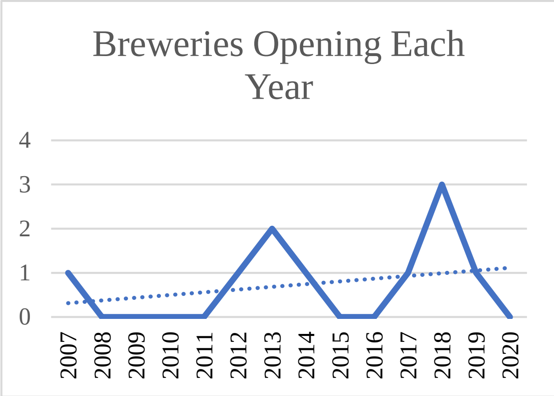
Global vision of the sector aims to inform about style trends in the region, annual volume of the breweries interviewed, points of sale, collaborations within the craft sector and future update plans as the world starts to come out of a global pandemic. As previously stated, the annual volume of the breweries was adjusted with yield percentages and then applied to appropriately rectify data when necessary. Graph 4.2 below shows us the unweighted, annual volume of each participating brewery and the weighted average.



Graph 4.2 Annual Volume in Hectoliters of Each Brewery (Average Weighted by Yield)

The brewers were also asked out of 100%, approximate percentages of production of five overarching styles. The five general styles were traditional ales (pale, red, stout, etc.), hoppy styles (IPAs, APAs, NEIPAs…), lagers, sours and barrel aged beers. Graph 4.1 shows each brewery and its percentages, not taking into account total hectoliters. Graph 4.5, displayed in the discussion section, rectifies this by separating the styles and calculating the actual hectoliter production of each, based on total production of the breweries and their percentage answers. The beer with the most production in the region is traditional ales, around 5000 hectoliters. Second place landed with the hoppy styles and then lagers, sours and finally barrel aged beers.

Trends in the opening of new breweries has been a bit skewed by the COVID pandemic, but prior to the year 2020, new breweries in the region were on an upward trend. Graph 4.3 to the right shows a positive trendline in the region, with the best year for brewery openings landing in 2018. The good news is that these breweries all survived the mess of 2020 and are still going in 2021!

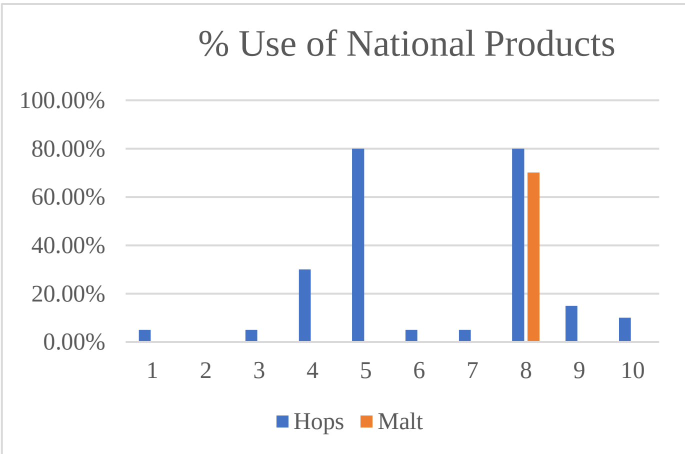


Graph 4.3 Breweries Opening Each Year with Linear Trendline

Graph 4.4 shows some interesting data about brews per year based on maximum mash capacity and total hectoliter production. This does not take into account that some brews could be less than maximum capacity and these averages are truly a rough estimate. The yearly average of brews per factory was right around 90 brews a year, making the monthly average around 7 brews!

Another very important part of craft beer is the food that goes with it. While 70% of the breweries studied had taprooms or bars in their brewery (Graph 4.6), only 20% of those surveyed had a brewpub associated with their brand (Graph 4.7). One of these brewpubs was onsite at the brewery and the other was a separate location, but the deciding factor in calling the location a brewpub was that it had to have a kitchen. Serving small plates or appetizers wouldn't be recognized as a brewpub, as many taprooms do so. It is interesting to see that around 26% of brewers do have a future plan to open a taproom or brewpub associated with their craft beer (Graph 4.10 below). It's great to see the potential that these bars or pubs could have once opened, as the brewpubs open now are still thriving even after Covid!

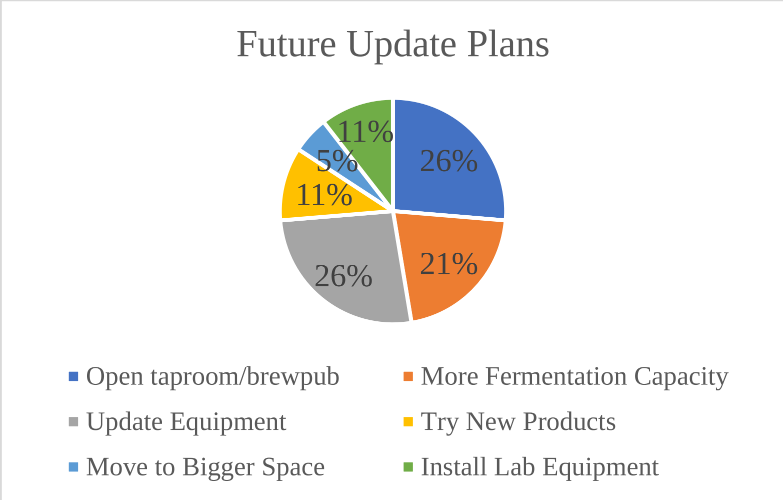
Other sector considerations were use of national products and collaborations within the sector. Only one brewery in this study could say they use any national malts at all (Graph 4.8 to the right). Nine out of the ten breweries said they did use some national hops, but with varying frequencies. A few brewers say they used as little as less than 5% of national hops and others said they used as much as 80% of hops sourced mainly from the Orbigo valley region.



Graph 4.8 Percent Use of National Products (Malt and Hops)

Collaborations have really taken a hit during the pandemic year, with the majority of brewers saying they are only doing around 3 collaboration beers a year (Graph 4.9). Many said this number used to be higher and the sector was more open and available to collaborations but many took hard hits in the last year. There is still hope to recover the pre-covid numbers as some brewers say they are back to doing collaborations as often as monthly or more already!

The future vision of many of these factories is to update equipment by reinvesting into the brewhouse, augmenting fermentation capacity with new fermenters and opening brewpubs as previously stated (Graph 4.10 to the right). It's always great to see the sector planning rebounds and recovery after a mess of a year. Hopefully there will be many future visits to Madrid craft breweries to see how these plans come to fruition.



Graph 4.10 Future Update Plans for Breweries

DISCUSSION

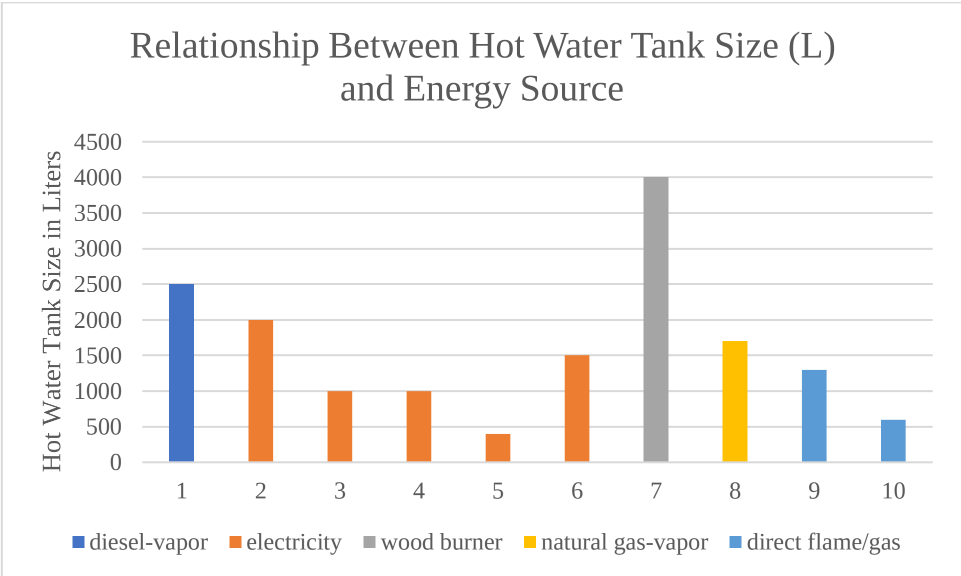
The average yield of the 21 breweries that provided a yield in Mayordomo's study was 76% (3), meaning the average of this study, around 80%, was slightly higher, which could be attributed to the size of these breweries comparatively to those in Cataluña and Valencia. Also, it should be noted that if the production numbers from 2020 were used, the coverage of this study would be incorrect (around 50%) due to the fact that the question asked was explicitly "annual production without taking into account the year of Covid". This is why the data from 2019 is used, giving this study a more transparent coverage, which as stated previously is around 30% of central Spain.

General equipment that could be up for interpretation would be Graph 1.4, which explains that 80% of breweries are still on their first brewhouse equipment. Less upgrades to brewhouses are correct for the region considering the newness of the craft sector in Spain and the majority (90% to be exact, Graph 4.3) of the studied breweries are less than 10 years old. As we can see in Graph 1.3, 80% bought their equipment new, so it wouldn't be sensible to upgrade quickly unless production calls for it right away. Mayordomo's findings were very similar (Mayordomo, Graph 1.2 & 1.3) in that around 80% of breweries are still on their first equipment and around 80% received their equipment new in Cataluña and Valencia.

Bottling or canning upgrades, which is at 70% in this study (Graph 1.43) but not considered in the Mayordomo study, could be linked to their cost. An initial investment of a brewhouse is the most important part of a brewery but the bottler usually gets the backseat until more funds are saved. This is considering that an automatic bottler or canning system can cost a microbrewery an initial investment of around 100.000€ and many, after spending capital on a brewhouse, do not have this level of savings. The majority will start small, some manual, and then move to the nicer, automatic systems.

Water that went into the mash was a notable point of investigation, considering Madrid, Toledo and Segovia have very different water profiles. The breweries in Madrid have access to city halls that treat and test water consistently and the quality is suitable for brewing as is. The water profile hardly ever changes. The only addition that was used within Madrid was salts to adapt to a certain style of water (Graph 3.9). One brewer, outside of Madrid, who doesn't treat their brewing water at all, neither with salts or filtering, left me with an interesting thought about water treatment: if we as brewers don't know what we are starting with, how can we justifiably rectify the situation with salts? Many areas of Spain do not have consistent water profiles and the city hall may not release mineral content often enough, so this brewer has an interesting take on the situation. Use the water you have and see how it goes! Another product that was interesting to see in mash rectification was ascorbic acid (Graph 2.3), which is normally used as an antioxidant in home brewing, not pH rectification, so it was surprising to see its use at the mash step of brewing. Its effectiveness could be a point of further investigation.

Another point of consideration is the energy utilized for heating water. A graphical view of this can be seen below in Graph 1.51.



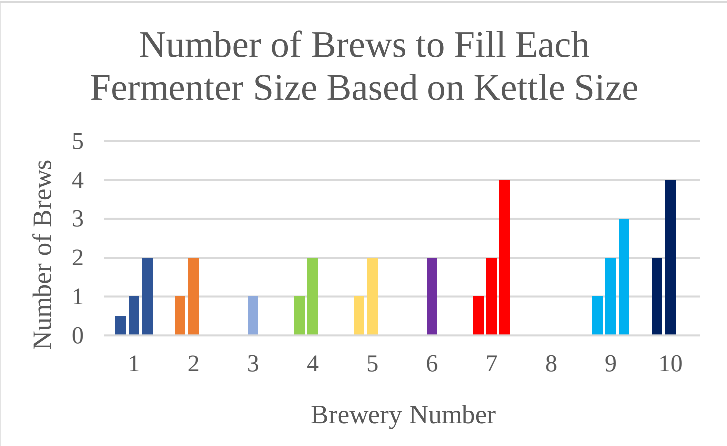
Graph 1.51 Relationship Between Size of Hot Water Tank and its Energy Source

Similarities to the Mayordomo (3, Graph 1.44) study can be seen, with electricity being used the most and normally in tanks of less capacity overall than vapor tanks. Direct flame, gas tanks were used significantly less and in tanks 2000L or smaller in both studies. This is something to take into consideration when mounting a brewhouse. The energy sources available to the factory can affect the size of the tank that would be most efficient. Electricity takes significantly longer than vapor, especially when the tank is larger. Mayordomo found hot water tanks as large as 4000 liters being heated with electricity but hours to heat the tank were not recorded in either study. This could be a point of further study to find out the biggest tank size where electricity becomes a massive loss of time in water heating and vapor is ultimately recommended.

When discussing the kettle, it is an interesting connection to note that while 30% of brewers are having issues with overboils and another 30% sometimes have issues (Graph 2.17), none of these breweries are utilizing defoamers (Graph 2.19). One brewery commented on incorporating its use in the near future and I believe this could be a helpful option for other breweries that experience frequent over boils. Quick mitigation of overboils in any case is key to a safe brewing environment!

As it was previously commented briefly in the results, the number of pumps in each brewery is another point of importance when planning or considering the current setup of one's own brewery. Graph 1.38 shows that while some breweries have as many as four or five pumps, a couple only have one single pump that is mobile. While the pump might seem trustworthy now, we must consider that anything at any time could break, which could hinder production to an extreme halt if such an important piece of equipment ceased to function. Investing in a backup pump could be a noteworthy point of protection to ensure that if the primary pump breaks, the brewery can still move forward same day, instead of losing an unknown number of days to find a replacement or fix the current machine.

The graph to the right, Graph 2.30, focuses on exactly how many brews have to be done to fill the fermenters of these breweries based on the size of the kettle and the different sizes of fermenters found in each respective brewery. Brewery number 8 did not provide the size of each respective fermentation tank, only total liters, so therefore this calculation could not be done for their brews.



Graph 2.30 Number of Brews to Fill Different Sized Fermenters in Each Brewery based on Size of Kettle

Breweries numbered 7 and 10 had the greatest number of cooks required to fill their largest tank or tanks, which was four brews! Whether this was done over the course of one, two or more days was not discussed but the kettle size can be a limiting factor or create harder work days depending on this number of brews. Two breweries shown, Numbers 6 and 10, do not have the option to have single cook days if they want their fermenters to be full! And as we will see in the next part of the discussion, total fermentation capacity, it is extremely important to utilize as much of the space you have available.

Total fermentation capacity will also be discussed as it is found to be a limiting factor in many breweries. Graph 1.31, previously displayed in the results section, found the average total fermentation capacity across all the breweries in this study was about 143 hectoliters. Half of the breweries were thousands of liters below the average but the issue has nothing to do with lack of desire to augment capacity. I believe this is a regional issue. The capitol city of Spain is significantly more expensive than other regions of Spain and there's not enough space for big brewhouses within the city limits that is viable and affordable. For those reasons, 3 out of 5 of the below average breweries were found within the "central" area of Madrid. Many others were outside in warehouse districts, other provinces or smaller towns away from the center. Those not in the central area generally had more space and the ability to augment total fermentation capacity, therefore making production increases possible. What I was interested in finding was if the Mayordomo study had a similar trend in fermentation capacity (3, Graph 1.30).

First, we have to take into account that the weighted average for annual production in the Mayordomo study (588 hL) was around 300 hectoliters lower than this study, meaning overall these breweries were smaller than the Madrid breweries. The average fermentation capacity was also less than this study, coming in at around 87 hectoliters across 24 of the 25 breweries. It is notably different that 83% of the breweries were below this average, instead of only half of the breweries demonstrated in the Madrid study! I believe that one of the breweries included in the Mayordomo study would have skewed data differently had it been weighted due to production differences. This brewery with the most production was almost three times larger than any other brewery in that study and this one as well, with a 6,000-hectoliter annual production (Mayordomo, Graph 4.2) but this was not taken into account in many cases across the study. It was stated in the discussion that breweries with a fermentation capacity above 100 hL were also breweries with an annual production of over 1000hL annually. For this study, that statement does not hold true, as one of the breweries here has less than 1000hL annual production but has 100hL of fermentation space. And another brewery is the opposite, producing more than 1000 hL yearly but is below that fermentation capacity threshold. The other 8 do hold true to Mayordomo's statement.

Moving on to post-fermentation treatments, filtration is usually something "unheard of" in the craft industry, but the reality is that there are clients who still expect a perfectly clear beer. This is why it is not surprising that in Graph 2.24, we see that some breweries do filter after fermentation. 30% said it depended on a number of factors and 10% said only the lager passes filtration as the style calls for a brilliantly clear beer. The previous study (Mayordomo, Graph 3.21) found that around 60% of breweries said no to filtration post-fermentation, but around 30% didn't have an answer to the question and that gap is curiously similar to those in this study who admitted filtration depended on certain factors, but they did use it when necessary. I was unable to find any brewery that is currently practicing some of the new post-fermentation treatments like sonification or centrifuging and wonder if and when such treatments will arrive to the region of Madrid.

After post-fermentation treatments comes bottling, and one bottler in particular comes into discussion. The most thought-provoking packaging machine of all that were seen in this study would have to be the two-in-one bottling and canning machine. The size of the factory that has this protype machine is above average for yearly hectoliter production, yet the speed at which this primary packaging machine runs is significantly insufficient, coming in way below the average packaging speed. It's running about 1000 bottles per hour slower than the average machine in the Madrid region and it is automatic. I had never seen a bottler and a canning system in the same machine in any brewery until I saw this prototype but as the technology is still so new, I don't believe the investment is worth the return at this current time. The engineers would have to improve the average speed to reflect speeds seen in many other craft industry machines on the market.

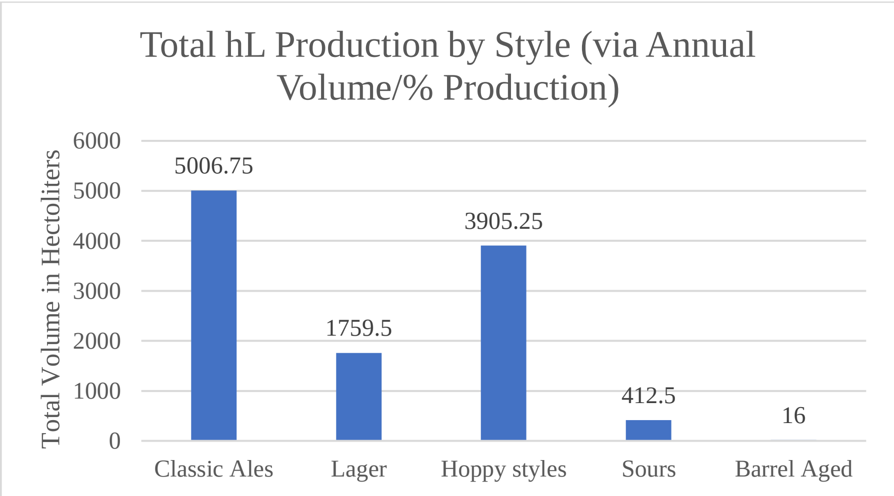
One piece of bottling and canning that was looked into here that didn't go into consideration in the Mayordomo study (3) was canning. As half of the breweries worked solely with cans or both bottles and cans, I included canning machine data where a bottler was not present in the factory. I also looked into sizes of bottles and cans being used throughout these factories. It was not surprising to see that all three popular can sizes added together, 33cl, 44cl and 50cl, were less percentage of use than the 33cL bottle (Graph 1.46). The craft canning industry is still arriving and growing in central Spain. A further point of study could include liters of beer that actually go into each type of deposit, between kegs, bottles and cans but neither the previous study nor this study included it. It could be difficult to calculate considering the current size of the craft industry and the lack of extra hands that have time to find such detailed information about packaging and sales.

Commenting on raw materials being used, we have to discuss the use of national hops and malts in the Madrid region. National products are a tricky situation, considering the market for Spanish malt and hops is quite small. Research done by the European Commission (2021) found that while overall quantity of hops produced from 2019 to 2020 did fall slightly, Spain still came in 5th in tonnage of hops production in the EU, producing 953 tons of hops in 2020. This explains why we see some usage of Spanish hops throughout the region, but the percentages are still extremely small considering the number of Spanish hops available (Graph 4.8). It is understandable that many US or German strains are needed for certain styles and recipes but many beers can be made with national products. We see significantly higher use in other breweries, proving it is possible to incorporate more national hops. National malt on the other hand is a different story. The majority of brewers are still getting malt from outside of Spain due to price and speed of delivery. They can get malt just as quickly and for less money from the big malt houses in Belgium and Germany. This is not an ideal outcome for the craft malt sector, which currently is overtaken by malt houses of the macrobreweries of Spain.

As far as global vision of the sector is going, I would like to comment in detail some of the future plans that were included in Graph 4.10. The different categories shown on the graph generalized many of those plans to centralize the data but for the sake of other brewers, I prefer more transparency on where the sector is aiming to go next. As many of the breweries in Madrid are experiencing rebounds in sales and distribution, the return of profit creates plans of reinvestment. One of the largest percentages was updating equipment. A few brewers are joining the trend of upgrading their primary packaging machine or looking into purchasing a canning machine. Some also feel it is necessary to update brewhouse equipment as what they have now is not giving yields that they would like to see. Some are looking into new post-fermentation stabilization equipment like a centrifuge. Others, around 11%, are looking to invest more time and money into laboratory equipment to have the ability to reuse yeast and starters in pitching.

The other biggest plan of many breweries now is to open taprooms or brewpubs, whether it be onsite at the factory or in a different location. The success of other craft brewpubs is moving the market in this trend but the investment in location, setup and personnel could be what is holding many others back still. As was previously discussed, one of the biggest limiting factors in production is fermentation capacity and 21% of answers to future updates were the need to augment fermentation liter capacity in these breweries. Many see this need but I believe this percentage is not higher because the space isn't there to fit more fermenters. Other plans mentioned were trying new products, which included advanced hop extracts, defoamers, and antioxidant agents for stabilization of the final product.

The other global vision graph that requires extra discussion is the previously mentioned separation of styles graph (Graph 4.5 below). This was calculated with the unweighted, annual production and the percentages of production given by each brewery.



Graph 4.5 Total Hectoliter Production by Style (via Annual Volume/% Production from Graph 4.1)

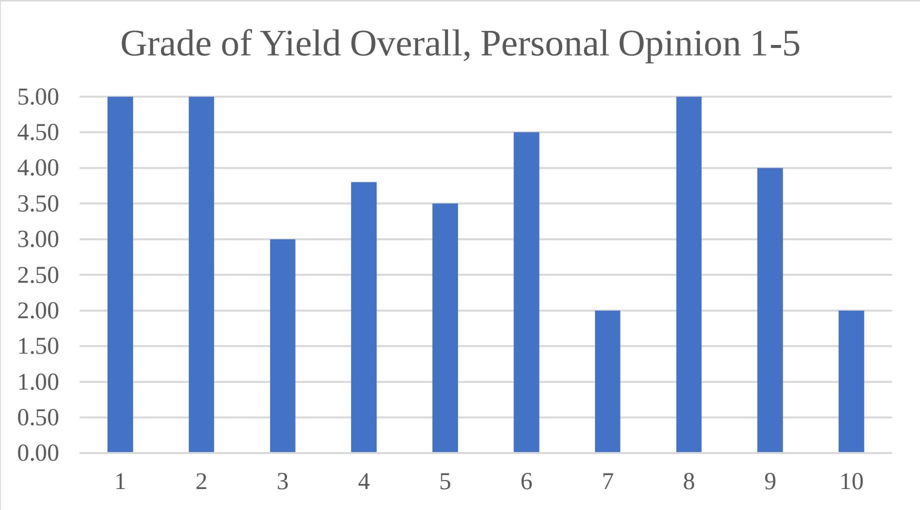
The overarching style that we see represented the most in the Madrid craft region is classic ales. As this is a craft industry study and no industrial sized brewing was accounted for, it isn't too surprising to see the lager style is not as popular when comparing it to classic ales and other hoppy styles. The trend of Indian, American and New England pale ales is still going strong in the Madrid region with 3900 hectoliters getting hopped up each year! Sours still account for a small amount of brewing, but I could see this growing as the sour trend is starting to increase in many craft beer cultures. As we can see, barrel aged beers account for only 16 hectoliters a year and this is not surprising as only one brewery found in the whole region actually has its own barrels (Graph 2.26). There has been a lot of discussion about non-alcoholic beers recently in many sectors and I did find one across this craft region, but the data for amount of production wasn't discussed. It could be interesting to see the evolution of the non-alcoholic, "sin-alcohol" on the peninsula, beer in the craft industry and see if it catches hold in Spain.

CONCLUSION

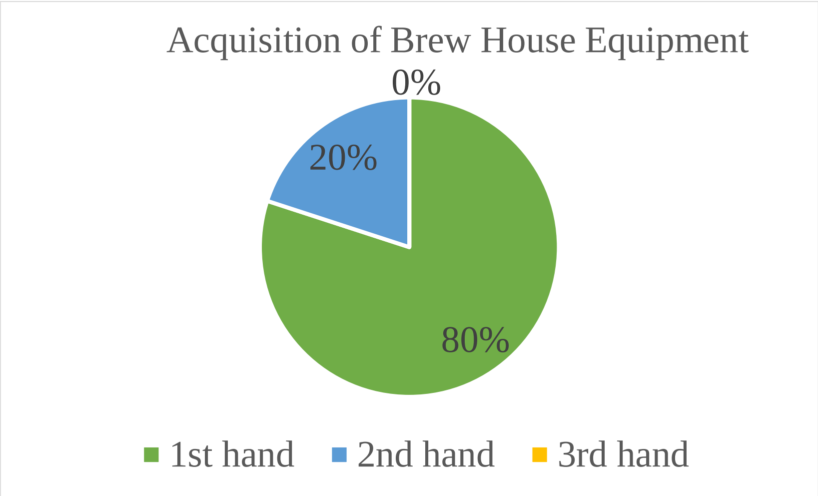
The goal of this study was to gather data from different microbreweries across central Spain, analyze that data and return it back to the craft sector. This was done across 102 graphs, all of which were commented on previously throughout the results and discussion. Points of improvement that were previously mentioned include the following ideas: the effectiveness of ascorbic acid use in mash pH rectification, investigating hot water tank sizes to discover where electricity becomes insufficient and vapor is ultimately recommended, and calculating the popularity of packaging deposits based on liters of beer that actually are packaged into each type or size, between kegs, bottles and cans. I believe it would help the craft sector to track sales of different styles too, as SIBA in England does but the Socioeconomic Report of Beer in Spain (4) does not. I decided not to use SIBAs data as it doesn't reflect trends anywhere else in Europe except England and is not accurate to data taken in Madrid, Spain. There are no recent reports of the craft beer sector except the one done by the Ministry and the AECAI (1), which doesn't report on styles specifically, only total liters sold and consumed in Spain, which is broken down between "big six" liter production and the rest of the industry.

Other notable points of improvement would be to continue to expand this study to other regions or, as Mayordomo mentioned in his study, the creation of an online survey option that would allow for anyone across the whole peninsula to partake, aggregating data digitally with ease as well. I believe there is more to be learned from talking to brewers and finding new brewing techniques while fine tuning the ones we already use. It helps to hear others' experiences and to see an overall vision of the craft sector in the region we are based. As we could see in some of the comparisons to the Mayordomo study, there are similarities between Madrid and Cataluña and also some notable differences. While Cataluña has more breweries overall, Madrid's craft industry is still a heavy hitter in the game of artisanal beer. I expect it will continue to grow and serve the people of Madrid good, real beer.

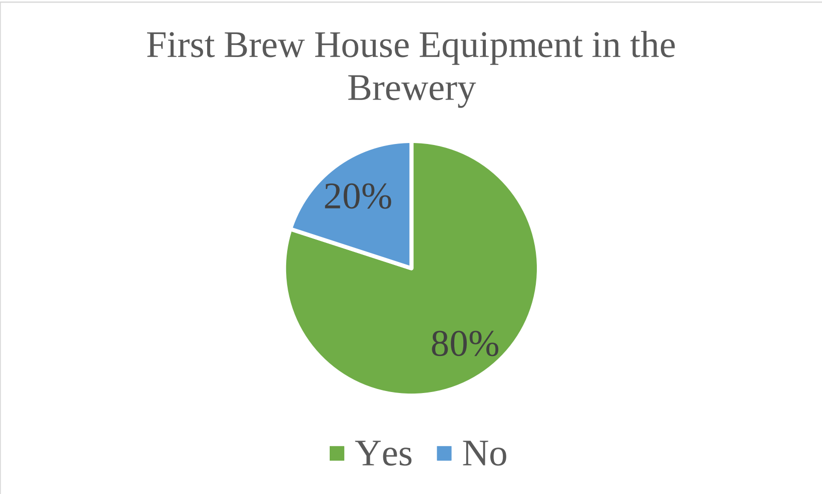
ANNEXES



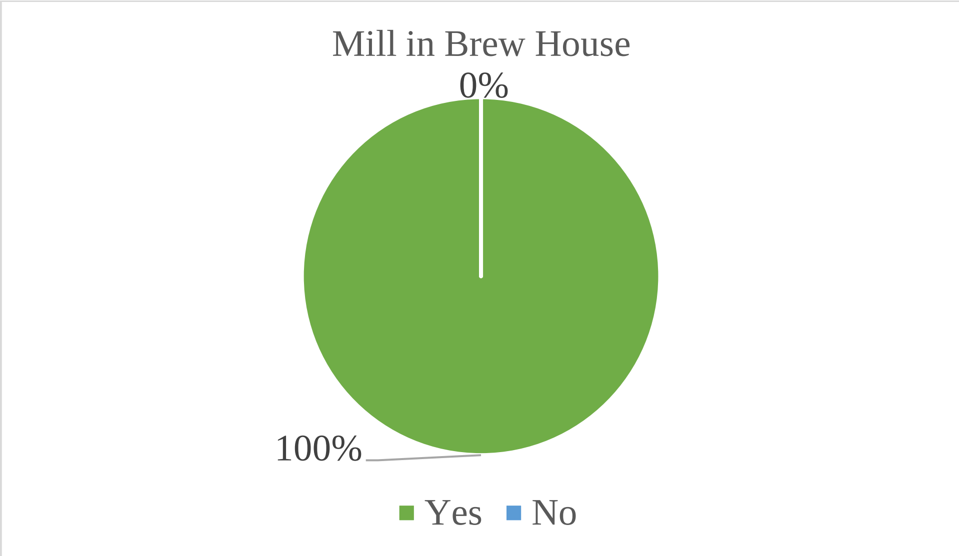
Graph 1.2 Personal Grade of Yield Overall 1 - 5 (5 is very satisfactory and 1 is unsatisfactory)



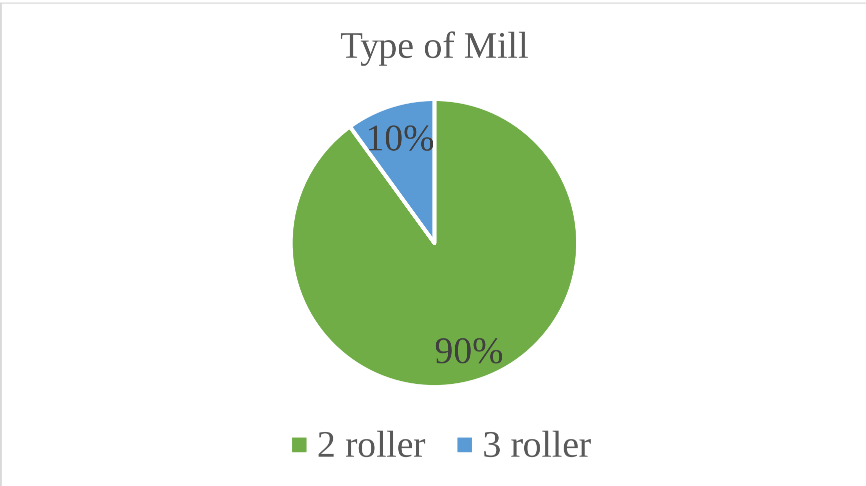
Graph 1.3 Acquisition of Brew House Equipment: First, second, third hand…



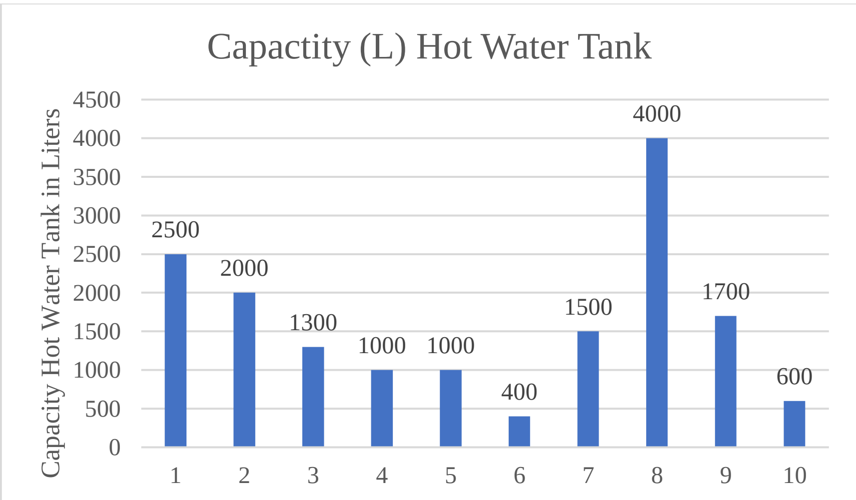
Graph 1.4 First Brew House Equipment in the Brewery



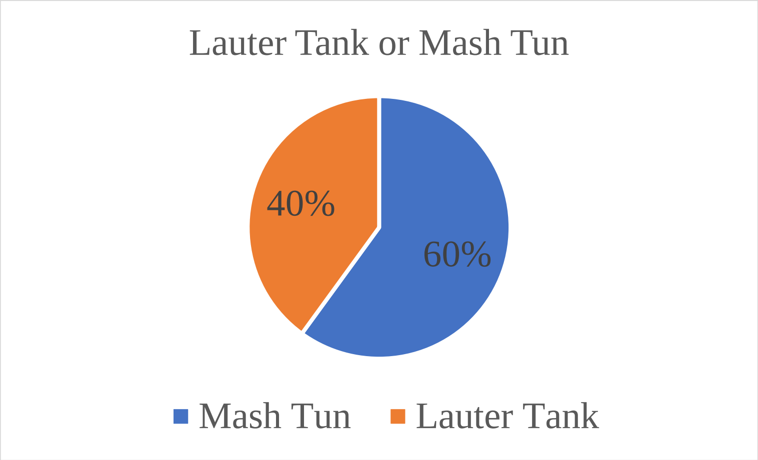
Graph 1.6 Presence of Mill in Brew House



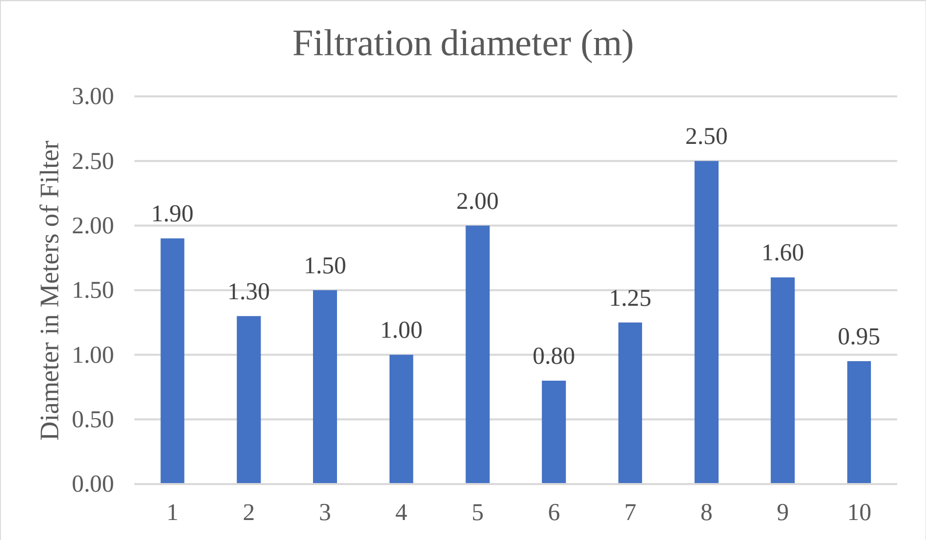
Graph 1.8 Type of Mill in Brewhouse



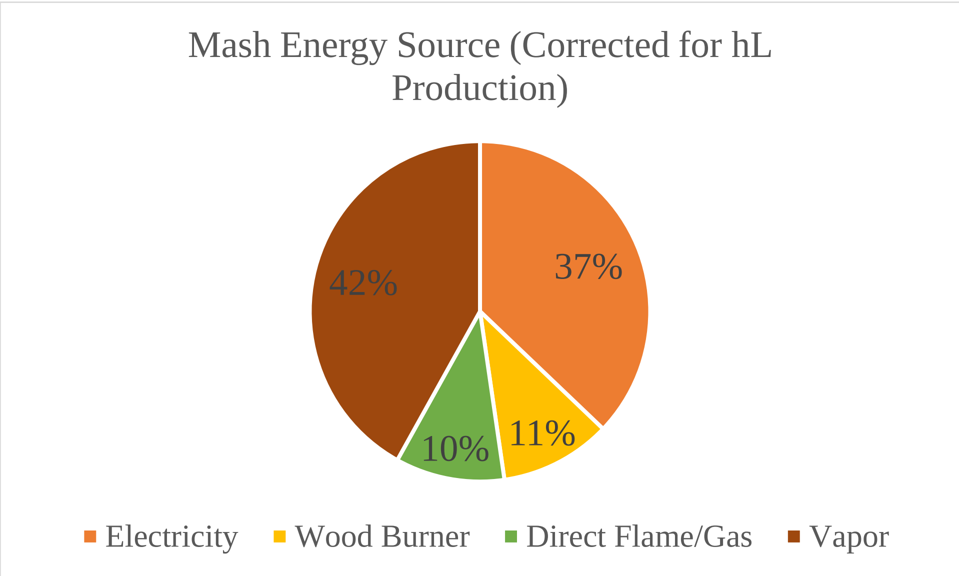
Graph 1.10 Capacity in Liters of the Hot Water Tank



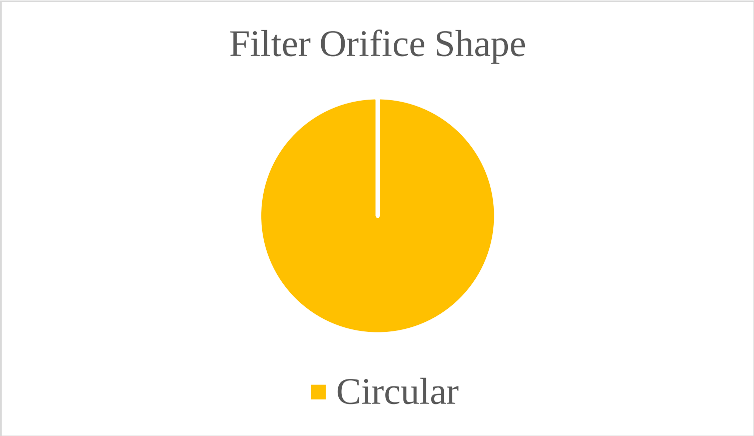
Graph 1.12 Lauter Tank or Mash Tun in Brew House



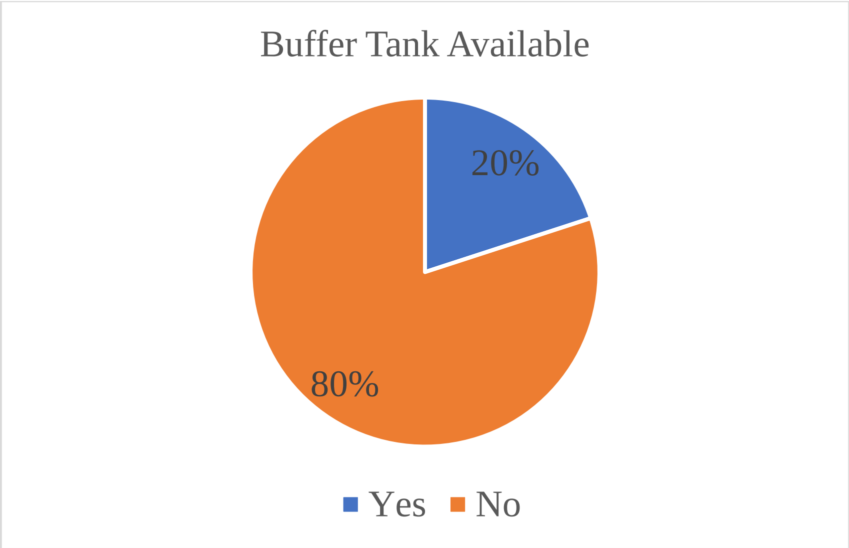
Graph 1.15 Filtration Diameter in Meters



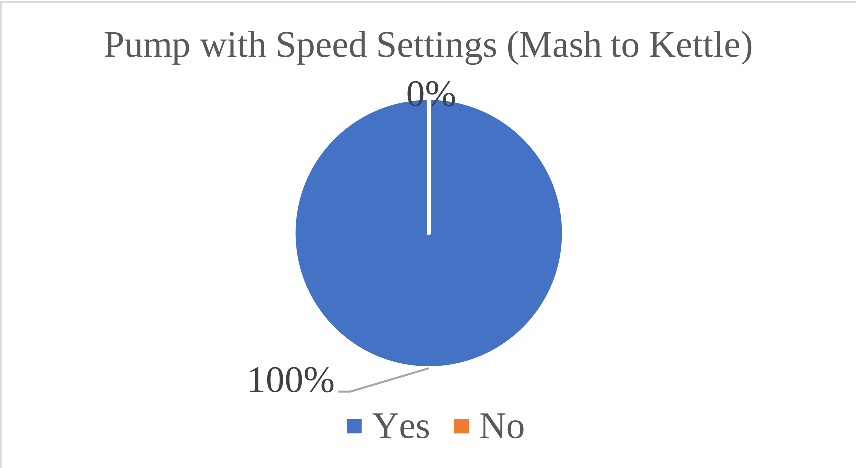
Graph 1.16 Mash Energy Source Corrected for Hectoliter Production



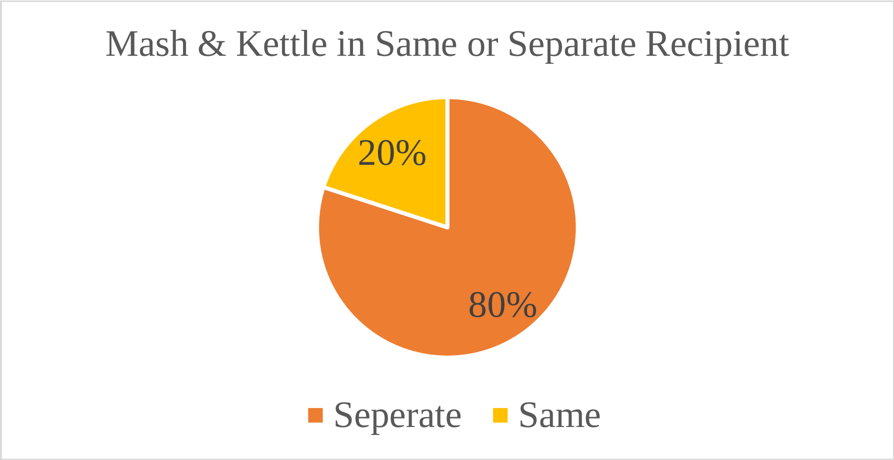
Graph 1.17 Filter Orifice Shape



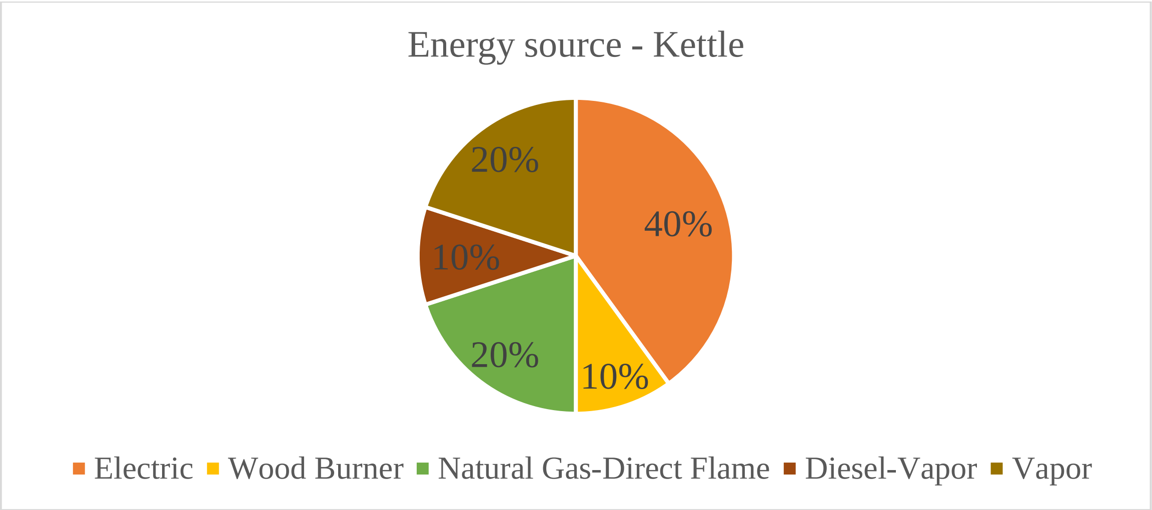
Graph 1.18 Buffer Tank Available to Mash or Lauter



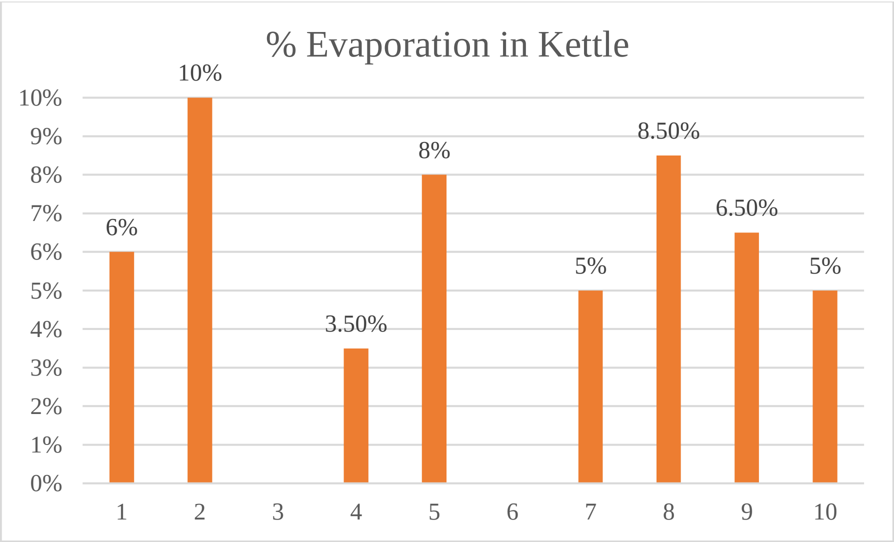
Graph 1.19 Pump that connects Mash to Kettle has Speed Settings



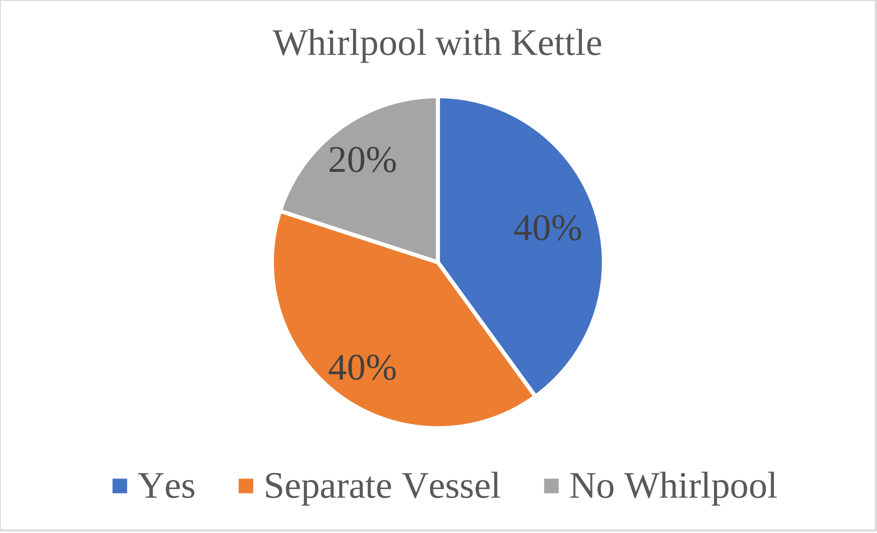
Graph 1.20 Mash & Kettle in Same or Separate Recipient



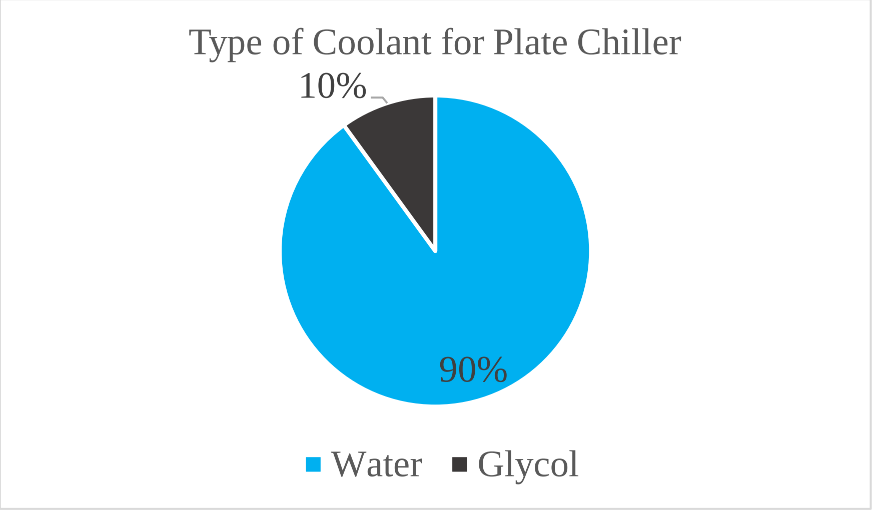
Graph 1.22 Energy source of Kettle



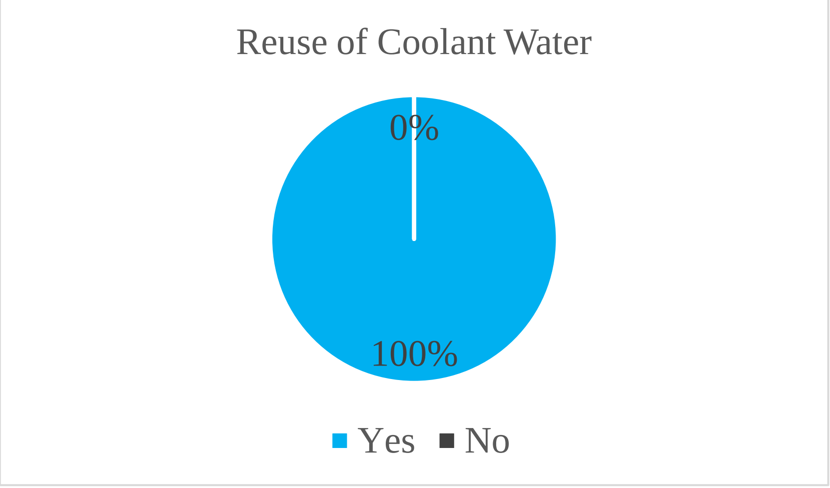
Graph 1.23 Percent Evaporation in Kettle During Boil



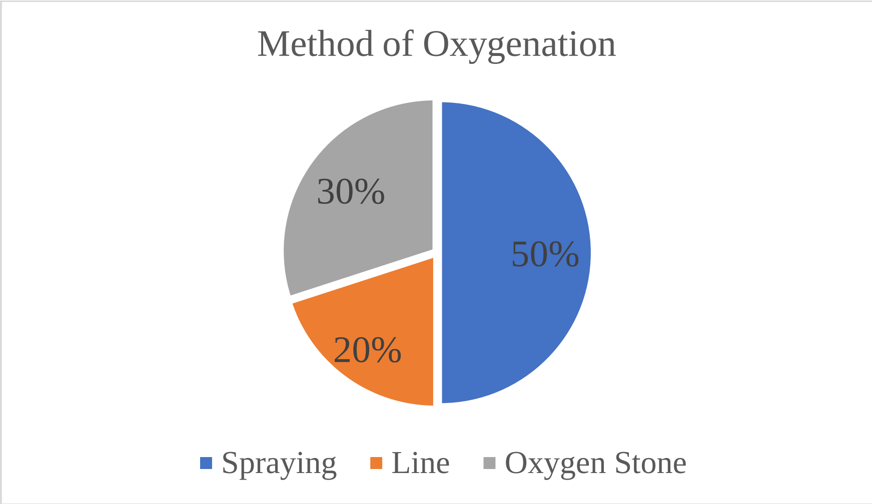
Graph 1.24 Whirlpool with Kettle, Separate or No Whirlpool in Equipment



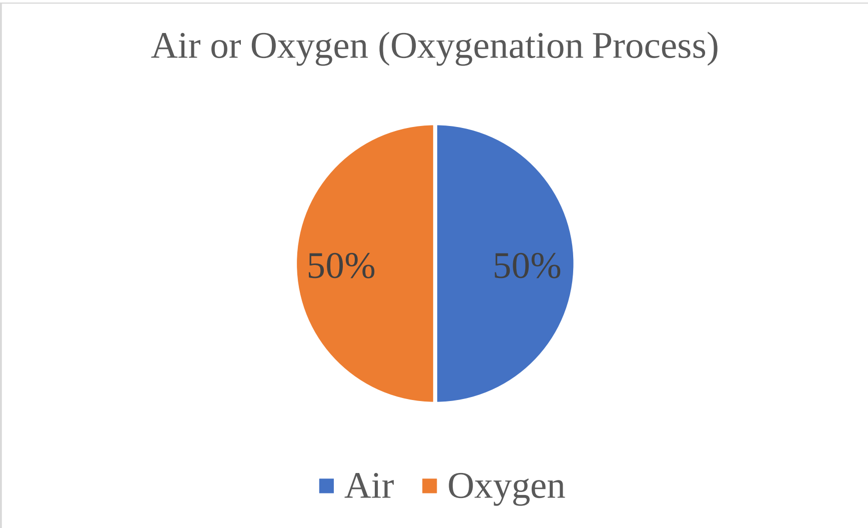
Graph 1.26 Type of Coolant for Plate Chiller



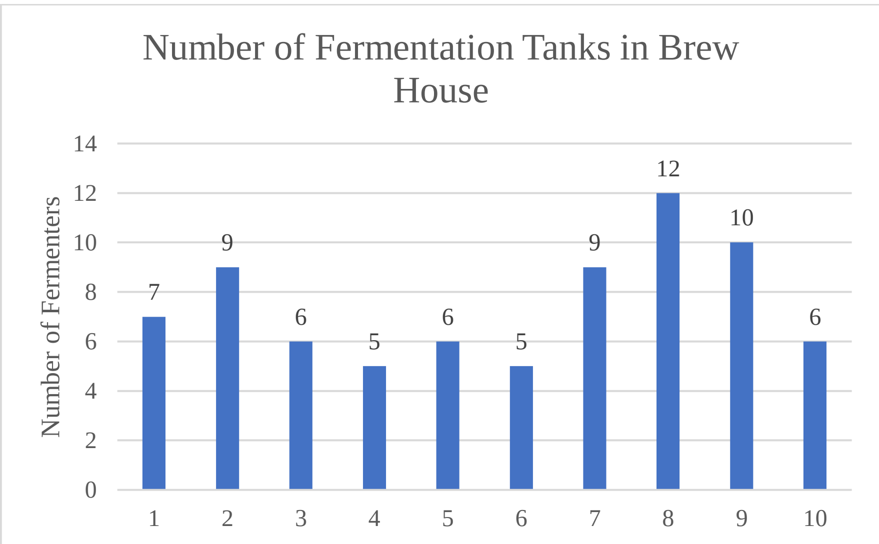
Graph 1.27 Reuse of Coolant Water for Brewing or Cleaning (Not specified)



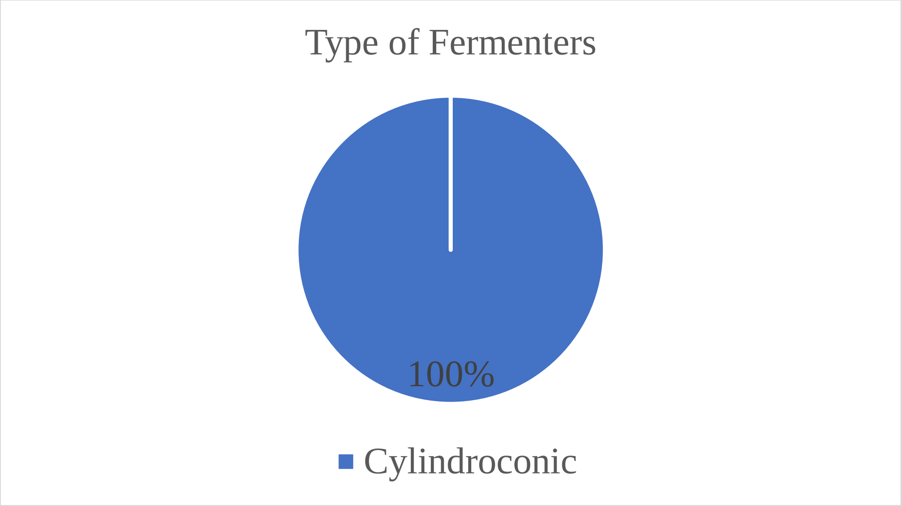
Graph 1.28 Method of Oxygenation of Wort



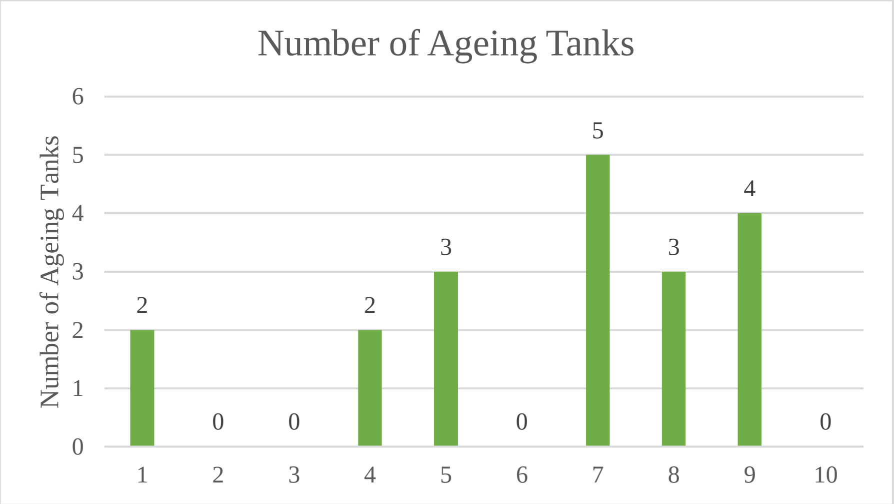
Graph 1.29 Air or Oxygen Use in Oxygenation Processes



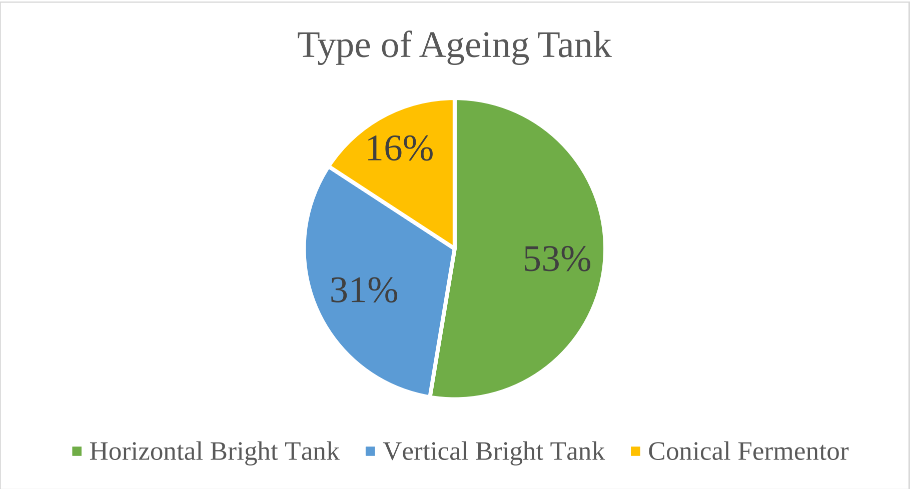
Graph 1.30 Number of Fermentation Tanks in Brew House



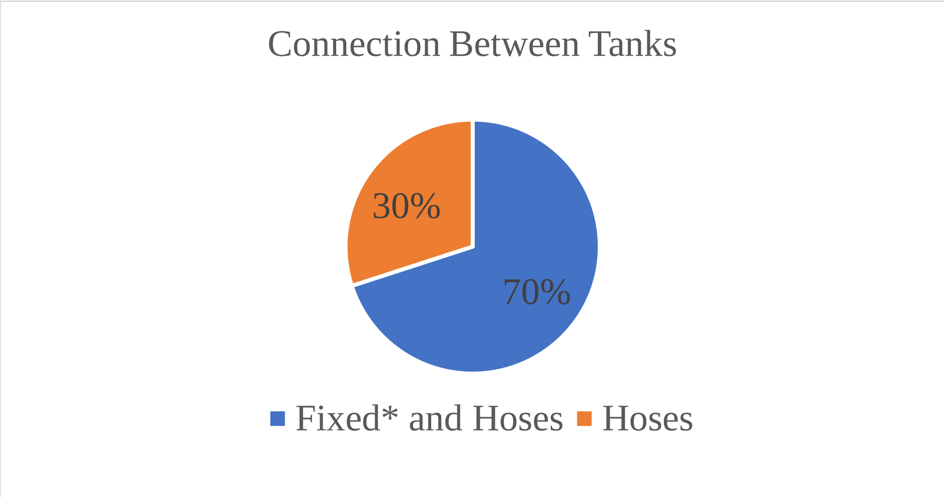
Graph 1.32 Type of Fermenters in Brewery



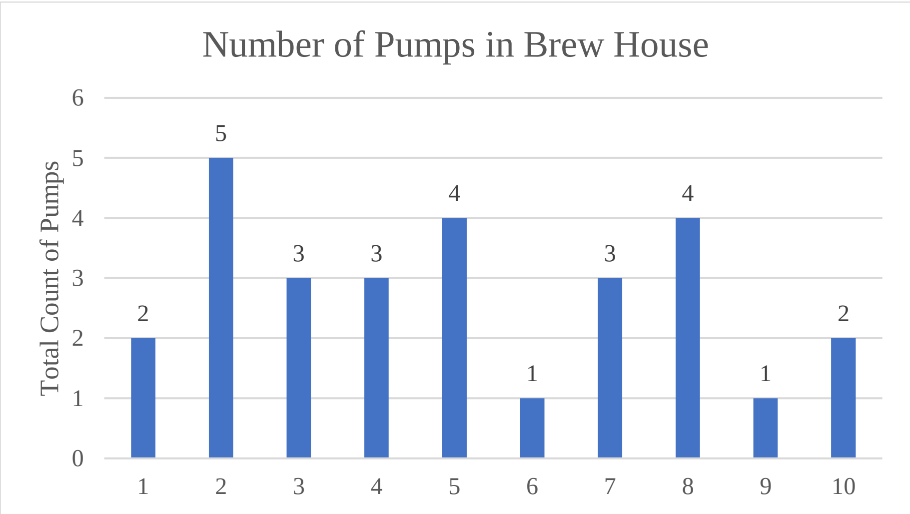
Graph 1.34 Number of Maturation Tanks (Only Tanks Specifically Set Aside for Ageing)



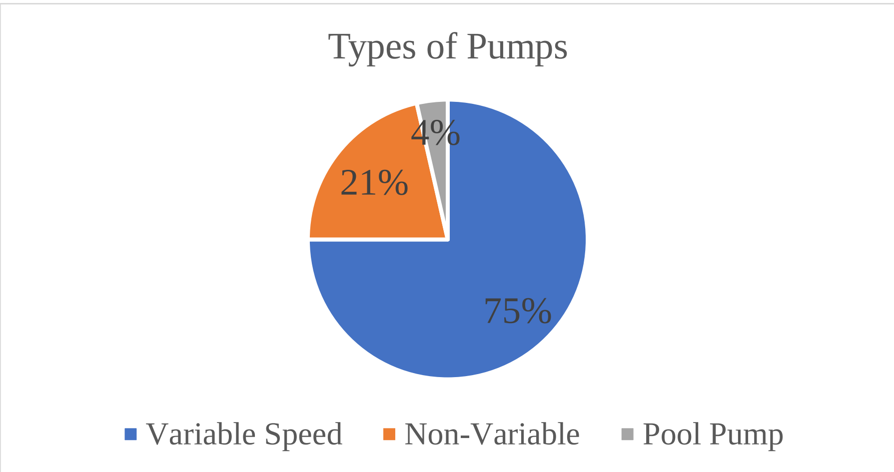
Graph 1.36 Type of Ageing Tank from Total Count of Tanks (18)



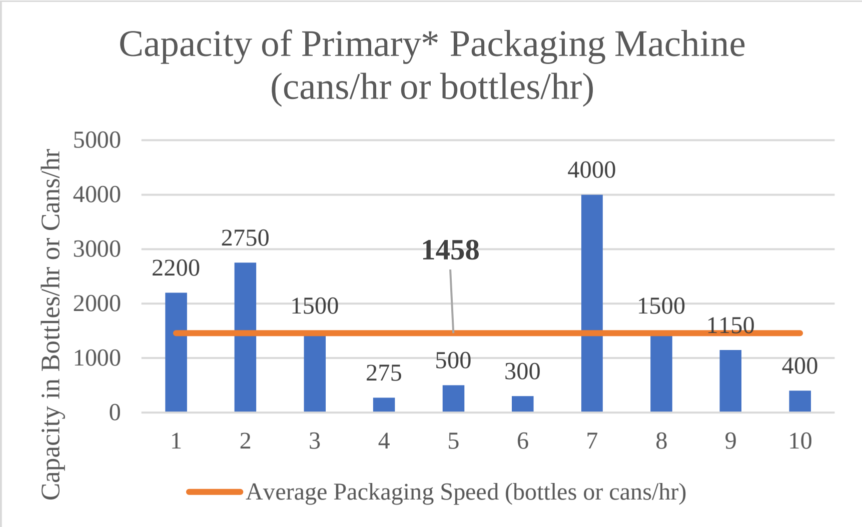
*Graph 1.37 Connection to Tanks (*Fixed pipes were ONLY between Mash and Kettle)*



Graph 1.38 Total Count of Pumps in Brew House

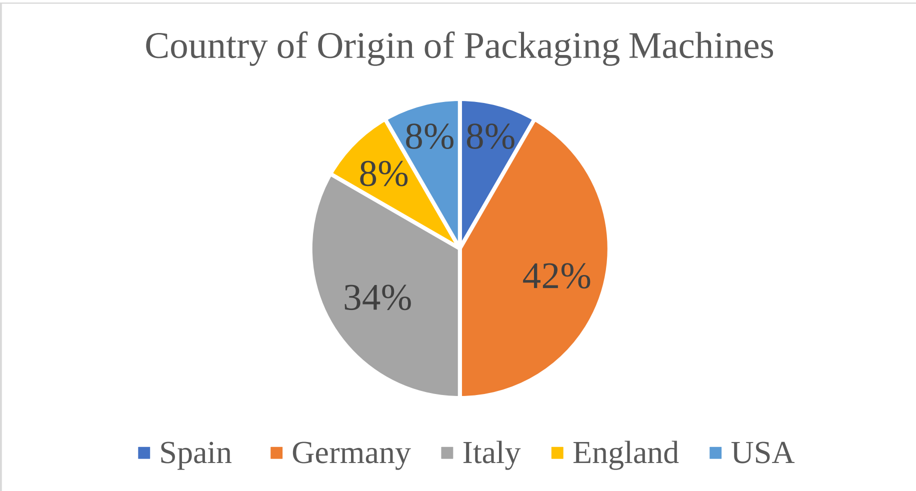


Graph 1.39 Types of Pumps from Total Number of Pumps (28)

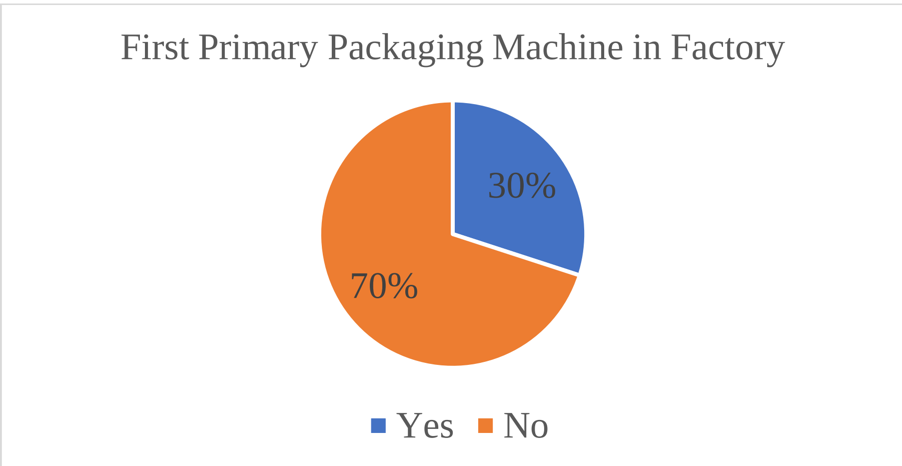


Graph 1.41 Capacity of Primary Packaging Machine (cans/hr or bottles/hr)*

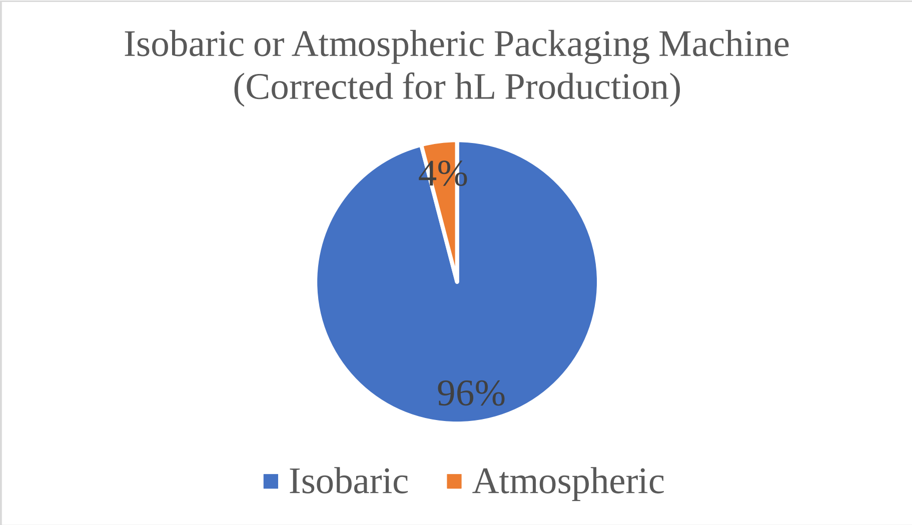
** Primary packaging machine is **Bottler** unless brewery is **cans only**.*



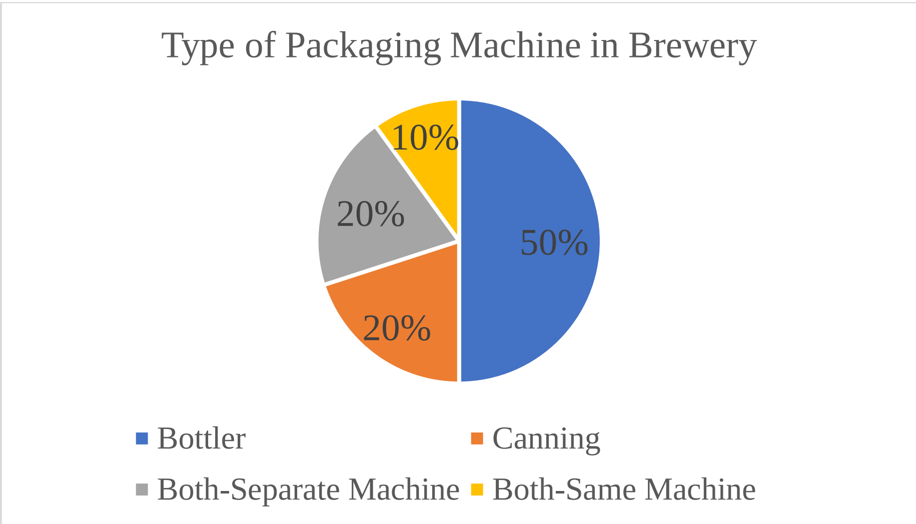
Graph 1.42 Country of Origin of Packaging Machines - Bottling and Canning Machines



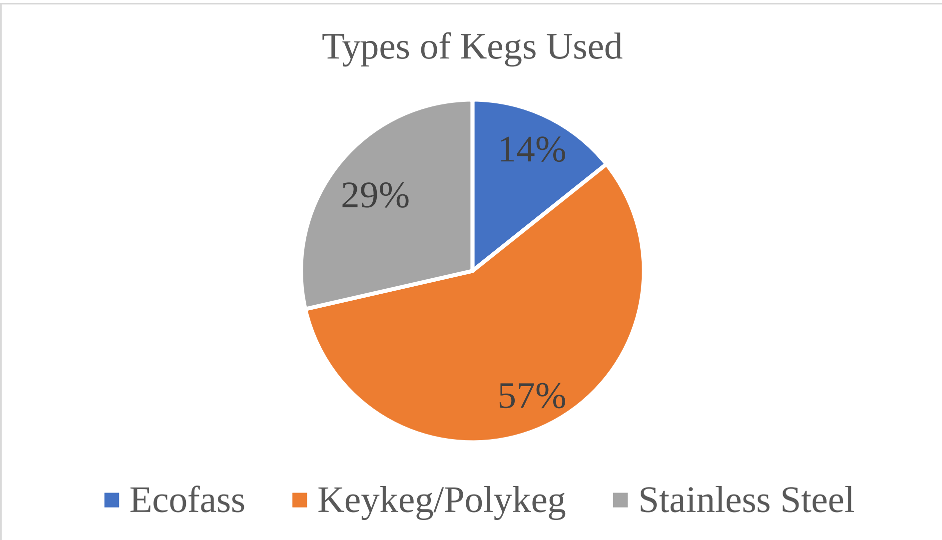
Graph 1.43 First Primary Packaging Machine in Factory



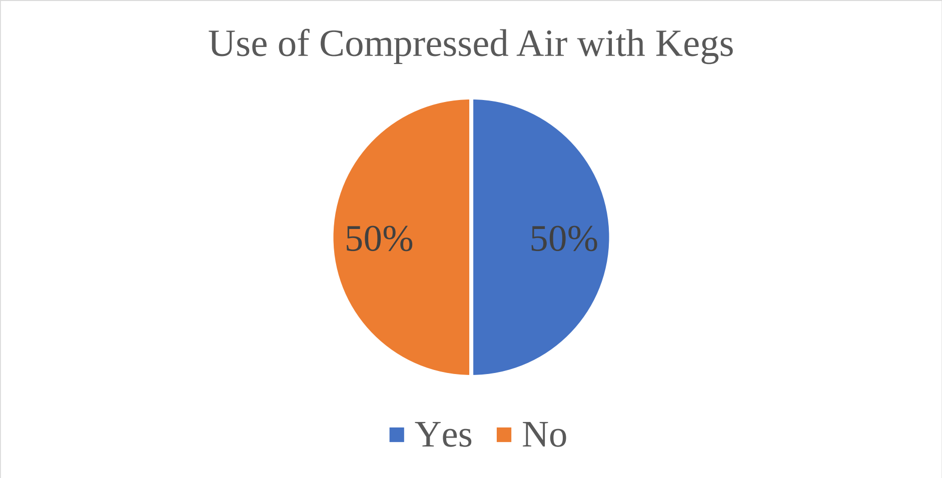
Graph 1.44 Isobaric or Atmospheric Packaging Machine (Corrected for hL Production)



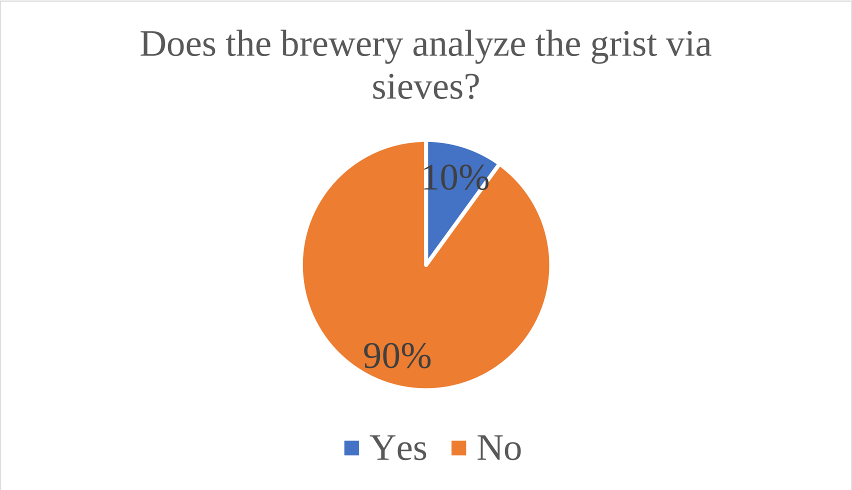
Graph 1.45 Type of Packaging Machine in Brewery



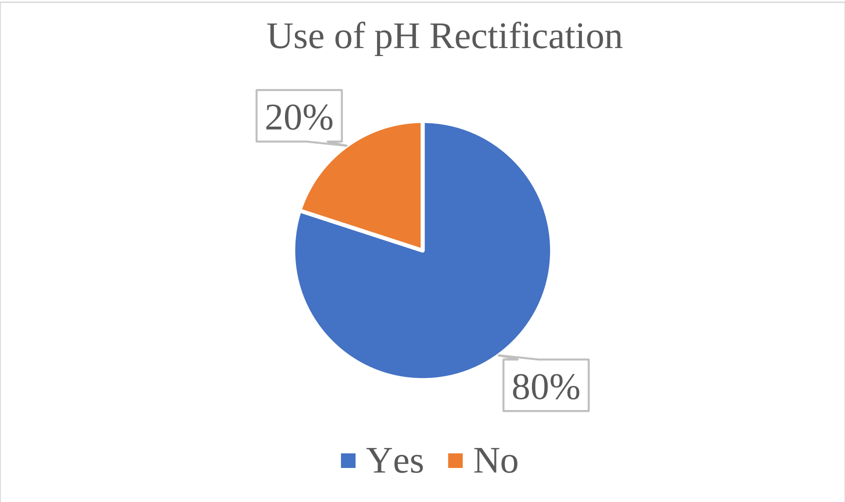
Graph 1.47 Types of Kegs Used



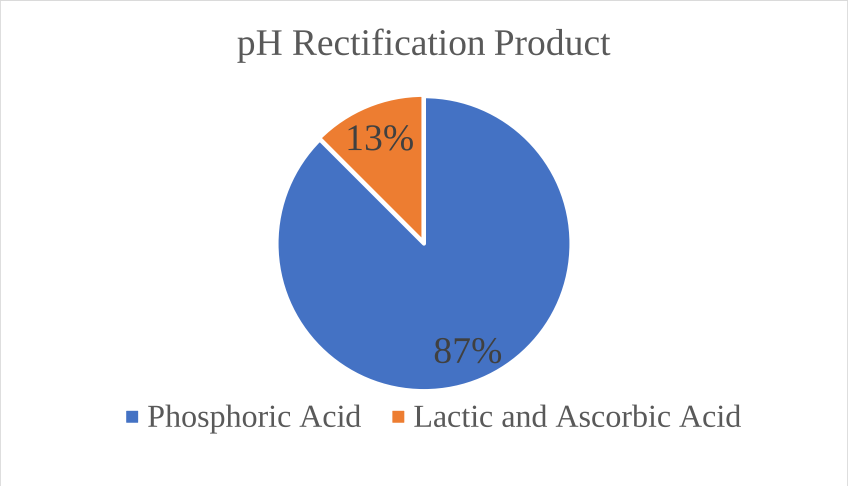
Graph 1.48 Use of Compressed Air with Kegs



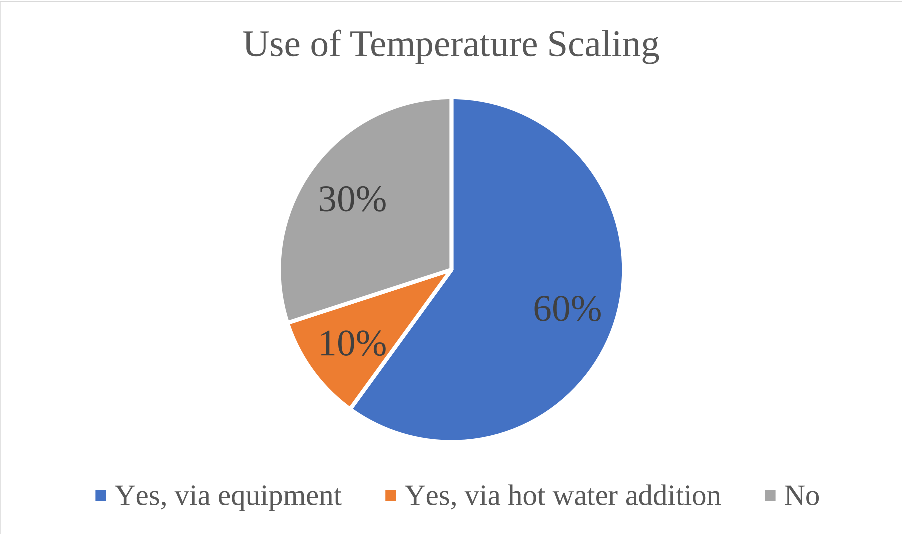
Graph 2.1 Use of grist analysis via sieves.



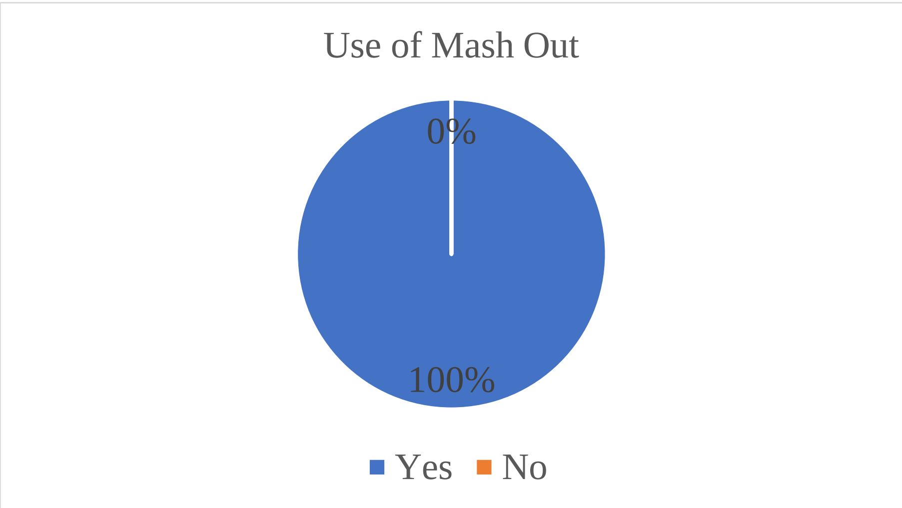
Graph 2.2 Use of pH Rectification in Mash



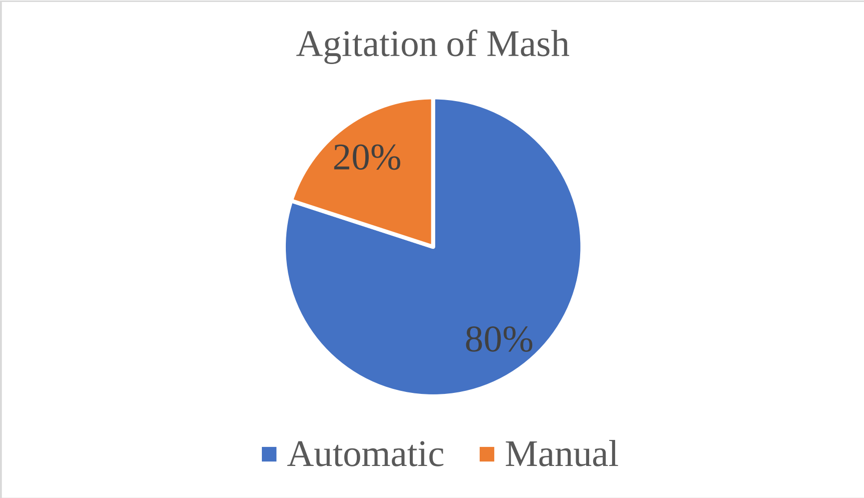
Graph 2.3 pH Rectification Product for Mash



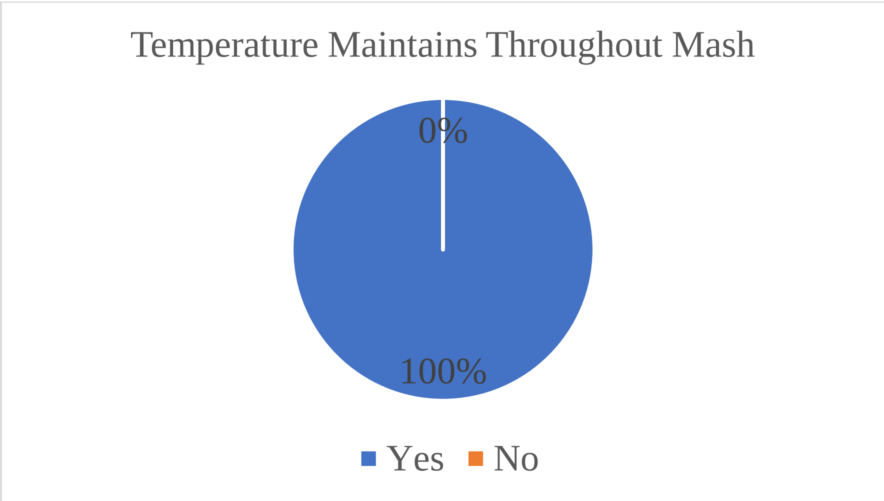
Graph 2.5 Use of Temperature Scaling in Mash



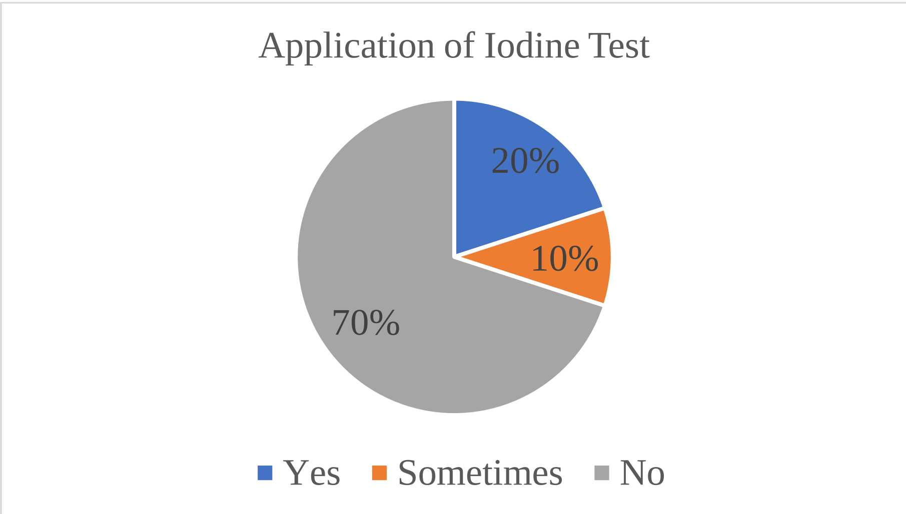
Graph 2.6 Use of Mash Out



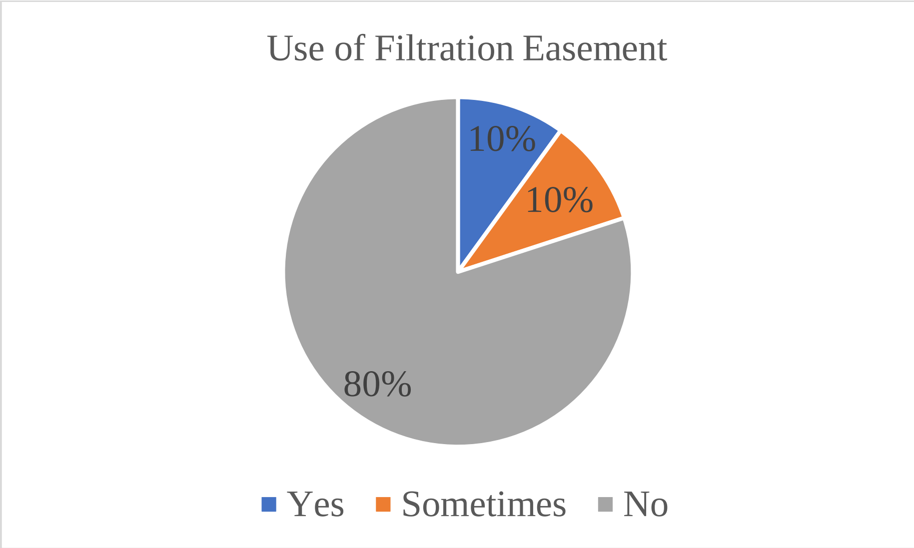
Graph 2.7 Automatic (via Arms) or Manual Agitation of Mash



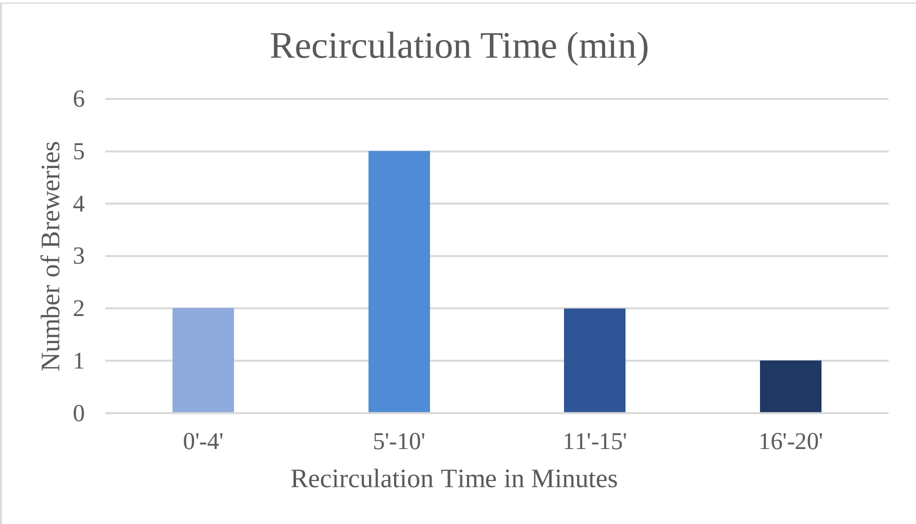
Graph 2.8 Temperature Maintains Throughout Mash



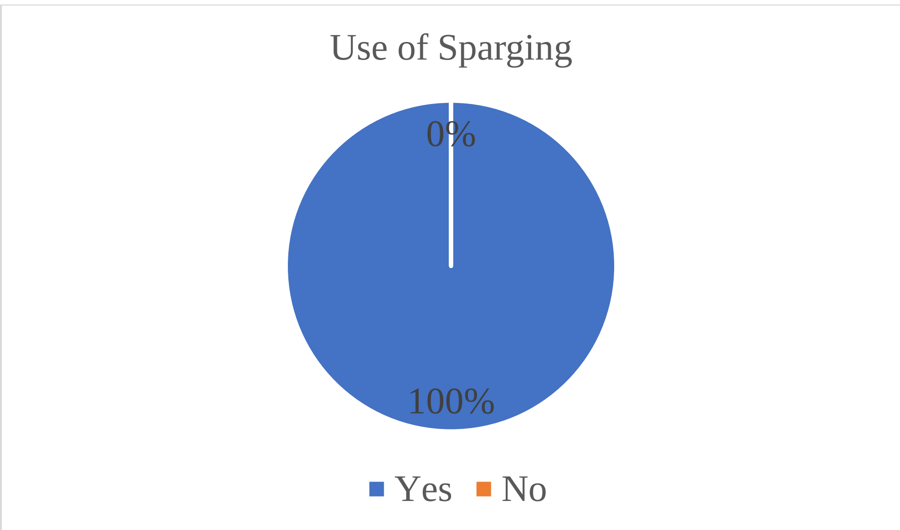
Graph 2.10 Application of Iodine Test



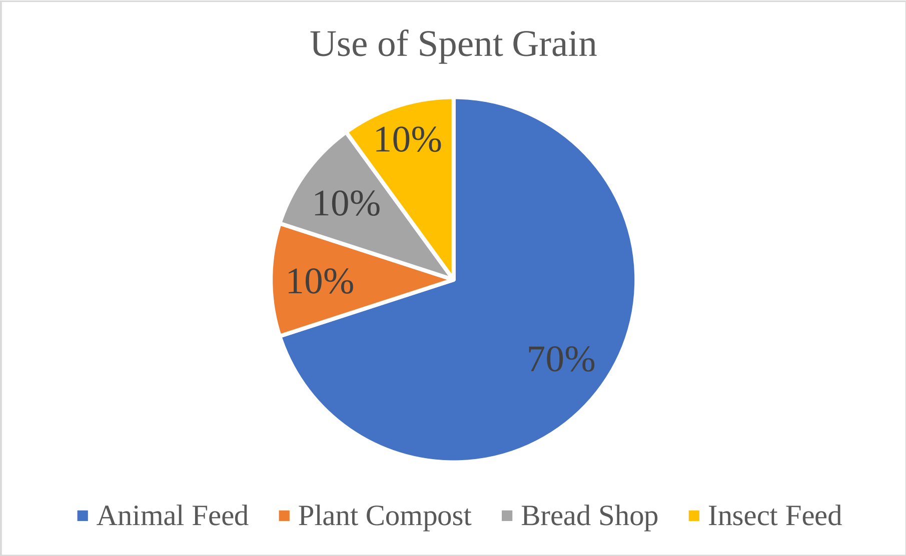
Graph 2.11 Use of Filtration Easement (Husks, Rice, etc.)



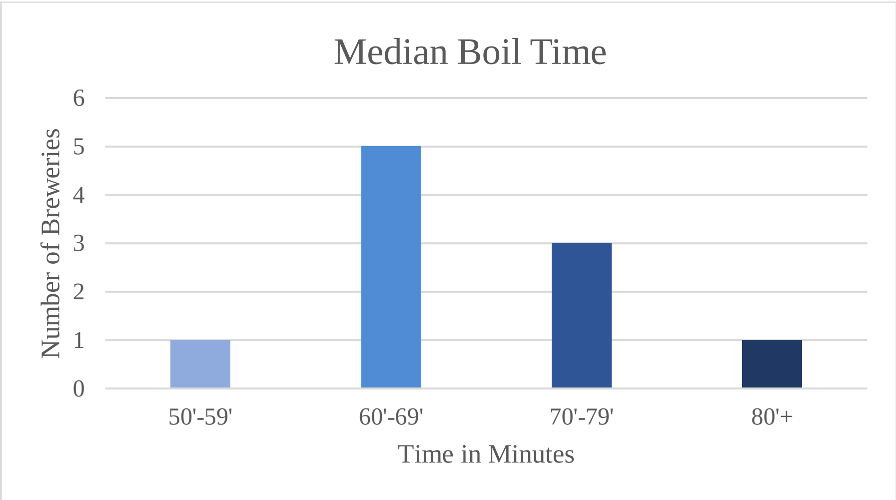
Graph 2.12 Recirculation Time of Sweet Wort in Minutes



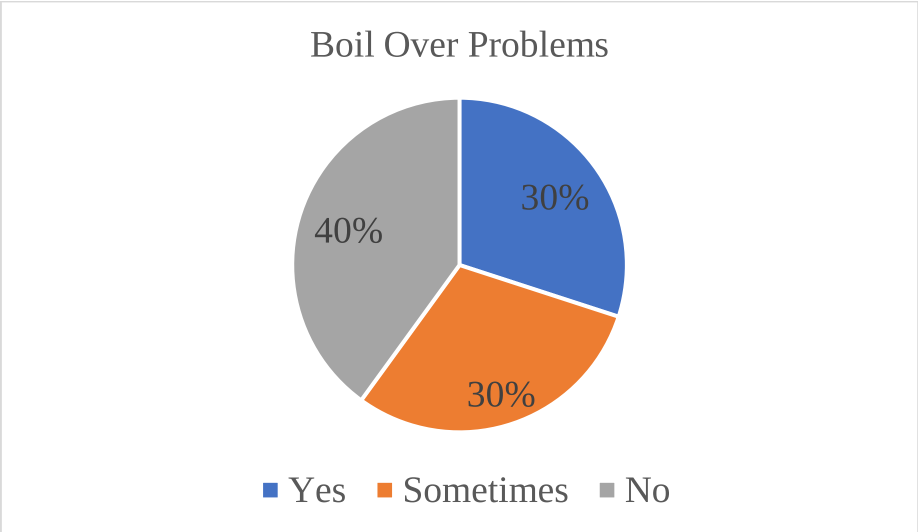
Graph 2.14 Use of Sparging



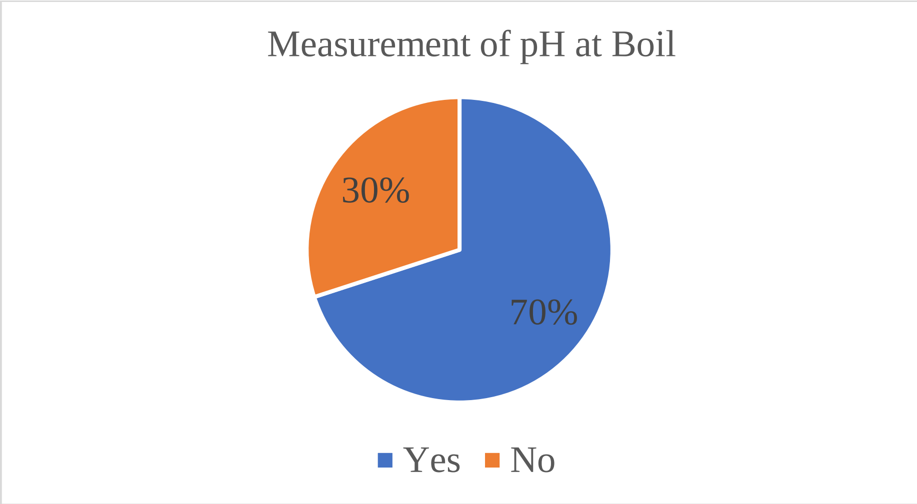
Graph 2.15 Use or Discarding of Spent Grain



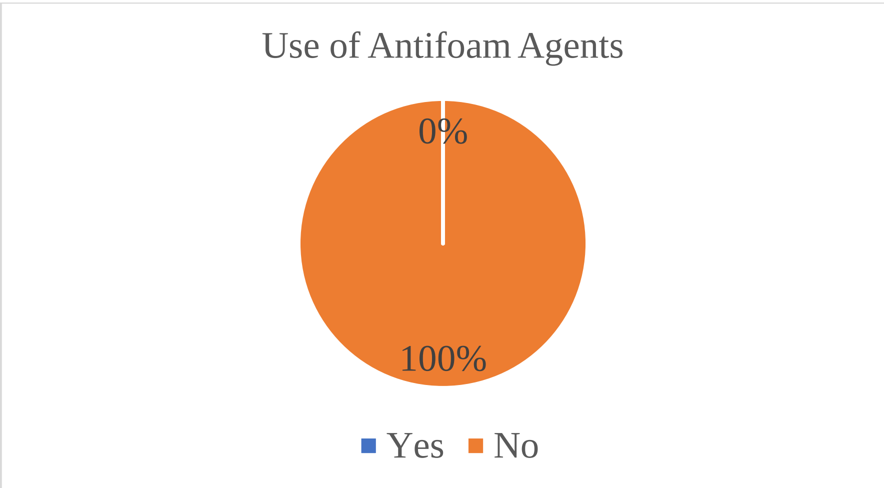
Graph 2.16 Median Boil Time in Minutes



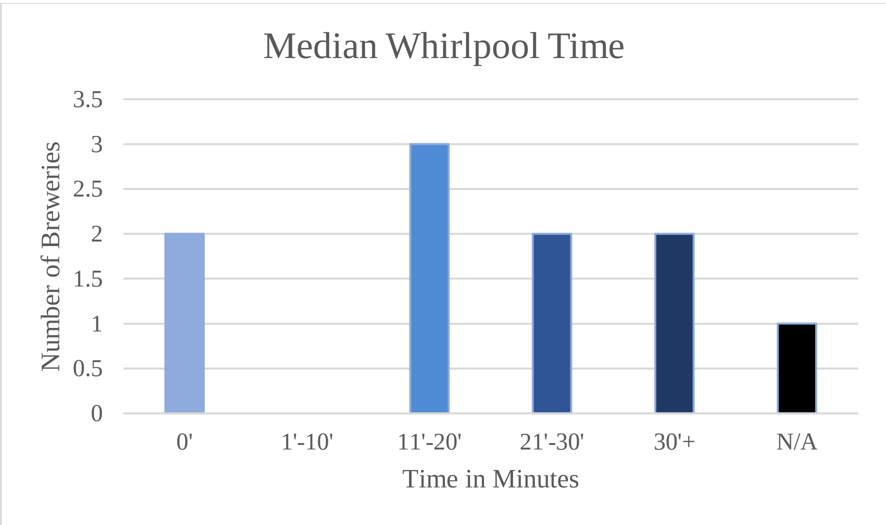
Graph 2.17 Boil Over Problems in Kettle



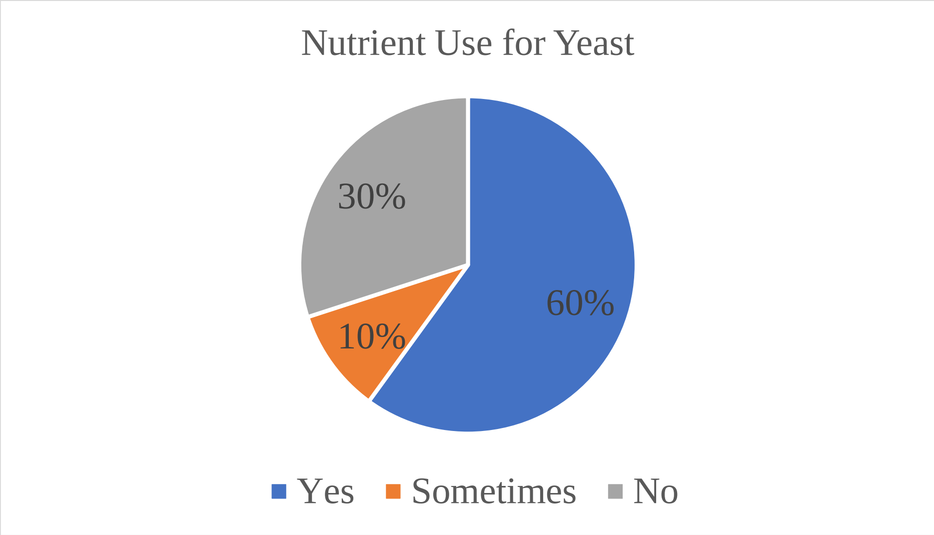
Graph 2.18 Measurement of pH at Boil



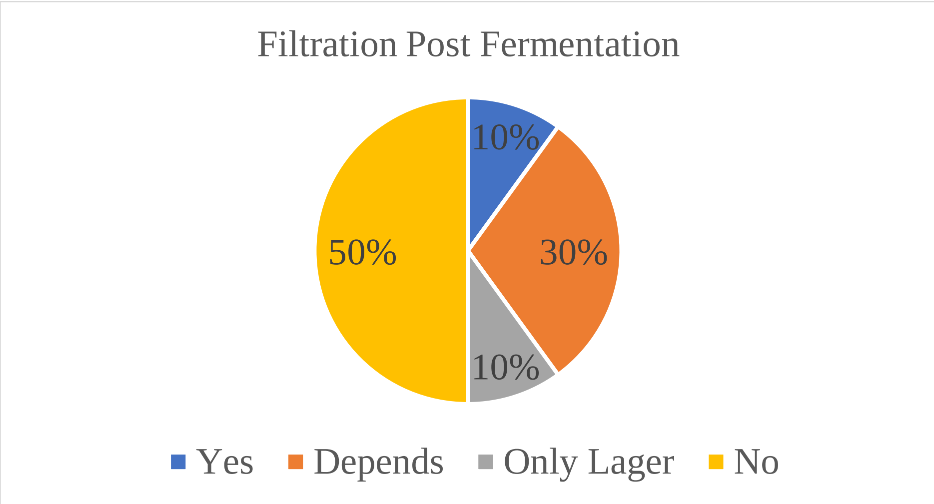
Graph 2.19 Use of Antifoam Agents



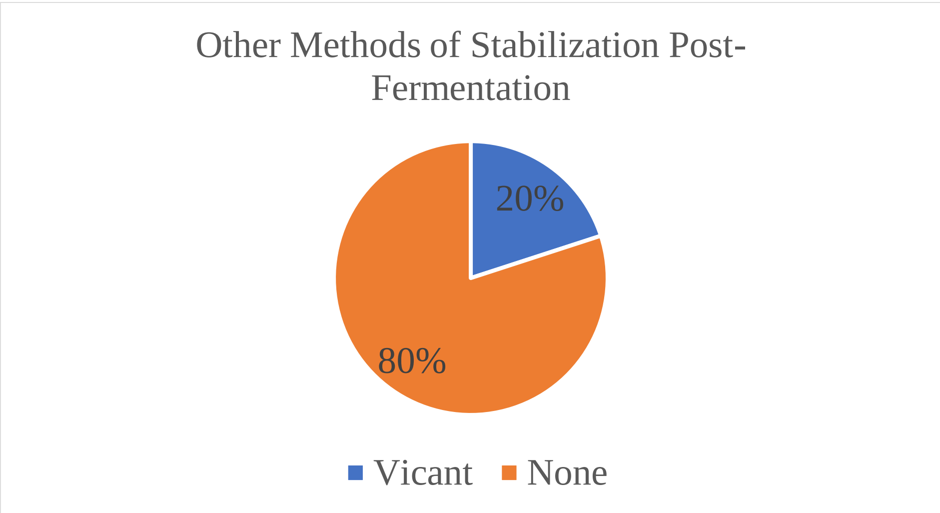
Graph 2.21 Median Whirlpool Time (min)



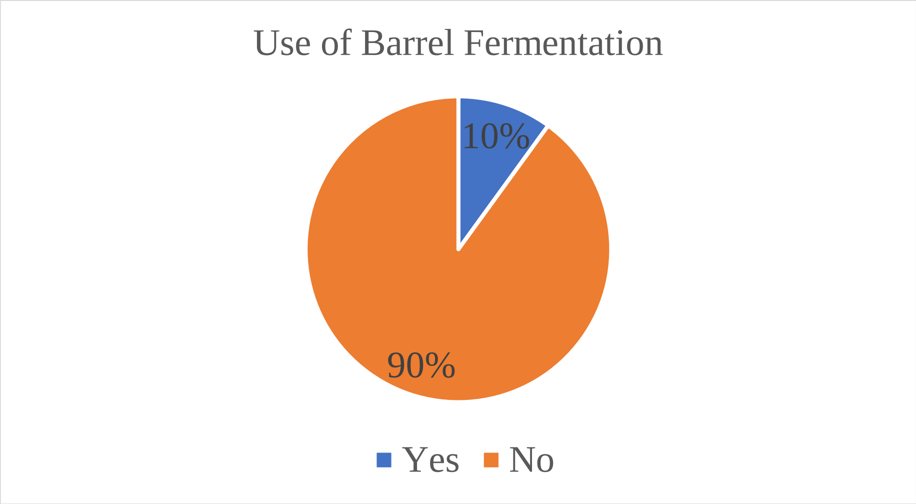
Graph 2.23 Nutrient Use for Yeast



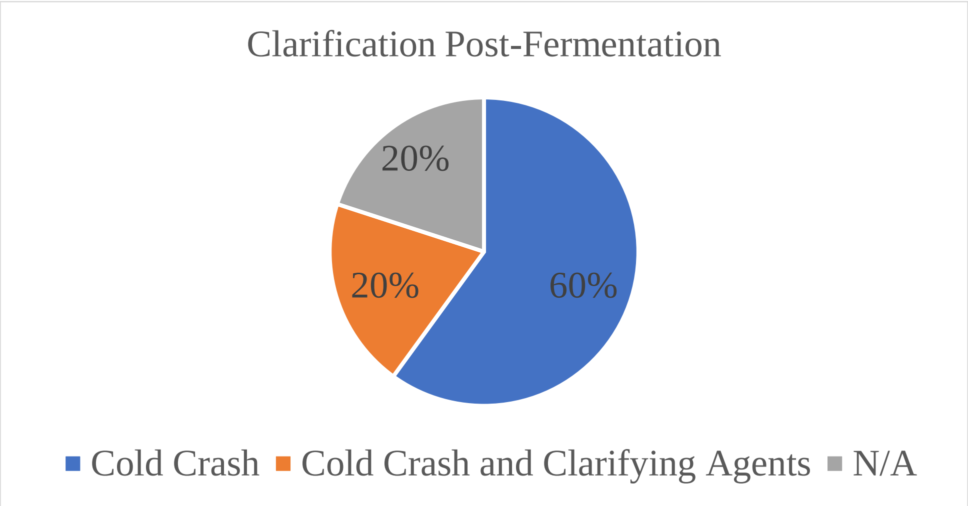
Graph 2.24 Filtration Post Fermentation



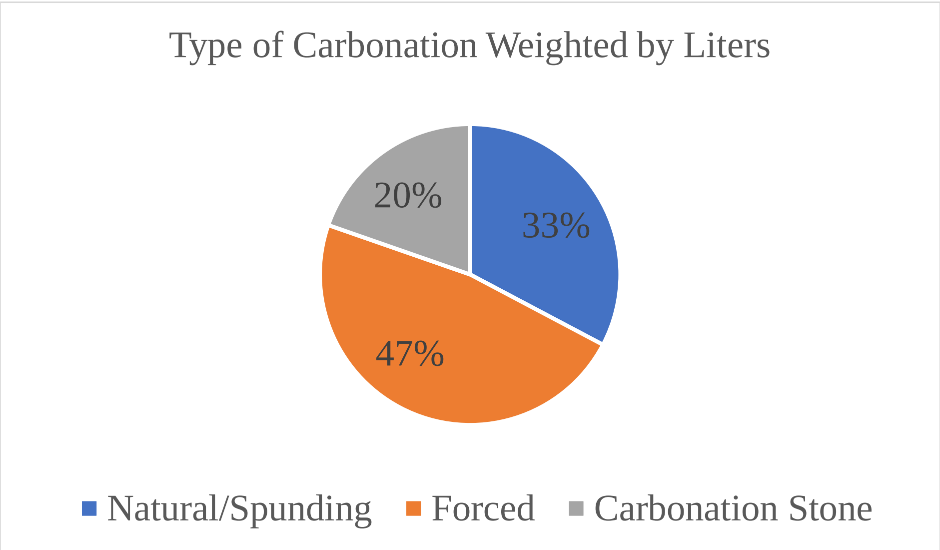
Graph 2.25 Other Methods of Stabilization Post-Fermentation



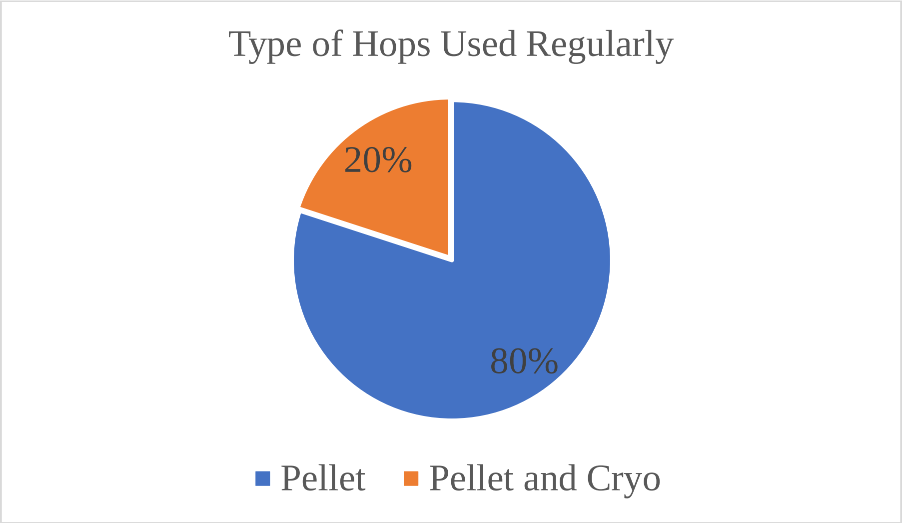
Graph 2.26 Use of Barrel Fermentation



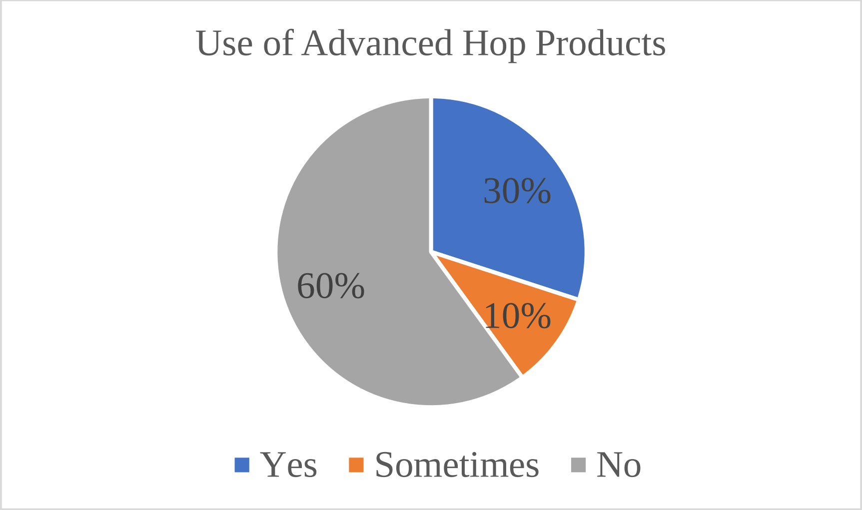
Graph 2.28 Clarification Post-Fermentation



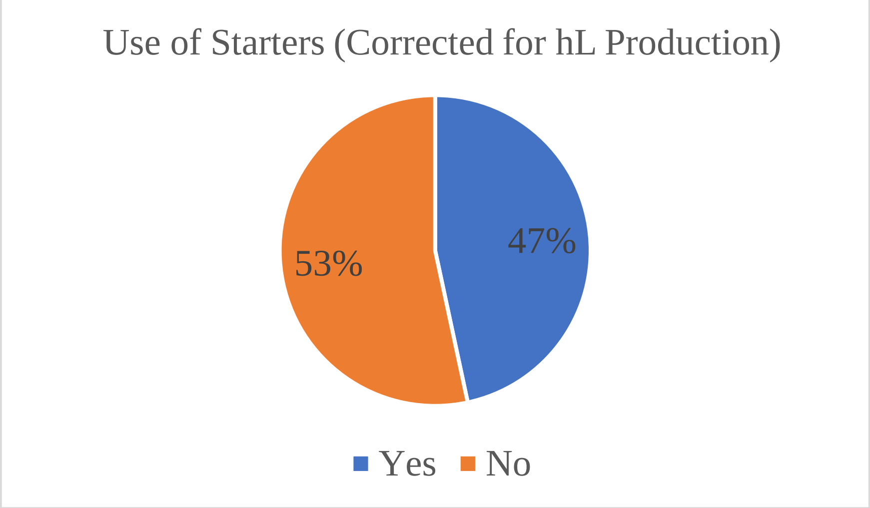
Graph 2.29 Type of Carbonation



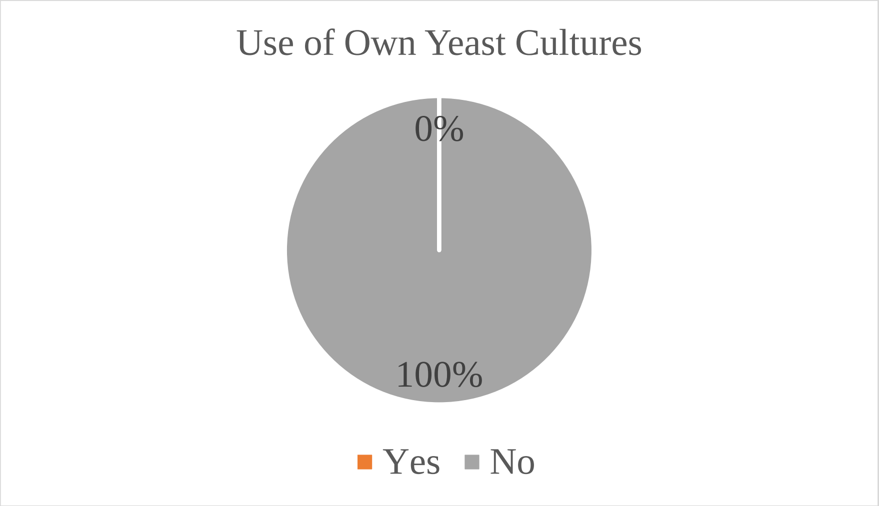
Graph 3.1 Type of hops regularly used in the brewery: pellet, flower, or cryo



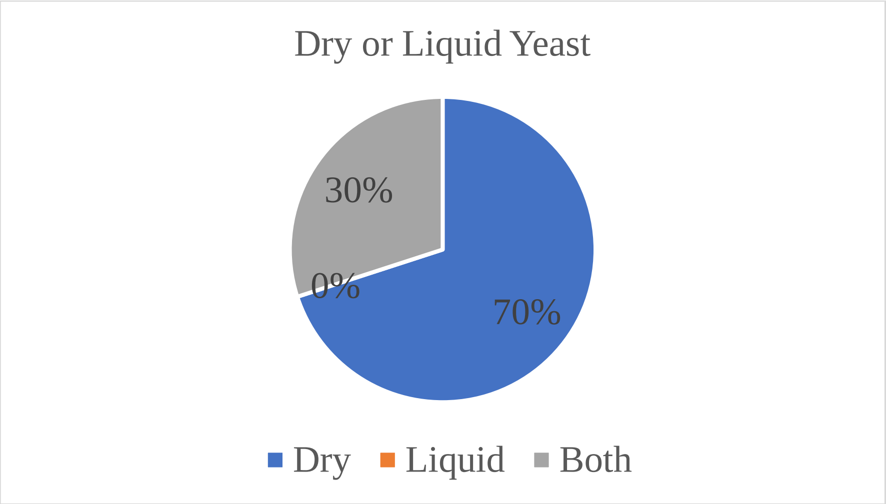
Graph 3.2 Use of Advanced Hop Products (Resins, oils, extracts etc.)



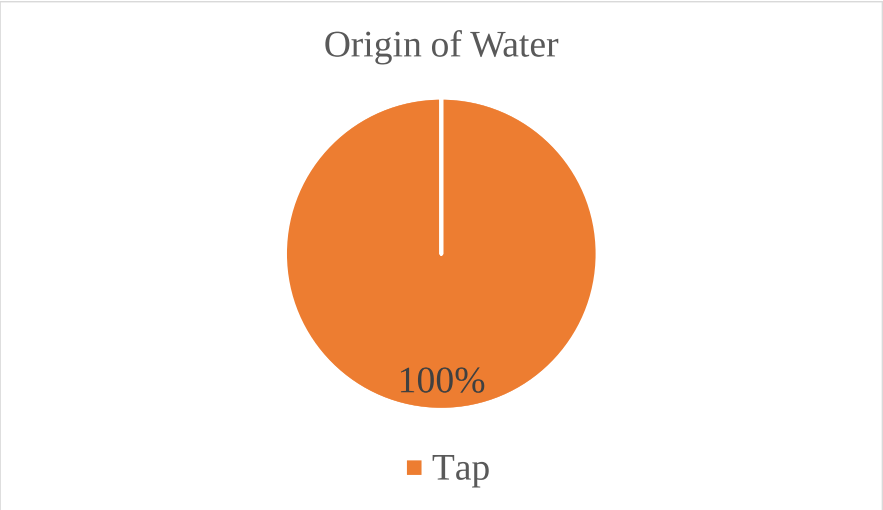
Graph 3.4 Use of Starters (Corrected for hL Production)



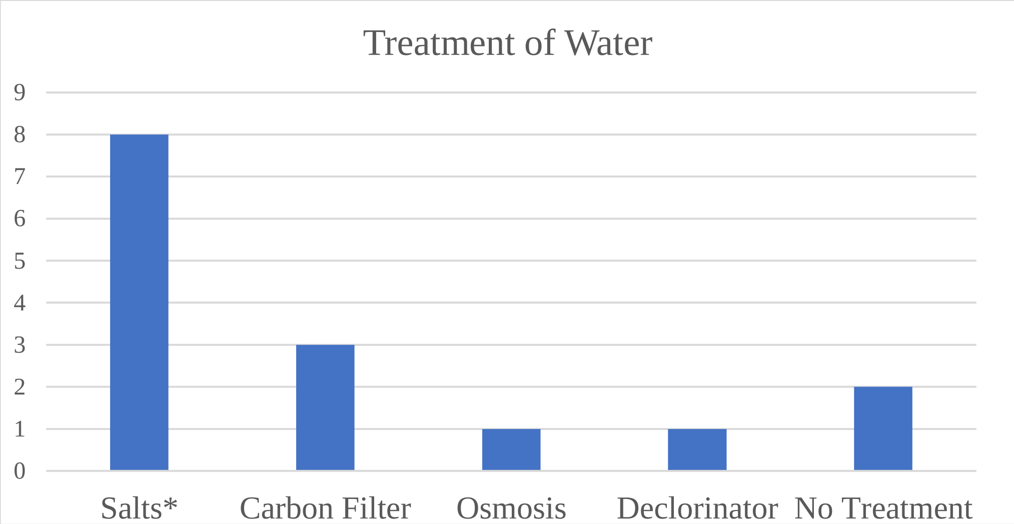
Graph 3.6 Use of Own Yeast Cultures



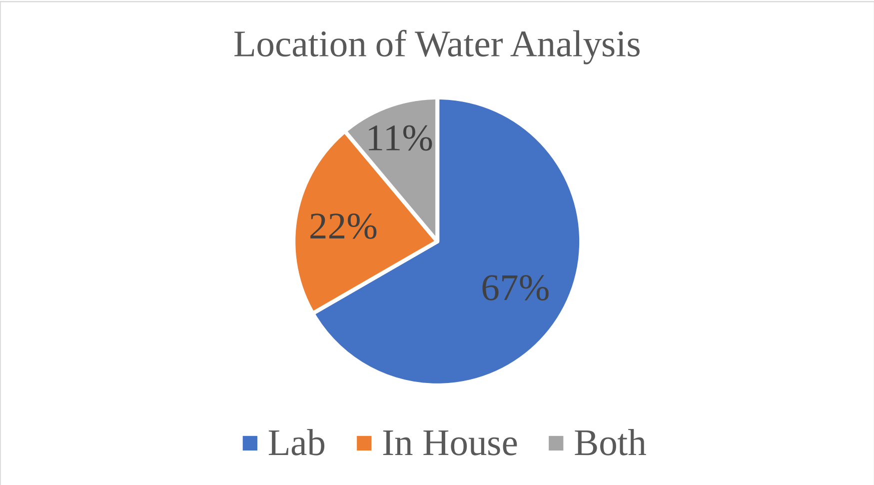
Graph 3.7 Dry or Liquid Yeast Use in Fermentation



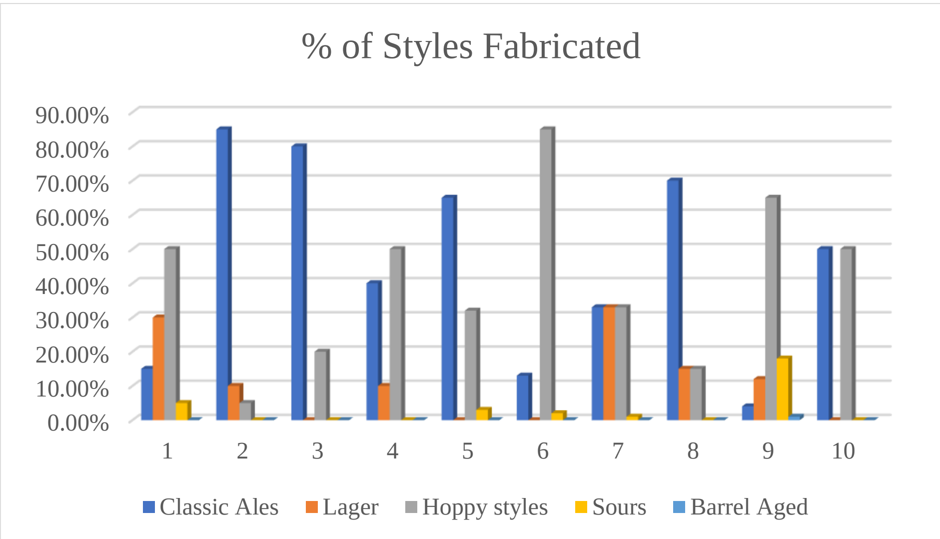
Graph 3.8 Origin of Water Used in Brewing



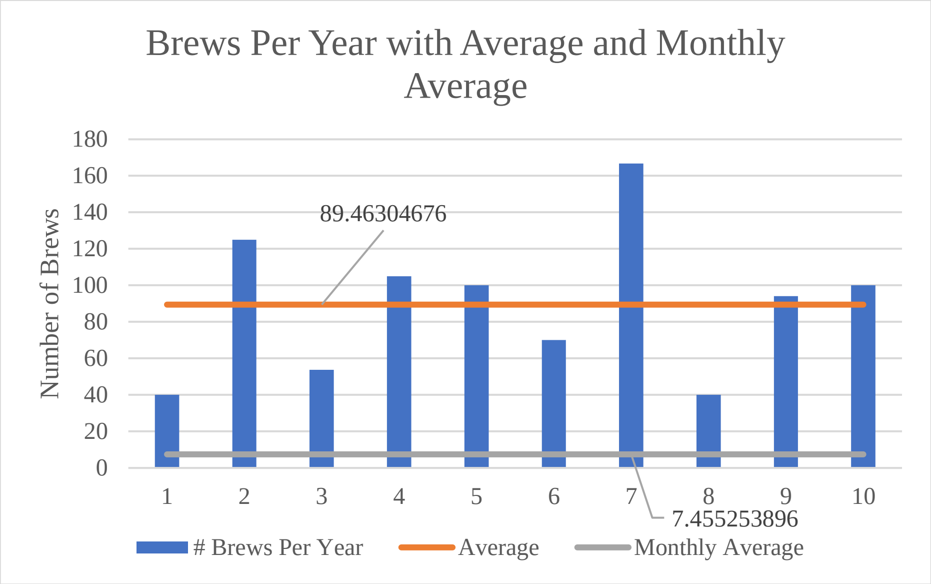
*Graph 3.9 Treatment of Water (*Breweries in **Madrid** used only salts)*



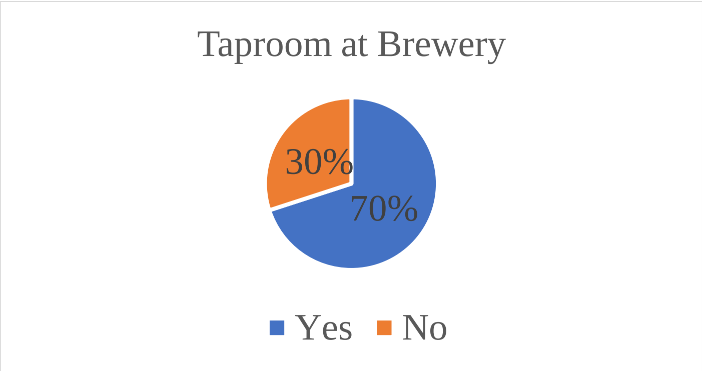
Graph 3.11 Location of Water Analysis



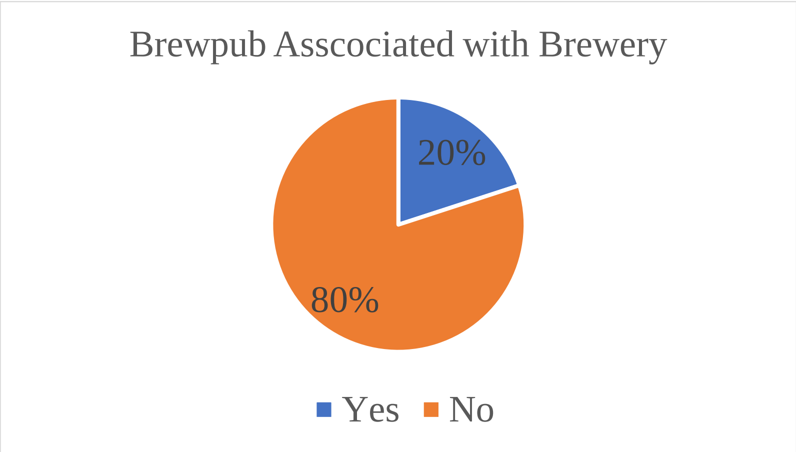
Graph 4.1 Percentage of Styles Fabricated (from 5 Overview Styles)



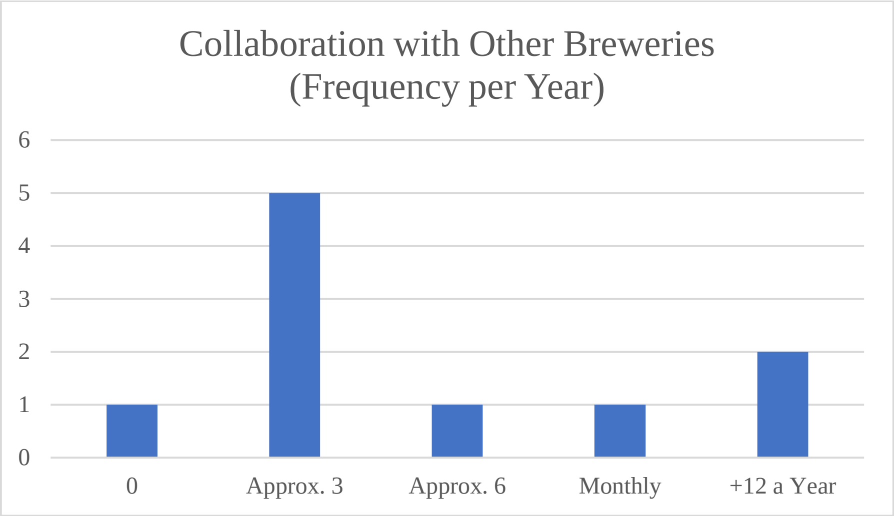
Graph 4.4 Brews Per Year (from Mash Capacity and Annual Volume) with Overall Average and Monthly Average



Graph 4.6 Taproom in Brewery (Food not taken into account)



Graph 4.7 Brewpub Associated with Brewery (Same place or separate from factory and has ***kitchen****)*



Graph 4.9 Collaborations with Other Breweries (Frequency per Year)

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