

Tecnológico de Monterrey

BT2004B. 404
Integration of transfer operation

*Entregable:*

# “Evidencia 2: Informe técnico sobre la solución del reto”

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**Team:**

| | |
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**Defining the problem:**

Researching and developing a brewing protocol for a lager beer with a lower amount of dextrins for a lower calorie alternative that has a good flavor, low bitterness and a refreshing taste, that meets the criteria established by the training partner, Metabrew, considering the different constraints, components such as unit operations, the standards and NOMs to be met, as well as the sustainability and ethical concerns involved in the production of beer.

**Parameters or process strategy:**

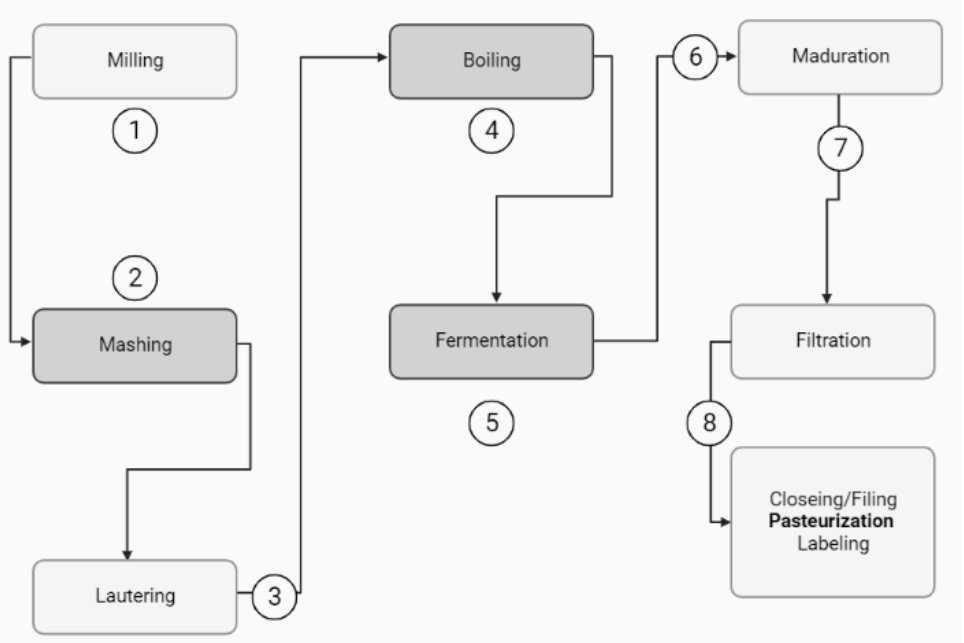
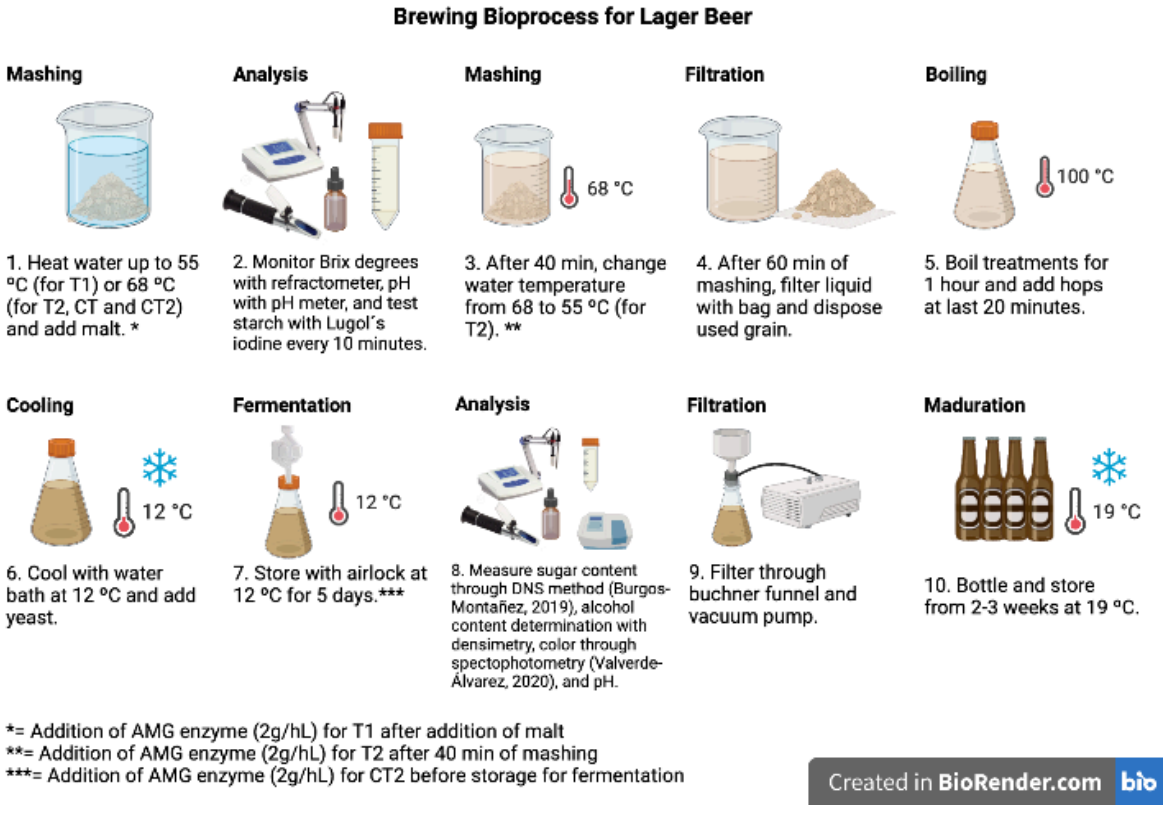



***Figure 1:*** *Unit operation diagram. The raw materials for this process are 100% Pilsner malt, water and Mittelfrüh hops. The unit operations that differ from color are the ones involved with heat transfer.*

The first step for the elaboration of a lager beer is milling **1**. It is a physical process in which the crushing of the malt occurs in preparation for mashing. After obtaining the product from the milling process we move on to the malting stage **2**. The main focus is to obtain starches and proteins. While in the mashing process the main goal is to break down starches and proteins obtained from the malting process. This is obtained by enzymes that degrade different components. Some important parameters for this process is the temperature to

optimize beta amylase activity, which is 54 - 66°C, while the alpha amylase works at around 68 - 72°C. After obtaining the mash we move to the lautering stage **3** which is a process that separates the mixture into liquid wort and residual grain. The wort goes through the boiling stage **4** to produce bittering in beer and dissolve hop resins. The mixture goes through fermentation **5** at 12°C. Then the maturation process **6** occurs in 21 days at 19°C, after that elevation of temperature occurs and fast cooling to avoid the buttery flavor. This can be made 2-3 days until the butter flavor disappears. For the last step the beer is filtered **7** to avoid any residue. The distribution operations are chosen by the training partners **8**.

**Lab Methodology:**




*https://app.biorender.com/illustrations/634daf253a6fcb4aab4c0db0*

***Figure 2:*** *Lager beer brewing methodology diagram. CT corresponds to control treatment (beer without exogenous enzymes), CT2 corresponds to the control treatment with the training partner's conditions (AMG enzyme added in fermentation), T1 corresponds to the first AMG addition variable (AMG enzyme added in the beginning of mashing), and T2 corresponds to the second AMG addition variable (AMG enzyme added at the end of mashing).*

**Results:**

During the maceration process the following data of Brix, pH, Dextrin content, Starch content, Density and optical density was obtained. In addition parameters after fermentation, that were established by the normatives, were considered and obtained the following values for attenuation, alcohol, pH, Dextin content, and optical density which is related to color.

| Brix (g/g) a (mg/ml) | | |
|---|---|---|
| Treatment | Pre Fermentation | Post Fermentation |
| Control | 110 | 75 |
| Control F | 115 | 65 |
| AMG MP | 116 | 68 |
| AMG MF | 120 | 70 |

| pH | | |
|---|---|---|
| Tatamieto | Pre Fermentation | Post Fermentation |
| Control | 6.68 | 4.59 |
| Control F | 5.37 | 4.56 |
| AMG MP | 5.52 | 4.61 |
| AMG MF | 5.41 | 4.61 |

***Figure 1****: Brix, total sugar content and pH where the best treatment for brix was the addition of amyloglucosidase at the end and the fermentation control. In addition, the pH levels were similar in all of the treatments, these oscillated from 4.59-4.61 which is a higher value compared to other lager beers 4.40-4.55.*

| Color ABS 540 nm | | |
|---|---|---|
| Treatment | Pre Fermentation | Post Fermentation |
| Control | 0.247 | 0.111 |
| Control F | 0.247 | 0.063 |
| AMG MP | 0.478 | 0.096 |
| AMG MF | 0.261 | 0.121 |

***Figure 2****:The color was measured using spectrophotometry, measuring the optical density, identifying that the fermentation was occurring correctly since the density decreased. The morse clear beers were the treatment with AMG in maceration initially and the fermentation control.*

| Dextrins | | | | |
|---|---|---|---|---|
| Treatment | Pre Fermentation C (mg/ml) | Post Fermentation C (mg/ml) | Pre Dextrins C (mg/ml) | **Post Dextrins C mg/ml** |
| Control | 0.257 | 0.247 | 109.743 | 74.753 |
| Control F | 0.255 | 0.253 | 114.745 | 64.747 |
| AMG MP | 0.198 | 0.152 | 115.802 | 67.848 |
| AMG MF | 0.186 | 0.204 | 119.814 | 69.796 |

***Figure 3:*** *Dextrin content was measured by DNS reactant measuring ABS to 540 nm and using a calibration curve to calculate the concentration in each sample.*

| Density | | | | |
|---|---|---|---|---|
| Treatment | Density Pre F (g/L) | Density Post F (g/L) | Specific G Pre | Specific G post |
| Control | 113.6666667 | 41 | 0.1136666667 | 0.041 |
| Control F | 110.6666667 | 30.33333333 | 0.1106666667 | 0.03033333333 |
| AMG MP | 104 | 37.33333333 | 0.104 | 0.03733333333 |
| AMG MF | 109.6666667 | 40 | 0.1096666667 | 0.04 |

***Figure 4:*** *The density was calculated by mass over volume, where the mass was measured in grams and the volume where 0.003 L. After that we obtained the specific gravity for the alcohol determination.*

| Alcohol | | |
|---|---|---|
| Treatment | % alcohol | APV |
| Control | 7.63 | 9.5375 |
| Control F | 8.435 | 10.54375 |
| AMG MP | 7 | 8.75 |
| AMG MF | 7.315 | 9.14375 |

***Figure 5:*** *The % of alcohol and Alcohol per volume was calculated with the a formula (Original specific gravity - final specific gravity = ((value)*0.040)*105 ) for % and multiplied by 1.25 for APV)*

**Discussion and concluding remarks (Group)**:

After analyzing the data we observed that the enzymes did their work, and are useful in the elaboration of lager beers. Nonetheless we made mistakes during the essays and the amount of beer that was produced. This is due to the situation that we did not have enough time nor resources for the elaboration of this type of beer. Also, we take into account many factors that affect the values established by the training partner. For example the pH that was above 6 before maceration did affect the pH of the beer, since the parameters that are established for a commercial lager beer oscillate between 4.40-4.55 as mentioned before. This makes our beer more basic which means that the fermentation was not as efficient as it was thought to be.

**Evaluation of the feasibility of the product/process/service proposed as a solution to the selected challenge, considering transport process calculations, standards, sustainability principles and bioethics fundamentals**

Microbreweries are aiming to make it into the beer market and produce their own take on a beer, microbreweries like the training partner *Meta Brews Co.* have come into the market to offer their products and are constantly looking for ways to make the process more efficient.

As nutrition trends grow towards healthy and light diets beer makers are in need of a change in their products being that beer is a high caloric beverage, as the training partner proposes the usage of an added enzyme (AMG) makes for that they can follow the same brewing process and only changing small variables such as time and temperature and resulting in a beer that has more fermentable sugars and therefore is lighter and with the same alcoholic potential.

In the elaboration of the product during this project it has been determined that the addition of this enzyme to the brewing process represents a minimal inversion since the amount needed is small and the enzyme is not very expensive, and the times needed to make the enzyme act need not be very different from the original time and of course, the results produced in the lab align with the interest of the training partner yielding a beer that has low bitterness, low complex carbohydrates and a alcoholic content a little over what was intended that shows the high potential of fermentation.

As for the NOMs, it can be observed that during the process we've respected, followed and produced a beer that accounts for all the needs, the alcohol volume with a minimum of 2% and maximum of 20%, the sanitary requirements of raw materials and pH of 2.5-5, these are described by the following, NOM-199-SCFI-2017, NOM-142-SSA1/SCFI-2014, NOM-142-SSA1-1995.

The brewing process also present an opportunity to strive for sustainability so firstly the raw materials like barley and hop should be obtained from a sustainable source and taking into account that it is a water intensive process it can be beneficial to look at recycled and treated

water as a viable option to use as well as the proper disposal of used water, but more importantly, waste management will be paramount for this process to be considered ethical and this can be achieved by giving another use to wastes like barley which can be used as cattle feed, other waste disposal techniques can be seen in the NOMs, NOM-083-SEMARNAT-2003 and NOM-098-SEMARNAT-2002.

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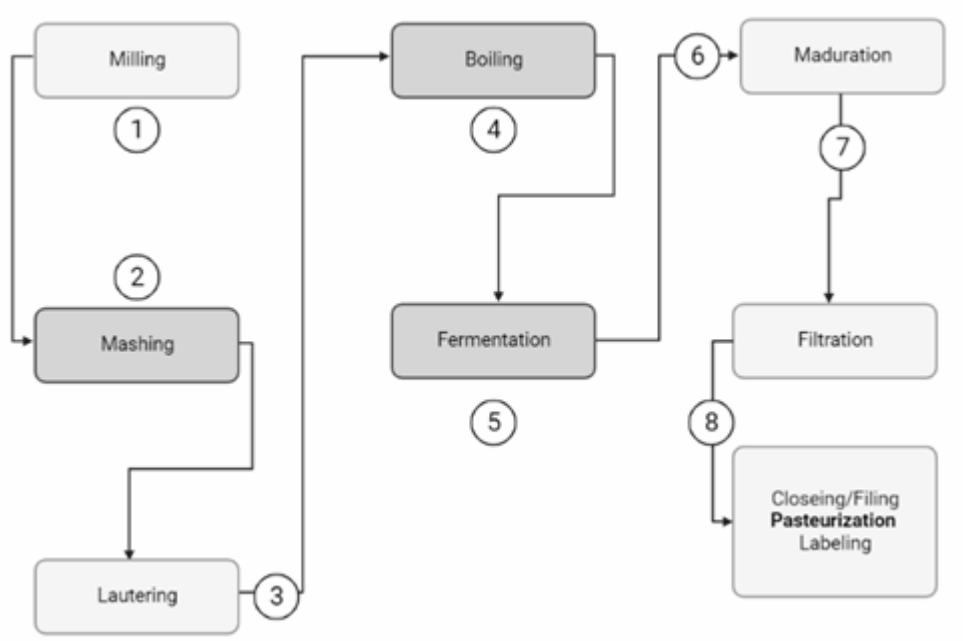
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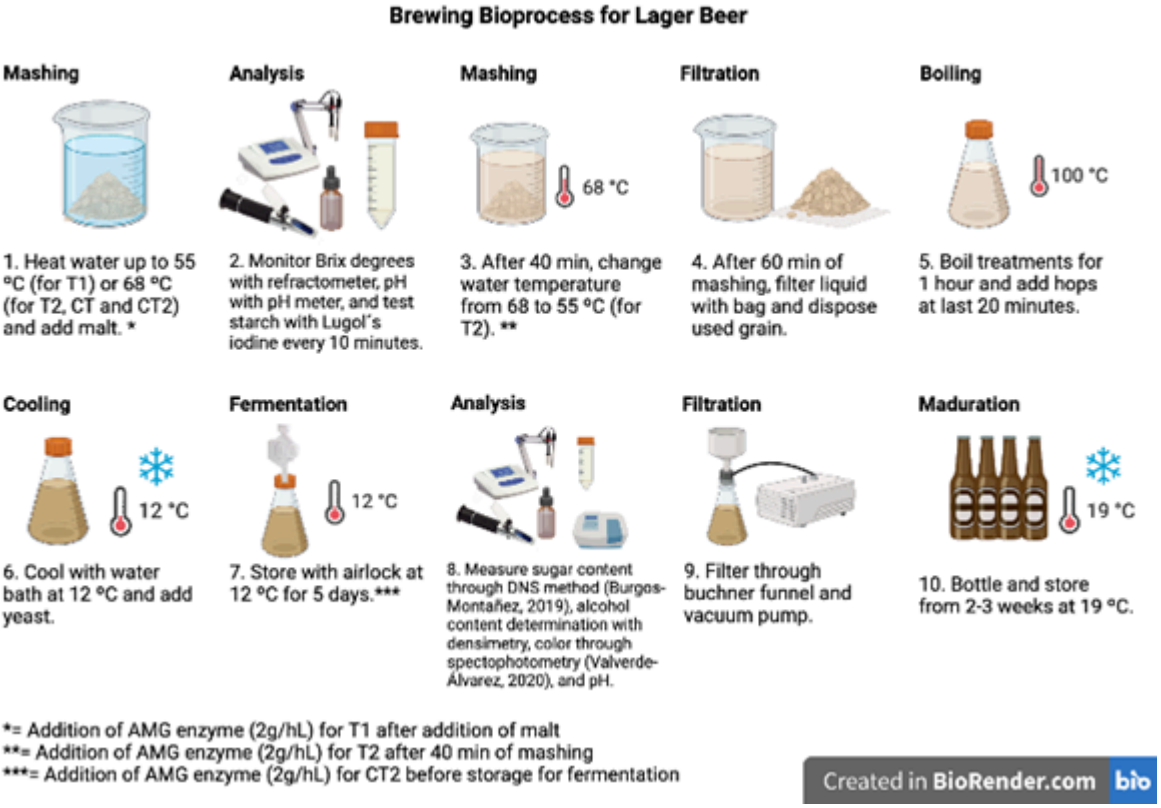
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**Annexes :**




*Annex 1: Unit operation diagram. The raw materials for this process are 100% Pilsner malt, water and Mittelfrüh hops. The unit operations that differ from color are the ones involved with heat transfer.*




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*Annex 3:* *Excel Curves*

*Annex 4:* *Datos Experimentales*

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