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### Types of barley (*Hordeum vulgare*) and their influence on beer making

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#### Abstract

Proximal analysis of the cultivation and quality of barley (*Hordeum vulgare*) in the brewing industry helps ensure excellence in beer production. The process begins with the selection of the appropriate varieties of barley, whose characteristics directly impact the flavor, color and body of the beer. Barley is an essential raw material in beer manufacturing, and its quality significantly influences the flavor, aroma and consistency of the final product. During this process, various factors are evaluated, such as the starch, protein, and moisture content in the barley, as these factors affect the efficiency of starch conversion into fermentable sugars during brewing. In addition, constant monitoring of the physical and chemical properties of the barley is maintained to ensure that it meets the required quality standards. High-quality barley cultivation contributes to the production of tastier, more consistent beers, which is essential to satisfying consumers and ensuring continued success in the brewing industry.

**Key words:** Proximal analysis, brewing, starch, proteins, barley moisture

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## 1 Introduction

Barley (*Hordeum vulgare*), one of the oldest cereals cultivated by mankind, focusing on various areas, from food to the production of iconic beverages such as beer. Its importance lies not only as an essential ingredient in brewing, but also in the diversity of types it presents, each with distinctive characteristics (Washington, 2023)

Barley is distinguished by its unique grain composition, with a high protein and mineral content (Molina, 2020). Its low presence of lipids and little lignified fibre makes it ideal for pig feed, although its energy value is lower than that of wheat and corn. Relevant standards: NTE INEN 2197 and ISO 7971:1988.

Classifying barley into two- and six-row varieties adds another layer of complexity to the picture: they are chosen by brewers looking to produce high-quality malts. In contrast, six-row varieties, with a higher protein content, present unique challenges and opportunities in the brewing process, influencing aspects such as the stability and texture of the final product (Washington, 2023) (Martín, 2021)

The enzymes important for breaking down starches into fermentable sugars during the maceration process. Different types of barley may have enzymatic profiles in the organoleptic characteristics of the resulting beer. (Fabián Enrique Rojas Estrada & Bárbara Darema Sarabia Aguila, 2023)

Understanding the differences between barley varieties and their impact on the brewing process allows craft and commercial brewers to create unique beers tailored to their preferences and market demands. Barley, in short, is not only an ingredient in the manufacture of beer, but a key element that defines its identity and complexity (Guzmán, 2020)

This article aims to conduct a comprehensive review of barley (*Hordeum vulgare*) types to understand their physical and chemical properties. Focus on the specific influence of these properties on the brewing process, analyzing in detail how barley characteristics affect the development and quality of the beer produced.

## 2 Importance of barley types

Barley (*Hordeum vulgare* L.) is a crop native to Asia and Africa (Ethiopia), and is considered to be one of the oldest plants in the world, having originally been cultivated in Egypt, Greece, and China. In most of Europe, the United States and Canada it is planted in the spring season. It is drought resistant and can be grown in shallow, stony soils. (TAPIA, 2020)

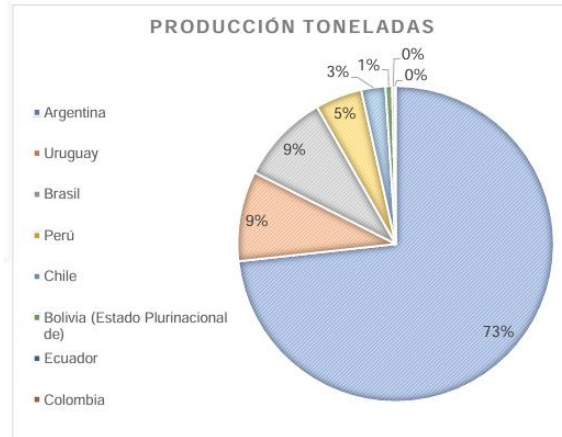
Archaeological excavations in the Nile Valley have uncovered barley remains, around 15,000 years old, and the discoveries also indicate the very early use of ground barley grain. (HERNÁNDEZ, 2011)

Barley, belonging to the species *Hordeum vulgare*, stands out worldwide for the diversity of its types and uses. Its quality has a direct impact on the sensory characteristics of the drink, such as taste, colour and aroma.

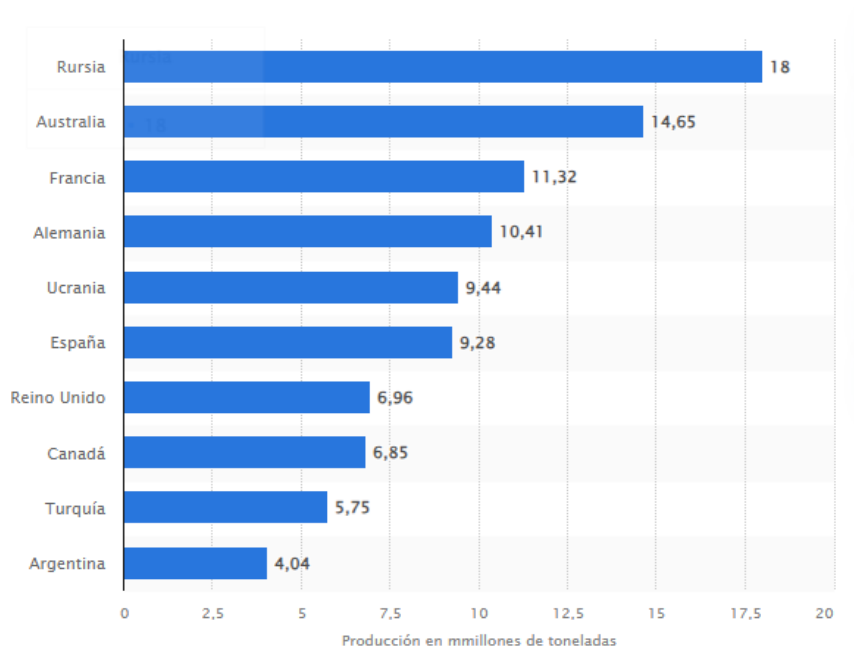
Farmers value forage barley for its ability to enrich the animal diet, thus contributing to the production of high-quality meat and dairy products.

Its nutritional content, which includes carbohydrates, proteins, vitamins and minerals, positions it as a valuable ingredient to promote a balanced and healthy diet. (Vera, 2023) Barley is the fourth most important cereal after wheat, maize and rice. Below are the main producing countries worldwide;

**Table 1:** Barley production in South America (Solis, 2020)



**Figure 1:** The main barley producing countries in the world in 2021 (Orús, 2023)



### 3 Barley Types -10%

Barley is grown for various purposes, highlighting its use as human food and seed. Varieties with a high protein value are intended for food, while those with a high starch and low protein content are used in malting. Agricultural practices and barley varieties vary according to the end use of the grain, which is a determining factor in its production. (Kirti Kumari, Piyush Kashyap, & Prasun Chakrabar, 2024) (Molina, 2020)

The diversity in barley production reflects the need to adjust agricultural strategies to optimize the nutritional characteristics of the grain according to its end use, thus highlighting the importance of considering these determining factors in the process of cultivation and production of barley. (Curillo, 2017)

### Characterization of the different types of barley

Barley (*Hordeum vulgare*) is mainly classified into two types: two-row barley (*Hordeum distichon*) and six-row barley (*Hordeum vulgare* var. *hexastichon*). The key difference between them lies in the arrangement of the spikelets on the spike. Double-row barley tends to have larger grains and is preferred in malting because of its superior malting characteristics. On the other hand, six-row barley is used in food and forage production due to its higher protein content. (Satan, 2023)

### Nutritional value of barley

Barley is certainly a very nutritious cereal and it can be found by its form: whole or pearl barley, in table 3 the data of whole barley is mentioned that provides greater nutritional content. (Cayo, 2024)

**Table 1:** Barley Nutrition Information (Cayo, 2024)

	<b>1 ración</b>	
	<b>200 g</b>	<b>100 g</b>
Calorías	704,00 kcal	352,00 kcal
Grasas	2,32 g	1,16 g
Grasas saturadas	0,49 g	0,24 g
Grasas poliinsaturadas	1,12 g	0,56 g
Grasas monoinsaturadas	0,30 g	0,15 g
Proteínas	19,82 g	9,91 g
Carbohidratos	155,44 g	77,72 g
Azúcar	1,60 g	0,80 g
Fibra	31,20 g	15,60 g
<b>Minerales</b>		
Calcio	58,00 mg	29,00 mg
Hierro	5,00 mg	2,50 mg
Sodio	18,00 mg	9,00 mg
Potasio	560,00 mg	280,00 mg
Magnesio	158,00 mg	79,00mg
Fósforo	442,00 mg	221,00 mg
Zinc	4,26 mg	2,13 mg
<b>Vitaminas</b>		
Vitamina A	44,00 IU	22 IU
Vitamina B1 (Tiamina)	0,38 mg	0,19 mg
Vitamina B6	0,52 mg	0,26 mg
Vitamina E	0,04 mg	0,02 mg
Vitamina K	4,40 µg	2,20 µg
Folato (ácido fólico)	46,00 µg	23,00 µg
Beta Caroteno	26,00 µg	13,00 µg
Agua	20,18 g	10,09 g

## **Physical and Chemical Characteristics**

### **Physical**

Barley (*Hordeum vulgare*) has distinctive physical characteristics as a cereal of agricultural and commercial importance. This herbaceous plant, which can reach heights between 60 centimeters and 1 meter, stands out for its elongated and compact spikelet, composed of spikelets arranged in two rows. Barley grains are small and elongated, with a protective shell. Its fibrous and shallow root system facilitates the efficient absorption of water and nutrients from the soil, contributing to its adaptability to various growing conditions. (Carrizales, 2022)

The deep green color of the leaves and the specific morphology of barley are key attributes in its development and recognition is fundamental for farmers, scientists and the food industry, as they influence the selection of varieties, cultivation methods and production processes, guaranteeing the quality of the grains and their versatility in different applications. (Lema-Aguirre, Basantes Morales , & Pantoja-Guamán, 2017)

### **Chemical**

Barley (*Hordeum vulgare*) composition includes a high starch content, constituting between 55% and 70% of its weight, which makes it a key source of carbohydrates as well, it also contains lipids in smaller amounts, as well as vitamins and minerals, such as niacin, thiamine, phosphorus and iron (Ayma, 2021)

In addition, barley contains protein in a range of 8% to 15%, with its quality and quantity varying between varieties, the presence of dietary fiber, minerals such as phosphorus and magnesium, as well as B vitamins, completes the chemical profile of barley, contributing to its nutritional value in both human food. These components make barley a nutritious food with a diverse chemical profile, contributing to its significant role in the global diet and in various industrial applications.

### **Agronomic aspects that affect the production of quality barley.**

Barley quality is strongly influenced by agronomic factors. The choice of cultivar, soil management and climate are crucial. Good soil drainage, along with proper nutrient application, is essential for healthy growth. In addition, the amount and distribution of rainfall during the growing cycle directly affects grain yield and quality. Disease and pest prevention, as well as proper weed management, are also key aspects to ensure a high-quality barley harvest. (Khaled, 2023) (Farinango, 2023)

## **4 Traditional Barley Methods**

The quality of the grain, focused on attributes such as protein content and suitability for malting, stands out as a key factor. This quality grain, subjected to traditional malting processes, in the brewing of beer, directly influences its flavor, color and distinctive characteristics. The preservation of these methods not only highlights authenticity, but also ensures the excellence of the final product. (Toapanta, 2023)

Traditional methods of growing barley begin with the careful choice of cultivars. Farmers, often guided by generations of passed down knowledge, select barley varieties that are best suited to climatic and soil conditions based on specific grain characteristics, such as its size, shape, and disease resistance, as well as its suitability for downstream processes,

such as malting. This attention to variety selection lays the foundation for successful cultivation and directly contributes to the quality of the final grain. (Recalde, 2020)

Grain quality is a central factor in traditional methods of barley cultivation. Barley destined for malting requires a specific balance of protein and starch to ensure successful malting. This quality of the grain is not only reflected in its chemical composition, but also in its appearance, size, and uniformity.

### **Brewing Formulation**

Brewing formulation is an art and science that involves the careful selection of key ingredients and precise process management. The choice of malt, hops and yeast defines the base of flavor, aroma and body, while the maceration and cooking process extracts the essential components of the grain. Fermentation, carefully controlled by the yeast strain and temperature, converts sugars into alcohol, shaping the final character of the beer. Maturation and filtration refine clarity and flavor profile prior to carbonation and packaging. Mastery in formulation allows craft brewers to create unique and satisfying experiences with every sip. (Vela, 2023)

### **Barley cultivation and harvesting**

Barley cultivation involves several essential steps. It starts with the proper selection of cultivars, considering factors such as climate adaptability and grain quality. Planting is typically done in spring or fall, with attention to planting density to optimize yield. During growth, agronomic practices are implemented to control weeds, diseases, and pests.

The harvest marks the end of the cycle and takes place when the beans reach physiological maturity, determined by their color and hardness. (Bhardwaj, 2021)

### **Barley for human consumption**

An early preference of wheat over barley correlates with the transition to baking and eating bread, based on the lack of gluten among the proteins stored in barley grains (Esquisabel, 2022)

In Ecuador, barley is mainly used for human food, such as: machica (roasted barley flour) and barley rice (split pearl barley), which are the most demanded products and together represent 88.3% of total barley grain consumption. Most barley used for food is pearl or flour. (Velástegui, 2023)

### **The quality of the grain and, therefore, in the brewing of the beer**

The quality of barley grain, the production of beer and other food products. The evaluation focuses on several factors, such as protein content, moisture, specific gravity, and the presence of impurities. A high protein content can negatively affect the clarity of beer, while excessive humidity can lead to storage problems. The specific gravity influences the amount of starches available for fermentation. The removal of impurities is essential to ensure a clean, high-quality bean. (Pilaguano, 2023)

Farmers and producers work closely together to maintain high standards in cultivation and harvesting, ensuring that barley meets the specific requirements of the food industry (MENÉNDEZ VERA ADRIANA MARÍA & VERA CEDEÑO DOLORES MELANÍA, 2023)

## **5 Brewing from barley**

The manufacture of beer from barley is an artisanal process that transforms this raw material into the popular alcoholic beverage these can vary in size, from small craft breweries to large industrial brewing companies maintaining the diversity of beers available in the market. (Torres, 2019)

### **Starch**

Starch is critical during the brewing process, as it is converted into fermentable sugars during malting. The amount and type of resulting sugars directly affect the alcohol content and sweetness of the beer. Good control over starch conversion is essential to achieve the right balance between the body and the dryness of beer (Cela, 2022)

### **Proteins**

Proteins have a significant impact on the texture and quality of the beer's foam. During maceration, enzymes break down proteins into amino acids, some of which contribute to mouthfeel and foam stability. Too much protein can result in an excessively persistent lather, while too little can result in an unsatisfactory lather

### **Humidity**

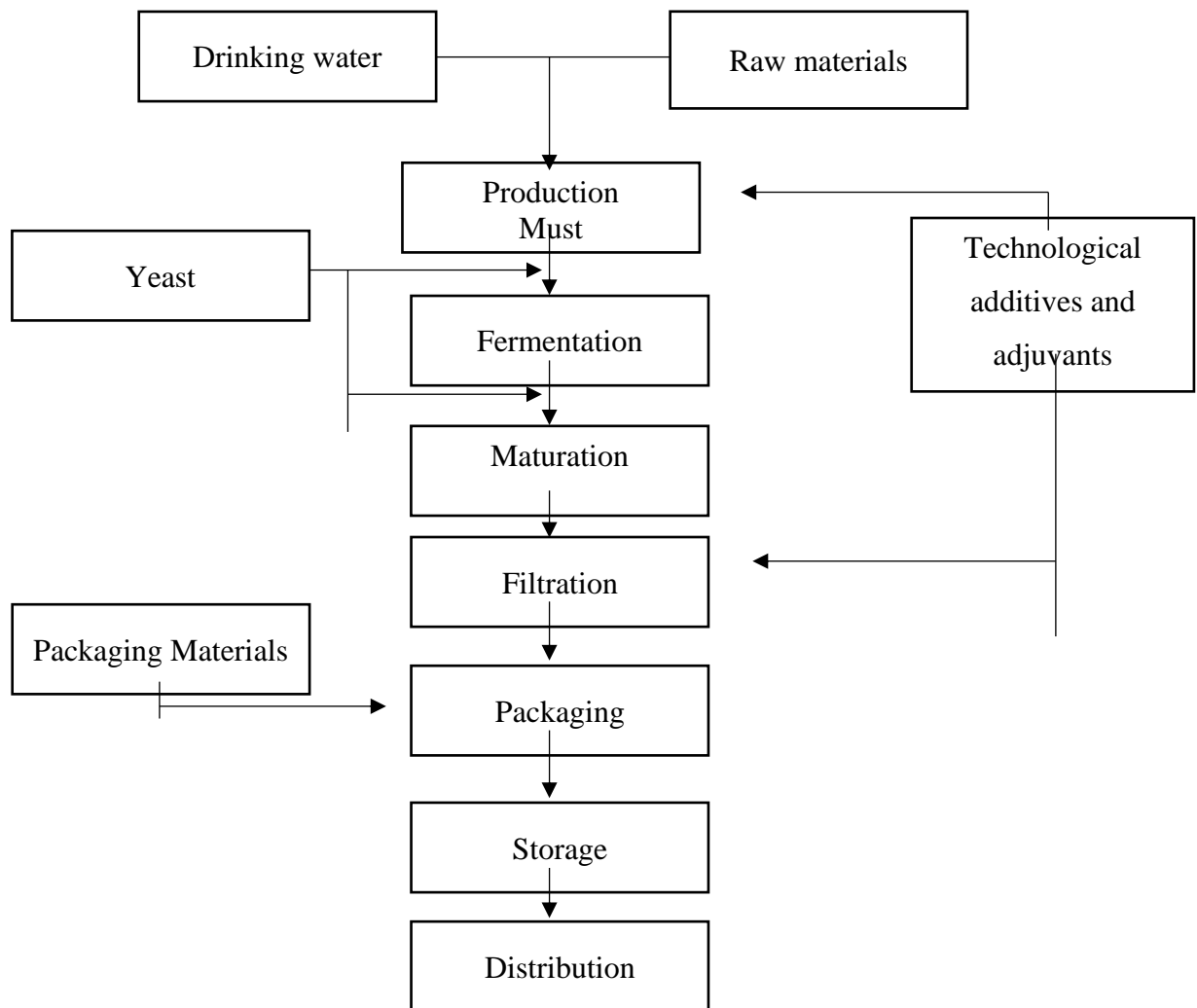
The moisture in beer is also an important factor. An adequate moisture content in malt grains and during maceration affects the efficiency of the extraction of flavors and sugars. In addition, moisture in the bottling process can influence the stability and shelf life of the bottled beer (Xiu Li, 2022)

## **6 Brewing Process**

It is obtained through the fermentation of basic ingredients such as water, barley malt, hops and yeast. The malt provides the necessary sugars, the hops add flavor and aroma, and the yeast transforms the sugars into alcohol and carbon dioxide during the fermentation process. There are numerous styles of beer, varying in taste, color, aroma, and alcohol content, and each culture has its own traditions and preferences in the brewing of this popular beverage. (Díaz L. , 2022)

### **Brewing**

Brewing beer involves a number of chemical, physical and biological processes.

**Figure 2.** Diagram of brewing processes (Velasquez, 2020)

Each of the processes involved in brewing beer are of vital importance for the quality of the product. However, the fermentation process is one of the important processes due to the fact that the bitterness and concentration of beer depends mainly on this process

### **Raw materials**

It is important to obtain a quality beer and are the following:

- Water: It should be free of unexpected odors and tastes.
- Barley: Provides the flavor and color, as well as the sugars needed for fermentation and the body.
- Hops: It is responsible for giving the bitterness, aroma and physical appearance
- Brewer's yeast: This is a non-photosynthetic, facultative aerobic, relatively sophisticated microorganism responsible for converting wort into alcohol.

### **Must production.**

Wort production consists of the extraction of liquid from the malt soaking process during the brewing process.

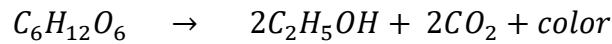
### **Fermentation**

The fermentation process is key in brewing, as the composition of the finished beer



depends on the preparation of the wort for good fermentation.

Approximately 1 pound of liquid yeast per barrel (3.9 grams per liter) is added to the cooled wort, representing an inoculation of 8 to 10 million yeast cells per milliliter.



Sugar, alcohol, carbon dioxide

**Figure 3:** Reaction in the fermentation process (Velasquez, 2020)

### Processes with yeast.

There are two processes that involve handling brewer's yeast. These processes are:

- **Addition of brewer's yeast for fermentation.** It is the process in which brewer's yeast is prepared in laboratories through chemical and physical procedures, after this treatment the yeast is added to the fermentation tank where the wort rests.
- **Purge of brewer's yeast during the final stages of fermentation.** It is the process of extracting yeast from the fermentation tank after the fermentation process.

These two processes are essential to control fermentation and maintain the desired quality and characteristics in the final beer. The initial addition of yeast starts the fermentation process, while the subsequent purge ensures that the beer is free of excess yeast and sediment, thus improving its taste and appearance. (CHACÓN, 2022)

### Maturation.

The maturation process takes place after the beer has been fermented, where the fermented liquid is stored in cellars at a temperature of 0°C, for a variable period of time. By keeping this temperature constant, the CO<sub>2</sub> is dissolved. It is filtered and given a second rest, being ready for packaging and later pasteurization. (Velasquez, 2020)

### Filtration

The filtration process is carried out before bottling, where beer goes through a filtration that eliminates the last remains that may remain from fermentation and also the remains of nitrogen that during rest have formed a kind of mucous, which could later cause the beer to come out cloudy, an effect that should not occur in beers without fermentation in the bottle.

### The boiling

Boiling in the brewing process is a critical phase where the wort, the liquid resulting from the alteration and filtering of barley grains, is boiled together with hops. This step, which usually takes around 60 to 90 minutes, serves several essential functions. Firstly, during boiling, the wort is sterilised, eliminating possible contaminants and unwanted microorganisms. This process contributes to the development of beer's characteristic flavors and aromas by allowing the bitter and aromatic compounds in hops to dissolve in the liquid.

Boiling in brewing is the isomerization of alpha-acids present in hops. This process converts alpha-acids into iso-alpha-acids, responsible for the beer's distinctive bitterness. The duration and specific timing at which hops are added during boiling significantly impact the final flavor profile of the beer, allowing brewers to adjust the bitterness, aroma, and flavor of the beverage according to their preferences or the style of beer they are brewing.

### **Beer maturation time**

A fundamental factor that significantly influences its quality and flavor. After primary fermentation, during which yeasts convert sugars into alcohol, the beer undergoes a period of maturation. During this time, chemical changes occur and flavors are stabilized, allowing the beer to reach its desired flavor profile. This process also allows unwanted byproducts to settle, improving the clarity and purity of the final product.

### **How long should beer mature?**

The first beer can be opened once the carbonation is finished and then tasted again every 1-2 weeks, to assess how the flavor evolves. If we are satisfied, we proceed to consumption. (García, 2021)

### **Beer shelf life**

A good rule of thumb is that the shelf life of a keg of pasteurized beer is about 90 to 120 days (or 3 to 4 months), and unpasteurized draft beer will last about 45 to 60 days (or 6 to 8 weeks) when stored at the right temperature. (Iza, 2019)

An accelerated treatment by the Multianálityca S.A. laboratory in the city of Quito (annex D). During this time, it is expected that the sensory and physicochemical characteristics of the product will comply with the microbiological requirements established by INEN 2262 (Montero, 2023)

## **7 Beer brewing storage -10%**

Information provided from brewers who can use the knowledge to improve their recipes, adapting them to market tastes and consumer preferences.

Storage in brewing is essential to ensure the quality and stability of the final product. Here is the storage process detailed in different stages:

### **Storage of malt:**

- Malts should be stored in a cool, dry place.
- Sudden changes in temperature and exposure to humidity should be avoided.
- Proper storage ensures that malts retain their characteristics and do not develop unwanted flavors.
- Wort storage:

After maceration and washing of the grain, the wort is transferred to the cooking pot.

Before boiling, the wort can be stored in specific tanks, and must be kept at controlled temperatures to prevent contamination.

### **Storage of Fermented Beer:**

After primary fermentation, the beer is moved to a secondary fermentation vessel or maturation tank, this storage allows for clarification and sediment removal. Fermentation tanks must be kept airtight and in controlled conditions to prevent oxidation and contamination. (Avalos García & Axel Estiven, 2021)

### **Storage before bottling:**

If additional maturation or clarification is carried out, the beer may require a storage period before bottling during this time, the temperature is monitored and controlled to ensure stability and quality.

### **Container Storage:**

Before filling the bottles or cans, they must be stored in a clean environment free of contaminants, this process is carried out rigorous cleaning and disinfection before bottling to avoid bacterial contamination.

### **Storage in Bottles or Cans:**

After bottling, the beer is stored under controlled conditions (temperature and light) to allow for carbonation and flavor development, within this stage the beer can go through an additional maturation period.

### **Final Storage:**

Bottled or canned beers are stored in cool, dark areas before being distributed to the market, allowing them to be controlled by storage conditions to maintain quality and avoid unwanted changes in flavor.

## **8 Brewing regulations and standards – 5%**

The INEN 22 62:2013 standard (Alcoholic Beverages. Beer. Requirements), where the following results were presented: alcohol content 3 °GL; total acidity 0.26%; carbonation 2.6 L CO<sub>2</sub>/L drink; pH 4.13; iron < 0.25 mg/L; copper <0.10 mg/L, zinc <0.20 mg/L; arsenic <0.005 mg/L, lead <0.5 mg/L, and in the microbiological analysis: the mesophilic anaerobic count <10 CFU/ml; yeasts 8.8 x 10<sup>4</sup> CFU/ml; molds <10 CFU/ml, which most of the parameters are within the ranges established in the standard, therefore, the beverage made is suitable for human consumption. (Lema, 2023)

- [NB 323001:2016] Beer – Craft Beer – Requirements
- [NB 084:1974] Beer – method for determining ash
- [NB 088:1974] Beer – usual method of determining acidity
- [NB 044:1997] Beer – sample preparation for analysis (first review)
- [NB 339:1997] Beer – electrometric method for determining pH (first check)
- [NB 083:1974] Beer - gravimetric method for determining alcohol content

### **Standards**

- International Food Code
- ISO 9001
- HACCP (Hazard Analysis and Critical Control Points):
- GMP (Good Manufacturing Practices)
- GMP (Good Manufacturing Practice)
- Food Labeling Standards
- Local and National Regulations:
- Environmental Regulations:

## 9 Conclusions

- The quality of barley is a fundamental factor in brewing, as it significantly influences the taste, aroma and consistency of the final product. They highlight the importance of barley quality, the brewing process, and maturation and fermentation time in the quality and flavor of the final product. In addition, the importance of humidity in beer and the quality of Ecuadorian barley in the national beer industry is highlighted.
- The maturation time of the beer is critical to stabilize the flavors and allow the beer to reach its desired flavor profile, as well as to improve the clarity and purity of the final product
- The quality of Ecuadorian barley is appreciated for its contribution to the characteristic flavor and aroma of the beers produced in the country, making it an essential component in the supply chain of the national beer industry

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