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# Innovations and challenges in the production of hard seltzers

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**ABSTRACT**
Hard seltzers, standing out in the global alcoholic beverage industry, are prized for their lightness, refreshing taste, and moderate alcohol content. Meeting the demand for healthier beverages, these low-calorie water- and cane sugar-based fermented beverages have gained popularity, especially with the growing concern for health and wellness. In the United States, following regulatory changes in 2016, the launch of the first hard seltzer marked the beginning of a new beverage category, with a notable increase in sales during the Covid-19 pandemic.
Production involves a careful fermentation process, with an emphasis on choosing the sugar source and using specific yeasts, such as Saccharomyces cerevisiae, to ensure quality and flavor. Sensory challenges are overcome with the addition of ingredients to enhance the taste while maintaining the healthy profile. The vital role of yeasts and the need for proper nutrition are critical to the success of the fermentation process. Hard seltzers, combining health, taste and innovation, promise a dynamic future in the beverage industry.

**Keywords:** Hard Seltzer, Alcoholic Beverages, Alcoholic Fermentation, Saccharomyces cerevisiae, Beverage Innovation, Yeast Nutrition.

## 1 INTRODUCTION

The production of alcoholic beverages has played a key role in the food and beverage industry, capturing a significant share of the global market. Among the various beverage categories, *hard seltzers* have emerged as a popular option, characterized by their lightness, refreshing taste, and moderate alcohol content. The growing demand for healthier alcoholic beverage alternatives with diversified flavors has driven the research and development of effective production methods, as most of the *hard seltezers* present in the Brazilian market are mixtures of various ingredients, such as grain alcohol, spirits, extracts, flavorings, and other products.

## 2 HARD SELTZER: MARKET AND DEMAND ASPECTS

The demand for drinks with fewer calories is growing around the world, this is because there is a greater concern about overweight, obesity, diabetes, and cardiovascular disease (Contreras-López et al. 2021).

Hard *seltzers* help meet this demand, being perceived as a healthier alternative to other alcoholic beverages. They have fewer carbohydrates than beers and have about 100 calories, while beers can reach up to 175 calories. (Harper, 2023). They are fermented beverages based on water, cane sugar and flavored, containing, predominantly, an alcohol content between 4% (v/v) to 5% (v/v). It is also necessary to use yeast nutrients to feed the yeast, which may contain, if necessary, the addition of acids and a stabilizing agent (Colby, 2020).

In the United States, in 2016, after the release of the TTB (Alcohol and Tobacco Tax and Trade Bureau*) regulation, which allowed the replacement of all malt used in the production of beer with sugar (TTB, 2015), the first* hard seltzer was launched on *the* market. The Mark Anthony Group launched White Claw (Colby, 2020), thus creating a new beverage that was categorized as beer according to American laws

In 2019*, hard seltzer sales in the United States reached $1.3 billion, accounting for 58% growth in the beer category (OGLESBY, n.d.). During the Covid-19 pandemic, the consumption of hard seltzer* was driven by generation X, with the concern of consuming healthier products and entertainment at home. Two examples of this growth are the sales of White Claw Hard Seltzer, which grew by *145%, and* Truly Hard Seltzer, *which grew by 614%, comparing 2020 compared to 2019 (IRI, 2021).*

## 3 THE PRODUCTION PROCESS OF HARD SELTZER

According to Colby (2020), there is a standard procedure for the production *of seltzer*, in which a solution of water and sugar is prepared by boiling or heating the solution so that the sugar is solubilized and the solution becomes homogeneous. Near the beginning of boiling, yeast nutrients are added. After boiling, after the solution has cooled, vitamins may or may not be added, and then the fermentation procedure begins.

First, it is important to select the right sugar source. Several options are available for the production of a *hard seltzer*, including dextrose, sucrose, liquid invert sugar, agave syrup, and honey, among others (LALLEMAND, 2020). The choice of sugar source can impact the speed of fermentation, with monosaccharide sugars tending to ferment faster (SCOTT LABORATORIES, 2021).

Fermentation is the most sensitive step in achieving success in the manufacture of a *hard seltzer.* It is possible to use brewer's yeasts or even yeasts for winemaking. The key to this success is adding the appropriate level of yeast and nutrients. It is common for fermentation to last between 8 to 11 days,

but if you do not have the right amount of nutrients available for the yeast, it can be even slower (COLBY, 2020).

Selecting strains that are suitable for fermentation is important, as yeast plays a vital role in the production of alcoholic beverages. Suitable strains will maximize ethanol yield and maintain the sensory quality of the beverage. In the production of alcoholic beverages, the strains of *Saccharomyces cerevisiae* are the most used (WALKER, STEWART, 2016).

After the fermentation of the water and sugar base, for the production of *a hard seltzer*, it is expected that it is colorless, with a neutral aroma and flavor, for this, after fermentation, cleaning is carried out, either by filtration, clarification or centrifugation. If the alcohol content is higher than intended, the solution is diluted in water. In the final stage, hard *seltzer* is mixed with flavors and acids and pasteurized. If pasteurization is not carried out, a stabilizer or preservative should be used. And so it will be ready for filling (Colby, 2020).

## 4 SENSORY CHALLENGES AND FLAVOR ENHANCEMENT

According to WILLIAMS, et al. (2022), the final taste of hard seltzer usually does not please most consumers due to negative sensory characteristics, and may have bitter and sour flavors. The addition of ingredients such as food-grade acidulants, mineral salt, flavorings, sweeteners, colorings, preservatives, emulsifiers, antioxidants, amino acids, caffeine, micronutrients, plant extracts, phytonutrients, buffering salts, stabilizers, thickening agents, vitamins, and their combinations can enhance the taste and attractiveness of a beverage. It has been observed that the inclusion of at least one mineral salt, selected from mineral bulks, trace minerals or their combinations, can improve the flavor profile of the beverage compared to a version without mineral salt added. In addition, combinations of at least one food acidulant, such as acetic acid, lactic acid, malic acid, fumaric acid, citric acid, tartaric acid, phosphoric acid, succinic acid, alkaline or alkaline earth metal salts, along with at least one mineral salt, can further enhance the flavor of the beverage. However, it's important to note that the inclusion of these ingredients can move the drink away from the category of healthy options.

## 5 THE ROLE OF YEAST: SACCHAROMYCES CEREVISIAE

Yeasts are unicellular eukaryotic fungi, and *Saccharomyces cerevisiae* are usually ellipsoids with a diameter of 5 to 10 µm (WALKER, 1998). Its properties, such as flocculation, fermentation capacity, osmotic pressure, ethanol tolerance, and oxygen requirements have a direct impact on fermentation performance (STEWART, 2016). *Saccharomyces* are able to use different sugars as a source of carbon and energy, preferentially consuming glucose and fructose (CARLSON, 1987), with glucose being the main source of carbon and energy (BEKATOROU et al., 2006). *Saccharomyces*

*cerevisiae* is one of the species most prone to fermentation, producing ethanol even with excess oxygen, in addition to exhibiting rapid rates of sugar consumption and ethanol production. *Saccharomyces cerevisiae* is also one of the few yeast species that can grow in anaerobic conditions with low nitrogen requirements. These physiological characteristics explain the aptitude of *Saccharomyces cerevisiae* for alcoholic fermentation (VISSER et al. 1990).

## 6 YEAST NUTRITION AND HEALTH

For its alcoholic fermentation, yeast essentially needs water. Mediums with high sugar content can cause osmotic stress, which would be the low availability of water, affecting your cellular physiology. In terms of temperature and pH requirements, most strains of *Saccharomyces cerevisiae* grow well in hot and acidic environments (WALKER, STEWART, 2016).

Unlike beer or wine fermentation, sugar-based fermentations have near-zero buffering capacity. As a result, the $CO_2$ produced by the fermenting yeast will react with the water to form carbonic acid ($H_2CO_3$) resulting in a rapid drop in pH in the absence of any buffer. To maintain optimal yeast health during fermentation, the pH should be kept between 3.5 and 4.0. This can be achieved by adding potassium bicarbonate ($K_2HCO_3$) as a buffer (LALLEMAND, 2020).

For the metabolic growth of yeasts, it is essential to have an adequate nutritional composition (WALKER, STEWART, 2016). These conditions are provided, for example, by malt mash, which is a source of nitrogen, minerals and most of the vitamins that yeast needs for good fermentation, such as riboflavin, inositol and biotin. Minerals such as phosphorus, sulfur, copper, iron, zinc, potassium, calcium, and sodium are also important for yeast. It is possible to improve the performance of yeasts, with nutritional supplements, ensuring that the wort contains the appropriate minerals and vitamins for fermentation (WHITE, ZAINASHEFF 2010). Yeast nutrients are generally divided into two groups, the basic ones being such as carbons, oxygen, hydrogen, and nitrogenous substances and the nutrients needed in small amounts, such as trace elements, macronutrients, and vitamins (VICTOROVNA, et al., 2021).

An important nutrient in yeast fermentation media is nitrogen, which plays an anabolic role in the biosynthesis of structural and functional proteins (enzymes) and nucleic acids, as well as playing a catabolic role in the production of flavor congeners, such as higher alcohols (WALKER, STEWART, 2016).

Oxygen is also an essential growth factor. After aeration or oxygenation before fermentation begins, the yeast membranes are enriched with ergosterol and oleic acid, as a consequence, the cells are much more fermentative and stress tolerant. It is important to pay attention to the oxygenation of the solution to achieve a good fermentation performance, it must be ensured that the fermentation media are adequately aerated or oxygenated before the start of anaerobic fermentation. For example,

brewers typically aim for 1 ppm of dissolved oxygen per degree Plato (P) in their wort before releasing yeast (WALKER, WALKER, 2018).

Careful attention to yeast nutrition is a prerequisite for achieving successful industrial alcoholic fermentations. Nutrient availability will have a significant impact on yeast growth, stress tolerance, and ethanol yields. Due to the lack of inadequate nutrition, problematic fermentations can arise. For example, stalled or slow fermentations can be the result of lack of oxygen, nitrogen deficiencies, mineral imbalances, and vitamin deficiencies (WALKER, WALKER, 2018). In this context, for hard seltzers that use a wort composed of water and sugar, the supply of nutrients is essential (SCOTT LABORATORIES, 2021).

## 7 FERMENTATION PROCESSES AND CONTROL

Industrial fermentations can occur in continuous and discontinuous processes (BAILEY, OLLIS, 1986). Discontinuous fermentations, or batch fermentations, occur in such a way that during the fermentation process nothing but oxygen is added (in aerobic fermentations), defoamers, and acid or base for pH control. So if no solution is added and there is no loss of liquid by evaporation, the volume of the solution remains the same (CARVALHO, SATO, 2001).

A process that is of great importance to industry and research is the fed batch fermentation, which has been used to regulate the growth of *Saccharomyces cerevisiae* since about 1900. This process occurs when nutrients are added to the fermenter during fermentation, and they remain there until the end of the process. The addition of nutrients can be done continuously or vary over time, and the addition of the wort can also be continuous or intermittent. The occurrence of variations in volume depends on substrate concentration and evaporation. This makes it possible to control the concentration of the substrate, directing the microbial metabolism to a specific metabolic pathway (CARVALHO, SATO, 2001).

## 8 CONCLUSION

This chapter offered a comprehensive overview of the production and market of hard seltzers, highlighting their rise as a popular alternative in the world of alcoholic beverages. The growing interest in healthier options, with fewer calories and differentiated ingredients, has put hard seltzers in the spotlight, especially in markets such as the United States, where we have seen a significant increase in sales and a remarkable diversification of the products available.

When it comes to production, we cover the essential aspects that make hard seltzers a unique drink. From the judicious choice of ingredients, such as different types of sugars and yeasts, to the challenges of fermentation and techniques to enhance flavor and sensory quality, every step of the

production process is crucial to ensure the lightness, refreshing taste, and moderate alcohol content that define these beverages.

Saccharomyces cerevisiae, in particular, play a central role in fermentation, highlighting the importance of a deep understanding of the characteristics and nutritional needs of these yeasts. Proper nutrition and control of the fermentation process are essential to achieving a high-quality product.

Looking ahead, the hard seltzers industry faces the challenge of balancing the demand for healthier beverages with the need to maintain an attractive flavor profile. Continued innovation in production techniques and ingredients will be key to meeting these expectations and maintaining relevance in the competitive alcoholic beverage market.

As the industry advances, research and development will continue to play a crucial role in exploring new flavors, more efficient production methods, and strategies to improve the nutritional profile of hard seltzers. The intersection of science, technology, and consumer preferences promises a dynamic and exciting future for this beverage category.

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