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# PROPOSAL AND DEVELOPMENT OF A CRAFT BEER WITH FRUIT FOR THE LOCAL MARKET IN PARAÍBA

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# PROPOSAL AND DEVELOPMENT OF A CRAFT BEER WITH FRUIT FOR THE LOCAL MARKET IN PARAÍBA

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*“No matter how narrow the portal, how full of punishments the list, I am the master of my destiny: I am the captain of my soul”.*

*(William Ernest Henley)*

## RESUMO

A cerveja é a bebida mais consumida e conhecida no mundo. Foi descoberta há milhares de anos e sua produção foi aperfeiçoada ao longo do tempo, até os dias atuais com diversos estilos de cerveja que utilizam os mais variados insumos. Esta contemporização da bebida levou o mercado a ficar cada vez mais exigente com a qualidade do produto, despertou o interesse em explorar cervejas com adições de insumo que remetam características regionais, e que além de um ótimo sabor, tenha propriedades funcionais. Visando esta nova e exigente demanda do mercado, o objetivo deste trabalho é desenvolver uma cerveja artesanal do tipo American IPA com adição de seriguela (*Spondias purpúrea*), a fim de desenvolver um produto acessível, que atenda as exigências do mercado, e que tenha alto valor agregado. Para atender esses objetivos, primeiramente foi elaborado um estudo para identificação dos principais recursos e capacidade voltados à inovação das cervejarias locais, assim foi possível identificar se as cervejarias já possuem práticas inovadoras para possível produção de uma cerveja mais complexa e inovadora. Segundamente, foi feito uma pesquisa de mercado para identificar as principais características sensoriais que os consumidores de cerveja artesanal desejam em uma American IPA. Por fim, uma cerveja artesanal com adição de seriguela foi produzida em concentrações diferentes (0%, 10%, 15%). As bebidas foram analisadas quanto ao seu teor de antioxidantes através de três análises distintas (FRAP, ABTS e DPPH), e foram submetidas à avaliação sensorial (teste de aceitação e compra). As três cervejas obtidas tiveram ótima aceitação e todas tiveram uma alta atividade antioxidante, assim, conferindo o caráter funcional à bebida. Desta forma, foi possível produzir uma cerveja inovadora, funcional e acessível tanto para as cervejarias artesanais quanto para os consumidores locais.

## ABSTRACT

Beer is the most consumed and known drink in the world. It was discovered thousands of years ago and its production has been improved over time up to the present day with different styles of beer that use the most varied inputs. This temporization of the drink led the market to become increasingly demanding with the quality of the product, aroused the interest in exploring beers with additions of input that refer to regional characteristics, and requires that in addition to a great flavor, it has functional properties. Aiming at this new and challenging market demand, the objective of this work is to develop a American IPA with the addition of Seriguela (Spondias purpúrea), in order to develop an accessible product, that meets the market demands, and that has high added value. To meet these objectives, a study was first developed to identify the main resources and capacity related to innovation practices of local breweries, thus it was possible to identify if they have the proper innovation tools to produce a more complex and innovative beer. Secondly, market research was carried out to identify the main sensory characteristics that craft beer consumers desire in an American IPA. Finally, a craft beer with the addition of Seriguela was produced in different concentrations (0%, 10%, 15%). The drinks were analyzed for their antioxidant content through three different analyzes (FRAP, ABTS, and DPPH), and were submitted to sensory evaluation (acceptance and purchase test). The three beers obtained had excellent acceptance and all had a high antioxidant activity, thus, giving the drink a functional character. In this way, it is possible to produce an innovative, functional and affordable beer for both craft breweries and local consumers.

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## ABBREVIATIONS

**RBV –** Resource based view

**VRIO –** Valuable, rare, inimitable, organized

**R&D –** Research and development

**QFD –** Quality function deployment tool

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# PART I – MAIN REPORT

# 1. INTRODUCTION

## 1.1. RESEARCH PROBLEM AND STRUCTURE OF THE DISSERTATION

How to develop a craft beer with functional properties considering the adoption of seriguela, a Brazilian northeastern region ingredient? This question is not only limited to the fact of producing a new beer with distinct sensory characteristics. It is necessary to have knowledge of the local brewing sector as a whole, in order to know what can be done to produce an accessible, innovative beer that adequately meets the requirements of local consumers.

According to Murray and O'Neill, 2012; Thomé *et al.*, 2016; Carvalho *et al.*, 2018, the craft beer market have been constantly conquering market share and transforming local consumers behavior towards the alcoholic beverage. The craft beer consumers are getting more savvy, sophisticated and demanding about the quality of the beers, and many times relating it to the local culture. In this manner, it is vital for breweries to remodulate themselves in order to get by into this new demanding market. One significant way to achieve differentiation within the craft beer niche is understanding how to apply innovative practices with the intention of brewing complex beers that will meet the local market requirements.

However, having a self-understand of the internal capabilities is not enough to craft the perfect beer. Aiming the external boundaries are extremely important measures that breweries must take to acquire an important share in the local market. Businesses which establish commitment to their niches based on knowledge and proper strategies, tend to gain differentiation and governance within the niche (Garver, 2009; Carroll and Swaminathan, 2011; Murray and O'Neill, 2012). Consequently, it is imperative to breweries comprehend their niche by listening closely to the local beer consumers.

One of the ways to build the company-consumer close relationship is through the Quality Function Deployment (QFD) tool, which can be applied in microbreweries, providing important information about consumers' needs. In such a way, the use of this tool can help the microbrewery to map the main necessities of consumers and apply them in their portfolio of products or services. The same was observed by Souza and Cauchick Miguel (2017), where the authors state that the QFD is a method that supports the planning and development of products or services, providing the company with a

structured path to ensure the quality and satisfaction of its portfolio through consumer requirements.

Once the gaps are acknowledged, the local breweries have total control of the production of an accessible, innovative, and satisfactory beer. From this moment, the breweries own the control of their internal resources and they also understand the main external factor: their niche. Therefore, gathering the necessary tools to start brewing a flawless beer. Moreover, more value can be added by exploring the functionality of the alcoholic beverage, which is of utmost importance (Cook and Samman, 1996; Akbaraly *et al.*, 2009; Babbar *et al.*, 2011; Dutra *et al.*, 2017). In this dissertation, it is produced a functional beer with high polyphenols concentration that meets the consumers' requirements, and the limitations of the internal capacity of the breweries.

## 1.2. RESEARCH OBJECTIVE

To develop a functional, innovative, and accessible craft beer with the addition of Seriguela (*Spondias purpurea*), a regional ingredient from the northeastern region of Brazil. With the specific objectives:

- To investigate resources and capabilities responsible for innovation strategies in local craft breweries to evaluate the support of the production of an innovative, regional, accessible raft beer.
- To understand the local market needs applying QFD for better comprehension of the requirements demanded by the craft beer consumers.
- To analyze the antioxidant activity of the craft beer produced according to the consumers' requirements.

## 1.3. JUSTIFICATIONS

- The lack of scientific research on the craft beer market, mainly with a focus on microbreweries. Such scientific lack in this sector is cited by Alonso et al. (2016,2017,2018) who reports on the use of scientific research in the wine sector to support his research in the microbrewery sector.
- The lack of studies on the craft beer market from the perspective of the entrepreneur and consumer.

- The search for innovation and value aggregation through the addition of regional inputs.
- The absence of structure and strategic technical knowledge of entrepreneurs in the craft beer sector in northeastern Brazil.
- The absence of studies using QFD in the beer and craft beer sector.
- Manufacture of a drink with regional products and functional character in terms of a high content of antioxidants.

## 2. PRESENTATION OF MAIN FINDINGS

### 2.1. PAPER 1: DO THE LOCAL BREWERIES HAVE INNOVATION STRATEGIES THAT CAN SUPPORT THE PRODUCTION OF A NEW AND ACCESSIBLE BEER?

In this paper, it was investigated the main resources and capabilities that support the adoption of innovation strategies. This study provides important data about the internal capabilities of the breweries, and how they are positioned in order to be able to perform new innovation practices, for instance: the production of a new beer to meet the local market requirements. The Figure 1 illustrate the most important resources and capabilities according to the breweries.

Figure 1. Most important Resources and Capabilities according to the breweries

| | **Most important Resources & Capabilities** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Microreweries** | Beer quality | Service quality | Brand reputation | Expertise in brewing | Microbrewery history | Microbrewery location | Investments in equipment | Social media | Human resources | Business strategies | New ingredients | Financial health | Social Relationship |
| **A** | | | **X** | | **X** | | | | **X** | **X** | | **X** | |
| **B** | **X** | | | | **X** | | | | | **X** | | **X** | **X** |

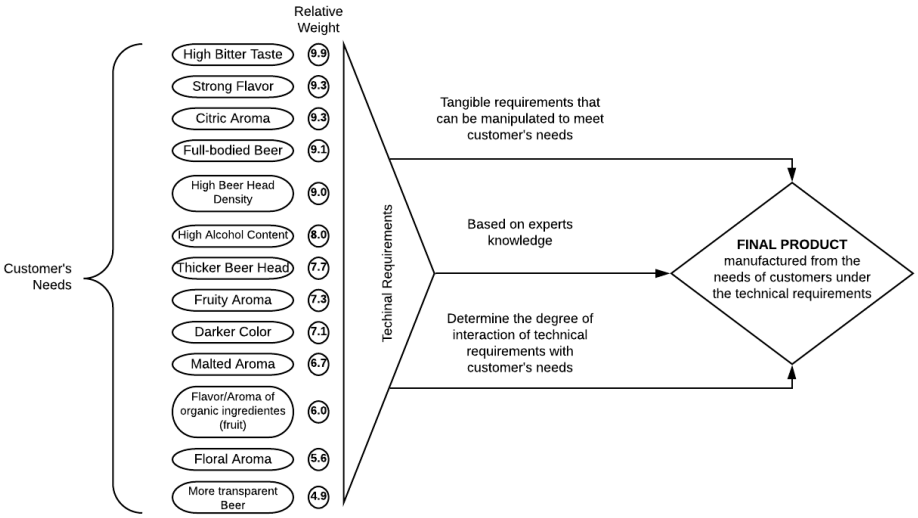
Source: Paper 1

According to the Paper 1, both breweries agree with the importance of business strategies and financial health. To apply the proper strategy can lead the breweries to conquer an expressive share of the local market, improve their relationship with stakeholders, and get ready for any upcoming external demand.

## 2.2. WHAT ARE THE DEMANDS OF THE LOCAL CRAFT BEER MARKET?

The utmost objective of this study was to obtain the craft beer style that the local market loves, and what are the sensorial requirements asked by the consumers. After a brief research, the Indian Pale Ale (IPA) beer style was determined as the most acceptable style among all beers. A Quality Function Deployment Matrix (QFD) was developed in order to obtain the key sensorial characteristics this beer should have. Figure 2 lists the most important characteristics determined by the local consumers.

Figure 2. Framework of the most important costumer's needs regarding the IPA style




Source: Paper 2

The correct use of the QFD matrix can help brewers to identify key consumer needs and, if operated properly, it can help brewers create effective production strategies that target their niche market directly. In addition, the correct application of the QFD tool in conjunction with the assembled structure could support product innovation strategies through the adoption of new adjuncts that could provide the essential sensory characteristics required by craft beer consumers.

## 2.3. PAPER 3: HOW TO BREW AN INNOVATIVE CRAFT BEER ACCORDING TO THE LOCAL MARKET NEEDS, AND ADDING FUNCTIONAL PROPERTIES?

The final paper was the production of a functional craft beer that meets the requirements of the local consumers and the internal capacity of the breweries. The craft beer brewed was an IPA with addition of a regional fruit with high polyphenol content, Seriguela (*Spondias purpurea*). According to the results, the addition of the Seriguela pulp increases the scavenging capacity of the drink. The three tests to measure the beer reducing capacity (ABTS, FRAP, DPPH), showed significant increases in the concentration of antioxidants as a greater percentage of the fruit pulp is added. Also, the crafted beer passed through a sensorial analysis, and presented good acceptability.

## 3. DISCUSSION

In this section it is discussed the implications of the three papers for research and practice. To reiterate, Table 1 offers a briefing of the papers.

Table 1. Briefing of the papers

| # | Title | Research Question | Key Findings | Contributions | Limitations |
|---|---|---|---|---|---|
| **1** | Innovation strategies through Resource-Based View Lens: A case study in microbreweries from northeast of Brazil | Do the local breweries have innovation strategies that can support the production of a new and accessible beer? | The use of the correct strategy can lead the breweries to acquire an expressive share of the local market, improve their relationship with stakeholders, and get prepared for any upcoming external demand. | Better understanding of microbreweries behavior towards innovation strategies and how they could sustain these innovations by resources and capabilities. Fulfill the research gap about microbreweries and innovation | The limited number of researched microbreweries |
| **2** | Framework for prioritizing craft beer parameters using the Quality Function Deployment (QFD) to understand the real consumers requirements | What are the demands of the local craft beer market? | The correct use of the QFD can help brewers to identify key consumer needs and, if operated properly, it can help brewers create effective production strategies to target their niche. | This paper fulfills a gap in the literature regarding the craft beer niche and the use of QFD to enhance the link between consumers and breweries. | The limited number of local consumers researched. |
| **3** | Analysis of the antioxidant activity of a beer added with Seriguela (*Spondias purpurea*) | How to brew an innovative craft beer according to the local market needs, and adding functional properties? | All the beer produces have a high content of antioxidants. Also, the crafted beers got great acceptability. | This paper enhances the studies regarding functional foods, and explore the use of Seriguela as the main vector of the functional compounds. | Investigate the use of the fruit in other stages of the process. |

## 4. CONCLUSION

The main objective of this work was to develop a functional craft beer based on the analysis of the current internal availability of the breweries and the needs of the local market. To achieve this goal, firstly, it was needed to understand the inside of the brewery organization (investigated in paper 1). Secondly, understand the outside, constituted by the market and the craft beer consumers (identified in paper 2). Finally, to tangible the theoretical data obtained in article 2, by producing a beer that would meet the consumers' needs and possible to the breweries.

This work has a great potential to help the brewers to map and build their strategies, in order to minimize the financial damages to obtain enough data to understand their niche and reach their niche needs. Moreover, this work aggregates significant value to understand how the innovations dimension could be improved by the breweries by exploring their resources and capabilities. Plus, to map the breweries bottlenecks and find ways to stanch them (paper 1).

Paper 2, demonstrates a quality tool that could be applied by the brewers in preparation for producing a beer that could closely meet the consumers' needs. Then, helping the breweries to upgrade their product innovation strategies by facilitating the creation of new products targeted to the costumer's behavior.

In this way, the merger of RBV and QFD can direct the entrepreneur to take the right measures, value the resources and capabilities they have and cultivate the company-consumer relationship. Implementing these visions and tools in the company, can assist in the construction of a portfolio of innovative products that directly meet the needs of consumers. This research could serve as a sustainable guide for entrepreneurs in the beer market and for those who plan to innovate in terms of product, for example.

The third paper, explored the production of a functional beer. Exploring the health potential of the functional ability of the beer and the power of using regional fruits to enhance this functional activity and a possible strong connection with the local market. The three beers produced had excellent acceptance and all had a high antioxidant activity, thus, giving the drink a functional character.

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# PART II – PAPERS

# PAPER 1: INNOVATION STRATEGIES THROUGH RESOURCE-BASED VIEW LENS: A CASE STUDY IN MICROBREWERIES FROM NORTHEAST OF BRAZIL

## 1. Introduction

In the beverage market, beer has a famous and an historical position. The beer has centuries of history and is the most consumed alcoholic beverage worldwide, followed by spirits, wine and cider (Statista, 2019). Therefore, the maturity of this sector has led entrepreneurs to invest constantly in innovation practices, most of the time the development of new craft beers, which require relatively low industrial development and a special care of the producer to ensure the product originality and a special flavor. The word "innovation" is essential in the vocabulary of all entrepreneurs involved in activities associated with the food and beverage industries, once the new economy requires to be on alert to quickly react to the changing demands. According to Carvalho *et al.* (2018), craft beers are directly committed to product innovation and the consumers are changing their behavior in search of more sophisticated beers, leading craft breweries to invest in this sector.

The importance of entrepreneurship in Brazil's economy is substantial. According to the last Global Entrepreneurship Monitor (GEM), (2017) report, entrepreneurship in Brazil has increased 36% in 2016, in which almost 26% related with initial and new entrepreneurs. This result granted Brazil the eighth position among 31 countries in economic development driven efficiency. Also based on the GEM, (2017), Brazil got higher rates than the G8 countries in economic development and initial entrepreneurship. The numbers above illustrate how important new entrepreneurs are for the country. The same could be applied to the microbreweries. According to MAPA (2018) the position of Brazil in this ranking is due to the increase in the number of breweries in operation, especially the microbreweries, also called craft breweries. Also, since 2010 the breweries in Brazil did not stop to grow and tendency is to increase even more.

Furthermore, the last Brazil Food Trends 2020 (BFT 2020) report the importance of food and beverage sensorial characteristics and pleasure. According to Instituto de Tecnologia de Alimentos - Ital; Federação das Indústrias do Estado de São Paulo Departamento do Agronegócio - Deagro, (2010): "this trend disseminates regional recipes and ethnic products, creating interest in the harmonization of foods and beverages, new

textures and flavors". In order to be recognized in this niche, local microbreweries need to create innovative products aiming the regional culture.

Despite the flourishing of the craft beer market, researchers such as Alonso *et al.*, 2016), highlights the lack of research and knowledge in the different dimensions in the microbreweries sector. Murray and O'Neill (2012) report the importance of studying the enthusiasts of this new segment. (Danson *et al.*, 2015, p. 142), report that "the field of microbreweries continues to be under-researched". In other words, the whole set of spheres of the craft beer segment needs to be studied.

Also, due to the lack of researches about microbreweries and innovation strategies, the wine entrepreneurship literature offered useful insights to support the empirical research development. Such as wine research on innovation (Ferreira *et al.*, 2013), and building brands (Reid, 2002).

Thus, it is vital to consider innovation in the brewing market as one of the main pillars for business strategy. Firms need to identify and explore resources and capabilities that support these strategies. A widely used theory for determining the key resources and capabilities observed in the business environment is Resource-Based View (RBV). The RBV, proposed by (Barney, 1991), highlights that firms are a pack of resources and/or capabilities that constitute a source of competitive advantage. The RBV is a useful theory that can help microbreweries' owners to find the main resources and capabilities that may support innovative strategies to achieve competitive advantage.

Thus, learning about their innovation strategies, entrepreneurs may understand what need to be done to improve these strategies and achieve competitive advantage. From a theoretical perspective, adopting RBV show how important resources and capabilities are to evaluate the competitiveness of a firm.

Therefore, the main purpose of this paper is to analyze the innovation strategies adopted by craft breweries taking as theoretical support the resource-based-view (RBV). This paper consists of acquiring significant information to try to help the entrepreneurs to trace the way their business strategies are aiming at innovation and seeking to answer the following research questions:

Q1. Which are the main innovation strategies adopted by the enterprises?

Q2. Which are the key resources and capabilities that support the adoption of innovation strategy implementation?

These research questions were addressed through exploratory case studies in two craft breweries in northeast of Brazil. The northeast region of Brazil has a powerful

cultural history and it is recognized nationwide. The culinary, the touristic spots, the people behavior, the environment are characteristics strongly perceived by the northeastern and could be important indicators to be explored inside the brewery market. Thus, this paper aims to contribute to the literature by addressing the subject in craft breweries in the context of Brazil and more precisely in the northeast region. Since this region is proved to have few breweries and most of them are nascent breweries. Thereby, a study of this nature may support microbreweries owners to identify their resources/capabilities towards innovation strategies.

## 2. Literature Review

### 2.1. Resources and capabilities

Wernerfelt (1984), stated that products and resources are two sides of the same coin. The difference is most products demand the use of several resources and most resources can be used in various products. According to Daft (1983), firms resources include all assets, capabilities, organizational processes, attributes, information, and knowledge controlled by a firm that enables it to learn and implement new strategies, improving its efficiency and effectiveness. On the other hand, strategies are how firms relate to their environment (Porter, 2008).

Firms build competitive advantage by adopting unique sets of resources and capabilities to implement sustainable strategies (Wernerfelt, 1984; Barney, 1991). The significance of firm resources is discussed by Barney (1991), who determine four must-have attributes: valuable, rare, imperfectly imitable, non-substitutable. This simple way to understand how RBV works were common sense inside the field of strategic management.

In this way, Sirmon, Hitt and Ireland (2007) complement this condition for firms to achieve competitive advantage. The authors suggest the management and the orchestration of firm's resources, including structuring the resource portfolio (acquiring, accumulating/developing, and divesting resources), bundling resources to create capabilities, and then leveraging those capabilities with the appropriate strategies.

Capabilities arise in part from learning, combining resources and leveraging complementary assets (Teece, 2017). Considering Teece (2017) research, capabilities might be divided into two related categories: ordinary capabilities and dynamic capabilities. “Ordinary capabilities are to a large extent operational (doing things right),

whereas dynamic capabilities are generally strategic in nature (doing the right things)" (Teece, 2017, p. 696). On the other hand, "dynamic capabilities are about doing the right things, at approximately the right time, based on new product (and process) development, unique managerial orchestration processes, a change-oriented organizational culture and a prescient assessment of the business environment and technological opportunities" (Teece, 2017, p. 698). A firm whose possesses strong dynamic capabilities conquers the ability to profitably create and renew resources, allowing them to be innovative according to changes in the market and business environment (Teece, 2017). This research relies on resource and capabilities, which allows firms to challenge competitors by prioritizing innovation strategies, considering the RBV point of view.

According to Barney and Hesterly (2010) RBV points out that heterogeneous resources and capabilities belonging to a single company that are valuable, rare, difficult to imitate and exploited by the company (characteristics of the VRIO framework - Value, Rarity, Inimitability and Organization) are the main responsible for the development of competitive advantages.

## 2.2. Innovation strategies

According to Knight and Cavusgil (2004), innovation results from two major sources: internal Research and Development (R&D) and replication of other competitors' innovations.

On the word of Duarte Alonso, Bressan and Sakellarios (2016) presents the innovation relating it with resources, competitive advantage and sustained competitive advantage. McGrath *et al.* (1996) explain that reliable and successful achievement of business leads to competitive advantages. Several definitions of innovation can be found in the literature, but in this paper, the OECD (2005) definition of innovation will be follow. They divide innovation into four dimensions:

- Product innovation: good or service that is new or significantly improved;
- Process innovation: new or significantly improved production or delivery method;
- Marketing innovation: new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing;
- Organizational innovation: a new organizational method in business practices, workplace organization or external relations.

## 2.3. Innovation, resources and capabilities

Organizational capabilities are the key foundation of the firm's performance advantages (Grant, 1991). Capabilities have two major aspects: (1) the shifting character of the business environment; and (2) strategic management in appropriately adapting, integrating, and re-configuring knowledge-based capabilities toward the changing environment (Knight and Cavusgil, 2004). Thus, innovation leads to capabilities. For example, Knight and Cavusgil (2004) argued that build the firm's strategy focused on innovation, facilitate the acquisition of knowledge, leading to capabilities that drive organizational performance.

Ideally, capabilities are dynamic, reflecting the ability of managers to renew the firm's competencies to achieve congruence with the changing business environment (Teece, Gary and Shuen, 1997). Innovation is deeply related to resources/capabilities, competitive advantage and sustained competitive advantage. Thus, innovation must be treated as one of the main pillars a company should pursue to sustain its competitive advantage and in the context of craft brewing firms are not different. For instance, Alonso *et al*. (2016) found that, continuous innovation in the brewery is significant for its survival. Considering this competitive niche, innovative aspects are essential to maintaining the firm ahead of its rivals. Marketing knowledge, brewing process knowledge, technological improvements, history background, R&D practices, external market knowledge, are substantial resources and capabilities a brewery may dispose to reach continuous innovation (Alonso, Bressan and Sakellarios, 2016, 2017; Mangini *et al.*, 2016; Alonso *et al.*, 2018).

A bulk of resources and capabilities related to innovation strategies were observed in articles regarding the beer and wine market, as can be seen in Tables I and II.

**Table I.** Innovation and Resources/Capabilities from the literature related to the beer industry

| Theory of Innovation applied | Innovation Dimensions | Observed Innovations | Observed Resources & Capabilities | Authors |
|---|---|---|---|---|
| Downs and Mohr (1979) | Benefits: 1. Programmatic; 2. Prestige; 3. Structural Costs: 1. Decision; 2. Implementation Resources: 1. wealth; 2. manpower; 3. expertise and time; 4. equipment; 5. information; 6. staff tolerance for change | New beer recipes; Social media; New working processes; New production techniques; New labels; Continuous innovation of the brewery equipment | Beer Quality; Knowledge of brewing process; Quality of the service; Brand reputation; Expertise in brewing; Consistency of the craft beer products; Branding knowledge; Financial benefits; Technologies; Flexibility in production; Ability to produce at low cost; | (Alonso *et al.*, 2018) |
| | | Social media; New beer recipes; Involvement in beer/culinary tourism activities; New working processes; New machines/equipment; New production techniques; New labels and bottles; | Brewing process knowledge; Quality improvements; Exploration of new ingredients; Creativity; | (Alonso, Bressan and Sakellarios, 2017) |
| - | - | Product innovation; Business strategies focusing on the demographic characteristics; Sustainable practices; | Product quality and uniqueness of product; Natural and sustainable resources; Marketing knowledge; Brewing knowledge; | (Alonso, Bressan and Sakellarios, 2016) |
| Open Innovation | Outside-in process & Inside-out process; Coupled process; | New labels; New recipes; | External R&D; Marketing knowledge; External knowledge; | (Mangini *et al.*, 2016) |

**Table II.** Innovation and Resources/Capabilities from the literature related to the wine industry

| Theory of Innovation applied | Innovation Dimensions | Observed Innovations | Observed Resources & Capabilities | Authors |
|---|---|---|---|---|
| OECD (2005) | Product innovation; Process Innovation; Marketing Innovation; Organizational Innovation | Machinery; Marketing and commercialization; Products uniqueness; Growing, production, management, and business techniques; Training; | Physical, environmental and human factors; Fermentation knowledge; Wine production knowledge; Business and managerial knowledge related to wine sales; Knowledge from external sources and networks; External and internal R&D | (Doloreux, Chamberlin and Ben-Amor, 2013) |
| Open Innovation | Outside-in process & Inside-out process; Coupled process; | New machinery and equipment; New products; Growing techniques; Production techniques; Business, management and marketing strategies; | Physical, environmental and human factors; knowledge from external sources and Network knowledge; R&D; External and internal knowledge; Training; | (Doloreux, Chamberlin and Ben-Amor, 2013) |
| The concept of innovation "territories" | Technological and industrial spread; knowledge, production, transmission and transfer; financial and business services; production and consumption; institutional; human capital; infrastructure; and cities as knowledge-hubs. | Infrastructure; Varieties of grapes, Types of wines; Methods of production; Information; | R&D; Human resources capabilities; Training; Institutional support; | (Aylward and Turpin, 2003) |

## 3. Research Methodology

The research develops exploratory case studies in two craft breweries in a state from northeast of Brazil.

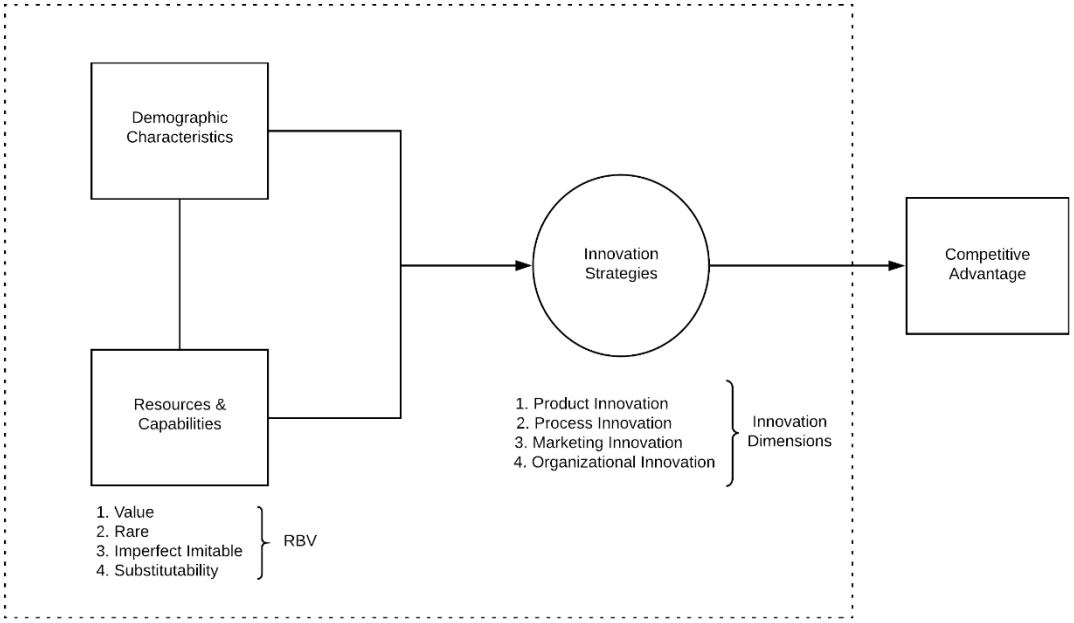
The case study methodology was applied (Yin, 2003) since the objective is to explore a phenomenon which the researchers has no domain on it. The central goal of a research that uses case studies is to shorten the distance between theory and practice, then the research will be worthwhile for practitioners (Choudhari, Adil and Ananthakumar, 2012).

Based on the literature review it was developed a case study protocol, where data collection instruments (semi-structured interviews and direct observations), procedures and general rules for carrying out the case studies were formalized (Yin, 2003).

The semi-structured interview was the main instrument to collect data and it was developed considering the literature review. Twelve resources/capabilities were chosen based on the articles reviewed by the authors of this paper. Regarding the innovation strategies, it was adopted the typology presented by OECD (2005).

Thus, the semi-structured interview was structured into four sections as demonstrated in Figure 1. The first one gathered information about demographic characteristics of the two microbreweries. The second section collected data about innovation strategies adopted by the microbreweries. The third section, demonstrate the key perceived resources and capabilities. The fourth section grouped data of how the resources and capabilities previously defined have the VRIO characteristics, and if they support somehow the microbreweries innovation strategies.

**Figure 1**. Research framework.




The third and fourth section responses were supported by a Likert-type scale, with the scale ranging from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree), in order to rank all the resources/capabilities observed. Moreover, blank spaces were also provided at the end of all sections to collect interviewee's comments. It was also adopted direct observations during the interviews. A regional microbrewery research was carried out, in order to help the researchers to identify the local microbreweries. To be considered as a viable microbrewery, these companies should be legally registered at the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA). The researchers conducted, recorded and transcribed the interviews with each owner. The Table III summarizes the two case studies.

**Table III.** Summary information of the firms

| Characteristics | Microbrewery A | Microbrewery B |
|---|---|---|
| Plant history | Outsource its production | Own its own plant |
| Employees | 1 | 3 |
| Products | 3 | 2 |
| Main materials used in the manufacturing process | Water, barley malt, yeast, hops | Water, barley malt, wheat malt, yeast, hops |
| Production | 1000L/month | 1400L/month |
| Exportation | No | No |

Data analysis involved two steps as suggesting Yin (2003) for case studies: within case and cross case. Thus, first, within case, the authors transcribed the interviews and categorized it considering the innovation strategies and resources and capabilities presented in the literature review. After we crossed the information to develop some inferences based on the interpretation of the information and the literature consulted.

It was assumed the content analysis during the data analysis. This method recognizes the importance of language, it is replicable and applicable, it is analytically flexible and, when properly conducted, it is a methodology that can be checked for its accuracy, reliability, and validity (Duriau, Reger and Pfarrer, 2007)

Finally, the case study method is a distinct form of empirical investigation, and many researchers challenge its application once the methodology is exposed to a certain degree of subjectivity (Yin, 2003). Thus, some tests were adopted to establish the quality of the information. Table IV presents these evaluation criteria and the tactics applied at each stage of the research.

**Table IV.** Evaluation criteria and tactics applied

| Evaluation Criteria | Research Applied tatics | Research Steps |
|---|---|---|
| External validity | • The development of propositions was based on an extensive analysis of the existing literature;<br>• Multiple case study with embedded analysis units;<br>• Criteria for selection of cases; | Research Planning Process |
| Reliability | • To ensure reliability, a case study protocol was developed. The protocol contains procedures for data collection, interviewees' description and case study questions;<br>• Data were collected from semi-structured interviews;<br>• During the interviews, tape recorders were used to capture the interviewees' speech;<br>• Codification of interviews;<br>• The research uses excerpts from the interviews to analyze the results; | Data collected |
| Validity of the construct | • Triangulation of data; | Data collection and data analysis |
| Internal validity | • Approximately 130 minutes of all interview content were transcribed and 20 pages were analyzed;<br>• Theoretical framework with relationship between factors and sub factors. | Data analysis |

## 4. Results

4.1. Case analyses

4.1.1. Within case analyses: Innovation Strategies

**Microbrewery A**

To improve the product innovation, Microbrewery A highlighted the importance of beer quality and variety of beer styles. The interviewee stated that "every beer has its standard recipe, but the owner's touch increases the beer uniqueness". Usually microbreweries are located inside residency neighborhoods, then facilitating the relationship with costumers and the constancy of feedback acquisitions support the microbrewery perception and the quick change of their strategy plans. As explained by Tardivo *et al.* (2017) customers could add immense value creation to the firm.

Moving to marketing innovation, this microbrewery observed the importance of having exclusive labels to their products. These labels are responsible for the company identity. Also, labels could get customized when the brewery is participating in events. When questioned about innovation in the beer bottles, the interviewee said that “nobody pays more for a stylized bottle”. Considering the brand exposure, he claimed that only use social media and share banners/ads at the distribution channels. He affirms that “still does not have enough capital to invest in other marketing exposing ways”.

The owner said that never did a market research before open the microbrewery, he based his product recipes on his friend’s opinion. According to the interviewee, a big regional brewery is used for benchmarking practices.

Based on "strategies on touristic resources" question, for Microbrewery A, the use of regional fruits is the main activity to reach strategies basing on touristic resources. He just fabricated a beer using a local fruit in the recipe; however, he is planning to produce a new beer with cashew. The "Sustainable practices" and "bottles returning" were classified by the authors as marketing innovation. However, sustainable practices such as "donate grain waste", "reuse yeast " were pointed out as organizational innovation. Whereas, the microbrewery does not use this practice to improve the company marketing.

Process innovation was not an innovation strategy once this microbrewery outsources its production. The company claims that “the only process innovation practiced by the company is the setup of their own process parameters”.

Regarding “organizational innovation”, a healthy relationship with the stakeholder is the main innovation strategy inside this dimension. The most interesting is that “rivalry among craft breweries” does not exist according to the interviewee. On the contrary, craft breweries have a friendly relationship and they try to help each other against the macro breweries.

Among all four dimensions, product and marketing innovations were classified as the most important ones, receiving grade 5 in the Likert scale. While organizational innovation received 4. No innovation was identified by the authors in the process innovation dimension, since the controlling of the process parameters is a mandatory practice and shall be done by all breweries to achieve the desired beer style.

**Microbrewery B**

Currently, microbrewery B produces two beer styles. According to the interviewee, he is trying to be as traditional as possible, thus bringing the classic German brewing school to the northeast of Brazil. In this way, since the beginning of their operations, the company “work with the traditional” and this idea came by the fact that they could not find “good classical German beer styles” in the local market. Also, the interviewee claimed that “work with different ingredients is too risky for a new company, this is a plan to be thinking later”.

Marketing innovation was led by unique label designs, market research, benchmarking, distribution channels, social media, wastewater and waste grains reuse. To grab the consumer's attention, they praised to develop their brand basing on one of the most important touristic spots in the microbrewery location city. The interviewee states that "the label was designed specifically to attend the citizens of this city/state". This label trend disseminates regional recipes and ethnic products, creating interest in the harmonization of local foods and their craft beers. Concerning “market research", Microbrewery B considers that this practice was done, and they verified the lack of local rivalry. They also claimed benchmarking activities basing on breweries from the south and a big regional brewery. For Microbrewery B, marketing practices are expensive, then, free social media is used. Sustainable practices such as wastewater and waste grain reuse are done by the microbrewery. However, these sustainable practices are not explored as marketing innovation.

Organizational innovation dimension is composed of R&D, innovation management and good relationship with stakeholders. This firm has a close relationship with students from two local universities. Thus, through researching these universities are trying to develop new beer recipes alongside. However, the most important practice for Microbrewery B is to have a

good relationship with stakeholders, as stated by Microbrewery B owner: “no matter which kind of entrepreneur you are; you shall have a good relationship with your stakeholders. On the contrary, you will be doomed to failure”.

Among all four dimensions, process and organizational innovations were classified as the most important ones, receiving grade 5 in the Likert scale. While the process and organizational innovation received score 4. The interviewee B claims “If you have a good process management and enhanced organizational skills, product and marketing innovation are directly affected”.

### 4.1.2 Cross-case analysis: Innovation strategies

A cross-case analysis was investigated and summarized in the Table V. The innovation strategies mentioned by each microbrewery was placed side by side, in order to a better comparison.

**Table V**. Cross-case analysis: Innovation strategies

| | **Microbrewery A** | **Microbrewery B** |
|---|---|---|
| **Product Innovation** | Beer quality and variety of beer styles | Brewing traditional beer styles |
| **Marketing Innovation** | Exclusive labels, social media, ads, benchmarking | Exclusive label designs, market research, benchmarking, distribution channels, social media, wastewater and waste grains reuse |
| **Process Innovation** | Setup of their own process parameters | Setup of their own process parameters |
| **Organizational Innovation** | Healthy relationship with the stakeholder, Sustainable practices | R&D, innovation management and good relationship with stakeholders. |

### 4.2.1 Within case analyses: Resources and capabilities

According to the previous literature, 12 resources and capabilities were mapped and applied in this research: beer quality, service quality, brand reputation, expertise in brewing, history of the brewery, brewery location, investments in equipment, social media, human

resources, business strategies, new ingredients, and financial health. However, more resources and capabilities could be mentioned if the interviewee thought it matters.

**Microbrewery A**

The interviewee states that "the microbrewery location influence directly in the brewery business strategies, such as logistics and supply chain". The only reason he chose to outsource his beer production to this another brewery, was the lack of opportunities to do it in other best-located-breweries.

After identifying resources/capabilities and relate them to innovation strategies it was evaluate considering VRIO framework. At the “value” section, it was observed that only one resource/capabilities allow the microbrewery to neutralize threats: financial benefits. According to the interviewee A, "if you have a financial benefit, you could do whatever you want. Then, you have the power to stop the threats". On the other hand, all the resources/capabilities but "microbrewery location" helps the firm to explore new opportunities.

In the "rare" section, only "beer quality" was the resource/capability classified as an easy one to be controlled by the rivals. Then, doesn’t apply as a rare resource.

Regarding “inimitability", brand reputation, expertise in brewing, microbrewery history, human resources, and business strategies, were stated as intangible resources/capabilities. It was verified that all these intangible resources/capabilities got at least score 3, meaning that a good amount of time is needed to achieve a good level of these resources/capabilities. However, none of them are protected by patents, because they claim that patent is not an interesting matter at the moment.

All resources and capabilities were ranked with score 3 (null) regarding “organization”, meaning that the organizational side of the identified resources/capabilities is undeveloped.

In the end, five resources/capabilities were ranked as the most important: brand reputation, microbrewery’s history, human resources, business strategies, and financial health.

**Microbrewery B**

After identifying the resources and capabilities and its relation with innovation strategies, they evaluated according to the VRIO framework. Beer quality, microbrewery history, human resources, financial benefits, and good social relationship were classified as the most important

resources/capabilities observed. Among them, only beer quality was categorized as a tangible resource/capability.

At the "value" section, participant B said that, the beer quality strongly allows the company to explore new opportunities (ranked 5 in the Likert scale) but the same can't be said about neutralize threats (ranked as null in the Likert scale). Moreover, beer quality was ranked positively when compared to rival's products quality and results to increase profits.

At the "rare" section, beer quality could be controlled by half of the rivals (graded as 3 in the Likert scale). The same was observed with the microbrewery A.

Inside the "inimitability" section, beer quality received at least score 4, meaning that would be necessary a long time to rivals develop this capacity, the product is protected by patent and the lack of this resource could lead the microbrewery B to a cost drawback.

Organizational section, beer quality is just related to formal quality reports. The brew master always reports to the other owners about the product quality control.

The next resource/capability was "microbrewery history". It was ranked as intangible and got positive scores to all other questions. In that case, it's a really hard resource/capability to be copied or developed by the other companies.

Human resources, financial benefits and good social relationship (mentioned as an extra resource and capability) were basically ranked in all questions with at least a score of 4. Meaning that they are resources/capabilities extremely important to the company and extremely hard to be developed by rivals.

Finally, five resources/capabilities were ranked as the most important: beer quality, microbrewery's history, business strategies, social relationship, and financial health.

4.2.2 Cross-case analysis: resources/capabilities

The Table VI demonstrates the five most important Resources and Capabilities determined by each Microbrewery.

**Table VI.** Cross-case analysis: resources/capabilities

| | **Most important Resources & Capabilities** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Microreweries** | Beer quality | Service quality | Brand reputation | Expertise in brewing | Microbrewery history | Microbrewery location | Investments in equipment | Social media | Human resources | Business strategies | New ingredients | Financial health | Social Relationship |
| **A** | | | **X** | | **X** | | | | **X** | **X** | | **X** | |
| **B** | **X** | | | | **X** | | | | | **X** | | **X** | **X** |

The microbrewery B mentioned an extra resource and capabilities as one of the most important: social relationship.

## 5. Discussion

Innovation strategies were perceived by both breweries, and a linkage among resources and capabilities and innovation strategies were also determined by both microbreweries and it's demonstrated in Figure 2.

Regarding resources and capabilities, beer quality was mentioned as an important resource/capability for Microbrewery B. According to Microbrewery B, beer quality affects the firm reputation and can support the microbrewery to take advantage on new opportunities. While Microbrewery A classified "microbrewery reputation" as one of the most important resources/capabilities, and it did not relate "beer quality" with "microbrewery reputation". However, beer quality was also defined by both interviewees as a tangible resource, so it could be easily obtained or copied by other breweries. The Microbrewery B have patent for their beer recipes, while Microbrewery A doesn't have. Alonso *et al.* (2016) found that beer quality was a "strong resource" for the breweries.

Beer history was classified by both breweries as an intangible resource/capability. Meaning that is hard to other breweries copy their historical path. The same was obtained by Alonso *et al.* (2016).

Alonso *et al.* (2016) proposed that brewery location was classified as an important resource/capability to explore new opportunities. Breweries A and B did not recognize the brewery location as one of the most important resource/capability, but it helps the organizational strategies for microbrewery A.

Beer variety is discussed as one of the main innovation strategies, but they are careful about this practice. While Microbrewery A do not proceed with market researches before release a new product, Microbrewery B claims that increase the product variety is a good strategy but not for new companies. Also, both companies state the lack of time and capital to invest in new equipment or process. Microbrewery A outsource its production and do not see that is an important improvement to be done. Whereas, Microbrewery B claims that they are studying the possibility to renew some of their process in the future after conquering a parcel of the market and establish as a renowned firm.

Due to the lack of capital to invest in expensive innovation strategies, both breweries relate the importance of social media to show the brand to the costumers. Moreover, due to the recent breweries' operation, the entrepreneurs aim to recover the initial investments. Investing

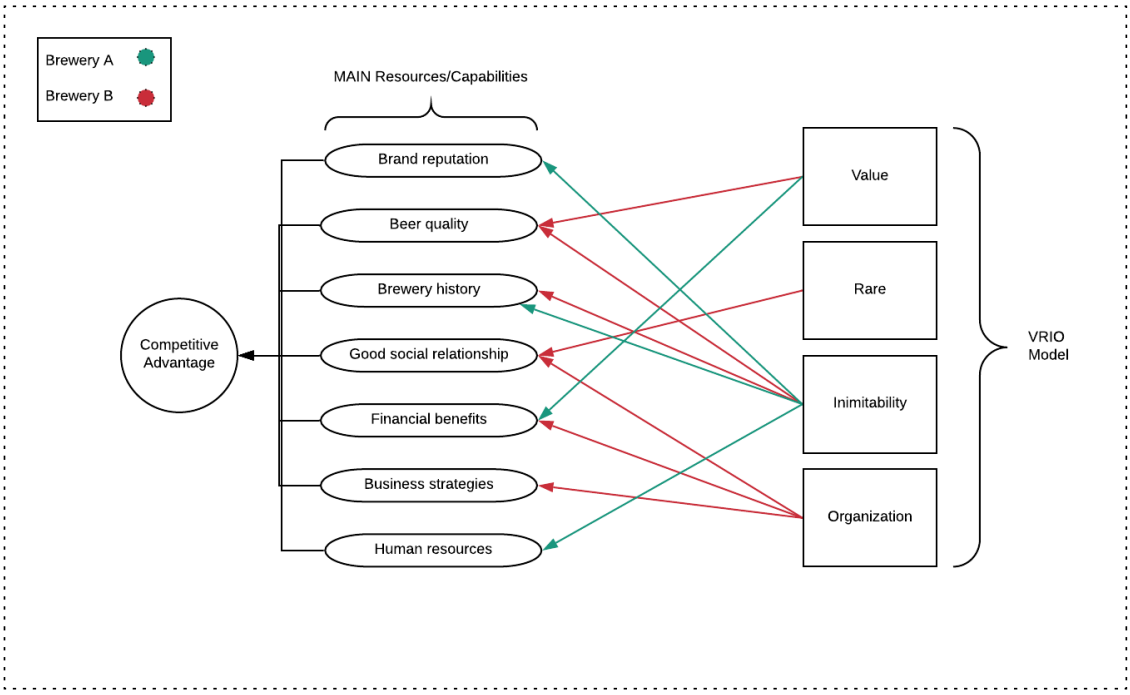
in marketing and doing constant market researches, would be onerous to the breweries and could damage their financial health.

The same information can be seen at Alonso *et al*. (2017) research, where social media was the second marketing innovation tool that participants most agreed with. Kleban and Nickerson (2012), consider that financial resources are adopted as a key factor of company to disseminate its marketing innovations. But, nowadays, social media has an important role and it is capable to "advertise" micro, small, big companies at the same level of intensity. Also, Microbrewery A do not perceive the beer bottle shape or style as an innovative practice. Whereas Microbrewery B, recognize the magnitude of a different beer bottle shape, claiming that costumers pay attention to it and sometimes they just purchase the beer because of it.

Despite the newness of the researched breweries, business strategies were ranked by Breweries A and B as an important and intangible resource/capability. In the other hand, business strategies were not classified as an important resource/capability by the work of Alonso *et al.* (2016), in which most of the breweries are already set in the market.

A good relationship with stakeholders were claimed as a very important resource/capability for Microbrewery B, providing all the necessary tools to run the business pacifically and meet all the business strategies requirements. The same was found by Alonso *et al.* (2016), stating the importance of client-brewery relationship.

**Figure 2.** Main Resources/capabilities according to the VRIO Model



## 6. Conclusion, limitations and opportunities for future research

This study began with two research questions. The first one, "RQ1. Which are the main innovation strategies adopted by the enterprises?" Analyzing the results, the research question was fully answered, providing interest information about the main perceived innovation strategies adopted by each microbrewery. Further, it is notorious that different insights by the two breweries were observed.

The second research question was "Q2. Which are the key resources and capabilities that support the adoption of innovation strategy implementations?" Through the research it was possible to identify the main resources/capabilities applied by the two breweries and determine which one is related with the four innovation dimensions proposed in this research.

This paper contributes to the understanding of the microbreweries' behavior towards innovation strategies. The RBV model aggregate a lot of value and deeper insights about which are the most important resources/capabilities that directly affect the breweries innovation strategies. The lack of studies in this area is one of the reasons that emphasize the importance of this work. It may help entrepreneurs in the beer market to have a more accurate insight about innovation and how they could precisely apply it to their business. Moreover, studies about craft breweries in Brazil is under investigation and the northeast of Brazil is a promising region within the beer market. As demonstrated before the northeast region has a big potential of growing in this business, regarding the strong cultural traditions, unique local food and the valuation of the craft beer market. Thus, this research has a unique contribution to the area, providing important information based on craft breweries owners point of view. Focusing on the new breweries, this paper could assist the entrepreneurs to have a deeper view of the whole process of innovation and how they can achieve it.

According to Duarte Alonso, Bressan and Sakellarios (2016, 2017); Duarte Alonso *et al.* (2018), none researches were taken in the microbrewery environment. For instance, Doloreux and Lord-Tarte (2013) discovered robust involvement in process, product and organizational innovation among Canadian wineries. Therefore, Duarte Alonso, Bressan and Sakellarios (2016, 2017); Duarte Alonso *et al.* (2018) research on the wine industry were of major importance to this paper. However, this paper goes even further because none of the previous works evaluate the resources and capabilities which support the innovation strategies according to VRIO model. Plus, this is one of the few researches performed in Brazil in which analyzes the linkage between innovation strategies and resources/capabilities. The model

presented in Figure 1 also contributes to a better understanding of which are the main resources/capabilities observed in the literature in the microbrewery environment.

The microbrewery market is rising in Brazil and this work englobe an important literature and results that could lead the breweries and new entrepreneurs to achieve competitive advantage and to implement innovation strategies.

This paper main limitations are the limited number of researched microbreweries, and the research method applied (case study, that cannot be generalized). Thus, further can be taken through statistical data by adopting survey method considering the variables presented in the research framework (Figure 1), or testing by survey method the results from the empirical research presented in Figure 2. Moreover, future research may develop longitudinal research in order to investigate which resources and capabilities are responsible for innovations over time. Once more, additional research could also investigate which resources and capabilities are the most important for innovations in this industry by applying multicriteria tools. Last but not least, to explore the resources and capabilities identified in this research may contribute to refine the knowledge acquired by these breweries over time and could be analyzed in other articles. For instance, "good social relationship" was mentioned as an important capability by both microbreweries, mainly microbrewery B. Then, investigate the external market by benchmarking, stakeholders, or consumers, may help the development of this specific capability.

These efforts could better inform practitioners, government representatives, and academics on resources and capabilities and the innovations process to achieve sustainable competitive advantage in the microbrewery industry.

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## PAPER 2: FRAMEWORK FOR PRIORITIZING CRAFT BEER PARAMETERS USING QUALITY FUNCTION DEPLOYMENT (QFD) TO UNDERSTAND THE REAL CONSUMERS REQUIREMENTS

### 1. Introduction

According to the Brazilian Beer Industry Association (CervBrasil, 2017), the beer sector in Brazil represents 1.6% of the national GDP, produces 14.1 billion liters of beer per year, and it has more than 690 breweries around the country. Plus, a large part of these breweries is composed by craft breweries, and the number keeps increasing. On the word of MAPA (2017), it can be said that the craft beer market is still small and under development. However, the craft breweries are responsible for the diversification of this market.

Two key factors have contributed to the development of new products such as craft beer. The first is related to market demand for product innovation; the second factor is changing consumer preferences following a worldwide change (Deagro, 2010).

With the high variation of beer styles, the Brazilian brewing market tends to be segmented, since consumers are more interested in trying different products. Thus, the various types of beer available become more accessible, as manufacturers are encouraged to produce and make available numerous variations of the drink in the market, seeking to meet this new desire of the consumer (Sicobe, 2014).

As stated by Murray and O'Neill (2012), the high competitiveness of the market imposes on producers a diversification of their product and the best ways to obtain this segmentation is the use of craft practices and exploring the consumers' needs, in order to obtain significant data to upgrade the breweries knowledge about the outer market. On the word of Murray and O'Neill (2012), niche markets that invest in deepening knowledge in this field can gain a competitive advantage over their competitors. However, the lack of studies in this area is mentioned by the authors.

Also, consistent with Carvalho *et al.* (2018), the market research is an important tool that assists in the study of the behavior of craft beer consumers. Consumer demographics, expectations about the product under the consumer's vision, satisfaction of the purchase, habits and attitudes towards the product, and reasons that lead them to buy craft beer are information used to quantify or understand the consumer relationship and may be obtained through a questionnaire that addresses all the necessary questionings. According to Gómez-Corona *et al.* (2016), the application of questionnaires provides significant results for decision making, thus

helping industries and entrepreneurs to avoid unnecessary spending and increase investments in strategic points determined by the questionnaire.

To obtain these data, the Quality Function Deployment (QFD) can be used. Along with Souza and Cauchick Miguel (2017), QFD is a method of supporting the planning and development of products or services, providing companies with a structured way to ensure quality and satisfaction from the requirements of your customers.

The QFD is an important quality tool that could be applied in any sector of the market to provide significant information about the consumers through listening their voices. The literature presents some examples of the adoption of QFD (Lee and Lin, 2011; Kuo, Yuo and Lu, 2014; Asadabadi, 2016; Camgöz-Akdağ, İmer and Ergin, 2016; Pillon, Da Silva and De Almeida, 2017; Suef, Suparno and Singgih, 2017). However, very few of them related to the beer market, and even less on the craft beer market (G. Davydenko, 2012).

In the craft beer industry, QFD can be used to direct the product strategic plans of beverage producers to produce a craft beer that has the ideal sensory characteristics for consumers in the brewing market, such as: alcohol content, foam density, aroma from cereals or hops, coloring, flavors, transparency, among others.

According to Carvalho *et al.* (2018), there have been significant changes in the behavior and habits of beer consumers that have begun to demand a better-quality product. These consumers represent a segment that considers the qualities of the ingredients used to prepare the beer and are willing to pay more for craft beer than conventional beers (Murray and O'Neill, 2012; Gómez-Corona *et al.*, 2016).

Craft beers are produced on a small scale through a slow fermentation process compared to the commercial beers (Brewers Association, 2017). The craft beers are marked by the high degree of innovation in their manufacture. By varying the inputs and the addition of adjuncts in the brewing process, numerous styles of beer can be created and improved. Therefore, one of the main factors distinguishing craft beers from traditional beers is the variety of beverage styles that are carefully developed, providing a better flavor and aroma to the drink (Kleban and Nickerson, 2012; Brewers Association, 2017).

With the purpose of understand the behavior and real needs of craft beer consumers, fulfil the gap of researches in the beer market sector, and to serve as an improvement tool for breweries to expand their knowledge about the external market. A market research was carried out through the application of the QFD in order to identify the consumption characteristics and habits of craft beer consumers, as well as their motivations for consumption, generating solid

information for the craft brewers in this sector to enter the market competitively by trying to meet all the needs of their consumers.

## 2. Literature review

### 2.1. The Quality Function Deployment (QFD)

Due to the high competitiveness of the market, technological advancement and constant demand for customer satisfaction, it becomes necessary to use tools that help in obtaining a product that meets the most diverse needs of the customer.

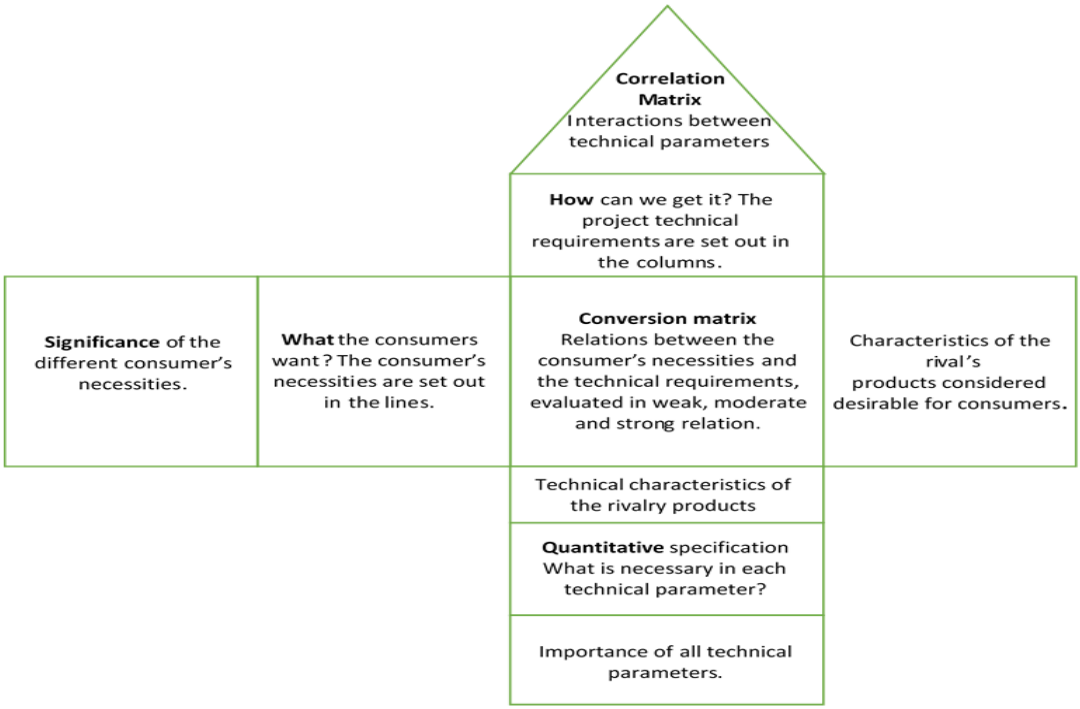
The Quality Function Deployment (QFD) is an important product or service development tool, which is based on the translation of the requirements quoted by consumers. It can be said that QFD aims to achieve greater consumer satisfaction and organizational integration in line with consumer desires, resulting in increased business profitability (Kumar, Antony and Dhakar, 2006; Zare Mehrjerdi, 2011).

One of the most important features of the Quality Function Deployment tool is the problem of constant changes in consumers' wishes (Özdağoğlu and Salum, 2009). Consumers without difficulty change brands when products do not match their requirements (Asadabadi, 2016). Therefore, products need to be constantly renewed to meet the needs of consumers. Improvement objectives need to be identified and prioritized, but this process is challenging (Rika Fatimah, 2014). The QFD is a tool that helps to find the priorities of the objective elements, based on the priority of the consumers' needs. It is applied in the strategic decisions of the companies (Zare Mehrjerdi, 2010). It acts as a structure in the process of translating consumer needs into product requirements (Andronikidis *et al.*, 2009). Meeting the needs of consumers is precisely the key to achieving the highest levels of customer satisfaction (Delice and Güngör, 2009).

According to Baxter (2011), product planning through QFD involves four steps. In the first step, a matrix is formulated that converts the characteristics sought by the consumers into technical attributes to the products. In the second stage, competitive products are evaluated and categorized as to their satisfaction by consumers and their technical attributes. In the subsequent step, the quantitative objectives for each technical attribute of the product are stipulated. In the fourth step, the goals are prioritized, indicating the orientation of the project's efforts. The diagram of quality deployment, also known as "quality house", proposed by (Baxter, 2011

p.228) can be visualized in Figure 1. This work was focused on the quality side of the QFD, leaving aside the "characteristics of the rival's products considered desirable for consumers".

Figure 1 – Diagram of quality deployment




Source: Modified from Pillon, Da Silva and De Almeida, 2017

According to what has already been quoted about the QFD tool, it is simple to understand how its proper use can help to obtain the information needed to design a product that meets the needs of consumers and is highly competitive in the market. Also, several articles that applied the QFD in the food and beverage industry demonstrated the applicability of the quality tool and how it helps in the development of a new product (Dolgun, 2017; Chen and Yeh, 2018; Hidayat *et al.*, 2018; Purba, Maarif and Yuliasih, 2018).

## 3. Materials and methods

A survey was carried out aiming the craft beer consumers. A structured questionnaire was developed to obtain demographic data and information that would convey the real needs of the craft beer consumer. The questionnaire was developed following the Beer Judge Certification Program (BJCP) providing sensorial information about the beer styles (BJCP, 2017).

The questionnaire was applied during the month of April/2018 to 50 people who are directly involved in the field of craft beer, such as consumers, producers, vendors, retailers or

shopkeepers. The questions were elaborated by a brainstorm among the researchers of this paper (specialists in beer production) and evaluating the sensorial characteristics provided by the Beer Judge Certification Program (BJCP) in such a way that at the end of the questionnaire it was possible to obtain numerical information enough to determine a style of craft beer with the ideal characteristics according to the interviewees. To verify the reliability of the questionnaire, the Minitab 17 Software was used to perform a multivariate analysis to obtain the Cronbach's alpha (Cronbach LJ, 1951). The Cronbach's alpha is the average of the correlations between the items that are part of an instrument (Streiner and Streiner, 2010). There is no minimum value defined for Cronbach's alpha coefficient to be accepted as good, but in the literature the value of 0.70 is at least acceptable (George and Mallery, 2000). The Cronbach's alpha obtained in this work was 0.7498.

The research was structured on the internet, by the Survio platform, due to the easy handling. The questions were sequenced in such a way as to avoid a possible lack of necessary information. After three weeks of data collection, the information obtained were statistically treated by the authors of this study and the QFD matrix was assembled based on the results obtained in the questionnaire.

A total of 50 people answered the questionnaire about the needs of the craft beer consumer. The age range of the interviewees, ranged from 21 years to 56 years, with 66% of respondents aged over 30 years. This work was limited to analyzing the needs of consumers (NC) in the state of Paraiba.

The interviewees were classified by level of contact with craft beer. It was defined 4 levels: Consumer, Producer, Producer and Vendor, Reseller/Shopkeeper. More than 50% of the respondents fall into the "Consumer" category. All respondents belonged to the craft beer niche and were familiar with the product. It was also asked about the frequency of consumption of craft beer per week. According to the information collected in the questionnaire, 48% of the respondents consumed one unit of craft beer per week, 8% consumed two units per week, 34% consumed three units per week, and the remainder consumed more than four craft beer units per week. Moreover, all respondents were interested in consuming more units than they already consume.

## 4. Results and discussions

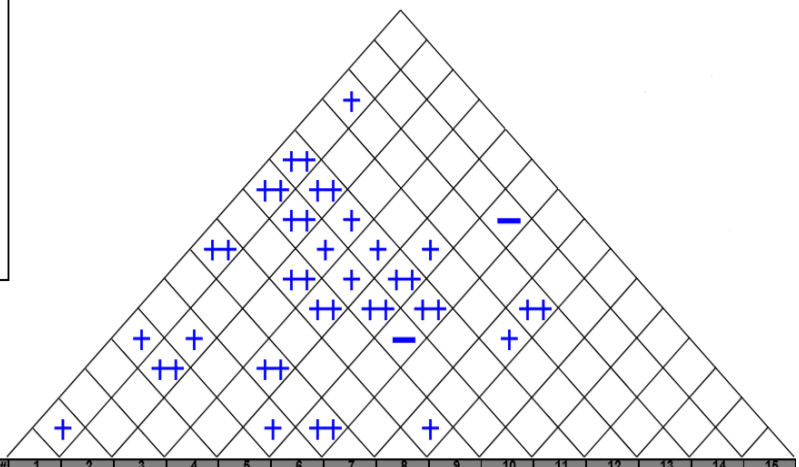
Due to the wide variety of styles of existing craft beers, the most preferred style was identified among the interviewees, and the subsequent analyzes were carried on exclusively under this style of beer. Therefore, according to the data obtained, 88% of the interviewees opted for the Ale family, and the most voted style was Indian Pale Ale (IPA), with 53.3%.

The quality house matrix was entirely based on IPA-type beer because most respondents chose this beer style. Figure 2 represents the QFD matrix found.

All the information discussed through the analysis of the QFD matrix was entirely based on the knowledge of the researchers of this paper and the main literature about beer processes (Palmer, 2006; White and Zainasheff, 2010; Venturini, 2016).

Figure 2 – House of Quality

| Legend | | |
|---|---|---|
| Θ | Strong Relationship | 9 |
| O | Moderate Relationship | 3 |
| ▲ | Weak Relationship | 1 |
| ++ | Strong Positive Correlation | |
| + | Positive Correlation | |
| − | Negative Correlation | |
| ▼ | Strong Negative Correlation | |
| ▼ | Objective Is To Minimize | |
| ▲ | Objective Is To Maximize | |
| X | Objective Is To Hit Target | |



| Row # | Max Relationship Value in Row | Relative Weight | Weight / Importance | Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows") | Yeast | Malt | Bitterness hops | Aromatic hops | Sugar concentration control | Protein concentration control | Acidity control | Alpha-acids concentration control | Concentração de alfa-ácidos | Process time | Optimum temperature conditions | Addition of organic components: fruits | Control of beer wort aeration | Filtration control | Addition of fining agent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | | | | Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x) | x | x | ▲ | ▲ | x | ▲ | x | ▲ | ▲ | x | x | ▲ | ▲ | ▼ | ▼ |
| 1 | 9 | 9.9 | 4.3 | High Bitter Taste (high IBU) | | | Θ | O | | | | | Θ | ▲ | ▲ | | | | |
| 2 | 9 | 7.1 | 3.1 | Darker color | | Θ | ▲ | ▲ | | | Θ | | | ▲ | ▲ | O | | | |
| 3 | 9 | 7.7 | 3.3 | Thicker beer head | Θ | ▲ | | | | Θ | | Θ | O | | | | | | |
| 4 | 9 | 9.0 | 3.9 | High beer head density | | | | | | Θ | O | Θ | O | | | | | | |
| 5 | 9 | 8.0 | 3.5 | High alcohol content | Θ | Θ | | | Θ | | | | | | O | ▲ | O | | |
| 6 | 9 | 7.3 | 3.2 | Fruity aroma | Θ | | | | | | | | | | Θ | Θ | | | |
| 7 | 9 | 9.3 | 4.0 | Citric aroma | O | | O | Θ | | | | | | | | O | | | |
| 8 | 3 | 5.6 | 2.4 | Floral aroma | ▲ | | | O | | | | | | | | O | | | |
| 9 | 9 | 6.7 | 2.9 | Malted aroma | | Θ | | | | | | | | | | | | | |
| 10 | 9 | 9.3 | 4.0 | Strong flavor | | O | Θ | | | | O | | | O | O | ▲ | | O | |
| 11 | 9 | 6.0 | 2.6 | Flavor/Aroma of organic ingredients (fruits) | | | | | | | | | | | | Θ | | | |
| 12 | 9 | 9.1 | 4.0 | Strong sharpness | | Θ | | | | ▲ | | | | O | O | ▲ | | ▲ | |
| 13 | 9 | 4.9 | 2.1 | More transparent beers | | | | | | | | | | | | | | Θ | Θ |
| | | | | Full-bodied beer<br>Target or Limit Value | | | | | | | | | | | | | | | |
| | | | | Difficulty (0=Easy to Accomplish, 10=Extremely Difficult) | | | | | | | | | | | | | | | |
| | | | | Max Relationship Value in Column | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 9 | 9 | 3 | 9 | 9 |
| | | | | Weight / Importance | 240.8 | 314.3 | 208.1 | 137.7 | 72.4 | 158.9 | 118.9 | 149.7 | 138.9 | 72.5 | 162.3 | 212.6 | 24.1 | 81.2 | 44.1 |
| | | | | Relative Weight | 11.3 | 14.7 | 9.7 | 6.4 | 3.4 | 7.4 | 5.6 | 7.0 | 6.5 | 3.4 | 7.6 | 9.9 | 1.1 | 3.8 | 2.1 |

Source: Authors of this work

## 4.1. Relation of dependence of the customer's needs (CN) with the technical requirements (TR)

The CN "high bitter taste (high IBU)" received weight of importance of degree 4.3. It has a strong relation with the TRs "bitterness hops" and "iso-alpha-acids concentration", since bittern hops have a high concentration of alpha acids in their composition. Thus, the bitterness hops become the main input that gives the bitterness to the beer. The TR "aromatic hops" also interfere with the bitterness of beer, but not with the same intensity due to its low iso-alpha acids content. Plus, aromatic hops are usually added in the end of the boiling process, or during the maturation process. Both additions contribute only to the aroma and not the bitterness.

The TRs "optimum temperature conditions" and "process time" received a low degree of interaction. However, they still interfere with the bitterness of beer, since both will determine the degree of extraction of hop bitterness compounds.

It is worth mentioning that there are several types of hops, and each one of them gives the beer a specific sensorial power, therefore, it is up to the producer to choose the best blend of these compounds to obtain a beer that meets the needs of its customers. The percentage of beer bitterness is measured by the IBU definition of the beverage. The bigger the IBU, the greater the bitterness of beer.

The CN "darker color", a weight of 3.1 was obtained. Therefore, it is interpreted that a beer colored between light and dark would be the most convenient. The color of the beer is directly linked to the type of grain used, the addition adjuncts, process time, optimal temperature conditions, and the pH control of the water. In addition to being slightly altered by the compounds present in hops. The last three with more relevance in the mashing out stage. To achieve this coloration between light and dark, it is important to use more than 2 types of malt, and to know the percentage of EBC/SRM that each malt confers to beer. There are two scales that are used to measure the color of beers: EBC, European, and SRM, American. A coloration that would be between light and dark for an American IPA would be somewhere around 6-14 SRM's (BJCP, 2015).

The pH of the wort and the temperature directly influence the performance of the enzymes. The various enzymes present in the process only work effectively with the proper control of temperature and pH. For example, the alpha-amylase enzyme works under optimum conditions only if the system is at temperatures between 70-75°C and pH between 5.6-5.8.

The "thicker beer head" received moderate weight, equal to 3.3. The TRs "yeast", "protein concentration control" and "carbon dioxide ($CO_2$) concentration control" have strong interaction with this CN, since $CO_2$ is the main responsible for the formation of the foam layer, the proteins prevent the molecules to disperse and the yeast is the agent that produces the $CO_2$ in the process. Worth noting that, carbonation is also possible through the usage of a $CO_2$ cilinder.

The CN "high beer head density" received a weight of 3.9. The TRs "protein concentration control", " $CO_2$ concentration control" and "acidity control" have a strong interaction with this CN and the TR "concentration of alpha acids" has moderate interaction with the CN “high beer head density”. This is because hops proteins and alpha acids adhere to $CO_2$ bubbles, increasing their molecular weight and preventing $CO_2$ from dispersing, thereby increasing the foam's density. And the acidity of the wort directly influences the performance of the enzymes that will break down the protein molecules. Therefore, it is of utmost importance to work under optimum pH conditions, thus controlling the acidity of the wort.

The CN "high alcohol content" received weight of 3.5. The TRs "yeast", "malt" and "sugar concentration control" have a high degree of interaction with this NC. Depending on the malt type used and its quantity, as the main source of fermentable sugars, the process yeasts will have higher source of substrate to turn into ethanol. The TRs "optimal temperature conditions" and "wort aeration" received a moderate degree of interaction. Since yeasts work under specific conditions of temperature and their efficiency also increases when one has a substrate with high content of O2. The TR "addition of organic components" slightly influences the final concentration of alcohol in the beverage, depending on the level of fermentable sugars from these organic components.

The CN "fruity aroma" received weight of 3.2. This CN can be achieved by TRs "yeast" and "optimum temperature conditions". Throughout the process, yeasts produce a bouquet of esters that will measure fruity aromas in the beverage. The high temperature favors the formation of esters in the fermentation. The type of organic ingredient inserted in the process may also infer fruity aromas to the beverage, thus also received high degree of interaction.

The CN "citric aroma" (weight = 4) is mostly achieved by the addition of aromatic hops and can also be achieved with the addition of organic compounds such as orange peels or citrus fruits. Therefore, aromatic hops were considered as the main TR that meets this specificity. The other TRs that had a relationship with this CN, received a moderate interaction ratio.

The CN "floral aroma" (weight = 2.4) can also be obtained by the type of aromatic hops used, by the addition of organic compounds that refer to this specific characteristic, and finally by the type of yeast used.

The CN "malted aroma" is exclusively achieved by the type of malt used in the process. In this way, the TR "malt" was the only one related to this CN receiving high degree of interaction.

According to the questionnaire data, most of the interviewees opted for an IPA beer that has a high citric content, and moderate levels of fruity and malted aromas. In order to achieve this equilibrium of aromas, a calibrated addition of malts and/or organic compounds, the use of a yeast of high fermentation which produces a good number of esters that grant fruit flavors, and the use of hops that refer to this citric character meet the specifications of the interviewees.

The CN "strong flavor" was very relevant for the interviewees, receiving a weight equal to 4. Due to the style of beer chosen by most of the interviewees, the TR that has the highest degree of interaction is " bitterness hops", since this type of hops introduces a striking and exclusive taste to the IPA beer style.

The TR "malt" also influences the taste of the beer, since each type of malt confers exclusive malted flavors to the drink.

The TRs "process time" and "optimum temperature conditions" have moderate interaction with the CN "strong flavor". These TRs control the contact time at which hops, and malts will be in the process. It is worth noting that both inputs are influenced by temperature and time at different stages of the process.

The TR "addition of organic ingredients" can influence the taste of the beer, since depending on its composition, new flavors and aromas can be increased to the beverage.

The TR "filtration" also influences the taste of the beverage. A sharp filtration can remove flavors from the beverage, so an unfiltered or lightly filtered beer should be selected to meet the consumer’s needs.

The TR "acidity control" also has moderate relation with the CN "strong flavor”. Since the water used to wash the grains must have pH below 6.0. Since pH's above 6.0 can cause unwanted extraction of bagasse tannins, which can result in an astringent taste.

The CN "flavors/aromas of organic ingredients (fruits)", the respondents defined as a mid-level need, giving 2.6 for this question. To meet this CN, the TR that most influences this character is the amount of fruit matter used. The addition of fruit matter is a delicate stage of the process and requires a high degree of subtlety, because depending on the target audience,

the concentration of these compounds can vary drastically. It is of great importance, the brewer to be aware of which fruit matter should be used, thus achieving the ideal flavor balance that satisfies its customers.

To meet the CN "full-bodied beer", which received weight 4, the beer must have a high density. The density of the beer is determined mainly by the concentration of total sugars present in the brewing wort. Therefore, the TR that obtained the highest importance, was: "malt". The TR "filtration" received poor level of interaction because to produce a sharp beer it is interesting that the filtration is not forced.

The "process time" and "optimum temperature conditions" TRs also received moderate degree of interaction because they determine the optimum conditions for the yeast to work efficiently, producing all the final compounds that infer in the density of the beverage.

The last CN analyzed was the "more transparent beer". Majority of the interviewees determined that a less transparent IPA beer would be the best choice. Therefore, the TR "filtration" and the TR "addition of clarifiers" have high interaction with this CN.

## 4.2. Relation of dependence between technical requirements (TR)

According to the House of Quality (HOQ) structured by the authors of this paper, there is a strong correlation between the TR "yeast" and the TRs " $CO_2$ concentration control", "process time" and "optimum temperature conditions". The three TRs are interlinked, so that for a high fermenting yeast to work under optimum conditions and produce significant $CO_2$ levels, it needs specific temperature ranges and specific fermentation/maturing times. Therefore, it is very important that the craft brewer be familiar with the processed yeast, respecting the temperature ranges that the microorganism works adequately, and have the knowledge about the microorganism growth kinetics.

In addition, it is observed that it has a good correlation with the TRs "malt", "concentration of sugars" and "aeration of the wort". Depending on the type of malt used and its quantity, the yeast will have more food to be consumed, thus producing a bouquet of essential components to the fermented beverage. Moreover, aeration of the proper wort will provide energy for the yeast to work properly.

The TR "malt" has a strong correlation with the TRs "sugar concentration", "process time", and "optimum temperature conditions". Considering that the main source of carbohydrates present in the process derives from the malt used, and for better extraction of

these sugars it is necessary to respect the time of the processes of mashing out and boiling, always controlling the temperatures of each stage. It is noteworthy that in order to produce a beer with suitable concentrations of fermentable sugars it is necessary to use temperature ramps for specific times, thus the malt enzymes will work efficiently and break the carbohydrate molecules in an orderly manner. The TR "malt" also has good correlation with the TR "protein concentration control" since these also derive from the malt used and its concentration can be increased or reduced depending on the boil time of the process. As the TR "concentration of sugars" is directly related to the TR "malts", the same levels of interaction are applied to the same TRs. The only difference will be the moderate interaction with the TR "addition of organic components". Since depending on the added organic ingredient, there may be a change in the concentration of sugars in the brew.

The TR "bitterness hops" directly influences the TR "concentration of alpha acids", which are the compounds that confer bitterness to beer. Thus, acquiring a strong correlation and it is considered the technical requirement of greater weight in relation to the level of bitterness sought by the interviewees. The greater the hops being added, the more intense the bitterness of beer. This addition can be done in three ways: addition of bitterness hops during the boiling step, addition of hops during the mashing out or addition of hops during fermentation/maturation (the addition of hops in this stage, doesn’t add notable changes in the bitterness of the beer). It is worth noting that the craft beer producer must find the ideal bitterness balance to satisfy its consumers.

The TRs "process time” and "Optimum Temperature Conditions" have a good relationship with the TR "bitterness hops", because when the hops are added in the beginning of the boiling stage, a great amount of the alpha-acids are converted into iso-alpha-acids (the particles that provide bitterness to the beer).

The TR "aromatic hops" also have a good relation with the same TRs that interact with the technical requirement "bitterness hops". However, these hops have a concentration of alpha-acids well below the other type of hops but a higher concentration of aroma molecules. Therefore, the aromatic hops should be added in the final minutes of the boiling stage, thus avoiding the complete evaporation of the aroma molecules.

The TR "protein concentration control" have negative correlation with the TRs "process time" and "filtration", since the longer the boiling stage, the lower the protein concentration. The same logic applies to filtration, the higher the filtration intensity, the greater the removal of protein compounds.

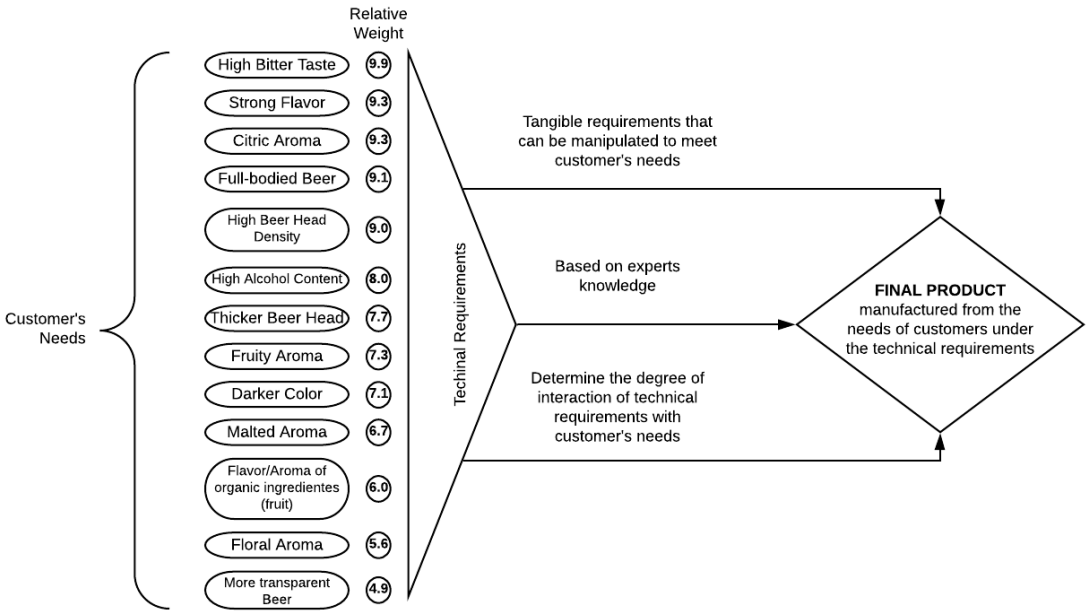
In order to obtain a full-bodied beer and a good-density foam, it is necessary to have a good concentration of small to medium chain-proteins in the brewing wort. To achieve these needs, it is necessary that the malt is not crushed vehemently and is not badly milled. Care must be taken in the grinding step, so the malt will be milled under the proper conditions, and adequate filtration will be achieved. Also, a proper whirlpool should be done to decant the heavy protein molecules.

The TR "acidity control" has a high correlation with TRs "protein concentration" and "sugar concentration". pH control directly influences the performance of the enzymes that will break down the carbohydrate molecules and proteins present in the system.

The TR "concentration of CO2" in the brewer's wort is directly related to the aeration of the must (in manual brewing processes), since the yeast needs that energy source to produce the CO2, and consequently to increase the carbonation of the brew. This TR also received good correlations with "protein concentration" and "alpha-acid concentration", as these compounds help to retain the CO2 molecules in the beer collar. It also has a good correlation with "addition of organic compounds", since these technical requirements provide the sugar molecules that will be consumed by the yeast, producing alcohol and CO2.

Finally, after collecting all the data available and understand the connection between the Consumer’s needs and the Technical requirements. It was possible to scheme the Framework of how to construct the QFD matrix in order to obtain a final product that could meet the consumer satisfaction. It can be seen in Figure 3, the level of significance of every consumer need observed in the matrix. According to the priority of the consumer’s needs, the brewer can take the right decisions to develop the final product.

Figure 3 – Framework of how to handle the QFD tool to develop the final product




Source: Authors of this work

Making a comparison between the obtained framework (Figure 3) and the beer style chosen (IPA) by the interviewees. It is reliable to state that costumers tend to appreciate a more bitter IPA, with a concentrated dosage of citric hops, and a blend of special malts to obtain the full-bodied and the desired density. Fruity aroma, is also a relevant feature that could be explored by adding fruits to the beer, by choosing a yeast that produces a high amount of fruited esters, or by picking the right hops that have fruity and citric characteristics. Thus, to make the right decisions by prioritizing the most significant customer's needs could directly have an affect on the ideal final product, and it was also observed in other authors papers (Chen and Yeh, 2018; Hidayat *et al.*, 2018; Purba, Maarif and Yuliasih, 2018).

## 5. Conclusions, limitations and future researches

The main objective of this paper was to identified and rank the most important costumer's needs in an Indian Pale Ale beer style. So, the assembled framework (Figure 3) reaches the utmost goal of this research. The use of the Quality Function Deployment tool, made possible to obtain a set of significant information for the characterization of a craft beer that meets the needs of its consumers. It could support the brewers to identify the main consumers' need and if operated properly, may aid the brewers to create effective production strategies directly aimed to their market niche. Moreover, the correct application of the QFD tool along with the assembled framework could support product innovation strategies through the adoption of new adjuncts that could provide the essential sensorial characteristics demanded by the craft beer consumers.

The main limitations of this paper are related with the amount of researched people, the isolated research location, and the restrictions of QFD. The questionnaire applied in this paper reached out 50 craft beer consumers located in one state of northeast of Brazil, thus hindering generalized application of the collected data. Implying the QFD matrix, the information interpreted through QFD matrix is mostly subjective and can lead to ambiguity and uncertainty in the human decision-making. Therefore, it is of the utmost importance the specialists discuss along step by step all the set of data provided in the QFD. Thus, decreasing the possibility of ambiguous information and unbalanced importance score for each one of the consumers' needs (CN) and technical requirements (TR).

For future researches it would be interesting to replicate the QFD matrix in other regions around the world in order to understand the local consumers behavior towards their craft beer consume necessities. To materialize the data collected through the survey and treated by the QFD matrix, it would be extremely important to produce a craft beer according to what was observed and test the product in the market. In this way, it will be possible to endorse what was previously found and reassure the functionality of the QFD matrix.

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## PAPER 3: ANALYSIS OF THE ANTIOXIDANT ACTIVITY OF A BEER ADDED WITH SERIGUELA (*Spondias purpurea*)

### 4.1.Introduction

The consumption of foods with a high antioxidant content helps to prevent oxidative processes directly involved with the pathology of many human diseases, such as stroke. atherosclerosis; diabetes; arthritis; and cancer (Cook and Samman, 1996; Babbar *et al.*, 2011). The study of functional foods and their influences on human health is of utmost importance. According to Lionetti *et al.* (2019), the study of new functional foods rich in polyphenols and the monitoring of the functional diet in patients with heart disease may provide relevant information to cardiovascular studies. Sastre-serra *et al.* (2019), reports the anti-cancer properties of antioxidants present in hops and the importance of studying these components in action against other types of cancer. Other studies report the importance of studying functional foods rich in antioxidants and the seriousness in the nutritional monitoring of human beings: R. tomentosa (Vo and Ngo, 2019), curcumin (Tsuda, 2018), olives (Cobrançosa *et al.*, 2007), strawberries (Rolstad, 2005).

Polyphenols are one of the most abundant antioxidant compounds in food (Ayala-zavala *et al.*, 2011). In addition to preventing disease, a diet rich in polyphenols can lead to better results in cognitive tests and decrease the risk of depression (Akbaraly *et al.*, 2009). Some polyphenols have anti-inflammatory potential, with applications in the treatment of diseases such as hypertension; allergy; hypercholesterolemia; heart disease and lung problems (Ames, Shigenaga and Hagen, 1993; Roy and Kulkarni, 1996; Stahl and Sies, 1997; Bravo, 2009; Devi *et al.*, 2014).

The seriguela (*Spondias pupurea*), for example, is a typical fruit from the northeast region of Brazil, its fruiting takes place during the months of December to March. It has a pleasant taste, slightly citrus and a high concentration of antioxidants. Being considered one of the fruits of the northeastern Brazilian territory with a higher content of antioxidant compounds (Dutra *et al.*, 2017). The seriguela is a fruit still little explored in the academic world when involved in the manufacture of new foods. Only one study was found involving the use of seriguela in food, in this case, the use of butter in the production of biscuits (Albuquerque and Duarte, 2016).

Thus, this work aims to formulate and produce a craft beer with the addition of seriguela in the beer maturation stage, to analyze the antioxidant activity of the fermented beverage. The maturation stage was chosen, due to the function of enhancing the flavor and aroma of the beer. In this way, the physicochemical characteristics of the seriguela tend to be better preserved. The results are compared with the data available in the literature on adding fruit to beers and other functional drinks. Finally, analyze the acceptability of the drink in the local beer market, through the application of a sensory analysis.

## 4.2.Materials and methods

2.1. The produced beer

The wort was prepared using the GrainFather's machinery, located in the UFPB's Fermented-Distilled Products (LPFD) laboratory, and immediately after boiling it was divided into 3 equal non-toxic plastic tanks, with 20 liters each. When the maturation stage started, different concentrations of seriguela were added in each tank, in order to provide a comparison analysis between the beers. In tank 1 (T1), seriguela was not added, in tank 2 (T2), 10% (mass/volume) of seriguela was added, and in tank 3 (T3), 15% (mass/volume) of seriguela was added. The beer style chosen was an Indian Pale Ale (IPA). The percentage of addition of seriguela was chosen by the authors of the work based on article 40 of decree No. 6,871, of 4 June 2009, which says: “Beer may be added with juice or plant extract, or both, which may be replaced, totally or partially, by essential oil, natural essence or vegetable distillate of its origin ”. After the end of the process, aliquots (50ml) were collected for the analysis of antioxidants.

2.2. Fruit handling

The fruit (*Spondias purpurea*) used in the beer process was purchased at the local market in the city of João Pessoa - Paraíba - Brazil during the months of January and February 2019. The fruit was properly washed, sanitized with vinegar and water (30ml of vinegar / 1 liter of water) for 30 minutes. The seeds were removed manually and the pulp was frozen (-5 ° C) in transparent plastic bags until being used in the beer production process.

## 2.3. Antioxidant activity

The ability of the samples to reduce the iron ion (FRAP) was evaluated using the methodology described by Benzie and Strain, (1999). The beer reducing capacity was calculated by referring to the ferrous sulfate calibration curve and reported equivalent to mM $Fe_2SO_4$ equivalent/L beer.

The ability of scavenging the DPPH (2,2-diphenyl-2-picrilhidrazil) radical was determined according to the methodology described by Brand-Williams *et al.,* (1995) . The readings were taken at 515 nm and the result was expressed in IC50, which corresponds to the concentration of the sample necessary to reduce the initial concentration of the radical DPPH by 50%.

For the elimination of free radicals (ABTS), the reducing capacity was measured with reference to the trolox calibration curve and expressed in mM trolox/L of beer. Following the methodology of (Re *et al.*, 1999).

## 2.4. Sensory analysis

The sensory analysis of Acceptance and Purchase Attitude was carried out at the Laboratory of Sensory Analysis of Food (LASA) of the UFPB Technology Center, and for the determination of the main sensory attributes, 90 untrained judges of both genders, and aged between 18 and 59 years were recruited through a printed questionnaire. The selection criterion was based on the frequent consumption of craft beers, not presenting intolerance, allergy or restriction to any of the ingredients of the formulation and having availability and interest in carrying out the test.

## 2.5. Statistical analysis

All experimental analyzes were performed in triplicates. The experimental data presented are means ± standard error. The probability of $p < 0.05$ was considered statistically significant.

For the sensory analysis, the statistical analyzes of the acceptance tests were performed in Microsoft Office Excel, using ANOVA.

## 3. Results

### 3.1. Beer characterization

An American Indian Pale Ale beer with the addition of seriguela (*Spondias purpurea*) at the maturation stage was produced and analyzed in this study. This style is characterized by having a high quantity of hops and consequently a stronger bitterness and a stronger aroma (above 2g of hops/L of beer). As previously mentioned, the brewing wort was divided into three tanks, where each tank had different seriguela additions, namely: tank 1 (T1) without added fruit pulp, tank 2 (T2) with 10% of fruit pulp; and, tank 3 (T3) with 15% of fruit pulp. Thus, it is possible to analyze the reducing activity between them, and most importantly, the influence of the fruit pulp on the supply of antioxidants to beer.

### 3.2. Antioxidant activity of beer

Since the antioxidant capacity of a food is obtained by measuring a mixture of different antioxidants with different mechanisms and molecular interactions, it is necessary to perform more than one method to have a significant notion of the food's reducing capacity (Frankel and Meyer, 2000; Saura-calixto and Pérez-Jiménes, 2006). Therefore, antioxidant activities were measured with three methods (FRAP, ABTS and DPPH), which show an increase in the reducing activity of beer, according to the increase in the concentration of fruit in beer (Table 2).

The tested beer style (IPA), already has a high content of antioxidants due to the high concentration of hops. The addition of a fruit with a high concentration of antioxidants can further enhance these product characteristics. Proving the reductive potential of seriguela (*Spondias purpurea*), we cite the work of (Almeida *et al.*, 2011; Gregoris *et al.*, 2013; Dutra *et al.*, 2017).

In FRAP and ABTS, there is a gradual increase in the concentration of Fe2SO4 and Trolox. In the analysis of the DPPH radical, a decrease in the IC50 can be observed, which indicates that a smaller amount of the sample is needed to reduce the initial concentration of the DPPH radical by 50%. Thus, the inhibition potential of the sample T3 (65.7%), is greater than T2 (52.4%) and T1 (46.0%). The gradual increase of the antioxidant activity can be seen in the Table 1.

Table 1 – Antioxidant activity of beers produced per analysis.

| Beer Code | FRAP Fe2SO4 Eq. mM | ABTS Trolox Eq. mM | DPPH (% of reduction) |
|---|---|---|---|
| T1 | 15.73 ± 0.21 | 0.86 ± 0.02 | 46.35% |
| T2 | 17.30 ± 0.34 | 1.08 ± 0.02 | 52.48% |
| T3 | 25.04 ± 0.94 | 1.31 ± 0.00 | 66.06% |

FRAP, Ferric-Reducing Antioxidant Power; ABTS, 2,2- azino-bis (3-ethylbezothiazoline) -6-sulfonic acid; DPPH, radical 2,2-diphenyl-1picrylhydrazyl
Values are mean ± standard deviation (n=3).

### 3.3. Sensory analysis

In the acceptance test, the appearance, color, aroma, bitterness, flavor, global acceptance and consumption attitude of the beers produced were analyzed (Table 2). The acceptance index (AI) was calculated considering as 100% the highest score achieved in the global acceptance of the analyzed samples. The acceptance rate of 70% or more was adopted as a criterion for satisfactory classification (Teixeira, Meinert and Barbetta, 1987). Therefore, the AI for each beer was: T1 = 79.6%, T2 = 74.7%, T3 = 74.3%. Thus, meeting the authors expectations.

Table 2 – Acceptance test

| Attributes | Samples | | | P-value |
|---|---|---|---|---|
| | T1 | T2 | T3 | |
| Appearance* | 7.7a | 6.8b | 6.5b | 0.00000036 |
| Color* | 7.5a | 6.8b | 6.5b | 0.00000165 |
| Aroma* | 7.6a | 7.3a | 7.2a | 0.10835220 |
| Bitterness* | 6.8a | 6.7a | 6.6a | 0.74575712 |
| Flavor* | 7.1a | 6.7a | 6.7a | 0.23664470 |
| Global acceptance* | 7.2a | 6.8ab | 6.7b | 0.04373776 |
| Consumer attitude** | 4.0a | 3.8a | 3.7a | 0.07417741 |

In the lines, equal letters do not differ statistically. Anova and Tukey's test ($p < 0.05$).
"a" is the sample with the biggest mean; "b" is the sample with lesser mean than "a"
* Hedonic scale of 9 points
**Hedonic scale of 5 points

## 4. Discussion

The percentage of addition of other components to the formulation of a craft beer is usually defined by the producer based on market information, considering consumers and competition. The antioxidant activity of beer depends on the quantity and quality of the products added in the process, on parameters such as: temperature, pH, chemical composition of the beer, on the unit processes adopted by the producer, and finally, the addition of seriguela. The study of Nardini and Garaguso, (2020), proves that beers with added fruit have a higher concentration of antioxidants when compared to commercial beers. It is clear that the higher the percentage of fruit added to beer, the greater the reducing capacity of the drink. But there is a limit to this addition, as the original characteristics of the chosen beer style must be maintained, such as body, texture, aroma, flavor and bitterness. In this way, it is possible to have a strong and convincing indication of the fruit's functionality and its contribution.

In addition to contributing to the drink's functional character, a high antioxidant content can also help with beer stability and color (Callemien *et al.*, 2005; Granato *et al.*, 2011) acting like a natural preservative. Beers rich in antioxidants have a high quality, more stable flavors and aromas, better foam stability and increase shelf life.

The beer produced in this article has significant indications of its antioxidant activity, especially when compared to previous studies (Table 3).

Table 3 – Antioxidant activity. Comparison between the author's beer and other research.

| Researches | Beer Code | FRAP Fe2SO4 Eq. mM | ABTS Trolox Eq. mM | DPPH (% of reduction) |
|---|---|---|---|---|
| Author | T1 | 15.73 ± 0.21 | 0.86 ± 0.02 | 46.35% |
| | T2 | 17.30 ± 0.34 | 1.08 ± 0.02 | 52.48% |
| | T3 | 25.04 ± 0.94 | 1.31 ± 0.00 | 66.06% |
| A | Lagers (mean) | | | 18.74% |
| | Ales (mean) | | | 29.32% |
| B | Acerola | | 3.68 | |
| | Camu-camu | | 3.37 | |
| | Acai* | | 1.46 | |
| | Acai** | | 2.60 | |
| | Cashew apple | | 1.09 | |
| | Yellow mombin | | 0.73 | |
| C (Fruit Beers) | CHERRY1 | 9.76 ± 0.11 | 3.53 ± 0.06 | |
| | CHERRY2 | 8.55 ± 0.04 | 3.41 ± 0.10 | |
| | ORANGE | 5.65 ± 0.04 | 2.67 ± 0.09 | |
| | GRAPE | 6.85 ± 0.18 | 2.81 ± 0.01 | |
| | PLUM | 5.66 ± 0.02 | 1.93 ± 0.02 | |
| | RASPBERRY 2 | 4.87 ± 0.11 | 1.98 ± 0.01 | |
| | PEACH | 4.56 ± 0.06 | 1.86 ± 0.03 | |
| | RASPBERRY 1 | 5.71 ± 0.09 | 2.35 ± 0.04 | |
| | APRICOT | 4.2 ± 0.05 | 1.66 ± 0.04 | |
| | APPLE | 3.08 ± 0.07 | 1.62 ± 0.02 | |
| C (Conventional Beers) | ALE 1 | 3.73 ± 0.17 | 1.69 ± 0.03 | |
| | ALE 2 | 3.38 ± 0.04 | 1.55 ± 0.02 | |
| | ALE 3 | 4.39 ± 0.18 | 2.03 ± 0.04 | |
| | LAMB | 3.31 ± 0.03 | 1.29 ± 0.02 | |
| | LAGE | 2.8 ± 0.04 | 1.55 ± 0.06 | |

A = Research about characterization of Brazilian lager and brown ale beers based on color, phenolic compounds, and antioxidant activity (Granato et al., 2010)
B = Research about antioxidant capacity in tropical fruit juices (Carolina et al., 2015)
C = Research about the antioxidant capacities differences between fruit beers and conventional beers (Nardini, 2020)

The work carried out by Granato *et al.*, (2011), referenced by the letter A, investigated the reducing capacity of Brazilian lager and ale beers. 18 beers of the lager type and 11 beers of the ale type. The average reducing capacity found by researcher A (18.74% for lagers and 29.32% for ales) is well below the reducing capacity of the DPPH radical found

in the beers produced in this research. Including the standard sample. Thus, strengthening the seriguela's reducing capacity.

Carolina *et al.*, (2015), referenced by the letter B, studied the antioxidant capacity of tropical fruit juices through the analysis of the sequestration of the radical ABTS. Acerola and camu-camu obtained the best results in terms of antioxidant capacity in relation to the other juices analyzed in the research. Also, it obtained better results when compared with the analyzes of this work. The author concludes that the increase in the antioxidant capacity of the juice increases according to the increase in the concentration of the fruit. A similar result is pointed out in this work.

Nardini and Garaguso, (2020), referenced by the letter C, compared the antioxidant activity between commercial beers and beers with added fruit. It turns out that all beers with added fruit have greater antioxidant capacity than commercial beers. With a greater discrepancy in the analysis via FRAP. While by ABTS analysis, two commercial beers have greater antioxidant capacity than four beers with added fruit. Although beers with fruits are considered by the author to have a great antioxidant capacity, the three beers produced in this work obtained results almost three times greater than the beer with fruit with greater antioxidant potential in work C. And results five times greater than that best commercial beer at work C. All these data considering the analysis of the reduction of the ferric radical (FRAP).

Finally, the data obtained in the sensory analysis were satisfactory and presented global acceptance higher than the minimum required (70%). It is noted in Table 3 that only the attributes of appearance, color, and global acceptance obtained a p-value <0.05, indicating that at least one sample differs from the others. The other attributes obtained a p-value> 0.05, showing that the three beers had no significant differences between them.

## 5. Conclusion

According to the data presented, the addition of the seriguela fruit pulp in the beer maturation process enhances the drink's reducing capacity. The three tests to measure the reducing capacity of beer, showed significant increases in the concentration of antioxidants as a higher percentage of the fruit pulp is added. It is worth noting that the pulp of the fruit was added during the maturation stage. Therefore, further studies with the addition of the fruit pulp at other stages of production (boiling or fermentation) would be necessary to compare what would be the best stage to add the seriguela pulp, in order to provide a reducing activity different from the result found. However, it is necessary to note that the stages of the beer production process have specific control parameters, such as temperature. This parameter, for example, can reduce the concentration of several bioactive substances and directly impact antioxidant activity.

With the focus on reusing the residues from the activities of the food industries that process fruits, the breweries could benefit from these residues in the production of fruity beers and explore other potentialities of this fermented drink in addition to the reducing power evaluated in this work.

In addition to being a highly functional drink, the sensory analysis also showed the potential of the product's acceptability in the beer market. Plus, the parameters evaluated with lower scores could be improved with new formulations and new sensorial analysis evaluations. In this manner, it is possible to produce a functional craft beer with an even higher market acceptance.

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