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Implementing a sustainable culture in wine production

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ABSTRACT: *This research looks at the wine production chain at Family Silva Juice Factory, highlighting the evolution of production practices and the environmental impact of viticulture. The study aimed to analyze the wine production chain and propose sustainable solutions to optimize processes and minimize environmental impacts. Wine production has several environmental impacts, such as the excessive use of water and energy, as well as the use of chemical products that can contaminate soil and water. The adoption of sustainable practices, such as the use of renewable energies and the reduction of chemicals, is crucial for the sustainability of the wine industry. The research is descriptive in nature and uses a qualitative approach, based on primary and secondary data. Data was collected through a technical visit to the winery. The production processes were modeled using the EKD (Enterprise Knowledge Development) methodology, which involves creating diagrams to visually represent the different elements of the process. It was observed that the production chain still lacks sustainable practices, with the main focus being on costs and finances. However, opportunities were identified to differentiate production and make it more sustainable, requiring the collaboration of local residents, market strategies and factory employees. The research suggests that innovation and sustainability are key to the future of wine production, and replacing wine bottles with cans could be a viable alternative to reduce costs and environmental impacts. In addition, studying and analyzing the wine production chain is crucial to strengthening the sector, modernizing production and attracting investors, promoting a more sustainable and competitive future for winemaking in the Angatuba region.*

KEYWORDS *- EKD methodology, wine production chain, innovation, sustainable practices.*

I. INTRODUCTION

Widely used culturally around the world, wine is an alcoholic drink made from the fruit of the vine *(Vitis sp.)*, commonly known as grapes. Around the world, there are around two hundred species that have adapted to viticulture, the name given to the field of study of grape production. These plants are cultivated on practically every continent in the world and were domesticated by humans approximately between 3300 and 1200 BC between the territories that today correspond to Armenia and Persia. As for wine, it is thought that it was produced by mistake, with forgotten containers containing grape juice, which consequently fermented and gave rise to the drink made in today's viniculture (the name viniculture is given to the process of making wine) (PEREIRA et al., 2022; SOUZA, 1996).

With strong cultural roots cultivated in the ancient societies of Greece and Rome, wine began to be marketed and, consequently, cultivated on the Iberian Peninsula, finally being produced in Portugal, where, in 1532, Martim Afonso de Souza set course for Brazil to introduce the first vines to the national territory, which had its first wine produced in mid-1551, on the Piratininga plateau, located in the northwest of the state of São Paulo (PEREIRA et al., 2022). Currently, Brazil has a reasonably important impact on the wine market. In 2021,

the country produced 1,697,000 tons of grapes (2.4% of world production), 19.9% more than in2020; it produced 360,000,000 liters of wine (1.4% of world production), 59.5% more than the previous year, and had a consumption of 410,000,000 liters (1.7% of world consumption), being the 13th largest consumer in the world, denoting the importance of viticulture in Brazil (OIV, 2023).

The state of São Paulo is the country's largest consumer, accounting for 32.1% of national consumption, with each person consuming an average of 2.85 liters of wine per year (BURGOS, 2022). Angatuba, in the south-west of São Paulo, is home to the Famíly Silva Juice Factory, founded in 2013 and created by Nelson José da Silva. The founder started wine production and initially produced whole grape juices, later expanding into wine production.

This study aims to analyze the wine production chain at the Famíly Silva Juice Factory, compare it with other production chains and present sustainable alternatives for production at the factory studied. In this way, studying and analyzing the wine production chain becomes a fundamental tool to help strengthen it, as well as presenting possible sustainable aspects for its production, making it more modern and aiming for an ecological future and, finally, bringing greater visibility to the sector, as well as possible investors for the chain studied.

II. THEORETICAL FRAMEWORK

First of all, it's important to say that in recent years Brazilian viticulture has benefited from important advances in the sector, including the adoption of new cultivars, the use of more sustainable practices and processes, as well as the diversification of production, the implementation of Geographical Indications (*on-site* production feasibility analysis) and expansion into new regions. However, this production has distinct and peculiar regional characteristics in terms of production cycles, harvest time and type of product. On the other hand, the activity is an important source of income for small properties in some regions, while in others it has contributed to sustainability through investments made by companies that generate jobs and income, thus becoming an important asset for the local economy in which the production is located (MELLO, 2019).

As the wine market has become increasingly competitive due to the diversity of products on the market and the diversification of consumer tastes, the quality of the product has become a key factor in differentiating the market and establishing customers. The quality of the wine depends on the characteristics of the grapes used as raw materials, which is directly related to the territory in which it is grown.

It is important to note that the quality of the grapes is inversely proportional to the volume produced, since vineyards with higher yields often do not allow the intensity of the color of the grapes, as well as the amount of sugar needed for a good wine, to develop, and pruning is of fundamental importance. As a result, the cost of making a quality wine is higher, which necessarily implies a higher selling price, thus dictating market prices (SOARES, 2008).

An essential factor in making a good wine is the use of production technology, especially in the processing and storage of the product. A number of wineries have been using sophisticated equipment to increase the quality and competitiveness of their products, such as bottling machines, which provide greater agility and precision in packaging the product, and stainless steel tanks. The use of these tanks, instead of wooden barrels, is an alternative and a possibility for artificially controlling the fermentation temperature, which makes production less dependent on climatic conditions (SOARES, 2008). In addition, there is growing concern about the reuse of waste in production. Grape pomace is the largest raw material residue, accounting for 5 to 10% of the grape. With the use of technology, this pomace, which is made up of the skin and seeds, has a very productive purpose in industry. The seeds and skins can be used to extract oils, fibers and phenolic compounds (Christ; Burrit, 2013; Brenes et al., 2016).

The wine production chain, according to Rizzon and Dall'agnol (2007), has 11 stages:

1. Receipt of the grapes at the cantinas (the place where the wine is produced): There are also is characterized by the entry point of the grape, at which the general aspects of the fruit are determined;

2. Separation of the rachis (pedicel, commonly known as the handle) from the grapes and crushing: This is an important stage because the separation of the rachis influences the quality of the wine, as this component of

the grape can give the wine bitterness and dilution if incorporated into the blend. This is also the stage at which the must (fresh grape juice) comes into contact with the yeasts responsible for fermentation (which is undesirable, as there is a stage exclusively for this) and the crushed grapes are sent to the winemaking container. This process is currently done entirely by machines;

3. Addition of potassium metabisulphite: The addition of this compound brings several results to the wine. Firstly, it releases 50% of its weight in the form of sulphur dioxide, bringing various beneficial actions to the must, such as antiseptic and disinfectant; antioxidant (prevents the loss of freshness caused by oxygen); solubilizer; anti-oxidase (blocks the action of rotting enzymes) and coagulant;

4. Correction of must sugar: Method used to ensure that the wine reaches the required alcoholic strength;

5. Alcoholic fermentation: This is responsible for fermenting sugar into ethyl alcohol by means of *Saccharomyces cerevisiae* yeasts, *which are* present on the skin of the grape.

6. Maceration: This is the stage at which red wine is given its characteristic color by mixing the must with the skins in the winemaking container (or not, if the wine is white);

7. Decubation and pressing: Decubation is the separation of the must from the rest of the solid part (not mixed during the maceration process) and pressing consists of crushing the remaining solid part in order to remove any liquid that has become lodged in the skins;

8. End of alcoholic fermentation (slow fermentation): In this stage, the yeasts ferment the last few grams of sugar, while, in an open container, the carbon dioxide generated during fermentation is gradually released. The stage ends when there is a maximum sugar content of 3.0 g/L in the wine;

9. Malolactic fermentation: The process of transforming malic acid into lactic acid, reducing the acidity of the wine;

10. Clarification and stabilization: The wine sedimentation stage, in which the remains of solid residues suspended in the liquid remain at the bottom of the storage area. To solve this problem, the wine can be stored in oak barrels so that the sedimentation process can take place and the wine can be sent to the last stage;

11. Bottling: The final product of the process is bottled, in which the 750ml bottle is the most common, and then closed with a natural cork stopper or threaded with metal/plastic caps. The wine can also be aged after the process, making it more complex in smell and taste (RIZZON, DALL'AGNOL, 2007).

When it comes to sustainability in production, there are a few essential factors that need to be taken into account for the manufacture of a given product to be considered sustainable. These factors are social development, economic interest and environmental protection, and they need to be in balance and harmony, without one factor harming the other. Considering the wine production in question, the same factors will be considered for this crop. Since it is rooted in specific localities and has commercial importance, it is necessary to pay attention to the specificities and environmental needs of each region of the country (EMBRAPA, 2019).

Considering an ideal environment, with sustainable practices in wine production, there are some essential standards to be practiced. According to Flores (2015), a survey of wineries concluded that it is necessary to monitor the quality of the water used in the chain, in addition to integrating a rainwater harvesting system. And Conama (1997, apud Flores, 2018) points out that Brazilian legislation makes it compulsory to treat effluents, such as spraying with a low volume of syrup.

Also according to Flores (2015), it is necessary to take measures aimed at energy efficiency, such as natural lighting and ventilation, and for thermal insulation it is recommended to use water mirrors with vegetated walls. Another very important condition is planned agricultural practices. When setting up a vineyard, it is necessary to carry out soil studies to improve insolation and optimize moisture drainage. As for the agrochemicals used, according to BRASIL (2000, apud Flores, 2018), it is essential to take responsibility for the waste generated, correctly disposing of the agrochemical packaging and storing it in a suitable place, following the laws in force in the sector.

Overall, the importance of making wine production more sustainable by minimizing its negative impacts on the environment in which it is produced is highlighted, taking into account geographical and population aspects. Although there is still much to be done, the sustainable practices adopted by many wineries around the world indicate that wine production can be carried out in a more responsible and environmentally conscious way,

highlighting the importance of public policies that encourage sustainability in wine production and the need for cooperation between producers, government and consumers to achieve more sustainable and responsible practices (ROCHA E NODARI, 2020).

One of the great benefits of producing wine lies in the area of health, since the drink has many benefits for human quality of life when consumed in moderation, due to the presence of antioxidants in wine (MORAES, 2010). In terms of benefits, the antioxidant present in wine (resveratrol) has been scientifically proven to help with cardiovascular diseases, lower cholesterol levels and also has an anticarcinogenic effect by retaining cell multiplication, inhibiting malignant breast cells and prostate cancer cells, for example, from multiplying and spreading (MORAES, 2010).

Another advantage of producing wine in the country is that Brazil has a very diversified viticulture, since the beverage and its derivatives can be produced in all regions of the country, from the far south to the regions close to the Equator (MACEDO, 2022). And because of this vast area of possible wine production, Embrapa estimates that Brazil has the capacity to supply a significant portion of future growth in demand (PEREIRA, 2008). Then, through an estimation of an Almost Ideal Demand System, it was found that the demand for wine is less elastic than for other alcoholic beverages such as beer, for example, which is an advantage for its producers as they don't have to worry about a possible increase in the price of their products (ALMEIDA.et.al, 2015).

One of the main impacts of wine production is the excessive use of water. Irrigating vineyards can lead to water shortages in regions with low water availability, and can alsoo affect the quality and productivity of production. In addition, wine production also requires large amounts of energy, especially during the fermentation process, which can be responsible for a large part of the greenhouse gas emissions associated with production (ROCHA E NODARI, 2020).

Another negative impact is the use of chemical products, such as pesticides and fertilizers, which can contaminate the soil and water and affect the health of workers and the local population. In addition, wine production can affect local biodiversity, especially when it takes place in sensitive natural areas (ROCHA E NODARI, 2020). Despite these negative impacts, many wineries are adopting sustainable production practices, such as using renewable energies, reducing the use of chemicals and preserving natural areas. It is clear that it is important for the wine industry as a whole to get involved in sustainability initiatives and that consumers are increasingly interested in consuming sustainable products. Therefore, companies that adopt sustainable practices can benefit from this interest, creating a positive image for their products and supporting sustainability initiatives (ROCHA E NODARI, 2020).

III. MATERIAL AND METHODS

The work in question is descriptive in nature, its purpose is to clearly and succinctly represent and analyze the wine production chain and to present, test and ultimately study sustainable solutions for the study, i.e. for wine production (FAO, 2021). It was based on a qualitative approach because, after describing the problem, it generated results from the research through analysis and perceptions.

However, the research itself was developed and based on primary data, acquired mainly through information from a face-to-face study carried out at the Family Silva Juice Factory. In addition, it was also based on bibliographic research, i.e. the investigation of theoretical material on the subject, resulting in the study of knowledge stored in electronic documents, from secondary data. Numerous technical visits and interviews were carried out, and documentary analysis was employed using the content analysis technique.

The data was analyzed in a comparative and systematic way, and the drawings of the production chain were made using Microsoft PowerPoint, describing the chain in a logical way, modeling the processes in order to make them easier to understand, thus enabling technical improvements through EKD, which stands for "Enterprise Knowledge Development", a tool and methodology that seeks to develop and manage the organizational knowledge of a given company, in this case.

IV. RESULTS AND DISCUSSIONS

The research data and results were obtained from a technical visit made by the project's authors on 03/03/2023 to the Family Silva Juice Factory. Considered to be the only one in the region, its history began in 1996 with the purchase of a property in Angatuba, Brazil. Originally from Osasco-SP, with no familiarity withwine production, the owner is from the Information Technology sector and very close to his family. He used to receive numerous visits from colleagues and family members. Once they got together and decided to try something new, they took on the challenge of producing wine that was much appreciated by family and friends. So they bought 800 kilograms of grapes on the Carnival holiday in 2008 and managed to produce 200 liters of wine from the family's own production and put to the test with their friends and family, since they were always visiting. The wine and juice served was approved by all and encouraged to be made for sale. Since then, techniques and tools have been perfected, and in the year.

The factory was inaugurated in 2013. Currently, the Family Silva Juice Factory has a modern infrastructure and state-of-the-art machinery, with three permanent employees and sporadic hiring during the harvest season, all of whom are hired from the region, meeting all the necessary demands and boosting the local market, characterizing a family business.

They run four-day courses to train winegrowers, bringing education to the region as a social project. The plant's main objective is to develop the region and be a hub for regional tourism, bringing a significant economic impact to the area the farm's own grape production accounts for 5% of the raw material, with 95% coming from imports from different places, such as Rio Grande do Sul and São Miguel. Harvesting is currently done by hand, and mechanization is too expensive for the time being, and wine production is mechanized.

The grapes are selected during the year with the producers, based on specific requests. The grapes imported from Rio Grande do Sul are harvested at night for technical reasons, while the grapes imported from the São Miguel region are carefully selected so that fermentation doesn't take place at the wrong time. Production uses a traditional fermentation process, which is carried out over a period of 6 months and then analyzed in the laboratory.

The current production offers B2B (Business-to-Business) services in bars and restaurants and B2C (Business-to-Consumer) in some markets. The company is highly competitive and there is little entry into this market. It started out only selling juices and later expanded into wine production, using different types of grapes such as Bordeaux and Niagara Reseda. On one occasion, a biological pesticide was used in production, resulting in a loss of quality in the grapes, according to Figure 1.

Figure 1: Factory entrance and final product filling

The critical processes highlighted by the owner are based on the selection of raw materials and preventive maintenance. The industry has the goal of delivering a quality product, while the company has the goal of producing products for them and for brands. The farm has interesting social projects for the development of the region, including some projects that should be implemented in the future, such as: Harvest and Pay, Pizzeria, Café Colonial and incentives for viticulture in the region. Nowadays, the company's main challenge is to reduce costs, which is a challenge faced by the entire sector: numerous taxes, duties and high freight charges make production costs high. The stock is only of inputs and the final product (manual management), while financial management is carried out manually by the owner using Excel spreadsheets and financial projections are made annually.

EKD and parameters

Modeling processes with the EKD involves creating diagrams that visually represent the different elements of the process, including inputs, outputs, activities and decisions. To model the processes of a wine production chain, it is necessary to identify all the processes involved in the wine production chain, from grape production to wine bottling. This stage involves interviews with those responsible for the different stages of the process, analysis and direct observation of the activities. Once the processes have been identified, this information is documented using EKD techniques such as interviews, questionnaires and workshops.

The information collected is used to create diagrams that visually represent the different elements of the process. Process modeling is carried out using EKD techniques such as mind maps, flowcharts and activity diagrams. These diagrams help to understand how the activities are carried out, what the inputs and outputs are and how the different activities relate to each other. Once the diagrams have been created, they are analyzed to identify strengths and weaknesses in the process and identify opportunities for improvement.

This analysis can help identify bottlenecks, waste and opportunities to optimize the process, and from this, improvements are proposed to optimize the process and reduce environmental impacts. These improvements can include changes to procedures, the implementation of more efficient technologies and the adoption of sustainable practices. In summary, the EKD methodology is a systematic approach to modeling and optimizing the processes of a wine production chain, with the aim of improving efficiency and reducing environmental impacts.

The wine production chain at Family Silva Juice Factory involves several stages, from growing the grapes to selling the bottled drink. Below is a step-by-step guide:

1. Preparing the soil and planting the Maple and Niagara pink grapes.
2. Caring for the vine: during the vine's development, it is necessary to carry out activities such as pruning, irrigation, pest and disease control, and harvesting.
3. Harvesting: the grapes can be harvested manually or mechanically. The grapes are analyzed at harvest using a sensory test and a refractometer to check the Brix level. In addition to the weekly sensory analysis, an analysis of acidity, sugar levels and bitterness is carried out in a third-party laboratory. It is important that the grapes are at the right point of ripeness to guarantee the quality of the wine.
4. Crushing: the grapes, both from the estate's harvest and from imports, are taken to the winery and crushed by machine, extracting the must, which is the juice of the grape, and discarding the stone and skin.
5. Fermentation: the must is placed in polypropylene fermentation tanks and the sugar is transformed into alcohol. During this process, the temperature, oxygen concentration and other variables are controlled to guarantee the desired taste and aroma.
6. Storage: the wine is placed in stainless steel tanks for storage and sensory tests and laboratory analyses are carried out.
7. Bottling: the wine is bottled using a bottling machine and the bottles are reusable and sterilized by a partner of the factory.
8. Corking: The bottles pass through a semi-automatic machine and the cork stopper is placed in the bottles.

9. Finishing: the paper label is placed on the wine bottle by hand and a plastic seal is also placed around the mouth of the bottle using a heat sealer.

10. Storage: the wines are stored horizontally in plastic boxes for transportation.

11. Distribution and sale: the wine is distributed and sold in restaurants, bars (B2B) and free market (B2C).

It's worth noting that each stage of the wine production chain involves specific and detailed processes that can vary according to the region and the winery responsible for production. From the processes presented, it can be seen that the model presented by Rizzon and Dall'agnol in 2007 has similarities to the Silva Family's production method, but the authors cited do not take into account the viticulture part of the winemaking process. The producer studied plants part of the grapes used, takes care of the vines and harvests them, as well as labeling, storing and distributing/selling the product. These aspects were not covered in the theoretical framework of the 2007 authors, and may vary according to the producer. It is therefore possible to see a level of standardization in wine production, both in theory and in practice.

Sustainability

At the Family Silva Juice Factory, the product is stored on the property in bottles that are kept in a horizontal position, so they last for a maximum of two years. The factory has sustainability proposals based on the use of bottles that have been reused, which come from an outsourced company. However, there is a problem with the lack of bottles, which makes it necessary to import the material. Despite this need, they offer the possibility of collecting the bottles used by customers.

A possible sustainability proposal for the previous paragraph would be to set up a commercial loyalty agreement between partners and customers (most of whom are restaurants and bars). One possibility would be to promote loyalty clubs, collecting bottles and providing discounts according to the number of bottles collected. This would guarantee greater reuse of the bottles or even proper disposal of broken bottles, as well as solving the problem of a shortage of bottles on the domestic market.

In addition, the bags and packaging used to sell the products are biodegradable; however, there is no waste management and there is no separation of seeds, as they are dumped into the septic tank used at the factory, which is negative for the factory because, in order to comply with Brazilian legislation, effluent treatment must be carried out, as pointed out by Conama (1997, apud Flores, 2018), which suggests spraying with a low volume of syrup.

So, in order to comply with the legislation, the owner plans to implement machinery to process one of the grape's most valuable by-products, its seed oil, reducing the amount of grape pomace and giving it a more appropriate destination. As mentioned, grape pomace is the biggest waste product of the raw material, representing 5 to 10% of the grape. With the use of technology, it is possible to extract oils, fibers and phenolic compounds from the skin and seeds of grape pomace (Christ; Burrit, 2013; Brenes et al., 2016).

Next, the repairs and monitoring of the equipment are divided into two stages: the first is through a CPI cleaning system, which is carried out before and after the use of the equipment, while the second stage involves periodic repairs by the employees themselves. Although there is no water reuse policy, the water from the property comes from its own supply (artesian well) and there is no irrigation system. In this sense, based on research carried out in wineries, according to Flores (2015), the importance of monitoring water quality and runoff was understood. Therefore, a possible improvement that could be applied at the Family Silva Juice Factory, considering its lack of a water reuse policy, is the integration of a rainwater harvesting system, increasing the reuse of water and reducing the consumption of water outsourced by SABESP, making the water used in production more sustainable.

In addition, the energy used on site is supplied by the utility company. Some companies have contacted us about offering solar energy, but the cost of installation, maintenance and tariffs has proved too high for possible investment. Nowadays, innovation and sustainability are intertwined. That said, as the wine from Family Silva Juice Factory has no tradition in the market, market research could be carried out to analyze the replacement of wine bottles with cans. This is fundamental for sustainability and saving on production

costs, and is an ideal alternative for reducing production costs and bringing in a new and larger audience. In addition, cans are recyclable, which can help reduce the environmental impact of wine without losing its properties. Furthermore, as cans protect the wine from light and air, they can help preserve the taste and quality of the wine for longer, and are more durable than glass bottles. In short, because it has many restaurants as customers, canned wine could be very well accepted and widespread.

In summary, given the characteristics of the region studied and the opportunities of the local residents, bearing in mind the productive growth of companies in the sector, and also following the environmentally acceptable practices mentioned above, it is pertinent to state that there is a possibility of achieving greater sustainability in local wine production, reaching better standards and with a more positive impact on the production chain in terms of sustainability.

V. CONCLUSION

The aim of this research was to critically analyze the wine production chain in the region of Angatuba (São Paulo), focusing on a factory in the sector, Family Silva Juice Factory. It was therefore possible to achieve the objective through a technical visit to the farm, which was essential for gathering primary data for the research, as well as conducting bibliographical research to acquire secondary data for the research material. With these primary factors, it was possible to obtain satisfactory and essential results to better understand the dynamics of wine production in the municipality, as well as proposing improvements to production.

The results show that there are technical differences between the production chain used in the region and the production chain in the theoretical framework, thus providing the necessary and essential analytical material for capturing data and metrics on the chain. Among them, it was possible to observe that the region's production chain does not yet have many sustainable practices for wine production, since the factory's focus is on costs and finances. Because it is a smaller market, sustainable production practices do not yet follow the minimum required, since the infrastructure is not ideal and resources and capital are limited, putting sustainability on the back burner. However, even with the facts presented and the analysis of this chain, points can be explored to differentiate production and make it increasingly sustainable, requiring the collaboration of local residents, market strategies and factory employees.

The Brazilian wine sector has been undergoing an important transformation, driven mainly by the evolution of consumer taste and the high competitiveness generated by the diversity of products on the market. Based on this, one of the recommendations for improvement is to add value to the brand through innovative ideas. This is a challenge that is part of the day-to-day running of companies and should be made a priority, especially for companies with a smaller market, such as Family Silva Juice Factory. Among these is the possibility shown by the authors of increasing production of aluminum cans instead of wine bottles, implementing an innovative, versatile and more sustainable idea. In addition, implementing more sustainable and low-cost ideas are tangible and accessible, such as structuring a loyalty club for restaurants and guaranteeing the return of reusable bottles, as well as inserting rain gutters to store and reuse rainwater for the process.

As future studies, we suggest further research into the chain in the region, implementing and deepening the sector, bringing even more visibility to the region and finally, improving the technique of reusing grape pomace, more specifically the stone for the extraction of the by-product (grape oil), showing ways to improve technique and reuse. Therefore, it was possible to demonstrate the importance and complexity of an increasingly expanding chain, both in terms of production, technique, technology and sustainability, thus consolidating a regional trade heated by the attractiveness of tourism and boosting the local economy of the municipality of Angatuba.

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