



# Artisanal beer production and evaluation adding rice flakes and soursop pulp (*Annona muricata* L.)

Mariana de Melo ALVES<sup>1\*</sup> , Marciane da Silva ROSA<sup>1</sup>, Pedro Paulo Alves dos SANTOS<sup>1</sup>, Marcelo Fossa da PAZ<sup>2</sup>, Priscila Neder MORATO<sup>1</sup>, Mariana Manfroi FUZINATTO<sup>1</sup>

## Abstract

The possibility of varying beer formulations is acquired by variations in beverage production and the usage of different ingredients such as wheat, rice, corn, rye, cassava, honey, fruits, and others. Consequently, this work aimed to develop artisanal beers adding rice flakes and soursop pulp as adjuncts. Four artisanal beer formulations were elaborated, evaluating the following parameters: °Brix, pH, density, alcohol content, total acidity, real extract, primitive extract, color and sensory acceptability. Results revealed that the samples were in accordance with the standards established by legislation. In the sensory analysis through the acceptance test, both pure malt beer and adjunct formulations exposed good acceptance in relation to the analyzed attributes. Regarding the beer formulations development, the results were satisfactory, ensuring quality artisanal beer varieties.

**Keywords:** ale; alcoholic beverage; sensory analysis; acceptance test; physicochemical analysis.

**Practical Application:** Results demonstrated the possibility of producing other artisanal beer varieties. It additionally revealed the rice flakes potential as partial substitute for barley malt to develop innovative beers. Rice flakes and soursop pulp beers can be a good artisanal beer alternative to consume.

## 1 Introduction

Beer is produced from barley malt, good quality water, hops, yeast, which eventually becomes a carbonated drink (Oliveira, 2011). Beer is the most consumed alcoholic beverage in the world. Generally there are two types, alcoholic and non-alcoholic, but most beers contain alcohol (Nogueira et al., 2017; Wang et al., 2018). There is also the possibility of varying the beer formulations, and adjuncts may be used to replace barley grain, these adjuncts may be numerous different ingredients such as wheat, rice, corn, rye, cassava, honey, fruits, and others (Soares, 2011).

According to the current legislation n° 2.314, September 4, 1997 (Brasil, 1997), in order to consider a drink as a beer, it must have at least 20% of barley malt in its composition. For beer processing, the most important raw materials are water, malt, yeast and hops. Thus, barley malt quantity may be exchanged for brewers' adjuncts, however, it must not exceed 45% in relation to the primitive extract. Consequently, major brands have been using rice in its formulation to reduce the costs, such as Budweiser<sup>®</sup> that uses 40% of rice (Almeida, 2005). Rice is employed in flake form, obtained from moist flour which passes through heated rolls (Reinold, 1997; D'Avila et al., 2012).

The fruit application in beer production promotes residual sweetness, characteristic citrus aroma and flavor, increasing the vinous character to beer through large ranges of aromatic compounds (Kunze, 2006). The nutritional and functional values can be further enhanced by incorporating fruit pulp (Guimarães et al., 2019). The soursop is considered a Brazilian

cerrado fruit that can be used in the artisanal beer production. Belonging to the *Annonaceae* family, it has a sweet, aromatic, highly nutritious and juicy pulp, promoting a beer with differentiated sensory characteristics (Sampaio et al., 2015).

With the growing expansion of the beer market, special beers, known as artesanais (Oliveira & Silva, 2017; Tozetto et al., 2019). Artisanal beers are progressively gaining consumer preference, opening up competition and acquiring more space in the domestic market. Consumers are continuously looking for innovative and differentiated beers, returning the artisanal beer culture that began in the United States in the 1970s and intensified in Brazil in the 1990s with the incorporation of micro breweries that were after flavors innovation. Artisanal beer manufacture has gained strength and demonstrates in the economy to be a sector of great importance, generating various direct and indirect jobs (Madeira, 2015).

Considering these factors and also searching to encounter the beer consumers' new needs and preferences, the exploration for new formulations is justified with the addition of rice flakes and Brazilian tropical fruits such as soursop, so as to obtain a differentiated product for the consumer market. Therefore, this study aimed to produce and evaluate the physicochemical characteristics of artisanal beers produced with the addition of rice flakes and soursop pulp, and the acceptance level of these products through sensory analysis.

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<sup>1</sup>Universidade Estadual de Mato Grosso do Sul – UEMS, Naviraí, MS, Brasil

<sup>2</sup>Universidade Federal da Grande Dourados – UFGD, Dourados, MS, Brasil

\*Corresponding author: mdeloalves@gmail.com

## 2 Materials and methods

### 2.1 Soursop pulp obtaining

Soursop used in the preparations were harvested ripe directly from the tree, pulped and frozen. The fruits were thawed only the exactly quantities required to produce the beers.

### 2.2 Beer production

Four artisanal beer formulations were added with rice flakes and soursop with percentages established through preliminary testing using typical Ale beer formulations as displayed in Table 1, the ingredients were weighed separately.

Beer production, physicochemical analysis and sensory analysis were performed at the Food Production Laboratory, in the Chemical Technology Development Center (CDTEQ) Laboratory of the Universidade Estadual do Mato Grosso do Sul, Naviraí unity and Processing Laboratory of the Universidade Federal de Grande Dourados.

Malts were obtained ready to start production, macerated by the company Brew Head Shop. In the mashing process, the Grain Bag, also known by the acronym BIAB (Brew in a Bag), was used. It is one of the simplest methods for artisanal beer brewing, mainly for the simplicity of the equipment (Palmer, 2006). Figure 1 presents the control artisanal beer production flowchart, the methodology used was according to Venturini (2010) with some adaptations.

The first process for beer production is mash. At this stage, malt and rice flakes were added to the equipment containing 10 L of mineral water, which was adjusted to the temperature of  $68 \pm 1$  °C for 60 minutes. From this process, the must was obtained. After mashing, the filtration was started using a cake retention mesh, leaving only the liquid part in the equipment and the solid part in the mesh. In another equipment, 6.5 L of water at 78 °C was slowly dispensed under the cake. Subsequently the liquid part proceeded to the boiling step and the solid part was discarded.

After filtration, the must was warmed to boiling, and the bitterness hops were added starting the 60 minutes' count. After 5 minutes, the aroma hops were added. The must presents high temperature, so the equipment containing it was inserted into a basin immersed in ice and cold water with temperature around 0 °C, and the decantation occurred, aiming the sedimentation process at the bottom of the pan, also known as trub.

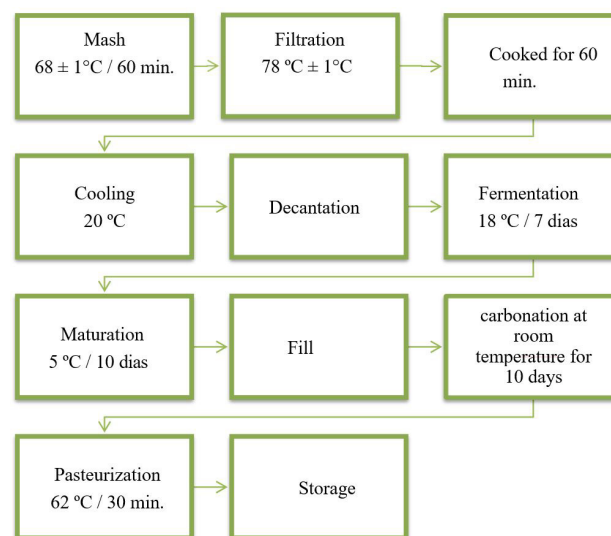
Must reaching the temperature of 20 °C, it was transferred to the fermenter and inoculated with high fermentation brewer's yeast of *Saccharomyces cerevisiae* and the equipment was closed. It was inserted in a greenhouse with temperature control at  $18 \pm 1$  °C, initiating the fermentation, in which it remained for 7 days.

After seven fermentation days, the must was transferred by filtration to a container. For the formulations with the soursop pulp addition, it occurred at this stage. The bucket was sealed, starting the maturation stage, which lasted 10 days at temperature of 5 °C.

After the maturation process, the beers were filtered and filled in sanitized bottles containing 4 mL of priming (inverted sugar). It was then stored at room temperature for 10 days in order to occur the carbonation through the sugar fermentation by the action of remaining yeasts. Soon after carbonation, the beers were pasteurized in water bath at 62 °C for 30 min and stored at room temperature until the analyzes were performed.

### 2.3 Physicochemical analysis

Physicochemical analyzes performed on the beers were: total acidity, soluble solids content, real extract, primitive (Instituto Adolfo Lutz, 2008), pH described by the Association of Official



**Figure 1.** Processing flowchart for control artisanal beer. Source: Own authorship.

**Table 1.** Ingredients used in beer processing.

Ingredients	Samples			
	Control*	F1	F2	F3
<b>Water</b>	16.5 L	16.5 L	16.5 L	16.5L
<b>Malt</b>	2.520 kg	2.520 kg	1.512 kg	1.512 kg
<b>Rice flakes</b>			1.008 kg	1.008 kg
<b>Hops (Bittering)</b>	4 g	4 g	4 g	4 g
<b>Hops (Aroma)</b>	8 g	8 g	8 g	8 g
<b>Yeast</b>	11.5 g	11.5 g	11.5 g	11.5 g
<b>Soursop pulp</b>		126 g		126 g

\*Control = Pure malt; F1 = Addition of 5% soursop; F2 = Addition of 40% rice flakes; F3 = Addition of 40% rice flakes and 5% soursop. % in relation to malt quantity.

Analytical Chemists (2000), density (Ferreira & Benka, 2014), alcohol content (Zenebon et al., 2008) and color, which was analyzed by the spectrophotometry method at wavelength of 430 nm (European Brewery Convention, 2005). Analyzes were performed in triplicate, except for alcohol content.

All determinations were performed on the decarbonated samples. To remove CO<sub>2</sub>, the samples were transferred to 600 mL beakers and shaken with glass stick; the beer temperature was maintained at 20-25 °C until complete CO<sub>2</sub> removal (Instituto Adolfo Lutz, 2008).

## 2.4 Sensorial analysis

For the sensory analysis, the 9-point hedonic acceptance test based on Dutcosky (2007) was applied; 1 corresponds to “very disliked” and 9 to “very much liked”. Hedonic scales are applied in sensory analysis of different food matrices (García-Gómez et al., 2019; Iuliano et al., 2019). The following attributes were evaluated: color, bitterness, aroma, taste and overall impression. Sensory analysis was approved by the UEMS Human Research Ethics Committee under Opinion n° 3.358.324.

Each taster received 30 mL of each beer sample at approximately 5 °C, coded with three random digits. Mineral water and salt and cracker were also served to clean the palate. The sensory panel was attended by 100 untrained judges of both sexes, aged from 18 years, being students, professors and employees of the Universidade Estadual de Mato Grosso do Sul - Naviraí Unit.

## 2.5 Statistical analysis

Physicochemical and sensory analyzes results were submitted to analysis of variance (ANOVA) and the means were compared by Tukey test with significance of 5%.

## 3 Results and discussion

### 3.1 Physicochemical analysis

Table 2 presents the physicochemical analyzes results performed on the samples. The °Brix mean values found in samples F2 and F3 differed from control and F1 samples statistically ( $p < 0.05$ ), which can be attributed to the usage of different raw materials (rice flakes and soursop), resulting in higher values (6.9 and 7.0 °Brix). Current legislation does not determine a default value for this parameter, but comparing to other studies, it presented higher values than those encountered

by Pereira & Leitão (2017), who analyzed pilsen artisanal beer and found values ranging from 5.3 to 6.0 °Brix.

The pH determination was performed in order to analyze its influence on the beer production process and to characterize the final product composition. All samples analyzed showed no significant difference ( $p < 0.05$ ), displaying values below 4.5, being of fundamental importance, since it maintains the samples free of pathogenic microorganisms, and prevents further contamination (Hoffmann, 2001). The results were within the limit mentioned by Hardwick (1995), from 3.9 to 4.5 and Venturini & Cereda (2001), with pH values from 3.8 to 4.7 for pure malt beers.

Relative density values showed significant differences between samples ( $p < 0.05$ ). According to Sousa (2009), the beer density determination allows the monitoring of alcoholic fermentation, because as yeast consumes sugars and produces alcohol, density values decrease, since sugars are denser than alcohol, or that is, for samples F2 and F3 which exhibited higher values, it can be said that both contained large sugars amounts in its compositions due to the added adjuncts (rice flakes and soursop).

Brasil (2009) determines as alcoholic beer the ones with alcoholic percentage superior than 0.5 °GL in volume. The values obtained for the alcohol content were 4° GL for beer samples containing only malt in its formulation and 3° GL for samples containing rice flakes as adjunct. The lower F2 and F3 beers alcohol content may be related to the low obtainable fermentable sugars during gelatinization and hydrolysis of  $\alpha$ -amylase flakes. This enzyme is characterized by producing from starch, mainly dextrins (non-fermentable) and peripherally glucose and maltose (Bamforth, 2003). Soursop addition in the maturation process did not interfere in the alcoholic fermentation, only conferred sensory characteristics to the beers. Schork (2015) obtained an alcohol content of 2.14 °GL for beer with rice flour addition, which is lower than that obtained in this work.

According to Goiana et al. (2016), total acidity is related to total titratable organic acids in beer. The results found for this parameter are in accordance with the Brazilian legislation (Brasil, 2009), which establishes a variation of 0.1 to 0.3% acidity in beers. Brunelli et al. (2014) obtained an average of 0.28% total acidity for beer made with honey and Maia & Belo (2017) obtained an average of 0.26% for beer with soursop, showing that the values are in agreement with the present work.

One of the factors responsible for acidity is carbonic acid, resulting from the reaction between CO<sub>2</sub> and H<sub>2</sub>O, which may be responsible for the increase in acidity in the most carbonated beers. Most of the acids present in beer already exist in the mash, but in different proportions, and its concentrations vary

**Table 2.** Physicochemical parameters results of beer samples.

Samples	SST (°Brix)	pH	Relative density	Alcohol content (°GL)	Total acidity (% m/v)	Real Extract (%)	Primitive Extract (%)	Color (EBC)
<b>Control</b>	6.3 <sup>b</sup> ± 0.06	4.10 <sup>a</sup> ± 0.02	1.011 <sup>a</sup> ± 0.00	4.0 <sup>b</sup> ± 0.00	0.22 <sup>c</sup> ± 0.01	4.59 <sup>b</sup> ± 0.03	12.33 <sup>c</sup> ± 0.03	25.71 <sup>c</sup> ± 0.09
<b>F1</b>	5.8 <sup>a</sup> ± 0.00	4.03 <sup>a</sup> ± 0.06	1.008 <sup>b</sup> ± 0.00	4.0 <sup>b</sup> ± 0.00	0.33 <sup>d</sup> ± 0.01	3.83 <sup>a</sup> ± 0.06	11.60 <sup>b</sup> ± 0.06	24.86 <sup>c</sup> ± 0.71
<b>F2</b>	6.9 <sup>c</sup> ± 0.06	3.98 <sup>a</sup> ± 0.11	1.014 <sup>c</sup> ± 0.00	3.0 <sup>a</sup> ± 0.00	0.16 <sup>a</sup> ± 0.01	5.49 <sup>c</sup> ± 0.04	11.33 <sup>a</sup> ± 0.04	10.04 <sup>a</sup> ± 0.17
<b>F3</b>	7.0 <sup>c</sup> ± 0.06	3.90 <sup>a</sup> ± 0.08	1.015 <sup>d</sup> ± 0.00	3.0 <sup>a</sup> ± 0.00	0.18 <sup>b</sup> ± 0.01	5.59 <sup>c</sup> ± 0.04	11.42 <sup>a</sup> ± 0.04	20.14 <sup>b</sup> ± 0.57

Mean ± standard deviation. Control = Pure malt; F1 = Addition of 5% soursop; F2 = Addition of 40% rice flakes; F3 = Addition of 40% rice flakes and 5% soursop; SST = Total Soluble Solids. Equal letters in the same column are not significant by the tukey mean test ( $p < 0.05$ ). EBC (European Brewing Convention).

**Table 3.** Average taster acceptance values for beer samples with rice flakes and soursop.

Treatments	Color	Bitterness	Aroma	Flavor	Global Impression
<b>Control</b>	6.99 <sup>b</sup> ± 1.61	7.01 <sup>a</sup> ± 1.63	7.37 <sup>a</sup> ± 1.34	7.20 <sup>a</sup> ± 1.43	7.31 <sup>a</sup> ± 1.46
<b>F1</b>	7.80 <sup>a</sup> ± 1.20	6.40 <sup>b</sup> ± 1.96	7.50 <sup>a</sup> ± 1.65	6.65 <sup>ba</sup> ± 1.62	7.00 <sup>ba</sup> ± 1.48
<b>F2</b>	6.58 <sup>b</sup> ± 1.70	6.27 <sup>c</sup> ± 2.01	6.91 <sup>a</sup> ± 1.77	6.28 <sup>b</sup> ± 1.95	6.56 <sup>b</sup> ± 1.63
<b>F3</b>	6.48 <sup>b</sup> ± 1.76	6.35 <sup>b</sup> ± 1.99	6.95 <sup>a</sup> ± 1.92	6.25 <sup>b</sup> ± 2.11	6.56 <sup>b</sup> ± 1.81

Mean ± standard deviation. Control = Pure malt; F1 = Addition of 5% soursop; F2 = Addition of 40% rice flakes; F3 = Addition of 40% rice flakes and 5% soursop. Equal letters in the same column are not significant by the tukey mean test ( $p < 0.05$ ).

depending on the raw material, malt variety and malting conditions (Venturini Filho, 200). According to Sousa (2009), acidity in beer is important for its characterization, standardization and for the control of undesirable changes by microorganisms in the beer taste and aroma.

According to Brazilian legislation (Brasil, 1997), the real extract percentage indicates the amount of non-alcoholic ingredients that are found in beer after fermentation. It provides the body, color, foam stability and flavor. In beers, the real extract values must be between 2% and 7%; values above 3% are for good beer quality. Therefore, all samples presented good quality according to the obtained values, and the sample F3 obtained the greatest result. This is due to the ingredients in its composition, as rice flake has a large amount of non-fermentable sugars, and soursop was added only at the end of the process, giving only color and flavor to the beer.

For Brasil (2009), “[...] the primitive extract is the must substances (extract) amount that gave rise to beer, expressed as percentage by weight”, being one of the usual classification forms; light beer rating 5 to 10.5%; beer 10.5 to 12.0%, extra 12.0 to 14.0% and strong > 14%. According to the results obtained, samples F1, F2 and F3 are classified as beer, and the control sample as extra beer, that is, the control formulation presented higher carbohydrates amount in the beer production, because in its formulation is used only malt that is rich in fermentable sugars.

Regarding color, beers with values below 20 European EBC (EBC) units are called light beers and for values above 20 EBC units, the beers will be classified as dark. Among the formulations, the only sample classified as light beer was F2, which had a value of 10.04 EBC units, while the other formulations were classified as dark beers. According to Venturini (2000), the assistant improves the beer physicochemical stability, reducing its turbidity. It is also responsible for giving the beer lighter color, as the pH reduction allows the loss of coloring substances.

### 3.2 Sensorial analysis

Table 3 presents the average sensory attributes result of the different beers with rice flakes and soursop additions. Attribute averages showed results within the product acceptance range, that is, between 6 and 7, ranging from “slightly liked” to “moderately liked”.

In the color sensory attribute, all formulations were well evaluated by the tasters, only the F1 formulation differed significantly ( $p < 0.05$ ) from the other samples, probably due to a lighter coloration. Regarding the bitterness attribute, formulations F1 and F3 showed no significant difference.

For the sensory attribute “aroma”, the F1 formulation presented the highest grade, but did not differ from the other formulations, indicating that the rice flakes and soursop addition pleased the tasters regarding this attribute. Formula F1 had a 6.65 grade for the “flavor” attribute, not statistically different from the control formulation that had the highest grade. This result indicates that the soursop addition pleased the tasters. Formulations F2 and F3 did not differ statistically from each other.

The scores for the F2 beer flavor and color attributes were higher than those found by Schork (2015) for gluten-free beer made with rice flour. According to the author the average grades were 3.18 (flavor) and 3.44 (color).

Regarding the attribute “Global impression” the formulations control and F1 were the ones that presented the highest scores and did not differ statistically from each other, also observing that there is agreement with the results of the sensory attributes “taste” and “aroma”. However, formulation F1 also showed no significant difference between the other formulations F2 and F3, so overall all formulations showed good acceptance by the tasters.

New studies should be conducted using complementary sensory analyses, such as descriptive analyses in order to identify and quantify sensory descriptors (Torres et al., 2017) and also projective techniques, as a tool to study needs, feelings and motivations of purchasing behavior (Gambaro, 2018; Judacewski et al., 2019)

## 4 Conclusion

The beer samples were within the standards established by Brazilian law. In the physicochemical analysis, F3 beer (with rice flakes and soursop) presented a relative density of 1.015, alcohol content of 3.0 °GL, real extract of 5.59%, primitive extract of 11.42%, and the sensory analysis obtained values between 6.25-6.95 for the attributes analyzed in this work.

The addition of rice flakes and soursop as adjunct in brewing proved to be a viable alternative as it did not cause large variations in physicochemical parameters and was well accepted by the tasters.

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