Revista Tecnológica - Universidade Estadual de Maringá - ISSN 1517-8048
DOI: 10.4025/revtecnol.v30i1.57643

FRUIT BEER DE JABUTICABA: AVALIAÇÃO FÍSICO-QUÍMICA E SENSORIAL

JABUTICABA FRUIT BEER: PHYSICOCHEMICAL AND SENSORY EVALUATION

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Resumo: Esse trabalho objetivou produzir artesanalmente cervejas *fruit beers* de jabuticaba (*Myrciaria cauliflora* Berg) e caracterizá-las físico-química e sensorialmente. O experimento foi dividido em quatro tratamentos que corresponderam à etapa em que os frutos foram adicionados ao processamento (fervura, fermentação e maturação) e o controle (puro malte), com três repetições cada. A mosturação foi realizada pelo método de infusão, sendo a fervura do mosto realizada por 60 minutos. A fermentação transcorreu à temperatura de 10 °C ± 1, sendo posteriormente envasadas e refermentadas em garrafas para carbonatação da bebida (*primming*). A maturação ocorreu nas garrafas por 30 dias à temperatura de 0 °C ± 1, com exceção ao tratamento de Maturação. As cervejas foram analisadas físico-quimicamente para os parâmetros de teor alcoólico, extrato real, extrato aparente, fermentabilidade aparente, fermentabilidade real, cor, amargor, turbidez, pH, acidez total e gás carbônico. As bebidas foram submetidas a análise sensorial por meio de teste afetivo utilizando-se escala hedônica. A adição da jabuticaba aumenta a acidez total, a carbonatação e o amargor da cerveja, porém não altera seu extrato real, extrato aparente e pH. Sensorialmente, os tratamentos e o Controle apresentaram a mesma preferência para todos os atributos analisados (aparência, aroma, sabor e avaliação global).

Palavras-chaves: *Myrciaria cauliflora* Berg., Lager; Bebida alcoólica; Fermentação.

Abstract: *This research focused on craft beer production of jabuticaba (Myrciaria cauliflora Berg) "fruit beer" and the physicochemical and sensory analisys of the samples. The research was divided into four treatments regarding the stage of fruit addition during the brewing process (Boiling, Fermentation, Maturation) and the Control (all malt), with three replicates each. The mashing was performed by the infusion method, and the wort was boiled for 60 minutes. The fermentation took place at 10 °C ± 1, and the green beer was later bottled with priming sugar and bottle conditioned for carbonation. The maturation occurred in the bottles for 30 days at 0 °C ± 1, except for the Maturation treatment. The beers were analyzed physicochemically for the parameters of alcoholic content, real extract, apparent extract, apparent fermentability, true fermentability, color, bitterness, turbidity, pH, total acidity and carbon dioxide. The beers were submitted to sensory analysis by affective test using 9-point hedonic scale. The addition of jabuticaba increases the total acidity, CO_2 content and bitterness of the beer, but does not alter its real extract, apparent extract and pH. Sensorially, treatments and Control had the same preference for all parameters analyzed (appearance, aroma, flavor and overall evaluation).*

Keywords: *Myrciaria cauliflora Berg.; Lager; Alcoholic beverage; Fermentation.*

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1 Introduction

Craft brewing is the descendent of the microbrewing movement that started in the UK in the late 1970s, flourished in the United States in the 1990s, and spread to the corners of the world in the first decade of the 21st century. In Brazil, the craft beer movement has grown a lot in recent years (OLIVER, 2012).

Fruit beer, defined as "beer made with any fruit or combination of fruit, under the definitions of this category", must present "a harmonious marriage of fruit and beer, but still recognizable as a beer. The fruity character should be evident, but in balance with beer, not so forward as to suggest an artificial product" (BJCP, 2015).

The jabuticaba (*Myrciaria cauliflora* Berg.) is an example of fruit that can be used during fruit beer brewing. Its fruits are berry type, round, black, smooth, with sweet and slightly acidic pulp, white to translucent, and can be used for both fresh consumption and the production of juices, syrups, liqueurs, spirits and jellies (DONADIO; MORO; SERVIDONE, 2004).

The seasonality of the jabuticaba tree does not allow its fruits to be harvested year-round. In addition, the fruit is highly perishable and does not last long periods of storage. One way to store the fresh fruit for long period is to freeze it or to dry it.

The objective of this work was to produce fruit beers (bottom fermented), adding frozen jabuticaba fruits in different stages of the brewing process and to analyze them physicochemical and sensory.

2 Materials and methods

2.1 Materials

- Water from public water supply system, filtered on activated charcoal (removal of chlorine) and cellulose (removal of particles).
- Barley malt for Pilsner beer (from Argentina). Color: 4.7 EBC; Diasthetic power: 266 EBC; Betaglucans: 158 mg L^{-1}; Friability: 91%.
- Bitterness hops from Germany "Hallertauer Magnum", pellet type T-90. Alpha-acids: 12.60%; Total oils 1.6-2.6 ml 100 g^{-1}.
- Alcoholic yeast for *lager* beers (bottom fermentation).
- Jabuticaba fruits variety Sabará.
- Crystal sugar.

Jabuticaba samples were collected in Botucatu city (São Paulo state, Brazil) - 22º53'09" S 48º26'42" W.

2.2 Experimental Planning

The experimental design was completely ramdomized. The research was divided into four treatments with three repetitions each.

- Tratament 1 Boiling: *Fruit beer* produced with addition of frozen jabuticaba fruits to the wort at the boiling stage.
- Tratament 2 Fermentation: *Fruit beer* produced with addition of frozen jabuticaba fruits to the wort at the fermentation stage.

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- Tratament 3 Maturation: *Fruit beer* produced with addition of frozen jabuticaba fruits to the green beer at the maturantion stage.
- Tratament 4 Control: Beer all malt, produced without jabuticaba addition.

2.3 Craft brewing process

The following steps describe the production of beer “control”. The description of the process of each treatment is in its specific stage.

The mashing stage started by pouring 2 kg of milled barley malt in an aluminum pan (15 liters) with 8 kg of water at 40 ºC. After 20 minutes at 40 °C the mash was heated 1 $°C.min^{-1}$ until 70 °C and remained in this temperature for 40 minutes. During lautering, the grains were washed with 8 kg of water at 75 °C. Thus, the sweet wort was boiled (100 °C) for 60 minutes. At this stage, 2 g of hops were added to the wort at the beginning of the boiling. The wort was cooled (25 °C) using an aluminum chiller (7.5 meters) and the “trub” was removed by decantation.

To perform the treatment 1, 2 kg of jabuticaba were added to the wort after 50 minutes of boiling. When adding the frozen fruits, the boil suddenly ceased due to the low temperature of the jabuticaba, therefore, the final 10 minutes were counted from the re-establishment of the boiling.

The wort was pitched with bottom fermentation yeast (1 $g.L^{-1}$) and the fermentation was carried out in non-toxic polyethylene bucket (18 L) at 10 °C±1 for 14 days.

To perform the treatment 2, 2 kg of jabuticaba were added to the wort shortly after pitching.

After fermentation, the green beer (immature beer) was transferred to a polyethylene bucket, to measure its mass. Priming sugar (1g.100 g^{-1}) was added to the beer, in order to induce the carbonation of the beverage. The beer was bottled in 600 ml amber glass bottles, which remained 5 days at 20 °C±1 for bottle conditioning.

After bottle conditioning, the bottles remained at 1 °C±1 for 30 days for maturation. To perform treatment 3, the green beer was transferred to a new bucket, where 2 kg of jabuticaba were added. To avoid contamination with aerobic microorganisms along with the fruits, 500 ml of liquid nitrogen was added. The beer was kept at 1 °C±1 for 30 days for maturation. After this period the beverage was bottled and bottle conditioned as previously described.

2.4 Physicochemical analysis

The jabuticaba fruits were manually crushed with a pestle, without breaking the seeds, and the resulting juice was analyzed for the parameters of soluble solids, pH and acidity, also calculating its Ratio (Brasil, 2008).

The beer samples of the three treatments and the control were analyzed for the following parameters: alcohol content, real extract, apparent extract, apparent fermentability, real fermentability, color, bitterness, turbidity, pH (EBC, 2005), original extract, total acidity and carbon dioxide (ASBC, 1958).

2.5 Sensory analysis

All samples were sensory evaluated by affective test, using a 9-point hedonic scale test with scores ranging from 1 (I highly dislike) to 9 (I like it very much), evaluating the parameters of appearance, aroma, flavor and overall assessment (Nicolas; Marquilly; O’mahony; 2010).

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The sensory analysis was carried out with undergraduate students and employees of São Paulo State University. The beer was tasted in glass cups (30 ml) at 5 °C±1. Samples were codified with 3-digit random numbers.

This research was registered in the Plataforma Brasil (CAAE: 66889817.7.0000.5411) and approved n° 2.076.208.

2.6 Statistical analysis

The statistical analysis of physicochemical and sensory results was performed using analysis of variance (ANOVA). The means of physicochemical results were compared by the Tukey test (p<0.05) using MiniTab 16® software. The medians of the results of the sensory analysis were compared by the Kruskal-Wallis test.

3 Results and discussion

3.1 Physicochemical analysis

Table 1 shows the results of physicochemical analisys of jabuticaba fruits. Lima et al. (2008) analyzing the chemical composition of the pulp of jabuticaba fruits obtained the 14.13 °Brix for soluble solids, 0.97 % for titratable acidity and pH of 3.5. Comparing data it is possible to notice that the fruits used in this research were less ripe than those used by Lima et al.

Table 1. Physicochemical analisys of jabuticaba fruit.

Brix	**pH**	**Acidity***	**Ratio**
11.2±0.2	3.1±0.0	1.2±0.1	9.1±0.7

*g.100g^{-1} of citric acid.

Analyzing Table 2, it is possible to verify that the addition of jabuticaba fruits increased the carbon dioxide content in the beverage, considering Control treatment low carbon dioxide content (2.0 v/v). The results indicate that treatments that received the fruits presented a higher presence of residual sugars at the end of the fermentation process, resulting in a higher production of the carbon dioxide during the process of bottle conditioning.

Similarly, the presence of high levels of solids increase the rate of carbon dioxide release during fermentation of grape must (PATERSON; SWANSTON; PIGGOTT, 2003).

Samples with jabuticaba added in Boiling and Fermentation stages presented carbon dioxide rates corresponding to beers found in the market. Beer matured in a closed cylindroconical vessel, with a top pressure, may contain up to 2.5 vol vol^{-1} (5.0 g L^{-1}) of dissolved carbon dioxide (PARKES, 2012) and results found were 2.4 v/v for Boiling and 2.8 v/v for Fermentation.

The gushing effect was observed in the Maturation treatment (SPEDDING, 2012). Therefore, it is not recommended to add jabuticaba at the maturation stage, due to the risk of bottle explosion.

The treatment of boiling presented higher turbidity possibly due to the higher extraction of high molecular weight compounds, such as proteins and polyphenols, from jabuticaba fruits (LIMA et al, 2008), during the boiling of the wort. In the other treatments, the jabuticaba was added in “cold phases”, resulting in a lower extraction of those

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macromolecules. Statistical analisys presented similarity between Fermentation (23.8 EBC), Maturation (21.1 EBC) and Control (7.8 EBC) results probably due to the comparison of these values with 130.1 EBC of Boiling treatment.

Beers produced with jabuticaba presented greater bitterness (5.8~6.2 IBU) compared with Control (4.3 IBU), but these results should be analyzed carefully. The jabuticaba literature does not mention the presence of alpha or beta acids (responsible for the bitterness of beer) in its chemical composition. Beer with jabuticaba probably contains fruit-derived substances that has been extracted by the iso-octane solvent and absorbed by the ultraviolet light at a wavelength of 275 nm, increasing the absorbance reading, resulting in a false higher bitterness reading.

Samples that received jabuticaba had higher acidity compared to the Control (0.14 %), indicating that the fruit provided organic acids to the beverage during brewing. Comparing treatments results, the Fermentation (0.41 %) was higher than Boiling (0.34 %) and Mauration (0.34 %) treatments, probably because during the fermentation process yeast releases organic acids in the beverage what can have been intensified by the fruit berries. The acids content of the whole jabuticaba fruit in quantitative order is citric>succinic>malic>oxalic>acetic, demonstrating that the fruit has a range of different acids in its chemical composition, with predominance of citric acid (LIMA et al., 2011).

Despite the difference in acidity between the beers, there was no variation of pH between samples. Although pH variation was expected, these results can be understood by the logarithmic pH scale and the possibility of buffer effect in beers.

It is possible to observe that the beers that received jabuticaba presented greater intensity of color compared to the Control (5.3 EBC). The Boiling treatment result (10.7 EBC) was higher compared to the Maturation treatment (9.1 EBC) probably due to the higher temperature of boiling may extract the fruit color more efficiently. The jabuticaba peel is rich in anthocyanin, tannins and other polyphenols that interfere with the color of beer. Cyanidin is the main form of anthocyanin in jabuticaba. It was observed that this pigment was unstable during brewing; jabuticaba's peculiar color was lost and not remained in the beverage (DORNBUSCH, 2012).

Although the original extract content of beers ranged from 11.6 to 12.5, there was no statistical difference between them. On the other hand, there was a statistical difference between the lowest alcohol content (Maturation treatment) and the highest (Boiling treatment). This result was not expected since there is a proportional relationship between original extract and alcohol content. Apparently, there is also a non-expected result between the values of alcohol content and carbon dioxide, since the ethanol production during alcoholic fermentation is stoichiometrically linked to the production of carbon dioxide. One possibility of understanding this result would be that the yeast's respirofermentative metabolism (KÄPPELI, 1986; ZANDYCKE, 2012) was not the same among the treatments.

There was no difference between the apparent extract content of all treatments. The same thing happened for the real extract. The apparent extract values shown in Table 2 are within the range for American lager beers (2.0 to 3.1) (COMPTON, 1978). The same happens for the real extract results of the present research, which fit the values presented by this author (3.7 to 4.8).

There was no difference between the values of apparent fermentability and real fermentability of the treatments. Table 2 shows that there is no difference between the results of the analyzes of the original extract, apparent extract and real extract, which shows that the addition of jabuticaba in beer production did not influence the fermentation process.

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Table 2. Physicochemical analisys of beer samples

Parameters	Boiling	Fermentation	Maturation	Control
pH	4.2±0.0a	4.1±0.0a	4.1±0.0a	4.2±0.1a
Total acidity (%)*	0.34±0.0b	0.41±0.0a	0.34±0.0b	0.14±0.0c
Bitterness (IBU)	6.2±0.4a	5.8±0.1a	6.2±0.4a	4.3±0.6b
Color (EBC)	10.7±0.5a	9.4±0.4ab	9.1±0.8b	5.3±2.2c
Turbidity (EBC)	130.1±26.8a	23.8±0.8b	21.1±4.9b	7.8±5.1b
CO_2 (v/v)	2.4±0.1c	2.8±0.2b	3.9±0.0a	2.0±0.1d
Alcohol content % (v/v)	5.2±0.2a	5.0±0.3ab	4.6±0.1b	4.9±0.1ab
Original Extract (Plato)	12.5±0.6a	12.2±0.4a	11.6±0.4a	11.6±0.2a
Apparent Extract (Plato)	2.5±0.2a	2.6±0.1a	2.6±0.2a	2.5±0.2a
Real Extract (Plato)	4.6±0.4a	4.5±0.1a	4.4±0.2a	4.0±0.3a
Apparent Fermentability (%)	80.8±1.6a	78.7±1.8a	79.1±0.7a	79.1±1.4a
Real Fermentability (%)	65.5±1.3a	63.7±1.5a	64.1±0.6a	64.1±1.1a

Means followed by equal letters in the cloumn do not differ by Tukey test (p<0.05); *% of lactic acid.

3.2 Sensory analysis

The beers that received jabuticaba presented the same preference of the all malt beer, for all parameters analyzed (appearance, aroma, flavor and overall assessment), as shown in Table 3.

Table 3. Sensory analisys of fruit beers and control

	Appearance	Aroma	Flavor	Overall Evaluation
Boiling	6±1.9a	7±1.6a	6±1.9a	6±1.8a
Fermentation	6±1.8a	7±1.6a	6±2.1a	6±1.9a
Maturation	7±1.4a	7±1.5a	7±2.1a	7±1.6a
Control	6±1.8a	7±1.5a	6±1.7a	6±1.4a

Medians followed by equal letters in the cloumn do not differ by Kruskal-Wallis test (p<0.05).

The medians were between 6 (like slightly) and 7 (like moderately), which means that both treatments and control were well evaluated. Samples containing fruit presented jabuticaba's peculiar characteristics such as flavor, aroma and color (red), what probably tasters look for in a beer brewed with jabuticaba. The Control presented lager beer peculiar characters such as flavor, aroma and golden color, which also pleases the consumers of this style of beer.

The taste and aroma of the fruit can hide or ameliorate the flavor of beers that might otherwise be found less than ideal. When added by a skilled artisanal brewer, fruit can help create colors, flavors and aromas unobtainable from grain alone (HOLLILAND, 2012).

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4 Conclusions

Jabuticaba is a fruit with high potential to be used by the craft beer industry for the production of fruit beers. The beverage is sensorially well accepted by tasters and raw materials are available in several locations of Brazil. The addition of jabuticaba fruits to the wort in the brewing process is recommended during the Boiling and Fermentation stages, but authors do not recommend the addition of jabuticaba fruits in the Maturation stage, due to the high amount of carbon dioxide in the bottle may explode it and cause serious injuries.

Acknowledgment

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

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