Physiochemical Characterization of the Brewers' Spent Grain from a Brewery Located in the Southwestern Region of Parana - Brazil

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***Abstract*— *Brewers' spent grain is a by-product generated in the production process of breweries formed by the solid part obtained from the wort filtration before boiling. It is mainly comprised of pulp and husk residues of the malt, but it also contains grains of the adjuncts, such as rice, maize and wheat. Quantitatively, brewers' spent grain is the main byproduct of the brewing process and currently it is used as animal feed. The objective of this study was to determine the physiochemical composition of the brewers' spent grain and its potential use in human food. To this end, brewers' spent grain samples were collected from a craft beer brewery located in the southwestern region of the state of Paraná, determining such parameters as moisture, ash, total proteins, lipids, crude fiber, carbohydrates and energy. The results revealed that the moisture and ash levels were 78.23 ± 1.45 and 3.76± 1.23g.100g^{-1}, respectively. The figures for carbohydrates, total proteins, total fats and crude fibers were 1.89±1.21; 4.89 ± 0.29; 2.67 ± 0.68 and 4.19 ± 0.56, represented in g.100g^{-1} respectively. The energy values obtained were 109.23± 4.23 kcal.100g^{-1}. As such, the conclusion can be drawn that brewers' spent grain can be used in both animal and human food.*

Keywords*— *Food, Waste, Agriculture, Bromatological Analyses.

I. INTRODUCTION

According to the Brazilian department of Agriculture (Brasil, 1977), every grain that is subjected to a malting process, i.e., the grain is subjected to partial germination and subsequent dehydration and/or toasting at appropriate technological conditions, should be called malt followed by the name of the grain. Malted barley, or malt, is one of the main raw materials used in the manufacture of beer (Reinold, 1997).

In the first step of the beer manufacturing process, called mashing, two fractions are obtained: a liquid fraction (wort) and a solid fraction (brewers' spent grain), which is characterized as waste. For every hundred liters of beer produced, 20 kg of dry waste is generated, representing 85% of the total solid residue from the production process (Reinold, 1997).

Brewers' spent grain is the brewing residue resulting from the initial beer manufacturing process and it is generated from the filtering of the wort (mixture of ground malt and water) before boiling. This spent grain is basically made up of the husks of the malted barley.

Brewers' spent grain is predominantly fibrous (70 percent of dry weight) and proteinaceous (15 to 25% of dry weight), and it also contains lipids, minerals, vitamins, amino acids and phenolic compounds. Starch is the main source of glucose in the human diet, representing 40 to 80% of the total energy value in daily nutrition and being of considerable importance. Proteins are essential molecules for maintaining the structure and functioning of all living organisms and they have different properties and functions (Aliyu and Bala, 2011; Lima 2010; Robertson *et al*., 2010).

Since brewery waste has a rich composition of organic compounds with a significant nutritional value, it must be treated before it is released to the environment in order to prevent changes to the ecological equilibrium. As such, there is a great incentive to reduce the generation of waste or to promote its reuse in other processes. From the perspective of producing higher value added products and allocating the generated waste to more noble ends, industrial bioprocesses have presented themselves as a potential way of allocating these residues (Pandey *et al.*, 2001), in addition to their potential applications in animal and human food (Mendonça and Oliveira 2012).

According to Aliyu and Bala (2011) and Souza *et al.*, (2011), various applications can be cited, such as: animal and human food and nutrition; energy production through direct burning or through biogas production via anaerobic fermentation; production of charcoal; adsorbing material in chemical treatments; cultivation of micro-organisms and obtaining of bio-products through fermentation; support for cellular immobilization; among others.

According to Borges and Neto (2009), Nogueira (2010) and Mega and Andrade (2011), it is estimated that the global annual production of brewing residue (RC) is approximately 30 million tonnes, while Brazilian production accounts for around 1.7 million tonnes/year. From the perspective of sustainability, social and environmental responsibility, these numbers have a severe impact and there is a lack of efficient waste management since its allocation is the responsibility of the generator, who may incur legal penalties if its removal is inappropriate. According to the authors, the inadequate disposal of these residues can cause damage to the environment and its direct elimination in the soil or in sanitary landfills has been shown to be inefficient because there are not enough of these to handle the large amount produced each year.

Considering the nutritional potential of the waste arising from the beer manufacturing process, the objective of this study was to determine the physiochemical composition of the brewers' spent grain in the Southwestern region of the state of Paraná in order to evaluate its use for consumption by humans and household pets.

II. MATERIALS AND METHODS

We used the humid brewers' spent grain from a brewery located in the southwestern region of the state of Paraná. Two kg of sample was collected at the end of the filtration, prior to the removal of the spent grain to the spent grain box. The sample was stored in hermetically closed and cooled packaging and was subsequently transported to the food analysis laboratory of the *Fundação para o Desenvolvimento Científico e Tecnológico* - Fundetec - located in the city of Cascavel - PR - Brazil.

The brewers' spent grain was subjected to physiochemical analyses, in triplicate, regarding the following parameters: moisture (oven drying method at 105º C for 24 hours), ashes (calcination of samples at 550º C), total proteins, lipids, crude fibers, carbohydrates and energy, according to the analytical standards of the *Instituto Adolfo Lutz* (Brazil, 2005).

III. RESULTS AND DISCUSSION

The results of the physiochemical characterization of the brewers' spent grain are shown in Table 1. The values of 78.23± 1.45 and 3.76 ± 1.23 were obtained for the moisture and ash content, respectively, when analyzing the data.

The values found for the moisture and ash content of the brewer's spent grain under analysis (Table 1) are consistent with the literature data. Santos et al. (2003) evaluated the moisture and ash content of 8 batches of brewers' spent grain, consisting of 80% of malted barley and 20% of malted corn, obtaining values between 76.8 and 78.9% for moisture, and between 3.4 and 4% for ashes on a dry basis. Zhaoxia *et al*., (2012) found a water content of 79% and an ash content of 4.4%, for the dry brewers' spent grain from commercial breweries. Robertson *et al*., (2010) determined the moisture content of the brewers' spent grain of the barley from 10 commercial breweries, and found values between 75 and 80%. Dei Cedri (2006) found an ash content of 3.3% for the brewers' spent grain after mashing of the pure malted barley. In other literature reviews, values between 2.3 and 7.9% were found for ashes, and between 75 and 85% for moisture in the composition of the brewers' spent grain (Olajire, 2012; Aliyu and Bala, 2011).

Table.1: Physiochemical composition of the brewers' spent grain (b.u).

Analyzed Parameters	Values Obtained*
Moisture ($g.100g^{-1}$)	78.23±1.45
Ashes ($g.100g^{-1}$)	3.76±1.23
Carbohydrates ($g.100g^{-1}$)	1.89±1,21
Total Proteins ($g.100g^{-1}$)	4.89±0.29
Total Fats ($g.100g^{-1}$)	2.67±0.68
Crude fiber ($g.100g^{-1}$)	4.19±0.56
Energy ($kcal.100g^{-1}$)	109.23±4.23

**Values for the sample expressed as a percentage ($g.100g^{-1}$) of the product on a wet basis (b.u).*

According to Schmidt (1989), brewers' spent grain has a moisture of around 79%. According to Ascheri *et al.*, (2016), brewers' spent grain is characterized by a high moisture of 86% (b.u.) that limits its shelf life to up to 30 days for its fresh consumption. The high amount of water in the wet residue may result in other limiting factors, such as difficulties in long distance transport and storage.

Regarding carbohydrates, total proteins, total fats and crude fibers, the values obtained were 1.89±1.21; 4.89 ± 0.29; 2.67 ± 0.68 and 4.19 ± 0.56, represented in $g.100g^{-1}$ respectively. The energy values obtained were 109.23± 4.23 $Kcal.100g^{-1}$.

When the data obtained in this study is compared with data from Murdock *et al.*, (1981); Polan *et al*., (1985), Rogers *et al.*, (1986); NRC (1986) and Costa *et al.*, (1994) one van see that the content of total proteins, total fats and crude fiber is similar to the literature.

The carbohydrate content obtained for the brewers' spent grain ($1.89g.100g^{-1}$) is in agreement with the literature data, which indicates that brewers' spent grain is predominantly a fibrous material (Aliyu and Bala, 2011; Lima 2010; Robertson *et al.*, 2010; Mussato *et al.*, 2006) that is poor in fermentable sugars. In addition, the washing until exhaustion of this residue for the recovery of the brewing wort extract, reduces the sugar content to its minimum.

The differences between the values obtained in this study and the literature are perfectly understandable when one takes into account that the proximate composition of the brewers' spent grain is a function of several factors, such as: barley variety, harvest time, grains used in the malting process, and the technological process used in the brewery, among others.

The total protein values found in this study were lower than those reported by Lima *et al.*, (2006) for crude green corn, rice and peas, and higher than those reported for tomatoes, paprika, avocado, pineapples, cashews, jackfruit and custard apples. Brewers' spent grain was also superior regarding the crude fiber content, coming second only to avocado and green peas.

Despite the great application of brewers' spent grains in animal feed, it can also be used for human consumption. Because according to Dongowski *et al.*, (2012), the high fiber value and the protein and sugar residues turn these spent grains into potential ingredients for use in bakery products, such as breads and cookies, where an increase in fibers, in particular, could bring benefits to consumers from a nutritional and functional point of view. These authors analyzed and characterized a bread with 10% brewers' spent grain (which was subjected to a drying and milling process) and concluded that after the addition of the residue, the bread took on a dark color with the appearance of whole bread. It also became more acid because spent grain has an acid pH.

Mattos (2010) also worked with brewers' spent grain and characterized a bread with 30% brewers' spent grain (which was not subjected to a drying and milling process) and he concluded that after the addition of the residue, the bread took on an appearance and texture similar to whole bread.

According to Cabral Filho (1999), the high availability, continuous generation and physiochemical characteristics of brewers' spent grains from the manufacture of beer are factors that corroborate its potential use as human food. One should also consider that the reuse of this brewing residue contributes to environmental sustainability by giving a proper destination to it, adding social and nutritional value to human food because of the increasing demand for nutritious and healthy food.

The obtained results reveal that brewers' spent grains can be used as human food since it has a similar, and in some cases even superior, composition when compared with other food items commonly consumed by human beings.

IV. CONCLUSION

Understanding the chemical properties of food is of fundamental importance to assess the availability of nutrients and the best characteristics for processing.

Brewers' spent grain has a high water content, and is therefore conducive to microbial development and rapid deterioration. On the other hand, it showed to have similar ash, protein, carbohydrate, fat and crude fiber contents as other foods, and it could therefore be used in animal and human foods.

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