Development of Novel Added-Value Products, Using Brewers Spent Grain as Ingredient

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Abstract

In recent years many studies have shown that brewers spent grain (BSG), the major by-product of the brewing industry, is no longer regarded as waste but rather as a rich source of bioactive compounds. With a hypothesis that this by-product could be efficiently valorized in developing new added-value food products this study evaluates the content of BSG in several bioactive compounds and assessed their influence on enhancing the nutritional quality of a basic snack composition. The substitution of wheat flour with 10%, 20% and 30% ground BSG led to development of three breadsticks formulations with increased nutritional value (protein, fiber, lipid and minerals) and enhanced antioxidant properties, in a dose dependent manner. Also, the sensorial analysis revealed that, compare with a control sample, the prototype with 10% and 20% BSG had good organoleptic attributes and overall acceptability. The obtained results emphasize the great opportunity to reuse this by-product in developing innovative added-value food products.

Keywords: bioactive compounds, brewers spent grain, functional ingredient, phenolic compounds, waste valorization

Introduction

In recent years, the consumers' global demand for healthier food products is steadily increasing and the development of novel functional ingredients has become a focus of the food industry. In this respect, the innovations on the waste valorization and recovery of new functional ingredients from natural sources can be regarded as being one of the most important challenges that concern the scientific world (Helkar et al., 2016; Ravindran and Jaiswal, 2016).

The new aspects concerning the use of agro-industrial wastes as by-products for further exploitation in the production of functional food, additives or supplements must be environmental friendly and sustainable from the economically point of view (Femenia, 2007; Babbar et al., 2014; Mathias et al., 2014). Thus, Directive 2008/98/EC was implemented to promote a new approach to the waste management by prioritizing the prevention and reduction of waste generation, followed by processing for reuse and recycling, with disposal as the least favored possibility (2008/98/EC).

In the last years several technological advances have provided the industry large savings by optimizing the generation of by-products in the process (Galanakis, 2013). However, certain wastes such as brewers spent grain, residual yeast and trub remain inherent in beer production, avoiding their generation and even reducing them being almost impossible to achieve. Although several agricultural residues can be safely discarded in the environment, the

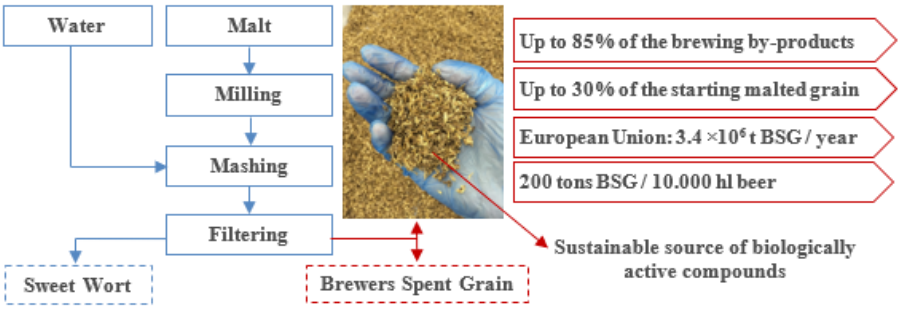

Figure 1. Brewers spent grain generated globally and the need to implement an efficient management

Table 1 Chemical composition of dried BSG and breadstick prototypes

Parameters	BSGd	BS 0%	BS 10%	BS 20%	BS 30%
Total polyphenols, mg GAE/100 g	204.08	5.72	20.16	32.42	40.88
Flavonoids, mg QE/100 g	27.21	1.08	1.09	1.18	1.22
Antioxidant activity, %	27.34	3.01	3.78	4.18	5.39
Proteins, %	17.76	6.04	6.9	7.31	7.92
Fibre, %	48.12	4.2	5.34	6.71	7.82
Minerals, %	3.92	1.08	1.16	1.29	1.36
Lipids, %	5.9	7.98	8.12	8.21	8.3
Hedonic test - overall acceptability	-	7.7	8.8	8.82	7.93

disposal of brewing residues in the environment results in a lot of inconvenience to the ecosystem, due to its significant nutritional value and high concentration of organic compounds that confers a high biochemical oxygen demand to the waste degradation (Robertson et al., 2010; Farcas et al., 2017; Mussato, 2014).

Brewers' spent grain (BSG) is the main by-product generated from the production of beer, many research studies already suggesting that cereal origin wastes represent a potential source of bioactive molecules, including proteins, polysaccharides, antioxidants, minerals, lipids and vitamins, components which remain unexploited in the brewing process. Therefore, the exploitation of BSG to develop innovative healthy products is a research direction of great interest which also can partially solve the problem of waste management (Niemi, 2012, Lynch et al., 2016; Spinelli et al., 2016; Ikram et al., 2017). Figure 1 summarizes the stage of the brewing process that produces the BSG by-product and the quantities generated.

With a hypothesis that this by-product could be efficiently valorized in developing new added-value food products, the objectives of the present study was to assess the chemical composition of BSG in several biologically active compounds and to evaluate its influence as food ingredient.

Materials and methods

The BSG used in this research was obtained as a by-product from the mashing process of dark lager beer with 100% all grain malted and supplied by a brewery located in Cluj-Napoca, Romania. Because of its initial high moisture content (about 75%), the amount of fermentable sugars, proteins and the presence of resident microflora, BSG is very unstable and susceptible to microbial degradation (Montusiewicz et al., 2017). In order to prolong its storage time, the fresh BSG was preserved by oven-drying at 78 ^{0}C for 12 h to reach a moisture content of 6% and to avoid a microbial degradation process. This common method reduces the BSG volume and maintains its chemical identity. Then, the dried samples were packed in sealed polyethylene bags and stored at room temperature until further analyses. All the solvents/chemicals obtained from Sigma Aldrich or Merck (Germany) were of analytical grade or high-performance liquid chromatography grade.

Three prototypes of breadsticks (BS), supplemented with 10 (BS 10%), 20 (BS 20%) and 30% (BS 30 %) BSG, were developed and analyzed in order to assess the contribution of BSG to the nutritional value. The proximate composition (protein, fiber, lipid, and minerals) was performed by near infrared spectroscopy, using a NIR FOSS 5000 system. The content in total phenolics (Folin-Ciocâlteu method), flavonoids (colorimetric

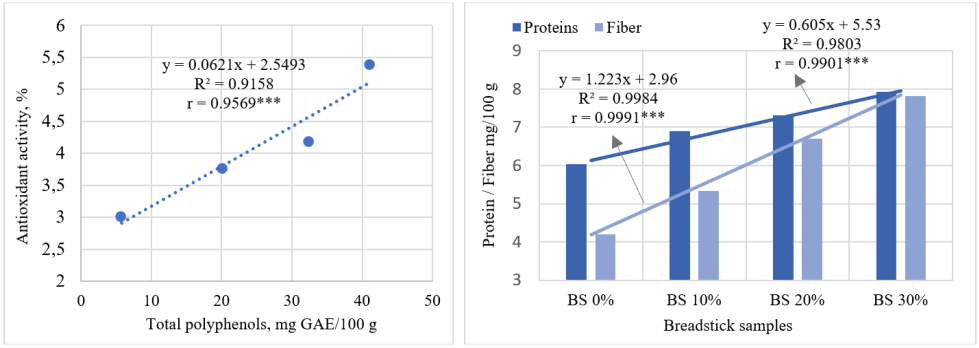

Figure 2. Pearson's coefficient for total polyphenol - antioxidant activity and Protein/ fiber – BSG percentage correlations (where $p < 0.05$)

method), antioxidant activity (DPPH assay), and consumer preferences (hedonic test) were also determined. A Pearson's correlation was run to assess the relationship between BSG percentage and the content in bioactive compounds of the breadstick prototypes.

Results and discussion

According to the obtained results (table 1), the BSG sample contain appreciable amounts of bioactive compounds (e.g. 17.76% protein, 48.12% fiber, 3.92% minerals) having as well good antioxidant activity (e.g. 204.08 mg GAE/100 g and 27.34% RSA).

Regarding the breadstick prototypes, the substitution of wheat flour with 10-30% dried BSG led to an increase in the nutritional value and antioxidant properties, in a dose dependent manner. Thus, compared with the control, the addition of 30% BSG increased the total dietary fiber level from 4.2 to 7.82% and the protein from 6.04 to 7.92%. Also, due to the presence of polyphenols, the antioxidant activity increased from 3.01 to 5.39%. As for the sensorial analysis, the most preferred sample was the prototype with 20% BSG.

As can be seen in Figure 2, the correlation coefficient obtained demonstrates the existence of a close, statistically significant link between the total polyphenol content and the antioxidant activity. The value of the correlation coefficient 0.9569 and the points clustered around the ascending slope indicates a direct and strong relation between these two parameters, with total polyphenols content explaining 91% of the antioxidant activity variation. The same pattern was also observed in the correlation between protein (r=0.9803) and fiber (r=0.9984) content and the percentage of BSG incorporated in the breadstick composition. In both cases were obtained strong positive correlations, with BSG percentage explaining 99% of the variation in protein and fiber content of breadsticks.

Following the obtained results it can be stated that an increase of BSG addition in breadsticks formulation led to a significant increase of the nutritional value. These results are also sustained by other studies in which the addition of BSG into dough formulation has shown to significantly improve the dietary fiber, protein, minerals and other bioactive compounds of the final products (Maneju et al., 2011; Ktenioudaki et al., 2013, Farcas et al., 2014).

Conclusion

The main objective of the present study was to assess the chemical composition of BSG in several biologically active compounds and to evaluate its influence as food ingredient.

The obtained results regarding the BSG composition and its influence on the tested prototypes emphasize the great opportunity to reuse this by-product in developing innovative added-value food products.

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