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A critical review on the topic of Brewer's spent grains (BSG)

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Abstract
Brewers spent grain is one of the by-products produced during the brewing process in brewery industry. It is made out of the solid barley grain husks left behind after wort production. It is accessible in large quantities but its use is limited to animal feed only. But it has high nutritional value, it is rich in dietary fiber and protein content, so it can be used for fortification of food. Its fiber content ranges in between 40-50% and its protein content ranges 20-30%. BSG contain health promoting bioactive substances in good amount which can be benficial for both human and animal purpose.

Keywords: Brewer's spent grains, by-products, brewing process, brewery industry

Introduction
Brewer's spent grain is one of the most extensive by-products produced during the process of brewing, accessible in large quantities (which contributes about 85%) and at a low cost across the year. It is a lingo-cellulosic material made up of around 28% non-cellulosic polysaccharides, mostly arabinoxylans, 17% cellulose, and 28% lignin. It contains 21-29% crude protein on a dry matter basis and is less expensive than rice bran and coconut oil cakes, is one such alternative source (Muthusamy, 2014) [11].
According to Dong *et al*. (2003) [3] it contains, dry matter content ranging from 26 to 31%. BSG holds 75-80% water and deteriorate quickly due to the growth of bacteria, yeasts and fungi. It is necessary to use them as early as possible after getting them and to ensure that they are in good working condition before doing so. (Dong *et al*., 2003) [3]. According to Dong *et al*. (2003) [3] the crude protein values ranged from 23.4 to 27.4%. There were reports of higher (30.1%) and lower (20%) crude protein values. The ether extract content of brewers spent grain was 10.6% (Senthilkumar *et al*., 2010) [13]**.** According to Dong *et al*. (2003) [3] the total ash content of BSG ranges from 3-5%. According to Senthilkumar *et al*. (2010) [13] the acid insoluble ash content was 4.42%. According to Senthilkumar *et al*. (2010) [13] the cellulose and hemi-cellulose contents of brewery spent grain was 13.14% and 29.96%, respectively. According to Senthilkumar *et al*. (2010) [13] the lignin content of brewers spent grain was 7.12%, which is higher to the value of 4-5%. High concentrations of calcium, magnesium, silicon, and phosphorus were observed, with values of 1y 038.5, 687.5, 242, and 1977 ppm, respectively, while other minerals found in BSG (such as iron, manganese, cobalt, copper, selenium, sodium, potassium, and sulphur) had lower concentrations. (Khildzir *et al*., 2010). Vitamins include (ppm): choline (1800), biotin (0.1), folic acid (0.2), pantothenic acid (8.5), niacin (44), riboflavin (1.5), thiamine (0.7) and pyridoxine (0.7) (Khildzir *et al*., 2010) and (Essien *et al*., 2008) [4].
BSG is available in large quantity all year, but its basic use has been limited to animal feed. It does, however, serve as an appealing supplement in human nutrition as it has high proportion of protein and fibre content (approx 20 and 70% on dry basis, respectively) (Mussatto *et al*., 2006) [10]. It degrades quickly due to its high moisture (> 70% w/w) and fermentable sugar content. In this sense, drying can improves the use and marketability of BSG as a feedstock. Other applications of BSG necessitate a certain level of drying. Plants for drying BSG are now available. The procedure consists of two steps: pressing (to obtain a material with a humidity less than 65%) and drying (to obtain a material with a humidity less than 10%) (Santos *et al*., 2003) [14]. Due to high nutritional value, BSG has potential for use in many applications and fortification of human food products, particularly given its low cost and widespread availability. It can be used to fortify food products and to increase its nutritional value.
The issues concerned with brewing industry are:

1. Large amount of waste produced
2. Low cost
3. Difficulty in storage
4. Landfill disposal

BSG is generated in a very high amount in brewing industry and the cost of this by product is low. It has high moisture content due to which its storage is difficult and it also gets spoiled easily. Usually BSG is disposed in landfill and burned to lack of knowledge of its nutritional value which leads to environmental pollution.

Extraction of Brewers Spent Grains

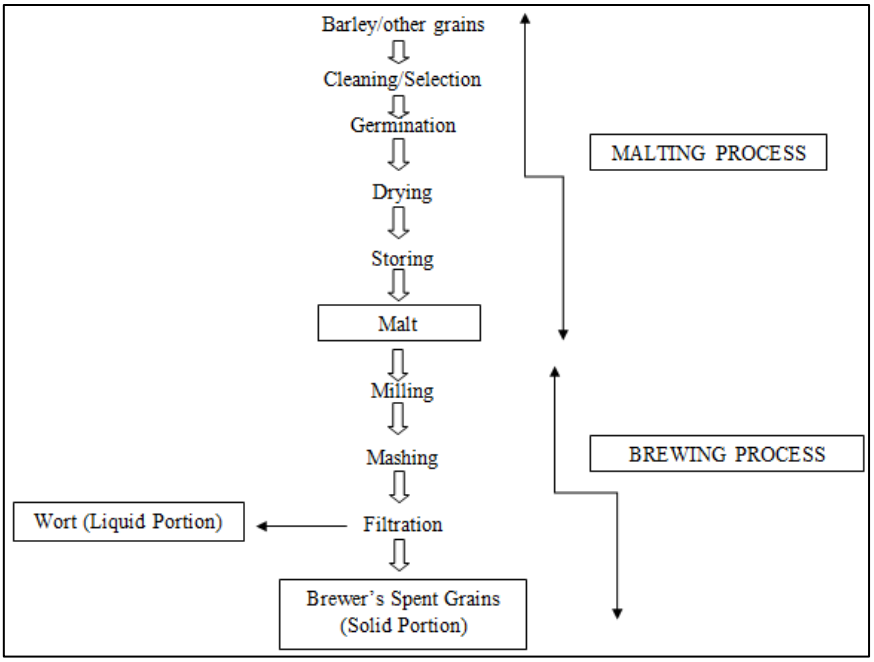

Fig 1: Schematic representation of the process to obtain BSG from natural barley. (Mussatto *et al*., 2006) [10]

Applications

Agro-industry operations usually generate a significant amount of biological content. As a result, recycling agricultural by-products is a significant problem for a circular economy. One of the most serious environmental issues is the waste by-product generated by the food and beverage industries. Brewery, for example, is one of the most significant environmental concerns in the beverage industry. The last of these is the most important by-product in the brewing process is BSG, which accounts for 85% of all by-products (Assandri *et al*., 2021) [2].

BSG is rich in cellulose, lignin, hemi-cellulose, dietary fiber and protein. Because of its high content of fiber and protein, it can be used for animal feed and fodder. However, because of its high nutritional value, BSG is of interest for food industries application due to enrichment of fibres and proteins industries can easily use BSG to make various fortified and value-added products. BSG also includes a variety of nutrients as well as health-promoting bioactive substances (Lynch *et al*., 2016) [7].

BSG is now widely regarded as one of the most plentiful and low-price brewing by-products, with considerable potential as a practical food ingredient. BSG can be used as a raw ingredient in bakery products because it is high in dietary fibre and protein. However, wheat flour with fortification of BSG can alter dough rheology as well as product structural and sensory properties (Amoreillo *et al*., 2020).

BSG flour was enriched with three industrial soft wheat flours and to create new baking product compositions at various levels (0%, 5%, and 10%) (bread, pizza and breadsticks). The enrichment resulted in a substantial increase in dietary fibres, lipids, proteins and ash in proportion to the BSG enrichment amount, as predicted. Considerable changes in the colour of the crumb and crust of bakery products were also identified, as well as alterations in dough rheological properties (e.g., lower production time and stability, higher water absorption, dough strength, and tenacity). Finally, the market test revealed that the proposed bakery items with 5% BSG supplementation had a higher overall acceptability (Amoreillo *et al*., 2020).

Cooking and baking may also be done with spent grain. The grain may be used either wet (after as much liquid as possible has been squeezed out of the grain) or dried and ground into flour. Variety of spent grain bread, crust, and baked sweets like cookies and brownies can be produced (Nick Carr., 2015) 12[]. Wet spent grain can be used in small amounts to add flavour and texture to bread and other baked goods. In most traditional ovens, drying it can take several hours. Preheat the oven to the lowest possible temperature, normally about 170°F. Spread spent grain at a thickness of around half an inch on a cookie sheet. Place the grain in the oven with the door slightly cracked to allow moisture to escape (Nick Carr., 2015) [12].

The phenolic (e.g. hydroxycinnamic acid) and fibre (e.g. glucans) components of BSG are the most valuable in terms of possible health benefits. In contrast to other cereal products, BSG's protein fraction is of interest because of its relatively high lysine content (an essential amino acid) (Lynch *et al*., 2016) [7].

Because of its high phenolic acid content, BSG has established itself as a reliable source of natural phenolic acids. Because of its antiallergenic, antioxidant, anti-inflammatory, and preservative properties, ferulic acid has a variety of uses, while p-coumaric acid has chemoprotectant and antioxidant

properties. There is emerging evidence that these phenolic acids appear to have anticarcinogenic properties, in addition to their promising antioxidant properties (Ikram *et al*., 2017) [5].

BSG has a huge potential to use as a raw material/food product due to its favourable chemical structure, which contains approximately 70% and 20% fibre and protein, respectively. For ruminants, BSG is a key component. BSG can provide all of the essential amino acids to ruminants when incorporating with low-cost N sources like urea. The impact of BSG on dairy cattle milk yield and composition, as well as blood components, has been investigated (McCarthy *et al*., 2013) [9].

Due to its high quantity of indigestible protein and water-soluble vitamins, BSG has a poor commercial value and is typically sold as a by-product for livestock feed. Since wet BSG includes a lot of water (75–80%) and transportation can be expensive, it must be used near to the plant that makes it. Therefore, it is normal practise to dispose of BSG in landfills, which, if unchecked, might cause environmental issues. However, animal farmers in locations with poor water quality and supply may find the water it contains to be quite helpful (Xiros *et al*., 2012) [15].

Various applications of BSG are – due to its physicochemical properties it can be used for making of building material. It can be used as a raw material in paper industry because of its high fibrous content and low amount of ash. Charcoal bricks can also be produced from BSG.

Conclusions

Efforts are increasing to reuse the biodegradable waste to produce many beneficial products. BSG is obtained during beer production in brewing industry. BSG has high nutritional value, still its use is restricted to animal purpose. On the basis of nutritional point of view, BSG is rich in dietary fibre and protein which makes it suitable for human consumption and fortification of food products. It also has various applications in industries such as in building material manufacturing, paper industry and charcoal bricks production.

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