Using unconsumed bakery products to produce top-fermented beer

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Abstract

The present paper focuses on matters related to gastronomic waste management by circular practices. Selected types of bakery returns were used as a substitution, i.e. a partial substitute for malt in beer production, to reduce the amount of bakery waste while obtaining a beer with an unusual taste profile. Eight batches of top-fermented Brown Ale and Porter were prepared with malt substitution (ranging from 10% to 80%) and two control batches using malt only. Subsequently, analysis and sensory evaluation of the prepared beers were carried out. The best rating was achieved by the sample in which 30% of malt was substituted with wheat-rye bread.

Keywords Food waste, bakery waste, beer, top-fermented beer, substitution with bread

1. Introduction

Worldwide, around 1.3 billion tonnes of food are wasted every year. The most common reasons are e.g. the use of inappropriate production technology, improper storage or the use of unsuitable packaging material [1]. There are also estimates that one-third of the food produced globally is not consumed [2]. Food waste leads to a loss of resources that are invested in the whole chain – such as energy and water, as well as soil, fertilisers and other materials, or, more generally, everything that is used in the production, transport and storage of food products. Over time, these facts can have various negative environmental impacts, such as global climate change, soil acidification and water eutrophication [3]. Equally clear are the impacts in the economic sphere. This problem has been recognised by the United Nations in the Sustainable Development Goals (2015). Specifically, the 'sustainable consumption and production patterns' goal includes its sub-goal 12.3 which aims to halve food waste at the consumer and retail level and reduce food losses in production and supply chains. Waste prevention is always a step that should precede alternative uses such as material and energy recovery. A material that is wasted in one industry can find a use as a raw material in another industry and thus cease to be waste. A specific and realistic example involves the use of bakery returns as an additive in beer production.

Beer is one of the most widely used beverages on earth and also one of the oldest fermented beverages [4, 5]. In 2003, global beer consumption exceeded 1.4 billion hl. [6] its quantity increased to 1.91 billion hl in 2019 [7, 8]. Beer is a fermented, slightly alcoholic, bitter-tasting beverage produced in a brewery by fermenting grain mash. The basic raw materials for beer production are cereal malt, water, hops and microorganisms – brewer's yeast. Malt is a grain germinated and dried under specific technological conditions, prepared from barley in classic recipes, making this particular grain one of the key raw materials in the brewing industry. In the 2020/2021 financial year, 159.74 million metric tons of barley were produced worldwide [7, 8]. Barley – more specifically barley malt – is the main ingredient in beer production, which has a large environmental impact due to the loss of energy and water during maturation and the production of carbon dioxide during transport to the point of use [9, 10]. For example, in Australia, approximately 1,200 m^3 of water is consumed by each hectare of barley. Studies conducted by ([11]) showed that the production of beer from bakery returns has environmental savings in the global warming category, which is the result of replacing malted barley with returned bread.

They are [12] conducted an assessment of food waste treatment options under six scenarios (landfilling, incineration, composting, anaerobic digestion, animal feeding and donation) for five foods: bananas, grilled chicken, salads, beef and bread. The results of the study showed that bread has the greatest potential for reducing greenhouse gases.

In the past, especially during economic crises, various sugary and starchy malt substitutes were used to reduce production costs. Today, we can use this to our advantage to reduce the amount of bakery waste from gastronomy. At the same time, however, it is known that brewing beer, like baking bread, is an ancient process. There are many theories about how the brewing of beer began, and what ingredients were used for the process. Some historical sources suggest that beer was made from bread at the beginning of the existence of the beverage and only later did malt start to be used. Due to the yeast content of the bread, the fermentation process began [13]. Also in some Slavic countries, there is an ancient drink called *kvas*, which is made from bread, water and sugar, also with or without yeast. It is necessary to distinguish what is termed kvas and what is termed beer. Kvas is a non-alcoholic beverage that has a different production technology than beer [14].

Beer is one of the food commodities in the production of which it is possible to effectively recycle unused goods in the form of baked goods, more specifically bakery returns. The substitution of malt with returned bread in the beer industry causes a reduction in the amount of discarded unused bread.

The objective of our approach was to replace malt with unconsumed bread. The research focused on the sustainable use of bakery remnants through beer production technology to reduce food waste. The work aimed to test the preparation of beer in a small university brewery using bread as a malt substitute. Therefore, the usual technological procedure for beer production was followed. How the objective was achieved and to what level of success the unconsumed bread was used were subject to evaluation through the sensory properties of the beer, more specifically by comparing the taste characteristics of a typical beer with those of a beer where part of the malt was replaced by bread during production. Samples of top-fermented beers (Brown Ale and Porter) were prepared for this study as there are more opportunities to mask undesirable tastes in this type of beer.

2. Raw materials and methods used

Three batches of Brown Ale, 4.5% alcohol (Figure 1), were prepared for pilot tests along with five batches of Porter, 4.5% alcohol (Figure 2); the volume was 10 litres per batch.

2.1 Raw materials

Water from the water mains was used as brewing water; its quality complied with the parameters for drinking water set out in Decree No. 252/2004 Coll. of the Czech Republic [15].

The main ingredients for the malt wort were a blend of malts Finest Pale Ale Maris Otter, Red Active and Caramel Mahogany, Pale Ale, Roasted Chocolate Wheat and Brown malt (Figure 1 and 2). Unconsumed bakery products involved wheat-rye bread of the *Šumava* type.

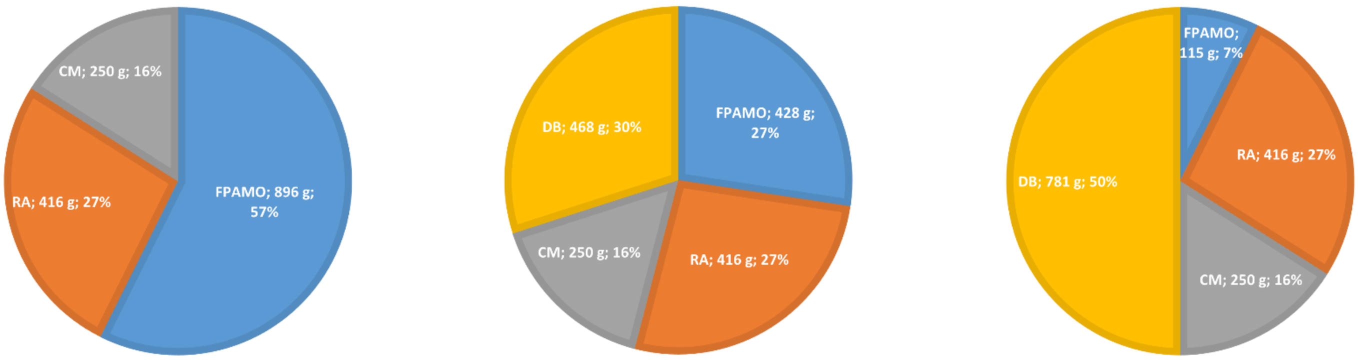

Figure 1: Bread to malt ratio (00:100, 30:70, 50:50; sample 1-3) for the production of Brown Ale. Where FPAMO is Finest Pale Ale Maris Otter, RA is Red Active, CM is Caramel Mahogany and DB is dry bread. That's a total of 1,562 g.

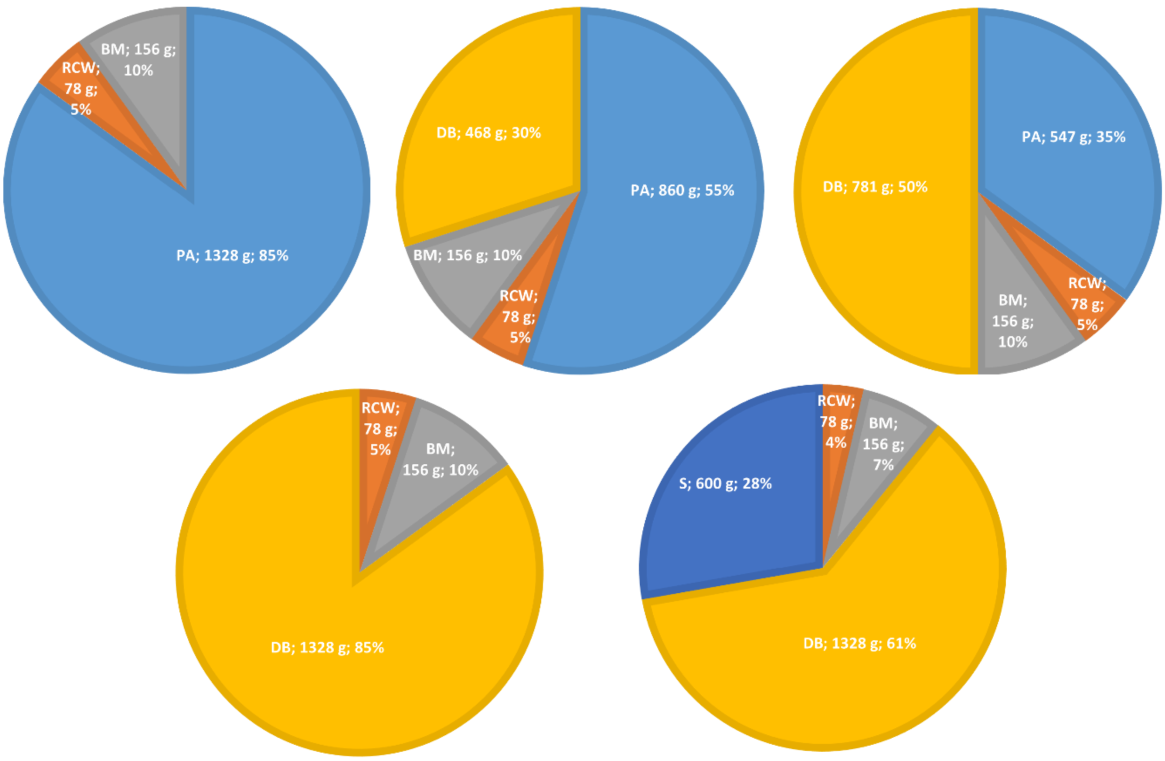

Figure 2: Bread to malt ratio (00:100, 30:70, 50:50, 80:20, 80:20; sample 4-8) for the production of Porter. Where PA is Pale Ale, RCW is Roasted Chocolate Wheat, BM is Brown Malt and S is sugar. That's a total of 1,562 g.

The hop pellets used for hopping were Bramling Cross hops with 6.5% α-acid content and Chinook hops with 13% α-acid content. Yeast type: top-fermenting, Safale S-04 brand. Safale S-04 yeast was used for the production of top-fermentation beer because of its speed of fermentation, high sedimentation rate and clearer final beer.

2.2 Brewing procedure

The crushing was done after the malt and bread were added to the brewing water at the temperature of 40 °C for 10 minutes. This was followed by mashing in an electric pot DOMO DO42326PC where the temperature was raised to 52 °C, with a 10 min delay; then raised to 62 °C with a 30 min delay and finally raised to 72 °C with a 40 min delay. To verify saccharification, an iodine test was carried out and after complete saccharification, the temperature was raised to 85 °C with a delay of 5 min. The wort was filtered using a lautering vat. The subsequent wort boiling was conducted under boiling conditions for 70 minutes. After this process was finished, aromatic hops were added and the wort was left to stand for 20 minutes. During pumping into the fermentation vat, the wort was filtered through a fine-mesh strainer and cooled down to 18 °C. Fermentation at 18 °C followed the addition of the yeast. After the main fermentation stage, the beer was bottled with an addition of 3 g of glucose per litre to carbonate the beer. The maturation stage was underway at 12 °C for 14 days.

2.3 Physical and sensory assessment

The methodology of the sensory analysis was performed according to ČSN ISO 6658. The sensory panel consisted of ten participants (2 females, 8 males, age range = 20 – 46 years). The beer tasting stage took place in a tasting room at a temperature of 18 °C. The beer was cooled down to 7°C before the tasting started. The quantity poured for the evaluation was 150 ml. The sample was poured into the middle of a glass jar made of colourless clear glass. After the beer was poured into the glass, the basic aroma was evaluated, and then after each sip, the other parameters were evaluated in turn. In the process, participants were completing a sensory evaluation form, which was made according to Cuřín [16] with minor modifications. According to [17], the quality of the head involves head stability, quantity, adhesion, whiteness, creaminess and firmness. The quality of the head was assessed by measuring the head stability in a 150 ml sample of beer, using a ruler and measuring the time for the head to disappear. The beer colour tint was analysed by spectrophotometer at a wavelength of 450 nm. The results are shown in SRM (Standard Reference Method; SRM = 12.7 × D × A_{450}), where D is the dilution factor (D = 1 for undiluted samples, D = 2 for 1:1 dilution, etc.), A_{450} = absorbance of light at 450 nanometres in a 1 cm cuvette). We examined alcohol content on the device for the automatic analysis of beer Funke Gerber FermentoFlash.

3. Results and discussion

Since sample 7 was found to be contaminated with mildew after fermentation, the physical and sensory parameters of this sample were not evaluated.

The results of the evaluation of the physical parameters of the beer and their values are given in Figures 3 – 5. The results of sensory panel and chemical composition of the beer are shown in Figure 6 – 8.

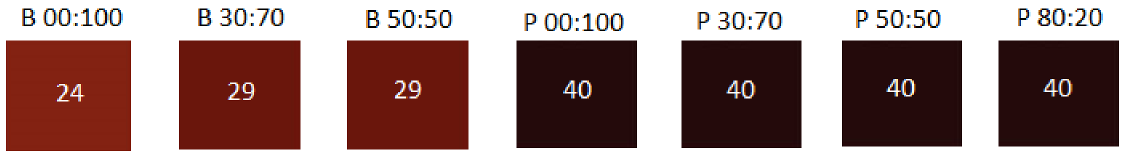

Figure 3: Beer colour measurement results. SRM methodology. Where B is Brown Ale and P is Porter

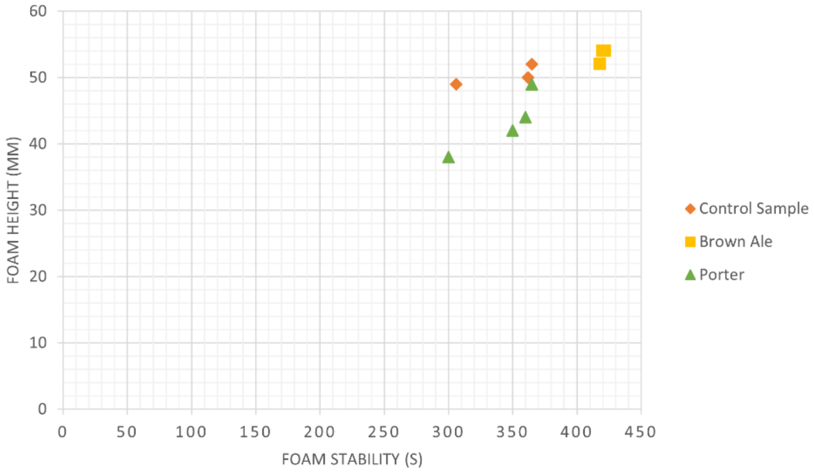

Figure 4: Head stability measurement results.
Brown Ale (00:100 – 54 mm, 420 s), (30:70 – 54 mm, 422 s), (50:50 – 52 mm, 418 s).
Porter (00:100 – 44 mm, 360 s), (30:70 – 42 mm, 350 s), (50:50 – 49 mm, 365 s), (80:20 – 38 mm, 300 s).
Control sample (malt beer 1 – 52 mm, 365 s), (malt beer 2 – 50 mm, 362 s), (malt beer 3 – 49 mm, 306 s)

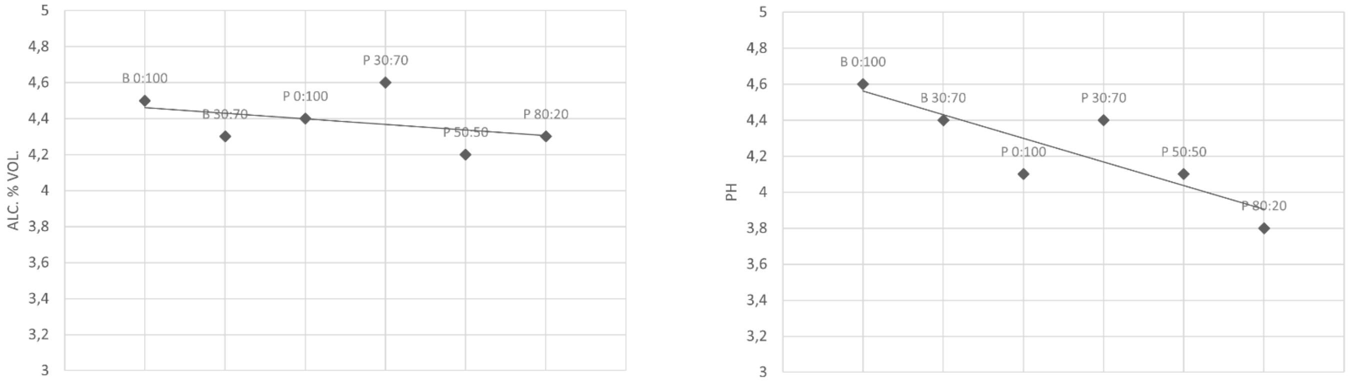

Figure 5: Alcohol and pH measurement values. We examined alcohol content on the device for the automatic analysis of beer Funke Gerber FermentoFlash. The level of pH was determined at 25 °C. B is Brown Ale and P is Porter.

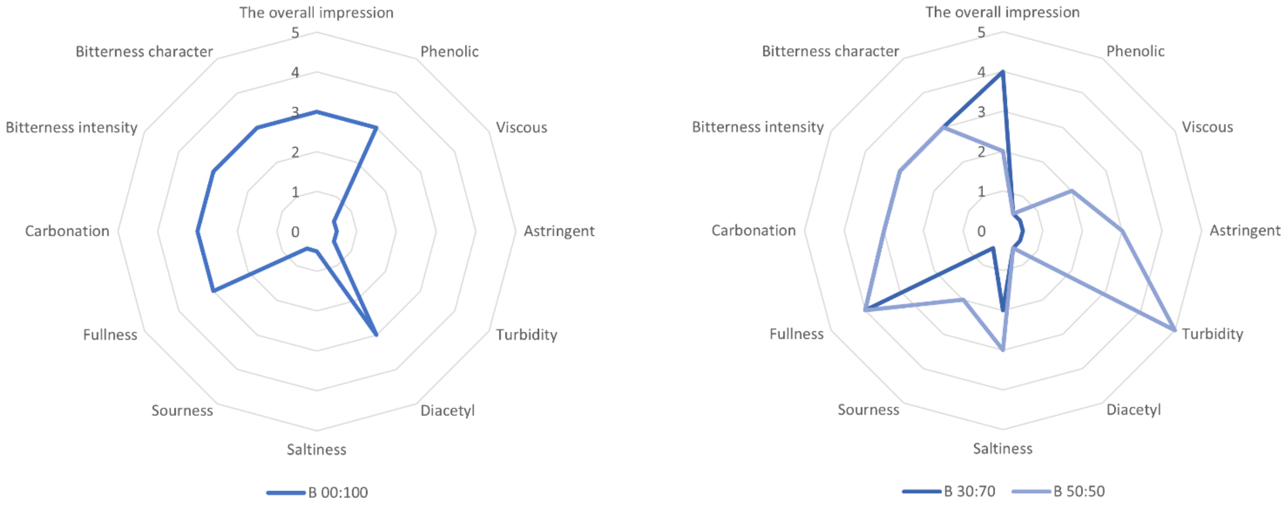

Figure 6: Sensory profile of Brown Ale. Where B 00:100 is 100 % of malt and B 30:70, B 50:50 with the use of bread

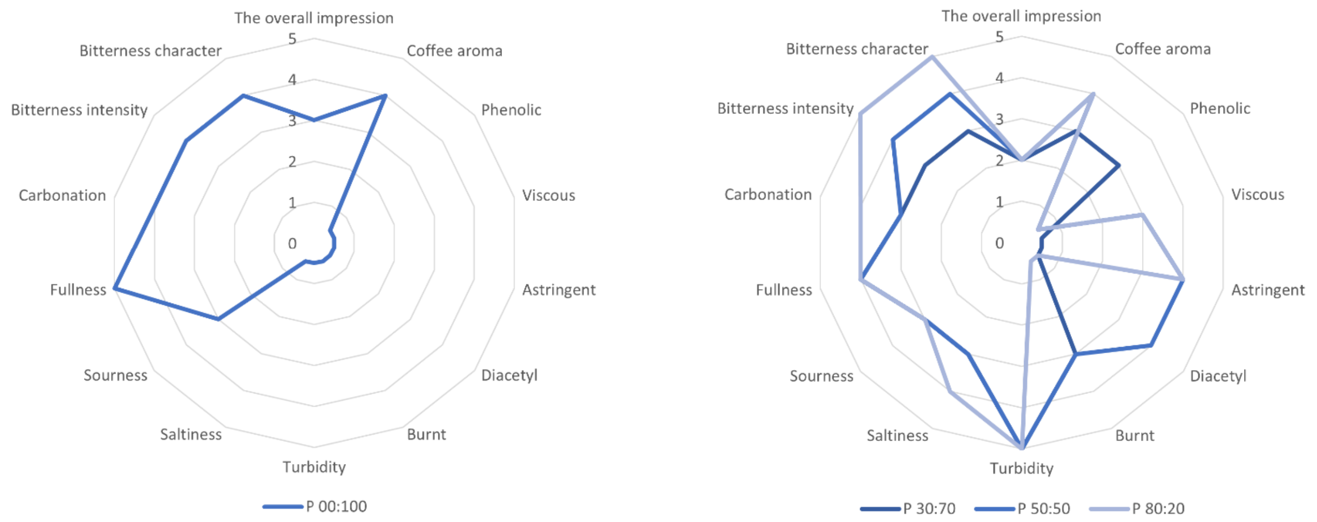

Figure 7: Sensory profile of Porter. Where P 00:100 is 100 % of malt and P 30:70, P 50:50, P 80:20 with the use of bread.

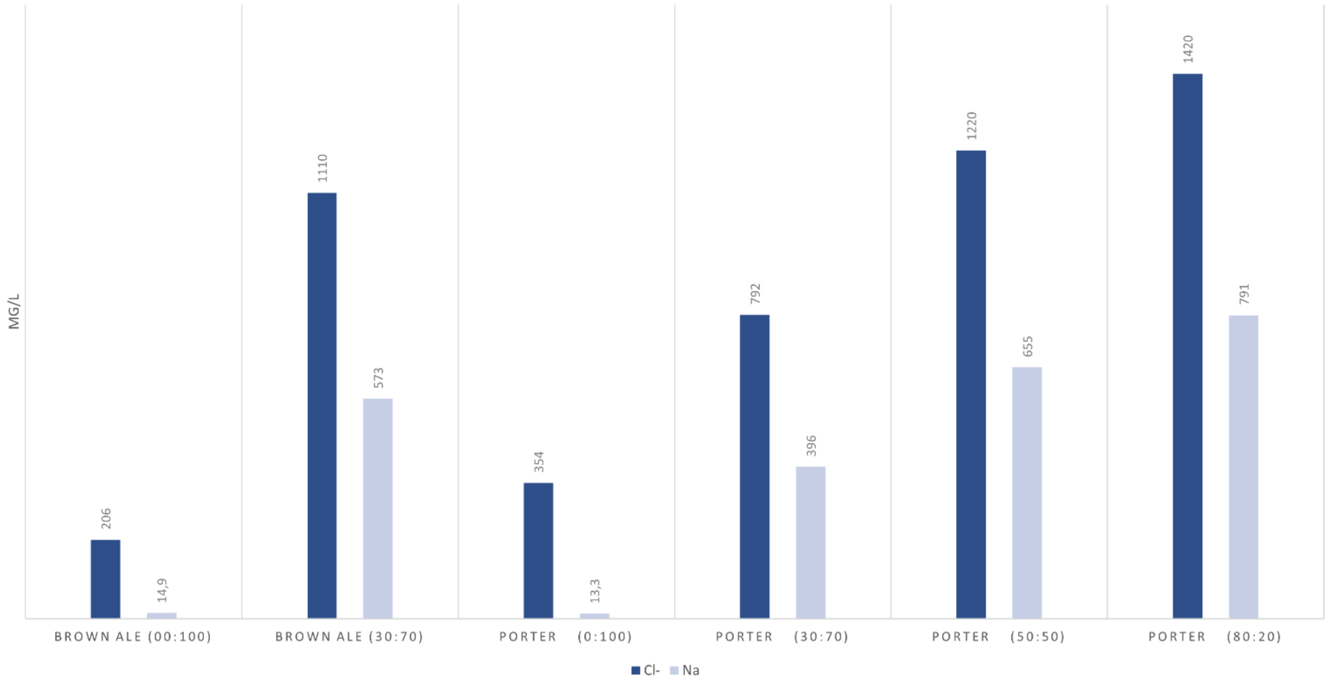

Figure 8: Chemical composition measurement values. We used ICP-MS Agilent Technologies 7700 for Na evaluation and HPLC method for Cl- evaluation.

For the final Brown Ale, the colour was a bit darker than a typical Brown Ale, which was more likely due to the mahogany caramel malt. We, therefore, recommend using mahogany malt in smaller quantities.

For beers with bread as a substitute, the head is comparable to that of the purchased ones assessed and is stable. For Brown Ale beers, the head height is larger than for Porter beers; this may be due to the larger amount of hops used in Brown Ale [18].

For all the Porter beers, the head was a deep white colour, while the head of the Brown Ale was slightly pinkish due to the addition of red and caramel mahogany malts. The head of both beers can be described as creamy and stable enough.

The bitter, astringent taste may indicate that polyphenol substances – oxidation products of bitter substances – may be present in the beer.

Phenols affect the taste, aroma, colour and colloidal/head stability; they also reduce the shelf life of beer. The main phenolic compounds are phenolic acids, tannins, flavones and flavonols [19]. Phenols have a variety of tastes and aromas: "stable", "barnyard", "horsey", "leathery", "smoky", "spicy", "clove", "medicinal" etc. [20]. Aroma-active esters are synthesized by yeast during fermentation. Esters add a fruity taste to the beer. The amount of esters depends on the yeast species and the fermentation temperature [21]. However, no unsuitable or disturbing tastes were found in any of the samples.

The slightly bitter to burnt taste of the beer comes from roasted malt or bread. Also, the large quantity of roasted and brown malt caused the sharp taste of the coffee. In pilot trials, some of the resulting beers showed increased viscosity and noticeable saltiness. We can see increased sodium chlorine values in beers with bread (Figure 8). In Porter's 80:20 sample, the pH is significantly decreased. Porter (0:100) had a lower pH than Brown Ale (0:100) due to the roasted malt used in Porter (Figure 5). The presence of bread did not affect the alcohol content of the beer (Figure 5).

Samples of top-fermented beers (Brown Ale and Porter) were prepared for this study as there are more opportunities to mask undesirable tastes in this type of beer. In previous studies [22], we brewed lager from the returned bread. The beer with a higher percentage of bread had a salty and diacetyl taste. However, starting to use roasted and special malts has satisfactorily resolved this issue.

4. Conclusion

The study aimed to replace part of the barley malt with unconsumed bread in the preparation of beer. Returned bakery products were used as a partial substitute for malt in the production of beer, which aims to reduce the amount of bakery waste. Preparing top-fermented beer can mask the unusual taste of the beer, which, for example, would not be desirable in a lager-type beer. Eight batches of top-fermented Brown Ale and Porter were prepared with malt substitute levels from 10% to 80%, and two control batches without the use of a substitute. Physical analysis and sensory evaluation of the prepared beers were carried out. The best rating went to the beer with 30% malt substituted by bread, while the second place went to two control samples of Brown Ale and Porter without the use of a substitute. Beers with a large amount of bread, more specifically, those containing over 30%, were rated the worst. At the same time, it is not advisable to replace the malt with more than 30% bread, so that the beverage prepared also remains a beer beverage in terms of terminology. Compared to control samples without the use of substitutes and commercial beers, the head of the beer with bread as the substitute was comparably stable. The colour of the prepared Porter was consistent with the canonical Porter, while the colour of the Brown Ale was slightly darker than the typical Brown Ale, which was more likely due to the mahogany caramel malt.

Opportunities for direct recycling of bread are limited in the food industry, mainly due to the relatively short shelf life of bread and hygiene requirements. The possibilities for the use of this raw material, as well as the way it is collected, clearly vary from one country to another and cannot be generalised at present. Yet the presence of pure and high-quality fermentable sugars, proteins and other nutrients makes bread an ideal substrate from which to ferment new foods.

Poděkování

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Využití pekárenských vratků při přípravě svrchně kvašeného piva

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Abstrakt

Práce je zaměřena na problematiku související s oběhovým hospodářstvím gastronomických odpadů. Vybrané druhy tzv. pekárenských vratků byly použity jako surogace, tedy částečná náhražka sladu při výrobě piva, a to s cílem snížit množství pekárenských odpadů a současně získat pivo nevšedního chuťového profilu. Bylo připraveno osm šarží svrchně kvašeného piva typu Red Ale a Porter s náhražkou sladu v rozmezí od 10 do 80 %, a dvě srovnávací šarže připravené pouze za použití sladu. Následně byly provedeny analýzy a senzorické hodnocení připravených piv. Nejlepšího hodnocení dosáhl vzorek se surogací 30 % sladu pšeničnožitným chlebem.

Keywords *gastronomický odpad, pekárenské vratky, svrchně kvašené pivo, surogace*