https://doi.org/10.15255/KUI.2024.060
KUI-26/2025
Original scientific paper
Received December 21, 2024
Accepted February 21, 2025

Use of Brewers' Spent Grain as an Emerging Protein and Fibre Source in Ćupter

A. Lalić,[a*] *A. Karlović*,[a] *J. Pleadin*,[b] and *M. Marić*[c,d]

[a] University of Mostar, Faculty of Agriculture and Food Technology, Biskupa Čule bb, 88 000 Mostar, Bosnia and Herzegovina
[b] Croatian Veterinary Institute, Savska cesta 143, 10 000, Zagreb, Croatia
[c] Herkon d. o. o. Mostar, Biskupa Čule bb, 80 000 Mostar, Bosnia and Herzegovina
[d] University of Mostar, Faculty of Science and Education, Department of Chemistry, Matice Hrvatske b.b., 88 000 Mostar, Bosnia and Herzegovina

Abstract

This study aimed to evaluate the physicochemical properties and nutritional composition of traditional Ćupter prepared solely with semolina (*i.e.*, the control sample) and compare it to Ćupter samples prepared with varying proportions of brewers' spent grain (BSG) as a replacement for semolina. The physicochemical and nutritional parameters analysed included pH value, water activity, water content, ash content, fat content, protein content, carbohydrate content, total sugar content, crude fibre content, salt content, and energy value. Six samples were prepared, of which two were traditionally prepared *Ćupter* samples (control samples) made with white or red must and semolina. The remaining four samples were prepared with white or red must, different ratios of BSG, and semolina. The results showed that the modified Ćupter had improved nutritional value, with a statistically increased ($p < 0.05$) protein and crude fibre content. Samples 5 and 6, containing 125.5 g of BSG had higher protein and crude fibre content compared to samples 3 and 4, which contained 25.5 g of BSG, and especially in comparison to the traditional samples 1 and 2, which contained no BSG.

Keywords

Ćupter, brewers' spent grain, red grape must, health benefits, traditional products, solar drying

1 Introduction

Traditional food is integral to the identity, culture, and culinary heritage of nations, passed down through generations. Interest in traditional foods remains strong among producers, consumers, and policymakers. Anders and Caswell highlighted the benefits and challenges of geographical labelling, particularly for developing countries.[1] Similarly, *Caputo et al.*[2] explored the relationship between traditional foods and consumer preferences. In Europe, traditional foods can obtain designations like Protected Designation of Origin, Protected Geographical Indication, or Traditional Speciality Guaranteed, *per* legislation ensuring authenticity and uniqueness.[3] These products must meet criteria related to traditional ingredients, composition, or production methods, as detailed by *Trichopoulou et al.*[4] An example from Herzegovina is *Ćupter*, produced in the Brotnjo area for centuries. Resembling jelly or gummy candy, it is made by boiling grape must from Herzegovinian grape varieties, such as Žilavka and Blatina, with flour or semolina as a gelling agent and then sun-drying.[5,6] Traditional sun drying, reliant on September weather, poses challenges like mycotoxin development and microbial growth during adverse conditions.[7] Researchers, including Betül[8] and *Lalić et al.*,[5] have proposed alternatives like solar drying and lyophilisation. Innovations, such as incorporating brewers' spent grain (BSG), aim to enhance production efficiency and quality. BSG offers numerous bioactive compounds, including ferulic and *p*-coumaric acids with antioxidant, anti-inflammatory, and antimicrobial properties.[1] It serves as a lignocellulosic substrate for producing value-added products like laccase enzymes and polyphenols.[9] BSG is rich in vitamins (*e.g.*, folic acid, niacin)[10] and minerals (*e.g.*, calcium, magnesium).[11,12] Its amino acid profile includes histidine, glutamic acid, and valine, with a high lignin content compared to rice straw or sugarcane bagasse.[13] Arabinoxylan in BSG exhibits probiotic effects, boosting *Lactobacillus* and bifidogenic levels during in vitro trials.[14,15] Given its nutritional and functional properties, a Ćupter modified with BSG could be classified as functional food, as described by *Lalić et al.*[16] Functional foods enhance health and may reduce disease risk.[17] This study investigates the physicochemical properties and nutritional composition of Ćupter and evaluates the impact of BSG incorporation on its nutritional value compared to traditional preparation methods.

2 Experimental

2.1 Raw materials

For the preparation of both traditional and modified Ćupter, BSG was obtained from the local brewery *Trojanska pivovara*, Čapljina. Semolina (*Franck*, Zagreb, Croatia) was bought from a local market, while grape must was purchased from *AgroOdak d. o. o.* Čitluk, Bosnia and Herzegovina. The must used for Ćupter preparation was derived from two autochthonous grape varieties, Žilavka (white)

* Corresponding author: Assoc. Prof. Anita Lalić, PhD
Email: anita.juric@aptf.sum.ba

and Blatina (red). Chemicals of analytical purity were used for the nutritional composition analysis.

2.2 Ćupter preparation

The process of Ćupter preparation is very simple. It begins with crushing the grapes, followed by filtration to obtain fresh juice free from grape skins. The grape juice was then cooked, and once it reached boiling point, semolina and/or flour were added. This process was followed by stirring the mixture continuously until a gelatinous consistency was obtained (Fig. 1). The thickened samples were then poured into small containers (20 cm in diameter, 2 cm in height) and left to cool at room temperature for 8 h.

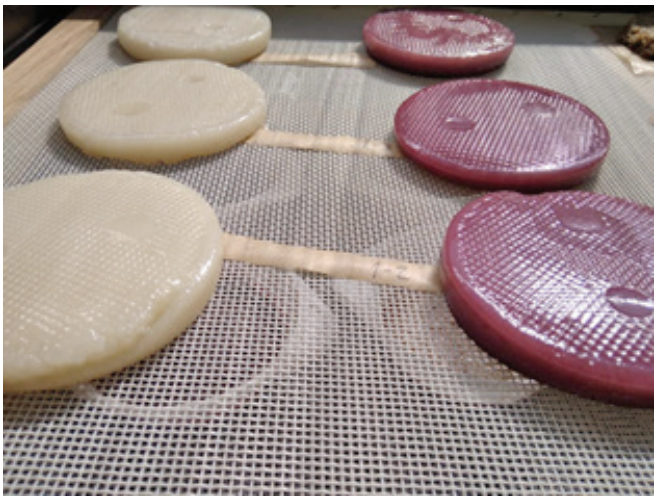

Fig. 1 – Samples of traditional red and white Ćupter solar-dried at the Faculty of Agriculture and Food Technology of the University of Mostar
Slika 1 – Solarno sušenje uzoraka tradicionalnog crvenog i bijelog ćuptera osušenog na Agronomskom i prehrambeno-tehnološkom fakultetu Sveučilišta u Mostaru

For this study, traditional Ćupter was prepared using semolina and must (samples 1 and 2). Modified Ćupter was prepared by partially replacing semolina with BSG (samples 3–6). Table 1 presents the recipes for each sample, along with the cooking time, and the mass of the Ćupter after cooking and drying. All six samples were processed in triplicate at the Faculty of Agriculture and Food Technology of the University of Mostar and dried in a solar dryer (Fig. 1). The solar dryer (150 cm wide, 50 cm deep, 70 cm high) consisted of a wooden inner section, thermal insulation board walls, and a transparent polycarbonate surface, with two fans to ensure adequate drying. It was equipped with an access door and a solar panel to power the fans (1.6 W). After drying, the samples were weighed (Table 1) and stored in vacuum-sealed bags in a dry, cool location prior to analysis. The ratio of ingredients added did not result in a statistically significant difference in final mass. However, the addition of BSG in the modified Ćupter influenced its texture, visual appearance, colour, and flavour.

2.3 Physicochemical and nutritional analyses

Samples of Ćupter (500 g *per* sample) were homogenised using a Grindomix GM200 knife mill (Retch, Haan, Germany) to obtain uniform samples. Physicochemical and nutritional analyses were conducted using validated standard and internal analytical methods. All measurements were performed in triplicate using chemicals of analytical grade. The pH was measured using a Seven Compact, Mettler Toledo pH meter following the method developed by *Nicolai et al.*[18] All prepared Ćupter samples were evaluated for water activity (a_w) using a HygroPalm device (Rotronic, Switzerland). Water content was determined by drying the final product at 103 ± 2 °C in an oven (UF75 plus, Memmert, Germany) according to the HRN ISO 6496:2001 method.[19] Ash content of the prepared samples was evaluated using the gravimetric method prescribed in HRN ISO 5984:2004[20] employing a muffle furnace (Nobertherm, Program Controller LV 9/11/P320, Germany) set at 550 °C. The fat content in the Ćupter samples was determined using a Soxtherm 2000 (Gerhardt, Germany) according to

Table 1 – Recipes used for the preparation of modified Ćupter with masses after drying
Tablica 1 – Recepti upotrijebljeni za pripremu modificiranog ćuptera s masama nakon sušenja

Sample	Recipe for Ćupter preparation	Cooking time after reaching boiling point / min	Final weight after drying / g, mean value of 3 measurements
1	250 ml of white must + 31.25 g of semolina	4–5	95.00
2	250 ml of red must + 31.25 g of semolina	4–5	122.00
3	250 ml of white must + 25 g of BSG + 15.6 g of semolina	10	96.33
4	250 ml of red must + 25 g of BSG + 15.6 g of semolina	10	110.33
5	250 ml of white must + 125 g of BSG + 5 g of semolina	30 (semolina is added in the last three min)	99.00
6	250 ml of red must + 125 g of BSG + 5 g of semolina	30 (semolina is added in the last three min)	126.33

the HRN ISO 6492:2001 method.[21] A 5 g sample was hydrolysed in a beaker with hydrochloride acid, then filtered and together with filter paper transferred into an extraction thimble. The thimble was then placed into a Soxlet extractor and extracted using petroleum. The residue was then dried in an oven at 103 °C and weighed to a final mass. The Kjeldahl method, following HRN ISO 5983-1:2008[22] and HRN ISO 5983-2:201023,[23] was used to determine crude protein content. This method involved the destruction of organic matter at 420 °C using a block digestion unit (Unit 8 Basic, Foss, Denmark), followed by a combination of titration and distillation using a Vapodest 50s unit (Gerhardt, Germany). Carbohydrate content was calculated based on the determined values of water, ash, fat, and protein content. Total sugar content (sucrose, D-glucose, and D-fructose) was determined using a commercial enzyme kit (Carbohydrates Kit – Sucrose/D-Glucose/D-Fructose, UV-test, R-Biopharm, Germany). A 5 g homogenised and diluted sample was added Carrez 1 and Carrez 2 solutions. After adjusting the pH value between 7.5 and 8.5 and filtering the sample, the absorbance was measured at a wavelength of 340 nm using a spectrophotometer DR/6000 (Hach, Germany). Before each measurement, a blank was used to subtract from the sample result. Salt content was determined using an EasyPlus™ Analyzer – Easy Na, (Mettler Toledo, Germany) A 1 g sample was diluted with distilled water, heated, and filtered into a plastic measuring cup. 20 ml of 1 M ISA solution was added, along with a stirring magnet, and electrodes were immersed. The mass of the sample was entered into the analyser's programme, and after the potentiometric measurement, the device printed out the sodium content, from which the sodium chloride content was determined using the stoichiometric method.[24]

Crude fibre content was determined using the Gerhardt FibreBag-Systems (Bonn, Germany) following the manufacturer's instructions. A 1 g sample was placed in a FibreBag, then boiled first in sulphuric acid and subsequently in potassium hydroxide. The sample was then automatically filtered and rinsed with distilled water and ethanol. The FibreBag containing the sample residue, was dried at 105 °C, weighed, and the result was converted into a percentage to determine crude fibre content. The energy content of Ćupter was calculated and expressed in kJ and kcal based on the determined values for fat, total sugars, and protein.

2.4 Microbiological analysis

Microbiological analyses of Ćupter samples (1 and 2) were conducted in line with the *Rulebook on the Conditions Regarding Microbiological Safety that Foodstuffs in Trade Must Meet*, (Official Gazette of SFRY No. 45/83)[25]. The tested microorganisms included coagulase-positive *staphylococci*, yeasts and moulds, *Escherichia coli*, *Proteus* species, and total microbial count at 30 °C. Sulphite-reducing clostridia were analysed according to the *Rulebook on Microbiological Criteria for Food* (Official Gazette of B&H, No. 11/13, 79/16, and 64/18).[26] Microbial counts were expressed as presence or absence *per* 1 g. *Salmonella* spp. was tested according to BAS EN ISO 6579:2005/Cor.2010 and expressed as presence or absence *per* 25 g.[27]

2.5 Data analysis

Each measurement of the physicochemical and nutritional composition of Ćupter is presented as mean ± standard deviation. The data were processed using IBM SPSS Statistics for Windows (Version 25.0. Armonk, NY: IBM Corp., 2017). The Kolmogorov-Smirnov test was used to evaluate normality, while one-way ANOVA was applied to compare determined values. *Post hoc* Tukey tests were used to evaluate significant differences ($p < 0.05$).

3 Results and discussion

The physicochemical properties and nutritional composition of Ćupter samples (Samples 1–6) are shown in Tables 2 and 3.

Sulphite-reducing clostridia, coagulase-positive staphylococci, yeasts and moulds, *Escherichia coli*, *Proteus* species, and total microbial count at 30 °C were not detected in 1 g of the samples. *Salmonella* spp. was not detected in 25 g.

Table 2 – Results of the physicochemical and nutritional properties of control samples (Samples 1, 2), and modified Ćupter (samples 3, 4, 5, 6), mean ± standard deviation values

Tablica 2 – Rezultati fizikalno-kemijskih i nutritivnih svojstava kontrolnih uzoraka (uzorci 1 i 2) i ćuptera s pivskim tropom (uzorci 3, 4, 5 i 6), srednja vrijednost ± vrijednosti standardne devijacije

Sample	pH	Water activity	Water / %	Ash / %	Fat / %	Protein / %
1	4.24 ± 0.08	0.78 ± 0.03	32.38 ± 1.48	0.76 ± 0.05	0.29 ± 0.10	3.87 ± 0.09
2	3.85 ± 0.03	0.38 ± 0.01	32.41 ± 0.84	0.73 ± 0.25	0.13 ± 0.03	3.19 ± 0.08
3	4.13 ± 0.05	0.65 ± 0.04	27.71 ± 1.95	0.87 ± 0.34	0.51 ± 0.01	3.63 ± 0.16
4	3.88 ± 0.03	0.68 ± 0.03	26.35 ± 0.97	0.99 ± 0.25	0.64 ± 0.09	3.38 ± 0.04
5	4.68 ± 0.01	0.46 ± 0.02	13.55 ± 0.91	1.50 ± 0.03	2.19 ± 0.13	8.03 ± 0.15
6	4.28 ± 0.09	0.49 ± 0.02	18.02 ± 1.74	1.25 ± 0.13	1.55 ± 0.05	5.89 ± 0.06

Table 3 – Results of the physicochemical and nutritional properties of control samples (Samples 1, 2), and modified Ćupter (samples 3, 4, 5, 6), mean ± standard deviation values

Tablica 3 – Rezultati fizikalno-kemijskih i nutritivnih svojstava kontrolnih uzoraka (uzorci 1 i 2) i ćuptera s pivskim tropom (uzorci 3, 4, 5 i 6), srednja vrijednost ± vrijednosti standardne devijacije

Sample	Carbohydrates / %	Total sugars / %	Salt / %	Crude fibre / %	Energy / kJ kcal^{-1}
1	62.40 ± 1.26	62.4 ± 1.26	0.02 ± 0.01	< 0.30	1137.33/267.33
2	63.42 ± 0.94	63.42 ± 0.94	0.02 ± 0.01	< 0.30	1136.67/267.66
3	66.86 ± 2.14	66.42 ± 2.15	0.03 ± 0.01	0.41 ± 0.02	1217.67/286.66
4	68.09 ± 1.17	67.38 ± 1.13	0.03 ± 0.01	0.68 ± 0.06	1238.33/291.33
5	71.6 ± 2.13	66.82 ± 2.19	0.02 ± 0.01	4.56 ± 0.26	1434.33/338.33
6	71.13 ± 3.01	67.90 ± 3.60	0.02 ± 0.01	3.20 ± 0.78	1367.00/322.00

3.1 pH value

As shown in Table 2, one-way ANOVA revealed significant differences in pH among the recipes ($p < 0.05$). Furthermore, Tukey's test identified statistically significant differences in pH values between samples 1 and 5, and samples 2 and 6. Statistically significant differences were also observed between samples 3 and 5, and samples 4 and 6. Red must samples (2, 4, 6) had a lower pH than white must samples (1, 3, 5), which corresponded to the grape must natural pH value. Both red and white must samples exhibited an increase in pH with the addition of BSG. The substitution of semolina with BSG significantly affected the pH of Ćupter. The pH of BSG itself, along with its interactions with other ingredients, altered the overall acidity of the final product, which in turn influenced its safety, taste, texture, and shelf life.[28] The pH levels play a crucial role in influencing microbial growth, enzymatic activity, and chemical reactions, all of which are essential for product stability and quality.[29]

BSG influenced protein structure by absorbing excess water around the protein molecules, promoting protein unfolding, aggregation, and gelation.[30] This effect could have led to the variations in pH values of samples not due to the addition of BSG but also due to differences in the total amounts of semolina and BSG used.

3.2 Water activity and water content

One-way ANOVA revealed a statistically significant difference in a_w values with respect to the recipe ($p < 0.05$). The water activity and water content values are presented in Table 2. Tukey's test showed statistically significant differences between samples 1 and 5, and samples 2 and 6. Additionally, statistically significant differences were determined between samples 1 and 3, and samples 2 and 4, as well as between samples 3 and 5, and samples 4 and 6. These findings indicate differences in water content among the Ćupter samples. Water content plays an important role in the storability of food products. Higher water content increases the risk of microbial spoilage, including the growth of bacteria and mould, thereby reducing shelf life.[31] One-way ANOVA revealed a statistically significant difference in water content between red and white must samples ($p < 0.05$). Tukey's test identified statistically significant differences between samples 1 and 3, and samples 1 and 5, as well as between samples 2 and 4, and samples 2 and 6. Statistically significant differences were also determined between samples 3 and 5, and samples 4 and 6. The lowest measured water content was found in sample 5, while sample 1 had the highest value. Samples with higher amounts of BSG and longer cooking times exhibited lower water content. Samples with a greater total mass added (31.25 to 130 g) contained less water. BSG binds more water than semolina, which emphasises the importance of sufficient drying time to prevent mould growth and spoilage.

3.3 Ash content

Ash content analysis provides insights into the presence of inorganic components and minerals.[10] One-way ANOVA revealed a statistically significant difference in ash content between red and white must samples ($p < 0.05$). Tukey's test identified statistically significant differences between samples 1 and 5, and samples 3 and 5 (Table 2). Samples with a higher proportion of BSG had a higher ash content. According to *Ikram et al.,* minerals present in BSG include iron, copper, potassium, and manganese.[10]

3.4 Fat content

Lipid content influences the texture, taste, and softness of the product.[32] Observed was a correlation between the fat content and the water content, where an increase in fat content resulted in a decreased water content, leading to a firmer texture of the Ćupter, which was to be expected because lipids do not absorb water well. One-way ANOVA revealed a statistically significant difference in fat values between red and white must samples ($p < 0.05$), (Table 2). Tukey's test determined statistically significant differences between samples 1 and 5, and between samples 2 and 6. In addition, statistically significant differences were determined between samples 3 and 5, and samples 4 and 6. A statistically significant difference was also observed between samples 2 and 4. In the Ćupter with a higher proportion of BSG, the fat content increased. The higher fat

content and reduced water content in BSG samples suggest potential differences not only in shelf life but also in sensory attributes compared to control samples. Extensive research has explored foods containing BSG, particularly focusing on consumer acceptance and sensory properties. BSG enrichment has been linked to alterations in texture,[33,34] colour,[35,36] taste,[37] aroma,[38] and rheological properties,[39] across a variety of products, including bread, cookies, biscuits, pasta, breadsticks, pizza, and baked snacks. In our previous paper[5], panellists moderately liked Ćupter samples prepared with BSG.

3.5 Protein content

Proteins, as essential macronutrients, provide energy, support amino acid balance, optimal growth, and aid digestion. Randomised clinical trials by *Li et al.*[41] have shown that incorporating plant proteins can reduce cardiovascular disease markers and lower blood lipid levels. Additionally, the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study found that replacing animal proteins with plant proteins contributes to reduced body fat percentages and lower BMI.[42] One-way ANOVA revealed a statistically significant difference in protein content with regard to the recipe ($p < 0.05$). With a value of protein shown in Table 2, Tukey's test revealed statistically significant differences between samples 1 and 5, and samples 2 and 6. Statistically significant differences were also determined between samples 3 and 5, and samples 4 and 6. Samples prepared with white must (1, 3, 5) exhibited a higher protein content compared to those prepared with red must (2, 4, 6). The addition of BSG to traditionally prepared Ćupter resulted in a product with increased protein content. Specifically, samples 5 and 6 exhibited an increase in nutrient content of over 30 % compared to the control samples (1 and 2). While the obtained results are promising, further research is needed to assess the impact of BSG enrichment on consumer preferences. Consumers are often willing to compromise on sensory attributes when a product carries a health claim.[43] For instance, *Curtchet et al.*[44] reported that consumer interest in bread and pasta significantly increased when they became aware of the health benefits associated with BSG enrichment.

3.6 Carbohydrate content

Carbohydrates are an essential nutritional component that provide a good source of energy. However, due to their impact on blood glucose levels, they are not recommended for diabetics.[45] BSG, incorporated in Ćupter, is rich in hemicelluloses, primarily arabinoxylan. One-way ANOVA revealed a statistically significant difference in carbohydrate values between red and white must samples ($p < 0.05$). Tukey's test revealed statistically significant differences in carbohydrate values shown in Table 3 between samples 1 and 5, and between samples 2 and 6. Samples 5 and 6 exhibited significantly higher levels of carbohydrates compared to samples 1 and 2 (Table 3). This is due to the higher proportion of BSG in samples 5 and 6, as BSG is rich in carbohydrates. *Naibaho* and *Korzeniowska* found variations in carbohydrate content, specifically, in cellulose and hemicellulose levels in BSG sourced from different breweries. They emphasised how these differences could significantly influence the final product.[46]

3.7 Total sugar content

One-way ANOVA revealed a statistically significant difference in sugar values with respect to the recipe ($p < 0.05$). Tukey's test did not show statistically significant differences between the samples. Sample 1 had the lowest measured sugar content, while sample 6 had the highest (Table 3). Sugar content increased slightly with the addition of BSG. Total sugars in a food product contribute to its overall energy content. When comparing carbohydrate and total sugar proportions, it was evident that the majority of sugars originated from the must, with a slight increase following the addition of BSG, similar to other carbohydrates. Sugars in particular determine the quality of the must and, consequently, Ćupter.[47] 'Herzegovinian Ćupter' is a traditional dessert that can be classified as a type of confectionery.[48] Therefore, all natural sugars, aside from refined sugars, are welcome. Among the basic tastes, sweetness appears to be universally perceived as pleasant and rewarding.[50]

3.8 Crude fibre content

One-way ANOVA revealed a statistically significant difference in crude fibre content between black must and white must samples ($p < 0.05$). Tukey's test revealed statistically significant differences in crude fibre content between samples 1 and 5, and samples 2 and 6. Statistically significant differences were also determined between samples 3 and 5, and samples 4 and 6. The lowest measured fibre content was found in sample 1, while the highest was recorded in sample 5 (Table 3). From a dietary perspective, the research of *Ifrah et al.*[50], supports the idea that high-fibre diets are essential for managing and preventing chronic illnesses.

3.9 Energy value results

The results in Table 3 indicate that the addition of BSG led to a slight increase in energy value in samples 5 and 6, which contained higher amounts of BSG. However, ANOVA did not show statistically significant differences. It is also important to highlight the findings from *Neylon et al.* who reported that replacing semolina with BSG leads to a lower predicted glycemic index.[51,52] A low glycemic index is associated with a reduced risk of type-2 diabetes and cardiovascular disease.[53]

3.10 Salt content

The Kolmogorov-Smirnov test showed a significant deviation from normal distribution for salt content ($p < 0.05$). As the data did not meet the normality condition, ANOVA could not be applied. When comparing the results in Table 3, no significant differences in salt content were observed.

3.11 Microbiological analyses results

Samples 1 and 4 represent Ćupter without BSG, (serving as control samples), that has been consumed in Herzegovina for decades. Given the high values of a_w obtained for these samples, a microbial analysis was conducted. The analysis included testing for sulphite-reducing clostridia, coagulase-positive staphylococci, yeasts and moulds, *Escherichia coli*, *Proteus* species, and total microbial count at 30 °C. None of these were detected in 1 g of the samples. *Salmonella* spp. was not detected in 25 g. Regarding stability and shelf life, the challenge lies in finding a balance between adequate water removal for preservation and maintaining the sensory attributes of Ćupter. This challenge is particularly pronounced in samples containing BSG, despite their water activity levels falling within the typical range (0.6–0.7 a_w). The increased fat content and reduced water content in BSG samples suggest that the behaviour of these samples during storage may differ from that of the control samples.

4 Conclusions

The addition of BSG to Ćupter significantly improved its nutritional composition, particularly in terms of protein, fibre, and carbohydrate content. Specifically, samples 5 and 6, which had the highest BSG content, exhibited a marked increase in protein content (8.03 and 5.89 %, respectively) compared to the control samples, fulfilling the criteria for the "increased protein content" nutritional claim. These modifications also led to higher levels of crude fibre (4.56 and 3.20 %) and carbohydrates (71.60 and 71.13 %), further enhancing the product's value as a functional food. However, the addition of BSG also resulted in significant variations in pH, water activity, and fat content, which may influence the product's shelf life, texture, and sensory characteristics. For instance, samples with higher BSG content (5 and 6) exhibited lower water content and higher fat content, which are critical factors for storage stability and consumer acceptance. Although these modifications position Ćupter enriched with BSG as a nutritionally superior product, further research is needed to optimise the recipe. This includes fine-tuning the balance between nutritional enhancements and maintaining traditional sensory qualities. Additionally, given the product's improved nutritional profile and the potential ecological benefits of reducing biological waste, future studies should focus on evaluating consumer acceptance and sensory attributes to ensure that the final product is both nutritionally beneficial and appealing to consumers. This study investigates the nutritional composition of Ćupter and evaluates the impact of incorporating BSG on its nutritional value compared to traditional preparation methods using semolina. It analyses samples prepared with white or red must and varying proportions of BSG as a replacement for semolina.

References
Literatura

1. *S. Anders, J. A. Caswell*, The Benefits and Costs of Proliferation of Geographical Labelling for Developing Countries, SSRN (2008) 7, doi: https://doi.org/10.2139/ssrn.1185248.
2. *V. Caputo, G. Sacchi, A. Lagoudakis*, Traditional Food Products and Consumer Choices, In: *A. Cavicchi, C. Santini*, eds. Case Studies in the Traditional Food Sector, Elsevier, 2018, pp. 47–87, doi: https://doi.org/10.1016/B978-0-08-101007-5.00004-X.
3. Regulation (EU) No 1151/2012 of the European Parliament and of the Council of 21 November 2012 on quality schemes for agricultural products and foodstuffs.
4. *A. Trichopoulou, S. Soukara, E. Vasilopoulou*, Traditional Foods: A Science and Society Perspective, Trends Food. Sci. **18** (2007) 420–427, doi: https://doi.org/10.1016/j.tifs.2007.03.007.
5. *A. Lalić, A. Karlović, M. Marić*, Use of Brewers' Spent Grains as a Potential Functional Ingredient for the Production of Traditional Herzegovinian Product Ćupter, Fermentation **9** (2023) 123, doi: https://doi.org/10.3390/fermentation9020123.
6. *R. Nurković*, Geographical Distribution of the Vineyards and Wine Production in Rural Areas of Bosnia and Herzegovina, Folia Geogr. **59** (2017) 50–59.
7. *M. Á. González-Curbelo, B. Kabak*, Occurrence of Mycotoxins in Dried Fruits Worldwide, with a Focus on Aflatoxins and Ochratoxin A: A Review, Toxins **15** (2023) 576, doi: https://doi.org/10.3390/toxins15090576.
8. *E. Betül*, Solar Drying of Traditional Herzegovinian Fruit Sweet Cupter, Master's Thesis, Faculty of Tropical AgriSciences, Prague, Czech Republic, 2020.
9. *M. Tišma, A. Jurić, A. Bucić-Kojić, M. Panjičko, M. Planinić*, Biovalorization of brewers' spent grain for the production of laccase and polyphenols, JIB **109** (2017) 200, doi: https://doi.org/10.1002/jib.479.
10. *S. Ikram, H. Y. Huang, J. Wang, M. Yin*, Composition and Nutrient Value Proposition of Brewers Spent Grain, J. Food Sci. **82** (2017) 2232–2242, doi: https://doi.org/10.1111/1750-3841.13794.
11. *N. G. T. Meneses, S. Martins, J.A. Teixeira, S.I. Mussatto*, Influence of extraction solvents on the recovery of antioxidant phenolic compounds from brewer's spent grains, Sep. Purif. Technol. **108** (2013) 152–158, doi: https://doi.org/10.1016/j.seppur.2013.02.015.
12. *S. I. Mussatto*, Biotechnological Potential of Brewing Industry By-Products, In: *P. Nigam, A. Pandey* (eds.), Biotechnology for Agro-Industrial Residues Utilisation, Springer, Berlin, 2019, pp. 313–326, doi: https://doi.org/10.1007/978-1-4020-9942-7_16.
13. *K. M. Lynch, E. J. Steffen, E. K. Arendt*, Brewers' spent grain: A review with an emphasis on food and health, JIB **122** (2016) 553-568, doi: https://doi.org/10.1002/jib.363.
14. *J. G. Cervantes-Ramirez, F. Vasquez-Lara, A. Sanchez-Estrada, R. Troncoso-Rojas, E. Heredia-Olea, A. R. Islas-Rubio*, Arabinoxylans Release from Brewers' Spent Grain Using Extrusion and Solid-State Fermentation with *Fusarium oxysporum* and the Antioxidant Capacity of the Extracts, Foods **11** (2022)

1415, doi: https://doi.org/10.3390/foods11101415.

15. *K. M. Lynch, C. R. Strain, C. Johnson, D. Patangia, C. Stanton, F. Koc, J. Gil-Martinez, P. O'Riordan, A. W. Sahin, R. P. Ross, E. K. Arendt*, Extraction and characterisation of arabinoxylan from brewers spent grain and investigation of microbiome modulation potential, Eur. J. Nutr. **60** (2021) 4393–4411, doi: https://doi.org/10.1007/s00394-021-02570-8.
16. *A. Lalić, M. Arapović*, Umjetna inteligencija donosi inovativna rješenja u otkrivanju funkcionalne hrane, In: J. Branković, eds. Scientific-Professional Conference "Artificial Intelligence in Bosnia and Herzegovina"/research, application and development perspectives/, Proceedings, Federalno ministarstvo obrazovanja i nauke/znanosti & Zaklada za inovacijski i tehnološki razvitak, Mostar, Bosnia and Herzegovina, 2022, pp. 132–140.
17. *O. Kanauchi, K. Mitsuyama, J. Araki*, Development of a Functional Germinated Barley Foodstuff from Brewer's Spent Grain for the Treatment of Ulcerative Colitis, J. Am. Soc. Brew. Chem. **59** (2018) 59–62, doi: https://doi.org/10.1094/ASBCJ-59-0059.
18. *M. Nicolai, P. Pereira, P. Rijo, O. Amaral, A. Amaral, L. V. Palma*, Vitis vinera L. Pomace: Chemical and nutritional characterization: Caracterização química e nutricional do bagaço de *Vitis vinera*, L., J. Biomed. Biopharm. Res. **15** (2018) 156–166, doi: https://doi.org/10.19277/BBR.15.2.182.
19. HRN ISO 6496:2001, Animal feeding stuffs – Determination of moisture and other volatile matter content, International Organization for Standardization (ISO), Brussels, Belgium, 2001.
20. HRN ISO 5984:2004, Animal feeding stuffs – Determination of crude ash, International Organization for Standardization (ISO), Brussels, Belgium, 2004.
21. HRN ISO 6492:2001, Animal feeding stuffs – Determination of fat content, International Organization for Standardization (ISO), Brussels, Belgium, 2001.
22. HRN ISO 5983-1:2008, Animal feeding stuffs – Determination of nitrogen content and calculation of crude protein content – Part 1: Kjeldahl method, International Organization for Standardization (ISO), Brussels, Belgium, 2008.
23. HRN ISO 5983-2:2010, Animal feeding stuffs – Determination of nitrogen content and calculation of crude protein content – Part 2: Block digestion and steam distillation method, International Organization for Standardization (ISO), Brussels, Belgium, 2010.
24. Operating Instructions, EasyPlus™ Analyzer - Easy Na, Mettler Toledo
25. Rulebook on the Conditions Regarding Microbiological Safety that Foodstuffs in Trade Must Meet, Official Gazette of SFRY **45** (1983).
26. Rulebook on Microbiological Criteria for Food, Official Gazette of B&H **11** (2013), **79** (2016), and **64** (2018).
27. BAS EN ISO 6579:2005/Cor.2010: Microbiology of food and animal feeding stuffs – Horizontal method for the detection of *Salmonella* spp., Institute for Standardization of Bosnia and Herzegovina, 2005, corrected 2010.
28. *A. Andrés-Bello, V. Barreto-Palacios, P. García-Segovia, J. Mir-Bel*, Effect of pH on Colour and Texture of Food Products, Food Eng. Rev. **5** (2013) 158–170, doi: https://doi.org/10.1007/s12393-013-9067-2.
29. *R. Bhat, A. Karim Alias, G. Paliyath*, Factors Affecting the Growth of Microorganisms in Food, In*: G. Paliyath, A. Karim Alias, D. Meckling, S. Sambanthamurthi, K. Senanayake*, (eds.), J. Food Process., Chapter 20, Wiley-Blackwell, Oxford, 2012, doi: https://doi.org/10.1002/9781119962045.ch20.
30. *Q. Yang, Y. R. Wang, Y. J. Li-Sha, H. Q. Chen*, The effects of basil seed gum on the physicochemical and structural properties of arachin gel, Food Hydrocoll. **110** (2020) 106189, doi: https://doi.org/10.1016/j.foodhyd.2020.106189.
31. *M. S. Tapia, S. M. Alzamora, J. Chirife*, Effects of Water Activity (a_w) on Microbial Stability as a Hurdle in Food Preservation, In: G. V. Barbosa-Cánovas, A. J. Fontana Jr., S. J. Schmidt, T. P. Labuza (eds.), Water Activity in Foods, Wiley-Blackwell, Ames, 2020, pp. 323–355, doi: https://doi.org/10.1002/9781118765982.ch14.
32. *A. B. D. Nandiyanto, R. Ragadhita, A. Ana, B. Hammouti*, Effect of Starch, Lipid, and Protein Components in Flour on the Physical and Mechanical Properties of Indonesian Biji Ketapang Cookies, Int. J. Technol. **13** (2022) 432–443, doi: https://doi.org/10.14716/ijtech.v13i2.5208.
33. *V. Stojceska*, Dietary Fiber from Brewer's Spent Grain as a Functional Ingredient in Bread Making Technology, In: V.R. Preedy, R.R. Watson, V.B. Patel (eds.), Flour and Breads and Their Fortification in Health and Disease Prevention, Academic Press, London, 2011, pp. 171–181, doi: https://doi.org/10.1016/b978-0-12-380886-8.10016-9.
34. *F. Nocente, F. Taddei, E. Galassi, L. Gazza*, Upcycling of Brewers' Spent Grain by Production of Dry Pasta with Higher Nutritional Potential, LWT **114** (2019) 108421, doi: https://doi.org/10.1016/j.lwt.2019.108421.
35. *J. S. Petrović, B. S. Pajin, S. D. Tanackov-Kocić, J. D. Pejin, A. Z. Fišteš, N. Đ. Bojanić, I. S. Lončarević*, Quality Properties of Cookies Supplemented with Fresh Brewer's Spent Grain, Food Feed Res. **44** (2017) 57–63, doi: https://doi.org/10.5937/ffr1701057p.
36. *A. K. Oluseyi, F. A. Dawodu, O. C. Ajanaku, O. C. Nwinyi*, Functional and Nutritional Properties of Spent Grain Enhanced Cookies, Am. J. Food Technol. **6** (2011) 763–771, doi: https://doi.org/10.3923/ajft.2011.763.771.
37. *A. Ktenioudaki, E. Crofton, A. G. M. Scannell, J. A. Hannon, K. N. Kilcawley, E. Gallagher*, Sensory Properties and Aromatic Composition of Baked Snacks Containing Brewer's Spent Grain, J. Cereal Sci. **57** (2013) 384–390, doi: https://doi.org/10.1016/j.jcs.2013.01.009.
38. *A. Ktenioudaki, L. Alvarez-Jubete, T. J. Smyth, K. Kilcawley, D. K. Rai, E. Gallagher*, Application of Bioprocessing Techniques (Sourdough Fermentation and Technological Aids) for Brewer's Spent Grain Breads, Food Res. Int. **73** (2015) 107–116, doi: https://doi.org/10.1016/j.foodres.2015.03.008.
39. *T. Amoriello, F. Mellara, V. Galli, M. Amoriello, R. Ciccoritti,* Technological Properties and Consumer Acceptability of Bakery Products Enriched with Brewers' Spent Grains, Foods **9** (2020) 1492, doi: https://doi.org/10.3390/foods9101492.
40. EFSA Panel on Dietetic Products; Nutrition and Allergies (NDA). Scientific Opinion on Dietary Reference Values for protein, EFSA J. **10** (2012) 2557.
41. *S. S. Li, S. Blanco Mejia, L. Lytvyn, S. E. Stewart, E. Viguiliouk, V. Ha, R.J. de Souza, L. A. Leiter, C. W. C. Kendall, D. J. A. Jenkins, J. L. Sievenpiper*, Effect of Plant Protein on Blood Lipids: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J. Am. Heart Assoc. **6** (2017), doi: https://doi.org/10.1161/JAHA.117.006659.
42. *Y. Lin, T. Mouratidou, C. Vereecken, M. Kersting, S. Bolca, A. C. F. de Moraes, M. Cuenca-Garcia, L. A. Moreno, M. Gonzalez-Gross, J. Valtuena, I. Labayen, E. Grammatikaki, L. Hallstrom, C. Leclercq, M. Ferrari, F. Gottrand, L. Beghin, Y. Manios, C. Ottevaere, H. Van Oyen, D. Molnar, A. Kafatos, K. Widhalm, S. Gómez-Martinez, L. E. Díaz Prieto, S. De Henauw, I. Huybrechts*, Dietary Animal and Plant Protein Intakes and Their Associations with Obesity and Cardio-Metabolic Indicators in European Adolescents: The HELENA

Cross-Sectional Study, Nutr. J. **14** (2015) 10, doi: https://doi.org/10.1186/1475-2891-14-10.

43. *I. I. Ijeh, C. E. Ejike, O. M. Nkwonta, B. C. Njoku,* Effect of Traditional Processing Techniques on the Nutritional and Phytochemical Composition of African Bread-Fruit (*Treculia africana*) Seeds, JASEM **14** (2011) 4, doi: https://doi.org/10.4314/jasem.v14i4.63314.
44. *A. Curutchet, M. Serrantes, C. Pontet, F. Prisco, P. Arcia, G. Barg, J. A. Menéndez, M. Míguez,* Effect of Information on Consumers' Response to Different Food Categories Enriched with Brewer's Spent Grain, Front. Food Sci. Technol. **2** (2022), doi: https://doi.org/10.3389/frfst.2022.899878.
45. *M. E. Shils, J. A. Olsen, M. Shike, A. C. Ross,* Modern Nutrition in Health and Disease, 9th ed., Br. J. Nutr. **82** (1999) 331–332.
46. *J. Naibaho, M. Korzeniowska,* The Variability of Physico-Chemical Properties of Brewery Spent Grain from 8 Different Breweries, Heliyon **7** (2021), doi: https://doi.org/10.1016/j.heliyon.2021.e06583.
47. *L. Cornehl, J. Krause, X. Zheng, P. Gauweiler, F. Schwander, R. Töpfer, R. Gruna, A. Kicherer*, Determination of Sugars and Acids in Grape Must Using Miniaturized Near-Infrared Spectroscopy, Sensors **23**,(2023) 5287, doi: https://doi.org/10.3390/s23115287.
48. *J. Beljo,* Ćupter naša autohtona slastica, **64**. 2019, *Turističko-kulturno-gospodarstvena manifestacija Dani berbe grožđa*, Brotnjo.
49. *P. Richardson, A. Saliba,* Personality Traits in the Context of Sensory Preference: A Focus on Sweetness, In: *V. R. Preedy, R. R. Watson* (eds.), Handbook of Behavior, Food and Nutrition, Springer, New York, 2011, pp. 95–104. , doi: https://doi.org/10.1007/978-0-387-92271-3_7.
50. *F. Ifrah, G. Imali, J. R. De A. Reuben, C. Peminda, K. Geetha,* Current understanding of dietary fiber and its role in chronic diseases, Mo Med. **120** (2023) 381–388.
51. *E. Neylon, E. K. Arendt, E. Zannini, A. W. Sahin,* Fundamental study of the application of brewers spent grain and fermented brewers spent grain on the quality of pasta, Food Struct. **30** (2021) 100225, doi: https://doi.org/10.1016/j.foostr.2021.100225.
52. *A. Rytz, D. Adeline, K. A. Lê, D. Tan,* Predicting Glycemic Index and Glycemic Load from Macronutrients to Accelerate Development of Foods and Beverages with Lower Glucose Responses, Foods **11** (2019) 1172, doi: https://doi.org/10.3390/nu11051172.
53. *M. Peres, H. S. Costa, M. A. Silva, T. G. Albuquerque*, The Health Effects of Low Glycemic Index and Low Glycemic Load Interventions on Prediabetes and Type 2 Diabetes Mellitus: A Literature Review of RCTs, Nutrients **15** (24) (2023) 5060, doi: https://doi.org/10.3390/nu15245060.

SAŽETAK

Upotreba pivskog tropa kao perspektivnog izvora bjelančevina i vlakana za ćupter

Anita Lalić,[a*] *Andrea Karlović*,[a] *Jelka Pleadin*[b] i *Marina Marić* [c,d]

Cilj ovog istraživanja bio je utvrditi fizikalno-kemijska svojstva i nutritivni sastav tradicionalnog ćuptera pripremljenog isključivo s grizom (kontrolni uzorak) te ga usporediti s uzorcima ćuptera pripremljenim s različitim udjelima pivskog tropa kao zamjene za griz. Za fizikalno-kemijski i nutritivni sastav analizirani su pH vrijednost, aktivnost vode, udio vlage, masti, bjelančevine, ugljikohidrati, ukupni šećeri, sirova vlakna, sol i energetska vrijednost. Pripremljeno je šest uzoraka, od kojih su dva bila tradicionalno pripremljena ćuptera (kontrolni uzorci) s bijelim ili crvenim moštom i grizom. Preostala četiri uzorka bila su modificirani ćupteri pripremljeni s bijelim ili crvenim moštom, uz različite omjere pivskog tropa i griza. Rezultati su pokazali da modificirani ćupter ima poboljšanu nutritivnu vrijednost, sa statistički značajnim povećanjem ($p < 0,05$) udjela bjelančevina i sirovih vlakana. Uzorci 5 i 6, koji su sadržavali 125,5 g pivskog tropa, imali su veći sadržaj bjelančevina i sirovih vlakana u usporedbi s uzorcima 3 i 4, koji su sadržavali 25,5 g pivskog tropa, kao i u odnosu na tradicionalne uzorke 1 i 2, koji nisu sadržavali pivski trop.

Ključne riječi
Ćupter, pivski trop, mošt od crnog grožđa, pozitivni zdravstveni učinci, tradicionalni proizvodi, solarno sušenje

[a] *Sveučilište u Mostaru, Agronomski i prehrambeno-tehnološki fakultet, Biskupa Čule bb, 80 000 Mostar, Bosna i Hercegovina*
[b] *Hrvatski Veterinarski Institut, Savska cesta 143, 10 000, Zagreb, Hrvatska*
[c] *Herkon d. o. o. Mostar, Biskupa Čule bb, 80 000 Mostar, Bosna i Hercegovina*
[d] *Sveučilište u Mostaru, Fakultet prirodoslovno-matematičkih i odgojnih znanosti, Odsjek za kemiju, Matice Hrvatske b.b., 88 000 Mostar, Bosna i Hercegovina*

Izvorni znanstveni rad
Prispjelo 21. prosinca 2024.
Prihvaćeno 21. veljače 2025.