Effect of some unconventional ingredients on the production of black beer

Marius Ciocan, Adriana Dabija, Georgiana Gabriela Codină

Stefan cel Mare University of Suceava, Suceava, Romania

Abstract

Keywords:

Black beer
Acorn
Topinambur
Molasses

Article history:

Received
02.09.2019
Received in revised
form 16.01.2020
Accepted
30.06.2020

Corresponding author:

Adriana Dabija
E-mail:
adriana.dabija@
fia.usv.ro

DOI:

10.24263/2304-
974X-2020-9-2-5

Introduction. The aim of this research is to determine the effect of some unconventional ingredients such as the acorn flour, topinambur flour and molasses in order to develop a beverage similar to black beer.

Materials and methods. Black beer was obtained according to a conventional method of obtaining beer in a pilot scale brewery. In the manufacturing recipe, brown malt has been replaced with acorn flour, topinambur flour and molasses with 50% sucrose in the following variants: variant 1 – 0.5:1.5:1; variant 2 – 1:1:1; variant 3 – 1:1.5:0.5; variant 4 – 1.25:1.25:0.5. For fermentation of bottom-fermenting yeast was used. The extract content, alcohol content and apparent fermentation for the black beer samples were analysed with the Anton Paar device.

Results and discussion. The CO₂ content, foam height, foam stability, total acidity of beer, for all the analyzed samples are within the admitted limits for the black beers. The sensory characteristics of the black beer samples evaluated, namely appearance, colour, odour, taste, gas release and foam stability indicates the fact that the variant 1 of the black beer received the lowest score whereas the variant 4 received the highest one. The sensory analysis results were unexpected ones, the non gluten beers obtained being very well appreciated, the panellists preferring them over commercial black beers made from traditional ingredients. The black beer obtained in all four experimental versions are beers with an alcoholic concentration which ranged between 7.06% and 8.16%, with a high degree of final fermentation, which ranged between 73.26% for variant 2 and 85.85% for variant 4. The data obtained with the unconventional raw materials as the acorn flour, topinambur flour and molasses were comparable to commercial black beer, which acted as the control sample. The best result regarding the final fermentation degree (85.85%) was obtained for the variant 4, even higher than those obtained for the commercial beer (80.20%). Also, the variant 4 was the best appreciated from the sensory point of view. This variant can be proposed to obtain black beer on an industrial scale because it has good physico-chemical properties comparable to a black beer on the market.

Conclusions. Black beer, obtained on the basis of an innovative manufacturing recipe, presented good sensorial characteristics, a freshly roasted coffee flavour, a fruity taste and bittersweet.

Introduction

Nowadays, the beer production from other raw materials than barley or wheat malt is an increasing one in the beer industry field. The new innovative products meet consumers demand especially those suffering from celiac disease. The gluten content in commercial beers is below the limits of Codex Alimentarius Standard (20 ppm), but even so may create healthy problems to the consumers due to their different clinical sensitivity to the beer gluten content [1].

Over the last years, different strategies can be applied to produce gluten-free beers [2]. Some approaches for the biological or chemical elimination of barley gluten (hordein) or wheat gluten (gliadin) have been proposed [3]. For example, Fanari et al. (2018) proposed two different deglutinization treatments: an enzymatic process based on *Aspergillus niger* prolyl endopeptidase and a precipitation process by silica gel [4].

Many studies has been carried out into the use of other cereals in the brewing of beer such as maize, rice, sorghum, teff, millet, and triticale, pseudocereals (buckwheat, amaranth, quinoa), and another ingredients such as cassava, chestnut, honey, sugar, molasses etc. [5-15].

The future studies should be performed to improve the quality of innovative beer assortments from new unconventional raw materials in order to satisfy the consumers demand.

This current study proposes the use of three ingredients as malt substitutes for obtaining black beer: acorn flour, topinambur flour and molasses.

Acorn flour is obtained from *Quercus* sp. fruits from ancient times through drying, maturation, milling, detanization processes and it is used in the manufacture of various bakery products, beverages, pastry-confectionery, pasta, biscuits, as a coffee substitute etc.[16,17,18]. Acorn flour is an important source of antioxidant substances, has a high fat content (of which over 80% unsaturated fat), protein and a considerable amount of calcium, magnesium, potassium, phosphorus, iron, copper and zinc, vitamins from the B complex (B₁, B₂, B₃ and B₆) [19,20]. Acorn flour has anti-inflammatory, mineralizing, antianemic, antirash, antitumor, antioxidant, diuretic, energizing favouring insulin secretion properties. This flour is recommended for the treatment of gastritis, ulcer, enteritis, anaemia, mental disorders, fatigue, mental exhaustion, overuse and headaches [21,22].

Topinambur tubers have been brought to the attention of specialists and consumers due to their properties, being recommended by many nutritionists for consumption. Topinambur is currently recognized as a culture used for the production of long-standing ethyl alcohol, including beer production [23,24]. The topinambur tubers were also used to produce brandy in France and Germany or for sake in Japan. The topinambur flour is a valuable, easy-to-use product, and its addition to bakery, pastry and pasta-making recipes improves their nutritional value [25,26]. The topinambur flour is rich in fiber (36.4% on average), mineral substances (calcium, iron, selenium, potassium, phosphorus) and vitamins (B vitamins, vitamin C, β -carotene) [27]. Topinambur is also rich in inulin (over 50% of the dry substance), which can be easily hydrolysed and then converted into ethyl alcohol. The yield in ethyl alcohol is equivalent to that of sugar cane and twice as high as that of ethyl alcohol obtained from corn. Other uses of topinambur flour are: extruded products, confectionery products, gelatine products, sugary products, functional granules, culinary products etc. [28,29,30].

Molasses is the last by-product from the manufacture of sugar following repeated crystallization of sucrose and from which can still be obtained by crystallization. Nowadays, in the US, Europe, Australia, as well as in our country, molasses is the main raw material used in the production of bakery yeast and a valuable raw material for the production of ethyl

alcohol (containing an average of 50% sucrose). The chemical composition of molasses varies depending on the raw material used in the manufacture of sugar (beet or sugar cane) and the technological process applied in the sugar factories. The benefits of molasses cover a wide range of health problems: acne and other skin diseases, headaches, anaemia, stress, obesity, diabetes, constipation, prostate disorders, premenstrual symptoms, or cancer [31,32].

The main objective of this research was to use these unconventional raw materials that have been previously developed to obtain brew, a beverage similar in aroma, taste and mouth feel to black beer. To our acknowledgments no other studies has been made for non-gluten black beer production with the ingredients used in this research. This fact will lead to a diversification of black beer assortments which may satisfy the consumers.

Materials and methods

Materials

In our research the following ingredients were used: acorn flour and topinambur flour obtained from Bio Boom Company Romania, molasses from Agrana Romania Company, a bottom fermentation yeast from Grama Trading Company under the trade name Saflager W 34/70 (Fermentis, Belgium), and hop pellets from Agrosiro Serv Impex Company (Sighisoara, Romania). All the raw materials used in the process came from trustworthy suppliers with technical quality specifications, in compliance with the current food safety legislation.

In order to obtain the black beer, several experimental variants were elaborated in which the three basic ingredients – acorn flour, topinambur flour and molasses – replaced the barley malt from the classic beer recipe. Thus, the ratio between acorn flour, topinambur flour and molasses was: variant 1 – 0.5:1.5:1; variant 2 – 1:1:1; variant 3- 1:1.5:0.5; variant 4 – 1.25:1.25:0.5.

Beer production

Brewing was carried out in a pilot scale brewery (30 L, Braumeister, Speidel, Germany). The technological process of obtaining the beer respected the classical technology through the decoction process with two mashes [33]. Thus, acorn flour and topinambur flour were mashing separately, until boiling for gelatinization of the starch. Then, those 2 mash were inserted into the main mash to obtain the wort using the following mashing programme: mashing in at 45 °C; rest for 30 min; ramp heating within 15 min to 63 °C; rest for 30 min; ramp heating within 5 min to 65 °C; rest for 30 min; ramp heating within 5 min to 72 °C and rest for 60 min. At this temperature saccharification was monitored every 10 min, until the reaction with iodine did not took place anymore. Mashing off temperature was 78 °C, and then the mash was filtered to obtain the wort.

The wort was boiled with hops for 60 min under atmospheric pressure, cooled to 12 °C and fermented for 5 to 7 days at 12 °C using a bottom fermentation yeast. The fermentation trials were performed simultaneously under the same conditions. Fermentation was followed by a maturation period of 21 days at 4 °C. Filtration was carried out using a plate filter, and then the filtered beer was bottled using a manual bottling unit.

Bottled black beer was stored to the dark at 4 °C until analysis.

Beer analyses

The final beer was analyzed for its physical-chemical and sensorial properties. The extract content, alcohol content and apparent fermentation were determined by Anton Paar (Anton Paar GmbH, Austria) using an automated beer analyzer. The CO₂ content, foam height, foam stability, total acidity of beer, was measured [34, 35].

A sensory evaluation of the beers was carried out by a trained, 25-member tasting panel (10 women and 15 men, 24-60 years old), following the 20 points method. The points ranged from 0 to 5 for each attributes: appearance, colour, odour, taste, gas release and foam stability. A point of 0 meant that the attribute was absent whereas a point of 5 indicated that the attribute was extremely strong [36].

Statistical analysis

Data were expressed as means $\pm$ standard deviations for triplicate determination. Statistical analysis was performed using XLSTAT statistical package (free trial version, Addinsoft, Inc. Brooklyn, NY, USA) at a significance level of $p < 0.05$.

Results and discussion

Physicochemical characteristics of black beer samples

The beer samples obtained were analyzed from the physicochemical point of view, and the results obtained were compared with an assortment of commercial black beer. The results obtained were shown in Table 1 and Table 2. Beer constituents were provided from the raw materials (acorn flour, topinambur flour, molasses, carbohydrate sources), bitter and flavour substances from wort production, as well as from fermentation and maturation.

Foam, foaming capacity and foam stability distinguish beer from other beverages. A good, white and stable foam stability is a key parameter which reflects the fact that it was handled correctly during the brewing process. The characteristics of the foam are: volume, density and persistence. The volume of the foam depends on the carbon dioxide content and the amount of surfactants. The slow release of carbon dioxide, in small, uniform bubbles, is explained by its bounding to colloids from the extract: dextrin, proteins, bitter resins from hops etc. [37].

The persistence of the foam depends on the degree of dispersion of the colloidal substances in the beer, which forms a resistant film around the carbon dioxide bubbles. The persistence of the foam is favoured by the bitter resins of the hops and by the nitrogenous substances, complex, but it is diminished by the presence of fats and the amount of alcohols content. The beer must have long and persistent foam, must be clear and shiny and must maintain these characteristics for the longest period of time possible [7].

Considering Table 1 one can observe that the samples with the highest foam stability are samples 2 and 4, followed by samples 3 and 1.

CO₂ content is crucial for the ability to foam and other beer sensory properties. In the beer samples analyzed, the CO₂ content is within the limit of min. 0.4 g/100 mL drink [34]. The highest value of this parameter was recorded for the sample 4, namely 4.8 g CO₂ /100 g beer. This value was higher even than those obtained for the market beer sample, whose value was only 4.06 g CO₂ /100 g beer.

Table 1

Physicochemical properties for black beers by standard methods

Beer samples – mean (SD)	CO ₂ [g/100 mL]	FH [mm]	FS [min]	TA [mL NaOH 1N /100 mL]
Beer 1 (B1)	4.1±0.1 ^{ab}	28.0±1.0 ^a	4.00±1.0 ^{ab}	2.80±0.20 ^{ab}
Beer 2 (B2)	4.0±0.1 ^{ab}	48.0±2.0 ^a	8.00±1.0 ^a	2.90±0.05 ^{ab}
Beer 3 (B3)	3.9±0.2 ^{ab}	42.0±2.0 ^a	5.00±0.0 ^{ab}	2.95±0.05 ^{ab}
Beer 4 (B4)	4.8±0.1 ^a	58.0±2.0 ^a	7.00±1.0 ^{ab}	3.50±0.10 ^a
Commercial beer sample (BC)	4.06±0.11 ^b	59.33±4.16 ^a	7.00±1.0 ^b	3.26±0.11 ^b
F-ratio	9.862	5.617	7.194	8.069
P-value	0.002	0.012	0.005	0.004

Physicochemical properties: CO, colour, FH, foam height, FS, foam stability, TA, total acidity
The values are means±standard deviations of three replicates.

Means in the same column followed by different letters are significantly different ($p < 0.05$).

Table 2

Physicochemical properties for black beers by Anton-Paar device

Beer samples – mean (SD)	OE [°P]	ALC [% v/v]	pH	GFF [%]
Beer 1 (B1)	17.85±0.08 ^a	8.16±0.04 ^a	4.60±0.02 ^{ab}	77.04±0.50 ^{ab}
Beer 2 (B2)	17.05±0.05 ^a	7.60±0.03 ^a	4.53±0.01 ^{ab}	73.26±0.33 ^{ab}
Beer 3 (B3)	16.87±0.03 ^a	7.06±0.04 ^a	4.56±0.03 ^{ab}	79.87±0.23 ^{ab}
Beer 4 (B4)	16.92±0.02 ^a	7.40±0.04 ^a	5.02±0.02 ^a	85.85±0.15 ^a
Commercial beer sample (BC)	14.85±0.08 ^a	7.20±0.20 ^a	4.60±0.03 ^b	80.20±0.20 ^b
F-ratio	12.178	9.972	9.500	8.965
P-value	0.001	0.002	0.002	0.002

Physicochemical properties: OE, original extract, ALC, alcohol concentration, GFF, final fermentation degree

The values are means±standard deviations of three replicates.

Means in the same column followed by different letters are significantly different ($p < 0.05$).

The extract of the primitive must and the alcohol concentration of the beer are the most important determinations, at least from the financial point of view [38]. The black beer obtained in all 4 experimental versions is a beer with an alcoholic concentration between 7.06% and 8.16%, with a high degree of final fermentation, with values between 73.26% for variant 2 and 85.85 % for variant 4 (Table 2). It can be observed that beer samples 4, recorded the best results regarding the final fermentation degree (85.85%), even higher than the beer from (80.20%).

Sensorial characteristics of black beer samples

Sensory analysis is of essential importance in assessing the quality of beer. The taste, the smell, the colour, the clarity, the foaming, the release of the carbon dioxide bubbles, are the best recommendation and are, at the same time, the result of all the technological operations [10, 39]. To perform the sensory analysis of the 4 experimental variants, the 20 points sensory method was used. The results of the sensory analysis are shown in Table 3.

Table 3

Sensorial properties for the dark beers samples

Beer samples – mean (SD)	AP	CO_S	OD	TA	GR	FS_S	PT
Beer 1 (B1)	2.00± 0.34 ^a	2.66± 0.46 ^a	0.66± 0.11 ^a	5.60± 0.10 ^a	1.80± 0.60 ^a	1.06± 0.23 ^a	13.80± 0.20 ^a
Beer 2 (B2)	2.20± 0.34 ^a	3.73± 0.46 ^a	0.80± 0.20 ^b	5.60± 0.10 ^a	2.20± 0.34 ^a	1.46± 0.23 ^a	16.00± 0.20 ^a
Beer 3 (B3)	2.20± 0.34 ^{ab}	2.94± 0.46 ^{ab}	0.60± 0.10 ^{ab}	6.06± 0.80 ^a	2.00± 0.34 ^{ab}	1.46± 0.23 ^{ab}	15.26± 0.61 ^{ab}
Beer 4 (B4)	2.60± 0.34 ^a	4.00± 0.10 ^a	1.00± 0.10 ^a	6.53± 0.80 ^{ab}	2.40± 0.10 ^a	1.86± 0.23 ^a	18.40± 0.40 ^a
Commercial beer (BC)	3.00± 0.10 ^b	4.00± 0.10 ^b	0.86± 0.11 ^b	6.53± 0.80 ^b	2.60± 0.34 ^b	1.86± 0.20 ^b	18.86± 0.41 ^b
F-ratio	7.228	9.088	11.933	10.294	7.865	8.695	9.221
P-value	0.009	0.004	0.001	0.002	0.007	0.005	0.004

Sensorial properties: AP, appearance, CO_S, colour, OD, odour, TA, taste, GR, gas release, FS_S, foam stability

Means in the same column followed by different letters are significantly different ($p < 0.05$).

From the sensory point of view, the most appreciated by tasters was beer sample 4, followed by beer sample 2 and beer sample 3.

Relationship between characteristics of the beer samples obtained

Table 4 shown the Pearson correlation between the sensorial and physico-chemical data of the black beer analyzed samples. It may be seen that all the sensorial values for total points (PT) are significant correlated with the physico-chemical data of the analyzed beer samples and with each sensory characteristics analyzed. Therefore the highest significant direct influence according to the correlation obtained ($p < 0.01$) on PT for the analyzed samples presented the beer's physico-chemical characteristics foam stability (FH), $r = 0.925$ and total acidity (TA), $r = 0.823$. A significant negative influence on PT presented the physico-chemical characteristics original extract (OE) $r = -0.776$ at a significant level of $p = 0.01$ and alcohol concentration (ALC), $r = -0.584$ at a significant level of $p = 0.05$. It may be also noticed that between physico-chemical data ALC and OE it is a direct significant correlation ($r = 0.648$) at a level $p = 0.01$, a similar one been also obtained by Codină *et al.* (2011)[40]. From the sensorial characteristics point of view, it seems that all of the analyzed sensorial parameters presented a highly significant ($p < 0.01$) influence on PT except gas release (GR) which presented a lower significant influence one ($p < 0.05$), between these characteristics (PR and GR) being the lowest correlation value of $r = 0.636$.

Table 4
Pearson correlation of physicochemical and sensorial properties for the black beers samples

	CO	FH	FS	TA	OE	ALC	pH	GFF	AP	CO_S	OD	TA	GR	FS_S	PT
CO	1	0.386	0.214	0.661**	0.077	0.008	0.939**	0.721**	0.216	0.359	0.595*	0.475	0.273	0.412	0.514*
FH		1	0.762**	0.789**	-0.731**	-0.654**	0.455	0.483	0.697**	0.845**	0.636*	0.396	0.689**	0.834**	0.925**
FS			1	0.337	-0.413	-0.307	0.201	-0.016	0.334	0.721**	0.485	0.000	0.639*	0.615*	0.603*
TA				1	-0.475	-0.485	0.758**	0.783**	0.708**	0.665**	0.671**	0.502	0.401	0.711**	0.823**
OE					1	0.648**	0.054	-0.235	-0.743**	-0.571*	-0.316	-0.456	-0.562*	-0.645**	-0.776**
ALC						1	-0.083	-0.401	-0.486	-0.384	-0.072	-0.426	-0.373	-0.644**	-0.584*
pH							1	0.845**	0.278	0.395	0.635*	0.403	0.236	0.460	0.520*
GFF								1	0.410	0.302	0.455	0.535*	0.281	0.536*	0.572*
AP									1	0.463	0.535*	0.387	0.522*	0.516*	0.763*
CO_S										1	0.627*	0.239	0.443*	0.733**	0.796**
OD											1	0.387	0.298	0.430	0.687**
TA												1	0.135	0.426	0.647**
GR													1	0.467	0.636*
FS_S														1	0.822**
PT															1

Significant at $p < 0.01^{**}$, at $p < 0.05^{*}$.

Physico-chemical properties: CO, colour, FH, foam height, FS, foam stability, TA, total acidity, OE, original extract, ALC, alcohol concentration, GFF, final fermentation degree.

Sensorial properties: AP, appearance, CO_S, colour, OD, odour, TA, taste, GR, gas release, FS_S, foam stability

Principal component analysis (PCA) shown in Figure 1 carried out on black beer samples explain all the data variation. The first two principal components explain 71.44% of the total variance (PC1=54.83% and PC2=16.61%). The both PCA components, PC1 and PC2 underline a very good correlation between physico-chemical characteristics CO and GFF and between OE and ALC. Also it may be noticed a very good correlation between all the sensorial characteristics analyzed, most of them being placed at the left part of the graph, characteristics which reflect highly significant correlation coefficients. The closed association between sensory and physico-chemical characteristics of the beer analyzed samples it may be noticed between CO_S, FS_S and FS at a level of $p = 0.01$ which may be clearly seen in the left part of the graph.

Figure 1. PCA loadings of black beer properties

Conclusion

These researches proposed to obtain a new assortment of black beer, having as basic ingredients unconventional raw materials, respecting the classical technological process of obtaining beer. The new product is part of the category of undistilled black beer alcoholic beverages, whose composition includes only natural ingredients: water, acorn flour, topinambur flour, molasses, hops and yeast, without the addition of food additives. The uniqueness of the product is mostly due to the ingredients used in the manufacturing recipe of the finished product: the use of acorn and topinambur flour as raw materials and the capitalization of molasses, as a by-product of sugar production.

The product has been conceived as a product that can be easily reproduced on an industrial scale, from micro-factories to high-capacity production companies, through a simple process, in accordance with the regulations in force, respecting food safety.

References

1. Deželak, M., Gebremariam, M. M., Zarnkow, M., Becker, T., Košir, I. J. (2015), Part I: the influence of serial repitching of *Saccharomyces pastorianus* on the uptake dynamics of metal ions and fermentable carbohydrates during the fermentation of barley and gluten-free buckwheat and quinoa wort, *J. Inst. Brew.*, 121(3), pp. 356–369.

2. Watson, H. G., Vanderputten, D., Van Landschoot, A., Declodet, A. I. (2019), Applicability of different brewhouse technologies and gluten-minimization treatments for the production of gluten-free (barley) malt beers: Pilot-to industrial-scale, *J. Food Eng.*, 245, pp. 33–42.
3. Kerpes, R., Fischer, S., Becker, T. (2017), The production of gluten-free beer: Degradation of hordeins during malting and brewing and the application of modern process technology focusing on endogenous malt peptidases, *Trends Food Sci Technol.*, 67, pp. 129–138.
4. Fanari, M., Forteschi, M., Sanna, M., Zinellu, M., Porcu, M. C., Pretti, L. (2018), Comparison of enzymatic and precipitation treatments for gluten-free craft beers production, *Innov Food Sci Emerg Technol.*, 49, pp. 76–81.
5. Ceccaroni, D., Sileoni, V., Marconi, O., De Francesco, G., Lee, E. G., Perretti, G. (2019), Specialty rice malt optimization and improvement of rice malt beer aspect and aroma, *LWT–Food Sci Technol*, 99, pp. 299–305.
6. Phiarais, B. P. N., Mauch, A., Schehl, B. D., Zarnkow, M., Gastl, M., Herrmann, M., Arendt, E. K. (2010), Processing of a top fermented beer brewed from 100% buckwheat malt with sensory and analytical characterisation, *J. Inst. Brew.*, 116(3), pp. 265–274.
7. Mayer, H., Ceccaroni, D., Marconi, O., Sileoni, V., Perretti, G., Fantozzi, P. (2016), Development of an all rice malt beer: A gluten free alternative, *LWT-Food Sci Technol*, 67, pp. 67–73.
8. Di Ghionno, L., Sileoni, V., Marconi, O., De Francesco, G., Perretti, G. (2017), Comparative study on quality attributes of gluten-free beer from malted and unmalted teff [*Eragrostis tef* (zucc.) trotter], *LWT-Food Sci Technol*, 84, pp. 746–752.
9. Adiamo, O. Q., Fawale, O. S., Olawoye, B. (2018), Recent Trends in the Formulation of Gluten-Free Sorghum Products, *J. Culin. Sci. Technol.*, 16(4), pp. 311–325.
10. Gebremariam, M. M., Zarnkow, M., Becker, T. (2014), Teff (*Eragrostis tef*) as a raw material for malting, brewing and manufacturing of Gluten-Free foods and beverages: a review, *J. Food Sci. Technol*, 51(11), pp. 2881–2895.
11. De Meo, B., Freeman, G., Marconi, O., Booer, C., Perretti, G., Fantozzi, P. (2011), Behaviour of malted cereals and pseudo-cereals for gluten-free beer production, *J. Inst. Brew.*, 117(4), pp. 541–546.
12. Bogdan, P., Kordialik–Bogacka, E. (2017), Alternatives to malt in brewing, *Trends Food Sci Tech*, 65, pp. 1–9.
13. Van Landschoot, A. (2011), Gluten-Free barley malt beers, *Cerevisia*, 36, pp. 93–97.
14. Hager, A.S., Taylor, J.P., Waters, D.M., Arendt, E.K. (2014), Gluten free beer—A review, *Trends Food Sci Technol.*, 36(1), pp. 44–54.
15. Rubio–Flores, M., Serna–Saldivar, S. (2016), Technological and engineering trends for production of Gluten-Free beers, *Food Eng. Rev.*, 8 (4), pp. 468–482.
16. Korus, J., Witczak, M., Ziobro, R., Juszczak, L. (2015), The influence of acorn flour on rheological properties of Gluten-Free dough and physical characteristics of the bread, *Eur Food Res Technol*, 240(6), pp. 1135–1143.
17. Ajo, R.Y. (2018), Effect of acorn flour substitution on arabic bread properties, *Pakistan Journal of Agricultural Sciences*, 55(4), pp. 913–919.
18. Parsaei, M., Goli, M., Abbasi, H. (2017), Oak flour as a replacement of wheat and corn flour to improve biscuit antioxidant activity, *Food Sci Nutr*, 6, pp. 253–258.
19. Al–Rousan, W.M., Ajo, R.Y., Al–Ismail, K.M., Attlee, A., Shaker, R.R., Osaili, T.M. (2013), Characterization of acorn fruit oils extracted from selected mediterranean *Quercus* species, *Grasas Aceites*, 64 (5), pp. 554–560.
20. Correia, P., Leitão, A., Beirão-da-Costa, M. (2009), Effect of drying temperatures on chemical and morphological properties of acorn flours, *Int. J. Food Sci. Technol.*, 44, pp. 1729–1736.
21. Ferraz de Oliveira M.I., Machado M., Cancela d’Abreu M. (2012), Acorn chemical composition depending on s hedding date and *Quercus* species, *Options Méditerr.*, 101, pp. 229–234.

22. Rakić, S., Kukić-Marković, J., Petrović, S., Tešević, V., Janković, S., Povrenović, D. (2018), Oak kernels—volatile constituents and coffee-like beverages, *J. Agric. Sci.*, 10(5), pp. 117–124.
23. Matías, J., González, J., Royano, L., Barrena, R. A. (2011), Analysis of sugars by liquid chromatography–mass spectrometry in *Jerusalem artichoke* tubers for bioethanol production optimization, *Biomass Bioenerg.*, 35(5), pp. 2006–2012.
24. Lim, S.H., Ryu, J.M., Lee, H., Jeon, J.H., Sok, D.E., Choi, E.S. (2011), Ethanol fermentation from *Jerusalem artichoke* powder using *Saccharomyces cerevisiae* KCCM50549 without pretreatment for inulin hydrolysis, *Bioresour. Technol.*, 102(2), pp. 2109–2111.
25. Goranova, Z., Baeva, M., Vrancheva, R., Petrova, T., Stefanov, S. (2019), Antioxidant properties and color characteristics of sponge cakes containing functional components, *Ukr. Food J.*, 8 (2), pp. 260–270.
26. Dabija, A., Codină, G. G., Ropciuc, S., Stroe, S. G. (2019), Studies regarding the production of a novel yogurt using some local plant raw materials, *J. Food Process. Pres.*, 43(6), e13826.
27. Yang, L., He, Q.S., Corscadden, K., & Udenigwe, C.C. (2015), The prospects of *Jerusalem artichoke* in functional food ingredients and bioenergy production, *Biotechnol. Rep.*, 5, pp. 77–88.
28. Munim, A., Rod, M.R., Tavakoli, H., & Hosseinian, F. (2017), An analysis of the composition, health benefits, and future market potential of the *Jerusalem artichoke* in Canada, *J. Food Res.*, 6(5), pp. 69–69.
29. Radovanovic, A., Stojceska, V., Plunkett, A., Jankovic, S., Milovanovic, D., Cupara, S. (2015), The use of dry *Jerusalem artichoke* as a functional nutrient in developing extruded food with low glycaemic index, *Food Chem.*, 177, pp. 81–88.
30. Zhang, T., Chi, Z., Zhao, C.H., Chi, Z.M., Gong, F. (2010), Bioethanol production from hydrolysates of inulin and the tuber meal of *Jerusalem artichoke* by *Saccharomyces* sp. W0, *Bioresour. Technol.*, 101(21), pp. 8166–8170.
31. Arshad, M., Hussain, T., Iqbal, M., Abbas, M. (2017), Enhanced ethanol production at commercial scale from molasses using high gravity technology by mutant *S. cerevisiae*, *Braz. J. Microbiol.*, 48(3), pp. 403–409.
32. Fadl, K.S.H., Abbashar, O., Musa, A. (2018), Utilization of mash treatment unit for sterilization and clarification of final molasses in ethanol plant, *Intern.J. Photochem. Photobiol.*, 2(2), 49.
33. Dabija, A. (2019), *Biotechnologies in the food industry*, Iasi, Performantica Press
34. SR 4230:2004, Beer, Standardization Association of Romania (ASRO), Bucharest, Romania.
35. SR 13355–6:2000, Beer. Analysis methods. Determination of total acidity, Standardization Association of Romania, Bucharest, Romania
36. SR 13355–1:1997, Beer. Analysis Methods. Sensorial Analysis, Standardization Association of Romania (ASRO), Bucharest, Romania.
37. Ceppi, E.L.M., Brenna, O.V. (2010), Brewing with rice malt – a Gluten-Free alternative, *J. Inst. Brew.*, 116, pp. 275–279.
38. Guerdum, L.J., Bamforth, C.W. (2011), Levels of gliadin in commercial beers, *Food Chem.*, 129, pp. 1783–1784.
39. Owhero, J., Ifesan, B., Kolawole, A. (2019), Physico-chemical properties of malted finger millet (*Eleusine coracana*) and pearl millet (*Pennisetum glaucum*), *Food Sci Nutr.*, 7(2), pp. 476–482.
40. Codină, G.G., Mironeasa, S., Leahu, A. (2011), Predicting the sensory quality of some Romanian beers from physical–chemical data using multivariate analysis, *Food and Environment Safety*, 10(1), pp. 36–42.