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INVESTIGATION OF THE PROCESS OF PRODUCTION OF CRAFTED BEER WITH SPICY AND AROMATIC RAW MATERIALS

Marija Zheplinska, Mikhailo Mushtruk, Volodymyr Vasyliv, Olena Deviatko

ABSTRACT

This scientific work demonstrates the stages of the process of inspiring the spicy aromatic raw materials of Badian, which is added to the craft beer in the process of its digestion. In addition, the work shows an analysis of the composition of spicy aromatic raw materials which will be used as an additive. The research proves the rational quantity and concentration of alcoholic spiro-aromatic raw materials for beer and determines the effect of alcoholic spiro-aromatic raw materials on beer indices. We have clarified the organoleptic and physicochemical parameters of beer with spicy aromatic raw materials Badian and composition based on infusions of Badian and cinnamon. As a result, we received water-alcohol infusions of spicy aromatic raw materials and developed new types of beer on their basis. On the basis of the conducted studies, the regression equation of the dependence of the content of actual dry substances and the volumetric fraction of alcohol from the change in the amount of spray-aromatic raw material and alcohol concentration in the alcohol-alcoholic infusion of spin-aromatic raw materials was obtained. In addition, we conducted calculations on the cost-effectiveness of adding these types of spiced aromatic raw materials to beer.

Keywords: crafted beer; Badian; cinnamon; spicy aromatic raw material; infusions

INTRODUCTION

Beer is a popular drink in many countries of the world due to its taste and aroma, especially among young people. Today, the technology of beer production is aimed at the development of new varieties with the addition of non-traditional vegetable raw materials, which give the drink specific characteristics of taste and increase the demand for products **(Basařová et al., 2010; Punčochářová et al., 2015)**.

In addition, beer, made with the addition of plant material, has improved organoleptic and physicochemical characteristics and a longer expiration date.

By adding antioxidants of plant material to beer, we can reduce the oxidative and toxic effects of alcohol on the human body. Non-harmful antimicrobial and antifungal substances of natural origin, in the case of adding to beer, may improve its qualitative parameters and prevent contamination by microorganisms and the use of preservatives in the production of beverage **(Hucker et al., 2016; Chaya et al., 2015; Ganbaatar et al., 2015)**. Beer with added spices has been known for a long time. In the past, adding spices helped to preserve the freshness of the beer, disguised any odd flavours and even prevented the beer from spoiling. Herbs served as a replacement for hops, adding bitterness and a specific astringency to beer. Now, on the contrary, spices, and herbs are used to produce beer with an unusual taste and aroma. They are added in the form of aqueous-alcoholic infusions during the boiling mash, during fermentation, in the period of digestion or just before bottling. In the production of such beer, both light and dark wheat malt can be used. To achieve the best result in the production of beer with herbs and spices it is necessary to withstand finished products for 2 – 3 months. During this time, beer acquires a richer aroma of added ingredients, it increases the content of alcohol and disappears sharp flavor **(Mascia et al., 2016; Salailenbi Mangang, Das and Deka, 2017)**.

Cinnamon, coriander, ginger, nutmeg, pepper, vanilla, various herbs, flowers, coniferous plants, as well as mixed compositions of berries and fruits are the most widely used in the production of beer **(Kábelová-Ficová et al., 2017; Sukhenko et al., 2019a)**.

In recent years, the importance of creating alcoholic beverages with the use of medicinal infusions of essential oils has increased: lemon, mint, sage, and others. Such infusions not only improve the organoleptic characteristics of products, but also enrich them with biologically active substances, which makes them useful for human health **(Omelchuk and Golovchenko, 2011; Baert et al., 2012)**.

This research seeks to explore the recent development of the craft beer industry, using brewing industry as a prism for development elsewhere in Ukraine. The research is

conceptual in nature. A conceptual approach has been taken for three reasons, firstly, it allows engagement with the research in order to introduce new concepts. Secondly, engagement with the research through conceptual frameworks enables people to see issues in a way they had not previously, and thirdly, findings from such research can help broaden our understandings about the kinds of solutions that should be considered and are most appropriate to pursue to enhance development of the craft brewing industry.

Scientific hypothesis

The scientific hypothesis is to create a new product – craft beer with the addition of infusion of spicy-aromatic raw material of almonds, which will lead to a drink with pronounced organoleptic characteristics. Scientific work involves the possibility of adding and composition of several spicy-aromatic additives in the form of infusions. This will allow us to get a harmonic drink with natural ingredients with a long shelf life.

MATERIAL AND METHODOLOGY

We chose Badian and cinnamon as an additive to beer. These spices are rich in essential oils, flavonoids, micro, and macro elements and have a positive effect on the human body **(Romanova, Pribylsky and Tertytsia, 2008)**.

Extraction of spicy-aromatic raw material is recommended by the method of infusion (maceration) since it does not require complicated and expensive technological equipment, skilled personnel, easy to carry out for mini-breweries **(Sukhenko et al., 2019b)**. For the extraction of components of spicy aromatic raw materials, we chose water-alcohol solutions, as they are the best solvents of essential oil compared to water **(Sukhenko et al., 2017)**. Spicy aromatic infusions are recommended to be introduced into beer before digestion **(Lazarov and Zheplinska, 2017; Zhosan and Zheplinska, 2018)**. Determination of the organoleptic parameters and the content of dry matter in the spices and aromatic raw materials were determined according to the method described in state standard of Ukraine 4705:2006 **(DSTU 4705:2006)**, which is based on the determination of the refractive index of the test solution after alcohol distillation.

Determination of the alcohol content in the prepared water-alcohol solutions was carried out by an aerometric method based on measuring the concentration of ethyl alcohol by the hydrometer in the distillate obtained after distillation of alcohol from the investigated infusion **(DSTU 4705:2006)**.

Determination of organoleptic parameters of the finished beer was carried out in accordance with state standard of Ukraine **(DSTU 7103:2009)**.

The transparency of beer was determined in a glass in which it is pre-poured and viewed in passing light.

The aroma and taste of beer were determined organoleptically, immediately after the sample was placed at a temperature 12.0 ±2.0 °C in the tasting glass.

Determination of physicochemical indices of infusions and prepared beer was carried out on the beer analyzer PBA-B generation M (Figure 1) **(Shakhvorostova and Zheplinska, 2018)**.

Statistic analysis

Mathematical and statistical processing of the experimental data was carried out in the determination of Kohren, Fisher and Student's criteria using full-factor experiment and using the least squares method. The accuracy of the data obtained was determined using the Kokhren criterion, and the adequacy of the mathematical model was verified using the Fisher and Student criteria. The values were evaluated through mean and standard deviation by Microsoft Excel 2013.

RESULTS AND DISCUSSION

First of all, we have prepared aqueous-alcohol solutions with concentrations of 45, 50 and 55% for the research. To do this, we took distilled water and alcohol 96.3%. We added 10 g of the chopped pelican in 0.9 m_3 of aqueous-alcoholic solutions. So, we prepared 9 samples for infusion, which was carried out within 14 days.

The organoleptic parameters of infusions are determined according to **DSTU 4705:2006**. In our case, the infusion of spicy-aromatic raw materials which had the parameters presented in Table 1.

According to **DSTU 4705:2006** the appearance of the infusion should be transparent, without external inclusions; color, taste, and aroma are inherent in the plant material from which they are made, without any taste and smell.

Figure 2 shows a change in the content of dry matter in bulk with the use of spicy and aromatic raw materials for 14 days.

As can be seen from the graphs presented in Figure 2, on the seventh day of infusion there is a noticeable increase in the content of dry matter in each of the infusions. Looking at the results obtained on the content of dry matter in virtually different concentrations with Badian, we can talk about their maximum values when reaching 8 days of insistence. However, after seven days of infusion, the dry matter content is also large and, compared with the first day, it increases by 45% and 50% of infusions by 1.5% by weight and for a 55% infusion of 2.0% by weight. Further tightening is inappropriate, because there is no increase in the content of dry matter, and sometimes such an action leads to a decrease in its value.

For conducting experimental studies on a mini brewery, a young beer that wandered for 7 days at a temperature of 8 – 10 °C was selected for this purpose: for this, a beer was made of 100% light malt and prepared beer wort with a concentration of dry matter of 11.0%, for the digestion of which was used the yeast S-23, which belongs to the germicidal yeast. For the chilling of the wort, bitter hops Tetnanger and aromatic honey Salaz were used.

In experimental samples of young beer, various volumes of water-alcohol infusions of Badian were added. Drinking was carried out in the laboratory for 7 days at +6 ºC, and then another 7 days at +2 ºC.

Ready-made samples of beer were compared among themselves by organoleptic and physicochemical indicators.

Table 2 shows the concentration and amount of alcohol – alcoholic spices and aromatic raw materials for different

beer samples, including the control sample. The organoleptic and physicochemical indices of beer with the addition of water-alcoholic tincture of Badian are given. In Table 4 can be observed a similar decrease in the pH value. The low pH value contributes to the diacetyl digestion, which positively affects the quality of the finished beer. Regarding the results of the actual extract, the content of dry matter in the initial wort and the content of alcohol, we see an increase in their values compared to the control due to the addition of a certain amount of water-alcohol infusion, so that alcohol is added to the samples and their concentration increases.

Compared to the control sample, the color of beer becomes more intense due to the transition of the colorants of Badian to beer. The actual degree of fermentation increases, the maximum value of which is 65.21% for sample 17 when added 55% water-alcoholic infusion. All samples of beer, except for one, have a higher actual degree of fermentation, which satisfies the requirements for beer.

The actual digestibility values obtained for 17 samples are larger, and therefore they all show better results than the control sample. However, sample 14 with a score of 23.3 can be considered the best because it feels a pleasant aroma and harmonious taste with an excellent tasting score and with a small amount of added extract.

The nature of the change in the pH value can be seen in Figure 3, the minimum value of which we have at 50% water-alcohol infusion.

In Figure 3 it is possible to see a change in the value of the actual extract, respectively, for infusions of Badian, from which it is evident that the addition of 0.002 m^3 of water-alcohol infusion of Badian to beer leads to an increase in the actual extract observed for all three concentrations of infusion. Further increase in the amount of infusion is not feasible due to a slight increase or even a decrease in the value of the actual extract.

In Figure 3 and Figure 4 depicts the graphs of alcohol content in beer depending on the amount of added alcoholic beverages of spices and aromatic substances – for ginger, parsley and nutmeg.

As can be seen from Figure 4, when adding from 0.001 to 0.003 m^3 of 55% alcoholic water-alcohol ginger to beer gives the same value of alcohol content, which is 4.69% vol. And when you add 45 and 50% of water-alcoholic infusions, the alcohol content is lower, but is in the area of the required values for beer in accordance with state standard of Ukraine 3888:2015 **(DSTU 3888:2015)**. Increasing the amount of infusion from 0.0015 m^3 is not feasible, as it leads to sharp jumps in alcohol content.

In Figure 5 it can be seen that the addition of Bayard extracts in different amounts and concentrations leads to an increase in the total alcohol content, and the tendency to increase this value at a higher concentration of aqueous-alcohol solution is clear. The content of alcohol with the addition of infusions in the amount of 0.0035 m^3 in all cases is the largest and is: at a strength infusion of 45% vol. – 4.5%; 50 and 55% vol. – 4.58% and 4.66% respectively; in the control sample – 4.14% by volume. The increase in the alcohol content is due to the addition of alcohol from alcoholic beverages to Badian.

After a detailed analysis of the organoleptic and physico-chemical parameters of the beer samples obtained during the use of infusions, it was found that the best are: infusion of Badian with a strength of 50% by volume added to the beer in the amount of 0.002 m^3.

The consumer, choosing one or another beverage (and especially beer), increasingly focuses on certain criteria, the main of which are organoleptic qualities, the content of natural ingredients, the health effect and the convenience of packaging. Raw materials of Ukraine are rich in natural, environmentally friendly vegetable spices and aromatic raw materials, which may be an alternative substitute for hazardous food additives of synthetic origin. Therefore, the issue of studying the chemical composition of plant spices and aromatic raw materials and technological aspects of its use in beverage technology is relevant **(Techakriengkrai et al., 2012; Sheiko et al., 2019)**.

To create a composition of beer, we selected a spicy aromatic infusion of Badian and cinnamon. The conducted researches allowed to establish rational amounts of data added to 0.002 m^3 of young beer substances, namely: Badian in the amount of 0.002 m^3 50% water-alcohol solution and cinnamon in the amount of 0.0025 m^3 45% water-alcohol solution.

Table 5 shows the organoleptic characteristics of beer, with the addition of the abovementioned mix. It demonstrates that the beers look the same, whilst the aromatic characteristics contribute to give the beer a clear taste and freshness, with notes of the anise tree. By taste, this composition differs from the control sample with the harmony and flavor of cinnamon. According to the tasting assessment, the composition of Badian and Cinnamon received

23.5 points, in contrast to the control sample, which is lower by one point.

According to the physical and chemical parameters of the finished beer, the sample obtained at 0.11 units showed less value of the pH value, which is indicated by an increase in the shelf life of such beer. The value of the actual extract decreased by 20% (from 5.82 to 4.65% by weight), which suggests the best of beer fermentation. The content of dry matter and alcohol has increased due to the addition of extracts of water and alcohol solutions. The color in the sample of beer with the composition of badyan and cinnamon extracts increased by 4.7% due to the transition of colorants in the infusion. The actual degree of fermentation has increased by 25%.

Consequently, on the basis of the results obtained from the organoleptic and physico-chemical parameters, it is possible to draw conclusions about the expediency of using the composition of spiced aromatic raw materials (Badian and cinnamon) in beer technology. Ready-made drink has pleasant organoleptic properties, necessary physical, chemical and functional qualities. Expanding the assortment of beer using a composition of spicy aromatic vegetable raw materials will saturate the modern market with healthy food.

Figure 1 Beer Analyzer PBA-B Generation M.

Table 1 Organoleptic parameters of infusion of Badian.

Parameter	Ginger		
	45% of alc.	50% of alc.	55% of alc.
Appearance	Transparent with brilliance		
Color	Dark brown		
Taste	Spicy, without any additional tastes		
Aroma	Spicy, without any additional tastes		

Table 2 Concentration and amount of alcohol-alcoholic infusion of spin-aromatic raw materials in beer samples.

Sample	**The concentration of the aqueous-alcoholic solution of spin-aromatic raw materials, %**	**Amount of water-alcohol solution of spiced-aromatic raw materials, m3**
1	45	1.0
2		1.5
3		2.0
4		2.5
5		3.0
6		3.5
7	50	1.0
8		1.5
9		2.0
10		2.5
11		3.0
12		3.5
13	55	1.0
14		1.5
15		2.0
16		2.5
17		3.0
18		3.5

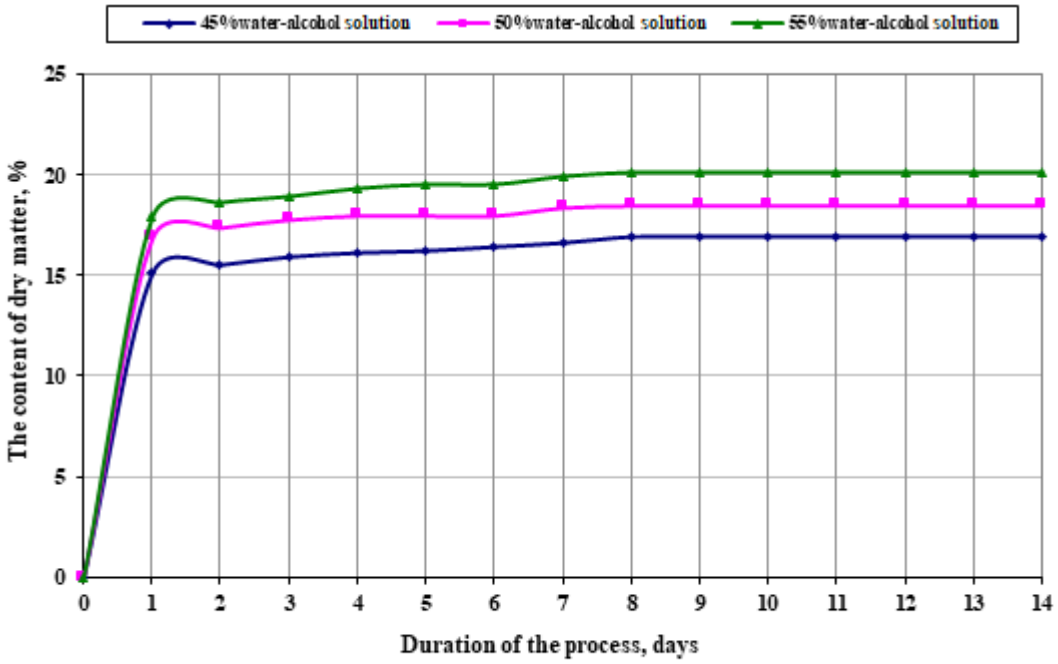

Figure 2 Change in the content of dry matter from the duration of infusion for Badian respectively in Table 2 and Table 3.

Table 3 Organoleptic parameters of beer samples with the addition of water-alcohol tincture of Badian.

Sample	Appearance	Aroma	Taste	Tasting, score
Controlling	Opaque foamy liquid	As in a regular light beer	Hop flavor, soft bitter bitterness, no scent of Badian	22.8
1	Same	Slight Badian aroma	Same	22.8
2	-«»-	Same	-«»-	22.8
3	-«»-	-«»-	-«»-	22.5
4	-«»-	-«»-	-«»-	22.8
5	-«»-	-«»-	-«»-	22.7
6	-«»-	-«»-	Harmonious, tangible taste of Badian, soft hops' bitterness	22.8
7	-«»-	The clear fragrance of Badian	Same	22.0
8	-«»-	Same	-«»-	21.3
9	-«»-	-«»-	-«»-	23.5
10	-«»-	-«»-	-«»-	23.5
11	-«»-	The clear fragrance of Badian	-«»-	22.5
12	-«»-	-«»-	-«»-	22.0
13	-«»-	-«»-	-«»-	21.7
14	-«»-	-«»-	-«»-	21.7
15	-«»-	-«»-	-«»-	21.7
16	-«»-	The vigorous scent of Badian	The vigorous scent of Badian	21.5
17	-«»-	Same	Same	21.5
18	-«»-	-«»-	-«»-	21.5

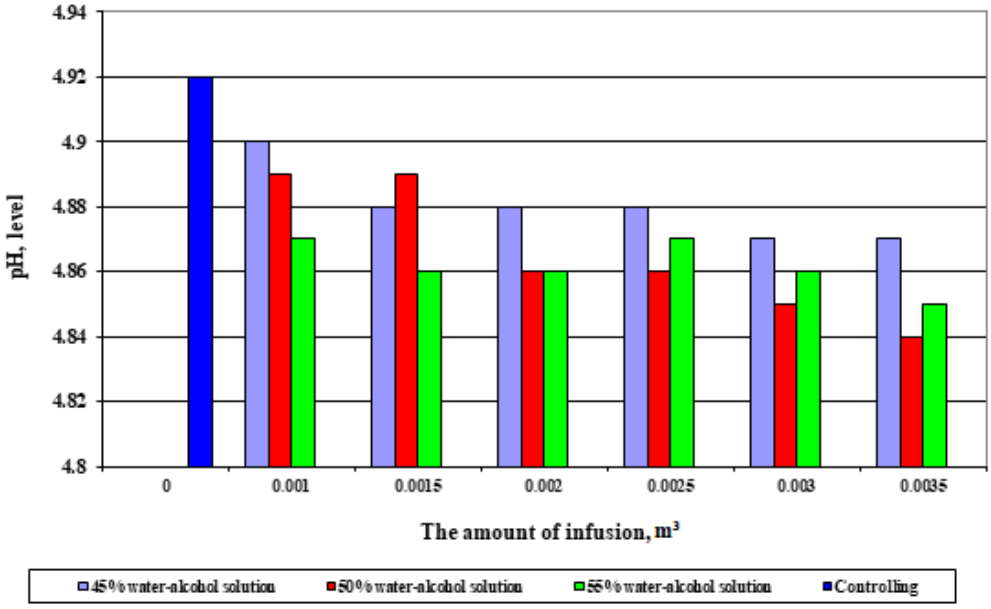

Figure 3 Changing the pH value from the amount of added water-alcohol infusion for Badian.

Table 4 Physico-chemical parameters of beer samples with the addition of water-alcohol infusion of Badian.

Sample	pH	Extractive, %		The content of dry matter in the initial wort, %	Alcohol		Color, EBC	The actual degree of digestion, %
		Visible	Actual		% of the mass	%		
K	4.92	2.53	4.04	10.39	3.24	4.14	18.9	62.37
1	4.90	2.61	4.15	10.56	3.28	4.19	20.8	62.06
2	4.88	2.58	4.15	10.68	3.35	4.28	18.9	62.52
3	4.88	2.68	4.24	10.75	3.34	4.27	26.9	61.96
4	4.88	2.65	4.21	10.75	3.35	4.28	19.0	62.16
5	4.87	2.48	4.11	10.97	3.51	4.49	20.8	63.84
6	4.87	2.51	4.16	11.02	3.52	4.50	21.7	63.66
7	4.89	2.57	4.11	10.56	3.30	4.21	19.5	62.37
8	4.89	2.49	4.07	10.69	3.39	4.33	19.0	63.24
9	4.86	2.46	4.07	10.78	3.44	4.39	21.9	63.58
10	4.86	2.43	4.08	10.97	3.53	4.51	20.7	64.16
11	4.85	2.46	4.13	11.12	3.59	4.58	34.5	64.20
12	4.84	2.39	4.08	11.19	3.65	4.66	26.5	64.88
13	4.87	2.56	4.12	10.64	3.34	4.26	19.1	62.61
14	4.86	2.58	4.15	10.74	3.37	4.31	20.3	62.68
15	4.86	2.56	4.17	10.89	3.44	4.40	23.9	63.06
16	4.87	2.44	4.09	10.96	3.53	4.50	20.8	64.08
17	4.86	2.37	4.09	11.31	3.71	4.74	18.9	65.21
18	4.85	2.52	4.19	11.18	3.59	4.58	19.2	63.87

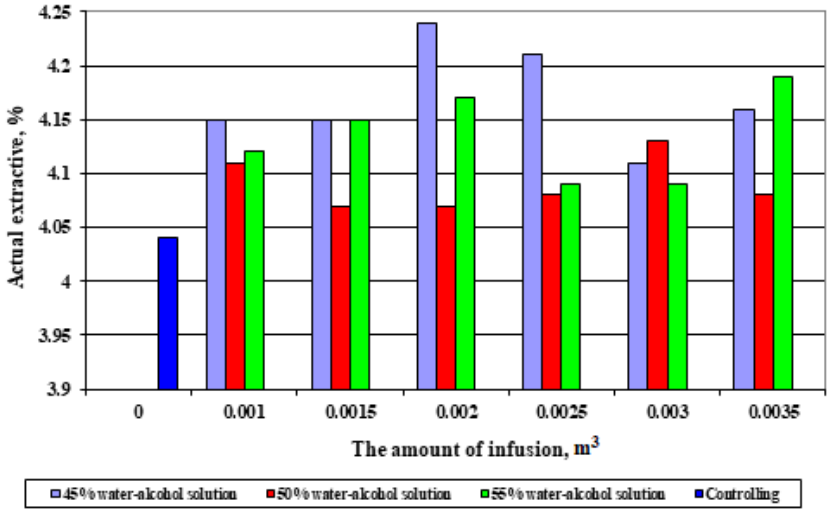

Figure 4 Dependence of the actual extract on the amount of added water-alcohol infusion for Badian.

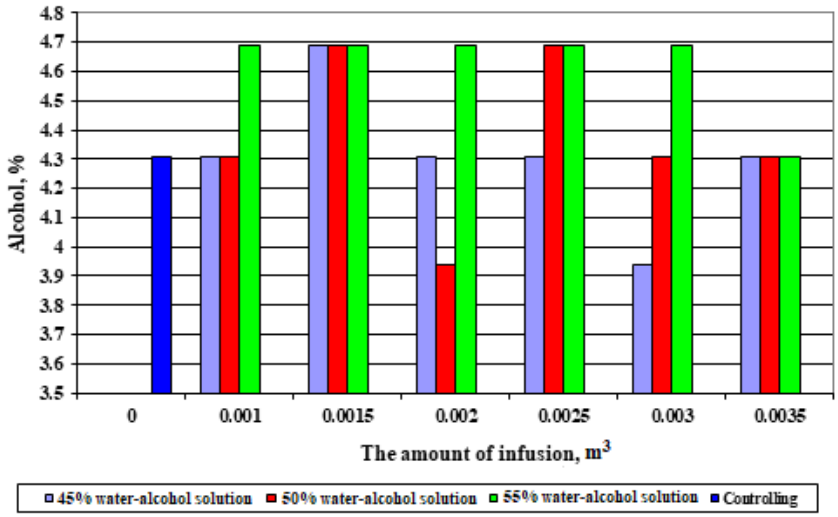

Figure 5 Dependence of alcohol content on the amount of added water-alcoholic infusion for Badian.

Table 5 Organoleptic parameters of beer with the addition of composition.

Sample	Appearance	Aroma	Taste	Tasting, score
Controlling	Opaque foamy liquid	Weak yeast flavor	Saturated, sweet, residual rough hops' bitterness	22.8
Composition	Same	Clear fresh taste with Badian aroma	Full, harmonious smell of cinnamon	23.5

Simulation of the infusion process was carried out using a complete two-factorial experiment **(Kolyanovska et al., 2019)**. On the basis of these experiments, the equation of the dependence of the content of the actual dry substances in the beer within the limits of the amount of the amount of Badian infusion from 0.001 to 0.0035 m3, the concentration of alcohol in the water-alcohol solution of Badian from 45 to 55% with an average relative error of 0.36%.

We got the alcohol dependence equation in beer within the limits of changing the amount of infusion Badian from 0.001 to 0.0035 m3, the concentration of alcohol in a water-alcohol solution Badian from 45 to 55% with an average relative error of 0.06%.

The economic effect of the sale of beer with the present in comparison with beer without them will be for beer with:

- Badyan – 0.08 $ for 10L;
- the composition of infusions of Badian and cinnamon – 0.1 $ for 10L.

CONCLUSION

It is established that the addition of tincture of Badian positively affects the organoleptic characteristics of beer, gives it a pleasant taste and aroma. Adding infusions of spices and aromatic substances leads to a decrease in the pH, increase the content of alcohol and color. Adding spicy aromatic raw materials to beer allows you to get the finished product, which will contain biologically active substances such as essential oils, vitamins, essential amino acids, micro-and macro elements, colorants that provide a pleasant taste and aroma, have a prophylactic act and increase the shelf life of beer. The conducted researches allow giving the following recommendations for the addition of tincture of spices and aromatic raw materials to beer:

- 50% water-alcohol infusion of banyan in the amount of 0.002 m3 to 2 m3 of young beer after 8 days of insistence;
- Badian – in the amount of 0.002 m3 prepared in 50% aqueous alcohol solution (10 g/dal) and cinnamon – in the amount of 0.002 m3, prepared in 45% water-alcohol solution (12.5 g/gave) – for the composition.

The obtained regression equations will allow to determine in beer the content of actual dry substances and the volume fraction of alcohol in the amount of changes in the amount of spices and aromatic raw materials intakes from 0.001 to 0.0035 m3 and the concentration of alcohol in them from 45 to 55% by volume. The economic effect of adding spices and aromatic raw materials to beer and the expediency of using such infusions for obtaining craft beer is established.

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Contact address:

Marija Zheplinska, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of Processes and Equipment for Processing of Agricultural Production, Heroev Oborony Str., 12 B, Kyiv, 03040, Ukraine, Tel.: +38(050)133-80-28,
E-mail: jeplinska@ukr.net
ORCID: https://orcid.org/0000-0002-7286-3003

*Mikhailo Mushtruk, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of Processes and Equipment for Processing of Agricultural Production, Heroev Oborony Str., 12 B, Kyiv, 03040, Ukraine, Tel.: +38(098)941-26-06,
E-mail: mixej.1984@ukr.net
ORCID: https://orcid.org/0000-0002-3646-1226

Volodymyr Vasyliv, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of Processes and Equipment for Processing of Agricultural Production, Heroev Oborony Str., 12 B, Kyiv, 03040, Ukraine, Tel.: +38(097)465-49-75,
E-mail: vasiliv-vp@ukr.net
ORCID: https://orcid.org/0000-0002-8325-3331

Olena Deviatko, National University of Life and Environmental Sciences of Ukraine, Mechanical and Technological Faculty, Department of Technical Service and Engineering Management th. M.P. Momotenka, Heroev Oborony Str., 12 B, Kyiv, 03040, Ukraine, Tel.: +38(066)205-43-01,
E-mail: helene06@ukr.net
ORCID: https://orcid.org/0000-0002-4743-6931

Corresponding author: *