UDC 615.451.1-021.462

INVESTIGATION OF THE EFFECTIVENESS OF USING WHEY POWDER TO REDUCE THE TOXICITY OF THE WATER/ALCOHOL MIXTURE

V. Kolesnyk,Candidate of Technical Sciences, Associate Professor
N. Penkina, Candidate of Technical Sciences, Associate Professor
V. Polupan,Candidate of Technical Sciences, Associate Professor
S. Sorokina, Candidate of Technical Sciences, Associate Professor
D. Odarchenko, Doctor of Technical Sciences, Professor
A. Penkin, Assistant
Department of Trade, Hotel, Restaurant and Customs
State Biotechnological University
Alchevskih str., 44, Kharkiv, Ukraine, 61002

DOI: https://doi.org/10.15673/fst.v16i2.2364

Article history

Received 29.09.2021
Reviewed 17.11.2021
Revised 15.02.2022
Approved 24.05.2022

Correspondence:

V. Kolesnyk
*E-mail:*vkol240584@gmail.com

Cite as Vancouver style citation

Kolesnyk V, Penkina N, Polupan V, et al. Investigation of the effectiveness of using whey powder to reduce the toxicity of the water/alcohol mixture. Food science and technology.2022;16(2):71-77. https://doi.org/10.15673/fst.v16i2.2364

Цитування згідно ДСТУ 8302:2015

Investigation of the effectiveness of using whey powder to reduce the toxicity of the water/alcohol mixture / Kolesnyk V., Penkina N., Polupan V., Sorokina S., Odarchenko D., Penkin A. // Food science and technology. 2022. Vol. 16, Issue 2. P. 71-77 https://doi.org/10.15673/fst.v16i2.2364

Abstract. A promising way of reducing the toxicity of ethanol is purifying the water/alcohol mixture with sorbents. This paper proves the effectiveness of the method when prepared whey powder is used to remove toxic elements from a water/alcohol mixture. In the test samples, the mass concentration of toxic substances (methyl acetate, ethyl acetate, methanol) was determined by high-performance gas chromatography. It has been established how the effectiveness of purifying the alcohol/water mixture depends on the amount of the sorbent added and on the resting duration. The amount of the sorbent was 3–9 kg per 1000 dal, when calculated as whey powder, and the resting time was 1–5 hours. The maximum decrease in toxic substances was observed when prepared whey (whey powder equivalent) was added in the amount 6.0±1.0 kg per 1000 dal, with 3 hours' resting. Under these purification conditions, the mass concentration of aldehydes in the water/alcohol mixture was reduced by 30%, the volume fraction of methanol by 27%, the mass concentration of esters by more than 70%, and the concentration of fusel oil did not exceed the detection threshold. The toxic substances decrease due to the coagulation of whey protein with quite a branched surface, which is accompanied by the sorption of toxic substances dissolved in the water/alcohol mixture, especially of those with a large molecular weight. These toxic components are the ones that can reduce the quality of raw materials and degrade the sensory properties. Purification of the water/alcohol mixture, when toxic compounds are removed with the help of prepared whey powder, improves the sensory characteristics. A sample purified with milk whey has a softer and more rounded flavour and a characteristic shine. The use of prepared whey as a sorbent to purify the water/alcohol mixture allows obtaining a low-toxic product with improved sensory properties.

Keywords: water/alcohol mixture, toxicity, whey, purification, quality.

Introduction. Formulation of the problem

The widespreadpractice of drinking alcohol involves a number of traditions and customs and is associated with social aspects and the psychological backgrounds of individuals. Although excessive alcohol consumption is a health hazard and a cause of death, the actual demand for distilled beverages is but higher year by year. The growing rates of alcohol-related morbidity and mortality are also due to the growing consumption of strong drinks including bootleg liquors of questionable quality [1].

Nowadays, when manufacturing distilled beverages, more attention is paid to developing new technologies and improving the existing ones in order to achieve a wider range of products and higher sales. However, today's consumer, who has a large variety of brands of any liquor to choose from, not only takes into account how well the product looks and tastes, but lays particular emphasis on its safety and effects on health. Thus, developing new, less toxic varieties of alcoholic products is a topical issue [2].

Analysis of recent research and publications

A promising direction in manufacturing high-quality alcoholic products is using new types of raw materials, which can make ethanol and its processing products less toxic for the human body. Of the existing methods that allow reducing the toxicity of distilled beverages (the water/alcohol mixture), some are worth noting.

One of them consists in introducing certain components (additives) into a liquor. Their properties allow them to neutralise the toxic effect of ethanol and ethanol products right in the human body. The components can be classified as raw materials of plant and animal origin, vitamin and mineral complexes, plant-derived and synthetic antioxidants, etc. [3].

Scientists established that extracts from plant raw materials could effectively reduce the toxicity of alcoholic beverages. Plant preparations, due to their properties, differ in their chemical composition, and this results in their different biological effects [4-6]. In developing any plant-based antitoxin, it is important to ensure that its biological effects are reproducible in practice. This can only be achieved when this product is standardised by objective parameters that can be quantified. Sadly, there are not enough research data today on the toxic effect of quite a number of plant-derived recipe components listed as approved raw materials for distilled beverages. Some plants contain certain chemical components that, on interacting with ethanol, produce potentially hazardous compounds, which are in vivo transformed into toxic compounds. Willow herb and coltsfoot extracts contain hepatoxic alkaloids. Sweet flag, elder, mint, wormwood, stones of cherries, apricots, and peaches contain virulent toxins too.

The research data [7,8] show that in the presence of alcohol, the activity of antioxidants increases, because these compounds can bind free radicals, active molecules with free chemical bonding, which damage cell membranes and DNA. Using antioxidant raw materials in formulations allows reducing the adverse effect of a liquor consumed and extending its shelf life. However, to exhibit their antioxidant properties to the maximum, different raw materials require different extraction conditions due to the complexity of the technological process.

New developments in introducing minerals and vitamin/mineral premixes into the composition of liquors are becoming more and more widespread. Mineral complexes, when added as anti-alcohol protectants, do not affect the sensory characteristics of a liquor, but activate the body's defences and reduce toxic elements in blood serum [9]. However, these developments have a number of disadvantages: they are difficult to use and costly, and there are no data on how these additives tell on the human body when consumed for a long time.

The classic method of purifying distilled beverages (of reducing the level of toxins) involves using the techniques based on filtering [10]. The process consists in adhesion of suspended and colloidal impurities in a water/alcohol mixture tothe grains of the filter material. Filtering systems are applied to reduce the number of suspended particles and the turbidity [11].

According to the technological guidelines on manufacturing vodkas and distilled beverages, the filter materials to be used in liquor production are chemically inert quartz sand, powdered anthracite filtrant (hydro-anthracite), powdered marble, pottery chips, etc. [12].

Higher requirements to the quality of distilled beverages call for using the most effective methods of removing impurities from raw materials. Of these, sorption purification belongs to the most effective [13]. The sorbents used should have extended or specific surface areas. The most promising direction is the use of sorbents at the intermediate technological stage of manufacturing distilled beverages. This ensures the preventive sorption of toxic elements when producing a liquor (due to extra treatment of the alcohol/water mixture) and makes it impossible for them to enter the human body [14].

There are but few studies of how certain sorbents can be used to reduce the toxic effect of the water/alcohol mixture. There exist technologies that use milk powder and powdered egg white in manufacturing distilled products, which results in less manifested post-intoxication and a milder flavour of the liquor [15].

All the above makes it clear how necessary it is to find alternative sources of animal-derived products that, when applied in the course of manufacturing, could help reduce the level of toxins in a finished product.

It was decided to use powdered whey as the source of milk protein to purify the water/alcohol mixture. It contains less protein than milk powder does, but its low production cost makes its use more practical.

The purpose is to substantiate scientifically the most practical conditions of purifying the water/alcohol mixture by means of milk whey powder.

For this purpose, **the objectives** to be achieved are as follows:

– by experiments and through mathematical modelling, to determine the conditions for the most efficient purification ofthe water/alcohol mixture by means of milk whey powder;

– to compare and assess the quality (sensory parameters) and safety (concentrations of aldehydes, methyl acetate, ethyl acetate, methanol) of the newly developed purified water/alcohol mixture and the same parameters of the untreated water/alcohol mixture.

Research materials and methods

The research materials were samples of the water/alcohol mixture purified by treating with prepared milk whey. The water/alcohol mixture for the research was provided by «Prime» LVP. The powdered whey, was produced using membrane installations, was provided by «Kharkiv Dairy Plant» LLC.The physicochemical characteristics were as follows: moisture content 3.0%, fat content 1.0%, protein content 10.0%, acidity 5^0T, solubility index 0.5 cm^3 of wet residue, lactose 80%, ash 1.0%, pH (of the 10% solution) 6.5.

The milk whey was prepared as follows: to 3–9 kg of powdered whey, 10 l of water (as hot as 40–45°C)

was added, the mixture was stirred and incubated for 2–3 hours.

To purify the water/alcohol mixture, the whey prepared was added to the alcohol/water mixture in the amount 3–9 kg per 1000 dal, in terms of whey powder, then rested at 20±5°C for 1–5 hours, and filtered according to the manufacturing regulations TR U 18.5084 (through sand filters, using a coal purification unit). The sampling was carried out at intervals of 0.5 hours.

The clearness, colour, taste, and aroma were assessed by sensory evaluation on a ten-point scale (Table 1). The results obtained were compared with the requirements of the State Standard of Ukraine DSTU 4256:2003.

The mass concentrations of toxins (aldehydes, methyl acetate, ethyl acetate, methanol) in the samples under study were determined by high-performance gas chromatography, and the classes of compounds that go into the solution were established. To identify them, standard samples were used. The study was conducted on a gas chromatograph Agilent GC System with a mass selective detector and a column HP-5, 30 mm long, with the inside diameter of the capillary 0.32 mm and the stationary phase 0.25 μm thick. This method of chromatographic analysis requires certain temperature conditions of the chromatograph: as soon as the material to be analysed is injected into the vaporiser of the chromatograph, the temperature in the thermostat of the column, being initially 30°C, is gradually raised to 300 at a rate of 20°C a minute. The volume of a sample tested was 1.0±0.1 μl, the duration of the experiment 18 min.

The main peaks on the chromatogram of the water/alcohol mixture represent the toxic substances contained in the solution. The retention time 4.425 corresponds to the acetaldehyde content, 5.241 characterises the methyl acetate content, 6.000 – the ethyl acetate content, and 6.167 – that of methanol. The peak at the retention time 6.743 characterises the ethanol content. The chromatogram of the whey-treated water/alcohol mixture shows that the test sample contains a reduced amount of toxins, as compared with the untreated mixture sample (the chromatograms visualise the reduction in the peaks at the retention times 4.425, 5.241, 6.000, and 6.167). Due to the whey treatment of the water/alcohol mixture, the chromatogram reflects the content of organic acids (the retention times 16.635, 17.025, 19.216) and sugars (the retention times 23.756, 24.190). The ethanol content of the solution is characterised by the peak at the retention time 6.743 [16]. The peaks on the chromatogram are distinct, and this proves its veracity.

To summarise the results of the chromatographic analysis, modern methods of mathematical modelling were used.

To determine what conditions ensure the most efficient whey treatment of the water/alcohol mixture and the adequate quality of a finished product, it is necessary to provide scientific evidence on which to ground the optimum combination of the addition of prepared whey and the resting time.

The number of experiments was minimised by choosing the optimum, most intensive, design of experiments. It included 9 experiments, one for each of the toxins under study. This design, unlike that of a full factorial experiment, does not involve testing all the combinations of the input values, but is close to it in the accuracy of the mathematical model. The design matrix is presented in Table 2.

Results of the research and their discussion

The results of studying the safety indicators the experimental design matrix is based on are shown in Table 3.

Table 1– Thewater/alcohol mixture score

Quality indicator	Organoleptic characteristic	Score	Note
Clear and color	Colorless, transparent, shiny liquid	1.9-2.0 (perfectly)	
	Colorless, transparent, glossless liquid	1.8-1.9 (fine)	
	Colorless liquid with opal	Lower then 1.8 (unsatisfactory)	Removed from the tasing
Aroma	Typical for this species, pronounced	3.8-4.0 (perfectly)	
	Typical for this species, pleasant	3.6-3.8 (fine)	
	Typical for this species, weakly expressed	Lower then 3.6 (unsatisfactory)	Removed from the tasing
Taste	Typical for this species, clean, soft	3.8-4.0 (perfectly)	
	Typical for this species, clean, but somewhat sharp	3.6-3.8 (fine)	
	Typical for this species, clean, but sharp, burning	Lower then 3.6 (unsatisfactory)	Removed from the tasing
Total score			
Score		Total score	Note
Total score «Perfectly»		9.5-10.0	It has an excellent rating for all indicators
Total score «Fine»		9.0-9.5	Has good and excellent grades
Total score «Unsatisfactory»		Lower then 9.0	Returned for processing as a repairable defect

Table 2 – Experimental design matrix

Amount of whey powder prepared (x_1), kg	Resting time (x_2), hour	Mass concentration of aldehyde (y_1), mg/dm^3	Mass concentration of methyl acetate (y_2), mg/dm^3	Mass concentration of ethyl acetate (y_3), mg/dm^3	Mass concentration of methanol (y_4), %
1	1	1	1	1	1
1	1	-1	1	1	-1
1	-1	1	1	1	-1
1	-1	-1	1	1	1
1	0	-1	0	1	0
1	0	1	0	1	0
1	-1	0	1	0	0
1	1	0	1	0	0
1	0	0	0	0	0

Table 3 – Results of studying the safety indicators onwhich the experimental design matrix is based

No. of experiment	Result of studying an indicator			
	Mass concentration of aldehyde (y_1), mg/dm^3	Mass concentration of methyl acetate (y_2), mg/dm^3	Mass concentration of ethyl acetate (y_3), mg/dm^3	Mass concentration of methanol (y_4), %
1	3.2	3.1	2.8	0.0040
2	3.1	2.9	2.0	0.0039
3	2.5	0.8	0.4	0.0029
4	2.4	0.7	0.4	0.0029
5	2.4	0.7	0.4	0.0029
6	2.5	1.0	0.5	0.0031
7	2.4	0.7	0.4	0.0029
8	3.1	3.0	2.2	0.0039
9	2.4	0.7	0.4	0.0029

The combination of input parameters ensuring the minimum value of the concentration of toxins is determined by means of the optimisation software Maximize of the Mathcad package [17].

When purifying a water/alcohol mixture with prepared whey, an objective necessity is to find a regular pattern in how well the mixture is purified depending on the amount of prepared whey added (in terms of whey powder) and on the resting time. The effectiveness of purification was assessed based on the dynamics of changes in the mass concentration of aldehydes, methyl acetate,ethyl acetate, on the proportion of methanol by volume. Along with this, the quality of the purified mixture was assessed by its sensory characteristics.

The mathematical model of the decrease in the mass concentration of aldehydes (when calculated as acetaldehyde in anhydrous alcohol) and of the duration ofresting the water/alcohol mixture with the whey solution added is described in formula 1 and presented in Fig. 1.

$$y_1 (x_1, x_2) = 2.4 + 0.35\, x_1 + 0.05\, x_{2+} + 0.35\, x_1^2 + 0.05\, x_2^2 \quad (1)$$

where y_1 is the mass concentration of aldehyde when calculated as acetaldehydein anhydrous alcohol, mg/dm^3;
x_1 is the amount of milk whey added, kg;
x_2 is the time of interaction, $\times 60^2$, s.

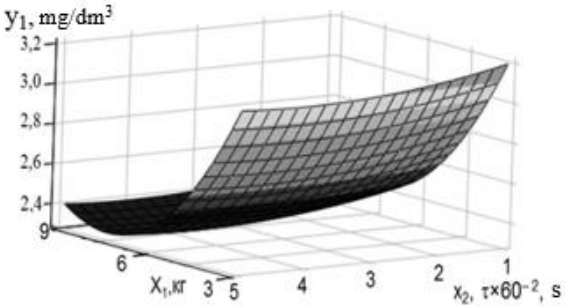

Fig. 1. Mathematical model of changes in the mass concentration of aldehydes when calculated asacetaldehyde in anhydrous alcohol, mg/dm^3

The data in Fig. 1 make it clear that the maximum decrease in the mass concentration of aldehydes (30% of their initial content) is possible if prepared whey is added in the amount 6.0±1.0 kg per 1000 dal (when calculated as whey powder) and the resting time is 3 hours. With larger amounts of prepared whey added and longer resting of the mixture, the reduction in the aldehyde concentration is within the margin of error.

Then follows the complex of tests on how the methyl acetate content changes in the water/alcohol mixture. Equation 2 describes how the reduction in this toxin depends on the amount of prepared whey added and on the resting time. The mathematical model of theprocess is shown in Fig. 2.

$$y_2 (x_1, x_2) = 0.756 + 1.133x_1 + 0.1x_2 + + 1.067x_1^2 + 0.067x_2^2 + 0.025x_1x_2 \quad (2)$$

where y_2 is the mass concentration of methyl acetate, mg/dm^3;
x_1 is the amount of milk whey added, kg;
x_2 is the time of interaction, $\times 60^2$, s.

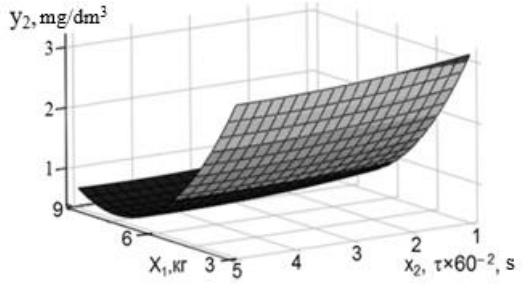

Fig. 2. Mathematical model of changes in the mass concentration of methyl acetate, mg/dm^3

The experimental data in Fig. 2 show that to decrease the mass concentration of methyl acetate, the optimum amount of prepared whey added (when calculated as whey powder) is 6.0±1.0 kg per 1000 dal, with the resting time 3 hours, which reduces the toxin by 70% of its initiallevel.

The further study has allowed determining how the degree of reduction in ethyl acetate depends on the amount of prepared whey added and on the resting time. The process is described by equation 3 and by the mathematical model (Fig. 3).

$$y_3 (x_1, x_2) = 0.378 + 0.967x_1 + \\ + 0.15x_2 + 0.933x_1^2 + 0.083x_2^2 + 0.2x_1x_2 \qquad (3)$$

where y_3 is the mass concentration of ethyl acetate, mg/dm^3;
x_1 is the amount of milk whey added, kg;
x_2 is the time of interaction, $\times 60^2$, s.

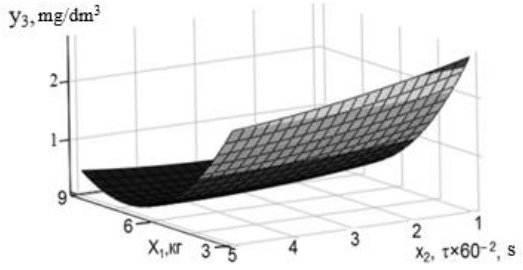

Fig. 3. Mathematical model of changes in the mass concentration of ethyl acetate, mg/dm^3

It has been proved (Fig. 3) that the mass concentration of ethyl acetate decreases by more than 70% of its initial level, if the prepared whey is added in the amount 6.0±1.0 kg per 1000 dal (when calculated as whey powder) and the resting time is 3 hours.

It is of practical importance, too, to consider the volume fraction of methanol in terms of anhydrous alcohol. Of all alcohols, methanol is the most toxic, and when oxidised in the human body, it creates a number of toxic compounds. The mathematical model of this process is characterised by dependence 4 and visualised in Fig. 4.

$$y_4 (x_1, x_2) = 2.933\times10^{-3} + 5.167\times10^{-4}\, x_1 + + 5\times10^{-5}\, x_2 + \\ + 4.5\times10^{-4}\, x_1^2 + 5\times10^{-5}\, x_2^2 + \quad + 2.5\times10^{-5}\, x_1x_2 \quad (4)$$

where y_4 is the volume fraction of methanol in terms of anhydrous alcohol, %;
x_1 is the amount of milk whey added, kg;
x_2 is the time of interaction, $\times 60^2$, s.

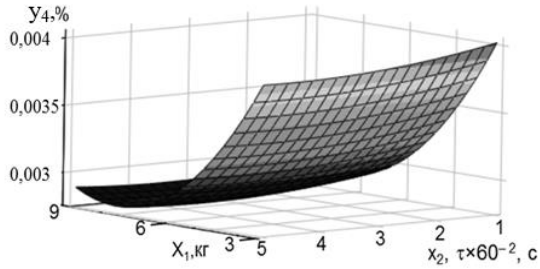

Fig. 4. Mathematical model of changes in the volume fraction of methanol in terms of anhydrous alcohol, %

Fig. 4 makes it clear that the maximum decrease in the methanol volume fraction (by 27%) is possible when prepared whey (in terms of whey powder) is added in the amount 6.0±1.0 kg per 1000 dal and the resting time is 3 hours.

The toxic substances decrease (Fig. 1–4) due to the coagulation of whey protein with quite a branched surface, which is accompanied by the sorption of toxic substances dissolved in the water/alcohol mixture, especially of those with a large molecular weight. These toxic components are the ones that can reduce the quality of raw materials and degrade the sensory properties.

Thus, regular tendencies have been found in how the level of toxins in the water/alcohol mixture treated with prepared whey changes depending on the amount of whey added and on the resting time. The alcohol/water mixture is purified most efficiently when prepared milk whey (calculated as whey powder) is added in the amount 6.0±1.0 kg per 1000 dal, with the resting time 3 hours. Larger amounts of whey added and longer resting are impractical, as they result in no decrease in the concentration of toxins (a decrease is observed within the margin of error).

At the next stage of the research, the quality of the whey-treated water/alcohol mixture was compared with that of the control sample. The latter was the untreated water/alcohol mixture. The strength of the samples was 40% ABV (Table 4).

Based on the research results (Table 4), it can be stated that the use of milk whey to purify the water/alcohol mixture allows reducing the content of toxins by several times: the mass concentration of aldehydes by 30%, the methanol volume fraction by 27%, the mass concentration of esters by over 70%. The concentration of fusel oil did not exceed the detection threshold.

Table 4 – Study of the physicochemical characteristics of the samples tested (p≥0.95, n=5)

Parameter, unit of measure	Value of the parameter by DSTU 4256:2003	Test results	
		Water/alcohol mixture	Water/alcoholmixture (treated with milk whey)
Massconcentrationofaldehydesintermsofacetaldehyde inanhydrousalcohol, mg/dm^3, not more than	4.0	3.4±0.1	2.4±0.1
Massconcentrationoffusel oil when calculated as a mixture of isoamyl alcohol and isobutanol (1:1)inanhydrousalcohol, mg/dm^3, notmore than	2.0	less than 0.5	
Massconcentrationoffusel oil when calculated as a mixtureof propanol, isobutanol, andisoamylalcohol (3:1:1)inanhydrousalcohol, mg/dm^3, notmorethan	4.0	less than 0.5	
Massconcentrationofesters, mg/dm^3, notmorethan: methyl acetate ethylacetate	 5.0 5.0	 3.2±0.1 2.9±0.1	 0.70±0.02 0.40±0.01
Volume fraction of methanol in terms of anhydrous alcohol, %, not more than	0.01	0.0040±0.0002	0.0029±0.0002

Sensory examination was conducted to determine the following parameters: clearness + colour, taste, and aroma. It has been found that the samples are a clear colourless liquid, with no sediment or impurities. The taste and aroma were characteristic of vodka, with no off-flavour or off-odour. The above meets the requirements of DSTU 4256:2003. The sample purified with milk whey has a softer andmore rounded flavour and a characteristic shine. Fig. 5 gives the results of assessing the sensory parameters on a ten-point scale.

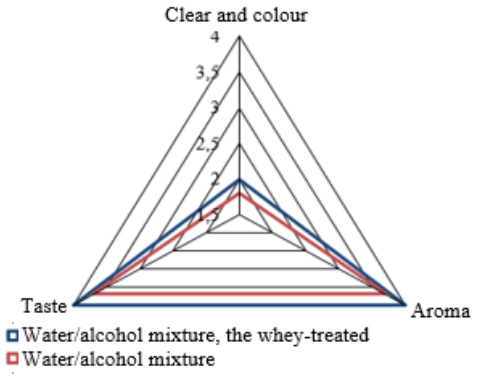

Fig. 5. Sensory characteristics of the quality of the samples tested

Analysis of the data in Fig. 5 allows concluding that, unlike the untreated sample of the water/alcohol mixture, the whey-treated sample had a characteristic shine. This sample got the highest score, 2.0, as compared to 1.8. The aroma of the whey-treated sample was characteristic of this kind of products: strongly pronounced (4.0 points). The untreated sample of the water/alcohol mixture had the aroma characteristic of this type of products: pleasant (3.7 points). The taste of the whey-treated sample was characteristic of this type, clean and soft, whereas the untreated mixture tasted somewhat harsh. Respectively, this parameter was rated 4.0 and 3.7.The total score of the water/alcohol mixture, the whey-treated was 10 points, which corresponds to the «excellent» rating. The sample of the water/alcohol mixture scored 9.2 points («good» rating).

Field testing of the research results. The newly developed method of purifying the water/alcohol mixture using milk whey, when introduced into production, does not require extra equipment or the staff's retraining. Some pilot batches of distilled beverages based on the whey-treated water/alcohol mixture were manufactured at the distilleries *Prime* and *Horobyna*. The formulation and the technological instructions for the distilled beverage based on the whey-treated water/alcohol mixture were approved by the Taste Panel of distilling and liquor-producing enterprises specialising in assessing the quality of alcohols, vodkas, special vodkas, distilled beverages, and low-alcohol drinks (Ukrainian Research Institute of Alcohol and Biotechnology of Food Products).

Conclusion

1.The experiments, mathematical modelling, and expert assessment have allowed determining the conditions for the most efficient purification of the alcohol/water mixture: adding prepared milk whey (when calculated as milk whey powder) in the amount 6.0±1.0 kg per 1000 dal, with resting for 3 hours.

2. The dynamics of the content of toxins in the water/alcohol mixture treated with whey has been experimentally established. The mass concentration of aldehydes was reduced by 30%, the volume fraction of methanol by 27%, the mass concentration of esters by more than 70%, and the concentration of fusel oil did not exceed the detection threshold.

3. It has been found that the samples are a clear colourless liquid, free of sediment or impurities, with the taste and aroma characteristic of vodka, having no off-flavour or off-odour. The sample purified with milk

whey had a softer and more rounded flavour and a characteristic shine.

References:

1. Holovko MP, Penkina NM, Kolesnyk VV, Polupan VV. Vykorystannia metodu apriornoho ranzhyruvannia chynnykiv pid chas stvorennia retseptur alkoholnykh napoiv. Naukovi pratsi NUKhT. 2017;23(2):200-207.
2. Holovko MP, Penkina NM, Kolesnyk VV, Polupan VV. Doslidzhennia prohnozovanoi stiikosti ta yakosti rozroblenykh nastoianok u protsesi zberihannia. Naukovi pratsi NUKhT. 2021;27(1):168-181. https://doi.org/10.24263/2225-2924-2021-27-1-18
3. Dubovkina I. et al. The influence of plant raw materials on the alcohol infusions quality. Ukrainian Journal of Food Science. 2020; 8(2):211-226. https://doi.org/10.24263/2310-1008-2020-8-2-4
4. Andreou V. et al. Herbal distillates: A new era of grape marc distillates with enriched antioxidant profile. Food Chemistry. 2018;253:171-178. https://doi.org/10.1016/j.foodchem.2018.01.162
5. Lai X. et al. Six Types of Tea Reduce Acute Alcoholism in Mice by Enhancing Ethanol Metabolism, Suppressing Oxidative Stress and Inflammation. Front Nutr. 2022;9:1-15. https://doi.org/10.3389/fnut.2022.848918
6. Chandrasekara A, Shahidi F. Herbal beverages: Bioactive compounds and their role in disease risk reduction – A review. Journal of Traditional and Complementary Medicine. 2018;8(4):451-458. https://doi.org/10.1016/j.jtcme.2017.08.006
7. Yuecheng S. et al. Vitamin E alleviates phoxim-induced toxic effects on intestinal oxidative stress, barrier function, and morphological changes in rats. Environ Sci Pollut Res. 2018; 25/26. https://doi.org/10.1007/s11356-018-2666-y
8. Kuzmin O. et al. Antioxidant capacity of alcoholic beverages based on infusions from non–traditional spicy–aromatic vegetable raw materials. Ukrainian Food Journal. 2020;9(2):404-424. https://doi.org/10.24263/2304- 974X-2020-9-2-12
9. Li G. et al. l-Theanine prevents alcoholic liver injury through enhancing the antioxidant capability of hepatocytes. Food and Chemical Toxicology. 2012;50(2):363-372. https://doi.org/10.1016/j.fct.2011.10.036
10. Pravyla ustalenoi praktyky 15.9-37-092:2006.Vyrobnytstvo horilok, horilok osoblyvykh, napoiv likerohorilchanykh. Zastosuvannia filtruvalnykh elementiv, antratsytovoho filtrantu, aktyvnoho vuhilliaS-835.Kyiv,UA; 2007; 25.
11. Roberts JD. Organic chemistry applications. Encyclopedia of nuclear magnetic resonance. Chichester. John Wiley & Sons Ltd. 2002;3386-3400.
12. TR U 18.5084-96.Tekhnolohichnyi rehlament na vyrobnytstvo horilok i likero-horilchanykh napoiv. Kyiv,UA; 1996.
13. Hu N. et al. Structurability: A collective measure of the structural differences in vodkas. Journal of agricultural and food chemistry. 2010;58(12):7394-7401. https://doi.org/10.1021/jf100609c
14. Qualls-Creekmore E, Gupta R, Yoshimur M. The effect of alcohol on recombinant proteins derived from mammalian adenylyl cyclase. Biochem Biophys Reports. 2017;10:157-164. https://doi.org/10.1016/j.bbrep.2017.03.011
15. Hughes P., Risner D., Meunier Goddik L. Whey to Vodka. Whey - Biological Properties and Alternative Uses. 2018. https://doi.org/10.5772/intechopen.81679
16. Nollet LM. Handbook of Food Analysis. New York; 1996.
17. Vlasova KP. Metody issledovanij i organizacija jeksperimentov. Harkov,UA; 2002; 256.

ДОСЛІДЖЕННЯ ЕФЕКТИВНОСТІ ВИКОРИСТАННЯ СУХОЇ МОЛОЧНОЇ СИРОВАТКИ ДЛЯ ЗНИЖЕННЯ ТОКСИЧНОСТІ ВОДНО-СПИРТОВОЇ СУМІШІ

В.В. Колесник, кандидат технічних наук, доцент, *E-mail*:vkol240584@gmail.com
Н.М. Пенкіна, кандидат технічних наук, доцент,*E-mail*:penkinanatali77@gmail.com
В.В. Полупан, кандидат технічних наук, доцент,*E-mail*:pvalvad@gmail.com
С.В. Сорокіна, кандидат технічних наук, доцент, *E-mail*:skrasvaya@gmail.com
Д.М. Одарченко, доктор технічних наук, професор,*E-mail*: FUTPMD@ukr.net
А.К. Пенкін, асистент, *E-mail*: penkinanatali77@gmail.com
Кафедра торгівлі, готельно-ресторанної та митної справи
Державний біотехнологічний університет, вул. Алчевських, 44, м. Харків, Україна, 61002

Анотація. Перспективним шляхом зниження токсичності етилового спирту є очищення водно-спиртової суміші сорбентами. У даній роботі обґрунтовано ефективний спосіб очищення водно-спиртової суміші від токсичних елементів за допомогою підготовленої сухої молочної сироватки. Визначення масової концентрації токсичних речовин у дослідних зразках, а саме метилацетату, етилацетату, метилового спирту, проводили методом високоефективної газової хроматографії. Встановлено закономірності ефективності очищення сортівки в залежності від кількості внесеного сорбенту та часу відстоювання. Кількість внесеного сорбенту складала 3-9 кг на 1000 дал, в перерахунку на суху молочну сироватку, час вистоювання протягом 1-5 год. Встановлено, що максимальне зниження токсичних речовин відбувається за умови внесення підготовленої молочної сироватки (у перерахунку на суху молочну сироватку) масою 6,0±1,0 кг на 1000 дал, час відстоювання протягом 3 годин. У результаті очищення водно-спиртової суміші за даних умов, масову концентрацію альдегідів у водно-спиртовій суміші знижено на 30%, об'ємну частку метилового спирту – на 27%, масову концентрацію естерів – більше ніж на 70%, концентрація сивушного масла не перевищувала поріг розпізнавання. Зниження токсичних речовин відбувається за рахунок коагуляції білка молочної сироватки, що має досить розгалужену поверхню, проходить сорбція розчинених у водно-спиртовій суміші токсичних речовин, особливо з великою молекулярною масою. Це токсичні компоненти, які здатні знижувати якість вихідної сировини та погіршувати органолептичні властивості. Під час очищення водно-спиртової суміші від токсичних сполук за допомогою підготовленої сухої молочної сироватки досягається покращення органолептичних показників Зразок, очищений молочною сироваткою, відрізняться більш м'яким та округленим смаком та має характерний блиск. Використання підготовленої молочної сироватки, як сорбенту для очищення водно-спиртової суміші, дозволяє отримати продукт зі зниженим токсичним ефектом та покращеними органолептичними властивостями.

Ключові слова: водно-спиртова суміш, токсичність, сироватка, очищення, якість.