The ionic composition of distilled beverages and its effect on their stability during storage

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Abstract. During prolonged storage of distilled beverages, turbidity may form in them, which leads to the loss of their presentation, so one of the main problems of the distillery is the increased stability of a finished product during storage and increasing shelf life of products. Identifying the causes of turbidity and precipitation is one of the most important and urgent tasks in the control of alcoholic beverages. In this work, industrial samples of alcoholic beverages containing inclusions, turbidity and precipitation were investigated using the method of ion chromatography. The ionic composition of the studied samples is represented mainly by cations of sodium, potassium, calcium and magnesium and anions of fluorides, chlorides, nitrates, phosphates and sulfates. Mass concentrations of the ions represented fluctuate over a wide range, which is explained by the rich microelement composition of plant components, the specifics of the formulations and the peculiarity of water treatment from different manufacturers. The analysis of results showed that one of the main reasons for the appearance of turbidity and precipitation in distilled beverages is the increased content of calcium and magnesium ions.

1. Introduction

During prolonged storage of distilled beverages, turbidity may form in them, which leads to the loss of their presentation, so one of the main problems of the distillery is the increased stability of a finished product during storage and increasing shelf life of products. The main factors determining the stability of alcoholic beverages are the qualitative characteristics of the primary raw materials: rectified ethyl alcohol, prepared water, plant materials and other ingredients included in the recipe. In the manufacture of distilled beverages, various types of plant materials are widely used: spicy aromatic herbs and spices, as well as fresh and dried fruits and berries. The chemical composition of plant materials is very complex and diverse. It depends on the zone and climatic conditions of growth, as well as the conditions of transportation and storage.

Due to the high content of alcohol and sugar, distilleries are not subject to the turbidity of a biological nature. At the same time, the turbidity of a physicochemical nature may occur in them; they are often classified as protein, polysaccharide, phenolic, metal.

It is known that 70% of the turbidity in alcoholic beverages is classified as colloidal turbidity resulting from the formation of insoluble high molecular weight compounds. High molecular colloids...
are polysaccharides, proteins, polyphenolic compounds make up the bulk of the substances that form precipitates [1].

The ionic composition of the process water has a significant influence on the distilled beverages stability. Calcium ions determine the fullness of taste, calcium bicarbonates soften the taste and reduce the hardness of spirits. But the calcium ion content in the process water is strictly regulated because the increased content of calcium carbonate is one of the causes of precipitation [2].

Alcoholic beverages, which include fruit and berry juices and fruit infusions, are complex colloidal systems, the balance of which may be disturbed by changing external conditions. For obtain drinks stable for a long time, a filtering operation is carried out. Filter boards of various brands are used as a filter element. However, it was found that micronutrients that have a catalytic effect on precipitation in semi-finished products of alcoholic beverages and finished products are washed out of the filter cartridges, as well as diatomite and asbestos used in the filtering. The most significant amount of leached cations is calcium, then silicon, and then iron. Iron and aluminium form complexes with amino acids, mono- and disaccharides, phenolic compounds. Under certain environmental conditions, calcium forms complexes with pectin substances that have passed into aqueous-alcoholic solutions when infused [3, 4].

The quality of used glass containers also affects the stability of distilled beverages during storage. If you deviate from the technical parameters, the formation of soluble components on the surface of the glass and their subsequent transition to an alcoholic beverage with the formation of opacities is possible. During storage of a bottle with an alcoholic beverage, the glass surface is broken, causing the drink is enriched with sodium and calcium cations. When storing glass containers, irreversible processes occur in the glass structure of the bottle, which lead to increased leaching of glass [5].

Identification, the causes of turbidity and precipitation, is one of the most important and urgent tasks in the control of alcoholic beverages during long-term storage.

Currently, ion chromatography has established itself as the most highly sensitive method for the analysis of cations and anions in water and vodka. The composition and concentration of cations (sodium, ammonium, potassium, calcium, magnesium, strontium, barium) and anions (fluorides, chlorides, nitrites, nitrates, phosphates, sulfates) can be used for judging the quality of water treatment and monitoring softening and water purification systems [2].

The objective of this work was to study the ionic composition of distilled beverages to identify possible causes of precipitation in the finished product during storage.

2. Materials and methods

2.1 Test samples

In our study, we used industrial samples of alcoholic beverages containing inclusions, turbidity and precipitation, and samples of the same name, that comply with normative documentation in appearance. Besides, an assessment was made of the quality of the bottles by the parameter of water resistance (GOST 13905-2005).

2.2 Materials and reagents

For preparing calibration solutions, standard samples of sodium, potassium, ammonium, strontium, calcium, magnesium, fluorides, nitrites, nitrates, sulfates, and phosphates were used.

For the preparation of the eluent, we used sodium carbonate (ACS), sodium hydrogen carbonate (ACS), sulfuric acid standard titer (fixanal) and nitric acid (standard titer).

For sample preparation, preparation of calibration solutions and eluents, deionized water obtained using the D-301 deionization system from Aquilon were used.

2.3 High-performance ion chromatography

The study was carried out on ion chromatographs ECO IC and COMPACT IC 761 from Metrohm (Switzerland) with a conductometric detector.
2.3.1 Sample preparation conditions
Samples of products with sediment were pre-filtered through a paper filter to remove sediment. Then the beverage sample was filtered through a 0.45 μm membrane filter, diluted with deionized water (a 10 cm³ beverage sample was pipetted into a 100 ml volumetric flask and adjusted to the mark deionized water) and introduced into the chromatograph.

2.3.2 Cation Separation Conditions
Chromatograph 761 COMPACT IC: chromatography column Metrosep C 2; 150 / 4.0 mm); eluent — 2.0 mmol/dm³ HNO₃ solution; eluent flow rate 1.0 cm³/min.
Chromatograph ECO IC: chromatographic column Metrosep C 4; 150/4.0 mm; eluent: 1.7 mmol/dm³ HNO₃ and 0.7 mmol/dm³ dipicolinic acid; eluent flow rate 0.9 cm³/min.

2.3.3 Anion Separation Conditions
Chromatograph 761 COMPACT IC: chromatographic column Metrosep A Supp 5; 150/4.0 mm; eluent — a solution of a mixture of 3.2 mmol/dm³ Na₂CO₃ and 1.0 mmol/dm³ NaHCO₃; eluent flow rate 0.7 cm³/min.
Chromatograph ECO IC: chromatographic column Metrosep A Supp 16; 150/4.0 mm; eluent: 7.5 mmol/dm³ Na₂CO₃ and 0.75 mmol/dm³ NaOH; eluent flow rate 0.8 cm³/min.

| Name | Na   | NH₃ | K   | Ca  | Mg  | F  | Cl  | NO₃ | PO₄ | SO₄ |
|------|------|-----|-----|-----|-----|----|-----|-----|-----|-----|
| Bitter tincture “Russia n crown with pepper on honey” | | | | | | | | | | |
| without sediment | 6.5±1. | 0.3±0. | 12.8±2.6 | | | | | | |
| heavy sediment in the form of large brown flakes | 5.8±1. | 0.2±0. | 12.8±2.6 | | | | | | |
| Bitter tincture “Stark” | | | | | | | | | | |
| without sediment | 40.7±6.1 | < 0.1 | 70.8±10.6 | | | | | | |
| with sediment | 21.2±3.2 | < 0.1 | 50.5±7.6 | | | | | | |
| Sweet tincture “Batko va Cherry on cognac” | | | | | | | | | | |
| without sediment | 21.4±3.2 | 1.9±0.5 | 213.4±32.0 | | | | | | |
| with sediment | 23.2±3.5 | 3.0±0.8 | 235.1±35.3 | | | | | | |
| Semi-sweet tincture “Dr. Di Chaser with Acai Berry Flavor” | | | | | | | | | | |
| without sediment | 3.2±0.6 | < 0.1 | 2.2±0.4 | | | | | | |
| with sediment | 13.0±2.6 | < 0.1 | 4.6±0.9 | | | | | | |

Table 1. Mass concentration of ions in the studied samples, mg/dm³
3. Results and discussion

In our work, it has been determined the cationic and anionic composition of alcoholic beverages with and without sediment. The results are presented in Table 1. The ionic composition of the studied samples is represented mainly by cations of sodium, potassium, calcium and magnesium and anions of fluorides, chlorides, nitrates, phosphates and sulfates. Mass concentrations of the ions represented fluctuate over a wide range, which is explained by the rich microelement composition of plant components, the specifics of the formulations and the peculiarity of water treatment from different manufacturers.

It was found that the sample of a bitter tincture "Russian Crown with Pepper on Honey" without sediment contains an increased amount of calcium and magnesium ions. It is known that the increased content of hardness salts contributes to sedimentation. In the sample of bitter tincture with sediment, the mass concentration of calcium and magnesium ions is not significant. This process can be explained by the fact that the salts of these ions precipitated.

Mass concentration of sodium, potassium, magnesium, calcium, fluoride, and sulfate ions in the sample of bitter tincture "Stark" with sediment is approximately two times less than in the sample without sediment. This process maybe because some of the above trace elements precipitated.

In samples of a sweet tincture "Batkova Cherry on cognac" with and without sediment, no significant change in ionic composition was detected. For the manufacture of this sample used natural plant materials. Based on this, it can be concluded that the nature of the sediment is not related to the cation-anion composition.

Additionally, water-resistance of the bottles was evaluated. It was found that the sample of a bottle from the semisweet tincture "Dr Di Chayser with acai berry flavour" with sediment in terms of quality does not meet the requirements of normative technical documentation (GOST 32131 – 2013). The remaining studied samples of the bottles met the requirements of normative technical documentation.

In a sample of semisweet tinctures, "Dr Di Chayser with Acai Berry Flavor" with sediment revealed an increased content of sodium, magnesium and sulfate ions compared to the sample without sediment. Based on the preceding, it can be assumed that the cause of the precipitation was a violation of the inner surface of the bottle.

4. Conclusion

Analysis of the study results showed that one of the main reasons for the appearance of turbidity and precipitation in distilled beverages is the increased content of calcium and magnesium ions (hardness salts). Also, calcium and magnesium ions can react with pectin and tannins of fruit and berry infusions used in the manufacture of alcoholic beverages, forming insoluble compounds that precipitate as sediment.

The use of ion chromatography allows timely identification and elimination of the reasons for the decrease in the stability of alcoholic beverages, thereby increasing the efficiency of technological control of alcoholic beverages quality. Also, the IC method can be successfully used for the development of formulations of multicomponent alcoholic beverages using vegetable raw materials and to establish the real shelf life of the finished product.

References

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