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INVESTIGACIÓN CIENTÍFICA

Use of Azerbaijan-grown berries to improve nutritional value and reduce toxic metals in soft drinks (including energy drinks)

Uso de bayas cultivadas en A zerbaiyán para mejorar el valor nutricional y reducir los metales tóxicos en los refrescos (incluidas las bebidas energéticas).

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ABSTRACT

Introduction: The research aims to investigate the possibility of using cornel/dogwood berries, to increase their nutritional value and reduce toxic metal content in soft drinks and energy drinks. **Material and Methods:** To achieve the set goal, the nutritional value of drinks was determined, the influence of cornel berries on the content of toxic metals was analysed and their influence on the organoleptic properties of drinks was evaluated. **Results and Discussion:** As a result of the study, it was found that the addition of cornel berries to soft drinks leads to a significant increase in the content of vitamins B2 (by 47%), C (by 25%) and K (by 39%). An increase in flavonoids and anthocyanins in the beverages was also observed, with 19.28 mg/100 g and 13.34 mg/100 g, respectively, in the experimental sample, compared to 15 mg/100 g and 10.12 mg/100 g in the control sample, and an increase in phenolic compounds, with 22.3 mg/100 g in the experimental sample, compared to 21.1 mg/100 g in the control sample. In addition, a reduction in mercury, lead and cadmium was found to be 11%, 5.3% and 2% respectively. **Conclusion:** Thus, the results indicate an increase in nutritional value and potential positive effects of adding cornel berries to beverages, as well as confirming their safety and improved organoleptic qualities. The results have important practical implications for the food industry and consumers, as they provide data and recommendations for the development of soft drinks that have increased nutritional value and guaranteed safety.

Keywords: Cornelian; Antioxidants; Cadmium; Flavonoids; Anthocyanins.

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INTRODUCTION

The use of berries to enhance nutritional value and reduce toxic metal content in soft drinks (including energy drinks) can be highly beneficial as berries are high in antioxidants. It helps protect the human body from free radicals and oxidative stress, as well as vitamins and minerals, which can help to improve the nutritional value and enrich the beverages. It is also worth noting that in recent years there has been a growing interest in healthy lifestyles and nutrition, as well as in sustainability and innovation in the food industry. More and more people are striving to improve their health and are more attentive to the quality of the food they consume. Therefore, the study aims to increase the nutritional value and reduce toxic metal content in soft drinks using local berries is of high relevance. Soft drinks are popular among many people, and incorporating local berries into them can greatly enhance their nutritional value. Berries contain antioxidants like anthocyanins, phenolic acids, flavonoids etc. along with vitamins such as vitamin C, folates and vitamin A. These components can increase nutritional value while also binding toxic metals. Furthermore, the use of locally grown berries in soft drinks promotes sustainable agriculture and reduces the ecological footprint. Locally grown berries generally require less energy to produce and transport, so their use contributes to reducing greenhouse gas emissions and maintaining environmental sustainability, which also adds relevance to the research conducted.

According to many scholars, namely S.C. Izah et al. [(1)], and A.A. Alsunni [(2)], one way to utilise berries is to add them to beverage formulas as extracts or juices. For example, pomegranate extract can be used to add antioxidants and give a pleasant flavour to beverages. Blackcurrant, elderberry, or blackberry berries can be used to add natural colour and flavour to soft drinks. Following J. Erdmann et al. [(3)], adding cornelian to soft drinks can give them a refreshing sourness and a certain sweetness. In addition, cornelian is a source of vitamin C and other nutrients such as vitamins A and E, antioxidants, and dietary fibre. Raspberries and strawberries are popular berries that are added to drinks to add a pleasant fruity taste and aroma. They are also rich in vitamins and antioxidants, which add to the nutritional value of the drinks. Lingonberries, too, have a sour taste and a distinctive aroma that can be used to add notes of sourness and refreshing flavour to different drinks. Kinkan, also known as kumquat or Japanese mandarin, is a small citrus fruit that can be used in soft drinks. Kinkan has a bright flavour and aroma that combines sweetness and sourness. Adding kinkan to drinks can give them a refreshing citrus flavour and aroma. Kinkan contains vitamin C, dietary fibre and antioxidants, making it a useful ingredient to enrich the nutritional value of beverages [(4)].

Tea leaves can also be used to enhance the nutritional value of soft drinks and to some extent reduce toxic metals. Tea leaves interact with certain heavy metals, such as lead and cadmium, and help to remove them from the body. However, the effect of tea leaves on toxic metal content in soft drinks may be limited and depends on several factors such as the quality of tea leaves, preparation method and dosage [(5)]. However, alongside this fact, S. Aliyev et al. [(6)] and T. Pinto et al. [(7)] also note that an important aspect of the use of berries for beverage fortification is the control of toxic metal content. Since berries may absorb some heavy metals from soil or surrounding water. Therefore, quality control of raw materials and processed products should be carried out to minimise the toxic metal content in the final products.

Excessive levels of heavy metals in the human body can have serious negative health effects. Certain common heavy metals that can cause problems include lead, mercury, cadmium, arsenic, and arsenic. Heavy metals can accumulate in body tissues, especially in the liver, kidneys, and brain, and cause a variety of harmful effects. They can also cause oxidative stress, deoxyribonucleic acid (DNA) damage and inflammation, which can lead to cell and tissue damage [(8)]. M. Zeiner et al [(9)] state that some heavy metals can penetrate the blood-brain barrier (reperfusion-injury mechanisms including oxidative stress, leukocyte infiltration, platelet activation, and complement activation) and damage the nervous system.

They can cause changes in neurotransmitters (chemicals that transmit signals between neurons) and disrupt normal brain function, which can lead to problems with memory, concentration, mood, and behaviour. In addition, heavy metals can affect numerous metabolic processes. They can interfere with the normal function of enzymes necessary for metabolism and interfere with the normal function of organs and body systems.

The Republic of Azerbaijan was chosen for the study because Azerbaijani berries may be less likely to be contaminated, due to low emissions from transport and have a distinctive flavour that demonstrates domestic agriculture. Considering the aforesaid, the research aims to study the possibility of using berries growing in the Republic of Azerbaijan to increase their nutritional value and simultaneously reduce the content of toxic metals in soft drinks and energy drinks. To achieve the stated aim, the following objectives were set:

1. Determine the nutritional value of beverages, namely the content of vitamins, minerals, flavonoids, and antioxidants.
2. Analyse the effect of cornel/dogwood berries (Cornus mas) on the content of toxic metals such as mercury (Hg), lead (Pb) and cadmium (Cd) in beverages and compare them with recommended safe standards.
3. Determine the effect of dogwood berries on beverage properties including appearance, texture, taste, aroma, and colour.

MATERIALS AND METHODS

Data from the Ministry of Health of the Republic of Azerbaijan [10], the State System of Technical Regulation of the Republic of Azerbaijan, and official updates from the World Health Organization (WHO) were used to study the requirements for the development and production of beverages in Azerbaijan. To investigate the nutritional value and the content of toxic metals in soft drinks, the drinks with the addition of cornel berries (experimental variant) and without their addition (control variant) were tested. The following types of raw materials were used for manufacturing soft drinks:

1. Water: SanPin 2.1.4.1074-01 compliant.
2. White sugar: GOST 33222-2015 compliant
3. Berries: GOST 33823-2016 compliant (Dogwood berries (GOST 33915-2016)).
4. Citric acid: GOST 908-2004 compliant.
5. Fructose: Technical Specifications (TS) 9111-196-79036538-2011 compliant.
6. Sorbitol: TS 9325-001-57661098-2005 compliant.
7. Saccharin: TS 64-6-126-80 compliant.

Ingredient preparation: cleaned berries cut into pieces. Syrup preparation: water and sugar, sorbitol, and fructose were mixed in a separate container, and then heated until dissolved. Berry addition: chopped and peeled berries were added to the hot syrup. The mixture was boiled over low heat for 30 minutes. This allows the aromas and flavours of the fruit to be extracted. Cooling and filtration: after brewing, the drink was cooled to room temperature, then filtered to remove berry particles. Adding acidity: citric acid was added to give a refreshing tartness and flavour. To determine the content of phenolic compounds, the direct spectrometry method was used using a UV-1800 spectrophotometer (Shimadzu, Japan). The acidity of ready drinks was determined by the titrimetric method, according to GOST 12788-87. The content of anthocyanins was determined by spectrophotometry, where the conversion to the main component of the anthocyanin complex – cyanidin-3-rutinoside was carried out. Anthocyanins are water-soluble vacuolar pigments that are responsible for the red, purple, blue, or black colors in various fruits, flowers, and other plant tissues. For this purpose, the filtrate was prepared by extraction with a 1% hydrochloric acid solution.

DPPH-test and ABTS-test were used to evaluate antioxidant activity. The content of vitamins and flavonoids was determined by liquid chromatography using an LC-2030 chromatograph (Shimadzu, Japan). Heavy metals were analysed using inductively coupled plasma optical emission spectroscopy (ICP-OES) with a synchronous vertical double view (SVDV) on an Agilent 5100 instrument (Agilent Technologies, USA) using Agilent Vapor Generation Accessory VGA 77 (Agilent Technologies, USA). Microbiological analysis was performed to determine the presence and number of microorganisms in the beverages and to assess their hygienic condition. For this purpose, the surface incision method was used. Organoleptic evaluation of the drinks was carried out with the help of a tasting committee consisting of seven people on a five-point scale. During the organoleptic evaluation, the main indicators for all samples were considered, namely: appearance, texture, colour, taste, and aroma (GOST 52474-2005). All the obtained data were statistically analysed. The mean value and standard error were obtained for each parameter. Significance was set at the level of $p \leq 0.05$.

RESULTS

Benefits of using berries in soft drinks (including energy drinks)

The incorporation of various berries, juices, and extracts into soft drink production offers a multitude of advantages [8]. First and foremost, it significantly boosts the nutritional value of these beverages. Berries are renowned for their richness in essential vitamins, minerals, antioxidants, and other nutrients. By incorporating berries, extracts, juices, or purees into soft drinks, their nutritional content is augmented, making them a healthier choice for consumers seeking added nutrients in their beverages. Another notable benefit is the enhancement of flavor. Berries have the innate ability to impart a delightful and refreshing taste to soft drinks. When used as natural flavorings, they introduce authentic fruit notes and aromas, creating a more appealing and enjoyable beverage experience. This natural flavor infusion can help reduce the reliance on artificial additives and sweeteners, aligning with the growing demand for clean label products.

Berries also serve as natural coloring agents, thanks to the pigments present in many varieties. By utilizing these pigments, soft drink manufacturers can eschew artificial colorants while endowing their products with visually appealing hues. This not only caters to consumers who prefer natural ingredients but also contributes to the overall attractiveness of the beverage. Furthermore, berries' antioxidant properties hold the potential to mitigate the presence of toxic metals in the body. The antioxidants found in berries can aid in reducing the accumulation of harmful metals when consumed. By incorporating berries into soft drinks, manufacturers offer consumers a beverage option that not only quenches their thirst but also provides potential health benefits by assisting in the detoxification process.

Beyond their nutritional benefits, berries possess functional properties that can enhance the appeal of soft drinks. These functional attributes encompass a wide range of advantages, from increased energy levels and immune system support to improved digestion. Infusing soft drinks with these functional benefits allows them to cater to health-conscious consumers seeking more than just refreshment from their beverages. In addition to the nutritional benefits derived from berries, it's essential to consider the role of flavonoids and antioxidant activity in evaluating the quality and health value of beverages. Elevated flavonoid content and antioxidant activity in soft drinks can be a substantial boon to human health, as they contribute to the body's defense against free radicals and oxidative stress. So, the use of various berries, juices, and extracts in the production of soft drinks can have several positive properties [8]s:

1. Increased nutritional value, as berries are rich in vitamins, minerals, antioxidants, and other nutrients. The use of berries, extracts, juices, or purees in soft drinks can increase their nutritional value and enrich them with useful substances.
2. Flavour enhancement. Berries can give soft drinks a pleasant and fresh flavour. They can be used as natural flavourings, adding natural fruit notes and aromas.
3. Natural colouring agents. Some berries contain pigments that can be used as natural colouring agents, this avoids the use of artificial colouring agents and gives drinks an attractive colour.
4. Reducing toxic metals. The antioxidants found in berries can help reduce toxic metals in the body. By adding berries to soft drinks, you can help reduce these metals in the body when consumed.
5. Functional properties. Berries have functional properties such as increasing energy, strengthening the immune system and improving digestion. The use of such berries in soft drinks can give them additional functional benefits.

Flavonoid (secondary metabolites) content and antioxidant activity are important indicators of the quality and nutritional value of beverages. An increase in flavonoid content and antioxidant activity has potential benefits for human health as they contribute to the body's defence against free radicals and oxidative stress. The importance of vitamins in beverages should not be underestimated. Vitamins play pivotal roles in metabolism, growth, development, and overall health maintenance. Water-soluble vitamins like vitamin C and the vitamin B group are crucial because they cannot be stored in the body and must be regularly consumed through food or beverages. Soft drinks enriched with these vitamins, such as fresh fruit and vegetable juices, provide an excellent source of these essential nutrients. The importance of vitamins in beverages can vary depending on the specific beverage and its composition. Water-soluble vitamins like vitamin C and the vitamin B group (B1, B2, B3, B5, B6, B7, B9, B12) are crucial because they cannot be stored in the body and must be regularly consumed through food or beverages. Soft drinks enriched with these vitamins, such as fresh fruit and vegetable juices, provide an excellent source of these essential nutrients. On the other hand, fat-soluble vitamins, including vitamins A, D, E, and K, can accumulate in the body and may be present in beverages containing fats or oils. Dairy-based drinks like milk and yogurt, as well as specific smoothies, are examples of beverages that may provide fat-soluble vitamins [9]. By offering a variety of beverages with diverse vitamin profiles, manufacturers can cater to consumers' varying nutritional needs and preferences.

In conclusion, the utilization of berries, juices, extracts, and vitamins in soft drink production represents a multifaceted approach to creating beverages that not only quench thirst but also offer substantial nutritional and health benefits [10]. As consumers increasingly seek beverages that align with their wellness goals, the incorporation of these natural ingredients and nutrients has the potential to drive innovation in the beverage industry and cater to a more health-conscious market.

The importance of using berries in beverages using cornel/dogwood as an example

Dogwood berries are a rich source of nutrients: vitamin C, K, A, folate, antioxidants, and dietary fibre. Vitamin C helps maintain a healthy immune system, vitamin K affects bone health, and vitamin A plays an important role in vision and skin health. Also, dogwood contains antioxidants such as anthocyanins and flavonoids that help protect cells from free radical damage [11]. The various flavonoids that dogwood berries contain vary depending on the variety and maturity of the fruit [12]:

1. Quercetin is one of the best-known flavonoids and has strong antioxidant properties. It may help in protecting cells from free radical damage and has anti-inflammatory properties. Quercetin may also be beneficial for heart and vascular health by improving their function.
2. Rutin, also known as quercetin rutinoside, is another flavonoid that may be present in dogwood. Rutin has antioxidant properties and may help strengthen capillary and blood vessel walls.

3. Quercetin-3-glucoside is a form of quercetin bound to glucose. Quercetin-3-glucoside is also an antioxidant and may help reduce inflammation and protect cells from damage.
4. Kaempferol has antioxidant and anti-inflammatory properties.

The specific flavonoids and their concentration may vary depending on the variety of dogwood and the maturity of its fruit. Typically, mature dogwood fruits have a higher flavonoid content compared to immature fruits. This results from flavonoids being normally synthesised in the plant in response to stressful conditions such as intense sunlight or the presence of pathogens. As dogwood fruit matures, flavonoid concentrations may increase. It is also worth noting that the flavonoid content of cornelian fruit can be increased by proper storage and processing. Some studies show that mechanical processing and long-term storage of cornelian fruit can increase flavonoid content [13].

Dogwood also contains dietary fibre, which helps the digestive system to function properly. Fibre helps maintain proper food digestion. Dogwood berries are good for the cardiovascular system due to their potassium content, which plays an important role in controlling blood pressure and maintaining a healthy heart rhythm. The rich vitamin C content in dogwood helps strengthen the immune system, helping to fight infections and colds. Dogwood extracts may have anti-inflammatory properties and may be useful in reducing inflammation in the body, and the presence of antioxidants helps reduce inflammation in the body and prevent DNA damage [7]. Furthermore, the use of dogwood berries in soft drinks has the potential to increase the nutritional value of these beverages and reduce toxic metal content. Dogwood berries can be incorporated into energy drinks to give them a distinctive flavour and aroma. The dogwood extract or juice can be used in combination with other ingredients such as caffeine, taurine, and B vitamins to create an energy drink with a unique flavour profile. But along with this, it is important to note that the use of berries in soft drinks must be compliant with regulation and food safety standards [5] as: assessing raw ingredient toxicity levels, monitoring production hygiene, testing final products for microbial contamination, and confirming shelf-life stability.

The study found that the addition of dogwood berries, juice and extract to beverages leads to an increase in the content of some vitamins, such as vitamin B2, C and B1, compared to the control sample without the addition of dogwood berries. However, the content of vitamin B6 and vitamin P in the experimental sample with the addition of dogwood berries is not significantly different from the control sample. As such, the analysis showed that the addition of cornel berries led to an increase in the content of vitamin B1 in the experimental sample of the drink compared to the control sample by 18%, this may be due to the content of vitamin B1 in the dogwood berries themselves. The addition of cornel berries increased the content of vitamin B2 in the experimental sample by 47%, as riboflavin (vitamin B2), present in dogwood berries, contributes to the increase in the content of this vitamin in the drink. It should also be noted that the addition of cornel berries increased the content of vitamin C by 25% and vitamin K – by 39%, as dogwood berries are a good source of these vitamins (Table 1).

Table 1. Vitamin content in drinks with and without the addition of cornel berries, mg/100 g

Variant	Vitamin B1	Vitamin B2	Vitamin B6	Vitamin C	Vitamin P	Vitamin K
Control	0.27±0.29	0.23±0.047	0.15±0.022	12±0.024	0.021±0.062	0.51±0.028
Control sample	0.32±0.041	0.33±0.019	0.21±0.048	15±0.012	0.032±0.021	0.71±0.037

Source: compiled by the authors.

The study also found that, in general, adding cornel berries to beverages increased flavonoids and anthocyanins, while the content of phenolic compounds remained about the same. This may imply that the addition of dogwood berries, juice and extract enriches beverages with bioactive substances

that may have positive effects on the overall health and well-being of the body. Flavonoids and anthocyanins are natural antioxidants that help protect cells from damage associated with oxidative stress. They may also have anti-inflammatory properties and help strengthen the immune system (Table 2).

Table 2. Content of phenolic compounds, flavonoids and anthocyanins in beverages, mg/100 g

Variant	Phenol compounds	Flavonoid	Anthocyanins
Control	21.1±0.21	15±0.04	10.12±0.09
Control sample	22.3±0.36	19.28±0.21	13.34±0.05

Source: compiled by the authors.

Thus, in the control sample, the content of phenolic compounds was 21.1 mg/100 g, while in the experimental sample, it was at the level of – 22.3 mg/100 g. This indicates a significant increase in the content of phenolic compounds in drinks with the addition of cornel berries. In addition, the content of flavonoids and anthocyanins in the experimental sample was 19.28 mg/100 g and 13.34 mg/100 g, respectively, which was higher than that in the control sample (15 mg/100 g and 10.12 mg/100 g). This indicates an increase in flavonoids and anthocyanins content in drinks with the addition of cornel berries. Consequently, the results indicate the potential enrichment of drinks with the addition of dogwood berries, juice and extract with bioactive compounds. Antioxidant activity (DPPH test): The experimental sample with the addition of cornel berries shows higher antioxidant activity (86.2%) compared to the control sample (78.5%). This indicates higher antioxidant content in the experimental sample which may help in fighting oxidative stress and free radicals. Antioxidant activity (ABTS test): The experimental sample also shows higher antioxidant activity (90.7%) as compared to the control sample (82.3%) in the ABTS test. This again indicates the higher antioxidant content in the experimental sample. Acidity: The acidity of the test sample (4.1) was slightly higher than that of the control sample (3.8). This may indicate a lower pH in the experimental sample, which may affect its flavour characteristics (Table 3).

Table 3. Assessment of antioxidant activity and acidity

Sample	DPPH-test	ABTS-test	Acidity
Control	78.5%	72.3%	3.8
Control sample	86.2%	80.7%	4.1

Source: compiled by the authors.

Thus, it is necessary to note that the addition of dogwood berries, juice and extract to beverages not only increases the content of vitamins, flavonoids and anthocyanins but also enhances the antioxidant activity of these beverages. This may help protect human body cells from oxidative stress and improve overall health. The World Health Organisation sets recommended hygienically acceptable concentrations (HACs) for heavy metals such as mercury (Hg), lead (Pb) and cadmium (Cd) in food, namely the recommended maximum allowable level for mercury is 0.02 mg/kg, lead 0.01 mg/kg and cadmium 0.01 mg/kg. The study determined that the control variant contains 0.019 mg/kg of mercury, 0.0096 mg/kg of lead and 0.0779 mg/kg of cadmium and the experimental sample contains 0.017 mg/kg of mercury, 0.0091 mg/kg of lead and 0.0763 mg/kg of cadmium. Hence, based on the data obtained, it can be concluded that both the variants (control and experimental) fulfil the WHO hygienic requirements of mercury, lead, and cadmium content. But comparing the content of heavy metals

between the control and experimental samples, it is possible to conclude that the addition of cornel berries to beverages affects reducing the content of mercury, lead, and cadmium. Therefore, the content of mercury, lead and cadmium in the experimental sample with the addition of dogwood berries was lower by 11%, 5.3% and 2%, respectively, compared to the control variant (Table 4).

Table 4. Heavy metal contents, mg/kg

Variant	Hg	Pb	Cd
Control	0.019±0.0021	0.0096±0.06	0.0779±0.015
Control sample	0.017±0.0021	0.0091±0.01	0.0763±0.023
WHO maximum	0.02	0.01	0.01

Source: compiled by the authors.

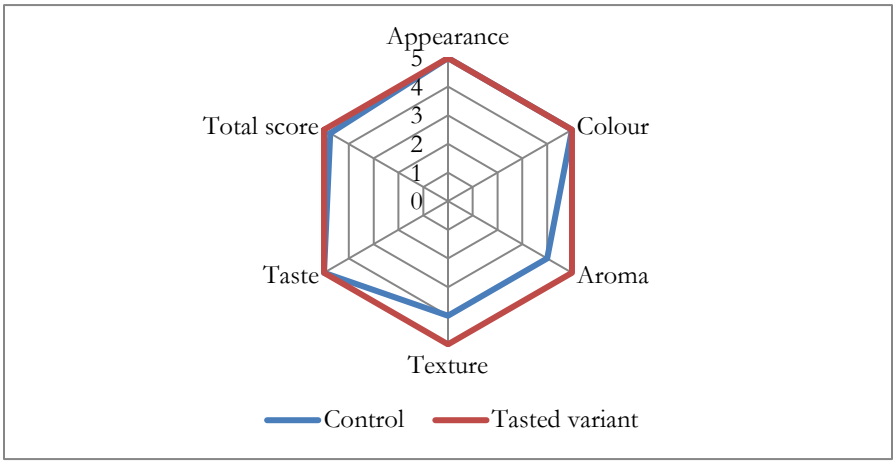
Microbiological analysis is an important step to evaluate and ensure food safety. This analysis involves checking the presence and quantity of microorganisms such as bacteria, moulds, and yeasts in beverages. During the production and storage of beverages, conditions can occur where microorganisms can multiply and cause various types of contamination or decomposition of the product. This can pose potential health risks to children, so microbiological analysis helps to monitor product quality and safety. The results of the microbiological analysis of the soft drinks showed no total bacteria, no coliform bacteria, no yeasts or moulds, and no pathogenic microorganisms. The absence of microbial contamination also emphasises the safety of the beverages for consumption and supports their nutritional value.

Colour, aroma, and flavour are among the most important characteristics of any product, including non-alcoholic and energy drinks. They are easily recognisable by the consumer and are the most noticeable characteristics. In the course of organoleptic evaluation of beverage samples by appearance and flavour, no significant differences or non-compliance with quality norms and standards were revealed. However, the results of the organoleptic analysis showed the following:

1. Appearance. The drink samples with the addition of dogwood berries had an attractive appearance with bright colours and the presence of berry fragments. Control samples without the addition of cornel berries had a more monotonous appearance.
2. Texture. Samples with the addition of dogwood berries had a more textured texture with the presence of fleshy berry fragments, which gave them additional texture in the mouth. The control samples without the addition of dogwood berries had a more uniform texture.
3. Colour. The drink with the addition of dogwood berries had a more intense colour reflecting the presence of berry pigments. Control samples of the drink without the addition of dogwood berries had a less vivid colour.
4. Aroma. Samples with the addition of dogwood berries had a characteristic berry aroma that made them fresh and fruity. Control samples without cornel berries had a less pronounced flavour.
5. Flavour. Samples with the addition of dogwood berries had a sour-sweet and fruity flavour with notes of sourness. Control samples without cornel berries were less sweet and less flavourful.

Overall, the results of the organoleptic analysis indicate that the addition of dogwood berries to soft drinks gives them an attractive appearance, texture, bright colour, and characteristic aroma and improves their taste characteristics (Figure 1).

Figure 1. Organoleptic analysis



Source: compiled by the authors.

Thus, the study revealed that the use of cornel berries, juice and extract in soft drinks is significant in terms of increasing the nutritional value and enriching the product with beneficial components. The cornel berries contain various vitamins such as vitamin C, vitamin B1, vitamin B2, vitamin B6, vitamin P and vitamin K which are important for maintaining health and normal functioning of the body. In addition, dogwood berries are rich in flavonoids, anthocyanins, phenolic compounds, and other antioxidants that may help protect cells from free radical damage and have anti-inflammatory properties. These components may also have positive effects on the immune system and overall health. In addition to their nutritional value, dogwood berries may also play a role in reducing toxic metals in beverages. The results of this study show that the addition of dogwood berries as a component of soft drinks can help adsorb heavy metals, which is an important aspect of product safety and quality. It was found that such an addition of dogwood berries does not change the characteristic organoleptic properties of the finished product, even improving them. However, the safety and quality of products must be ensured by complying with the necessary standards and regulatory requirements. This includes quality control of raw materials, the production process, storage, and packaging of products, as well as compliance with hygiene standards and regulations for consumer safety. To ensure soft drinks with added cornel berries, juice, and extract are of the highest quality, safe, and potentially beneficial to consumers, all these factors should be taken into account during the development and production process. Thus, the use of dogwood berries in soft drinks may benefit consumers by offering them additional nutrients and antioxidants, as well as potentially reducing the risk of toxic metal accumulation in the body. Based on these results, the inclusion of cornel berries in soft drinks and energy drinks can be recommended, as it can improve their nutritional value and organoleptic characteristics.

DISCUSSION

The use of berries, juices, and extracts to increase nutritional value and reduce toxic metals in soft drinks, including energy drinks, has several potential benefits. Many authors such as L. Seconda et al. [(14)], M. Salomé et al. [(15)], and D. Rose et al. [(16)], agree that berries are generally rich in vitamins, minerals, antioxidants, and other nutrients. The use of berries in beverage formulations can significantly increase their nutritional value by enriching them with beneficial components. This can be especially important for non-alcoholic energy drinks, which are often consumed to increase energy and stamina. Increasing

the antioxidant content of soft drinks may help maintain health and protect cells from oxidative stress. An important feature of berries is their ability to serve as "traps" for toxic metals in the beverage manufacturing process. They can bind and remove toxic substances, including some heavy metals, from beverage formulations. This can reduce the risk of toxic metals entering the human body when consumed. It is also especially important given the potential presence of toxic metals in the environment. Berries can also add a fresh and pleasant flavour to soft drinks. They can impart a naturally sweet tint and flavour, reducing the need to add artificial flavourings and sweeteners, which was also proven in the study conducted.

The use of local berries grown in the Republic of Azerbaijan in the production of soft drinks has several potential advantages. These berries can significantly increase the nutritional value of beverages and give them a special flavour and aroma. In addition, they can be rich sources of vitamins, minerals, and antioxidants, which help to improve the nutritional value of beverages and support a healthy lifestyle. At the same time, the use of local berries may also help to reduce the toxic metal content in soft drinks [17]. As these berries are locally grown, they may be less likely to be contaminated with toxic metals such as lead or cadmium than imported berries. This may help improve the safety and quality of the beverages. Azerbaijan is rich in a variety of berries that can benefit the nutritional and safety of beverages. Some Azerbaijan-grown berry species that can be utilised include pomegranates, blackcurrants, blackberries, raspberries, cinnamon, hawthorn, dogwood, and elderberries [18-20]. Each of these berries has unique properties that can contribute to the nutritional value of beverages.

For example, raspberries are widely found in Azerbaijan, have a sweet and aromatic flavour and are rich in vitamins, minerals, and antioxidants. Raspberries are often used to make juices, compotes, cocktails and added to various beverages. Kinkan also grows in Azerbaijan. It has orange-yellow berries with a juicy and sweet flavour. They contain vitamin C and antioxidants, making them a great addition to juices, teas, or fruit drinks. Hawthorn is a popular plant in Azerbaijan, from which berries are extracted for use in the food and medical industries [21]. Hawthorn berries have a sweet-sour flavour and contain beneficial compounds such as flavonoids and vitamins [22]. They are often used to make teas, tinctures, and traditional beverages. Elderberry, or black elderberry, grows in Azerbaijan and is known for its berries, which can be used for food and beverage purposes. Elderberries have a deep purple colour and a sweet and sour taste. They are often used to make syrups, compotes, teas, and added to cocktails [4; 23].

Pomegranates, for example, are known for their high content of antioxidants such as polyphenols. These can help protect the body from free radicals and have positive effects on heart and vascular health. Adding pomegranate juice or pomegranate extract to soft drinks can give them not only a pleasant flavour but also additional nutritional benefits [24; 25]. In addition, S. Aliyev et al. [26] in their study proved that the addition of pomegranate extract to a soft drink significantly increased its antioxidant activity and reduced the content of toxic metals such as mercury. Blackcurrants and blackberries are also rich in antioxidants and vitamins. They can be used to add natural colour and flavour to soft drinks, as well as enhance their nutritional value. In addition, blackcurrants and blackberries are known for their benefits to the immune system and overall well-being. Coriander, on the other hand, has vitamin C, carotenoids, and other nutrients. Its addition to soft drinks can give them a sour flavour and increase their nutrient content, which is also confirmed in the study conducted [27]. In addition, G.N. Abdel-Rahman et al. [8] in their study note that dogwood and blackcurrant, have antimicrobial properties and can help in fighting certain types of microorganisms such as bacteria and fungi. The authors' research has shown that extracts of these berries can be effective antimicrobial agents that can be used in the beverage industry.

A similar study by T. Yahaya et al. [28] found that the addition of cornelian extract to an energy drink improved its antioxidant properties and reduced the levels of metals such as lead, cadmium, and mercury, which is also displayed in the study conducted. Black elderberry is also a valuable source of

antioxidants and other nutrients. Its addition to soft drinks can give them a fruity flavour and aroma, as well as enrich them with nutritional properties. However, according to V. Šimora et al. [12], some factors need to be considered when using berries to enhance nutritional value and reduce toxic metals in soft drinks. For example, berries can absorb toxic metals from soil or the environment, so it is important to ensure their high quality and safety. It is also important to properly process berries before use in beverages to minimise toxic metal content [29]. Many researchers, namely M. Zeiner et al. [9], and S.C. Izah et al. [1] analysed the high antioxidant content of berries and their ability to fight free radicals that may be responsible for oxidative stress and cell damage. Studies have shown that adding berry extracts or juices to beverages can increase the total antioxidant content and enhance their protective properties.

Another confirmation of the conducted research can be found in the study of S. Kilic et al. [30] on the assessment of toxic metals such as lead, cadmium, and mercury in different berries, which showed that berries have a lower tendency to accumulate toxic metals and can be safely used in the beverage industry. D. Vanham et al. [13] also prove that some berries have high biological activity and can have a positive impact on human health. Studies have revealed the presence of biologically active components in berries, which may contribute to strengthening the immune system, protection against oxidative stress and reducing the risk of various diseases. M. Balali-Mood et al. [31] and F. Vieux et al. [32], state that berries often contain high levels of vitamins such as vitamin C, vitamin A, vitamin E and vitamin K. Therefore, adding berries to soft drinks can increase the vitamin content, which has a positive effect on a person's overall health and immune system. Also, studies have proven the ability of vitamins to be preserved during processing and storage [33]. The results of a study by F. Visioli et al. [34] showed that the addition of bilberry extract to an energy drink has a positive effect on its characteristics. In particular, this addition was found to increase the antioxidant activity of the drink. Furthermore, the study also revealed a reduction in toxic metals such as lead and cadmium in the energy drink with the addition of blueberry extract. This is significant in terms of product safety and quality; as toxic metals can hurt human health when they accumulate in the body.

Consequently, adding various berries to soft drinks and energy drinks not only increases their antioxidant activity but also helps to reduce toxic metal content, making them healthier and safer to consume [35]. All of these effects can contribute to the creation of more nutritious and safer soft drinks, improving their quality and functional properties [36]. However, the exact results and effects will depend on the specific berries, how they are used, production techniques, and other factors like base ingredient matrices, processing conditions, shelf life and packaging. More research on different beverage types would clarify variability.

CONCLUSIONS

A growing number of people have been focusing on healthy eating and lifestyle choices in recent years. Soft drinks, including energy drinks, have become a popular choice for those seeking refreshing and invigorating alcohol-free beverages. In the context of increasing the amount of nutrients in such drinks, the use of dogwood berries can make a meaningful difference. Dogwood is a natural source of vitamins, minerals, and antioxidants, making it an attractive ingredient for enriching soft drinks. Due to its nutritional properties, dogwood berries can enhance the nutritional value of beverages and add additional health benefits to them.

The addition of cornel berries, juice and extract to beverages leads to an increase in some vitamins, namely vitamin B2 by 47%, vitamin C by 25% and vitamin K by 39%. This is attributed to cornel berries being a good source of these vitamins. The addition of cornel berries enriches the beverages with flavonoids and anthocyanins, natural antioxidants. The flavonoids and anthocyanins increased to 19.28 mg/100 g and 13.34 mg/100 g respectively in the experimental sample, compared to 15 mg/100

g and 10.12 mg/100 g in the control sample. The body may benefit from the higher concentration of these substances since they have anti-inflammatory, anti-oxidative stress, and immune-boosting qualities that help shield cells from harm. The content of phenolic compounds in drinks with the addition of cornel berries also increased compared to the control sample, indicating additional beneficial properties of such drinks. The content of phenolic compounds increased from 21.1 mg/100 g in the control sample to 22.3 mg/100 g in the experimental sample. In the analysis of heavy metal content, it was discovered that both variations (control and experimental) satisfied WHO hygienic requirements for mercury, lead, and cadmium. However, the addition of cornel berries to the beverages showed some reduction in the content of these heavy metals. Thus, in the experimental sample with the addition of dogwood berries the content of mercury was lower by 11%, lead – by 5.3% and cadmium – by 2%, compared to the control variant. This indicates the potential ability of dogwood berries to absorb these toxic metals and reduce their content in beverages. Microbiological analysis did not reveal the presence of total bacteria, coliform bacteria, yeasts, moulds, and pathogens in the beverage samples. This emphasises the safety and nutritional value of these beverages. Organoleptic analysis showed that the samples of drinks with dogwood berry addition had an attractive appearance with bright colours and the presence of berry fragments. They also had a more textured structure, a more intense colour, a characteristic berry aroma and a sour-sweet fruity taste. Thus, the addition of dogwood berries, juice and extract to beverages can be recommended to increase the content of vitamins and biologically active substances, which may help to improve overall health and protect the body from harmful effects.

The study findings have practical implications for the food industry and consumers, providing scientific data and recommendations for the development of soft drinks with increased nutritional value and safety. This may contribute to the development of new products that fulfil consumers' needs and preferences and promote healthy lifestyles. The prospect for further research is to investigate the optimal conditions for processing berries before use in beverages. This includes investigating methods of extracting beneficial substances, and optimising temperature regimes and process duration to preserve the maximum nutritional value and antioxidant properties of berries.

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