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ANALYSIS OF BIOACTIVE COMPOUNDS IN PLANT EXTRACTS BASED ON GC-MS DATA

Abstract: *This study presents a comparative analysis of organic compounds in extracts obtained from cherry (Prunus cerasus), stevia (Stevia rebaudiana), and soybean (Glycine max). The chemical composition of the extracts was characterized using gas chromatography-mass spectrometry (GC-MS), allowing identification of the main constituents and determination of their relative abundances. In the cherry extract, furan derivatives were found to be predominant, with 5-hydroxymethylfurfural being the major component. The soybean extract contained significant amounts of sugar derivatives and phenolic compounds, which are known*

for their antioxidant activity. Analysis of the stevia extract revealed the presence of polyols and phenolic compounds, including hydroquinone. The detected furan derivatives, phenolic compounds, and polyols may contribute to the antioxidant and anti-inflammatory properties of the extracts. Overall, the findings suggest that these plant materials are promising sources of naturally occurring bioactive compounds, which could be further utilized in the development of functional foods, dietary supplements, or nutraceutical applications.
Key words: *bioactive substances; plant extracts; antioxidant activity; anti-inflammatory properties; phenolic compounds; organic compounds; gas chromatography-mass spectrometry.*

Introduction. The prevention and progression of many diseases are closely linked to nutrition, as dietary patterns and bioactive components of food have a significant impact on human health [1].

One of the most effective approaches to improving public health and preventing chronic diseases is a balanced and specialized diet with defined functional properties that support a healthy lifestyle [2].

An increasing number of people suffer from degenerative-dystrophic joint diseases, among which osteoarthritis is one of the most common. Approximately 10-12% of the world's population live with this diagnosis, and according to some data, this figure may reach up to 20%.

In recent years, there has been growing interest in the study of natural biologically active compounds possessing antioxidant and anti-inflammatory properties. Chronic inflammation plays a key role in the development of many diseases, including cardiovascular, metabolic, and neurodegenerative disorders. The investigation of natural compounds that can alleviate inflammation and oxidative stress constitutes a key area of study in current biochemistry, pharmacology, and food technology research [3].

Plant raw materials are a rich source of phenolic compounds, organic acids, furan derivatives, and various secondary metabolites with diverse biological activities. Numerous studies have shown that phenolic compounds are capable of inhibiting free radical formation, suppressing the synthesis of pro-inflammatory cytokines, and regulating signaling pathways associated with inflammatory responses. Due to these properties, plant polyphenols are considered promising natural anti-inflammatory agents [4, 5].

Particular attention is given to such plants as sour cherry (*Prunus cerasus*), stevia (*Stevia rebaudiana*), and soybean (*Glycine max*), which contain a wide range of biologically active compounds. Cherry fruits are rich in phenolic substances and furan derivatives with antioxidant properties. Stevia is known as a source of natural glycosides and other metabolites with potential antioxidant activity, whereas soybeans contain various phenolic compounds, fatty acids, and aromatic components that may exhibit biological activity and participate in the regulation of inflammatory processes [6, 7].

Gas chromatography coupled with mass spectrometry (GC-MS) is widely used to study the chemical composition of plant extracts. This method enables accurate identification and quantification of organic compounds in complex natural mixtures due to its high sensitivity and selectivity. The use of GC-MS makes it possible to detect various classes of compounds, including phenolics, furan derivatives, and sugars, which may determine the biological properties of plant extracts [8, 9].

Despite the large number of studies devoted to individual types of plant materials, the comparative analysis of organic compounds in different plant extracts remains insufficiently explored. Exploring the primary constituents of plant materials and assessing their biological activity can expand their potential use in functional food and dietary supplement formulation [10].

Notably, compounds formed during carbohydrate processing, including 5-hydroxymethylfurfural (5-HMF), have been reported to possess biological activities such as anti-inflammatory effects. It has been established that this compound can inhibit MAPK and NF-κB signaling pathways, which play a crucial role in the development of inflammatory responses. This confirms the relevance of studying plant extracts to identify compounds with potential anti-inflammatory activity [11].

The aim of this study is to perform a comparative analysis of organic compounds in cherry, stevia, and soybean extracts using gas chromatography-mass spectrometry, as well as to evaluate their potential biological activity.

The main component of cherry extract was identified as 5-hydroxymethylfurfural (60.78%). This compound is widely found in carbohydrate-processing products and exhibits biological activity. Studies indicate that 5-hydroxymethylfurfural demonstrates antioxidant and anti-inflammatory properties by reducing the expression of pro-inflammatory enzymes such as iNOS and COX-2 and inhibiting MAPK and NF-κB signaling pathways [11-13].

Phenolic compounds, including phenol derivatives, were detected in soybean extract. Phenolic compounds are well-known natural antioxidants and are capable of inhibiting the formation of pro-inflammatory mediators such as nitric oxide (NO) and prostaglandins. Due to these properties, phenolic compounds exhibit pronounced anti-inflammatory activity [14-16].

In the stevia extract, the phenolic compound hydroquinone (6.09%) was identified, belonging to the group of aromatic diphenols. Compounds of this group exhibit strong antioxidant properties due to their ability to neutralize free radicals, which plays an important role in suppressing inflammatory processes [17, 18].

Thus, the results of the gas chromatographic analysis revealed the presence of compounds with potential antioxidant and anti-inflammatory activity. The presence of furan derivatives, phenolic compounds, and polyols may contribute to the reduction of oxidative stress and suppression of inflammatory mediators, making the studied plants promising sources of natural biologically active substances [19].

Materials and Methods. The objects of the study were extracts of cherry, stevia, and soybean. Analysis of organic compounds in plant extracts was performed using gas chromatography-mass spectrometry (GC-MS) (Agilent 7890A/5975C). A 1.0 μL aliquot of each sample was injected at an injector temperature of 280 °C in splitless mode. Separation was achieved on a DB-5ms capillary column (30 m × 0.25 mm × 0.25 μm) with helium as the carrier gas at a constant flow rate of 1 mL/min. The oven temperature was programmed from 40 °C to 250 °C at 10 °C/min and held at 250 °C for 10 min, resulting in a total analysis time of 31 min.

Detection was carried out in full scan mode (m/z 34-650). Instrument control, data acquisition, and processing were performed using Agilent MSD ChemStation software (version 1701EA). Retention times, peak areas, and mass spectral data were analyzed, and compound identification was performed by comparison with the Wiley 11th edition and NIST'02 libraries (>550,000 spectra). The results are presented in Figures 1-3 and Table 1.

Results of the Study

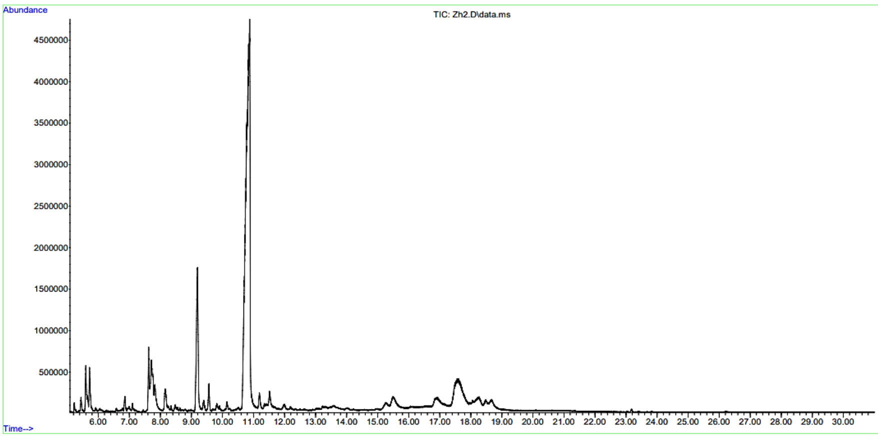

Figure 1 – Gas chromatography-mass spectrometry (GC-MS) chromatogram showing the composition of cherry extract

Based on the findings from gas chromatography-mass spectrometry (GC-MS) (Figure 1), 17 organic compounds were identified in the cherry extract with a mass spectral match probability ranging from 65% to 90%. The chromatogram is characterized by a pronounced dominant peak at a retention time of 10.87 min.

The major compounds identified in the cherry extract were 5-hydroxymethylfurfural (60.78%), 4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl (9.51%), and 1,4-anhydro-D-galactitol (8.52%). The predominance of 5-hydroxymethylfurfural suggests that dehydration of hexoses and thermal transformations of carbohydrates occurred during extraction. This compound is known to possess antioxidant properties and is commonly present in products derived from plant materials.

Additionally, furan derivatives including 2-furanecarboxaldehyde and methyl-2-furoate were detected, indicating the presence of carbohydrate structures and their thermal transformation products in the extract.

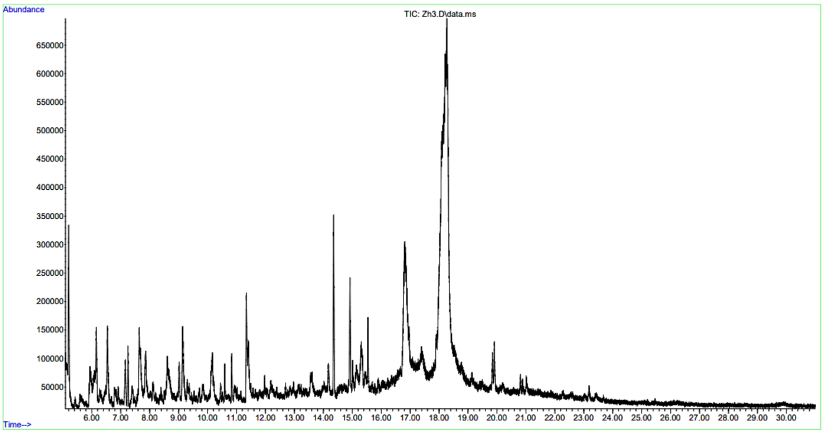

Figure 2 – Gas chromatography-mass spectrometry (GC-MS) chromatogram illustrating the composition of soybean extract

GC-MS analysis of the soybean extract revealed the presence of 19 organic compounds. The predominant constituents were 3-O-methyl-D-glucose (54.19%), ethyl-α-D-glucopyranoside (16.96%), 2,6-dimethoxyphenol (3.76%), and 9,12,15-octadecatrienoic acid, ethyl ester (1.65%).

The high content of sugar derivatives indicates the presence of glycosidic structures in the extract (Figure 2). The detection of the ethyl ester of linolenic acid suggests the presence of unsaturated fatty acids characteristic of soybeans.

In addition, pyrazine compounds, including trimethylpyrazine and dimethylpyrazine, were identified in the extract. The presence of these compounds may explain the characteristic aromatic profile of soybeans and their processed products.

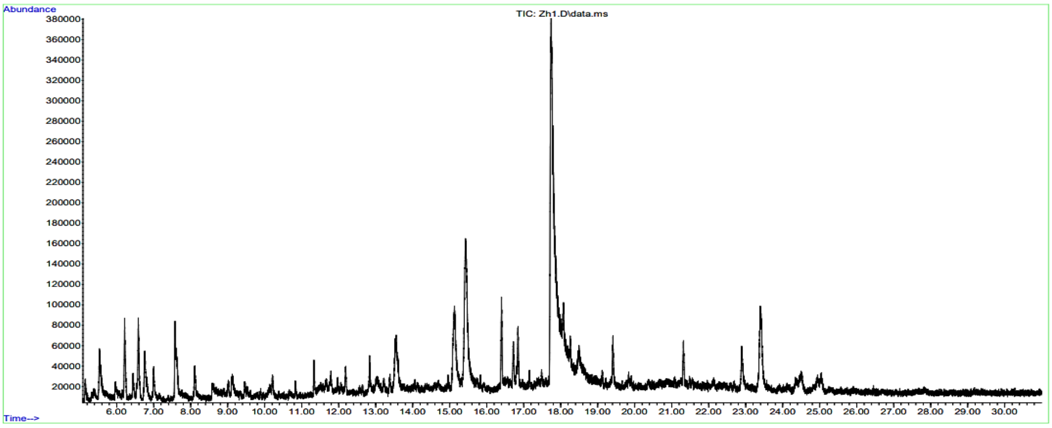

Figure 3 – Gas chromatography-mass spectrometry (GC-MS) chromatogram illustrating the composition of stevia extract

According to the results of gas chromatography-mass spectrometry (GC-MS) analysis, 13 organic compounds were identified in the stevia extract (Figure 3).

The most significant components include:

- 1,2,3,5-Cyclohexanetetrol - 52,74%;
- β-D-Glucopyranose, 1,6-anhydro - 15,67%;
- Hydroquinone - 6,09%;
- 2,5-Dimethylfuran-3,4-dione - 5,08%.

The predominance of polyol compounds and sugar derivatives is associated with the nature of stevia as a source of sweet glycosides. The presence of hydroquinone and other phenolic compounds may indicate the potential antioxidant activity of the studied plant.

Table 1 – Comparative Analysis of the Main Components of Cherry, Soybean, and Stevia Extracts

Parameter	Cherry	Soybean	Stevia
Dominant Class	Furan Compounds, Anthocyanins	Sugar Derivatives and Pyrazines	Polyols and Sugars
Major Component	5-HMF (60,78 %)	3-O-Methyl-D-glucose (54,19 %)	Cyclohexanetetrol (52,74 %)
Presence of Fatty Acids	Minor	Detected	Virtually Absent
Pharmacological Activity	Antioxidant, Anti-inflammatory	Antioxidant, Metabolic, Cardioprotective	Hypoglycemic, Antioxidant

Thus, cherry is characterized by a high content of sugar dehydration products. Soybeans contain aromatic nitrogen-containing compounds and fatty acids, while stevia is rich in polyol structures and glycosidic derivatives.

Conclusion. As a result of the conducted study, an analysis of organic compounds in extracts of cherry (*Prunus cerasus*), stevia (*Stevia rebaudiana*), and soybean (*Glycine max*) was performed using gas chromatography-mass spectrometry (GC-MS). The main components of the studied extracts were identified, and their relative contents were determined.

It was established that furan derivatives predominate in the cherry extract, among which 5-hydroxymethylfurfural was identified as a major compound. In the soybean extract, sugar derivatives and phenolic compounds were detected, whereas the stevia extract contained polyol and phenolic compounds, including hydroquinone.

The obtained results indicate the presence of biologically active compounds in the studied plant extracts, possessing potential antioxidant and anti-inflammatory properties. The conducted research confirms the prospects of using these plants as sources of natural biologically active substances.

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ӨСІМДІК ЭКСТРАКТТАРЫНДАҒЫ БИОАКТИВТІ ҚОСЫЛЫСТАРДЫ ГХ-МС ДЕРЕКТЕРІ БОЙЫНША ТАЛДАУ

Мақалада шие (Prunus cerasus), стевия (Stevia rebaudiana) және соя бұршақтарының (Glycine max) экстракттарындағы органикалық қосылыстардың салыстырмалы талдауы қарастырылған. Қосылыстардың құрамын анықтау газды хроматография-масс-спектрометрия (ГХ-МС) әдісі арқылы жүргізілді. Зерттеу барысында зерттелген экстракттардың негізгі компоненттері анықталып, олардың салыстырмалы мөлшері белгіленді. Шие экстрактында фуран туындыларының басым екендігі анықталып, олардың ішінде 5-hydroxymethylfurfural қосылысы идентификацияланды. Соя бұршақтарының экстрактында антиоксиданттық белсенділікке ие қант туындылары мен фенолдық қосылыстар анықталды. Стевия экстрактында полиолдық және фенолдық қосылыстар, соның ішінде hydroquinone табылды. Фуран туындыларының, фенолдық қосылыстардың және полиолдардың болуы антиоксиданттық және қабынуға қарсы қасиеттердің байқалуына ықпал етуі мүмкін екендігі анықталды. Алынған нәтижелер зерттелген өсімдіктердің табиғи биологиялық белсенді заттардың перспективалы көзі екенін көрсетеді.

Түйін сөздер: *өсімдік экстракттары, газды хроматография-масс-спектрометрия, органикалық қосылыстар, фенолдық қосылыстар, антиоксиданттық белсенділік, қабынуға қарсы қасиеттер, биологиялық белсенді заттар.*

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БИОАКТИВНЫЕ СОЕДИНЕНИЯ РАСТИТЕЛЬНЫХ ЭКСТРАКТОВ ПО ДАННЫМ ГХ-МС

В статье рассмотрен сравнительный анализ органических соединений в экстрактах вишни (Prunus cerasus), стевии (Stevia rebaudiana) и соевых бобов (Glycine max). Определение состава соединений проведено методом газовой хроматографии с масс-спектрометрическим детектированием (ГХ-МС). В ходе исследования выявлены основные компоненты исследуемых экстрактов и установлено их относительное содержание. Определено, что в экстракте вишни доминируют фурановые производные, среди которых идентифицировано соединение 5-hydroxymethylfurfural. В экстракте соевых бобов выявлены производные сахаров и фенольные соединения, обладающие антиоксидантной активностью. В экстракте стевии обнаружены полиольные и фенольные соединения, включая hydroquinone. Установлено, что наличие фурановых производных, фенольных соединений и полиолов может способствовать проявлению антиоксидантных и противовоспалительных свойств. Полученные результаты свидетельствуют о перспективности исследуемых растений как источников природных биологически активных веществ.

Ключевые слова: *растительные экстракты, газовая хроматография-масс-спектрометрия, органические соединения, фенольные соединения, антиоксидантная активность, противовоспалительные свойства, биологически активные вещества.*

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ФУНКЦИОНАЛДЫ ЙОГУРТТАҒЫ СҮТҚЫШҚЫЛДЫ БАКТЕРИЯЛАРДЫҢ ӨМІРШЕҢДІГІНЕ ЕРІГІШ ӨСІМДІК ТЕКТЕС ТАҒАМДЫҚ ТАЛШЫҚТЫҢ ӘСЕРІ

Аңдатпа: *Мақалада ерігіш өсімдік тектес тағамдық талшықтың функционалды йогурттағы сүтқышқылды бактериялардың өміршеңдігі мен микробиологиялық тұрақтылығына әсерін зерттеу нәтижелері ұсынылған. Зерттеудің өзектілігі қышқыл сүт өнімдерінің функционалдық құндылығын арттыру және сақтау мерзімі бойы пробиотикалық микрофлораның тұрақты деңгейін қамтамасыз ету қажеттілігімен байланысты.*

Зерттеу нысаны ретінде майлылығы 1,0% пастерленген сүттен дайындалған, құрамында Streptococcus thermophilus *және* Lactobacillus delbrueckii subsp. Bulgaricus *бар ашытқы қолданылған йогурт алынды. Ерігіш өсімдік тектес тағамдық талшық 0,3; 0,5 және 1,0 % мөлшерінде енгізілді.*

Сүтқышқылды бактериялардың өміршеңдігі MRS-агарға себу әдісі арқылы анықталып, колония түзуші бірліктерді санау нәтижелері log КТБ/г түрінде көрсетілді. Зерттеулер 4 ± 2 °C температурада сақтау кезінде 1, 7 және 14 тәуліктерде жүргізілді.

Зерттеу нәтижелері өсімдік тектес тағамдық талшықтың сүтқышқылды микрофлораның дамуына тежеуші әсер етпейтінін көрсетті. Керісінше, талшық қосылған үлгілерде бақылау нұсқасымен салыстырғанда бактериялардың өміршеңдігі жоғары деңгейде сақталды. Сақтаудың 14-тәулігінде бақылау үлгісінде өміршең жасушалар саны 7,6 log КТБ/г дейін төмендеген болса, 0,5 % концентрациясында 8,1 log КТБ/г деңгейінде сақталды.

Алынған нәтижелер өсімдік тектес тағамдық талшықтың ықтимал пребиотикалық әсерін және өнімнің микробиологиялық тұрақтылығына оң ықпалын көрсетеді. Ең тиімді концентрация ретінде 0,5 % анықталды, ол микрофлора тұрақтылығы мен технологиялық көрсеткіштердің оңтайлы үйлесімін қамтамасыз етеді. Әзірленген өнім нормативтік талаптарға сәйкес келеді және функционалды қышқыл сүт өнімдерін өндіруде қолдануға ұсынылады.