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RESEARCH ON THE EFFECT OF SUPER HIGH FREQUENCY FIELD ON GREEN TEA EXTRACTION AND EXTRACT QUALITY

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Abstract. The article characterises non-brick green tea as a product of mass consumption. It has been described how practical it is to produce liquid extracts based on it and use them further in the non-alcoholic drinks technology. Achieving high yields of extractives from tea requires intensification of the mass transfer process. The analysis of scientific sources has shown that pre-treatment of raw materials is one of the most promising methods for this purpose. The article presents comparative characteristics of green tea extracts obtained using pre-treatment in the super high frequency field and of ones produced without it. The optimal power of the super high frequency field for extracts heated up to 60°C has been selected and analysed. If the energy of super high frequency is applied to a fresh mixture of tea and an extractant, with its further extraction in a rotary extractor IKA-RV-10 at the dilution 280 mBr, the yield of extractives doubles. The action of the microwave field leads to a 40% increase in the content of extractives in the resulting extract: the yield of phenolic substances increases by 44%, of caffeine by 45%, of substances with vitamin P activity by 23%, compared with the extracts produced without additional treatment. However, the chlorophyll and aldehyde content decreases. Pre-treatment with super high frequency energy in the course of green tea extraction helps effectively extract phenolic compounds like catechins that affect the taste of final beverages. This technique allows doubling the yield of catechins. Besides, it has been confirmed that the chemical composition (namely the quantity of hydroxyl groups in the catechin structure) determines the intensity of the transition of catechins into the composition of the extract. The findings on the safety of the extracts obtained have allowed establishing that though the contents of mercury, arsenic, lead, copper, and iron increase, they do not exceed the maximum permissible concentrations. This proves the safety of the extracts produced. The research results obtained make it possible to intensify the plant extract production technology without using any special extractors.

Keywords: non-brick green tea, extraction, extract, catechins, super high frequency field.

Introduction. Formulation of the problem

Production of plant extracts is a priority area in processing food plant-derived raw materials, as these extracts can be used in food technologies [1], in particular, to manufacture general-purpose and functional drinks [2]. Tea is of particular interest to consumers, because beverages of this type have a pleasant flavour and a tonic effect on the body. This is due to the sensory, physicochemical, and therapeutic properties of tea and tea products [3].

The extraction process is one of the main stages in obtaining extracts from raw materials of vegetable origin. It determines the completeness of extraction of raw materials and, consequently, the quality of the final product.

So, the topical problem of achieving high quality tea extracts is how to ensure complete extraction of valuable components.

Analysis of recent research and publications

Nowadays, to intensify the mass transfer process, the effect of different force fields on raw materials is used, including such fields as ultrasonic [4,5], electric [6], impulse [7] discrete-impulse [8]. It is obvious that in their search for methods of intensifying extraction, researchers look for how to influence cellular structures in order to increase their diffusion activity. However, most of these promising methods often remain at the stage of research or industrial tests, which means that there are a number of complex unresolved theoretical and practical problems [8]. Therefore, the extraction process is more and more often intensified by pre-processing either the raw material itself or its fresh mixture with an extractant. This allows destroying a plant's cellular structures and increasing the diffusion in the raw material.

For this purpose, such methods are commonly used as blanching, enzyme preparations, alternating electric current on electroplasmolysers, high frequency electric pulses, sonic and ultrasonic oscillations, freezing, ionising radiation, microwave energy, etc.

Preliminary freezing of raw materials increases the extract yield by 1.5–2.5 times [9], but negatively reflects on its taste. Due to the changes in chemicals (increased acidity, decrease in tannins, oxidation of organic substances leading to darkening of tissues), loss of soluble dry matter (DM), and difficulties that arise during their defrosting and compression, this method has not been widely used in production [9].

The action of the electromagnetic field changes some properties of water, and these changes remain for some time. Magnetisation of extracts affects the permeability of membranes (artificial as well as biological). Electromagnetic processing changes the degree of hydration of ions of colloidal and suspended particles, affects ion-exchange adsorption.

In a rotating electromagnetic field, the vortex layer of ferromagnetic particles can be formed (when ferromagnetic particles are placed into a rotating electromagnetic field, their complex motion starts). In the vortex layer, there are several factors that accelerate the processes. These factors include intensive mixing and dispersion of the phases, high local pressure due to collisions of the particles, acoustic vibrations of the medium processed, with magnitudes and directions rapidly varying, electromagnetic fields, potential difference on the ferromagnetic particles, which leads to electrolytic phenomena. In some cases, there can be a break in polymerisation and production of low molecular weight compounds. The authors [9] show that the vortex layer of ferromagnetic particles is an effective source of energy that can have a targeted effect on product processing.

It is known [10] that quite high yields result from using enzymatic pre-treatment (biochemical method). It allows you to destroy, in a targeted way, the components of the cellular structure (cellulose, hemicellulose, pectin substances, proteins). The following enzymes are used: pectofoetidin, xylonigrin, celloviridin, and others. Treatment with pectolytic enzyme preparations decreases the viscosity and increases the yield, reduces the amount of precipitate, improves the technological operations of illumination and filtration of the extracts [11].

Some publications [12] highlight that high-quality extracts can be obtained by super high frequency treatment. It has been established that this treatment increases the yield and reduces the extraction time. The extracts obtained can be used in the formulations of multicomponent food products. Besides, a number of papers [13] show that using microwave electromagnetic radiation is the most effective method to intensify the extraction process and obtain a quality product. The action of microwave energy usually results in rapid and quite uniform heating, high quality of the extraction process, and low consumption of thermal energy. Microwave treatment of products allows increasing significantly extraction of bioactive substances (BAS) and improving the quality of extract [14], since most of the compounds in the extracts do not break down and retain their properties. The time necessary to process raw materials is significantly reduced, as well as the effect of pathogenic microorganisms. Products become more stable and environmentally safer [7]. However, introduction of extractors with microwave ovens in industrial enterprises is a difficult process, because the depth of penetration of SHF energy is limited. To overcome this disadvantage, it is practical to pre-treat the raw materials with microwaves [12] prior to the traditional solid-liquid extraction.

Thus, we find it practical to pre-treat green tea extract in the SHF field. This will intensify the extraction process and increase the nutritional value of the final product.

The purpose of the article is to study the process of green tea extraction and the quality of extracts obtained in the super high frequency field.

For this purpose, it is necessary to achieve the following **objectives**:

- to select the optimal power for pre-treatment of a mixture of an extractant and green tea in the SHF field;
- to study the chemical composition of the tea extract obtained using SHF field treatment, in comparison with the extract obtained by the classic technology;
- to establish whether extracts obtained using SHF field treatment are safe in terms of heavy metals.

Research materials and methods

The object of research:

- whole-leaf Chinese green tea *Golden Pekoe* (TM *Mayskiy*, packaged in Ukraine);
- green tea extract not processed in the microwave field. Its extraction was carried out with an extractor IKA-RV-10 at 60°C and the dilution 280 mBr for 60 minutes. The raw material – extragent ratio was 1:12;
- green tea extract pre-treated in the super high frequency field. The pre-treatment of the tea extracts was carried out in a household microwave oven. It was studied how SHF energy, with the frequency 360 to 860 W\kg effected on a freshly-made mixture of an extractant and green tea (in the ratio 1:12). The extractant and green tea were treated for different periods of time until the temperature was 60°C,

avoiding overheating the extract, according to the data presented in Table 1.

Table 1 – Conditions of preparing the samples

Sample	Sample volume, cm^3	Microwave Power, W/kg	Heating time, min
1	600	360	6
2		510	5
3		680	5
4		860	4

After selecting the optimal power, further extraction was carried out similarly to the sample of green tea extract not treated in the microwave field.

Physicochemical methods of analysing the extracts. The transition of extractives into the extractant was determined by drying the extracts to the constant weight at 105°C. The dry matter weight fraction was measured using a universal refractometer according to the method [15]. The total number of flavonoids characterised by vitamin P activity in the samples studied was determined by the colorimetric method [16] based on the ability of the Folin–Ciocalteu reagent to oxidise the phenolic groups of rutin colouring them blue. The intensity of the colour is directly proportional to the content of vitamin P. When determining phenolic substances in the raw material and in the dry extracts obtained, they were first triple-extracted with 95% and 70% ethanol or diluted with a solution of alcohol of an appropriate concentration.

The content of phenolic substances was determined by the photocolorimetric method [16], which is based on the ability of the substances under study to change the colour of the solutions during interaction with aluminium salts. The amount of chlorophyll contained in the studied samples was also determined by the photocolorimetric method, acetone being used as a solvent for chlorophyll [17]. P-active substances, phenolic compounds, and chlorophyll were analysed with a spectrophotometer ULAB 101 UV. The amount of caffeine was determined iodometrically, with caffeine having been preliminarily extracted with chloroform from the sample under study preheated and treated with aqueous ammonia [15]. The total content of acids in the raw materials and extracts was determined by potentiometric titration [15]. The pH of the tea extracts was determined using a pH meter Hanna Instruments HI 80-14 [18].

Identification of phenolic compounds by mass spectrometry. The content of gallic acid, catechin, epicatechin gallocatechin, epicatechingallate, epigallocatechin, and epigallocatechingallate in the raw materials and tea extracts, pre-diluted with an aqueous alcohol solution, was analysed by chromatography-mass spectrometry on a gas chromatograph FINIGAN FOCUS with a mass selective detector Thermo Electronics. To determine phenolic compounds of tea, it was extracted with 70% aqueous alcohol solution in a bain-marie for 30 minutes, with the ratio between the raw materials and the extractant 1:10. The ready extracts made with or without pre-treatment were diluted with alcohol of the same concentration.

Chromatography was performed under the following conditions: HP-5MS fused silica column with the diameter 0.25mm, length 30m, and phase film thickness 0.25µm. The carrier gas was helium, the carrier gas flow in the column was 1.2ml/min. The split mode was used, with the stream splitting 1:10. The injector temperature was 250°C, the MSD interface temperature 280°C. The temperature in the thermostat of the chromatograph was programmed as follows: the initial temperature 50°C was retained for 0.5min, then, at a rate of 25°C/min, it was raised to 125°C, then, at a rate of 10°C/min, to 255°C, then, at a rate of 25°C/min, to 300°C and retained so for 10 min. Electron-impact ionisation was used, with the electron energy 70 eV. The MSD mode involved full scanning of ions with the atomic mass ranging 29-450 (SCAN mode). To identify the components, the peak retention times on the chromatogram and the full mass spectra of individual components were compared with the corresponding results for pure compounds in the NIST 5 mass spectral library, and besides, linear retention indices were used. The relative quantitative content of the chemical components of the extract was calculated by the method of internal normalisation of peak areas without corrective sensitivity coefficients.

Methods of determining the content of heavy metals in the raw materials and extracts. The content of lead, cadmium, copper, and zinc was determined in the ash of the corresponding sample by the atomic absorption method using a spectrophotometer Semy C-115 M 1 (Ukraine), that of mercury by the cold vapour method using a spectrograph GRG-107, that of arsenic by means of an atomic absorption spectrophotometer with thermal atomisation Varian SpectrAA 240 Z (Australia) [19].

Results of the research and their discussion

Selecting the optimal supply of microwave energy. Analysis of literary sources [12] has shown that pre-treatment of tea SHF energy increases the transition of extractives, but there is a problem of selecting the optimal high frequency power supply. Besides, microwave pre-treatment of green tea extracts can destroy BAS, because the extract is heated up too rapidly. Fig. 1 presents the findings on how microwaves with the frequency 360–860 W/kg effect on a fresh mixture of an extractant and green tea treated to the temperature 60°C.

It has been established that the preliminary preparation of tea with SHF energy results in a significant (up to double) increase in the transition of extractives into the solution. It is explained by the excess pressure that appears in the middle of tea tissues as a result of vapour formation. The water vapour formed "expel" the compounds out of the cells to the surface of the leaves.

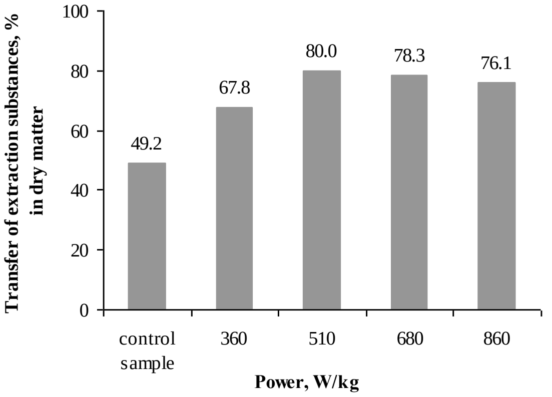

Fig. 1. Transition of extractive substances of green tea treated with the SHF field with different frequencies to the temperature 60°C

However, this parameter grows unevenly in comparison with the sample prepared according to the classic technology. Thus, before the power of the microwave field rises to 510 W/kg, the diffusion of water-soluble substances into the extract increases. For the extract, the value of transition of extractives is 80% of the dry matter of green tea. A further increase in the power of SHF energy, though, reduces the transfer of extractives by 5% till the power is 860 W/kg. this irregular pattern of changes in the transition of extractives is due to the chemical composition of extracts, which are semiconductors from the electrophysical point of view.

Perhaps heating the extract, when the power is up to 510 W/kg, makes more acids and salts pass into solution, as they are electrolytes and, thus, dissociate in water, which results in ion formation and the active conductivity of the material. Diffusion of proteins, phenol substances, alkaloids, and carbohydrates, which are semiconductors, is inhibited: an increase in the external electric field creates displacement currents in the product [13], which is accompanied by reduced transition of extractives if the power of SHF energy exceeds 510 W/kg. Thus, the power 510 W/kg is the most practical for pre-treatment of tea extract.

Analysis of the physical and chemical parameters of the raw materials and finished extracts. It is known [14] that applying SHF field energy to plant raw materials allows extracting BAS almost completely. Still, it remains unclear how the pre-treatment of extracts affects the chemical composition and safety of the final extracts. That is why it was considered reasonable to study the physicochemical parameters and the chemical composition of the tea extract pre-treated with SHF energy and compare them with those of the extract made by the classic technology. Extraction was carried out at 60°C, due to thermolability of most bioactive substances. The dilution 280 mBr makes the extractant close to the saturated state and prevents its evaporation. The selected hydromodulus (1:12) and duration of extraction (60 minutes) provide the maximum yield of extraction substances with the minimum expenditure on the process [3]. This fact has been established experimentally. The findings on the quality of green tea extracts are presented in Table 2.

According to Table 2, after the treatment of green tea with super high frequency energy, transition of extractives increases by 40% compared with the extract produced without pre-treatment. Pre-treatment of tea extract decreases the pH value, probably because a larger quantity of freely dissociated ions H^+ passes into the solution. This has been confirmed by the results of analysis of the total acids content. The content of these acids increases 3 and 4 times for the samples without pre-treatment and for the pre-treated ones respectively, in comparison with green tea leaves in terms of the dry matter of the product under study.

The results of studying the chemical composition have shown that treating tea extract with SHF energy contributes to an increase in the yield of phenolic substances, free acids, and P-active substances.

Table 2 – Physicochemical parameters and chemical composition of green tea extracts with and without SHF-energy pre-treatment: M±0.05; n=3

The main chemical components of tea leaves	Green tea	Green tea extract without SHF pre-treatment	Green tea extract after SHF pre-treatment
Extractivity, % of DM	43.3	–	–
Transition of extractives, % of DM of the product under study	–	53.8	74.5
Mass fraction of dry matter, %	94.0	0.9	1.4
Caffeine, % of DM of the product under study	2.23	2.45	3.56
Phenolic compounds, g % of DM of the product under study	0.93	1.24	1.78
Volatile aldehydes, mg/100g of DM of the product under study	1.41	1.32	1.05
Total acidity, mg/100g of DM of the product under study	3.52	10.50	12.60
Chlorophyll, mg % of DM of the product under study	0.61	0.48	0.44
Vitamin P, mg % of DM of the product under study	18.35	15.36	18.90
pH	–	6.10	6.80

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Caffeine is resistant to external factors [3,15], so it is not destroyed during extraction, but diffuses into the extractant. Its quantity increases by 10% during extraction of green tea without pre-treatment of the extracts, and by 60% when the green tea infusion has been pre-treated, in terms of the dry matter of the product under study.

The amount of P-active substances increases by 3% due to pre-treatment, whereas, with the classic technology used, their amount decreases by 16%. The properties of P-active substances are characteristic of catechin, epicatechin, quercetin, rutin, gallic acid, and other substances that differ in their redox potentials, thermal and acid resistance, and therefore are extracted differently. The content of common phenolic substances, too, increases up to 70% due to additional treatment.

The increase in caffeine, phenolic compounds, and vitamin P after pre-treating the extracts with SHF energy is explained by the increase in the rate of molecular diffusion, which is due to water evaporation inside tea cells and to the destruction of their cell walls and plasma membranes [7].

The amount of chlorophyll during the extraction is reduced by 21% in the samples not treated in the SHF field. Chlorophyll is easily phaeophytised and thermally destroyed [15], which explains its loss during extraction. The effect of the super high frequency field causes greater destruction of chlorophyll, and 28% of it is lost.

Thus, using SHF energy with the power 510 W/kg to pre-treat green tea extract up to 60°C increases the transition of phenol substances, caffeine, and vitamin P into the extract, thus adding to the nutritional value of the final extract.

Analysis of the content of polyphenolic compounds of tea. Tea compounds like gallic acid, catechin (C), epicatechin (EC), gallocatechin (GC), epicatechingallate (ECG), epigallocatechin (EGC), epigallocatechingallate (EGCG) are characteristic constituents of tea [21]. They contribute to the taste of the finished beverage, making it tartish [22, 23]. Moreover, these compounds retain their quality and stability during processing [24]. Therefore, the analysis of these compounds is an important step in determining whether it is practical to pre-treat green tea infusions with the SHF field. The results of studying the main phenolic compounds are presented in Table 3.

It has been determined that the identified (±) C, (-) EC, (±) GC, (-) ECG, (-) EGC, (-) EGCG and gallic acid during the extraction process diffuse into the extractant in the amount 22 to 49% in the case of traditional extraction, and 34-37% if SHF energy is used. The transition of these compounds, if they are in their free forms, is due to their solubility in warm water, and for bound forms of catechins, it is explained by washing them out of ruptured cells [22] (which may also be facilitated by reduction of the pressure in the system to 280mBr). Besides, pre-treatment of the freshly made extracts in the SHF field results in up to twice as big a content of these compounds in the extract compared with the extraction without pre-treatment. Their transition, though, varies for different compounds. The ones that diffuse the most are (±) C and (-) EC, the least – (±) GC, (-) ECG, (-) EGC, (-) EGCG. This difference in their ability to pass into water is explained by the different chemical compositions of these compounds. That is, the phenolic compounds with the para position of hydroxyl groups (C and EC) have a high redox potential, and therefore are extracted better. The three hydroxyl catechins (GC, ECG, EGC, EGCG), on the contrary, have a low redox potential and, accordingly, are more difficult to extract [21].

The amount of gallic acid extracted with SHF energy used is 2 times higher than it is when the technology includes no additional treatment. Thus, the increased number of catechins when the microwave field acts on the freshly made green tea infusions confirms the results of G. Spigno and D.M. De Faveri's research [7].

Analysis of the content of heavy metals in the raw materials and extracts. For a more objective assessment of the quality of the extracts obtained by the above technology, the content of heavy metals in these extracts has been investigated, since they can pass to the extract and contaminate it with toxic substances. The data of studying the content of heavy metals in the tea extracts are presented in Table 4.

The analysis of these data shows that the maximum permissible concentration (MPC) of plant-derived extracts is within the acceptable limits. The amount of heavy metals that passed into the extract ranged from 24 to 75%. However, in the tea extracts made using pre-treatment with SHF field energy, increased transition of heavy metals and arsenic into the extract was observed. This is because the action of the external field energy increased the kinetic energy of molecules, which leads to an increase in the diffusion of heavy metals into the extract. иThe maximum transition of toxic elements into the extract is observed for lead (0.394mg/kg), and the minimum is that of arsenic ($0.003 mg/kg \cdot 10^{-3}$). These results indicate that the use of raw materials in which the concentration of heavy metals does not exceed the MPC, but is near-critical, can lead to contamination of extracts based on them. Therefore, the MPC standards for heavy metals should be set for the raw materials used to prepare extracts, taking into account the MPC of extracts.

Table 3 – Phenolic components of green tea extracts with and without SHF pre-treatment, mg/g of DM (M±m; n=5)

The main phenolic components of tea	Green tea	Green tea extract without SHF pre-treatment	Green tea extract after SHF pre-treatment
(±) Catechin	2.19±0.10	3.06±0.10	3.77±0.10
(-) Epicatechin	0.60±0.05	0.86±0.05	1.06±0.05
(±) Gallocatechin	0.23±0.01	0.28±0.01	0.32±0.01
(-) Epicatechingallate	0.62±0.01	0.77±0.01	0.83±0.01
(-) Epigallocatechin	1.18±0.01	1.76±0.01	1.83±0.01
(-) Epigallocatechingallate	2.01±0.05	2.53±0.05	2.88±0.05
Gallic acid	0.97±0.05	1.13±0.05	1.30±0.05

Table 4 – Content of heavy metals and arsenic in the raw materials and in the tea water extracts (M±m; n=5)

Sample	Hg, mkg/kg	Pb, mg/kg	Cu, mg/kg	Zn, mg/kg	Cd, mg/kg	As, mkg/kg·10^{-3}
Maximum permissible concentration of heavy metals for green tea	0.02	1.0	25.0	50.0	0.05	1.0
Maximum permissible concentration of heavy metals for extracts	0.005	0.5	3.0	10.0	0.03	1.0
Green tea	0.004±0.001	0.385±0.005	2.354±0.005	6.233±0.005	0.037±0.005	0.005±0.001
Green tea extract made by the classic technology	0.003±0.001	0.365±0.005	1.441±0.005	2.691±0.005	0.004±0.005	0.002±0.001
Green tea extract made using SHF field pre-treatment	0.003±0.001	0.394±0.005	1.786±0.005	2.935±0.005	0.005±0.005	0.003±0.001

Conclusion

The research results on how the process of green tea extraction involving pre-treatment of extracts in the super high frequency field effects on the quality of finished extracts have allowed drawing the following conclusions.

It has been established that diffusion of substances contained in tea increases with an increase in the power of super high frequency energy. The maximum transition of extractives into water (80.0% of DM) takes place with the microwave power 510W/kg. A further increase in the microwave power reduces the extracting ability of tea, which may be due to its chemical composition and water-solubility of its individual components.

It has been proved that the action of the super high frequency field does not only increase significantly the yield of extract, but also facilitates extraction of bioactive substances, such as phenolic substances, P-active substances, acids (up to 60%). When infusions of non-brick green tea are pre-treated in the super high frequency field, the phenolic compounds C, EC, ECG, EGC, EGCG, and gallic acid (which are responsible for the quality of extracts) are extracted in an amount which is by 22-49% larger than it is with extracts produced using no pre-treatment. It should be noted that phenolic compounds such as catechins are capable of redox processes. As a result of these processes, they are transformed into quinones [25], which results in a worse taste and lower nutritional value of extracts they are in. So, every degree of an increase in the tea extraction temperature, as well as extension of its duration can lead to the loss of valuable components.

As for the presence of heavy metals, it has been confirmed that the green tea extracts under study are safe to consume.

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ДОСЛІДЖЕННЯ ВПЛИВУ ПОЛЯ НАДВИСОКОЇ ЧАСТОТИ НА ПРОЦЕС ЕКСТРАГУВАННЯ ЧАЮ ЗЕЛЕНОГО ТА НА ЯКІСТЬ ЕКСТРАКТІВ

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Анотація. У роботі охарактеризовано зелений байховий чай як продукт масового споживання. Описано доцільність виробництва рідких екстрактів на його основі з подальшим використання у технології безалкогольних напоїв. Забезпечення високого виходу екстрактивних речовин з чаю потребує застосування інтенсифікації процесу масопереносу. Із аналізу літературних джерел доведено, що використання попередньої обробки сировини - один із найперспективніших методів у даному аспекті. В статті представлено порівняльну характеристику екстрактів зеленого чаю виготовлених із застосуванням попередньої обробки в полі надвисокої частоти та без. Проаналізовано та підібрано оптимальну потужність поля надвисокої частоти у разі прогріву екстрактів до температури 60ºС. Застосування енергії надвисокої частоти на щойно змішані чай та екстрагент з подальшою екстракцією в роторному екстракторі IKA-RV-10 при розріджені 280 mBr, дозволяє збільшити вихід екстрактивних речовин в два рази. Дія мікрохвильового поля сприяє підвищенню в готовому екстракті вмісту екстрактивних речовин на 40%, а саме підвищується вихід фенольних речовин на 44%, кофеїну – на 45%, речовини з Р вітамінною активністю – на 23%, порівняно з екстрактами отриманими без додаткової обробки. Проте вміст хлорофілу та альдегідів знижується. Використання попередньої обробки енергії надвисокої частоти у процесі екстрагування чаю зеленого, сприяє ефективному вилученню фенольних сполук типу катехіни, які впливають на смак готових напоїв. Даний технологічний захід дозволяє збільшити вихід катехінів до двох разів, крім того підтверджено, що залежно від хімічної будови, а саме кількості гідроксильних груп в структурі катехінів, залежить інтенсивність їхнього переходу до складу екстракту. Із результатів досліджень безпечності виготовлених екстрактів визначено, що вміст ртуті, миш'яку, плюмбума, міді та заліза хоча і підвищується, але не перевищує гранично допустимі концентрації, що підтверджує безпечність виготовлених екстрактів. Отримані результати дозволять інтенсифікувати технологію виготовлення рослинних екстрактів, не застосовуючи спеціальних екстракторів.

Ключові слова: чай байховий зелений, екстракція, екстракт, катехіни, поле надвисокої частоти.

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