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RESEARCH ON THE QUALITY OF ESSENTIAL OILS

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Abstract. This article provides information on the chemical composition, biological activity and application of some types of essential oils, describes the results of the analysis of essential oil samples. The purpose of the study is to determine the quality and compliance of fragrant oils with the requirements of national standards, sanitary norms and rules for organoleptic and physicochemical characteristics.

Key words: essential oils, organoleptic characteristics, refractive index, density, acid number.

Introduction.

Essential (fragrant) oils are multicomponent mixtures of volatile organic compounds (mainly terpenes and their derivatives), which are obtained from plant raw materials by distillation, extraction or pressing. Due to a wide range of biological activity, they are used in pharmacy, cosmetology, aromatherapy, food and perfumery industries [1-2]. Marketers note an increase in the consumption of essential oils by an average of 6-8% each year and predict that this trend will continue until 2030 [3], which is associated with their ability to effectively treat many common diseases among the population (rheumatism, neuralgia, colds, diseases of the oral cavity and gastrointestinal tract). However, the therapeutic properties are inherent only to natural essential oils. At the same time, in recent years, a significant number of counterfeit products that do not meet pharmacopoeial requirements have appeared on the market. Any deviation from the standard chemical composition of an essential oil leads to a decrease in its effectiveness, and in cases of deliberate falsification - to a potential



danger to the consumer. Product falsification can be carried out in several main ways. The simplest ones include diluting the oil with cheaper vegetable fats or solvents, which affects its density and mixing ability. More complex methods include the addition of isolates (for example, individual terpenes or cheap aromatic substances that are present in natural oil, but obtained synthetically) or the use of synthetic analogues of key active components. For example, for lavender oil, a common falsification is the addition of synthetic linalool and linalyl acetate. Counterfeit oils may have a similar smell but different efficacy and safety, so quality control of these products is an important task.

Analysis of recent research and publications.

A significant number of scientific studies carried out by specialists from different countries are devoted to the study of essential oils. In the article “Fundamental Chemistry of Essential Oils and Volatile Organic Compounds, Methods of Analysis and Authentication”, the English scientist Nicholas J. Sadgrove conducts a thorough analysis of the chemical composition of essential oils and volatile organic compounds, considers modern methods of their isolation and authentication, and also proposes new approaches to analysis. The author emphasizes the need for accurate analytical methods to ensure the quality and safety of products [4]. The publication “Essential Oils and Health”, written by a group of American scientists J. T. Ramsey, B. S. Shropshire and others, examines popular methods of extracting essential oils and their effect on human health. The authors analyze numerous scientific works that confirm the positive effect of essential oils on physical and mental health [5]. In the scientific publication “Chemical Characterization of Essential Oils and Studies on Their Biological Activities: A Critical Review”, scientists from Saudi Arabia Wissal Dhifi, Sana Bellili and Sabrina Jazi study the chemical composition of essential oils and their biological properties. They also consider different extraction methods and their effect on the composition and biological activity of essential oils, focusing on the possibilities of using these substances in medicine and pharmacy [6]. Ukrainian scientists Kalashnyk O.V., Moroz S.E., Kyrychenko O.V., Boroday A.B. investigated the quality and safety of coriander essential oil and recommend focusing further research on analyzing the



domestic essential oil market, their quality, industrial application and export potential [7].

Goal of work: to assess the quality of samples of essential oils of various origins in order to determine their compliance with pharmacopoeial requirements.

Research object: the following essential oils were used in the study: lavender, rosemary, Siberian pine, tea tree, fir, eucalyptus, peppermint, and orange, which are available to consumers in pharmacy chains and are sold without a doctor's prescription. Brand "flora secret", manufacturer LLC "PKK "DND", Ukraine, Cherkasy region, Cherkasy district, village of Balakleya.

Presentation of the main research material.

Essential oils – are complex mixtures of substances with different or similar chemical structures. Individual oils may contain from three to five to twenty or more components in varying ratios (Table 1). The presence of certain components in the oil is key to its therapeutic effect. Fragrant oils are named after the species of plants from which they are extracted (rose, geranium, jasmine flowers, etc.) or by the name of the main fragrant component of the oil (eugenol, camphor, citronella, etc.). Essential oils are natural oily liquids with a characteristic odor that are synthesized by plants and determine their unique aroma [2]. Since essential oils are a concentrated mixture of volatile organic components that evaporate easily at room temperature, they are also classified as volatile oils.

Fragrant oils are contained in different parts of plants (buds, flowers, leaves, stems, seeds, roots, wood) and depending on this, their chemical composition may differ. The chemical composition depends not only on the type of plant, but also on the geographical location (climate), season, and degree of maturation of the plant. For example, in palms, cereals, and sedges, the amount of essential oils is much smaller, while in plants of the Asteraceae, Saleraceae, Laurel, and Conifer families, on the contrary, it is much larger. Young plants contain the most essential oils. In plants, essential oils are found both in a free state and in the form of glycosides.

**Table 1 - Main components of some essential oils**

№	Oil name	Main components
1	Lavender (<i>Lavandula vera</i>)	Linalyl acetate (30-56%), linalool (10-20%), geraniol, caryophyllene, coumarins, lavandulol
2	Rosemary (<i>Rosmarinus officinalis</i>)	1,8-Cineole (15-30%), α -pinene (10-25%), camphor (10-25%), β -pinene (5-10%), borneol (10-15%), camphene (up to 8%), verbenone, limonene, caryophyllene, bornyl acetate
3	Siberian pines (<i>Pinus sibirica</i>)	α -Pinene (35-60%), β -pinene (15-25%), limonene (up to 10%), camphene (5-10%), borneol, 3-carene, terpineol, sabinene, myrcene, cedrene, and other compounds in smaller quantities
4	Tea tree (<i>Melaleuca aeterfolia</i>)	Terpinen-4-ol (29-45%), γ -terpinene (10-28%), α -terpinene (5-13%), 1,8-cineole (4.5-16.5%), <i>p</i> -cymene (0.5-12%), α -pinene
5	Yalytseva (<i>Abies sibirica</i>)	Bornyl acetate (32-45%), α -pinene (10-30%), camphor (up to 40%), (15-25%), camphene (20%), borneol(3-5%), santhene (3-4%), limonene, myrcene
6	Peppermint (<i>Mentha piperita</i>)	Menthol (35-50%), menthone (20-25%), isomenthone (2-10%), menthyl acetate (4-10%), 1,8-cineole (3-6%), limonene, β -caryophyllene, pulegone
7	Eucalyptus (<i>Eucalyptus globulus</i>)	1,8-Cineole (70-75%), pinocarveol (up to 20%), hexanal (up to 6%), piperitone (up to 40%), <i>p</i> -cymene, phellandrenes, pentanal
8	Orange (<i>Citrus sinensis</i>).	Limonene (85-95%), myrcene (about 1-2%), decylaldehyde (0.5-1%), linalool (0.5-1%), α -pinene and β -pinene (less than 1%), sabinene, geraniol, neral (in small amounts)

The composition of essential oils varies depending on the method of collection of raw materials and the extraction method. This affects the organoleptic and pharmacological properties of oils. Medicinal raw materials containing essential oil are collected at a certain phase of plant development - when the concentration of oil is highest. This period is individual for each plant and is indicated in its description [1-2].

By physical properties, essential oils are transparent, colorless or slightly yellowish liquids with a characteristic pleasant odor and a spicy, pungent, burning taste. They are almost insoluble in water, but dissolve well in alcohol, chloroform, petroleum ether, and fats. They do not leave greasy stains on paper.

Biological action and use of some essential oils.

Lavender essential oil is the most popular essential oil. This oil contains linalool



and its esters with various acids, coumarins, geraniol, etc. Lavender oil has antiseptic, antiviral, antispasmodic, and wound-healing effects. It is used as an antidote for bites of poisonous insects and snakes. It helps treat diseases of the respiratory system, gastrointestinal tract, and affects the hormonal state of a person. Lavender essential oil not only treats, but also eliminates nervous excitement, depression, improves sleep, and soothes. It is an excellent hair care product, and also promotes skin renewal.

Rosemary essential oil is one of the most valuable oils in aromatherapy. It is a vegetoregulator with a stimulating effect, improves blood rheology, helps eliminate spasms of cerebral vessels. Strengthens memory, improves venous outflow and coronary circulation. It helps fight pain in joints, muscles, and also relieves spasms of smooth muscles of the digestive tract, biliary and urinary tracts. This oil has antioxidant, antiseptic, antiviral, antifungal, antimicrobial, analgesic, expectorant and mucolytic effects. Rosemary essential oil is added to shampoo to nourish, moisturize and strengthen hair, as well as to cleanse skin pores.

Siberian pine essential oil is an effective remedy that nourishes, cleanses, rejuvenates the skin and improves its elasticity. This oil has a tonic, antiseptic, wound-healing, antimicrobial, analgesic, anti-inflammatory, expectorant, hemostatic, immunomodulatory, choleric, diuretic effect, which allows it to be widely used in the treatment of various diseases. It is widely used in the treatment of colds, bronchitis, pneumonia, tuberculosis, smoker's cough, muscle spasms, rheumatic pains. Reduces anxiety, restores strength during overwork, soothes stress. Eliminates dandruff, stimulates growth and reduces hair loss.

Tea tree essential oil is one of the safest oils, a broad-spectrum plant antibiotic. It has pronounced antiseptic, anti-inflammatory, antimicrobial, antiviral, antifungal, antiparasitic and deodorizing effects. Tea tree oil is used for wound healing due to its pain-relieving properties, helps eliminate inflammation, swelling, improves venous outflow, blood microcirculation.

Fir essential oil has antiseptic, analgesic, anti-inflammatory, expectorant, immunomodulatory, tonic, stimulating effects. It is able to activate regenerative processes for aging skin, in dermatology it is used to combat angulitis, pustular rashes,



dermatosis. This oil effectively fights viral infections, colds and respiratory diseases, stimulates blood circulation and tones muscles. It has a calming, tonic, warming effect. Therefore, it is used for frostbite or hypothermia.

Peppermint essential oil has a calming effect. It helps to cope with emotional exhaustion and anxiety. Peppermint oil has a cooling, antibacterial, antipyretic, analgesic, expectorant, anti-inflammatory and antiviral effect. In addition, it cleanses, improves digestion, relieves spasms, renews cells, relieves pain, invigorates and clarifies thoughts. Peppermint essential oil can be used as a separate cosmetic product in its pure form, or as part of cosmetic creams, tonics, lotions, toothpastes and mouthwashes for oral care. Depending on the amount of essential oil in the composition of the cosmetic product, it can act as a flavoring, antioxidant or biologically active additive.

Eucalyptus essential oil has a very strong antibacterial effect. It is an effective means for disinfecting and deodorizing indoor air. Eucalyptus oil exhibits antiviral, antibacterial, regenerating, wound-healing, anti-inflammatory, analgesic effects and provides expectorant, diaphoretic and anti-cold effects. It is able to prevent the spread of viruses, normalize secretions, cleanse mucous membranes, restore and strengthen the immune system.

Orange essential oil has antiviral, antibacterial, tonic and immunostimulating properties. Orange oil has antioxidant and sedative effects. It improves lymph and blood circulation, helps lower cholesterol and normalizes blood pressure, therefore it is used to treat cardiovascular diseases [1-2, 8-9].

Research on the quality of essential oils.

Experimental methodology.

Determination of impurities. Ethyl alcohol. 1. A few drops of the oil to be tested are placed on water poured onto a watch glass and observed against a black background; there should be no noticeable cloudiness around the oil drop.

2. 1 ml of the oil in a test tube is heated to boiling. The test tube should be covered with cotton wool with a fuchsin crystal. The alcohol vapor dissolves the fuchsin. There should be no violet-pink coloration of the cotton wool.



Fatty and mineral oils. 1 ml of essential oil is shaken in a test tube with 10 ml of 90% ethyl alcohol; no turbidity or oily drops should appear.

Color (transparency) is determined by placing 10 ml of oil in a 2-3 cm diameter clear glass cylinder and observing it in the light transmitted through the glass cylinder. Transparency is a critical parameter: the oil should be clear, free of turbidity, suspensions or sediment.

Scent is determined in the following way: 0.1 ml (2 drops) of oil is applied to a strip of filter paper about 12 cm long and 5 cm wide so that the oil does not wet the edges of the paper and the smell is determined. The smell should not change within one hour.

Taste is established by applying a strip of filter paper with a drop of oil applied to it or a grain of a mixture of 1 g of powdered sugar with 1 drop of the tested oil to the tongue and tasting it [10].

Determination of acid number.

The sample of the oil sample to be examined is mixed and filtered at a temperature of 15-20 °C. Next, 1 g of the oil sample is weighed into a conical flask, 10 ml of ethyl alcohol neutralized with potassium hydroxide is added and mixed until the free fatty acids are completely dissolved. To speed up the dissolution, the flask can be heated in a water bath, preventing the solvent from boiling. The resulting solution is titrated with 0.1 M potassium hydroxide solution with constant stirring in the presence of phenolphthalein until a faint pink color appears, stable for at least 15 s. The corresponding calculations are performed.

Discussion of research results.

The quality, effectiveness and safety of essential oils depend on many factors: the method of their production, the region of plant cultivation, the time of collection of raw materials, the conditions and duration of storage, compliance with the temperature regime in production, and of course the content of the main components. In this regard, it is especially important to conduct research on essential oils produced in Ukraine. Although essential oils are not considered medicines, their quality control is important if they are used.



The assessment of the quality of essential oils is based on the determination of organoleptic, physicochemical and chromatographic indicators, which allow to establish the authenticity, purity and stability of the product. The quality of essential oil products in Ukraine must comply with the fundamental Ukrainian standards:

✓ **DSTU 2729-94** "Essential oils and products of essential oil production. Rules for acceptance, sampling and methods of organoleptic testing" is the main standard regulating the procedure for batch acceptance, sampling and primary sensory control [11].

✓ **DSTU 2728-94** establishes a method for determining the acid number for essential oils and essential oil production products [12].

Ukraine has taken a course towards harmonizing the regulatory framework with international requirements, as evidenced by the adoption of DSTU, identical (IDT) to ISO standards. This ensures the use of internationally recognized control methods, which is necessary for the competitiveness of products. Important documents for our study were:

- DSTU ISO 279-2002 Essential oils. Determination of relative density at 20 °C. Control method (ISO 279:1998, IDT) [13].

- DSTU ISO 280-2002 Essential oils - Determination of refractive index (ISO 280:1998, IDT) [14].

For oils that have direct national standards harmonized with ISO (for example, rosemary - DSTU ISO 1342:2019 or tea tree oil - DSTU ISO 4730:2006), the established ranges of physical constants and chemical composition should be strictly adhered to.

The study of essential oils consisted in determining the absence of impurities and determining the quality using organoleptic evaluation (determination of color, odor, taste, transparency), physical and chemical constants. Samples of fragrant oils were studied according to the methods specified in the manual [10].

According to the results of the study, impurities: alcohol and vegetable oils were absent in all the samples studied. However, it was found that fir oil and tea tree oil weather poorly, unlike other essential oils studied.



The results of the conducted study of the appearance, uniformity of essential oils, smell and taste are presented in Table 2. According to organoleptic control, the color of the oils corresponded to the typical characteristics of oils, the studied oil samples were transparent, without turbidity. This may indicate the absence of moisture and non-volatile fatty oils. The smell of the oils was characteristic of the corresponding oil sample, for example, Siberian pine essential oil had a fresh, resinous, bitter aroma. The results of the conducted study indicate that according to organoleptic indicators, the essential oils of the “flora secret” brand meet the requirements of the standards. Organoleptic assessment has its limitations. It can easily detect dilution with non-aromatic oils, but it is completely blind to falsification using synthetic isolates, since synthetic fragrant components reproduce the corresponding smell.

Table 2 - Results of the study of organoleptic indicators of oil samples

Sample	Oil Name	Color (transparency)	Smell	Taste
1	Lavender	Pale yellow, transparent	Fresh, characteristic lavender smell, pleasant	Bitter, spicy, sour
2	Rosemary	Colorless, transparent	Camphorous, fresh	Very bitter, sour, spicy
3	Siberian Pine	Colorless, transparent	Fresh, resinous, slightly bitter	Not bitter, quite pleasant pine taste
4	Tea Tree	Colorless, transparent	Spicy with a hint of camphor	Bitter and sour
5	Fir	Colorless, transparent	Pleasant, fresh, woody-resinous	Bitter, pronounced fir taste, similar to needles
6	Peppermint	Pale yellow, transparent	Spicy, minty, refreshing	Bitter menthol taste, pleasant
7	Eucalyptus	transparent	Tart-bitter,	Bitter, spicy,
8	Orange	Pale yellow, transparent	Spicy	Bitter, spicy, sweetish burning

Determination of physical constants is a mandatory quantitative control step that allows you to check the basic compliance of the oil with the established regulatory ranges.

Physical constants include density, angle of optical rotation, refractive index, and solubility in alcohol. Among the chemical constants, the main ones are acid number,



ester number, and ester number after acetylation.

Refractive index and density are parameters of primary quality control of essential oils. Deviation of refractive index may indicate adulteration or degradation of components of the fragrant oil. Density helps to identify the oil, confirm its compliance with the standards of a particular botanical species and verify its purity. Both indicators are used in pharmacy, cosmetology and food industry to ensure the accuracy and safety of essential oils. The refractive index of fragrant oils was determined by the refractometric method [14], the density – by the pycnometric method [13]. The results of the determination of physical constants are given in Table 3.

Table 3 - Physical constants of the tested oil samples

Sample	Oil Name	Pharmacopoeial limits of refractive index	Refractive index n_D^{20}	Pharmacopoeial density limits g/ml	Density g/ml
1	Lavender	1,460-1,470	1,461	0,877-0,896	0,894
2	Rosemary	1,471-1,474	1,467	0,917-0,922	0,917
3	Siberian Pine	1,468-1,473	1,470	0,895-0,912	0,869
4	Tea Tree	1,475-1,482	1,474	0,885-0,900	0,875
5	Fir	1,468-1,473	1,466	0,895-0,912	0,929
6	Peppermint	1,459-1,470	1,461	0,900-0,910	0,899
7	Eucalyptus	1,458-1,470	1,464	0,910-0,930	0,887
8	Orange	1,473-1,475	1,474	0,842-0,848	0,847

It was found that the refractive index and density values of tea tree and fir oil do not meet the requirements of the standards.

Among the chemical parameters, the acid number in essential oils was determined (Table 4) [12]. Acid number is the number of milligrams of potassium hydroxide required to neutralize the free fatty acids contained in 1 g of essential oil. The acid number thresholds for aromatic oils should be low (usually no more than 1.0-5.0 mg KOH/g), as this is an indicator of their freshness and quality. A high acid number



exceeding the regulatory maximum is a clear indicator of oil degradation. This most often occurs due to ester hydrolysis or oxidation caused by improper storage (exposure to light, heat or moisture). An increased acid number can affect the properties and pharmacological activity of essential oils. The determination of the acid number is a critical indicator of shelf life and good manufacturing practice (GSP).

Table 4 - Acid value of the tested oil samples

Sample	Oil Name	Acid value, mg KOH/g
1	Lavender	0,34
2	Rosemary	0,56
3	Siberian Pine	0,50
4	Tea Tree	2,75
5	Fir	1,40
6	Peppermint	2,20
7	Eucalyptus	1,92
8	Orange	7,15

It was found that in terms of acid number, essential oils mainly meet the requirements of DSTU, with the exception of orange essential oil.

Conclusion

Primary (physical-organoleptic) and intermediate (chemical) quality control of samples of aromatic oils was carried out. It was established that essential oils of lavender, rosemary, Siberian pine, eucalyptus and peppermint of the brand "flora secret" meet the requirements of analytical and control documentation for organoleptic and physico-chemical indicators (refractive index, density, acid number). To ensure absolute authenticity, purity and therapeutic quality of essential oils, it is necessary to conduct a control (instrumental) analysis.

Gratitude

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