ABSTRACT

Today in the world recognized the need for environmentally friendly products for a healthy food and quality life. Products with natural ingredients, including flavoring become very popular. Coriander is one of herbs that functions as both, spice as well as herbal medicine. Coriandrum sativum L. is a major aromatic crop in Ukraine. The plants of Coriandrum sativum contain the essential oils and other compounds in the seeds and leaves and have an important role as flavorings. The main objective was to investigate possibility effective utilization of coriander essential oil in national economy of Ukraine. It was necessary to study the chemical compounds of coriander fruits by instrumental analysis and odor by sensory analysis with following creating new aroma compositions. Search had been carried out throughout 2009 – 2014 years. The aerial parts of aromatic plants were harvested at the plots of National Botanical Garden of National Academy of the Sciences of Ukraine. Essential oil was obtained by hydro distillation procedure in National University of food technology. Main and specific components of essential oils from seeds coriander were characterized. Qualitative structure of essential oils was determined by the gas-liquid chromatography method on the chromatograph Agilent Technologies 6890 with mass-spectrometric detector 5973. The run of components was done using Device of Fractional Distillation. Linalool, limonene, geranyl acetate, d-camphor, myrcene and geraniol were found as the major components. In the composition of essential oils each component has its own flavor, the combination of which determines the flavor of the oil. We investigated the possibility of target separation of essential oils of coriander fruits into fractions of different flavor. The article presents the results of research sequential processing fruits Coriandrum sativum to obtain a series of natural flavors. Principles and laws of the vacuum distillation were used for directional control of the process distillation of complex mixtures of hydrocarbons on the distillation column. Mode of selection process the fractionation of essential oils allowed changing the component composition of the fractions and to provide more variety of flavors. Monitoring of the fractioning process allows concentrating the key aromatic components and receiving highly concentrated flavors of original pure notes. Combinations of the individual fractions with a specific weight have been created. We obtained some fractions which can be used as flavorings in food industries. Highly concentrated flavor "Coriander fragrance" was developed with fraction № 3 of essential oil coriander. "Coriander fragrance" can be used instead of the aromatic spirits of coriander seeds in liquors and spirits production for producing bitters, liquors and other drinks, e.g. vodkas "Gorilka", "Chernihivska", "Starokyivska". The flavors "Coriander fragrance" was used in processing for "Lollipop" candies, vodka special "Captain", dessert drink "Married couple".

Keywords: Coriandrum sativum; distillation; essential oil; fraction; flavor
Research of Peter (2004) supports that some of these foods, as part of an overall healthful diet, have the potential to delay the onset of many age-related diseases, so there is urgent need to explore the role of these compounds. Coriander leaves are used as garnish like parsley with a fresh fragrance that is vital in soups, and meat dishes because these are rich in vitamin A, B2 (riboflavin), C and dietary fiber. Salads are incredibly beneficial for weight conscious persons due to their lofty vitamins and fiber contents. The dried seeds contribute to pleasantly aromatic spice that is much used in stews, cuisine, sweet breads, sausages and cakes.

There is experience of using of seeds and essential oil Coriandrum sativum in different areas of industry (Khan and Abourashed, 2011) and medicine (Garnik et al., 2003). An essential oil from leaves and fruits C. sativum L. showed biological, antifungal and antimicrobial activity (Soares et al., 2012; Deaquis et al., 2002; Mandal and Mandal, 2015; Petrová et al., 2015), anti-hyperglycemic and diuretic activity (Bhat, 2014).

We took into consideration the experience of medicine, perfume and cosmetic industry regarding fractional distillation of complex organoleptic blends, including those of natural origins (Patent no. 20100197801, 2013).

Such actions are directed to purposefully single out one or several components as a source of flavor, or derivative valuable biologically active components of medicaments, or prophylactic remedies (Krichkovskaya et al., 2008; Roshina, 2010; Brindza et al., 2013). In food productions, this technological method has not been used before.

Fruit and vegetable processing industry is very important for Ukraine regarding both the internal and the external market. The main objective was to investigate possibility effective utilisation of coriander essential oil in national economy of Ukraine. It was necessary to study the chemical compounds of coriander fruits by instrumental analysis and odor by sensory analysis with following creating new aroma compositions.

MATERIAL AND METHODOLOGY

In the researches, there was used tree samples of the aromatic raw material collected in Kyiv region in 2008 – 2012 on the plots of National Botanical Garden named after N. N. Gryshko. The samples of Coriandrum sativum were examined according to the branch standards methods (DSTU 4654: 2006) upon the organoleptic and physical-chemical indications.

Essential oil from freshly ground coriander was allocated by distillation method (Bondarenko, 2010).

The ground materials (200 g) were placed in a 1000 mL round bottom flask containing 250 mL distilled water to which two drops of antifoam were added.

The device also consisted a fridge, an essential oil catcher, and a bain-marie with saturated solution of calcium chloride. The contents were subjected to distillation for 2 h. The collected essential oil was dried over anhydrous Na2SO4.

Qualitative structure of essential oils was determined by the gas-liquid chromatography method on the chromatograph Agilent Technologies 6890 with mass-spectrometric detector 5973. The chromatographic column is capillary INNOWAX with an internal diameter of 0.25 mm and length of 30 m. The gas-carrier’s speed (helium) is 1.2 mL.min⁻¹. Temperature of the thermostat was linearly programmed from 50 to 250 °C with speed 4 °C.min⁻¹. For identification of components there was used a library of mass-specters NIST 05 and WILEY 2007 with a general quantity of specters more than 470000 combined with the programs for identification AMDIS and NIST (NIST/EPA/NIH 1994). The identification of the components under study was made at the mass-specters and component’s retention times.

Fractioning of essential oil Coriandrum sativum was performed on a pilot universal automatic facility – DFD (Device of Fractional Distillation). This chromatographic method of investigation was developed in the research laboratory of the National University of Food Technologies (Frolova et al., 2004). Short technical description; column type – three-section; number of real plates, pcs – 20; number of side-hars, pcs – 3; diameter of refractive part, mm – 30; head type – full condensation; regulation of the reflux ratio and temperature in a cube - from the control unit; control of temperature – automatic. Facility elements are made of inert material – heat-resistant glass produced by Simex.

RESULTS AND DISCUSSION

In the laboratory conditions, using water distillation on granulated fruitage of Coriandrum sativum there were received samples of essential oil. The research results of the quality indicators of essential oil Coriandrum sativum were compared with the basic norms (Table 1).

Obviously, the quality indicators of essential oil of Coriandrum sativum not exceed base values. Number of substandard and cracked fruit and mericarps was less permissible on the 24% and 22%. The dynamics of process distillation of essential oil was studied using the method of fractional distilled.

There was conducted fixing of the essential oil and by-products outflow during certain periods of time. Further, the outflow of essential oil on every distillation stage was calculated compared to its total output in each experiment (Table 2). After completion of the distillation 13.49% of the essential oil left in distilled water and 0.73% was irretrievably lost. Quality indicators of the received samples were checked for conformity with normative documents of Ukraine and are presented in Table 3.

The investigated qualitative composition and the mass

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**Table 1** Quality indicators of Coriandrum sativum fruits (%).

<table>
<thead>
<tr>
<th>Quality indicator</th>
<th>Norms of quality indicators</th>
<th>Investigation results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humidity</td>
<td>13.0</td>
<td>10.8 ±0.05</td>
</tr>
<tr>
<td>Waste</td>
<td>2.0</td>
<td>1.5 ±0.01</td>
</tr>
<tr>
<td>Substandard fruits and mericarps</td>
<td>10.0</td>
<td>7.6 ±0.05</td>
</tr>
<tr>
<td>Cracked mericarps</td>
<td>15.0</td>
<td>11.7 ±0.05</td>
</tr>
<tr>
<td>Admixtures of other aromatic plants</td>
<td>Is not acceptable</td>
<td>Not detected</td>
</tr>
</tbody>
</table>
ratio of the components of the samples of essential oil *Coriandrum sativum* are shown in Table 4.

Modes of fractional distillation were based upon theoretical calculations, according to which the essential oil was considered as a sum of binary mixtures ([Ukrainec’ and Frolova, 2009](#)). Model calculations were adequately coordinated with the results of real distillations. The optimized operating modes of distillation of essential oil *Coriandrum sativum* are listed in Table 5.

On the results of distillations 4 fractions and a distillation residue were received. Alternately, as the accumulation process is going on, all fractions are collected in sealed glass capacities. In Table 6 the material balance of the essential oil distillation in DFD (Device of Fractional Distillation) is shown (calculated as 3.5 kg per 1 charge).

Changing the content of essential oil components in the different fractions has a significant effect on the sensory characteristics of odor, because each component has its original flavor and odor. The major descriptors of *Coriandrum sativum* odor were pleasant, herbal, green, cooling, earthy, rose-like, sweet and floral aroma with turpentine note.

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**Table 2** Material balance of receiving the *Coriandrum sativum* essential oil in the laboratory experiment.

<table>
<thead>
<tr>
<th>Name of the raw material</th>
<th>Mass (g)</th>
<th>Essential oil Content (%)</th>
<th>Mass in the raw material (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ripe fruits of <em>Coriandrum sativum</em></td>
<td>200</td>
<td>0.52</td>
<td>1.04</td>
</tr>
</tbody>
</table>

**Table 3** Physical-chemical index of quality of essential oil *Coriandrum sativum*.

<table>
<thead>
<tr>
<th>External appearance</th>
<th>Thickness at 20 °C (g.cm⁻³)</th>
<th>Deflection indicator at 20 °C</th>
<th>Acid index (mg KOH) not more</th>
<th>Scent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow easily moveable liquid</td>
<td>0.870</td>
<td>1.460</td>
<td>1.35</td>
<td>Savory, fragrant with a floral tone</td>
</tr>
</tbody>
</table>

**Table 4** Composition of essential oil *Coriandrum sativum*.

<table>
<thead>
<tr>
<th>Reference compound</th>
<th>Contents in essential oil (%)</th>
<th>Reference compound</th>
<th>Contents in essential oil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>β- pinene</td>
<td>7.04 ±0.05</td>
<td>Linalool</td>
<td>67.30 ±005</td>
</tr>
<tr>
<td>camphene</td>
<td>1.30 ±0.02</td>
<td>D- camphor</td>
<td>2.90 ±0.02</td>
</tr>
<tr>
<td>myrcene</td>
<td>2.49 ±0.03</td>
<td>Linalacetate</td>
<td>0.22 ±0.01</td>
</tr>
<tr>
<td>limonene</td>
<td>3.13 ±0.05</td>
<td>L-borneol</td>
<td>0.13 ±0.01</td>
</tr>
<tr>
<td>1,8-cineole</td>
<td>10.56 ±0.05</td>
<td>δ-terpineol</td>
<td>0.32 ±0.02</td>
</tr>
<tr>
<td>β-phellandrene</td>
<td>0.25 ±0.01</td>
<td>Geranilacetate</td>
<td>1.42 ±0.05</td>
</tr>
<tr>
<td>n-cymene</td>
<td>0.17 ±0.05</td>
<td>Geranilacetate</td>
<td>2.90 ±0.05</td>
</tr>
</tbody>
</table>

**Table 5** Modes of fractionation of essential oil *Coriandrum sativum*.

<table>
<thead>
<tr>
<th>No of fraction</th>
<th>Temperature (°C)</th>
<th>Reflux ratio</th>
<th>Pressure (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In the cube</td>
<td>In the column</td>
<td>Distillation waters</td>
</tr>
<tr>
<td>First</td>
<td>85…91</td>
<td>57…59</td>
<td>29…32</td>
</tr>
<tr>
<td>Second</td>
<td>90…94</td>
<td>57…66</td>
<td>33…49</td>
</tr>
<tr>
<td>Third</td>
<td>94…97</td>
<td>66…79</td>
<td>54…58</td>
</tr>
<tr>
<td>Fourth</td>
<td>97–114</td>
<td>79–94</td>
<td>60–76</td>
</tr>
<tr>
<td>Distillation residue</td>
<td>122</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The given data show that the outflow of the fractions constitutes 97.6% from the initial raw material. Losses are estimated at 2.4% (incomplete capture of essential low-boiling components, losses occurring during column flooding). From each fraction, after thorough mixing, the average sample of the product was selected. A qualitative composition was defined in it by means of gas chromatography, and aromatic properties – by generally accepted and standardized methods (State standard 2729-94) (Table 7).

Descriptors and reference compounds were used for sensory profiling of essential oil.
Every received fraction of Coriandrum essential oil is an independent highly concentrated natural flavor agent with stable physicochemical characteristics. It should be noted that changing the process modes leads to changes in the fraction structure.

Besides that, fractioning allows to exclude from fraction constitution those components that worsen organoleptic, physical, chemical and functional properties of a flavor including solubility in liquid mediums, and the expiration date. It is harder to single out such components using other methods (Sarker et al., 2005).

It is advised to use fraction 3 of essential oil Coriandrum sativum for "Lollipop" candies with original savory scent. Besides a nice taste and scent, lollipops are advised to be used for prophylaxis of bronchial diseases. The formulation of aromatic component of "Lollipop" candies consists of 10% alcohol solvent: 3 fractions of coriander essential oil – 59%; 3 fractions of fennel essential oil – 29%; 4 fractions of cat mint essential oil – 6%; 2 fractions of clary sage essential oil – 6%.

During the development of flavor for non-alcoholic drinks of immunostimulatory action with a harmonious flavor of lemon floral tone, 10% alcohol solution components were used: 4 fractions of coriander essential oil – 62%; 3 fractions of fennel essential oil – 31%; 5 fractions of cat mint essential oil – 6%.

Apart from receiving flavored products that have formulations which involve fractions of various essential oils, model combining of fractions of essential oil Coriandrum sativum was used, and as a result there was developed a formulation of a highly concentrated flavor – "Coriander fragrance".

The scheme of receiving the flavoring is shown in Figure 1. To receive flavor "Coriander fragrance" fractions of essential oil Coriandrum sativum were mixed in the following quantities, g: the first fraction – 0.81 g, the second one – 1.7 g, the third fraction – 4.37 g, the fourth fraction – 36.61 g, the fifth fraction – 1.70 g, which corresponds to the mass ratio 1:2:3:4=1.0:21:54:44:2.1.

The flavor "Coriander fragrance" is a slightly yellow liquid with a specific pure scent of coriander. Floral, rose-like, pleasant, green, herbal, cooling, earthy, spicy, sweet and were the major descriptors of coriander aroma.

The developed flavor can be advised for usage in the production of vodka, brandy, whisky, rum, and other strong alcoholic as well as low alcoholic and non-alcoholic drinks. "Coriander fragrance" can be used instead of the aromatic spirits of coriander seeds in liquors and spirits production for producing bitters, liquors, and other drinks, e.g. "Gorilka", "Chernihivska", "Starokyivska".

Together with a team of authors there was developed a formulation of special vodka "Captain" (Patent Ukrainy. Gorilka osoblyva «Kapitan, 2011) which by its aromatic palette has a harmonious combination of a honey citrus scent with the fragrance of field flowers.

In table 8 the quality characteristics of vodka "Captain" are shown.

In the formulation, a composition of flavors "Coriander fragrance" and "Fennel - elite fragrance" are used (1.6 : 0.9).

Adding of orange and star-anise essential oils creates a taste impression of an exotic citrus (1.63 : 0.10). Orange oil can be substituted with aromatic spirit, and star-anise essential oil - with the anise one. The expiration date of the drink is 6 months.

Figure 2 shows the sensory profilogram of flavor vodka special "Captain".

Dessert drink "Married couple" is made by mixing rectified ethyl spirit of the highest cleaning, drinking water, citric acid, sugar in the form of 65,8% sugar syrup, apple fortified juice, flavors, lemon essential oil (State Intellectual Property Service of Ukraine Patent of Ukraine. Napii desertni «Podruzhkhya»).

**CONCLUSION**

Coriandrum sativum fruits are the main industrial essential-oil raw material in Ukraine. Its consecutive processing by means of physical procedures into the essential oil, aromatic fractions extenda natural flavors assortment of a savory floral note. Monitoring of the fractioning process allows concentrating the key aromatic components and receiving highly concentrated flavors of original pure notes. Results of the study indicate the possibility to combine the components of the fractions for use in the product to provide the desired flavor notes. The flavors not only give products a special scent, but also are

![Figure 2 Sensory profilogram of flavor vodka special "Captain".](image-url)
characterized by the orientation of the physiological action; saturation, and improved stability. Application flavour enables to expand assortment of developed products to improve them tasting properties.

REFERENCES


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