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Nitrogen containing Volatile Organic Compounds

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Abstract

This review presents a general analysis of the scienthr information about nitrogen containing volatile organic compounds (N-VOC's) in plants. N-VOC's in plants are: nitriles, nitro compounds, anthranilates, indole and pyrazine derivatives. The range of the substance types mentioned above is reviewed in the study: nitriles - 2-methylbutanenitrile, 3-methylbutanenitrile, allylcyanide, benzonitrile; nitro compounds - 1-nitro-2- methylbutane, 1-nitro-3-methylbutane; anthranilates - ethyl anthranilate, methyl-N-methylanthranylate, damascenin; indole derivatives - indole , skatole; pyrazine derivatives - 2-sec-butyl-3-methoxypyrazine ("Galbanum pyrazine"), 3,5-dimethyl-2-ethylpyrazine.

Also, the biosynthesis of some of these substances in living organism has been studied and their toxicity reviewed. Conclusions have been drawn on biological activities of these compounds in the plant and in animal life. The chemical mimicry of these compounds in communication with different types of living organism has been analyzed. The use of these compounds by men is shown in this research. The intelligence about plants producing the substances given above is mentioned in this study. Attributes and composition of the essential oils containing these compounds are shown. The perspective the possibility of their further using is analyzed.

Zusammenfassung

Diese Studie beinhaltet eine Zusammenfassung da wissenschaftlichen Literatur den letzten Jahren über nitrogenhaltige, flüchtige organische Verbindungen als Inhaltsstoffe in Pflanzen. Auch wird eine Einteilung der Verbindungen in Nitrile, Nitrobestandteile, Antranilate, Indol- und Pyrazin-derivate gegeben. Die im folgenden genannten Substanzarten werden in dieser Studie dargestellt: Nitrile - 2-Methylbutannitril, 3-Methylbutannitril, Allylcyanid, Benzonitril; Nitrobestandteile – 1-Nitro-2methylbutan, 1-Nitro-3methylbutan; Anthranilate – Ethyl-anthranilat, Methyl-N-Methylanathranilat, Damascenin; Indolderivate - Indol, Skatol; Pyrazinderivate - 2-sec-Butyl-3-methoxypyrazin (“Galbanum Pyrazin”), 3,5- Dimethyl-2-ethylpyrazin.

Ebenso wird die Biosynthese einiger dieser Substanzen und deren Toxitzität in lebenden Organismen beleuchtet. Es werden Schlussfolgerungen über die biologischen Effekte dieser Bestandteile in tierischen und pflanzlichem Leben gezogen. Die chemische Mimikry dieser Bestandteile in Wechselwirkung mit verschiedenen lebenden Organismen wurde ebenfalls analysiert. Die Studie zeigt ebenfalls die Nutzung dieser Teile durch den Menschen. Die Studie unterstreicht ebenfalls die Genialität der Pflanzen in der Produktion dieser Substanzen. Die Attribute und die Zusammensetzung der ätherischen Öle, welche diese Bestandteile enthalten, wurden auch dargestellt. Perspektiven zukünftiger Nutzung der genannten Substanzen wurden ebenfalls analysiert.

Абстракт

В данном исследовании проведен анализ, обобщение, систематезация научной информации за последние 20 лет об азотсодержащих летучих органических веществах, содержащихся в растениях. Приведена классификация азотсодержащих летучих органических веществах, содержащихся в растениях: нитрилы, нитросоединения, антранилаты, производные индола и пиразина. Рассмотрены ряд веществ вышеназванных классов. Нитрилы - 2-Methylbutanenitrile, 3- Methylbutanenitrile, Allylcyanide, Benzonitrile. Нитросоединения - 1-Nitro-2-methylbutane , 1-Nitro-3-methylbutane. Антранилаты - Ethyl anthranilate, Methyl-N-Methylanthranylate, Damascenin. Производные индола - Indole , Skatole. Производные пиразина - 2-sec-Butyl-3-methoxypyrazine (Galbanum pyrazine), 3,5-Dimethyl-2-ethylpyrazine.

Рассмотрен биосинтез некоторых из этих веществ в живых организмах. Проанализирована их токсичность. Сделаны выводы о биологической роли этих соединений в жизни растений, насекомых и животных. Проанализировано значение химической мимикрии при участии этих веществ в коммуникации между различными видами живых организмов. Показано применение этих соединений людьми. Приведены сведения о растениях, производящих вышеназванные вещества. Указаны свойства и состав эфирных масел, содержащих вышеназванные соединения. Проанализированы перспективы дальнейшего использования вышеназванных веществ.

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1. INTRODUCTION

Volatile compounds of the plants – mainly constitents of essential oils, are used for intraspecific and interspecific relationships between plants and insects in order to control behavioral reactions (signals of panic, aggression, and collective efforts).

The scientific literature of the last years was studied about nitrogen containing volatile organic compounds, however there were no reviews found with general information about these compounds.

Systematization of ones knowledge about nitrogen containing volatile organic compounds may be important for choosing raw materials for creation of perfumery.

Essential oils which contain these substances possess biological activity. A study of this information concerning these compounds does possibly enable the finding of new derivatives with higher biological activity. Also the study about biogenesis of them in plants can help to understand their production by plants.

Some of these nitrogen containing organic compounds probably can be used as insecticides, repellents, fungicides, herbicides and antimicrobial preparations.

This report is devoted to the systematization and generalization of information about nitrogen-containing volatile organic compounds emitted by plants. This report contains a classification of nitrogen-containing volatile organic compounds emitted by plants, and a description of the plants which produce them, their functions in the life of plants, their biogenesis in plant cells, application of these plants and those essential oils, which contain these substances, further a discussion of their properties and influence on the organism of animals and humans.

2. NITRILES

2-methylbutanenitrile (2-methylbutyronitrile) **(I)**

Molecular Formula: C_5H_9N

3-methylbutanenitrile (Isovaleronitrile) **(II)**

Molecular Formula: C_5H_9N

Allylcyanide (3-butenenitrile) **(III)**

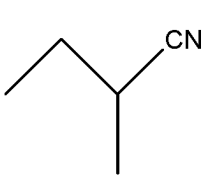
Molecular Formula: C_4H_5N

Odor: onion-like [3].

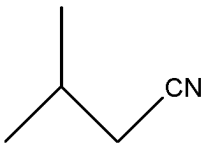
Benzonitrile (Phenyl cyanide) **(IV)**

Molecular Formula: C_7H_5N

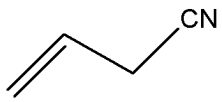
Odor: Odor of volatile oil of almond [4].



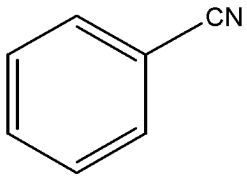
I



II



III



IV

Nitriles can be found in some fruit pits, such as almonds or some others. Nitriles are released by these fruit pits through hydrolysis. A cyanohydrine that is produced by ingesting almonds or some fruit pits is called mandelonitrile and is known for its property to release hydrogen cyanide. It is also accountable for the toxic properties of cyanogenic glycosides [5].

In order to survive in complex biotic environment, plants produce a range of secondary metabolites, which function as repellents, toxins and deterrents that provide protection to the plants against antibiotics that

defend the plants from pathogen attacks, herbivores, signals that influence neighbor plants, and volatiles that serve as "intermediary" between tritrophic interactions[6].

When the enzyme myrosinase that is contained in plants comes into contact with water, it cleaves off the glucose group from a glucosinolate, also called mustard oil glycoside. The molecule that remains becomes an isothiocyanate, a nitrile, or a thiocyanate. These three substances are active and defend the plant. The isothiocyanate (mustard oil) is the usual standard product of the reaction; a nitrile, or a thiocyanate occur normally in the presence of certain specialized plant proteins which lead to a different result of the reaction [7].

Myrosinase and glucosinolates remain collected in separate compartments of the cell in order to avoid damage to the plant itself. They mainly come together in case of physical injury.

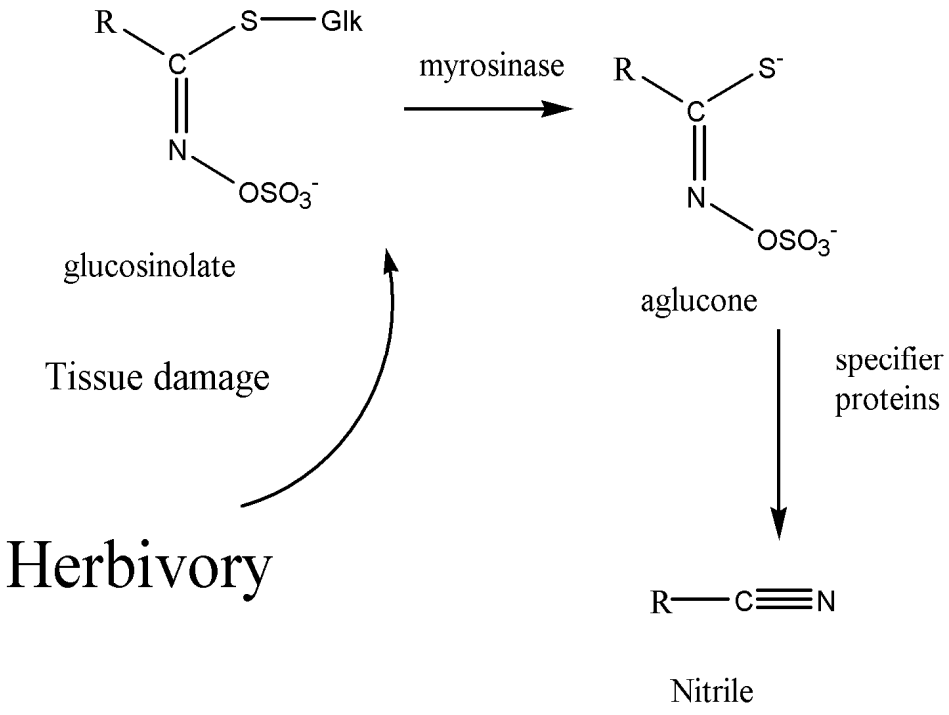


Fig. 1. Glucosinolate hydrolysis [8].

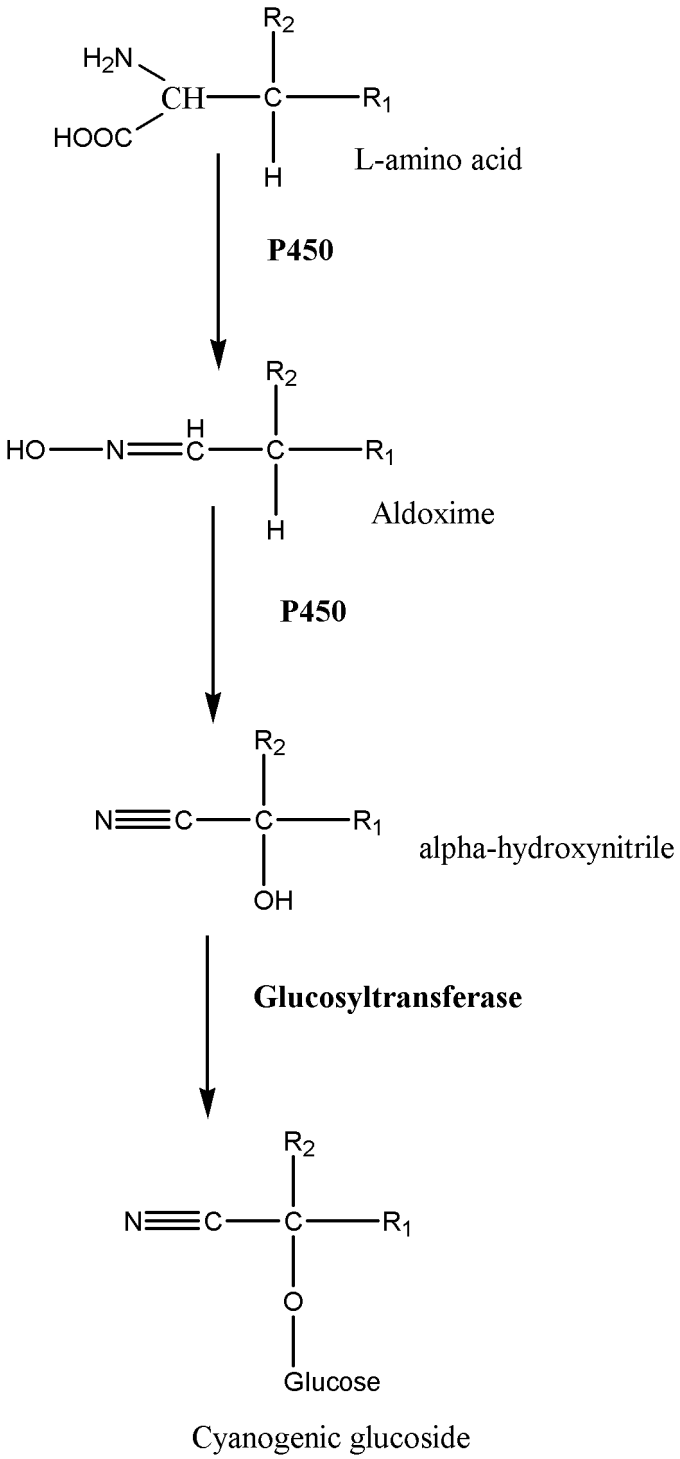


Fig. 2. Biosynthesis of cyanoglycosides in plants, insects and higher animals. Enzymes involved are shown in bold [9].

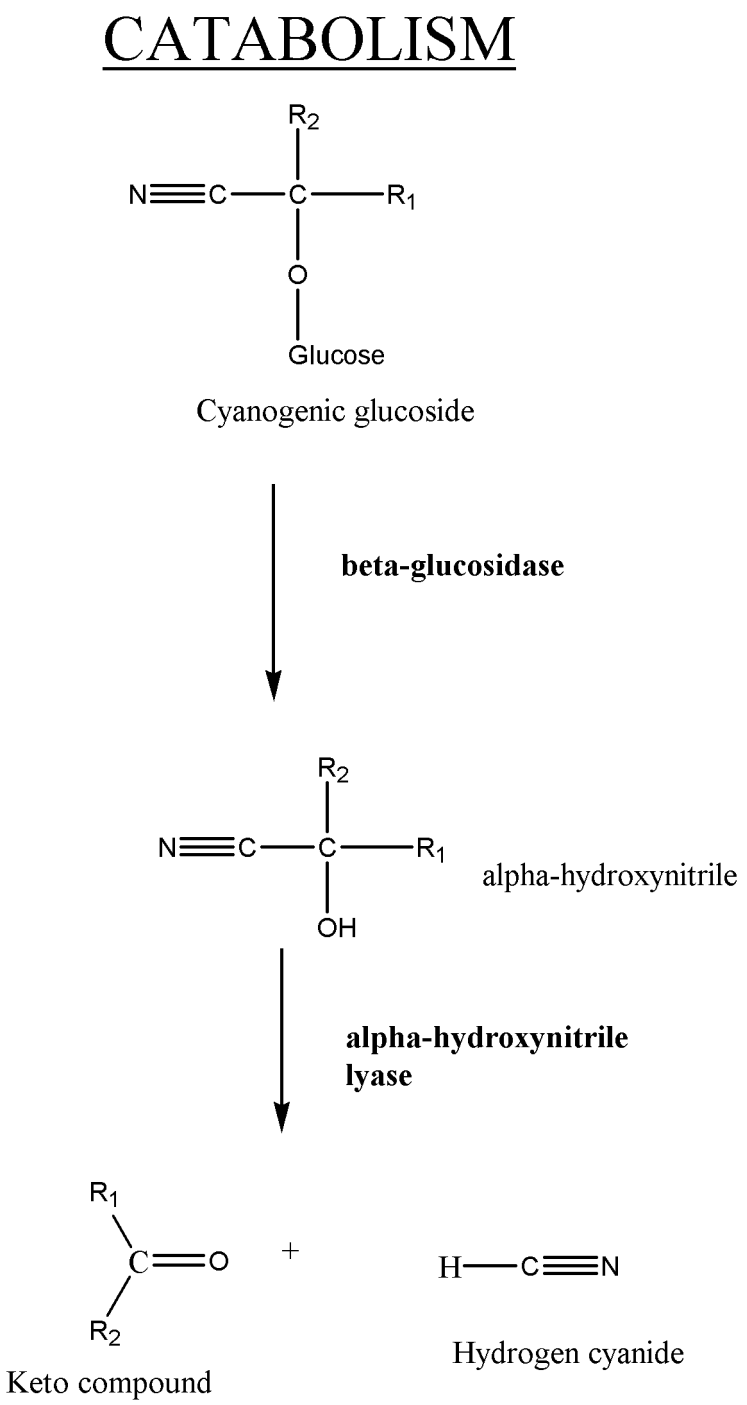
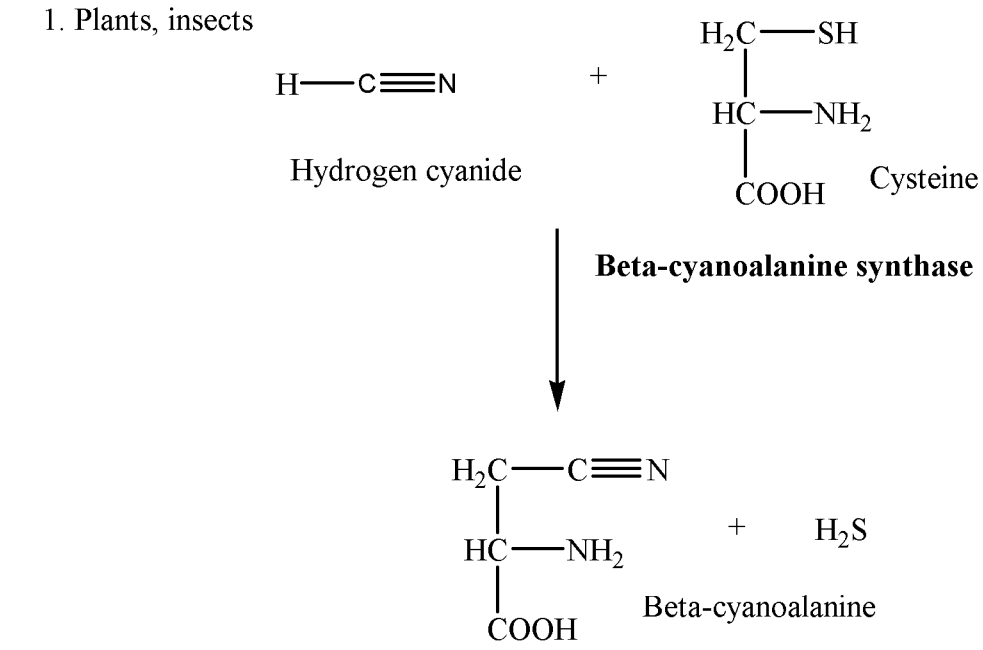


Fig. 3. Catabolism of cyanoglycosides in plants, insects and higher animals. Enzymes involved are shown in bold [9].

DETOXIFICATION



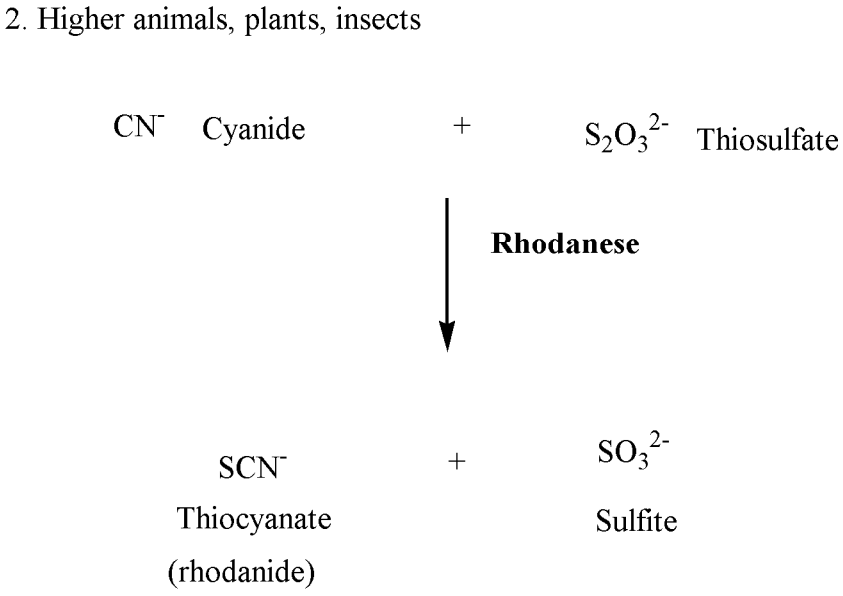


Fig. 4. Detoxification of cyanoglycosides in plants, insects and higher animals. Enzymes involved are shown in bold [9].

Cyanogenic plants constitute the nutrition of some herbivores, especially insects, who preferentially consume these plants. This kind of herbivores is able to metabolize cyanogenic glucosides. Some can set them apart and use in the defense against predators. Cyanogenic glucosides can be synthesized by some species of arthropoda (within Millipeda, Centipeda, Insecta). Besides that, it is also sequested from the host plant (Zygaenidae) by some of these species [9].

Usage:

2-methylbutanenitrile – is an intermediate for the production of 2-methyl propionic acid [10] and is used as component of polymerisation promoter for production of high-molecular-weight polyacrylamide [11].

Allylcyanide – is used as a cross-linking agent in polymerization [12].

Benzonitrile – is added to perfumes at a maximum level of 0.2% in the final product [12].

It is an intermediate for rubber chemicals; a solvent for nitrile rubber, for special lacquers, and many resins and polymers, and for many anhydrous metallic salts; and for manufacturing of benzoguanamine, and also an additive in nickel-platting baths; for separating naphthalene and alkylphthalenes from non-aromatics by azeotropic distillation; as a jet-fuel additive; in cotton bleaching baths; as a drying additive for acrylic fibers; in the removal of titanium tetrachloride and vanadium oxytrichloride from silicon tetrachloride [12].

Some beetles (*Anthophagus angusticollis* Mannerheim, *Megarthrus denticollis* Beck, *Megarthrus sinuatocollis* Lac.) use benzonitrile as allomone (defense substance).

Benzonotrile is a poison by ingestion and subcutaneous routes, and moderately toxic by inhalation and skin contact. It is also dangerous, emitting highly toxic fumes of NO_X and CN^- when heated to decomposition or on contact with acids or acid fumes [13].

Some essential oils contain nitriles:

Honeysuckle:

The honeysuckle flowers, which during the daytime have almost no odor, produce fragrance in the evening. When they are highly fragrant they are pollinated by sphinx moths (Sphingidae), which drink nectar hovering in front of the flowers. The honeysuckle has got a beautiful fragrance – a fusion of lily aroma with a vanilla touch. Flowers which have been cut and are kept in a vase uphold their daily rhythm. The undertaking of a fragrance analysis of honeysuckle using the Headspace-GC-MS method rather conceals than discloses its special aroma. Nervertheless, a number of unusual odorants have been detected. For instance, secondary metabolites of the phenylalanine, amino acids valine, leucine and isoleucine, that is nitro-compounds, oximes and nitriles have been identified. They are not the main constitutive elements of the basic notes of the particular honeysuckle fragrance, but they are responsible for its special character to a certain degree [14].

Honeysuckle Absolute (Authentic). Honeysuckle species. Family: Caprifoliaceae. Production method: Solvent extraction. Parts of plant - Flowers. It has a deep, sweet floral aroma. It is specialty oil from a natural perfumer. It should not be applied as a perfume straight from the bottle [15].

Honeysuckle (Natural Blend). Trumpet Honeysuckle **(***Lonicera sempervirens* L). Family: Caprifoliaceae. Production method: Steam distilled and solvent extraction. Parts of plant - Flowers. It is characterized by an intensive jasmine-like, honey-sweet fragrance with a light scent of green. After a while it becomes softer and gives out a delightful sensual scent. Be aware of the fact, that this is a mixture of absolutes and essential oils that was created to imitate the aroma of honeysuckle [15].

European Honeysuckle Maceration. Woodbine (*Lonicera*

periclymenum L). Family: Caprifoliaceae. Production Method: Cold process maceration. Parts of plant - Flowers [15].

Japanese Honeysuckle Maceration. Japanese Honeysuckle (*Lonicera japonica* L). Family: Caprifoliaceae. Production Method: Cold process maceration. Parts of plant: Flowers [15].

European Honeysuckle Enfleurage Pomade. Woodbine (*Lonicera periclymenum* L). Family: Caprifoliaceae. Production Method: Cold process enfleurage. Parts of plant - Flowers [15].

Honeysuckle oil is used in aromatherapy and for production of scent candles. Having a sweet-smelling and comforting scent, honeysuckle oil is added to perfume body, massage and bath oils, soaps and other products of skin care. It is also a component of a number of cleansing and detoxifying mixes, because of its property to clear toxins from the liver and blood. Also, honeysuckle oil has antibacterial and anti-inflammatory effect and is applied to reduce heat, clear toxins. Additionally, this oil it is leveraged for treatment of pyrexia (fever), sore throat, to achieve a blemish- and rush-free skin. Health care products which have honeysuckle oil as an ingredient make the hair soft and are helpful when the hair is dry or brittle [16].

Meadowsweet oil. Meadowsweet (*Filipendula ulmaria* L). Family: Rosaceae. Parts of plant – whole plant. Uses: meadowsweet oil is used for joints and muscles treatment. Under the conditions of self-treatment it should be applied two times daily in order to achieve an sensible effect. Massage therapists agree on the beneficial effect of the meadowsweet oil, especially for sports and remedial massage. For a complete body treatment, a few drops of meadowsweet oil can be added when taking a hot bath [17].

Mustard seed oil. Black mustard (*Brassica nigra* L). Family: Brassicaceae. Parts of plant – seeds. One of the mustard seed oil's main and most important component is Vitamin E which is a known nutrient that, when used, helps to maintain a good quality of skin and hair. In several

hormonal processes in the human body it constitutes one of the basic components. One portion of mustard seed oil is able to provide enough Vitamin E for a day [18].

There have been a lot of debates regarding the properties of one component of mustard seed oil - the erucic acid. Though it is still not known what impact the erucic acid can have on health of humans, there are some food scientist who argue that this acid can negatively affect human organism. Some people, who are aware of potential danger of mustard seed oil, avoid consuming it if it has high level of erucic acid [18].

Conclusions

1. At first the plants produce nitriles for defence from herbivores.

2. Then some insects can metabolize nitriles and produce own nitriles for protection from predators.

3. Also in some cases probably nitriles can attract pollinators.

4. Very important application of nitriles in polymerization.

5. It is important that nitriles are very toxic for human and animals.

6. Some essential oils of plants which contain nitriles are very expensive.

Sinapis alba L.

Synonym: *Brassica alba* L. Common name: White Mustarda. Russian name: Горчица белая. Family: Brassicaceae. Description: *Sinapis alba* L. is a annual growing to 0.6 m by 0.3 m at a fast rate. It is in flower from June to August, and the seeds ripen from Jul to September.

Fig. 5 http:// bg.wikipedia.org/wiki/ Бял_синап

It grows in Europe – Mediterranean and naturalized in Britain. In China it is applied to treat coughs that are accompanied by strong phlegm, tuberculosis and in those cases, when the pleura inflames (pleurisy) [19]. The principal constituent of volatile oil of mustard is allyl-isothiocyanate with small amounts of allyl cyanide and carbon disulphide [20]. The seed of Brassica alba has a set of properties: antibacterial, antifungal, flatus-releaving, diaphoretic, rubefacien. It provokes appetite, stimulates digestion, acts as an emetic agent, promotes and facilitates expulsion of sputum from the respiratory tract, has a diuretic effect and serves as stimulant. As a result of hydrolytic liberation of hydrogen sulphide the seed has a cathartic action. For external use the seeds are used in mustard plasters, where the ground seeds is applied; in the form of poultices; or is added to the water when taking a bath. Further, skin eruptions, chilblains, joints, affected by arthritis, respiratory infection and other can be treated with the seed of white mustarda. The leaves have an carminative effect [21].

Filipendula ulmaria (L.) Maxim

Synonym: Dropwort. Common name: Meadowsweet. Russian name: Таволга вязолистная. Family: Rosaceae. Description: Is a perennial herb. The stems are 1–2 m (3–7 ft) tall, erect and furrowed, reddish to sometimes purple. The leaves are dark-green on the upper side and whitish and downy underneath, much divided.

Fig. 6 http://en.wikipedia.org/wiki/File:Filipendula-ulmaria.JPG

It grows in Europe and Western Asia, naturalized in North America. The herb is a valuable medicine in the treatment of diarrhoea. It is also considered to be a useful stomachic, being used to treat hyperacidity, heartburn, gastritis and peptic ulcers, for which it is one of the most effective plant remedies [22]. The leaves and flowering stems are alterative, anti-inflammatory, antiseptic, aromatic, astringent, diaphoretic, diuretic, stomachic and tonic [23,24]. The flower head contains salicylic acid, from which the drug aspirin can be synthesized. This remedy should not be given to people who are hypersensitive to aspirin [31]. A strong decoction of the boiled root is said to be effective, when used externally, in the treatment of sores and ulcers [25]. Chemical composition: salicylates (75% salicylaldehyde in essential oil), flavonoids, tannins, heparin (in the flowers) [26], benzonitrile [27].

Lonicera japonica Thunb.

Common name: Japanese Honeysuckle. English name: Gold-and-silver flower. Russian name: Жимолость японская. Family: Caprifoliaceae. Description: It is a twining vine able to climb up to 10 meters high or more in trees. The flowers are double-tongued, opening white and fading to yellow, and sweetly vanilla scented. The fruit is a globose dark blue berry 5–8 millimeters diameter containing numerous seeds.

Fig. 7 http://hsb.wikipedia.org/wiki/Japanski_kozylist

It is native to eastern Asia including China, Japan, and Korea, naturalized in North America [28]. Parts uses: flower but, flowers and leaves. It is of high medicinal value in traditional Chinese medicine. Honeysuckle should be taken in combination with chrysanthemum flowers. Traditional uses: dysentery, diarrhea, pain, swelling [28]. Bio-Activities: antiulcer, antibacterial, antiviral, antispasmodic, diuretic, anti-inflammatory, analgesic [28]. Chemical components: wax, luteolin, lonicerine, inositol, triterpenoid saponins, flavonoids [29], indole [30]. Poisonous Part – Berries. Symptoms: vomiting, diarrhea, pupil dilation, cold sweat, rapid heartbeat, respiratory failure, convulsions, and coma. Vine with saponic and cyanogenic glycosides; fruit with carotenoids [31].

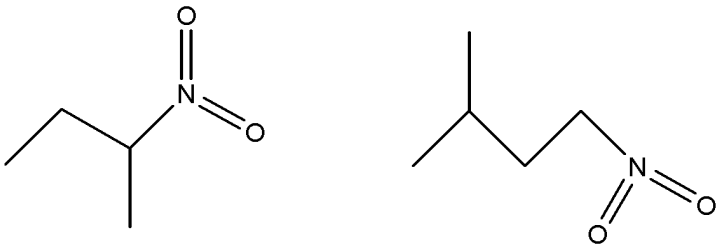
3. NITROCOMPOUNDS

1-nitro-2-methylbutane (2-methyl-1-nitrobutane) **(V)**

Molecular Formula: $C_5H_{11}NO_2$

1-nitro-3-methylbutane (3-methyl-1-nitrobutane) **(VI)**

Molecular Formula: $C_5H_{11}NO_2$



V VI

Nitroalkanes usually are toxic substanses. The toxic effect of vapors is headache, nausea, vomiting, and convulsions. Chronic exposure to animals indicates some liver and kidney injury. Even though the vapors of nitrocompounds cannot be absorbed through the skin, due to the solvent action they have, they can lead to mild skin irritation. Also, if the levels of threshold limit value are exceeded, they can irritate eyes [32].

Nitropropane-2 has hepatocarcinogenic properties and, when given to rats, leads to an oxidative damage of liver DNA and RNA. The damaged liver RNA and DNA of the rat was used to identify if the pattern of the damage caused by Nitropropane-2, as a result of oxidative nucleic acid intake, also took place after intraperitoneal administration of cyclopentanone oxime, primary nitroalkanes, other secondary nitroalkanes and a tertiary nitroalkane, 2-methyl-2-nitropropane [33].

The mutagenic characteristics of the secondary nitroalkanes (2-nitropropane, 2-nitrobutane, 3-nitropentane and nitrocyclopentane) and

their anionic forms - nitronates; as well as of the primary nitroalkanes (1-nitropropane, 1-nitrobutane, and 1-nitropentane) and their respective nitronates; of the nitrocarbinols 2-nitro-1-propanol, 2-nitro-1-butanol, 3-nitro-2-butanol, and 3-nitro-2-pentanol and their respective nitronates and also of 2-methyl-2-nitropropane, and 2-nitroso-2-nitropropane, were studied by implementing the Ames Salmonella assay using strains TA98, TA100 and TA102. The results showed that the secondary nitroalkanes (2-nitropropane, 2-nitrobutane, 3-nitropentane) and nitrocyclopentane were considerably mutagenic to the Salmonella strains TA100 and TA102 at 10-80 micromoles/plate; on the other side, the parent compounds showed mutagenic properties at only a single dose level or haven´t shown any mutagenic reaction if the same dose was administered. The primary nitroalkanes 1-nitropropane, 1-nitrobutane, and 1-nitropentane and the above mentioned nitrocarbinols were not or only partially mutagenic at the concentration administered. Under the conditions of the assay, the nitronates of the primary nitroalkanes and the nitrocarbinols are re-protonated too fast in order to assess the mutagenicity. 2-Methyl-2-nitro propane and nitroso-2-nitropropane were not mutagenic when strains TA100 and TA102 were used. 2-nitroso-2-nitropropane led to an equivocal mutagenic response in TA 98 [34].

Probably, 1-nitro-2-methylbutane and 1-nitro-3-methylbutane are toxic, cancerogenic and mutagenic substances.

Nitroalkanes are explosive compounds. The detonation properties of the nitroalkanes are inversely related to the length of the chain. The nitro group belongs to the most widely used explosophore [34]. So, 1-nitro-2-methylbutane and 1-nitro-3-methylbutane have to be explosive compounds.

Some antimicrobial, antiprotozoal and antifungial but not volatile pharmaceutical substances contain the nitro-group, e.g., chloramphenicol, nitrofurazone, or metronidazole. Probably, 1-nitro-2-methylbutane and 1-nitro-3-methylbutane show also antimicrobial, antiprotozoal and antifungal

properties. Plants use them for protection from the microorganisms, protozoes and fungus.

Nitro groups are encountered in several bioactive compounds. The majority of them occur as a result of a mono-oxygenation of amino groups. Among authors (Zocher et all.) it is assumed that one of the constituting enzymes is AurF. It takes part in the biosynthesis of aurothin, which holds a nitro group [35]. Probably, 1-nitro-2-methylbutane and 1-nitro-3-methylbutane are biosynthesized from aminoacids by enzyma oxygenation.

Fresh tomatoes (*Lycopersicon esculentum* L) contain 1-nitro-2-methylbutane [36]**.** 1-nitro-3-methylbutane could be only isolated from green walnuts that had been infested with codling mot, but not in healthy nuts [37].

1-nitro-2-methylbutane and 1-nitro-3-methylbutane were found studing the scent of Honeysuckle (*Lonicera caprifolium* L) by the headspace method [38]**,** and the latter is a content of the essential oil of Christmas orchid (*Angraecum sesquipedale* Thouars) [39].

Conclusions

1. Probably 1-nitro-2-methylbutane and 1-nitro-3-methylbutane are toxic, cancerogenic and mutagenic substances.

2. 1-nitro-2-methylbutane and 1-nitro-3-methylbutane are explosive compounds.

3. Probably 1-nitro-2-methylbutane and 1-nitro-3-methylbutane show antimicrobial, antiprotozoal and antifungal properties, the plants use them for protection against microorganisms, protozoa and fungi.

4. 1-nitro-2-methylbutane and 1-nitro-3-methylbutane are biosynthesized from aminoacids by enzymatic oxygenation.

Nicotiana alata Link&Otto.

Synonym: Winged Tobacco. Common name: Tobacco. Russian name: Табак крылатый. Family: Solanaceae. Description: Stout, annual herb; leaves large, alternate, simple, with sticky hairs; flowers tubular, cream, pink, or green-white, 5-lobed at top; fruit a capsule with many, minute seeds.

Fig. 8 http://fr.wikipedia.org/wiki/Fichier:Nicotiana_alata.jpg

All parts are poisonous [40].

Chemical composition: Nicotine and other alkaloids, 2-methylbutanenitrile, 3-methyl-1-mitrobutane, 2-methyl-1-nitrobutane, 3-methylbutanenitrile [41].

Nicotiana glauca: The leaves have cathartic, emetic, sedative as well as narcotic properties. They are intended for external use in form of poultice and a wash as a remedy to rheumatic swelling, skin diseases and stings of scorpions. The poultice made of the leaves of nicotiana glauca is used to treat inflamed throat glands as well as cuts, bruises and other wounds. It is also applied as poultice in order to remove the pus from boils and scrofulous sores. For rheumatism treatment the infusion of the leaves as a steam bath are have been applied [42].

Angelica archangelica L.

Synonym: *Archangelica officinalis* Hoffm. English name: Holy Ghost. Russian name: Дягиль лекарственный. Family: Apiaceae. Description: In the first year of its growth only the leaves appear; during the second year its stem grows significantly and can reach a two meters mark. The leaves of Angelica consist of many small leaflets. It has many small either yellowish or greenish flowers, which are gathered into umbels shaped like globes.

Fig. 9 http://commons.wikimedia.org/wiki/File:Angelica_archangelica_002.JPG

Angelica has been used in folk medicine as remedy to target digestive disorders and blood circulation problems for a long time. Especially angelica´s root is useful medicinally. It is harvested in the fall of the first growth year. Also, seeds and leaves on angelica have medicinal properties. Angelica has carminative, diuretic, stimulant, tonic, expectorant, diaphoretic stomachic and antispasmodic properties [43]. It can be responsible for the increase of sugar level in the urine. That is why it should not be used by people with inclination towards diabetes [43]. Angelica essential oil is used for massages to address rheumatic conditions [44]. Also, the oil from the seeds and the root are applied in perfumery, food flavoring and for medical purposes. The seeds oil carries a musk-like aroma and is sometimes used as an additive for liqueurs [45]. The essential oil has various chemical components such as: ***Ŭ***-pinene, camphene, ***ß***-pinene, sabinene, ***Ŭ***-phellandrene, myrcene, limonene, ***ß***-phellandrene, cis-ocimene, trans-ocimene, p-cymene, terpinolene, copaene, bornyl acetate [46].

Daucus carota L.

Synonym: *Sylvestris* M. Common name: Wild carrot. English name: Queen Annes lace. Russian name: Морковь обыкновенная. Family: Apiaceae. Description: Erect, biennial herb; leaves basal and alternate, 2-pinnately divided with narrow segments; flowers small, white, in a terminal, umbrella-shaped cluster; fruit small, dry, ribbed, with bristly hairs.

Fig. 10 http://en.wikipedia.org/wiki/File:Daucus_carota_May_2008-1_edit.jpg

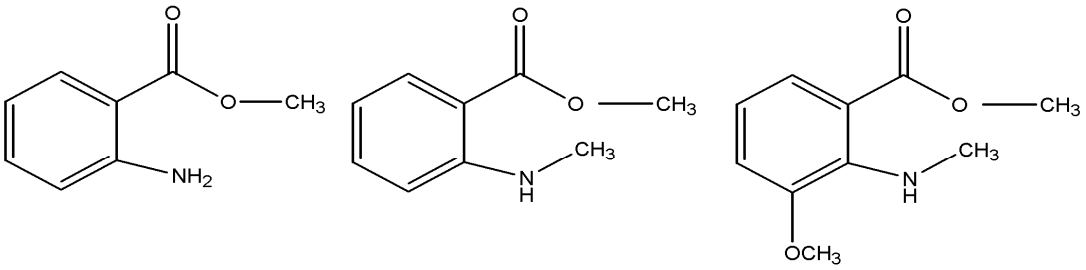
It is native to temperate regions of Europe, southwest Asia and naturalised to northeast North America and Australia. An essential oil obtained from the seed has an orris-like scent. The main chemical constituents of carrot seed oil include **Ŭ**-pinene, camphene, **ß**-pinene, sabinene, myrcene, **ɔ**-terpinene, limonene, **ß**-bisabolene, geranyl acetate and carotol. In smaller amounts, carbohydrates and nitrogenous are compositants. It is used in perfumery and as for food flavouring. The oil has also been used cosmetically in anti-wrinkle creams [47]. Edible parts: Leaves, roots, flowers and seeds. The wild carrot is an aromatic herb that acts as a diuretic, soothes the digestive tract and stimulates the uterus [47]. Poisonous parts are the leaves, based on the toxic falcarinol. Skin irritation arises from cell sap and in light [48] .

4. ANTHRANILATES

Methyl anthranilate (VII) (methyl ether, 2-aminobenzoic acid)

Methyl-N-methylanthranylate (VIII) (methyl ether, 2-methylaminobenzoic acid)

Damascenin (IX)



VII VIII IX

Anthranilates are as well esters and aromatic amines, and they have the properties of both of these classes of compounds. A distinctive feature of many plant metabolites of carbohydrate, terpenoide, phenol and alkaloide nature is the presence of structural fragments of ester linked aromatic acids. This compound is anthranilic acid and shows a decisive influence on the biological activity of metabolites. Recently, the development of a study was aimed to study the synthetic transformations available in natural anthranilates. Development methods modify the model compound methyl ester of anthranilic acid, obtaining data on the relationship between "structure and activity", it is relevant and represents a great potential in the synthesis of new agents with selective pharmacological action [49].

The UV radiation is important for photosynthesis, but also UV radiation can be harmful for plants. Scientists found out about a "photoreceptor" sensitive to UV-B. If the harmful UV increases the receptor also increases the production of sun block substances, the

production of UV-absorbing flavonoids [50].

Probably the anthranilate production also increase due the rising level of UV radiation as part of the sunlight protecting properties and anthranilate take active part in protection of plants.

Methyl 2-aminobenzoate (methyl anthranilate; anthranilic acid, methyl ester; neroli oil (artificial))

Molecular Formula: $C_8H_9NO_2$

Odor is described as medium-strong and fruity, like grapes or orange blossoms [51].

Uses: As perfume for ointments; manufacture of synthetic perfumes. Flavoring, perfume. In addition to many foods, it is found in some cosmetic products such as shampoos. Artificial scents that may contain methyl anthranilate include grape, currant, passion fruit, banana, lemon, tangerine, orange blossom, "citrus," "floral," and "oriental" [52].

Anthranilate serves as most commonly used ingredient for sunscreens as it protects from the rays of UVA, and the rays of UVB [53].

Methyl anthranilate acts as a non-toxic and non-lethal bird repellent with application potential for protecting crops (corn, sunflowers, rice, fruit), seeds, turf and golf courses, fish stocks from bird damage. Furthermore, methyl anthranilate can be added to liquids for the purpose of protecting migratory birds, e.g. addition to waste water associated with mining or to standing water pools at airports [54]. It irritates birds´ pain receptors which are associated with their taste and smell senses. For birds this compound is repelling and impels them to leave the crops [55]. This method is very useful when trying to avoid birds damaging crops and proved to be better than the netting. Further, mathyl anthranilate proved to

be an effective repellent (in form of aerosol spray) against Africanized honey bees ("killer" bees). When it was applied the number of stings reduced by 95 %. A 100% success was achieved when applying it against building of paper wasps colonies [56]. The Africanized honey bees are very aggressive and commonly can sting a big about of times, which can have lethal outcome for a human. Therefore, a reduction of stings can be significant in saving human lives. Paper wasps are not as aggressive towards humans, as “killer” bees are. They are rather considered as pest and are very spread in New Zealand [56].

In nature, anthranilic acid methyl ester is present in tower flower oil, neroli oil, ylang-ylang, jasmine oil, tuberose oil, distilled from orange tree leaves and peels of both ripe and unripe fruit.

Petitgrain Oil: Bitter orange (*Citrus aurantium* L). Family: Rutaceae. Parts of plant: Petitgrain oil is one of the three oils that are gained from the bitter orange tree. The other two oils are neroli oil (from the flowers) and bitter orange oil (from the fruits peels). Petitgrain oil is obtained from the fresh leaves. Uses: As a rule, petitgrain oil has no toxic, irritant, sensitizing or phototoxic properties. It serves as antiseptic, anti-spasmodic, anti-depressant, deodorant, sedative and nervine remedy. It is used during the recovery period after an illness and to treat insomnia. It is widely used in skin care: against acne, as perspiration reducing remedy and to clear up oily type of skin. Constituents: geraniol, linalool, nerol, ↄ-terpineol, geranyl acetate, linalyl acetate, myrcene, neryl acetate and trans-ocimene, methyl anthranilate [57].

Bergamot Oil: Bergamot orange (*Citrus bergamia* Risso). Family: Rutaceae. Parts of plant: The rind of both ripe and unripe fruit. Uses: The therapeutic properties of bergamot oil are analgesic, antidepressant, antiseptic, antibiotic, anti-spasmodic, stomachic, calmative, cicatrisant, deodorant, digestive, febrifuge, vermifuge and vulnerary. Bergamot oil can be used in the treatment of depression, stress, tension, fear, hysteria,

infection (all types including skin), anorexia, psoriasis, eczema and general convalescence. Constituents: **Ŭ**-pinene, myrcene, limonene, **Ŭ**-bergaptene, **ß**-bisabolene, linalool, linalyl acetate, nerol, neryl acetate, geraniol, geraniol acetate and **Ŭ**-terpineol, methyl anthranilate [57].

Petitgrain-portugal essential oil: Sweet Orange. (*Citrus sinensis* (L) Osbeck)Family: Rutaceae. Parts of plant: Leaves. N-constituents: methylantranilate, methyl-N-methyl-antranilate. Resembles the composition of Petigrain oil but contains lesser aldehydes almost no esters and is characterized by a low content of neroli and geraniol. Besides, petitgrain-portugal oil contains right-handed linalool (like the flowers of the sweet orange), as opposed to other oils of the citrus group in which left-handed linalool is a consistent [58].

Tuberose Oil: Tuberose (*Polianthes tuberose* L). Family: Asparagaceae. Parts of plant: Flower. Uses: Tuberose Absolute is very popular in the perfume and aromatic industries. It is effective also for dispelling anxiety and negativity, offering support throughout a transformation of character. This makes tuberose absolute ideal for treating obsessive behavioural problems. Constituents: benzyl alcohol and -acetate, methyl and benzyl benzoate, methyl salicylate, methyl anthranilate, eugenol, geraniol and nerol and -acetates, and farnesol [59].

Methyl 2-(methylamino)-benzoate (dimethyl anthranilate; methyl-N-methylantranilate.)

Molecular Formula: $C_9H_{11}NO_2$

Odor: Orange flower, mandarine, neroli [60].

Uses: A pleasent orange blossom character for fine fragrances. Synthetic flavor. Used in concord grape, green apple, cherry and dried fruit (raisin,

prune) flavors for pitty woody notes [61].

Benzoic acid derivatives substituted by a hydroxy group or an ester containing oxygen atom possess active bacteriostatic and fragrant properties. They are typically used in pharmaceutical and perfumery industry. They are used as intermediates for pharmaceuticals (especially for antipyretics, analgesics, antirheumatismic agents) and other organic syntheses [62]. If applied on skin areas, which are usually exposed to sunlight, (except bath preparations, soaps and other rinse-off products) the use in the finished cosmetic products applied should be limited to 2% [63].

It is also used in agriculture as a safe repellent against birds, and has been shown to calm killer bees.

In nature, dimethyl anthranilate is present in mandarin *(Citrus reticulata* Blanco) leaf oil; is specific to Clemantine mandarins and contributes to the floral orange blossom character [64].

Genet (Broom) Absolute: Spanish Broom (*Spartium junecum* L). Family: Fabaceae. Parts of plant: Flower.

Is a perfumer's speciality oil with an intensely sweet hay-honey-floral fragrance, underscored with tea-herbal and tobacco-coumarin notes. Broom Absolute is highly used in cosmetic as well as in perfumery formulations [65].

Yuzu leaf oil: Yuzu (*Citrus junos* Siebold). Family: Rutaceae. Parts of plant: Leaves. Aromatically, this Yuzu is dry and tangy a tart initial note, reminiscent of very tart grapefruit. Use: Flavor and fragrance agents [66].

Damascenine (3-methoxy-2-(methylamino)benzoic acid methyl ester; nigelline)

Molecular Formula: $C_{10}H_{13}NO_3$

The alkaloid damascenine is the principal constituent of nigella oil which was first prepared by A. Schneider in 1890. The damascenine is

derived from tryptophan by oxidation of indole to anthranilic acid followed by hydroxylation and methylation.

Therapeutic Uses: Mildly narcotic properties [67].

The love-in-a-mist refers to one of the oldest spices and medicinal plants in the world. The seeds are black, with an aromatic odor and taste. They are used as a spice as well as diuretic and analgesic; furthermore they are added to bread and cheese as flavouring agent. From the seeds a very special essential oil, smelling like honey is processed.

Love-in-a-mist oil: Love-in-a-mist (*Nigella damascena* L). Family: Ranunculaceae. Parts of plant: Seeds. The main component of the love-in-a-mist oil, called alkaloid damascening, possesses analgesic properties. It is used in skin care and as an additive in fragrance production. Its natural aroma is warm and comforting [68].

Conclusions

1. Probably anthranilates can protect allso plants from excess of UV radiation.

2. The table shows that methylantranilate is attractant for some beetles und flys and acts as pheromone for some ants (Tab.1). Probably this case of chemical mimicry of plants is needed to attract pollinators.

3. It is interesting that anthranilates are used in high priced perfumery. The study of their biosynthesis is important for increasing their production by plants. The study of plants which contain anthranilates probably leads to find new plants for extraction.

4. It is important that anthranilates also are used as bird repellents, for synthetic flavors and raw material for pharmaceutical compounds.

Nigella damascena L, *Nigella sativa* L.

Common name: Black Cumin. English name: Love-in-a-mist. Russian name: Чернушка. Family: Ranunculaceae. Description: It grows to 20–50 cm tall, with pinnately divided, thread-like, alternate leaves. The flowers are most commonly different shades of blue, but can be white, pink, or pale purple; with 5-25 sepals. Are pollinated by Bees.

Fig. 11 http://de.wikipedia.org/wiki/Echter_Schwarzk%C3%BCmmel

It is native to southern Europe, north Africa and southwest Asia. It is also commonly grown in gardens in North America. The seeds where damascenine is concentrated in proportion of 0.7% and essential oil 9%. Properties: hepatic, astringent, carminative, vermifuge. Toxicity: Very high [69]. The oil of *Nigella sativa* L contains over a hundred constituents which are responsible for its beneficial properties. Among its components are vitamins, enzymes, aromatic oils and trace elements. 58% of the essential fatty acids (among them omega 6 and omega 3) are contained in this oil. These acids form Prostaglandin E1, an agent that makes the immune system balanced and stronger providing it with ability to control chronic diseases and to avoid getting infections or developing allergies. Cells, which are healthy, are also protected from viruses; this prevents the growth of tumours. Also, the blackseed oil is known for its -histamine, anti-oxidant, anti-infective and broncho-dilating properties, which emerge due to the presence of volatile oils (0.5 - 1.5 %) such as nigellone and thymochinone in its composition [70].

Hyacinthus orientalis L.

Synonym: Garden Hyacinth. Russian name: Гиаци́нт восто́чный. Family: Asparagaceae. Description: Bulbous perennial herb; leaves basal and narrowly strap-shaped; flowers on an erect stalk, each 6-parted, funnel-shaped, variously colored, fragrant.

Fig. 12 http://hsb.wikipedia.org/wiki/Zahrodna_hyacinta

Growth place: native to southwestern Asia, southern and central Turkey, northwestern Syria, Lebanon and northern Israel. It was introduced to Europe in the 16th century. Chemical composition: benzyl alcohol, cinnamyl alcohol, benzaldehyde, phenylethyl alcohol, benzoic acid, benzyl acetate, benzyl benzoate, eugenol, methyl eugenol, hydroquinone. Dimethyl anthranilate, indole [71]**.** *Hyacinthus* absolute derived from the flowers. Hyacinth primarily used in perfumery. Its fragrance is refreshing and soothing. In aromatherapy hyacinth is rarely used, except to create individualized fragrances. However, it has potential for its psychological effects to treat addictions, burnout, depression, fatigue, apathy and stress related conditions [72]. Warning: Poisonous part - Bulbs, all parts. Toxic alkaloids such lycorine. Toxic only if large quantities eaten. Skin irritation minor, or lasting only for a few minutes. Symptoms: Stomach cramps, salivation, vomiting, and diarrhea. Dermatitis after contact with cell sap. Possible nasal irritation and asthma in susceptible persons[73].

Vitis labrusca L.

Common name: Fox Grape. English name: Concord grape. Russian name: Виноград вида. Family: Vitaceae. Description: *Vitis labrusca* L is a deciduous climber growing to 15 m at a fast rate. The flowers are hermaphrodite and are pollinated by insects.

Fig. 13 http://da.wikipedia.org/wiki/Amerikansk_Vin

Growt place: Eastern N. America - Maine to S. Carolina and Tennessee. It is locally naturalized in Europe. Concord grape oil is obtained from seeds of the grapes. It is applicable in form of an infusion in order to treat diarrhoea, hepatitis, stomach aches, fevers, headaches and thrush. Also, concord grape leaves poultices are used to cure sore breasts, rheumatic joints and headaches. Its bark is used for preparation of infusion that is applied to treat urinary complaints [74]. Chemical composition: Methyl anthranilate (responsible for the musk)[75], and non-volatile bioactive phenolic compounds in grape. Anthocyanins, flavanols, flavonols and resveratrol are the most important grape polyphenols because they possess many biological activities, such as antioxidant, cardioprotective, anticancer, anti-inflammation, antiaging and antimicrobial properties. Resveratrol is one of powerful anti-oxidants, which has been found to play protective function against cancers of colon and prostate, coronary heart disease (CHD), degenerative nerve disease, Alzheimer's disease and viral/ fungal infections [76].

Citrus aurantium L.

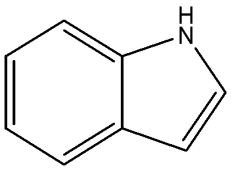
Synonym: *Citrus bigaradia*. Common name: Bitter Orange. English name: Neroli. Russian name: Померанец. Family: Rutaceae. Description: *Citrus aurantium* L. trees grow to a height of 9 meters and a width of 6 meters. They are evergreen trees which are in leaf all year and carry flowers from April to June.

Fig. 14 http://de.wikipedia.org/wiki/Bitterorange

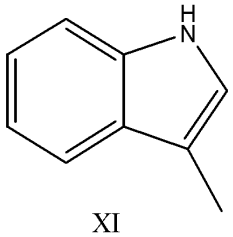
These citrus species have a number of active components such as vitamin C, volatile oils, acids and flavonoids. Other important ingredients are coumarinssuch as bergapten which has the function to make the skin sensitive towards the exposure to sunlight (sensitization). Due its pigmentation promoting characteristics bergapten is used as an additive for tanning preparations [77]. The essential oil is widely used in aromatherapy as a remedy against depression, tension or skin problems [77]. The plant as well as the oil has an ingredient – umbelliferone- that is responsible for their antifungal and antibacterial properties. The effect of the leaves and the flowers is sedative, digestive and antispasmodic. Infusion prepared out of the leaves is applied when stomach related problems occur [78]. To treat anorexia, chest pains, colds or coughs the seeds and the pericarp are applied. The fruit has carminative, diaphoretic, digestive, antitussive, antiemetic and expectorant properties [78]. Nitrocompound: methyl anthranilate, indole, phenylacetonitrile and 1-nitro-2-phenylethane - constituents are odor-determining [79].

5. INDOLE DERIVATIVES

Indole (X), skatole (XI)



X



XI

A case worth of a closer look are indole and skatole, which belong to the same family- the pyrrole family. When indole is in an isolated and in a pure condition it has a similar aroma as the moth balls do. In a number of popular favourite flowers such as orange blossoms, jasmine or some flowers of Narcissus family such as including jonquil, daffodil, crocus, and tazetta the indole and skatole are encountered.So, in the valuable jasmine oil there there is up to 3 percent of these substances. Samples with highly concentrated indole or skatole have a strong unpleasant odor. It is also produced, when indol and skatole get in contact with proteins or amino acids. In less concentrated amounts and when mixed with essential oil compounds, they release a pleasant floral scents. For this reason indole is used for production of patented perfumes [80].

The scent of flowers which contain skatol and indole are probably equally important for attraction of pollinators. Mechanisms of attraction must be different but anyway based on chemical mimicry. By producing particular scents plants attract insect to their flowers. The produced scents may closely imitate food resources aromas, insect pheromones, broodsites or prey odors [81]. For example the *Coccinella septempunctata* indole is the attractant and also a pheromone. The plants produce indole probably in order to attract aphid-eater insects, such as Coccinella septempunctata, which defend the plants from aphid infestation. Most of the insects

involved are bees and wasp, a few plants depend upon beetles for pollination.

The importance of indole and skatole for animal taxa (Table.1).

2,3-benzopyrrole (indole; ketole)

Molecular Formula: C_8H_7N

Indole can occur as a degradation product of the amino acid tryptophan. Indole received its name by joining the words indigo and oleum. This is due to the fact that the first time indole was isolated, it was performed by treating of the indigo dye with oleum [82]. It occurs naturally in human feces and has an intense fecal odor. Besides that it is encountered in coal tar. The structure of indole is encountered not only in a number of organic compounds such as the amino acid tryptophan and in tryptophan-containing protein, but also in alkaloids in pigments. The plant hormone, auxin (indolyl-3-acetic acid, IAA), is found in some other indole compounds.

The scheme of biosynthesis of auxine is presented at Fig. 15. Indole-3-carbinol is produced by the breakdown of the glucosinolate glucobrassicin which can be found at relatively high levels in cruciferous vegetables [83]. Indole-3-carbinol is the subject of on-going biomedical research into its possible anticarcinogenic, antioxidant, and anti-atherogenic effects. Even though lilac, gardenia, orange flower and jasmine have different aromas they all have in common the indole as one of the ingredients; it provides the flowers with a pleasant, narcotic scent.The importance of indole for recreation of the scent of blooming flowers is crucial. Already a small amount of indole, which in a pure form reminds of a diamond dust, can define flower´s scent. Besides from fragrances, they are also used as additives of chocolate, coffee and other compositions of

flavors. It is also applied in food preparations – it enables to achieve a quality imitation of flavor accords [84].

Indole is also used as a feedstock in the synthesis of plant growth regulators, such as indole-3-acetic acid and indole-3-butanoic acid [85]. Uses in perfumery (fixative) [86]. Indole is widely used in production of fragrances and was a forerunner of many pharmaceuticals. The indole test is used to identify bacteria. Indole is basic for pigments, hormones and alkaloids. The most widespread known pigment based on indole is indigo, as well as the since ancient time well known purple pigment [87].

Some essential oils contain indole:

Neroli essential oil. Plants: Bitter Orange, Sweet Orange. Family: Rutaceae. Parts of plant: Flower. Properties and Uses: anxiety, stress, premenstrual stress, stretch marks, digestive, depression, headaches, antispasmodic, antiseptic, sedative, insomnia, aphrodisiac, dry skin, carminative, tonic. N-constituents: indole alkaloids, methyl anthranilate given the sensual scent [88].

Ylang-ylang essential oil: Plants: Ylang-ylang (*Cananga Odorata* (Lam.)Hook.f&Thomson). Family: Annonaceae. Parts of plant: Flowers. Use: impotence, frigidity, anxiety. Properties: skin tonic, aphrodisiac, productive system tonic, antiseptic, antidepressant, sedative. N-constituents: indole (2-5%), heigh content of methyl anthranilate causes the aphrodisiac properties of ylang-ylang oil [88].

Jasmine essential oil: Plants: Royal jasmine (*Jasminum grandiflorum* L). Family: Oleaceae. Parts of plant: Flowers. Uses: dry skin, period pain, sedative, antiseptic, bronchitis, postnatal depression, antispasmodic, coughs, depression, uterine, aphrodisiac. N-constituents: indole, methyl anthranilate it has an aphrodisiac effect. Methyljasmonate und indole determines the typical smell of jasmine and have a strong character of pheromones [89].

3-methyl-1H-indole (skatole)

Mlecular Formula: C_9H_9N

Skatole is a plant hormone whose degradation is a key determination of plant growth and development, showing auxinic effects [90]. Its name is derived from the Greek root skato- meaning "dung".

It functions as an insect attractant. Such compounds as skatole attract males of several species of orchid bees. It is assumed that the males of these bees gather skatole to synthesize pheromones. Therefore the skatole is applied as a kind of a bait that attracts bees and allows to collect them for studies [91]. Odor characteristic is fecal at high levels, but is becoming pleasant, sweet, and warm at very low levels [92]. It is used in perfumery (fixative) as a flavoring agent in cosmetics, food processing and production of cigarettes [93].

Skatole is also found in civet – the substance that some animal secret in order to mark their territory. This substance has an intensive faecal odor, to a certain extent due to skatole. When ageing and in diluted concentration it develops a rather pleasant odor that gains a high value in perfumery [94].

Conclusions

1. It is interesting that indole and skatole in high concentrations show a horrible smell but in small concentration exert a pleasant smell so some important perfume compositions contain them.

2. It is interesting that the heterocyclic structure of indole is derived from anthranilate.

3. Indole and its derivatives are biological active compounds in many organisms.

4. Indole and its derivatives are interesting examples of different types of chemical mimicry for attraction of pollinators and protectors of plants from herbivores

Biosynthesis of antranilate and indole in plants

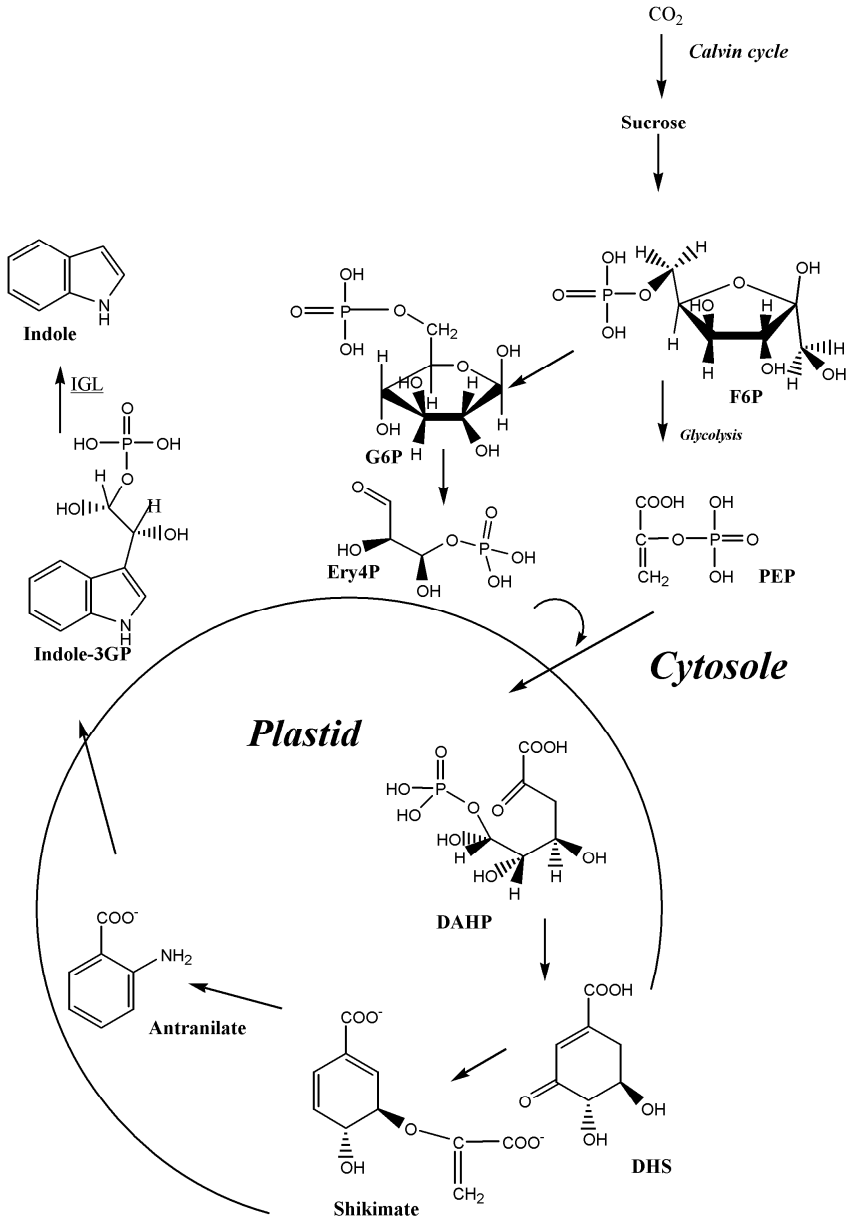


Fig. 15 Natalia Dudareva, Florence Negre, Dinesh A. Nagegowda & Irina Orlova (2006): Plant Volatiles:Recent Advances and Future Perspectives, Critical Reviews in Plant Sciences, 25:5, 424.

Metabolic pathways leading to the biosynthesis of antranilate and indole volatile compounds in plants. Abbreviations: DHS, 3-dehydroshikimic acid; Ery4P, erythrose 4-phosphate; F6P, fructose 6-phosphate; G6P, glucose 6-phosphate; IGL, indole-3-glycerol phosphate lyase; Indole-3GP, indole 3-glycerol phosphate; PEP, phosphoenolpyruvate; DAHP, 3-deoxy-D-arabino-heptulosonate 7-phosphate.

Narcissus tazetta Linn.

[From Greek, *narkuq* = numbness and from Latin, *tazetta* = little cup]. Common name: Chinese daffodil. English name: Narcissus, Daffodil, Lent Lily. Russian name: Нарцисс Тацета. Family Amaryllidaceae. Description: Leaves: simple, 23 cm × 1 cm, the flowers are bright yellow, 5-lobed. Narcissus absolute derived from the flowers.

Fig. 16 http://cs.wikipedia.org/wiki/Soubor:Narkis002c.jpg

Growth place: All over Europe. Grown in Indian gardens. Action: Bulbs - powerfully emetic, diuretic, purgative. Oil is applied for curing baldness. The bulbs are imported into India. Dried and sliced bulbs are sold as a substitute for bitter hermodactyls. Chemical composition: Alkaloids, lycorine, pseudolycorine, alanthamine, haemanthamine and narcisine, have been isolated from the bulbs of the species. The alkaloid narcisine is toxic. The mucilage, narcissus T-glucomannan, isolated from the bulbs, was found to exhibit significant hypoglycaemic activity in mice [95]. Uses: In China and Japan, the bulb is used to heal ulcers and boils, calm the itching, assuage pain, treat eye diseases and to resolve swellings. The flowers are used to combat fever [96]. Warning: It is a poisonous herb [96].

Jasmine: *Jasminum officinale* Linn. var.*grandiflorum* (L.) Kobuski.

Synonym: *J. grandiflorum* Linn. English name: Spanish Jasmine. Russian name: Жасмин белый. Family: Oleaceae. Description: It is a deciduous climber growing to 10 m. The flowers are hermafrodite **(**have both male and female organs) and are polinated by insects.

Fig.17 http://de.wikipedia.org/wiki/Echter_Jasmin

Growth place: It can grow in semi-shade (light woodland) or no shade. It requires moist soil [97]. Action: Flowers—calming and sedative, CNS depressant, astringent and mild anaesthetic. A syrup prepared from the flowers is used for coughs, hoarsenesses and other disorders of the chest. Plant—diuretic, anthelmintic, emmenagogue; used for healing chronic ulcers and skin diseases. Oil—externally relaxing [98]. Chemical composition: Indian oil sample contains benzyl acetate, benzyl benzoate, phytol, jasmone, methyl jasmonate, linalool, geranyl linalool, eugenol, isophytyl acetate, and isophytol. The leaves contain ascorbic acid, anthranilic acid and its glucoside, indole, oxygenase, alkaloid jasminine and salicylic acid. The flowers contain pyridine and nicotinate derivatives and were tested positive for indole. Tne flowers also contain 3,5-dimethyl-2-ethylpyrazine. The flowers and leaf juice are used for treating tumours [99].

Cananga tree *(Cananga odorata* Lam.*)*

Synonym: Ylang-ylang. English name: Fragrant cananga. Russian name: Иланг-Иланг. Family: Annonaceae. Description: Evergreen tree, 25-30 ft., rarely more; zones 10-11. Blooms warm months. The essential oil derived from the flowers is used in aromatherapy and in perfume.

Fig.18 http://uk.wikipedia.org/wiki/ Іланг-іланг

Growth place: Southeast Asia to northern Australia; widely cultivated [100].

Traditional Medicinal Uses: It is used for asthma, malaria, fever, cholera, typhoid, scabies, dermatitis, ulcer and wounds. The seeds are used for stomach complaints with fever and in Indonesia, the bark is used for scabies. In Malaysia, a paste of fresh flowers is applied to the chest for asthma and to treat malaria. In Solomon islands, a paste of fresh flowers is applied to boils while in India, the essential oil from the flowers makes an external remedy for cephalgia, ophthalmia and gout. The essential oil of ylang-ylang is used in aromatherapy. It is believed to relieve high blood pressure, normalize sebum secretion for skin problems, and is considered to be an aphrodisiac. Action: Antibacterial, Antifungal, Antihypertensive, Antioxidant, Antineoplastic and Antiprotozoal [101]. Chemical composition: Acetogenin, aporphine, liriodenine, canangone, ***Ŭ***-humulene, ***ɓ***-cubebene, germacrene D, cananodine, ***ɔ***-eudesmol [101], 2-sec-butyl-3-methoxypyrazine [102].

Ophrys bombyliflora L.

Synonym: Bumblebee Orchid. Common name: Bumblebee Flower Eyebrow. Russian name: Орхидея. Family: Orchidaceae. Description: *Ophrys bombyliflora* is a perennial growing to 0.3 m. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Insects (pseudocopulation) [103].

Fig. 19 http://en.wikipedia.org/wiki/Ophrys

They are terrestrial or ground orchids from central to South Europe, North Africa, Asia Minor, up to the Caucasus Mountains, but mostly in the Mediterranean region. Root - cooked. It is a source of 'salep', a fine white to yellowish-white powder that is obtained by drying the tuber and grinding it into a powder [104]. Salep is said to be very nutritious and is made into a drink or added to other cereals and used in bread etc [105]. One ounce of salep is said to be enough to sustain a person for a day [106] .The salep can also be made into a drink [107]. Salep is very nutritive and demulcent. It has been used as a diet of special value for children and convalescents, being boiled with water, flavored and prepared in the same way as arrowroot. Rich in mucilage, it forms a soothing and demulcent jelly that is used in the treatment of irritations of the gastro-intestinal canal [108]. Contains skatole [109].

Indigofera tinctoria L.

Synonym: *Brassica alba*. Common name: True indigo. Russian name: Индигофера красильная. Family: Fabaceae. Description: It may be an annual, biennial, or perennial herb, depending on the climate in which it is grown. It has light green pinnate leaves and sheafs of pink or violet flowers. It can fix nitrogen [110].

Fig. 20 http://en.wikipedia.org/wiki/Indigofera_tinctoria

A dye is obtained from the processing of the plant's leaves. They are soaked in water and fermented in order to convert the glycoside indican naturally present in the plant to the blue dye indigotin. The precipitate from the fermented leaf solution is mixed with a strong base such as lye, pressed into cakes, dried, and powdered. The powder is then mixed with various other substances to produce different shades of blue and purple. *Indigofera cassioides*: A decoction of the roots is used in the treatment of coughs [111]. The root is dried, ground into a powder and applied externally in the treatment of pains in the chest [112]. *Indigofera decora*: A broth made from the leafy shoots is used in the treatment of cough, dyspepsia, haemorrhage and poisoning [113]. Several species of this group are used to alleviate pain. The herbs are generally regarded as an analgesic with anti-inflammatory activity, rather than an anodyne. *Indigofera articulata* was used for toothache, and *Indigofera oblongifolia* was used as an anti-inflammatory for insect stings, snakebites, and swellings. *Indigofera suffruticosa* and *Indigofera aspalthoides* have also been used as anti-inflammatories [114].

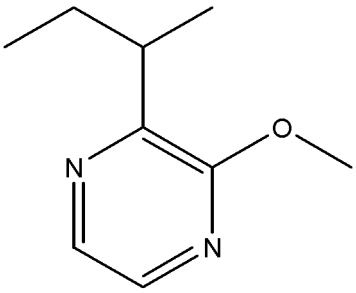
6. PYRAZINE DERIVATIVES

2-sec-butyl-3-methoxypyrazine (galbanum pyrazine) (XII)

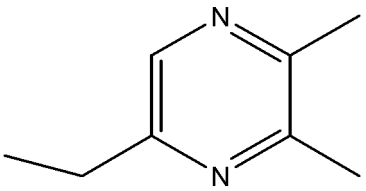
Molecular Formula: $C_9H_{14}N_2O$

3,5-dimethyl-2-ethylpyrazine (XIII)

Molecular Formula: $C_8H_{12}N_2$



XII



XIII

The pyrazine nucleus contains an aromatic ring with six compartments, which holds two para-oriented tertiary nitrogen atoms. In nature, the aromatic pyrazines are wide-spread [115], and serve as alerting signals. The nucleus is obtained biosynthetically from amino acids and products of sugar degradation. His further characteristic is the possession of low olfactory threshold [116].

Some beetles (seven-spot ladybeetle, asian ladybird beetle, convergent lady beetle, Harlequin bug) use 2-sec-butyl-3-methoxypyrazine in its chemical communication system as pheromone [117]. Seven-spot ladybeetle feeds greenfly. Also some flys (mediterranean fruit fly, leaf cutting ant and others) use 3,5-dimethyl-2-ethylpyrazine as pheromone [118].

It is possible that plants produce this compound for attraction of its

beetle for defence from greenfly. Probably, plants also attract insects by this substance for pollination.

Some essential oils contain pyrazines:

Galbanum essential oil. Galbanum (*Ferula galbaniflua* L). Fammily: Apiaceae. Distillation method: Steam distillation. Parts of plant: Resin. Propeties: Analgesic, anti-inflammatory, antimicrobial, antiseptic, antispasmodic, balsamic, carminative, digestive, diuretic, emmenagogue, expectorant, hypotensive, restorative, tonic. Use: The oil has been used as a fixative in perfumes. Medicinally it has been used on wounds and skin discorders [119].

A few compounds in low concentration are responsible for the interesting odor characteristics, e.g. 1,3(*E*),5(*Z*)-undecatriene (galbanolene), exerting a unique, transparent, marine, somewhat green and metallic odor, and 2-sec-butyl-3-methoxypyrazine (galbanum pyrazine), having a powerful pea-pod odour and a very low odor detection threshold [120].

Black pepper essential oil. Black pepper (*Piper nigrum* L). Family: Piperaceae. Production method: Steam distillation. Parts of plant: Dried fruit. Properties: Analgesic, antibacterial, antimicrobial, antiseptic, antispasmodic, aperitive, aphrodisiac, bitter, carminative, diaphoretic, digestive, diuretic, febrifuge, laxative, rubefacient, stimulant, stomachic, tonic, vasodilatoric. Of interest: Studies have shown that black pepper oil is able to reduce nicotine craving, and symptoms of anxiety in individuals cutting back on smoking [121].

Coffee essential oil. *Coffea Arabica* L. Family: Rubiaceae. Production method: Cold pressed. Parts of plant: Seeds/Coffee berries. Uses: It is used in beauty products such as soaps and skin lotions. It has

also been used in lotions to reduce the appearance of cellulite. Essential coffee oil is used in candles, air fresheners and perfumed oils for its fresh aroma. Essential oil of coffee is used for improving a person's well-being, physically and mentally. It can decrease the occurrence of respiratory issues, lower fevers, treat bug stings and decrease feelings of nausea. Coffee contributes to metabolizing glucose in the system and increasing the body's response to insulin when taken internally. Studies have shown that antioxidants in coffee improve liver function by decreasing the risk of liver cancer and cirrhosis [122].

Conclusions

1. It is possible that plants produce 2-sec-butyl-3-methoxypyrazine for attraction of seven-spot ladybeetle for defence from greenfly. Probably, plants also attract insects by this substance for polination.

2. Probably, plants use 3,5-dimethyl-2-ethylpyrazine for attraction of pollinators.

3. It is interesting that the essential oils which content 3,5-dimethyl-2-ethylpyrazine and 2-sec-butyl-3-methoxypyrazine are used in high quality parfumery.

Piper nigrum L.

Synonym: Peppercorns. Common name: Black Pepper. Russian name: Перец чёрный. Family: Piperaceae. Black pepper is native to India and is extensively cultivated there and elsewhere in tropical regions. Currently, Vietnam is the world's largest producer and exporter of pepper.

Fig. 21 http://en.wikipedia.org/wiki/Black_pepper

Black Pepper was believed to cure illness such as constipation, diarrhea, earache, gangrene, heart disease, hernia, hoarseness, indigestion, insect bites, insomnia, joint pain, liver problems, lung disease, oral abscesses, sunburn, tooth decay, and toothaches [123]. Extracts from black pepper have been found to possess antioxidant properties [124] and anti-carcinogenic effects [125]. Black pepper oil is extracted from the fruit of *Piper nigrum* L. Black pepper's aromatic, slightly musty odor comes from the volatile oils found largely in the flesh and skin; its pungent bite comes from the alkaloids - piperine and piperidine - and resins found mostly in the seeds. The oil is added into perfumes and flavorings. Piperine is also an effective insectide against houseflies, and gardeners use pepper sprays against several kinds of pests [126]. The essential oil is composed of various chemical constituents and includes thujone, ***Ŭ***-pinene, camphene, sabinene, ***ƃ***-pinene, ***Ŭ***-phellandrene, myrcene, limonene, caryophyllene, ***ƃ***-farnesene, ***ƃ***-bisabolene, linalool and terpine-4-ol [127].

Conium maculatum L.

Synonym: Conium. Common name: Poison Hemlock. Russian name: Болиголов. Family: Apiaceae. Description: Biennial herb with a smooth, purple-spotted or -lined, hollow stem; taproot solid and parsnip-like; leaves large, 3-4-pinnately divided, the leaflets very small; flowers small, white, in umbrella-like clusters.

Fig. 22 http://ru.wikipedia.org/wiki/ Болиголов

Occurrence: Europe, including Britain, from Norway and Finland south and east to N. Africa and Iran. Conium contains the pyridine alkaloids coniine, N-methylconiine, conhydrine, pseudoconhydrine and γ-coniceine (or g-coniceïne) [128]. Poisonous part: All parts. Leaves mistaken for parsley and seeds mistaken for anise. "Cup of hemlock" once used by early Greeks for capital punishment [129]. Hemlock is a very poisonous plant that has a long history of medicinal use, though it is very rarely used in modern herbalism. The whole plant is analgesic, antispasmodic, emetic, galactofuge and sedative. It is still used externally, usually in ointments and oils, in the treatment of mastitis, malignant tumours (especially breast cancer) anal fissure and haemorrhoids [130].

Apium graveolens L.

Common name: Celery. English name: Wild Celery. Russian name: Сельдерей пахучий. Family: Apiaceae. Description: *Apium graveolens* L. grows to 1 m tall. The flowers are creamy-white, 2–3 mm diameter, produced in dense compound umbels. The seeds are broad ovoid to globose, 1.5–2 mm long and wide.

Fig.23 http://de.wikipedia.org/wiki/Echter_Sellerie

Occurrence: Central and southern Europe, including Britain, to temperate areas of Africa and Asia. Wild celery it is an aromatic bitter tonic herb that reduces blood pressure, relieves indigestion, stimulates the uterus and is anti-inflammatory. The ripe seeds, herb and root are aperient, carminative, diuretic, emmenagogue, galactogogue, nervine, stimulant and tonic [131]. An essential oil obtained from the plant has a calming effect on the central nervous system. Some of its constituents have antispasmodic, sedative and anticonvulsant actions. It has been shown to be of value in treating high blood pressure. A homeopathic remedy is made from the herb. It is used in treating rheumatism and kidney complaints [132]. Celery oil contains large amounts of terpenen: limonene (70-90%), the sesquiterpenes β-selinene (10%) and humulene. It is also contains phthalides in very small amounts (3-5.6-dihydro Butylphthalide and his Sedanenolid). Phthalides are responsible for the specific scent of celery oil [133].

7. CONCLUSION

The nitrogen containing Volatile Organic Compounds are significant biologically active agents of plants. The compounds given above are being protective in insect and plant life. e.g. nitrils protect plants against being eaten by insects and animals. They may also protect insects against being eaten by animals and birds. Due to bactericidal and fungicidal qualities, nitro compounds may protect plants against microorganism and mushrooms. Nitriles, nitro compounds, anthranilates, indole and pyrazine derivatives may serve as a communication between plants and animals. The important thing is the fact of the chemical mimicry which serves as an attraction for pollinators, desiminators, as well as plant protectors against being eaten by insects.

Due to their special odor, the compounds given above comprise the structure of a high-quality expensive elite perfumery.

Due to their high biological activity, the compounds given above may serve as a proptotype for a developing of brand new medicine.

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9. ANHANG

Tabl. 1 The importance of N-compounds for animal taxa

http://www.pherobase.com/database/compound/compounds-detail-1H-indole.php

a-Indole, b-skatole, c-methylanthranilate, d-2-sec-butyl-3-methoxypyrazine,

e-3,5-dimethyl-2-ethylpyrazine, f-benzonitrile, g-allylcianide.

A –attractant, Al — allomone, K — kairomone, P — pheromone

Taxonomy	Name	a	b	c	d	e	f	g
Giraffa	Giraffe Afrikaans	P	P					
Bear	Giant Panda	P						
Speiders	Jumping Spider	K						
Beetle	Western striped cucumber beetle	A						
	Striped cucumber beetle	K,A						
	Corn rootworms barberi	A,K						
	Corn rootworms cristata	A						
	C.r. undecimpunctata howardi	A,K						
	Spotted cucumber beetle	A						
	Western corn rootworm	A,K						
	Seven-spot ladybird	A,P			P			
	Asian lady beetle				P			
	Convergent lady beetle				P			
	Agrypnus murinus	Al						
	Long-nosed lycid beetle				Al			
	Dung beetles		A					
	Soybean beetle			A				
	Phyllopertha horticola			A				
	Kheper bonellii	P	P					
	Kheper lamarcki		P					
	Kheper nigroaeneus		P					
	Kheper subaeneus		P					
	Levesta longelytrata						Al	
	Anthophagus angusticollis						Al	
	Megarthrus denticollis						Al	
	Megarthrus sinuatocollis						Al	
Fly	Screewworm	A						
	Thaumatomyia glabra			A				
	Townsend	A	A					
	Anopheles gambiae	A						

	Mosquito amboinensis	K	K					
	Mosquito moctezuma	K	K					
	Culex quinquefasciatus	A	A,K					
	Culex tarsalis	A	K					
	Musca autumnalis	A	A,K					
	Musca vetustissima	A						
	Spotted flesh fly	A	A					
	Medfly					P		
True bugs	Geocoris pallens	A						
	Murgantia histrionica				P			
Bees	Euglossa despecta		A					
	Euglossa fimbriata		A					
	Euglossa pleosticta		A					
	Euglossa purpurea		A					
	Euglossa securigera		A					
	Euglossa truncata		A					
	Eulaema cingulata		A					
	Eulaema nigrita		A					
	Melipona interrupta triplaridis		P					
Bethylidae	Cephalonomia gallicola		P					
	Cephalonomia stephanoderis		P					
Wasps	Aphidius sp	A						
	Cotesia marginiventris	A						
	Ceranisus menes			P				
Ants	Cerapachys jacobsoni		P					
	Aenictus rotundatus			P				
	Aenictus sp			P				
	Camponotus thoracicus fellah			P				
	Myrmecocystus romainei			P				
	Myrmecocystus semirufus			P				
	Acanthomyops claviger		P					
	Lasius alienus		P					
	Lasius neoniger		P					
	Leptanilla sp		P					
	Myrmecia nigriceps	Al						
	Acromyrmex octospinosus					P		
	Atta cephalotes		P					
	Myrmica incompleta					P		
	Aphaenogaster fulva			P				

	Xenomyrmex floridanus			P				
	Nothomyrmecia macrops	Al						
	Odontomachus brunneus					P		
	Odontomachus troglodytes					P		
	Diacamma ceylonense	P						
	Diacamma indicum	P						
	Pachycondyla obscuricornis	P						
Butterfly	Pieris brassicae							A
	Pieris rapae crucivora	P						
Net-winged insects	Chrysopa oculata		Al,P					
	Chrysopa sinica	A						
Thrips	Megalurothrips distalis			P				
	Thrips coloratus			A,K				
	Thrips flavus			K				
	Thrips hawaiiensis			A,K				

Tabl.2 Content of N-compounds in plants (http://www.pherobase.com/)

a-Indole
b-Methylanthranilate
c-3-Methylbutanenitrile
d-2-sec-Butyl-3-methoxypyrazine
e-2-Methylbutanenitrile
f-1-Nitro-2-methylbutane
g-Skatole
h-Methyl-N-methylanthranilate
i-Benzonitrile
k-3,5-Dimethyl-2-ethylpyrazine
l-1-Nitro-3-methylbutane

Family	Genus, Species	a	b	c	d	e	f	g	h	i	k	l
Arum familii	Amorphophallus albispathus	*						*				
	Amorphophallus albus	*										
	Amorphophallus annulifer	*						*				
	Amorphophallus arnautovii	*										
	Amorphophallus brachyphyllus	*										
	Amorphophallus bulbifer	*										
	Amorphophallus cicatricifer	*										
	Amorphophallus eichleri	*										
	Amorphophallus elatus	*										
	Amorphophallus fallax	*										

	Amorphophallus glossophyllus	*										
	Amorphophallus haematospadix	*										
	Leopard Palm	*										
	Amorphophallus lacourii	*										
	Amorphophallus margaritifer	*										
	Amorphophallus maximus	*										
	Elephant Yam	*										
	Amorphophallus prainii	*										
	Amorphophallus sagittarius	*										
	Titan Arum (largest flower structure)	*						*				
	Amorphophallus zenkeri	*						*				
	Anthurium antioquiense	*										
	Anthurium huixtlense	*										
	Anthurium nymphaeifolium	*										
	Arum apulum	*						*				
	Arum creticum	*						*				
	Arum cyrenaicum	*						*				
	Arum dioscoridis	*						*				
	Arum idaeum							*				
	Arum idaeum	*										
	Italian Lords-and-Ladies	*						*				
	Cuckoo Pint	*						*				
	Arum nigrum	*						*				
	Arum palaestinum	*						*				
	Arum purpureospathum	*						*				
	Arum rupicola	*						*				
	Dracunculus vulgaris							*				
	Hydrosme rivieri							*				
	Sauromatum guttatum	*						*				
Apiaceae	**Bishops weed**		*									
	Anthriscus sylvestris		*									
	Caraway or Persian cumin		*									
	Laserpitium latifolium		*									
	Parsnip		*									
Umbelliferae	Heracleum sibiricum		*									
Palme	Aiphanes minima	*			*							
	Ammandra decasperma				*							
	Aphandra natalia				*							
	Asterogyne martiana	*	*									

	Bactris gasipaes	*			*							
	Calyptrogyne costatifrons	*	*									
	Calyptrogyne ghiesbreghtiana	*	*									
	Ceroxylon alpinum	*			*							
	Chamaedorea linearis	*			*							
	Chelyocarpus ulei	*			*							
	Geonoma brongniartii	*	*									
	Geonoma congesta	*	*									
	Geonoma cuneata var. Cuneata	*	*									
	Geonoma cuneata var. procumbens	*	*									
	Geonoma cuneata var. sodiroi	*	*									
	Geonoma irena	*	*									
	Geonoma longepedunculata	*	*									
	Geonoma macrostachys	*	*		*							
	Geonoma maxima	*	*									
	Geonoma orbignyana	*	*									
	Geonoma poeppigiana	*	*									
	Geonoma polyandra	*	*		*							
	Geonoma stricta var. piscicauda	*	*									
	Geonoma stricta var. stricta	*	*									
	Geonoma tenuissima	*	*									
	Geonoma triglochin	*	*		*							
	Geonoma undata	*	*		*							
	Iriartea deltoidea	*			*							
	Mauritia flexuosa	*			*							
	Pholidostachys synanthera	*	*									
	Ecuadorean Ivory Palm				*							
	Phytelephas macrocarpa ssp. tenuicaulis				*							
	Phytelephas seemannii				*							
	Prestoea schultzeana	*			*							
	Welfia regia	*	*									
	Wettinia kalbreyeri	*			*							
	Wettinia maynensis	*			*							
Agavoideae	**Tuberose**		*									
Amaryllis family	Narcissus assoanus ssp. assoanus	*										
	Narcissus assoanus ssp. praelongus	*										
	Narcissus bugei	*										
	Narcissus bulbocodium	*										
	Narcissus cuatrecasasii	*										

	Narcissus gaditanus	*										
	Jonquil	*										
	Paperwhite Daffodil	*										
	Narcissus serotinus	*										
	Narcissus tazetta	*										
	Narcissus tazetta var. chinensis	*										
	Angels Tears	*										
	Narcissus triandrus ssp. pallidus	*										
Hemerocallidoideae	Hemerocallis minor	*								*		
Scilloideae	**Garden Hyacinth**	*							*			
Orchid family	Acacallis superba	*	*	*	*	*	*					
	Aerangis appendiculata	*	*	*	*	*	*					
	Aerangis biloba	*	*	*	*	*	*					
	Aerangis brachycarpa	*	*	*	*	*	*					
	Aerangis confusa	*	*		*							
	Aerangis confusa			*		*	*					
	Aerangis distincta	*	*	*	*	*	*					
	Aerangis fastuosa	*	*	*	*	*	*					
	Aerangis kirkii	*	*	*	*	*	*					
	Aerangis kotschyana		*	*	*	*	*					
	Aerangis kotschyana	*										
	Aerangis modesta	*										
	Aerangis somalensis		*	*		*	*					
	Aerangis somalensis	*			*							
	Aeranthes grandiflora	*	*	*	*	*	*					
	Aerides crassifolia	*	*	*	*	*	*					
	Aerides fieldingii	*	*	*	*	*	*					
	Aerides jackianum	*										
	Aerides lawrenceae	*	*	*	*	*	*					
	Ancistrochilus rothschildianus	*	*	*	*	*	*					
	Angraecopsis amaniensis	*	*	*	*	*	*					
	Angraecum aporoides	*	*	*	*	*	*					
	Angraecum bosseri	*	*	*	*	*	*					
	Angraecum eburneum	*	*	*	*	*	*					
	Angraecum eichlerianum	*	*	*	*	*	*					
	Angraecum girymae	*	*	*	*	*	*					
	Angraecum sesquipedale	*	*	*	*	*	*					
	Anguloa clowesii	*	*	*	*	*	*					
	Ansellia gigantea	*	*						*			

Aspasia epidendroides	*										
Aspasia principissa	*										
Aspasia variegata	*										
Bifrenaria flagillaris	*										
Bollea coelestis	*	*	*	*	*	*					
Brassavola digbyana	*	*	*	*	*	*					
Brassavola glauca	*	*	*	*	*	*					
Brassavola nodosa	*	*	*	*	*	*					
Brassavola sp	*										
Brassavola tuberculata	*	*	*	*	*	*					
Brassia lobbii	*	*	*	*	*	*					
Brassia verucosa	*	*	*	*	*	*					
Catasetum expansum	*										
Catasetum fuchsii	*	*						*			
Catasetum integerrimum	*										
Catasetum longifolium	*										
Catasetum macroglossum	*										
Catasetum maculatum	*										
Catasetum russelliana	*										
Catasetum viridiflavum	*	*	*	*	*	*					
Cattleya araguaiensis	*	*	*	*	*	*					
Cattleya bicolor	*	*	*	*	*	*					
Cattleya dowiana	*	*	*	*	*	*					
Cattleya labiata	*	*	*	*	*	*					
Cattleya lawrenceana	*	*	*	*	*	*					
Cattleya leopoldii	*	*	*	*	*	*					
Cattleya luteola	*	*	*	*	*	*					
Cattleya maxima	*	*	*	*	*	*					
Cattleya percivaliana	*	*	*	*	*	*					
Cattleya porphyroglossa	*	*	*	*	*	*					
Cattleya schilleriana	*	*	*	*	*	*					
Caularthron bicornutum	*	*	*	*	*	*					
Chondrorhyncha lendyana	*	*	*	*	*	*					
Cirrhaea dependens	*	*	*	*	*	*					
Cirrhopetalum fascinor	*	*	*	*	*	*					
Cirrhopetalum robustum	*	*	*	*	*	*					
Clowesia russelliana	*										
Clowesia thylaciochila	*										
Clowesia warczewitzii	*										

Cochleanthes aromatica	*	*	*	*	*	*						
Cochleanthes discolor	*	*	*	*	*	*						
Cochleanthes marginata	*	*	*	*	*	*						
Coelogyne zurowetzii	*	*	*	*	*	*						
Constantia cipoensis	*	*	*	*	*	*						
Coryanthes elegantium	*	*						*				
Coryanthes horichiana	*	*						*				
Coryanthes leucocorys	*	*	*	*	*	*						
Coryanthes mastersiana	*	*	*	*	*	*		*				
Coryanthes picturata	*	*	*	*	*	*						
Coryanthes vieirae	*	*	*	*	*	*		*				
Cycnoches loddigesii	*											
Cymbidium goeringii	*	*	*	*	*	*						
Cypripedium acaule	*											
Cypripedium arietinum	*											
Cypripedium calceolus	*											
Cypripedium calceolus var. parviflorum	*											
Cypripedium calceolus var. pubescens	*											
Cypripedium candidum	*											
Cypripedium guttatum	*											
Cypripedium kentuckiense	*											
Cypripedium macranthum	*											
Cypripedium reginae	*											
Dendrobium anosmum	*	*	*	*	*	*						
Dendrobium antennatum	*	*	*	*	*	*						
Dendrobium beckleri	*	*	*	*	*	*						
Dendrobium brymerianum	*	*	*	*	*	*						
Dendrobium carniferum	*	*	*	*	*	*						
Dendrobium chrysotoxum	*	*	*	*	*	*						
Dendrobium delacourii	*	*	*	*	*	*						
Dendrobium lichenastrum	*	*	*	*	*	*						
Dendrobium moniliforme	*	*	*	*	*	*						
Dendrobium monophyllum	*	*	*	*	*	*						
Dendrobium pugioniforme	*	*	*	*	*	*						
Dendrobium superbum	*											
Dendrobium trigonopus	*	*	*	*	*	*						
Dendrobium unicum	*	*	*	*	*	*						
Dendrobium virgineum	*	*	*	*	*	*						
Dendrobium williamsonii	*	*	*	*	*	*						

Dendrochilum cobbianum	*	*	*	*	*	*						
Diaphananthe pellucida	*	*	*	*	*	*						
Diaphananthe pulchella	*	*	*	*	*	*						
Dichaea rodriguesii	*	*	*	*	*	*						
Dracula chestertonii	*	*	*	*	*	*						
Dryadella edwallii	*	*	*	*	*	*						
Embreea rodigasiana	*	*	*	*	*	*						
Encyclia adenocarpa	*	*	*	*	*	*						
Encyclia baculus	*	*	*	*	*	*						
Encyclia citrina	*	*	*	*	*	*						
Encyclia fragrans	*	*	*	*	*	*						
Encyclia glumacea	*	*	*	*	*	*						
Epidendrum ciliare	*	*	*	*	*	*						
Epidendrum lacertinum	*	*	*	*	*	*						
Epidendrum nocturnum	*	*	*	*	*	*						
Epigeneium lyonii	*	*	*	*	*	*						
Eria hyacinthoides	*	*	*	*	*	*						
Gongora aceras	*											
Gongora armeniaca	*	*	*	*	*	*		*				
Gongora atropurpurea	*											
Gongora bufonia	*											
Gongora cassidea	*	*	*	*	*	*		*				
Gongora cruciformis	*							*				
Gongora galeata	*							*				
Gongora gibba	*											
Gongora odoratissima	*							*				
Gongora quinquenervis	*							*				
Gongora superflua	*											
Gongora tricolor	*											
Gongora truncata	*							*				
Gongora unicolor	*											
Gymnadenia conopea	*	*	*	*	*	*						
Himantoglossum hircinum	*	*	*	*	*	*						
Houlletia odoratissima	*	*	*	*	*	*		*				
Huntleya heteroclita	*	*	*	*	*	*		*				
Huntleya meleagris	*	*	*	*	*	*						
Laelia albida	*	*	*	*	*	*						
Laelia anceps	*	*	*	*	*	*						
Laelia autumnalis	*	*	*	*	*	*						

Laelia gouldiana	*	*	*	*	*	*						
Laelia perinii	*	*	*	*	*	*						
Liparis viridiflora	*	*	*	*	*	*						
Lycaste aromatica	*	*	*	*	*	*						
Lycaste cruenta	*	*	*	*	*	*						
Lycaste locusta	*	*	*	*	*	*						
Masdevallia caesia	*	*	*	*	*	*						
Masdevallia estradae	*	*	*	*	*	*						
Masdevallia glandulosa	*	*	*	*	*	*						
Masdevallia laucheana	*	*	*	*	*	*						
Masdevallia striatella	*	*	*	*		*						
Masdevallia tridens	*	*	*	*	*	*						
Maxillaria nigrescens	*	*	*	*	*	*						
Maxillaria picta	*	*	*	*	*	*						
Maxillaria tenuifolia	*	*	*	*	*	*						
Maxillaria variabilis	*	*	*	*	*	*						
Miltonia regnellii	*	*	*	*	*	*						
Miltonia schroederiana	*	*	*	*	*	*						
Miltonia spectabilis	*	*	*	*	*	*						
Miltoniopsis phalaenopsis	*	*	*	*	*	*						
Miltoniopsis warscewiczii	*							*				
Mormodes andreetae	*							*				
Mormodes hookeri	*											
Mormodes sinuatum	*											
Mystacidium venosum	*											
Neofinetia falcata	*	*	*	*	*	*						
Nigritella nigra	*	*	*	*	*	*						
Odontoglossum cirrhosum	*	*	*	*	*	*						
Odontoglossum constrictum	*	*	*	*	*	*						
Odontoglossum pendulum	*	*	*	*	*	*						
Odontoglossum pulchellum	*	*	*	*	*	*						
Oncidium longipes	*	*	*	*	*	*						
Oncidium ornithorhynchum	*	*	*	*	*	*						
Oncidium sarcodes	*	*	*	*	*	*						
Oncidium tigrinum	*	*	*	*	*	*						
Peristeria elata	*	*	*	*	*	*						
Pescatorea cerina	*	*	*	*	*	*						
Pescatorea dayana	*	*	*	*	*	*						
Pescatorea lehmannii	*	*	*	*	*	*						

Phalaenopsis violacea	*	*	*	*	*	*						
Platanthera bifolia	*	*	*	*	*	*						
Platanthera chlorantha	*	*	*	*	*	*						
Plectrelminthus caudatus	*	*	*	*	*	*						
Polystachya campyloglossa	*	*	*	*	*	*						
Polystachya cultriformis	*	*	*	*	*	*						
Polystachya fallax	*	*	*	*	*	*						
Polystachya mazumbaiensis	*	*	*	*	*	*						
Rangaeris amaniensis	*	*	*	*	*	*						
Rhynchostylis coelestis	*	*	*	*	*	*						
Rodriguezia refracta	*	*	*	*	*	*						
Stanhopea anfracta	*											
Stanhopea annulata	*											
Stanhopea avicula	*											
Stanhopea candida	*											
Stanhopea carchiensis	*											
Stanhopea connata	*											
Stanhopea costaricensis	*											
Stanhopea dodsoniana	*											
Stanhopea ecornuta	*											
Stanhopea embreei	*											
Stanhopea florida	*											
Stanhopea frymirei	*											
Stanhopea gibbosa	*											
Stanhopea grandiflora	*											
Stanhopea graveolens	*											
Stanhopea impressa	*											
Stanhopea inodora	*											
Stanhopea jenischiana	*	*	*	*	*	*						
Stanhopea lietzeii	*											
Stanhopea martiana	*											
Stanhopea nigripes	*											
Stanhopea oculata	*	*	*	*	*	*						
Stanhopea panamensis	*											
Stanhopea peruviana	*											
Stanhopea pozoi	*											
Stanhopea pulla	*											
Stanhopea radiosa	*											
Stanhopea reichenbachiana	*											

	Stanhopea ruckeri	*										
	Stanhopea saccata	*										
	Stanhopea tigrina	*	*	*	*	*	*					
	Stanhopea tricornis	*										
	Stanhopea wardii	*										
	Stanhopea warscewicziana	*										
	Stanhopea xytriophora	*										
	Trichocentrum tigrinum	*	*	*	*	*	*					
	Trichoglottis philippinensis	*	*	*	*	*	*					
	Trichopilia suavis	*										
	Trixspermum arachnites	*	*	*	*	*	*					
	Vanda coerulescens	*	*	*	*	*	*					
	Vanda denisoniana	*	*	*	*	*	*					
	Vanda tessellata	*	*	*	*	*	*					
	Vanilla pompona	*										
	Zygopetalum crinitum	*	*	*	*	*	*					
	Zygopetalum mackayi	*										
Nolinoideae	**Lily of the Valley**	*										
	Sansevieria cylindrica	*										
Compositae	Centaurea scabiosa					*						
	Creeping Thistle					*						
	Eupatorium cannabinum					*						
	Inula salicina					*						
Cabbage family	Arabis demissa	*										
	Arabis drummondii	*										
	Holbolls Rockcress	*										
	Turnip	*										
	Cleome anomala					*						
	Thlaspi montanus	*										
Cactus	Discocactus cristallophilus	*	*									
	Discocactus silicicola	*	*									
	Dolichothele longimamma	*	*									
	Echinopsis coronata	*	*									
	Echinopsis mamillosa	*	*									
	Espostoa blossfeldiorum	*	*									
	Harrisia adscendens	*	*									
	Hylocereus polyrhizus	*	*									
	Hylocereus venezuelensis	*	*									
	Pereskia aculeata	*	*									

	Pilosocereus arrabidae	*	*									
	Pilosocereus catingicola	*	*									
	Pilosocereus pachycladus	*	*									
	Rebutia marsoneri	*	*									
	Rebutia narvaecense	*	*									
	Large-flowered Cactus	*	*									
	Selenicereus hamatus	*	*									
	Sulcorebutia kruegeri	*	*									
Pink family	Saponaria officinalis	*										
	Silene maritima	*										
	Nottingham Catchfly	*										
	Bladder Campion	*										
Nyctaginaceae	Acleisanthes acutifolia	*										
	Texas trumpet	*										
	Acleisanthes longiflora	*										
	Acleisanthes obtusa	*										
	Acleisanthes wrightii	*										
	Mirabilis alipes	*										
	Mirabilis bigelovii	*										
	Mirabilis greenei	*										
	Mirabilis jalapa	*										
	Mirabilis longiflora	*										
	Mirabilis macfarlanei	*										
	Mirabilis multiflora	*										
	Mirabilis pudica	*										
	Mirabilis triflora	*										
	Selinocarpus angustifolius	*										
	Selinocarpus chenopodioides	*										
	Selinocarpus lanceolatus	*										
	Selinocarpus parvifolius	*										
	Selinocarpus purpusianus	*										
	Selinocarpus undulatus	*										
Dayflower family	Cochliostema odoratissimum	*										
Cornales, Hydrangeaceae	Philadelphus coronarius	*										
Cucurbitaceae	Cucurbita maxima	*										
	Cucurbita pepo	*										
	Luffa acutangula	*										
	Bitter melon	*										
Honeysuckle family	Lonicera americana	*										

	Japanese Honeysuckle	*										
Valerian family	Centranthus ruber	*										
Lecythidaceae	Corythophora amapaensis	*		*								
	Couratari stellata	*		*								
	Couroupita guianensis	*	*	*								
	Eschweilera coriacea	*		*								
	Eschweilera pedicellata	*		*								
	Grias neuberthii	*		*								
	Grias peruviana	*		*								
	Gustavia longifolia	*		*								
	Gustavia serrata	*		*								
	Lecythis confertiflora	*		*								
	Lecythis persistens ssp. aurantiaca	*		*								
	Lecythis persistens ssp. persistens	*	*									
	Lecythis pisonis	*		*								
Phlox family	Phlox drummondii			*								
	Phlox paniculata			*								
Bean family	Albizia julibrissin			*		*				*		
	Dioclea reflexa					*						
	Inga marginata					*						
	Parkia biglobosa		*									
	Spartium junceum	*										
Dogbane family	Hoya carnosa		*									
	Plumeria alba	*										
	Stephanotis floribunda		*									
Coffee family	Cephalanthus occidentalis	*		*		*						
	Coffea arabica						*					
	Coussarea sp	*										
	Gardenia jasminoides	*										
	Hillia parasitica	*										
	Leptactina senegambica					*						
	Posoqueria latifolia						*					
	Rothmannia annae	*										
	Tabernaemontana amygdalifolia	*										
	Warszewiczia coccinea	*		*		*						
Oleaceae	Jasminum grandiflorum	*									*	
	Jasminum polyanthum	*										
	Jasminum sambac	*										
	Osmanthus fragrans	*									*	

	Syringa vulgaris	*								*		
Spicebush family	Chimonanthus nitens	*										
	Chimonanthus praecox	*										
Custard apple family	Anaxagorea brevipes	*										
	Anaxagorea dolichocarpa	*										
	Cananga odorata				*							
	Duguetia asterotricha	*										
	Rollinia insignis	*										
	Xylopia aromatica	*										
	Xylopia benthamii	*										
Rhizophoraceae	Bruguiera gymnorrhiza	*										
	Kandelia candel	*										
	Rhizophora stylosa	*										
Mallow family	Ceiba trischistandra			*								
	Ochroma pyramidalis			*								
	Tilia cordata	*										
	Tilia flores	*										
	Tilia platyphyllos	*										
Berberidaceae	Mahonia japonica	*										
Buckthorn family	Zizyphus mauritiana							*				
Mulberry family	Ficus carica	*										
Rose family	Filipendula ulmaria								*			
Citrus family	Citrus limon	*	*									
	Citrus madurensis	*	*									
	Citrus medica	*	*									
Potato family	Brugmansia candida	*										
	Brugmansia suaveolens			*								
	Datura sp			*								
	Jasmine Tobacco			*		*	*					*
	Nicotiana forgetiana			*		*	*					*
	Nicotiana longiflora					*	*					
	Nicotiana suaveolens	*										
Guttiferae	Cordylandra paralicola	*										
	Criuva parviflora	*										
Ginger family	Hedychium coronarium	*		*		*						

LEBENSLAUF

Angaben zur Person

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Beruflicher Werdegang

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03/1999 – 12/2003	**Pharmazeutin**, FA Optima Pharm in der Zentrale, Kiev
07/1997 – 03/1999	**Pharmazeutin**, VVS-LTD, Kiev
08/1988 – 07/1997	**Pharmazeutin** in Krankenhausapotheke, Kiev

Schul- und Berufsbildung

Seit 09/2011	**Vergleichstudium der Pharmazie zur Erlangung der Nostrifikation**, Universität Wien
06/1988	**Diplomprüfung Pharmazie** Staatliche Medizinuniversität Zaporizzja
09/1983 – 06/1988	**Studium der Pharmazie** Ukraine
06/1983	**Matura**
1976 – 1983	Allgemeinbildende Schule in
1973 - 1976	Volksschule in Zaporizzja

Sprachkenntnisse

Deutsch	gut in Wort und Schrift
Englisch	gut in Wort und Schrift
Ukrainisch	Muttersprache
Russisch	sehr gut