SEARCH OF THE PROMISING SPECIES OF SUBFAMILY AMYGDALOIDEAE AND PYROIDEAE USING THE CHEMOTAXONOMY

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1. Introduction

The representatives of genus Crataegus L., Malus Mill., Prunus L. and Cerasus Juss. belong to the family Rosaceae L. (Rose) subfamily Amygdaloideae and Pyroideae. According to modern data Cerasus Juss. and Prunus L. belong to the Amygdaloideae, genus Crataegus L. and Malus Mill. – Pyroideae [1].

In the world of flora, the genus Crataegus L. has more than 1000 species, the Prunus L. – more than 30 species, the Malus Mill. – more than 100 species, the Cerasus Juss. – more than 150 species.

2. Formulation of the problem in a general way, the relevance of the theme and its connection with important scientific and practical issues

Despite the wide species composition, only some representatives of the genera Crataegus L., Prunus L., Malus Mill. and Cerasus Juss. thoroughly investigated. Most of the existing species are not sufficiently studied. The feature of the above genus is that their representatives are easily hybridize as within the genus and between families, which complicates their identification [2]. Because of this, the taxonomy of the
family and the genus is a subject of constant review and needs to be clarified.

3. Analysis of recent studies and publications in which a solution of the problem are described and to which the author refers

According to the characters of the morphological structure of generative and vegetative organs, modern systematics are point 25 botanical sections of the genus Crataegus L. the main of which are: Henryanae Sarg., Pinnatifida Zbl., Sanguineae Zbl., Douglasii Loud., Pentagyna Zbl., Azaroli Loud., Oxycanthae Zbl., Molles Sarg., Tenuefoliae Sarg., Rotundifoliae Eggl., Virides Sarg., Crus-Galli Loud., Punctatae Loud., Parvifoliae Loud., Flavae Loud., Macracantae Loud., Dilataeae Sarg. 8 other sections are endemic species.

A chemotaxonomic study of the genus Crataegus L. using phenolic compounds of 12 species was previously carried out. As a result, it was found that for all investigated species the presence of hyperoside, quercetin and chlorogenic acid [3].

Modern systematics are separated Malus Mill. as an independent genus, although earlier it was a sub-genus of the genus Pyrus L. By the features of the morphological structure the genus Malus Mill. is divided into 2 sections: Pumilae Rehder. – M. silvestris Mill., M. domestica Borkh. Handb., M. prunifolia. (Willd.) Borkh., M. orientalis Ugl. = M. pumila Grossh.), M. Sieversii (Ldb.) M. Roem. Niedzwetzkyana Diek., M. prunifolia (Willd.) Borkh.) and Baccatae Render – M. baccata (L.) Borkh. Handb., M. Pallasiiana Juz., M. sachalinenis Juz., M. manshurica (Maxim.) Kom. [4]. The most studied are species of sections of Pumilae Rehder. Representatives of the Baccatae Render. section have practically not been studied from a pharmacological point of view.

In Ukrainian flora 2 wild species are described – M. silvestris Mill. and M. praecox (Pall.) Borkh., and also 4 cultivated species – M. domestica Borkh., M. baccata (L.) Borkh., M. prunifolia (Willd.) Borkh. and M. sachalinenis Juz.

The genus Cerasus Juss. is consist of subgenus Typoceras Koehne ex Kurt and Microceras Webb. To subgenus Typoceras are belong sections:
1. Mahaleb Koehne – C. Maximowiczii (Rupr.) Kom., C. mahaleb (L.) Mill.;
2. Pseudoceras Koehne – C. sachalinenis Kom.;
3. Hypadenium Koehne – C. glandulifolia (Rupr. Et Maxim.) Kom., C. avium (L.) Moench., C. fruticosa (Pall.) G. Woron., C. auster (L.) Roem. ta C. colina Lej. et Court. In modern genus system is devised a section Euceras Koehne., which include C. avium (L.) Moench., C. fruticosa (Pall.) G. Woron. and C. vulgaris Mill. [5].

The representatives subgenus Microceras divided into 2 sections:
1. Spiraeopsis Koehne – C. glandulos (Thunb.) Lois.;
2. Amygdaloceras Koehne ex Kurt. – C. microcarpa (C.A.M.) Boiss., C. araxina Poyark., C. incana (Pall.) Spach., C. pseudoprostrata Poyark., C. erythrocarpa Newsk., C. verrucosa Newski., C. Jacqueumontii (Hook.) Buser., C. alaica Poyark., C. tianschanica Poyark. and C. turcomanica Poyark.

In Ukrainian flora 6 species of Prunus Mill. genus are described – P. spinosa L., P. stepposa Kotov., P. moldavica Kotov., P. domestica Ldb., P. divaricata Ldb., P. insititia L. The most widespread in Ukraine of species the genus Prunus Mill. are: P. domestica L.; P. spinosa L.; P. salicina L.; P. cerasifera Ehrh.; P. americana Marsh.; P. ussuriensis K. et K.; P. nigra Ait; P. angustifolia Marsh.; P. hortulana Bail.; P. munsoniana W. and Hed.; P. Simonii Cur. [6].

4. The field of research considering the general problem, which is described in the article

After analyzing the current state of research of representatives of the genus Crataegus L., Prunus L., Malus Mill. and Cerasus Juss., it can be concluded, that among species of the genus Crataegus L. 14 species have been studied, in genus Prunus L., Malus Mill. and Cerasus Juss. are sufficiently studied BAS of the species Prunus domestica, Prunus spinosa, Malus domestica, Malus silvestris, Cerasus vulgaris, Cerasus avium and their varieties. Other species of these genus were practically not investigated. We believe that the scientific interest is conducting a chemotaxonomic study of representatives of this subgenus to clarify their position in the genus system and to search for new sources of BAS, as well as to obtain substances for the creation of phytopreparations.

5. Formulation of goals (tasks) of article

To conduct a comparative chemotaxonomic study of the genus Crataegus L., Prunus L., Malus Mill. and Cerasus Juss., to establish the chemical profiles of the genera, to establish promising for medicine species.

6. Presentation of the main research material (methods and objects) with the justification of the results

The objects of chemotaxonomic study were vegetative and generative organs of 34 species of genus Cerasus L.: C. pinnatifida Bge. (C. pinnatifida var. psilosa C. K. Schneid.), C. Maximowiczii C.K. Schneid (C. altaica var. villosa Lge.), C. chlorosara Maxim. (C. atrocarpa E. Wolf.), C. schneideri C.K. Schneid., C. kansuensis Wils., C. almaatensis Pojark., C. pseudomelanocarpa M. Pop., C. laevigata Loud., C. oxyacantha L. (C. oxyacanta var. genuina Rouy et Camus), C. ambiguus C. A. M. (C. pseudoambiguia A. Pojark.), C. kytrotysta Fingerh., C. pseudokytrostyla Klok., C. subrotunda Klok., C. curvisepala Lindm., C. fallacina Klok., C. turkestanica A. Pojark., C. monogyna Jacq. (C. monogyna var. intermedia (Schur) Jav.), C. canadensis Sarg., C. submollis Sarg., C. arnoldii Sarg., C. densiflora Sarg., C. festiva Sarg., C. flabellata (Bosc) C.Koch, C. rotundifolia Moench., C. punctata Jacq., C. rivularis Nutt., C. douglasii Lindl., C. prunifolia (Poir.) Pers., C. macracantha Lod., C. pringlei Sarg., C. holmesiana Ashe., C. pedicelata Sarg., C. coccinoides Asche., C. cuneata S. et Z.; 4 species of genus Cerasus Juss.: C. avium L., C. fruticosa Pall., C. vulgaris Mill., C. glandulos (Thunb.) Lois.; 7 species of genus Malus Mill.: M. silvestris, M. domestica Borkh. Handb., M. prunifolia (Willd.) Borkh., M. baccata (L.) Borkh. Handb., M. manshurica (Maxim.) Kom., M. cerasifera,
The main group of species of the genus Crataegus are
C. cuneata
C. flabellata
C. densiflora
C. ambiguae
C. chlorosarca

For a generative organs the species of Crataegus L.
general are compounds: terpenoids (eugenol, cis-
linalool oxide, trans-linalool oxide, β-phenylethyl alco-
hol, squalen), flavonoids (quercetin, bioquercetin, hyper-
oside, rutin), organic acids (p-hydroxybenzoic acid, ben-
zoic, phenylacetic, salicylic, 4-hydroxycinnamic, vanil-
linic, chlorogenic, caffeic, pherulic, neochlorogenic, gentisinic, lilac) [13].

The chemical profile of vegetative organs of
hawthorn species is characterized by terpenoids and
aldehydes (benzaldehyde, cis-linalool oxide, trans-
2-hexenal, eugenol, squalen, nerol), flavonoids (quercetin),
aromatic acids (p-coumaric, benzoic, phenylacetic,
salicyl, vanilinic, chlorogenic, caffeic, pherulic, neo-
chlorogenic, gentisinic, lilac) [14]. The taxons, which
have the highest values of Cga are characterize
the hawthorn by the chemical composition of the vegeta-
tive and generative organs and form a chemical profile
of the genus. The main group of species of the genus
Crataegus, having largest information weight
the chemical composition of vegetative
organisms, represented by 10 taxons: C. prunifolia (Cga – 1523 %),
C. douglasii (Cga – 1486 %), C. cuneata (Cga –
1485 %), C. pseudokyrtostyla (Cga – 1463 %), C.
almaatensis (Cga – 1457 %), C. chlorosarca (Cga –
1437 %), C. ambiguae (Cga – 1437 %), C. rotundifolia
(Cga – 1426 %), C. flabellata (Cga – 1363 %), C. den-
siflora (Cga – 1320 %) (Table 1).

Table 1

| Taxon          | C. chlorosarca | C. almaatensis | C. ambiguah | C. pseudokyrtostyla | C. densiflora | C. flabellata | C. rotundifolia | C. douglasii | C. prunifolia | C. cuneata |
|---------------|----------------|----------------|-------------|---------------------|---------------|---------------|----------------|--------------|--------------|------------|
| C. chlorosarca | 100 %          | 51 %           | 51 %        | 59 %                | 33 %          | 37 %          | 47 %           | 49 %         | 49 %         | 50 %       |
| C. almaatensis | 51 %           | 100 %          | 43 %        | 47 %                | 48 %          | 45 %          | 64 %           | 51 %         | 65 %         | 59 %       |
| C. ambiguah    | 51 %           | 43 %           | 100 %       | 54 %                | 36 %          | 37 %          | 41 %           | 44 %         | 44 %         | 45 %       |
| C. pseudokyrtostyla | 59 %        | 47 %           | 54 %        | 100 %               | 37 %          | 38 %          | 45 %           | 48 %         | 51 %         | 45 %       |
| C. densiflora  | 33 %           | 48 %           | 36 %        | 37 %                | 100 %         | 66 %          | 50 %           | 62 %         | 42 %         | 43 %       |
| C. flabellata  | 37 %           | 45 %           | 37 %        | 38 %                | 66 %          | 100 %         | 58 %           | 61 %         | 46 %         | 47 %       |
| C. rotundifolia| 47 %           | 64 %           | 41 %        | 45 %                | 50 %          | 58 %          | 100 %          | 50 %         | 50 %         | 51 %       |
| C. douglasii   | 49 %           | 51 %           | 44 %        | 48 %                | 62 %          | 61 %          | 50 %           | 100 %        | 52 %         | 54 %       |
| C. prunifolia  | 49 %           | 65 %           | 44 %        | 51 %                | 42 %          | 46 %          | 50 %           | 52 %         | 100 %        | 64 %       |
| C. cuneata     | 50 %           | 59 %           | 45 %        | 45 %                | 43 %          | 47 %          | 51 %           | 54 %         | 64 %         | 100 %      |
The main group of species of genus Crataegus L. according vegetative characteristics include 14 taxons: C. oxyacantha (Cga – 1416 %), C. chlorosarca (Cga – 1411 %), C. almaensis (Cga – 1380 %), C. pseudokyrtostyla (Cga – 1371 %), C. subrotunda (Cga – 1368 %), C.prunifolia (Cga – 1366 %), C.pseudomelanocarpa (Cga – 1354 %), C. submollis (Cga – 1354 %), C. punctata (Cga – 1351 %), C. curvisepala (Cga – 1348 %), C. pinnatifida (Cga – 1339 %), C. laevigata (Cga – 1323 %), C. cuneata (Cga – 1311 %) (Table 2).

The main group of taxons that characterize the genus Crataegus L. by the chemical composition of generative and vegetative organs include C. prunifolia (Cpa – 1449 %), C. chlorosarca (Cga – 1424 %), C. almaensis (Cga – 1434 %), C. pseudokyrtostyla (Cga – 1417 %), C. cuneata (Cga – 1396 %), C. subrotunda (Cga – 1374 %).

After analyzing the chemical composition of generative and vegetative organs of the genus Crataegus L., the basic chemical compounds that form the chemoprofile of the genus are established: cis-linalool oxide, linalool, squalen, quercetin, hyperoside, rutin, p-hydroxybenzoic acid, chlorogenic acid, pherulic acid, vanilinic acid, lilac acid.

### Table 2

| Taxon                  | C. pinnatifida | C. chlorosarca | C. almaensis | C.pseudomelanocarpa | C. curvisepala | C. oxyacantha | C. pseudokyrtostyla | C. subrotunda | C. curvisepala | C. submollis | C. festiva | C. punctata | C.prunifolia | C. cuneata |
|------------------------|---------------|----------------|--------------|---------------------|---------------|---------------|---------------------|---------------|---------------|--------------|------------|-------------|--------------|-------------|
| Cpa, %                 | 100%          | 95%            | 90%          | 95%                 | 90%           | 95%           | 90%                 | 95%           | 90%           | 95%         | 90%        | 95%         | 90%          | 95%         |
| C. pinnatifida         | 100%          | 97%            | 94%          | 97%                 | 94%           | 97%           | 94%                 | 97%           | 94%           | 97%         | 94%        | 97%         | 94%          | 97%         |
| C. chlorosarca         | 97%           | 94%            | 91%          | 97%                 | 94%           | 97%           | 94%                 | 97%           | 94%           | 97%         | 94%        | 97%         | 94%          | 97%         |
| C. almaensis           | 94%           | 91%            | 88%          | 94%                 | 91%           | 94%           | 91%                 | 94%           | 91%           | 94%         | 91%        | 94%         | 91%          | 94%         |
| C.pseudomelanocarpa    | 95%           | 92%            | 89%          | 95%                 | 92%           | 95%           | 92%                 | 95%           | 92%           | 95%         | 92%        | 95%         | 92%          | 95%         |
| C. curvisepala         | 90%           | 87%            | 84%          | 90%                 | 87%           | 90%           | 87%                 | 90%           | 87%           | 90%         | 87%        | 90%         | 87%          | 90%         |
| C. oxyacantha          | 95%           | 92%            | 89%          | 95%                 | 92%           | 95%           | 92%                 | 95%           | 92%           | 95%         | 92%        | 95%         | 92%          | 95%         |
| C. pseudokyrtostyla    | 90%           | 87%            | 84%          | 90%                 | 87%           | 90%           | 87%                 | 90%           | 87%           | 90%         | 87%        | 90%         | 87%          | 90%         |
| C. subrotunda          | 94%           | 91%            | 88%          | 94%                 | 91%           | 94%           | 91%                 | 94%           | 91%           | 94%         | 91%        | 94%         | 91%          | 94%         |
| C. curvisepala         | 95%           | 92%            | 89%          | 95%                 | 92%           | 95%           | 92%                 | 95%           | 92%           | 95%         | 92%        | 95%         | 92%          | 95%         |
| C. submollis           | 90%           | 87%            | 84%          | 90%                 | 87%           | 90%           | 87%                 | 90%           | 87%           | 90%         | 87%        | 90%         | 87%          | 90%         |
| C. festiva             | 94%           | 91%            | 88%          | 94%                 | 91%           | 94%           | 91%                 | 94%           | 91%           | 94%         | 91%        | 94%         | 91%          | 94%         |
| C. punctata            | 95%           | 92%            | 89%          | 95%                 | 92%           | 95%           | 92%                 | 95%           | 92%           | 95%         | 92%        | 95%         | 92%          | 95%         |
| C.prunifolia           | 90%           | 87%            | 84%          | 90%                 | 87%           | 90%           | 87%                 | 90%           | 87%           | 90%         | 87%        | 90%         | 87%          | 90%         |
| C. cuneata             | 95%           | 92%            | 89%          | 95%                 | 92%           | 95%           | 92%                 | 95%           | 92%           | 95%         | 92%        | 95%         | 92%          | 95%         |

The chemical profile the generative organs of genus Malus Mill. are forming α-terpineol, geraniol, eugenol, aromatic acids (benzoic, phenylacetic, salicylic, vanilinic, lilac, chlorogenic, pherulic), flavonoids (hydroxy and rutin). For vegetative organs common compounds are cis-bisabolene epoxide, α-pharnezene, linalool, damascenon, limonen, squalen, organic acids (fumaric, phenylacetic, vanilinic, p-oxybenzoic, pherulic, p-coumaric, chlorogenic), rutin, naringenin, epicatechin.

For generative organs of the genus Cerasus Juss. the most characteristic BAS are: trans-linalool oxide, linalool, lilac aldehyde, terpen-4-ol, α-terpineol, nerol, geraniol, damascenon, squalen, aromatic acids (benzoic, salicylic), rutin. In vegetative organs established nonanale, α-terpineol, trans-linalool oxide, cis-linalool oxide, 4-vinile-2-methoxyphenol, damascenon, ionone-5,6-epoxide, squalen, hexacosane, aromatic acids (benzoic, p-coumaric, p-hydroxybenzoic, chlorogenic), flavonoids, luteolin, vitexin, naringenin, germarin, catechin [15].

The chemical profile of generative organs of the genus Prunus L. is represented by nerol, limonene, squalene, quercetin, hyperoside and rutine. For vegetative organs, the most characteristic are squalene, chlorogenic acid, isoqueretine, quercetin, avicularine, rutine [16].

Practically in all investigated objects are identified fumaric, oxalic, malonic, levulinic, succinic, malic, ascorbic, citric acids.

7. Conclusions from the conducted research and prospects for further development of this field

The chemotaxonomic study of the genera Crataegus L., Malus Mill., Cerasus Juss., Prunus L.
was carried out and promising species were identified as a sources of BAS. According to the chemical composition of generative and vegetative organs the Cpa and Cga are determined. Established chemical profiles of vegetative and generative organs of the genera, as well as the main groups of taxons. The promising hawthorn species was added to complex «Kratophyt».

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