

## Morphological variability, biochemical parameters of *Hippophae rhamnoides* L. berries and implications for their targeted use in the food-processing industry

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The results of studying the morphological and biochemical parameters of plants of sea buckthorn are presented. For the first time, genotypes of sea buckthorn ranked by ontogenetic and morphological characteristics and ecological features (relation to the level of soil moisture and humidity air, providing soil nutrients, its pH, amount and mode of precipitation, lighting, positive and negative temperatures) natural, semi-natural and anthropic coenopopulations genotypes of sea buckthorn be ranked by ecomorphic affiliation to certain climate ecotypes (polissia, forest-steppe) and subecotypes (western-forest-steppe, northern-forest-steppe, polissia-forest-steppe, central-forest-steppe).

Biotypes, that have been a limited ability to carry soil and atmospheric drought (in which the root system is well developed, ground part with copious leaf cover), selected in natural and semi-natural places of growth appertain to mesophytes (Ms). The genotypes, selected in catchment areas, the lowlands of Forest-Steppe, Polissia of Ukraine, appertain to mesohydrophytes (MsHg) (by morphological and physiological features characterized by weak drought and heat resistance – 6 points, require sufficient moisture and sufficient provision of organic and mineral substances, are weak frost resistant, but very resistant to temperature changes during the winter). A special group makes up widely ecological flexibility mesophyte plants of sea buckthorn – mesoxerophytes (wfMsKs) – are presented polissia-forest-steppe subecotype, characterized by wide environmental plasticity, due to the high winter, drought and frost resistance, compared to others subecotype. Its have adapted to withstand prolonged of soil and air in the extreme phases of ontogeny, in particular, in the phase of fruit filling and ripening, giving high stable harvest. Particular breeding and economic value in terms of formation stably high yields under conditions of global climate change, its aridization and displacement borders zoning of fruit crops have xeromesophytes (KsMs) presented central forest-steppe subecotype – in view of the its relatively average demanding to soil and air moisture and resistance to moisture deficiency. Highlighted forms – sources of valuable economic features of sea buckthorn (large berry, firm skin, long berry peduncles and dry separation of berries and its increased biological value, freezing capacity and making beverages, high yields).

**Keywords:** sea buckthorn, ecotype and subecotype, biometric indicators, quality of soft fruit berries by biochemical and technological criteria.

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### Introduction

The genus of sea buckthorn (*Hippophae* L.) – includes perennials, related to the family *Elaeagnaceae* Lindl, order *Rosales* L. and combines three types of: sea buckthorn (*H. rhamnoides* L.), sea buckthorn willow-leaved (*H. salicifolia* Don.) and sea buckthorn tibetan (*H. tibetana* Schlecht). Until recently, genus *Hippophae* L. was represented by only two species: *H. rhamnoides* L. and *H. canadensis* L., the last was later classified as a separate genus *Schepherdia* Nutt. (Mikolajko & Shlapak, 2014).

According to another classification, by markers DNA chloroplasts this genus has 6 species and 12 subspecies (Chen et al., 2003; Ulf & Bartish, 2008; Moskalets et al., 2019):

1. *H. salicifolia* Don.;
2. *H. rhamnoides* L. (subsp. *carpatica* Rousi, subsp. *caucasica* Rousi, subsp. *fluviatilis* van Soest, subsp. *mongolica* Rousi, subsp. *rhamnoides*, subsp. *sinensis* Rousi, subsp. *turkestanica* Rousi, subsp. *yunnanensis* Rousi);
3. *H. goniocarpa* (Lian) X.L. Chen & K. Sun (subsp. *litangensis* Lian & X.L. Chen, subsp. *goniocarpa* Lian);
4. *H. gyantsensis* (Rousi) Lian;
5. *H. neurocarpa* S.W. Liu & T.N. He (subsp. *stellatopilosa* Lian & X.L. Chen, subsp. *neurocarpa* S.W. Liu & T.N. He);
6. *H. tibetana* Schlecht.

Also, scientists (Sheng et al., 2006; Ulf & Bartish, 2008) suppose that subspecies *H. goniocarpa* is advisable to recognize as a species *H. litangensis*, because these representatives are non-monophylogenetic (Mikolajko & Shlapak, 2014). Scientists of China (Chen, et al., 2003; Chen, et al., 2014) described a new seventh species (*Hippophae rhamnoides* subsp. *wolongensis* Y.S.) and they offered to carry its to genus *Hippophae* L.

Today, sea buckthorn – is a species that is once again in the circle of scientific research (Ulf & Bartish, 2008; Chen et al., 2014; Hakeem et al., 2018). In particular, in the branch of ecology, breeding and genetics, food and processing industry, medicine. Its fruits, leaves and the bark of shoots as a valuable vitamins and energy, adaptogenic product in the market of many countries of the world, is very popular and the purchase price, which determines the laying of industrial plantations (Pantelieieva, 2006; Skalski et al., 2018; Moskalets et al., 2019 A). The most common fruit processing products are sea buckthorn oil, cider, wine, jelly, sauces, jams, marmalade, juices – not replaceable components of healthy eating (Litovchenko & Kuznetsov, 2019; Tkachenko et al., 2019).

It's worth noting that plantations of sea buckthorn play an important role as forest ameliorants, protecting the soil from wind and water erosion (Bobyliov et al., 2014; Grynyk et al., 2018). But interest to *H. rhamnoides* in Ukraine is low, because above 90 % all its plantations are concentrated in the area of fallow lands, forest strips and natural tracts (coastal area at the mouth of the Danube), remainder – partly in private households and in private industrial gardens (Cherkasy, Chernihiv, Kyiv, Volyn, Ternopil, Poltava and other regions) (Moskalets et al., 2019 C). In 'State register of plant varieties suitable for dissemination in Ukraine' as of December 2019 sea buckthorn included eight varieties (Grynyk et al., 2018; State register of plant ..., 2019), which opens up opportunities for its industrial cultivation and providing food, processing and pharmaceutical industry raw materials. Considerable environmental flexibility of sea buckthorn allows its to be introduced in different soil and climatic conditions, but performance adaptation highlights some of the environmental niches inherent in its, where the most complete productive biological potential is revealed in time (Pantelieieva, 2006; Sheng et al., 2006). In connection with global climate change the selection of genetic diversity is needed *H. rhamnoides* L. as high and as a narrow ecological plasticity to environmental conditions, that will help more successful address introductions new genotypes. In this regard, breeding work with formation of new ecological-adaptive, high-yielding genotypes of sea buckthorn with high economically valuable properties of berries is relevant.

**The purpose** of our research was to conduct an expedition monitoring natural, semi-natural and anthropic coenopopulations of sea buckthorn by ontogenetic and morphological features and pick perspective forms by economically valuable features for further selection, including by quality of berries for processing and targeted use of raw materials.

The research tasks were:

- to conduct an expedition monitoring natural, semi-natural and anthropic coenopopulations of sea buckthorn different ecotopes of Ukraine;
- to investigate ontogenetic and morphological features of plants;
- to rank the studied genotypes of *H. rhamnoides* by ecotypes (polissia, forest-steppe) and subecotypes;
- to determine the organoleptic, biochemical, technological indicators of berries;
- to carry out selection of perspective forms of sea buckthorn by basic economic and valuable features for further selection and find out the suitability berries raw materials for target production products of functional purpose.

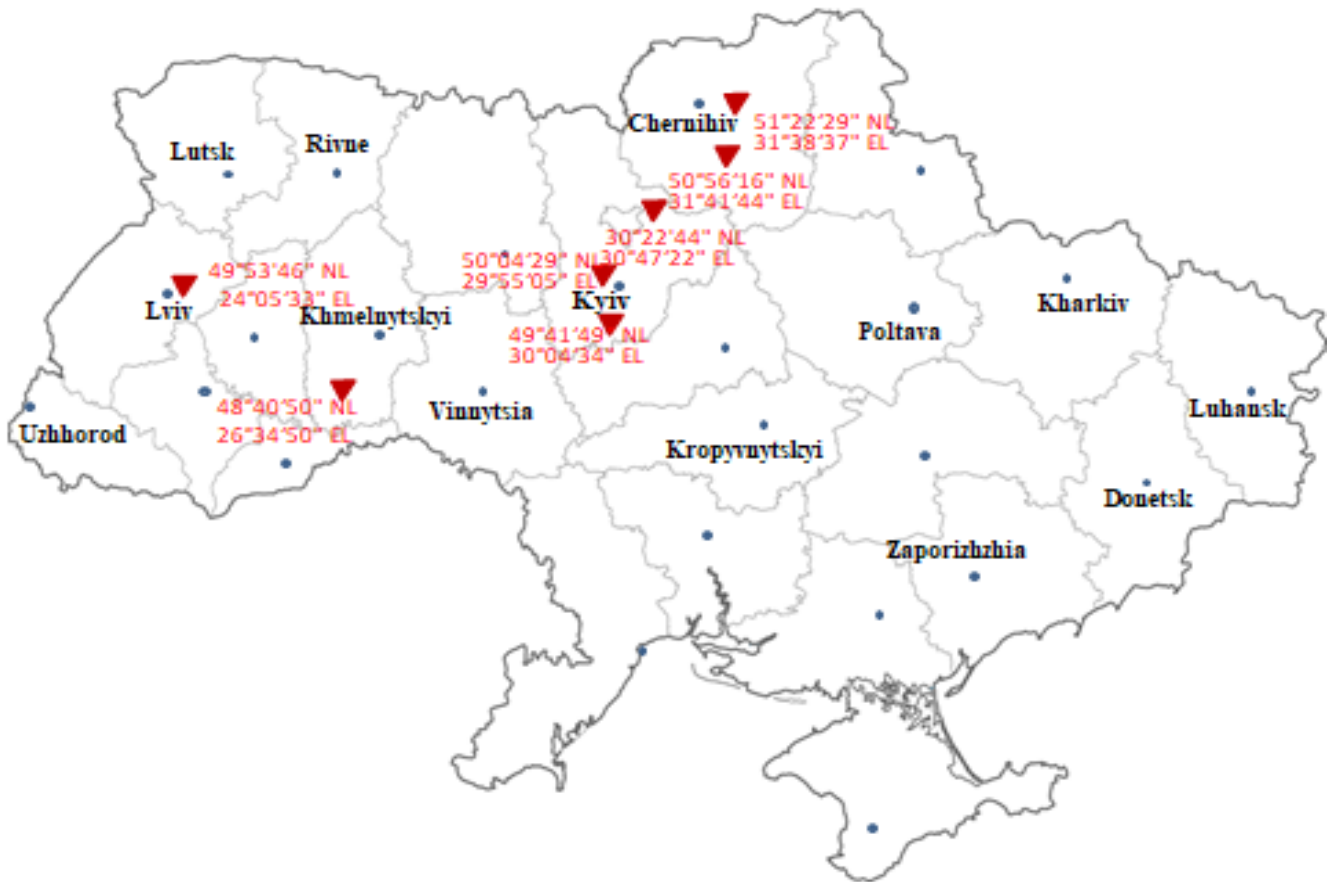
The objects of our research were genotypes, clones, varieties and populations of sea buckthorn of natural, semi-natural and anthropic ecosystems, berries and products of their processing.

## Materials and Methods

The study was conducted 2015–2019 in the condition of Polissia, Forest-Steppe of Ukraine (Figure 1), which differed in weather and climatic conditions. In particular, on the value of the average temperature for the year (7.3–8.4 °C – in Polissia; 6.4–7.8 °C in Polissia-Forest-Steppe; 7.6–9.3 °C – in the central part of the Forest-Steppe; 7.4–8.6 °C in the Western Forest-Steppe); by the value of positive air temperatures > 5°C (2910–3200 °C – in Polissia; 2775–3080 °C in Polissia-Forest-Steppe; 2990–3410 °C – in the central part of the Forest-Steppe; 2925–3190 °C – in the Western Forest-Steppe), average rainfall per year (670–994 mm in Polissia; 550–700 mm – in Polissia-Forest-Steppe; 575–615 mm – in the central part of the Forest-Steppe; 572–769 mm in the Western Forest-Steppe), according to the GTC value and the duration of the growing season – average daily air temperatures 5°C and above (207–218 days – in Polissia, 200–210 days – in Polissia-Forest-Steppe, 209–227 days – in the Western Forest-Steppe, 207–227 days – in the central part of the Forest-Steppe).

The research conditions were different by the mechanical and physico-chemical composition of the soil (sod-mid-podzolic with such agrochemical characteristic: pH – 4.3–5.6; easily hydrolyzed nitrogen – 8–97 mg/kg, P<sub>2</sub>O<sub>5</sub> (by Chirikov) – 19–53 mg/kg, K<sub>2</sub>O (by Chirikov) – 46–102 mg/kg in soil; humus – 1.2–1.8 % (by Tiurin) – in Polissia. In Polissia-Forest-Steppe – chernozem is a deep low humus leached loam; pH – 4.0–5.5; easily hydrolyzed nitrogen – 71–119 mg/kg, P<sub>2</sub>O<sub>5</sub> – 84–109 mg/kg, K<sub>2</sub>O – 33–75 mg/kg in soil; humus – 2.5–3.2 %. In the central part of the Forest-Steppe – the soil is dark gray podzolic: easily hydrolyzed nitrogen – 53–89 mg/kg, P<sub>2</sub>O<sub>5</sub> – 117–153 mg/kg, K<sub>2</sub>O – 76–111 mg/kg in soil; in the Western Forest-Steppe – light gray forest sandy large dusty

the content of total humus 1.1–2.3 %, pH – 4.6–5.5, easily hydrolyzed nitrogen – 78–134 mg/kg, P<sub>2</sub>O<sub>5</sub> – 80–115 mg/kg, K<sub>2</sub>O – 67–110 mg/kg in soil).



**Figure 1.** Geolocation data of the route for collecting plant forms of sea buckthorn

Clones of sea buckthorn plants laid in the base nursery-garden of the Institute of Horticulture NAAS (soil dark gray podzolic, content of total humus 2.3 %, pH – 5.9; easily hydrolyzed nitrogen – 89 mg/kg, P<sub>2</sub>O<sub>5</sub> – 153 mg/kg, K<sub>2</sub>O – 111 mg/kg in soil). Care of the experimental plants was carried out by applying common agricultural measures. Protection measures from pests and pathogens were not conducted. Phenological observations in plant growth and development, and biometric indicators (weight of berries, its number on II-III year shoots, etc.) determined by methods of the State commission of Ukraine for testing and protection of plant varieties. The berries were harvested by hand, performance accounting – weighted method. All biometric indicators of the plants carried out in the middle part of the crown on the south side. Annual shoots measured from their base and the beginning of a typical spine on top of the shoot. The berryful two-year branches were measured from their base and to the branch point the highest upper one-year shoot. The degree number of spines of plants was scored on a 5-point scale.

The ecomorphic characterization of plants was carried out by A. Belgard (1971) and V. Tarasov (2005). Phenological observations marked from the third growing year after planting and noted the date of onset of such phenophases: the beginning of flowering buds; the beginning and duration of flowering; occurrence of technical maturity of berries. Based on the data of occur technical maturity the varieties share on: very early, early, medium maturity, late, very late maturity. The growth force is determined visually, watching the shoots continue the skeletal branches II and III levels on scale: 3 – weak growth of young plants in Forest-Steppe – less 50 and 45 cm, in Polissia – less 40 cm, fruit-bearing plants in all zones – less 25 cm; 5 – average growth of young plants in Forest-Steppe – 40–60 cm, in Polissia – 30–40 cm; fruiting plants in Forest-Steppe – 25–45 cm, in Polissia – 25–35 cm; 7 – strong growth of young plants in Forest-Steppe – above 60 cm, in Polissia – 40 cm; fruit-bearing plants respectively – above 35 cm.

The shape of the crown is distinguished by the following basic types: rounded, pyramidal, wide, cone-shaped. The density of the crown is determined visually: not dense, moderately dense, dense and very dense. Productivity of sea buckthorn plants was determined by the formula:  $Y = A * B * C * N * L$ ,

where Y – the weight of berries one plant;

A – medium weight of berries, g;

B – medium number of berries per inflorescence, pcs.;

C – medium number of inflorescences with berries on 10 cm long second year shoot (take into account 10 shoots that vary in length);

N – total number shoots berries from a plant (take into account at the beginning of the growing season), pcs.;

L – medium length of shoots berries (take into account at the beginning of the growing season), cm.

Differentiated berries by size, depending on the weight of 100 pieces: little – 50 g, middle – 50–70 g, big – 80–100 g, very big – more 100 g. Tasting evaluation of berries was performed according to organoleptic parameters on a set of taste (appearance,

consistence, taste and aroma of berries. Was adopted 9-point scale: 9 – berries above excellent quality, 8 – berries of excellent quality, 7 – berries above good quality, 6 – good quality berries, 5 – berries above satisfactory quality, 4 – berries of satisfactory quality, 3 – berries of poor quality, 2 – berries of very poor quality, 1 – the berries are completely unsuitable for consumption. The solids content was determined weighted method according to SSU 7804:2015 (2015); content of total sugars – photocalorimetric method on the photocalorimeter KFK-3-01 – to SSU ISO 4954:2008 (2009); organic acids – by titration with 0.1 n NaOH in terms of malic acid – to SSU 4957:2008 (2009); vitamin C – to restore the Tillmans reagent, by extraction acid solution of sample berries followed by filtration of the resulting substrate titrometric method according to SSU 7803:2015 (2015); content of  $\beta$ -carotene – by paper chromatography with the follower photoelectrocolorimetry to SSU 4305:2004 (2005); content of polyphenolic compounds – using the Folin-Dennis reagent spectrophotometric method on the spectrophotometer Spekol 1500 at a wavelength of 270 nm with a photometric accuracy of 0.004 to SSU ISO 4373:2005 (2006; Kucherenko, 2001); content of pectic substances – spectrophotometrically to SSU ISO 8069:2015 (2017). The suitability of sea buckthorn berries to freeze determined by loss of its weight during prolonged storage in the frozen state (180 days). Biochemical analyzes were performed in 4<sup>th</sup> repetition in each variant of the experiment.

For DNA extraction of plants sea buckthorn and for the construction of molecular genetic profile was used: lysis CTAB buffer from PVP (20 g/l CTAB, 1.4 M NaCl, 20 mM EDTA, 100 mM Tris-HCl pH 8.0, 20 g/l PVP, 40.5 mM ascorbic acid, 4.0 mM DIECA); mixture – chloroform:isoamyl alcohol (24:1); isopropanol; 70 % ethanol; TE buffer (10 mM Tris-HCl, pH 8.0, 1 mM EDTA). Total DNA from plant material was isolated by CTAB by the express method (cetyltrimethylammonium bromide). To determine the size of products used a molecular weight marker GeneRuler™ DNA LadderMix (ThermoScientific) (the size of the amplicons 1000, 500 b.p.). Electrophoresis time was chosen from 2 to 4 hours. To get an image gels were used UV light source and camera 'Canon'. The resulting image was processed using a graphical editor GIMP. Selection of DNA markers and primer design, characterization of their loci conducted by markers SSR primers (Garg et al., 2011).

The differences between the values in the control and experimental groups determined using the ANOVA, where the differences considered significant at  $P < 0.05$  (with Bonferroni correction). The results were defined as means  $\pm$  standard error ( $\bar{x} \pm SE$ ). The standard error of the mean ( $SD\bar{x}$ ) was calculated using analysis of variance subject to the Bessel's correction, because took a small sample ( $n \leq 16$ ).

## Results and Discussion

As a result of the expeditionary studies during the 2015 – 2019 in the conditions of Forest-Steppe and Polissia of Ukraine (Figure 1), the selected source material of sea buckthorn of natural and semi-natural origin. Sea buckthorn is dioecious plant, meaning that the male and female flowers grow on different shrubs. The sex of seedlings can only be determined at the first flowering, which mostly occurs after 3–4 years. The male inflorescence is built up of four to six apetalous flowers, while the female inflorescence normally consists of only one apetalous flower and contains one ovary and one ovule. Fertilization occurs solely via wind pollination, which is why male plants need to be planted near the female plants to allow for fertilization and fruit production.

We found out that the genetic diversity of *H. rhamnoides* selected in different growth conditions (forest strips, fallows, forest edges) has high morphological variability by habitus, crown shape; color and size of leaves, berry, shoot (Table 1).

**Table 1.** Ecological features and morphological characteristics natural and cultural forms of sea buckthorn (♀ – female individual; ♂ – male individual; h – the height of middle age generative individuals. Ms – mesophytes; Ks – xerophytes; KsMs – xeromesophytes; wfMsKs – widely ecological flexibility mesoxerophytes (mesophyte, withstand prolonged drought of soil and air in the extreme phases of ontogeny); MsHg – mesohygrophytes; OItr – oligotrophs; MsTr – mesotrophs; OIMsTr – oligomesotrophs; MsMgTr – mesomegatrophs; He – heliophytes; ScHe – scioheliophytes. '++' – strong, in the form of solid thickets; '+' – alone thickets; '-' – thickets absent.

N	Name of Form, Variety, Number of National Catalog	Life Forms	Ecomorphic Characteristics	Sex	height, m	Placing Branches	Form, Type of Crown	Prickly Thorns (Spines), Point	Formation Thickets Bush or Tree
1	2	3	4	5	6	7	8	9	10
2	Form 2-12-4 ('Obriy') (UA 3700086)	tree	MsTr, wfMsKs, He	♂	8.7	semi-vertical	oval, compact	0	+
3	Form 1-10-11 ('Oliana') (UA 3700085)	tree	MsTr, wfMsKs, He	♀	5.3	semi-vertical	conical, compact	1	+
4	Form 1-2-500 ('Nadiyna') (UA 3700087)	tree	MsTr, MsHg, He	♀	5.9	semi-vertical	oval, compact	2	-
5	'Morkviana' (UA 3700077)	bush	MsTr, MsHg, He	♀	3.1	semi-vertical	oval, spacious	3	++

1	2	3	4	5	6	7	8	9	10
6	'Dublianska osin'	bush	MsTr, MSHg, He	♀	4.2	semi-vertical	conical, spacious	3	++
7	Form 1-15-8 B ('Osoblyva') (UA 3700083)	bush	OIMsTr, wfMsKs, He	♀	4.6	semi-vertical	conical, compact	4	+
8	Form 1-15-5 ('Adaptyvna') (UA 3700078)	bush	OIMsTr, wfMsKs, He	♀	5.0	semi-vertical	conical, compact	3	+
9	Form 1-15-9 ('Karotylna') (UA 3700082)	bush	OIMsTr, Ms, He	♀	4.5	semi-vertical	conical, compact	3	+
10	Form 5-17-144	bush	OIMsTr, MSHg, SChе	♀	3.9	semi-vertical	wide oval, spacious	1	+
11	'Bilotserkivska osinnia'	bush	MsMgTr, KsMs, He	♀	4.3	semi-vertical	oval, spacious	2	+
12	Form 8-18-32	tree	MsMgTr, wfMsKs, He	♂	8.5	vertical	conical, compact	0	++
13	'Aboruhен 6-11' (UA3700080)	bush	OIMsTr, wfMsKs, SChе	♂	5.7	vertical	conical, compact	4	+
14	Form 3-15-17	bush	OIMsTr, wfMsKs, SChе	♂	7.8	semi-vertical	conical, spacious	4	+
15	'Strumkovyi dublianskiy 1-19-1'	tree	MsTr, MSHg, SChе	♂	8.5	semi-vertical	conical, drooping	0	+
16	'Aboruhен 7-11'	bush	OIMsTr, wfMsKs, He	♂	6.2	vertical	conical, compact	4	++
17	'Aboruhен nosivskiy 2-11'	bush	OIMsTr, wfMsKs, He	♂	5.5	vertical	conical, compact	3	+
18	'Zapyliuvach Hachyka dublianskiy'	tree	MsTr, MSHg, SChе	♂	11.4	semi-vertical	conical, drooping	0	-
19	'Adam'	bush	MsTr, MSHg, SChе	♂	2.2	semi-vertical	oval, compact	0	-
20	'Pollmix'	bush	OIMsTr, MSHg, SChе	♂	3.7	semi-vertical	conical, compact	3	-
21	'Solodka zhinkka'	tree	MsMgTr, KsMs, He	♀	4.3	semi-vertical	oval, compact	1	+
22	'Chuiskaia'	tree	MsTr, KsMs, SChе	♀	3.9	semi-vertical	oval, compact	1	+
23	Form 1-15-8 D	bush	OIMsTr, wfMsKs, SChе	♀	4.1	semi-vertical	conical, spacious	3	++
24	Form 1-15-11 ('Lymonna')	bush	OIMsTr, MSHg, SChе	♀	5.5	semi-vertical	wide oval, spacious	4	++
25	Form 1-15-6 ('Apelsynova')	bush	MsTr, wfMsKs, SChе	♀	6.8	semi-vertical	conical, spacious	3	++
26	'Tovarna'	tree	MsTr, KsMs, He	♀	6.0	semi-vertical	wide oval, spacious	1	-
27	'Shcherbinka 1'	tree	MsMgTr, KsMs, He	♀	4.0	semi-vertical	conical, compact	1	-
28	'Kulykivskiy'	tree	OIMsTr, MSHg, SChе	♂	5.3	semi-vertical	conical, spacious	2	-
29	1-15-4 ('Rankova')	Bush	OIMsTr, wfMsKs, SChе	♀	3.5	semi-vertical	wide oval, spacious	3	+
30	'Pahorbova'	Bush	MsTr, Ms, He	♀	4.0	semi-vertical	wide oval, spacious	2	+
31	'Muksh kytayhorodska'	Tree	MsTr, wfMsKs, He	♀	5.9	semi-vertical	conical, compact	3	+
32	Form 1-15-5 A ('Sribnolysta')	Bush	OIMsTr, wfMsKs, SChе	♀	3.8	semi-vertical	conical, compact	3	+
33	Form 1-15-8 C ('Mitsna')	Bush	OIMsTr, wfMsKs, SChе	♀	6.2	semi-vertical	wide oval, spacious	3	++

1	2	3	4	5	6	7	8	9	10
34	Form 1-15-8 V (‘Soniachne siayvo’)	Bush	OIMsTr, wfMsKs, He	♀	4.3	semi-vertical	conical, compact	4	+
35	Form 1-15-1 (‘Nosivchanka’)	Bush	OIMsTr, wfMsKs, He	♀	4.0	semi-vertical	conical, compact	4	++

Also observed variability by ontogenetic parameters: the duration of the growing season, time of onset of individual phases of development (budding, flowering, fruit ripening, leaf fall). Morphological studies of sea buckthorn allowed to discover different life forms of morphotypes, most of them are bushes (Form 1-15-8 B, Form 1-15-5, Form 1-15-9, Form 5-17-144, ‘Aboruhen 6-11’, Form 3-15-17, ‘Morkviana’, ‘Dublianska osin’), slightly less to tree-like (Form 1-10-11, Form 1-2-500, Form 2-12-4, Form 2-12-4, ‘Strumkovyi dublianskyi 1-19-1’, others), and based on the modeling experiments explore biotypes sea buckthorn by growth force and height, depending on the ecological growth zone.

We found that most bushes biotypes (Form 1-15-1, Form 1-15-5, Form 1-15-11, ‘Morkviana’, ‘Dublianska osin’) and some tree-like (‘Strumkovyi dublianskyi 1-19-1’, Form 1-10-11, Form 2-12-4) are characterized by the highest annual growth rates 0.88–1.11 and 0.73–1.29 m under the conditions of the Forest-Steppe and Polissia of Ukraine, respectively. This is important in terms of nursery, providing replication of genetically homogeneous material due to vegetative reproduction. The smaller growth force of other genotypes (Form 1-2-500, Form 1-15-9, Form 1-15-8 B, Form 1-15-8 D) allows to reduce manual work by care of plants in the case of growing them in industrial gardens.

It was found that the source material, selected in different ecological zones, differs in morphological features, and environmental specifics (relation to the level of soil moisture and humidity air, providing soil with nutrients, its pH, amount and mode of precipitation, lighting, positive and negative temperatures). This prompted them to be ranked by ecomorphic affiliation.

Biotypes, that have been selected in natural and semi-natural places of growth appertain to mesophytes (Ms), which have a limited ability to carry soil and atmospheric drought, in which the root system is well developed, ground part with copious leaf cover. Plants, selected from catchment areas, the lowlands of the Forest-Steppe, Polissia, which by morphological and physiological features characterized by weak drought and heat resistance (6 points), require sufficient moisture and sufficient provision of organic and mineral substances appertain to mesohygrophytes (MsHg): Form 1-2-500, ‘Morkviana’, ‘Dublianska osin’, Form 5-17-144, ‘Strumkovyi dublianskyi 1-19-1’, ‘Zapyliuvach Hachyka dublianskyi’, ‘Adam’, ‘Pollmix’, Form 1-15-11 are weak frost resistant, according to the data artificial freezing of tissues and buds not withstand temperatures above minus 35 °C. But these genotypes are very resistant to temperature changes during the winter.

A special group makes up widely ecological flexibility mesophyte plants of *H. rhamnoides* – mesoxerophytes (wfMsKs). These are forms and varieties: Form 2-12-4 (‘Obriy’), Form 1-10-11 (‘Oliana’), Form 1-15-8 B (‘Osoblyva’), , Form 1-15-5 ‘Adaptyvna’, Form 8-18-32, ‘Aboruhen 6/11’, Form 3-15-17, , Form 1-15-9 (‘Karotylna’), Form 1-15-8 D, characterized by wide environmental plasticity, due to the high winter, drought and frost resistance, compared to polissia ecotype (Form 5-17-144, ‘Kulykivskyi’) and forest-steppe ecotype (‘Shcherbinka 1’, ‘Chiuyskaia’, ‘Altayskaia’) and also compared to the central forest-steppe subecotype and west-forest-steppe subecotype (‘Morkviana’, Form 1-2-500 (‘Nadiyna’), ‘Pahorbova’, ‘Zapyliuvach Hachyka dublianskyi’, ‘Strumkovyi dublianskyi 1-19-1’). Widely flexibility mesoxerophytes (wfMsKs) in fact are mesophytes, but have adapted to withstand prolonged drought of soil and air in the extreme phases of ontogeny, in particular, in the phase of berries filling and ripening, giving high stable impressions under these conditions.

Among biotypes stands out a group of xeromesophytes (KsMs) – ‘Bilotserkivska osinnia’, ‘Solodka zhinkka’, given their relatively average requirement to soil and air moisture and resistance to moisture deficiency these biotypes can be attributed to separate central forest-steppe subecotype. It should be noted that this group of plants has a special breeding and economic value in terms of forming a consistently high yield in the face of global climate change, its aridization and displacement borders zoning of berries and fruit crops.

We found that genotypes differ by trophic, allowing them to be attributed to individual ecotrophomorphs. Thus, plants of polissia ecotype (Form 5-17-144, ‘Kulykivskyi’), pertain to oligomesotrophs (OIMsTr), since they are relatively medium demanding to the soil fertility conditions. Polissia-forest-steppe subecotype: Form 1-15-11 (‘Lumonna’), Form 1-15-6 (‘Apelsynova’), Form 1-15-8 C (‘Mitsna’), Form 1-15-5 (‘Adaptyvna’), Form 1-15-8 B (‘Osoblyva’), Form 1-15-8 V (‘Soniachne siayvo’) – are medium demanding, or mesotrophs (MsTr), and the western forest-steppe subecotype (Form 1-2-500, ‘Morkviana’, ‘Dublianska osin’, ‘Pahorbova’), and also central forest-steppe subecotype (‘Bilotserkivska osinnia’, ‘Solodka zhinkka’) are relatively demanding to soil fertility conditions and belong to mesomegatrophs (MsMgTr).

In relation to the level of illumination plants of ecotypes and subecotypes sea buckthorns also differed somewhat, moreover this features reflected in ontogeny and morphological characteristics, such as placement of branches vertical profile, color, leaf shape, leaf index, spines. In relation to the level of light the plant of sea buckthorn ranked on heliophytes (He) – light-loving, most of them are tree-shaped form (Form 2-12-4 (‘Obriy’), Form 1-10-11 (‘Oliana’), Form 1-2-500 (‘Morkviana’), Form 8-18-32 and others), in which the arrangement of the branches is semi-vertical, rarely happens vertically (‘Aboruhen 7-11’ ‘Aboruhen nosivskyi 2-11’).

To relatively light-loving – scioheliophytes (ScHe), who feel well in an open habitats, but can grow with little shading, we include bush forms with semi-vertical arrangement of branches, green and dark green color of leaves (‘Aboruhen 6-11’, Form 3-15-17, ‘Strumkovyi dublianskyi 1-19-1’, ‘Zapyliuvach Hachyka dublianskyi’, Form 1-15-8 D, Form 1-15-11 (‘Lumonna’), Form 1-15-6 (‘Apelsynova’), Form 1-15-4, (‘Rankova’) Form 5-17-144, Form 1-15-5 A (‘Sribnolysta’), Form 1-15-8 C (‘Mitsna’)).

The shape of the crown for most biotypes are: round, oval and conical, there are also drooping ('Zapyliuvach Hachyka dublianskyi', 'Strumkovyi dublianskyi 1-19-1'), compact (most forms), spreading ('Morkviana', 'Dublianska osin', Form 1-15-8 D, Form 1-15-6 ('Apelsynova'), 'Tovarna', Form 1-15-8C ('Mitsna'), Form 1-15-5 ('Adaptyvna') others); by density – tight ('Strumkovyi dublianskyi 1-19-1', Form 5-17-144); medium density (Form 1-10-11 ('Oliana'), 'Morkviana', Form 1-15-11 ('Lumonna'), Form 1-15-6 ('Apelsynova'), 'Tovarna'); density (Form 1-15-5 ('Adaptyvna'), Form 1-15-1 ('Nosivchanka')); very density shape of crown (Form 1-15-8 B ('Osoblyva'), 'Shcherbinka 1', 'Aboruhon 6-11', others).

Sea buckthorn's leaves vary in color. They are light green, green and dark green. It is found that among the natural, semi-natural genotypes of polissia, forest-steppe ecotypes and varieties are forms with different intensities of silvery shade of leaves, the presence and size of spines. The morphotypes selected in the Northern Forest-Steppe conditions are mostly small and average the number of spines. Diversity of Polissia, Western Forest-Steppe is representing wide range of morphological diversity of features. Among them are selected as small spines (Form 1-15-5 ('Adaptyvna'), Form 2-12-4 ('Obriy'), Form 1-10-11 ('Oliana'), Form 5-17-144, 'Strumkovyi dublianskyi 1-19-1', 'Tovarna') and forms with average the number of spines (Form 1-15-4 ('Rankova'), 'Bilotserkivska osinnia', 'Kulykivskyi', 'Pahorbova', Form 1-15-5 A ('Sribnolysta'), Form 1-15-8 C ('Mitsna'), Form 1-15-5 ('Adaptyvna'), Form 1-15-9 ('Karotynna').

Selected forms: 'Strumkovyi dublianskyi 1-19-1', Form 2-12-4 ('Obriy'), Form 8-18-32, 'Zapyliuvach Hachyka dublianskyi', which by life form – are tree, and by biometric parameters, reach heights above 4.5 m is important because of the lack of root shoots, because intensive formation root overgrowth require additional measures for their destruction, which is undoubtedly in bush forms leads to death (through 6–7 years) of central plant. High growth is another adaptation feature sea buckthorn plants due to the height, increase the area of distribution of dust.

However, bush shape forms ('Aboruhon 7-11', 'Aboruhon nosivskyi 2-11', 'Zapyliuvach Hachyka dublianskyi', 'Adam', 'Pollmix') have their advantages over the tree-like pollinators ones, namely high regenerative capacity of ground part, resistance to adverse abiotic environmental factors, high pollen viability. That is important in analytical and synthetic breeding in the creation of high pollen productivity male varieties of sea buckthorn. Among the studied plants should be noted the tree forms without spines, usage which as pollinators allows to get a little spines or without spines hybrid material, and also in industrial gardens reduce the number of male forms by 8–16 % per unit area at the expense smaller the area of supply, compared to the bush forms.

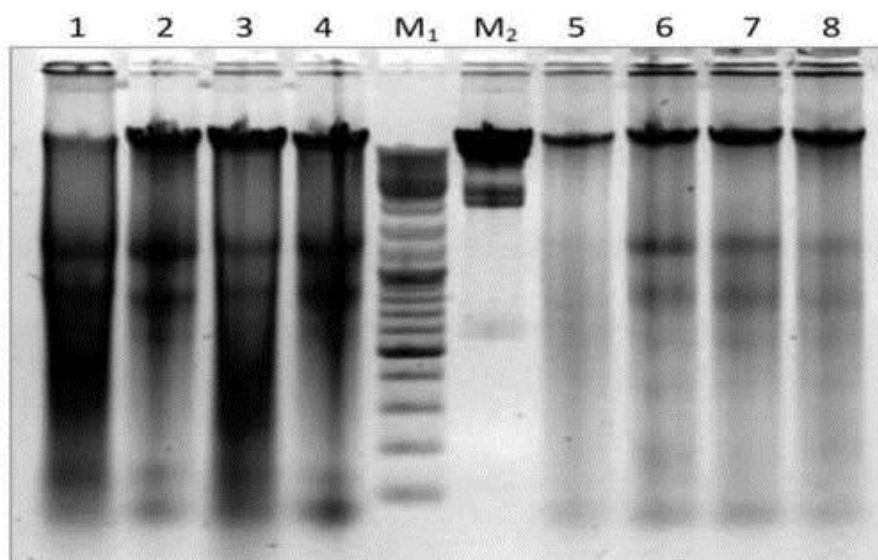
So, results of the study of natural, semi-natural populations of *H. rhamnoides* in different physical-geographical zones of Ukraine (Polissia, Forest-Steppe) by morphological features, ontogenetic and ecological characteristic made it possible to assign them to specific climatic ecotype and subecotype – as separate groups cenopopulations, selected from a certain part of a separate area, formed under the influence of specific climatic, soil conditions. That's ranking of plants is important for using its in target synthetic breeding, obtaining a new hybrid material and its successful address (targeted) introduction.

Considering that, the selected material of the sea buckthorn though different among themselves, we, after all, referred to species *H. rhamnoides* subspecies *rhamnoides* and *carpatica*, which is clearly different from other subspecies (*caucasica*, *fluviatilisvan*, *mongolica*, *sinensis*, *turkestanica*, *yunnanensis*).

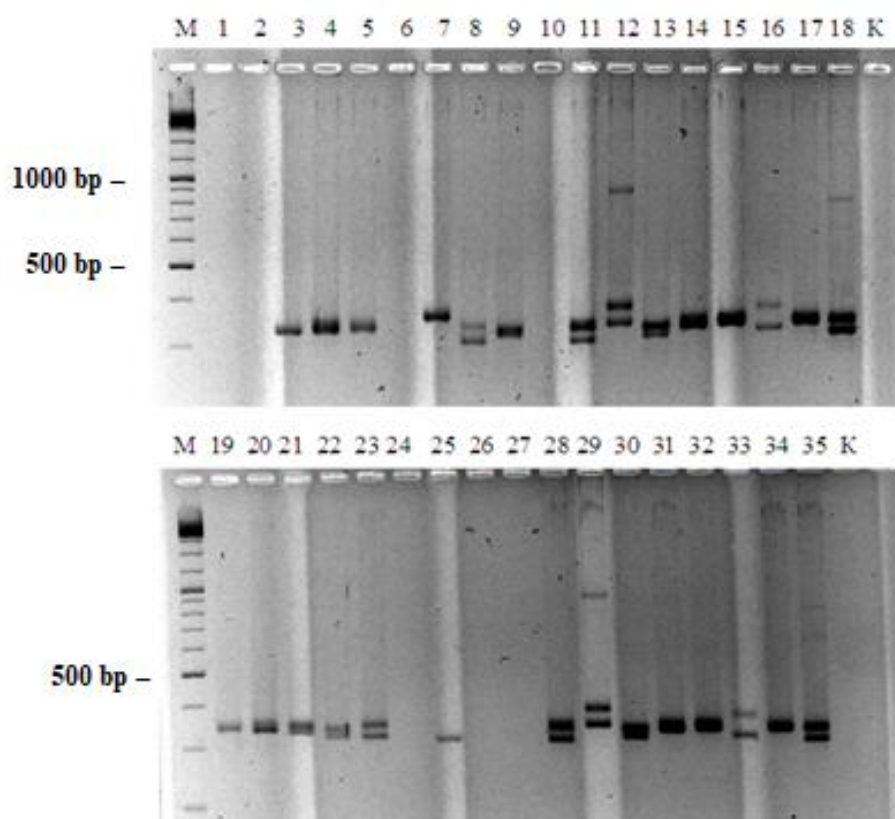
Genetic and epigenetic differences between ecotypes and subsubtypes of *H. rhamnoides* fixed and inherited from generation to generation, causing changes in the phenotype under the influence environmental factors, causing the emergence of new different biotypes, search and detection of which are important in analytical and synthetic selection. According to some scientists (Chen et al., 2003), plants of sea buckthorn inherent low environmental sustainability, in particular during the introduction in adverse soil and climatic conditions, in particular, heavy soils, in which plants are often affected pathogens and pests, they are exhausted and fall out. The most susceptible to the impact of adverse ecological factors – male pollinating plants. And, most importantly, their underestimation leads to significant losses productivity of female plants in industrial conditions.

PCR analysis by nucleic acid electrophoresis in agarose gel (Figure 2, 3) made it possible to explore the intraspecific difference of new forms, selected analytical way, compared to existing varieties and set the affinity range between them (Figure 4), and to detect genetic polymorphism investigated sea buckthorn geneplasm. As a result of using 5 DNA markers for molecular genetic characteristics sea buckthorn – the most polymorphic markers were HrMS025 and HrMS026, other markers also appear in all samples, but they are more monomorphic. Conducting electrophoresis in 2.5 % agarose gel (1×LB buffer + ethidium bromide) allowed to get electrophoregrams with a clear image of the fragments nucleotide sequences by 500, 1000 base pairs (Figure 3). Analysis of family relationships of the phylogenetic tree made possible to discover genetic identity such samples, which are distributed 5<sup>th</sup> affinity groups: *I group*: Form 8-8-32, Form 8-18-33, variety 'Lybid' and Form 2-15-174; *II group*: Form 3-15-17 and variety 'Solodka zhinka'; *III group*: Form 1-15-5 A ('Sribnolysta') and Form 1-15-5 ('Adaptyvna'); *IV group*: varieties 'Nivielena', 'Moskvichka' and 'Obilnaia'; *V group*: Form 1-15-8 V ('Soniachne siayvo') and Form 1-15-5 B ('Osoblyva'). Other varieties and forms included in the list of samples studied are heterogeneous and individuals.

The next task of our work was the estimation of berries new forms of *H. rhamnoides* by biochemical parameters and their suitability for storage. Biochemical analysis of sea buckthorn berries showed that all the new forms and varieties under study have a high solids content, and their amount varies within 14.9–25.6 %. The highest content of the total soluble solids content of the berries (more than 11 %) accumulate berries of 'Hergo' (*st*), 'Sribnolysta', 'Mitsna', 'Pamiatka', 'Nosivshanka' (Table 2).



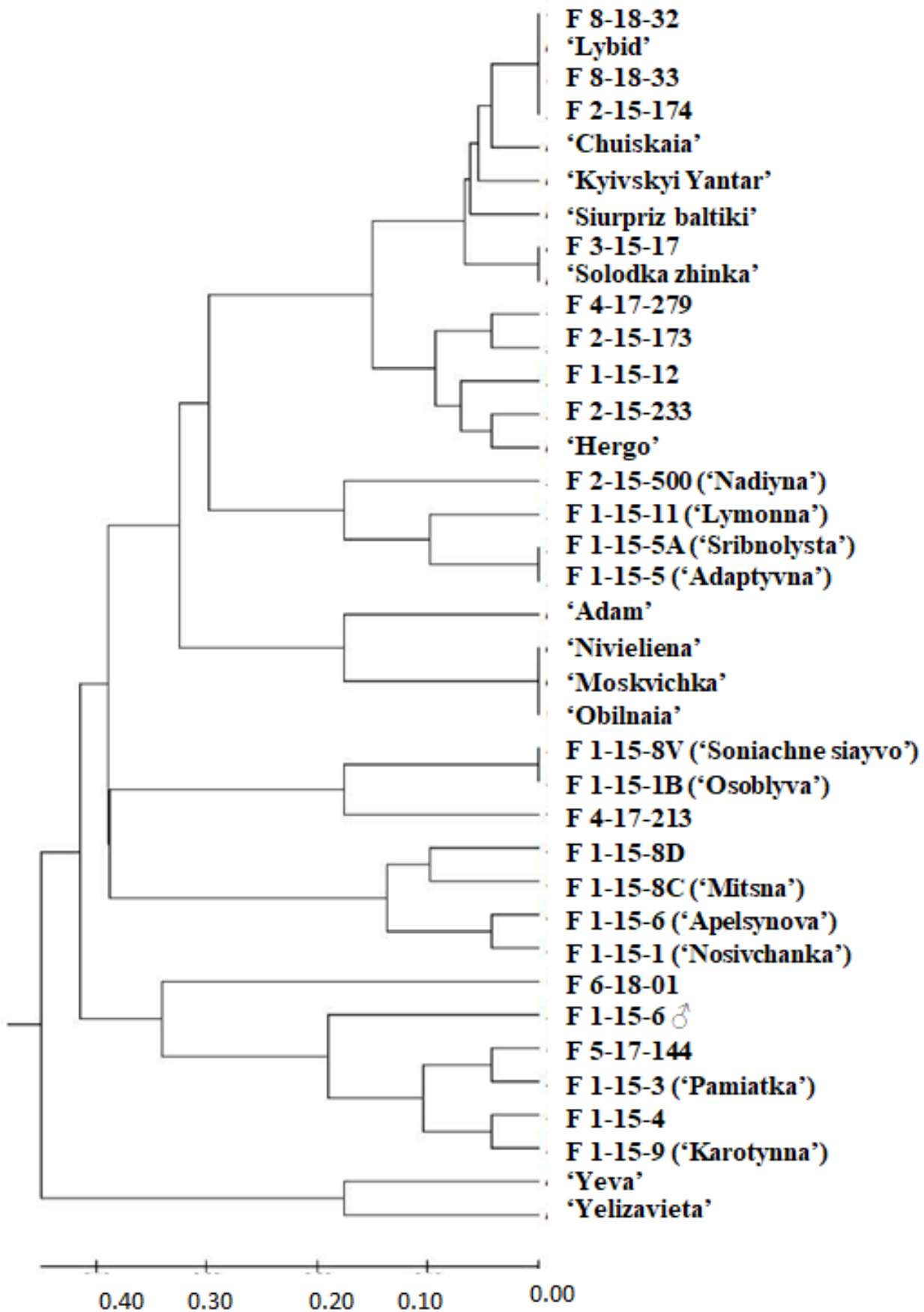
**Figure 2.** Electrophoregram total DNA samples of sea buckthorn in 1.0 % agarose gel with 1xLB electrode buffer: **1** – Form 6-18-01; **2** – Form 4-17-279; **3** – Form 3-15-17; **4** – Form 5-17-144; **5–8** – total wheat DNA as a control; **M<sub>1</sub>** – marker molecular mass of DNA LadderMix; **M<sub>2</sub>** – marker molecular mass of DNA A/HindIII



**Figure 3.** Electrophoregram products amplification of system HrMS025F/ HrMS025R: **M** – control marker molecular mass; **1** – Form 2-15-174; **2** – Form 8-18-33; **3** – ‘Yeva’ (st); **4** – ‘Nivieliena’; **5** – ‘Moskvichka’; **6** – ‘Lybid’; **7** – ‘Yelizavieta’; **8** – ‘Adam’ (st); **9** – ‘Hergo’ (st); **10** – ‘Solodka zhinka’ (st); **11, 28** – ‘Oliana’; **12, 29** – Form 4-17-279; **13, 30** – Form 5-17-144, **14, 31** – ‘Aboryhen 6/11’; **15, 32** – ‘Lymonna’; **16, 33** – Form 2-15-233; **17, 34** – ‘Adaptyvna’; **18, 35** – ‘Apelsynova’; **19** – ‘Obilnaia’; **20** – ‘Karotylnna’; **21** – Form 1-15-8 D, **22** – Form 1-15-3 (‘Pamiatka’); **23** – Form 1-15-1 (‘Nosivchanka’); **24** – Form 8-18-32; **25** – ‘Siurpryz baltyky’; **26** – ‘Kyivskiy yantar’; **27** – ‘Chuiskaia’ (st); **K** – negative control (without DNA)

One of the most common and numerous classes natural compounds exhibiting biological and antioxidant activity are polyphenols. The amount of polyphenolic substances in berries of the investigated varieties and hybrids of sea buckthorn varies from 1540 to 3946 mg/kg, coefficient of variability, high  $V = 57\%$  (Table 3). More 3000 mg/kg these compounds accumulate the berries of the varieties: ‘Oliana’, ‘Adaptyvna’, ‘Morkviana’, ‘Osoblyva’, Form 1-15-8 D, ‘Soniachne siayvo’, ‘Pamiatka’. Enough high content of polyphenols in berries ( $\geq 1000$  mg/kg) and flavonoids (1620–2410 mg/kg) makes possible to use berries these samples as raw materials for the production of products therapeutic and prophylactic purpose (juices, sauces, smoothies, jellies, pastels, yoghurts, etc.).





**Figure 4.** Phylogenetic tree, built on the basis of the conducted molecular genetic analysis forms and varieties of sea buckthorn

**Table 2.** Biochemical composition of berries of selected forms and varieties of sea buckthorn (n = 4), during 2017–2019

N	Variety, Form	Total Solidst	Total Soluble Solidst	Titration Organic Acids	Total Sugars	Vitamin C**, mg/kg	Pectic Substances, %		
							Hydro-pectin	Proto-pectin	The Total Number
1	'Hergo' (sđ)	22.5 ± 0.3	11.8 ± 0.2	2.1 ± 0.1	3.7 ± 0.1	118 ± 6.4	0.04	0.48	0.52 ± 0.03
2	Form 1-10-11 ('Oliana')	14.9 ± 0.4	8.3 ± 0.2	2.3 ± 0.1	5.8 ± 0.2*	106 ± 7.5	0.05	0.46	0.51 ± 0.04
3	Form 1-2-500 ('Nadiyna')	25.2 ± 0.2*	12.1 ± 0.2	2.1 ± 0.1	4.4 ± 0.2*	129 ± 5.7*	0.05	0.59	0.64 ± 0.03*
4	'Morkviana'	19.8 ± 0.2	8.6 ± 0.3	2.3 ± 0.2	5.8 ± 0.1*	143 ± 4.6*	0.07	0.66	0.73 ± 0.05*
5	Form 1-15-8 B ('Osoblyva')	24.7 ± 0.3*	11.5 ± 0.1	4.4 ± 0.2*	6.2 ± 0.1*	60 ± 6.3	0.04	0.27	0.31 ± 0.02
6	Form 1-15-5 ('Adaptyvna')	21.7 ± 0.1	11.3 ± 0.2	4.2 ± 0.1*	5.8 ± 0.1*	72 ± 8.5	0.04	0.28	0.32 ± 0.03
7	Form 1-5-30 Z	25.6 ± 0.2*	11.1 ± 0.1	4.5 ± 0.3*	3.0 ± 0.1	100 ± 3.4	0.02	0.19	0.21 ± 0.04
8	Form 1-15-9 ('Karotynna')	19.7 ± 0.3	10.3 ± 0.2	4.2 ± 0.1*	4.4 ± 0.1*	71 ± 6.8	0.03	0.06	0.09 ± 0.02
9	Form 1-15-8 D	21.9 ± 0.1	11.5 ± 0.1	4.2 ± 0.1*	3.1 ± 0.1	98 ± 7.5	0.02	0.40	0.42 ± 0.04
10	Form 1-15-6 ('Apelsynova')	18.6 ± 0.1	9.3 ± 0.1	3.5 ± 0.1*	4.4 ± 0.1*	72 ± 4.4	0.03	0.44	0.47 ± 0.05
11	Form 1-15-8 V ('Soniachne siayvo')	22.1 ± 0.2	11.9 ± 0.3	4.7 ± 0.1*	3.6 ± 0.2	40 ± 9.8	0.03	0.23	0.26 ± 0.03
12	Form 1-15-8 C ('Mitsna')	22.9 ± 0.1	13.1 ± 0.2*	4.2 ± 0.2*	4.0 ± 0.1*	75 ± 3.5	0.04	0.14	0.18 ± 0.05
13	Form 1-15-3 ('Pamiatka')	25.6 ± 0.3*	12.9 ± 0.1*	4.7 ± 0.1*	3.2 ± 0.2	52 ± 8.5	0.05	0.25	0.30 ± 0.06
14	Form 1-15-1 ('Nosivshanka')	22.4 ± 0.2	13.1 ± 0.4*	4.5 ± 0.3*	3.4 ± 0.1	59 ± 2.8	0.07	0.15	0.22 ± 0.04
15	Form 1-15-5 A ('Sribnolysta')	23.9 ± 0.3*	13.8 ± 0.1*	4.4 ± 0.1*	4.7 ± 0.2*	68 ± 1.5	0.06	0.19	0.25 ± 0.02
16	Form 1-15-2	21.7 ± 0.2	13.4 ± 0.3*	5.5 ± 0.1*	3.6 ± 0.1	83 ± 3.4	0.03	0.25	0.28 ± 0.06
17	Form 1-15-11 ('Lymonna')	19.5 ± 0.2	10.5 ± 0.1	4.1 ± 0.1*	3.8 ± 0.1	92 ± 3.5	0.02	0.40	0.42 ± 0.04
	Medium-range	22.1 ± 0.2	11.6 ± 0.2	4.3 ± 0.2*	3.5 ± 0.2	107 ± 4.7	0.03	0.24	0.27 ± 0.03
	Min-max	14.9–25.6	8.3–13.1	2.8–5.5	3.0–6.2	40–143	0.02–0.07	0.06–0.66	0.09–0.73
	V, %	27	23	30	54	53	38	53	62

Note: \*P < 0.05 compared to the control (standart); V – coefficient of variability; \*\* – defined in the technical maturity of berries.

Berries of the varieties 'Oliana', 'Nadiyna', 'Morkviana', 'Osoblyva', 'Adaptyvna', 'Sribnolysta' and others contain the highest amount of total sugars compared to others – 4.4–6.2 %, in accordance. But their content offsets the high content of titrated acids (more 3.0 %), defining, respectively, low sugar-acid index (SAI) at the level 1.3–2.6 (table 3). Accumulation of high content of organic acids in berries, which have antioxidant properties, causes increase of resistance of plants to pathogens and pests, that also, extends technological capabilities obtaining regulatory safe organic raw materials for its multidisciplinary use.

Biochemical analysis showed that the berries of different ecological groups of *H. rhamnoides* are different by the accumulation of ascorbic acid. Content of vitamin C varies from 40 to 143 mg/kg. Should be noted, that varieties 'Hergo', 'Oliana', 'Nadiyna', 'Morkviana' have its content in 2–3 times higher than others. Positive impact of vitamin C increases on the human body in the presence of polyphenolic compounds, which have P-vitamin activity. Analysis of content pectic substances showed that content in berries hydropectin of selected forms and varieties don't exceed 0.07 %, protopectin 0.66 % (table 2), which is insufficient to obtain gelling products from berries of the above forms without adding thickeners. Given the high biological value and the limited shelf life of the berries of sea buckthorn, freezing is a universal way of processing them. For this need to find out which varieties are most suitable for freezing. Frozen berries can be used as raw material for further processing, in particular for making juices, sauces, compotes, jams, low alcohol drinks, food powders etc.

**Table 3.** Organoleptic and technological features of selected forms and varieties of sea buckthorn (n=4), during 2017–2019

N	Variety, Form	Berries weight, g	Productivity of plant, kg**	SAI	Polyphenolic Compounds, mg/kg	Juiciness of the Berries, %	Tasting Evaluation (point)	Suitability for Processing and Production of Target Products
1	'Hergo' (st)	0.5	9.5 ± 2.1	1.8	2890 ± 29.0	71	6.0	fruits pastilles; alcohol-free and low alcoholic beverages; sauces; filler for dairy, bakery and confectionery products
2	Form 1-10-11 ('Oliana')	0.7*	13.7 ± 1.8*	2.6*	3440 ± 21.9*	75*	6.2*	
3	Form 1-15-5 ('Adaptyvna')	0.3	11.4 ± 2.3	1.4	3160 ± 25.3*	77*	5.1	
4	Form 1-2-500 ('Nadiyna')	0.4	11.7 ± 1.5	2.1*	2880 ± 32.5	51	5.6	
5	'Morkviana'	0.9*	13.4 ± 1.6*	2.5*	3946 ± 22.6*	78*	6.5*	fruits pastilles; oil; sauces; filler for dairy, bakery and confectionery products
6	Form 1-15-8 B ('Osoblyva')	0.2	9.2 ± 2.5	1.3	3792 ± 11.7*	66	4.8	low alcoholic beverages; sauces; filler for dairy, bakery and confectionery products
7	Form 1-15-1 ('Nosivshanka')	0.2	7.7 ± 2.8	0.8	2408 ± 20.3	66	4.3	
8	Form 1-15-5 A ('Sribnolyta')	0.3	6.0 ± 2.1	1.1	2074 ± 26.0	59	4.4	
9	Form 1-15-9 ('Karytnna')	0.2	8.1 ± 1.4	1.1	1540 ± 20.9	62	4.4	
10	Form 1-15-8 V ('Soniachne siayvo')	0.2	6.5 ± 1.9	0.8	3028 ± 17.0*	59	4.0	sauces; alcohol-free and low alcoholic beverages
11	Form 1-15-8 C ('Mitsna')	0.3	12.6 ± 2.2	1.0	2045 ± 20.3	63	4.3	
12	Form 1-15-8 D	0.2	6.4 ± 1.3	0.7	3785 ± 18.3*	61	4.1	
13	Form 1-15-11 ('Lymonna')	0.3	13.4 ± 1.1*	0.9	2110 ± 23.0	74*	3.7	
14	Form 1-15-5 A ('Sribnolyta')	0.3	8.1 ± 2.5	1.1	2359 ± 15.6	62	3.6	sauces; filler for dairy, bakery and confectionery products
15	Form 1-15-3 ('Pamiatka')	0.1	9.4 ± 2.8	0.7	3091 ± 14.5*	55	3.8	
16	Form 1-15-1 ('Nosivshanka')	0.2	10.8 ± 2.0	0.8	2570 ± 10.8	61	3.3	
17	Form 1-15-6 ('Apelsynova')	0.2	12.7 ± 2.6	1.3	1712 ± 13.7	63	3.9	
18	Form 1-15-2	0.2	11.3 ± 2.9	0.7	2494 ± 16.9	52	3.4	
	Medium-range	0.31		1.24	2731.5	63.8	4.44	
	Min-max	0.1–0.9	6.0–13.7	0.7–2.6	1540–3946	52–78	3.3–6.5	
	V, %	47	69	63	57	38	55	

\*P < 0.05 compared to the control (standart); V – coefficient of variability; SAI – sugar-acid index; \*\* – productivity in middle age generative plants.

Suitability of sea buckthorn fruits for freezing was determined by loss of its weight after long-term storage at minus 18 °C. The largest weight loss of the berries were in the varieties: 'Osoblyva', 'Apelsynova', 'Oliana' (4.2–6.8 %), and the smallest in 'Adaptyvna', 'Nadiyna', 'Mitsna' and others (1.9–2.8 %). Changes in the biochemical composition of berries studied varieties of sea buckthorn were observed by all features without exception. The smallest losses the total soluble solidst (0.7–1.1 %) and

total sugars (0.03–0.17 %), regarding its content in fresh, had defrosted berries of varieties 'Osoblyva', 'Adaptyvna', 'Nadiyna', 'Mitsna', 'Soniachne siayvo' and others. The smallest losses of titration organic acids and vitamin C marked in 'Oliana', 'Morkviana', 'Mitsna', 'Karotynna', 'Lymonna'. SAI of all defrosted berries decreased in 1.2–1.6 times and was within – 0.6–2.2.

Sea buckthorn berries are product of diet and medical nutrition. Its low in calories: 1 kg of berries contains 300 calories. The main direction use of sea buckthorn still remains beverage production and biologically active food additives (Litovchenko & Kuznetsov, 2019), despite the fact that these raw materials are promising for getting food concentrates functional purpose. Food products based on the berries of sea buckthorn possess good taste properties, nutritional and biological value. According to a comprehensive study of berries natural, semi-natural populations and varieties of sea buckthorn can conclude, that its berries have no dessert purpose, confirmation of which is high acid content, low sugar-acid index – 1.1–1.4 (in berry and fruit crops for dessert purpose SAI, usually  $\geq 5.0$ ) and as a result, a low tasting evaluation (2–3 points).

Assessment of defrosted sea buckthorn berries by organoleptic parameters showed the mismatch of defrosted berries of varieties 'Osoblyva', 'Nosivshanka', 'Pamiatka' requirements of the current standard SSU (SSU 4837:2007, 2007). So, 16–24 % berries of these varieties are deformed, what exceeds maximum permissible standards, specified in SSU 4837:2007 (2007). When for berries of other varieties ('Morkviana', 'Karotynna', 'Adaptyvna', 'Nadiyna' and others) the percentage of deformed berries is not more than 3, which is less than the norm (5 % for the first commodity variety), but berries of the varieties 'Oliana', 'Mitsna', 'Lymonna' – don't suffer deformation (Figure 5 a – i). Discolored and cracked defrosted berries we didn't find any of the samples tested. Foreign odors were also absent.

High enough nutrient content (vitamins, trace elements, simple sugars, pectins, organic acids, essential oils) in berries of sea buckthorn allows to use its raw materials in the production of semi-finished products, including as fruit and berry fillers, thus, adjust the taste and smell of the product. One of the most evolving destinations the food industry today – production of functional products (smoothies, berries pastilles, dairy including enriched curd products) using sea buckthorn berries (Stobdan et al., 2017).

Sea buckthorn is used as a multivitamin plant, can be used as a choleric agent, hemopoiesis stimulator for anemia, a wound healing agent, activator of regenerative processes at malignant tumors as an antimicrobial agent, in the treatment of arthritis, at bleeding as an anti-radiation agent, at inflammatory processes of the oral cavity and other mucous membranes of the skin (Chen, et al., 2014; Stobdan et al., 2017).

Because berries of not all samples of *H. rhamnoides* are suitable for processing in the frozen state, it was interesting to do research their chemical and technological properties and the suitability for making semi-finished products, namely blend puree for the preparation of pastilles, production of low alcohol beverages, etc. For blended puree used fruit and berry components, one of which was the berries of sea buckthorn, dried to a moisture content 12 %. The composition of the three parts of apple (variety 'Antonivka') and one part of sea buckthorn variety 'Osoblyva' (c) gives to receive raw materials with low sugar content (their contents in the pastilles at the level 40–42 %) and as a result the low SAI and tasting evaluation 3.5 point (with 5 the maximum possible).

More successful, but not the best there was an option where to the apple and sea buckthorn puree plum puree of variety 'Stenley' was added. This semi-finished product had a high content, as titrated acids (19.3 %) and sugars (73.9 %), which provided higher tasting mark – 4. The most successful blend for getting pasty it was puree, received with one part of sea buckthorn, one part of raspberry and two parts of apple puree. Exactly such a semi-finished product provided high rates the quality of the finished product (tasting evaluation 4.5 point and SAI 5). This blended puree is the optimal ratio of sugars and titrated acids, creating a harmonious sour-sweet taste of the finished product – pastilles (Figure 6 a – c).

Therefore, for the manufacture of pastilles worth carrying out blending of sea buckthorn puree with berries puree other fruits and berries, what have content of sugars in more 7.0 % titrated acids and less 0.5 % Such can be berries of apple, pear, cherry, honeysuckle, the third component can be other stone fruits and berries, but in proportions that will provide SAI no less 5 (Moskalets et al., 2019 C). The most suitable varieties for processing for juice products according to the obtained indicators are varieties 'Hergo', 'Oliana', 'Adaptyvna', 'Morkviana', 'Karotynna', 'Lymonna' the yield of juice from berries of which is 62–78 %, total soluble solidst – 11–12 %, sugars 8.2–9.4 g/dm<sup>3</sup>, at titrated acidity 35–37 g/dm<sup>3</sup>.

Fruit and berry wines were prepared according to SSU (SSU 6036:2008, 2008) to the mass concentration of titrated acids in terms of malic acid 5–8 g/dm<sup>3</sup> depending on the type of wine. Under the direction of the professor O. M. Litovchenko developed recipes juice with high content of biologically active substances, resulting in defined best samples of sea buckthorn juice compositions ('Osoblyva', 'Adaptyvna', 'Karotynna') with low acid (apple, birch, and pumpkin) juices. Technological process production of fruit and berry wines predicted grinding of raw materials, push-ups, infusion, fermentation and addition of honey or sugar. Of all berries samples tested natural and semi-natural genotypes of sea buckthorn marked varieties 'Adaptyvna', 'Osoblyva' and 'Karotynna'. From which juices are obtained wine materials higher alcoholism 11.8–13.4 % vol. accordingly, lower sugar content 8.5–10.0 g/100 cm<sup>3</sup> (with tasting evaluation obtained wine materials 7–8 points), at a time when alcoholism of berries of other varieties was smaller 6 % vol., however, with a slightly higher content of residual sugars 11.0–12.0 g/100 cm<sup>3</sup> and with 5–6 points tasting evaluation.

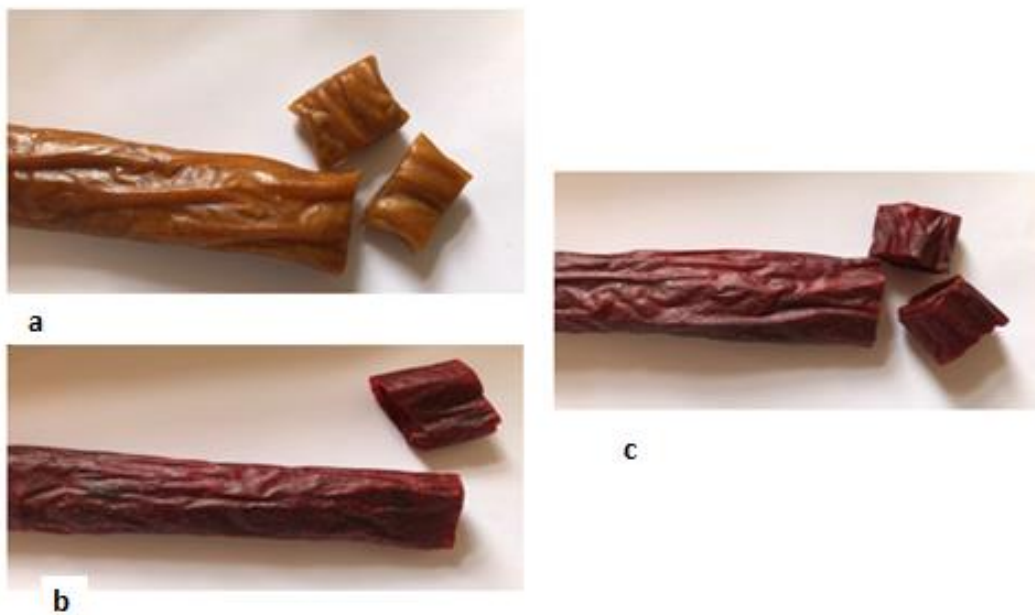
The best organoleptic characteristics and high evaluation characterized sea buckthorn wine material of the variety 'Osoblyva', with the gradual addition of sugar – 8.0. The aroma of the drink is pure, pleasant, sea buckthorn; taste – smooth, nice harmonious. In second place from quality is the wine material of the berries of sea buckthorn 'Karotynna' with the gradual addition of sugar and in the third place is the wine material of the variety 'Adaptyvna', made with the gradual addition of honey (tasting evaluation 8.0 points). Characteristics of the drink: color is light straw-golden; aroma – pure, with wine-sea buckthorn; taste – balanced, harmonious and pleasant.

So, according to the results of determining the suitability of berries raw materials wild genotypes of buckthorn buckthorn in technologies of production of pastilles, juices and drinks selected varieties 'Adaptyvna', 'Osoblyva' and 'Karotynna', which are

most suitable for the manufacture of products functional purpose, which is a prerequisite development projects competitive and energy-saving recipes, technological instructions for their production.



**Figure 5.** Defrosted berries of varieties of sea buckthorn: (a) – ‘Mitsna’; (b) – ‘Oliana’; (c) – ‘Morkviana’; (d) – ‘Lymonna’; (e) – ‘Nadiyna’; (f) – ‘Karotynna’; (g) – ‘Osoblyva’; (h) – ‘Nosivshanka’; (i) – ‘Adaptyvna’



**Figure 6.** Pastilles made of blended puree: (a) – apple (3 parts) + sea buckthorn (1 parts); (b) – sea buckthorn (1 parts) + plum (2 parts) + apple (2 parts); (c) – sea buckthorn (1 parts) + raspberry (1 parts) + apple (2 parts)

## Conclusions

1. As a result of expeditionary studies natural, semi-natural and local populations of Forest-Steppe, Polissia of Ukraine during 2015–2019. Valuable forms and clones – sources of valuable economic features of sea buckthorn: large berries (weight of berry 0.7–0.9 g – ‘Oliana’, ‘Morkviana’), high yields (> 10 kg/bush – ‘Adaptyvna’, ‘Oliana’, ‘Morkviana’, ‘Lymonna’, ‘Nadiyna’); firm skin (‘Mitsna’, ‘Tovarna’, ‘Dublianska osin’); small spines and without spines (‘Zapylivach Hachyka dublianskiyi’, ‘Strumkovyi dublianskiyi 1-19-1’, Form 8-18-32, ‘Oliana’, ‘Nadiyna’, ‘Obriy’); low growth (‘Morkviana’, ‘Dublianska osin’, ‘Rankova’, ‘Adam’, ‘Pollmix’); long berry peduncles and dry separation of berries (‘Mitsna’, ‘Karotynna’, ‘Adaptyvna’, ‘Oliana’, ‘Nadiyna’) and its increased biological value, freezing capacity (‘Dublianska osin’, ‘Oliana’, ‘Tovarna’, ‘Mitsna’, ‘Apelsynova’, others) and making beverages (‘Osoblyva’, ‘Adaptyvna’, ‘Karotynna’), suitable for mechanized berries harvesting (‘Tovarna’, ‘Adaptyvna’, ‘Oliana’, ‘Morkviana’, ‘Lymonna’, ‘Nadiyna’) were selected.
2. Comparative study new forms of sea buckthorn by ontogenetic and morphological characteristics, ecomorphic affiliation allowed its to attribute two certain climate ecotypes (polissia, forest-steppe) and four subecotypes. Biotypes, that have been a limited ability to carry soil and atmospheric drought selected in natural and semi-natural places of growth appertain to mesophytes (Ms). The genotypes, selected in catchment areas, the lowlands of Forest-Steppe, Polissia of Ukraine, appertain to mesohydrophytes (MsHg). A special group makes up widely ecological flexibility mesophyte plants of sea buckthorn – mesoxerophytes (wfMsKs) – presented polissia-forest-steppe subecotype, characterized by wide environmental plasticity, due to the high winter, drought and frost resistance, compared to other subecotypes. They have adapted to withstand prolonged of soil and air in the extreme phases of ontogeny, in particular, in the phase of berries filling and ripening, giving high stable harvest. Particular breeding and economic value in terms of formation stably high yields under conditions of global climate change, its aridization and displacement borders zoning of berry and fruit crops have xeromesophytes (KsMs) presented central forest-steppe subecotype – in view of the they relatively average demanding to soil moisture and air and resistance to moisture deficiency.
3. Genotypes of polissia ecotype, appertain to oligomesotrophs (OIMsTr), since its relatively average to the soil fertility conditions. Polissia-forest-steppe subecotype is medium demanding or mesotrophs (MsTr), the western forest-steppe subecotype and also central forest-steppe subecotype are relatively demanding to soil fertility conditions and belong to mesomegatrophs (MsMgTr). In relation to the level of light the plant of sea buckthorn ranked on heliophytes (He) – light-loving, most of them are tree-shaped form in which the arrangement of the branches is semi-vertical, rarely happens vertically. To relatively light-loving – scioheliophytes (ScHe), who feel well in an open habitats, but can grow with little shading, we include bush forms with semi-vertical arrangement of branches, green and dark green color of leaves.
4. Family relationships of the phylogenetic tree made possible to discover genetic identity such samples, which are distributed 5<sup>th</sup> affinity groups: *I group*: Form 8-8-32, Form 8-18-33, variety ‘Lybid’ and Form 2-15-174; *II group*: Form 3-15-17 and variety ‘Solodka zhinka’; *III group*: Form 1-15-5 A (‘Sribnolysta’) and Form 1-15-5 (‘Adaptyvna’); *IV group*: varieties ‘Nivieliena’, ‘Moskvichka’ and ‘Obilnaia’; *V group*: Form 1-15-8 V (‘Soniachne siayvo’) and Form 1-15-5 B (‘Osoblyva’). Other varieties and forms included in the list of samples studied, are heterogeneous and individuals. Selected material of the sea buckthorn referred to species *H. rhamnoides* subspecies *rhamnoides* and *carpatica*, which is clearly different from other subspecies (*caucasica*, *fluviatilisvan*, *mongolica*, *sinensis*, *turkestanica*, *yunnanensis*).
5. At the Institute of Horticulture (National Academy of Agrarian Science of Ukraine), the collection of nursery garden plants has been created. Nursery has more than 80 valuable forms, clones of natural and semi-natural populations of sea buckthorn and also national and foreign varieties.

## References

- Belgard, A. L. (1971). Stieпноie liesoviedieniie [Steppe forest management], Moscow. Forest industry (in Russian).
- Bobyliov, Y. P., Brygadyrenko, V. V., Bulakhov, V. L., Gaichenko, V. A., Gasso, V. Y., Didukh, Y. P., Ivashov, A. V., Kucheriavyi, V. P., Maliovanyi, M. S., Mytsyk, L. P., Pakhomov, O. Y., Tsaryk, I. V., Shabanov, D. A. (2014). Ekologija [Ecology]. Folio, Kharkiv, 12–25 (in Ukrainian).
- Bryła, P. (2016). Organic food consumption in Poland: Motives and barriers, 105, 737–746. doi: <https://doi.org/10.1016/j.appet>.
- Chen, X. L., M., R. J., Sun, K., Lian, Y. S. (2003). Germplasm resource and habitat types of seabuckthorn in China. Xibei Zhiwu Xuebao 23, 451–455.
- Chen, L., Xin, X., Yuan, Q., Su, D., and Liu, W. (2014). Phytochemical properties and antioxidant capacities of various colored berries. Journal of the Science of Food and Agriculture, 94, 180–188. doi: [10.1002/jsfa.6216](https://doi.org/10.1002/jsfa.6216)
- Christaki, E. (2012). *Hippophae rhamnoides* L. (Sea buckthorn): a potential source of nutraceuticals. Food Public Health. 2012, 2, 69–72. doi: [10.5923/j.fph.20120203.02](https://doi.org/10.5923/j.fph.20120203.02)
- Cory, H., Passarelli, S., Szeto, J., Tamez, M., Mattei, J. (2018). The role of polyphenols in human health and food systems: a mini-review. Frontiers in Nutrition, 5, 87. doi: [10.3389/fnut.2018.00087](https://doi.org/10.3389/fnut.2018.00087)
- Derzhavnyi reiestr sortiv roslyn, prydatnykh dlia poshyrennia v Ukraini na 2019 rik [State register of plant varieties suitable for dissemination in Ukraine in 2019] (2019). Ministry of Agricultural Policy and Food of Ukraine, Kyiv (in Ukrainian).
- Dulf, F. V. (2012). Fatty acids in berry lipids of six sea buckthorn (*Hippophae rhamnoides* L. subspecies *carpatica*) cultivars grown in Romania. Chemistry Central Journal, 6, 1–12. doi: [10.1186/1752-153X-6-106](https://doi.org/10.1186/1752-153X-6-106)

- Fang, R., Veitch, N.C., Kite, G.C., Porter, E.A., Simmonds, M.S. (2013). Enhanced profiling of flavonol glycosides in the fruits of sea buckthorn (*Hippophae rhamnoides*). *Journal of Agricultural and Food Chemistry*, 61, 68–75. doi: [10.1021/jf304604v](https://doi.org/10.1021/jf304604v)
- Garg R., Patel, R. K., Tyagi, A. K., Jain, M. (2011). De novo assembly of chickpea transcriptome using short reads for gene discovery and marker identification. *DNA Research*, 18, 53–63. doi: [10.1093/dnares/dsq028](https://doi.org/10.1093/dnares/dsq028)
- Goszcz, K., Duthie, G. G., Stewart, D., Leslie, S. J., Megson, I. L. (2017). Bioactive polyphenols and cardiovascular disease: chemical antagonists, pharmacological agents or xenobiotics that drive an adaptive response? *British Journal of Pharmacology*, 174, 1209–1225. doi: [10.1111/bph.13708](https://doi.org/10.1111/bph.13708)
- Grynyk, I. V., Moskalets, T. Z., Moskalets, V. V., Shevchuk, R. S. (2018). Oblipykha krushynovydna (*Hippophae rhamnoides* L.) – spozhyvcho-tsinnny ta perspektyvnyi syrovynnyi resurs zdorovoho kharchuvannia liudyny [Sea buckthorn (*Hippophae rhamnoides* L.) as perspective valuable for consumption raw material resource of the sound nutrition of man]. *Horticulture*, 73, 17–24 (in Ukrainian).
- Hakeem, K. R., Ozturk, M., Altay, V., Mamedov, N. (2018). An alternative potential natural genetic resource: sea buckthorn [*Elaeagnus rhamnoides* (syn.: *Hippophae rhamnoides*)]. *Global Perspectives on Underutilized Crops*. doi: [10.1007/978-3-319-77776-4\\_2](https://doi.org/10.1007/978-3-319-77776-4_2)
- Kucherenko, M. Ye (2001). Suchasni metody biokhimichnykh doslidzhen [Modern methods of biochemical research]. Phitosocenter, Kyiv (in Ukrainian).
- Litovchenko, O. M., Kuznetsov, A. V. (2019). Naukove zabezpechennia vyrobnytstva bezalkoholnoi ta slaboalkoholnoi produktsii u plodopererobnii haluzi [Scientific providing of making non-alcoholic and low alcoholic products in the fruit processing]. *Horticulture*, 74, 133–139 (in Ukrainian). doi: [10.35205/0558-1125-2019-74-133-139](https://doi.org/10.35205/0558-1125-2019-74-133-139)
- Mikolajko, I. I., Shlapak, V. P. (2014). *Hippophae rhamnoides* L. u filohenetychnii systemi roslynnoho svitu [Hippophae rhamnoides L. in the phylogenetic system of the plant world]. *Scientific Bulletin NFTU of Ukraine*, 24(1), 125–131 (in Ukrainian).
- Moskalets, T. Z., Rybalchenko, V. K. (2016). Kontseptualna model keruvannia zhyttievym stanom roslynnykh ekomorf za kryteriiamy mekhanizmiv adaptivnosti [Conceptual model of management the vital state plant ecomorphs by the criteria of adaptation mechanisms]. *Visnyk of Dnipropetrovsk University. Biology, ecology*, 4(1), 211–221 (in Ukrainian). doi: [10.15421/011626](https://doi.org/10.15421/011626)
- Moskalets, V. V., Grynyk, I. V., Moskalets, T. Z., Frantsishko, V. S. (2019 F). Metodichni rekomendatsii z vyznachennia ekoloho-adaptivnoho i produktyvnoho ahrobiopotsialu henotypiv oblipykhy (*Hippophae rhamnoides* L.) dlia selektsii ta intensyvnoho sadivnytstva [Methodical Recommendations to determine Ecological-Adaptive and Productive Agrobio Potential Genotypes of Sea Buckthorn (*Hippophae rhamnoides* L.) for breeding and intensive horticulture], 58 (in Ukrainian).
- Moskalets, T. Z., Moskalets, V. V., Vovkohon, A. H., Shevchuk, O. A., Matviichuk, O. A. (2019 B). Modern breeding and cultivation of unpopular fruits and berries in Ukraine. *Ukrainian Journal of Ecology*, 9(3), 204–213. doi: <http://dx.doi.org/10.15421/2019082>
- Moskalets, V. V., Moskalets, T. Z., Grynyk, I. V., Litovchenko, O. M., Shevchuk, L. M., Kryvoshapka, V. A., Kytayev, O. I., Hrusha, V. V. (2019 C). Zvit pro naukovo-tekhnichnu robotu stvorennia ekolohoadaptivnykh henotypiv oblipykhy krushynopodibnoi dlia intensyvnoho sadivnytstva [Report on scientific and technical work of creation of ecological adaptive genotypes of sea buckthorn for intensive horticulture]. Kyiv, Institute of Horticulture NAAS of Ukraine, 206–249 (in Ukrainian).
- Olas, B., Żuchowski, J., Lis, B., Skalski, B., Kontek, B., Grabarczyk Ł., Stochmal, A. (2018). Comparative chemical composition, antioxidant and anticoagulant properties of phenolic fraction (a rich in non-acylated and acylated flavonoids and non-polar compounds) and non-polar fraction from *Elaeagnus rhamnoides* (L.) A. Nelson fruits. *Food Chem.*, 247, 39–45. doi: <https://doi.org/10.1016/j.foodchem.2017.12.010>
- Pantielieieva, Ye., I. (2006). Oblepiha krushinovaia (*Hippophae rhamnoides* L.) [Sea buckthorn (*Hippophae rhamnoides* L.): monograph], Barnaul, 249 (in Russian).
- Sheng, H. M., An, L. Z., Chen, T., Xu, S. J., Liu, G. X., Zheng, X. L., Pu, L. L., Liu, Y. J., Lian, Y. S. (2006) Analysis of the genetic diversity and relationships among and within species of *Hippophae* (*Elaeagnaceae*) based on RAPD markers. *Plant Systematics and Evolution*, 260, 25–37. Doi: <https://doi.org/10.1007/s00606-006-0413-1>
- Skalski, B., Kontek B., Olas, B., Żuchowski, J., Stochmal, A. (2018). Phenolic fraction and nonpolar fraction from sea buckthorn leaves and twigs: chemical profile and biological activity. *Future Med Chem.*, 10(20), 1–14. doi: <https://doi.org/10.4155/fmc-2018-0144>
- Skrovankova, S., Sumczynski, D., Mlcek, J., Jurikova, T., Sochor, J. (2015). Bioactive compounds and antioxidant activity in different types of berries. *International Journal of Molecular Sciences*, 16, 24673–24706. doi: [10.3390/ijms161024673](https://doi.org/10.3390/ijms161024673)
- SSU ISO 2173:2007 (2009). Fruky, ovochi ta produkty yikh pereroblennia. Metod vyznachennia sukhykh rehovyn refraktometrychnym metodom [Fruit and vegetable products. Determination of soluble solids by refractometric method]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU ISO 4954:2008 (2009). Fruky, ovochi ta produkty yikh pereroblennia. Metod vyznachennia tsukriv [Products of processing fruits and vegetables. Methods for determining sugars]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU ISO 4373:2005 (2006). Fruky, ovochi ta produkty yikh pereroblennia. Metody vyznachennia vmistu polifenoliv [Fruits, vegetables and products of processing. Methods determination content of polyphenols]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU ISO 8069:2015 (2017). Produkty pereroblennia fruktiv ta ovochiv. Tytrometrychnyi metod vyznachennia pektynovykh rehovyn [Products of processing fruits and vegetables. Titrimetric method determination of pectin substances]. State consumer standard of Ukraine, Kyiv (in Ukrainian).

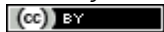
- SSU ISO 6557-2:2014 (2015). Produkty pereroblennia fruktiv ta ovochiv. Metody vyznachannia askorbinovoi kysloty [Fruits, vegetables and products of processing. Methods determination content of ascorbic acid]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU 4305:2004 (2005). Fruky, ovochi ta produkty yikh pereroblennia. Metod vyznachennia karotynu [Fruit, vegetables and products of their processing. The method of determining carotene]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU 4837:2007 (2007). Fruky ta yahody shvydkozamorozheni. Tekhnichni umovy [Fruits and berries quickly frozen. Specifications]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU 4283.1:2007 (2007). Konservy. Soky ta sokovi produkty. Chastyna 1. Terminy ta vyznachennia [Canned food. Juices and juice products. Part 1. Terms and definitions]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU 4069-2002 (2002). Napoi bezalkolnii. Zahalni tekhnichni umovy [Soft drinks. General specifications]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- SSU 6036:2008 (2008). Vyna plodovo-yahidni. Zahalni tekhnichni umovy [Fruit's and berries wines. General specifications]. State consumer standard of Ukraine, Kyiv (in Ukrainian).
- Stobdan, T., Dolkar, P., Chaurasia, O., Kumar, B. (2017). Seabuckthorn (*Hippophae rhamnoides* L.) in trans-Himalayan Ladakh, India. Defence Life Science Journal, 2(1), 46-53. doi: <https://doi.org/10.14429/dlsj.2.11074>
- Tarasov, V. V. (2005). Flora Dnipropetrovskoi ta Zaporizkoi oblasti. Sudynni roslyny. Biolohekolohichna kharakterystyka vydiv [Flora of Dnipropetrovsk and Zaporizhzhya regions. Vascular plants. Biological and ecological characteristics of species], Dnipropetrovsk, DSU, 276 (in Ukrainian).
- Tkachenko, A., Birta, G., Burgu, Y., Floka, L., Kalashnik, O. (2018). Substantiation of the development of formulations for organic cupcakes with an elevated protein content. Eastern-European Journal of Enterprise Technologies, 3 (93), 51–58. doi: <https://doi.org/10.15587/1729-4061.2018.133705>
- Tkachenko, A., Syrokhman, I., Lozova, T., Ofilenko, N., Goryachova, E., Hmelnitska, Y., Shurduk, I. (2019). Research of consumer properties of developed biscuits based on organic raw materials. EUREKA: Life Sciences, 1, 59–64. doi: <http://dx.doi.org/10.21303/2504-5695.2019.00849>
- Ulf, S., Bartish, I. V. (2008). Taxonomic synopsis of *Hippophae* (*Elaeagnaceae*). Nordic Journal of Botany, 22, 369–374. doi: [10.1111/j.1756-1051.2002.tb01386.x](https://doi.org/10.1111/j.1756-1051.2002.tb01386.x)

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