

USING THE ANALYTIC HIERARCHY PROCESS TO SELECT THE MOST IMPORTANT NON-WOOD FOREST PRODUCTS FOR IAȘI COUNTY

UTILIZAREA PROCESULUI DE IERARHIZARE ANALITICĂ ÎN SELECTAREA CELOR MAI IMPORTANTE PRODUSE FORESTIERE NELEMNOASE DIN JUDEȚUL IAȘI

BLAGA Tatiana^{1*}, *DINCĂ L.*¹, *ENESCU C. M.*²
Corresponding author e-mail: tatiana.blaga@yahoo.com

Abstract. *In Romania, the non-wood forest products are mainly represented by the fauna of hunting interest, forest fruits, truffles and edible mushrooms and medicinal plants. The aim of this research was to study the most important non-wood forest products from Iași County. The analyze model used in similar studies done in the case of other counties across Romania was taken into account. The Analytic Hierarchy Process (AHP) was used to assess the performance of selected alternatives by means of pairwise comparisons. The analyses were carried out using the Expert Choice Desktop software package. Honey and pheasant were the most promising non-wood forest products, while the less promising was the European elderberry. According to the results of this study, we conclude that Iași County has a great potential for harvesting and marketing of NWFPs.*

Key words: AHP, Expert Choice Desktop, Iași County, non-wood forest products

Rezumat. *În România, principalele categorii de produse forestiere nelemnoase sunt speciile de faună de interes cinegetic, fructele de pădure, trufele și ciupercile comestibile și plantele medicinale. Scopul acestui studiu a constatat în evidențierea celor mai importante produse forestiere nelemnoase pentru județul Iași. Modelul de analiză utilizat în studii similare efectuate în cazul altor județe din România a fost folosit. Procesul de ierarhizare analitică a fost utilizat pentru a evalua alternativele prin analizarea lor două câte două. Analizele au fost realizate cu pachetul software Expert Choice Desktop. Mierea și fazanul s-au dovedit a fi cele mai importante produse forestiere nelemnoase, iar socul negru cel mai puțin important produs. Având în vedere rezultatele acestui studiu, concluzionăm că județul Iași prezintă un potențial ridicat în ceea ce privește recoltarea și comercializarea produselor forestiere nelemnoase.*

Cuvinte cheie: AHP, Expert Choice Desktop, județul Iași, produse forestiere nelemnoase

¹"Marin Dracea" National Institute for Research and Development in Forestry Bacau, Brasov, Romania

² University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

INTRODUCTION

In Romania, according to the Forest Code (Law no. 46/2008), the non-wood forest products (NWFPs), also known as non-timber forest products (NTFPs), include fauna of hunting interest, forest fruits, forest seeds, truffles and edible mushrooms, medicinal and aromatic plants, resin, a.s.o.

At national level, the most important NWFPs as regards the harvested and marketed quantities are the berries of European blueberry (*Vaccinium myrtillus* L.), raspberry (*Rubus idaeus* L.), dog rose (*Rosa canina* L.), sea-buckthorn (*Hippophaë rhamnoides* L.), common hawthorn (*Crataegus monogyna* Jacq.) and blackthorn (*Prunus spinosa* L.) and the edible mushrooms such as penny bun (*Boletus edulis* Bull.), honey fungus [*Armillaria mellea* (Vahl) P. Kumm.] and chanterelles (*Cantharellus cibarius* Fr.) (Enescu *et al.*, 2018a).

In the last years, more stakeholders both from non-governmental and governmental organizations are interested in the utilization and promotion of NWFPs in several fields (Timiș-Gânsac *et al.*, 2018). Also the private sector is very interested in harvesting and marketing of NWFPs, the forest owners paying an increasing attention to this category of forest products aimed to obtain new revenues (Janse and Ottitsch 2005), especially in rural communities (Barbir and Negrea, 2014), where they represent sources of food, medicines and others (Cioacă and Enescu, 2018).

The aim of this study was to assess the potential of the most common NWFPs from Iași County by using a multi-criteria decision analyze.

MATERIAL AND METHODS

Iași County is located in the north-eastern part of Romania, between Siret and Prut Rivers (fig. 1). It is situated in a plain region and it has an area of 5,476 km². The northern part of the county is situated in the Moldavian Plain, while the southern part is situated on the Central Moldavian Plateau, where the altitude may exceed 400 m a.s.l. In the west, the area is crossed by Siret River corridor, the last fragments of the Fălticeni Plateau and also the "Big Hill", with altitudes exceeding 500 m a.s.l. The most important forested area is represented by Repedeș-Bârnova massif, situated on the Central Moldavian Plateau, in the south of the county.

Forests account for more than 63.000 hectares, most of them being managed by Iași Forestry Directorate (IFD), a territorial branch of National Forest Administration ROMSILVA. IFD is divided into eight forest districts (ro. ocoale silvice), namely: Dobrovăț, Hârlău, Iași, Lunca Cetățuii, Pădureni, Pașcani, Podu Iloaiei and Răducăneni, respectively.

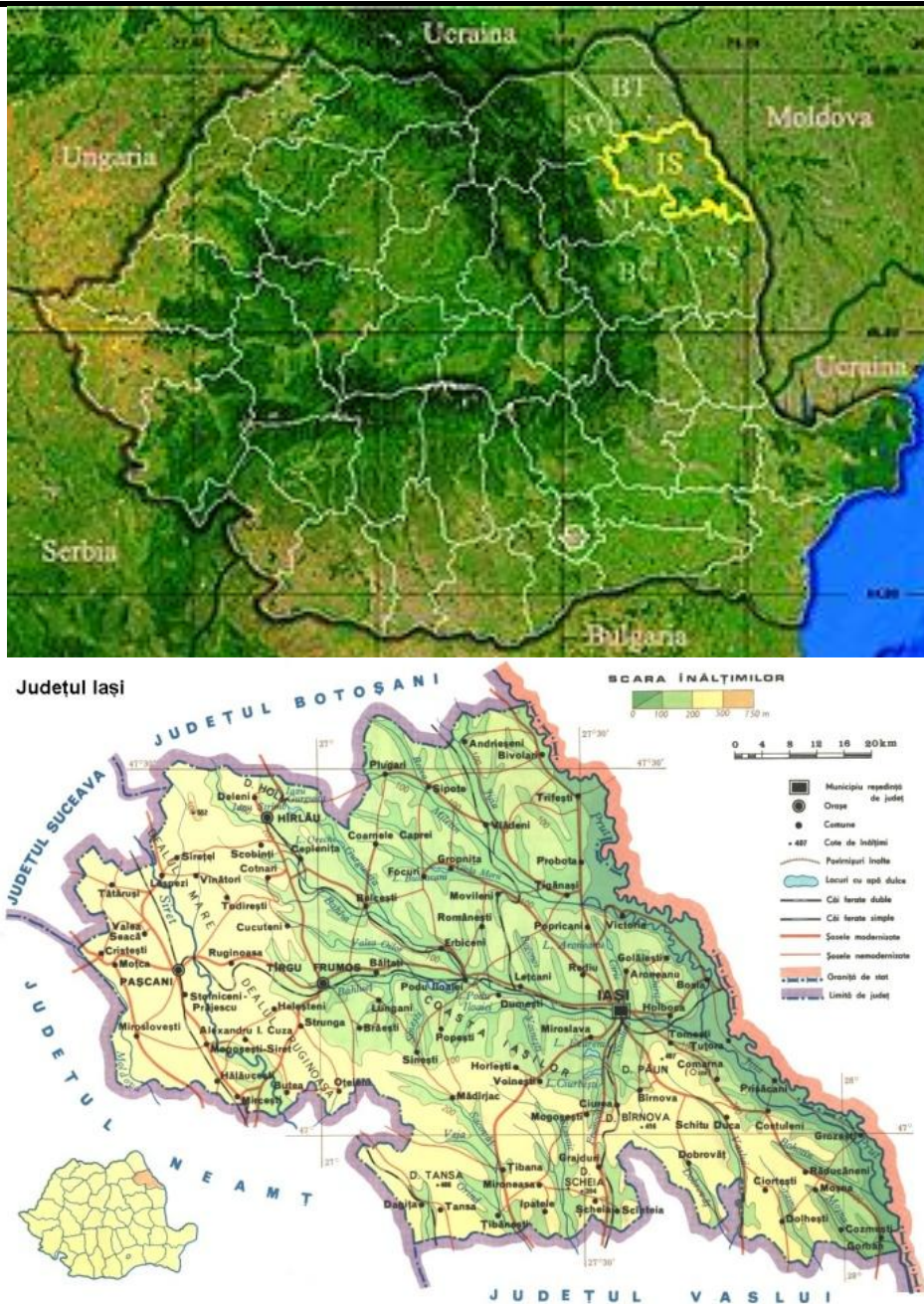


Fig. 1 Location of Iași County (Source: <http://pe-harta.ro/iasi/>)

The hardwood species are the main forest tree species, the oaks (Genus *Quercus* L.) - 21% being the main tree species. The resinous species hold only 2% of the forested area across the county.

The list of the most important NWFPs was done based on the data available in the forest management plans of the above-mentioned forest districts. The analysis model (*i.e.* 19 criteria, 8 alternatives – the selected non-wood forest products and 4 categories of NWFPs) was recently used for similar studies in the case of Prahova, Timiș and Bihor counties, respectively (Enescu *et al.*, 2018a; Enescu *et al.*, 2018b; Timiș-Gânsac *et al.*, 2018). The criteria used were the following ones: Criterion 1: Harvesting period (1: the shortest harvesting period ... 8: the longest harvesting period); Criterion 2: Portfolio of derived products (1: the smallest number of derived products ... 8: the highest number of derived products); Criterion 3: Harvested quantity by one worker in 8 hours (1: the lowest quantity ... 8: the highest quantity); Criterion 4: Harvesting cost (1: the lowest cost ... 8: the highest cost); Criterion 5: Knowledge for recognition (1: most recognizable product ... 8: hardest recognizable product); Criterion 6: Knowledge for harvesting (1: the less knowledge necessary ... 8: most knowledge necessary); Criterion 7: Tools needed for harvesting (1: the least ... 8: the more); Criterion 8: Complexity of harvesting process (1: lowest ... 8: highest); Criterion 9: Distribution range (1: lowest ... 8: highest); Criterion 10: Market potential (1: low ... 8: high); Criterion 11: The price of raw product (1: lowest ... 8: highest); Criterion 12: The price of the derived product (1: lowest ... 8: highest); Criterion 13: Transport from the harvesting point to the storage center (1: the most easy ... 8: the most complicated); Criterion 14: Perishability (1: lowest ... 8: highest); Criterion 15: “Celebrity” of the product on the market (1: the least known ... 8: the most popular); Criterion 16: Market demand (1: lowest ... 8: highest); Criterion 17: Biotic threats (1: the fewest threats ... 8: the most threats); Criterion 18: Abiotic threats (1: the fewest threats ... 8: the most threats); Criterion 19: Development of the process of harvesting (1: undeveloped ... 8: extremely developed). Analytic Hierarchy Process (AHP), a decision-making technique which can be used to analyze and support decisions that have multiple objectives (Mohammadi and Limaie, 2018), was performed in order to determine the most important NWFPs for Iași County. The analyses were conducted by the aid of Expert Choice Desktop (v. 11.5.1683).

RESULTS AND DISCUSSIONS

The selected non-wood forest products were the following ones: parasol mushroom [*Macrolepiota procera* (Scop.) Singer], penny bun (*Boletus* spp.), linden flowers (*Tilia* spp.), berries of blackthorn (*Prunus spinosa* L.), European elderberry (*Sambucus nigra* L.), peppermint (*Mentha piperita* L.), honey and the common pheasant (*Phasianus colchicus* L.). The AHP alternative ranking is given in table 1.

Table 1

AHP alternative ranking

Criterion	<i>Macrolepiota procera</i>	<i>Boletus</i> spp.	<i>Tilia</i> flowers	<i>Prunus spinosa</i>	<i>Sambucus nigra</i>	<i>Mentha piperita</i>	Honey	<i>Phasianus colchicus</i>
1	4	7	3	6	2	5	8	1
2	6	7	1	4	3	2	5	8
3	6	7	1	4	5	8	3	2
4	5	6	3	4	2	1	7	8
5	7	8	2	5	1	4	3	6
6	7	6	2	4	1	3	5	8
7	5	6	4	3	2	1	7	8
8	4	5	6	3	2	1	7	8
9	1	3	4	2	5	6	8	7
10	6	7	5	1	3	2	8	4
11	5	6	4	3	2	1	8	7
12	5	6	4	3	1	2	8	7
13	5	6	3	4	2	1	8	7
14	6	8	4	7	3	2	1	5
15	3	7	6	1	2	4	8	5
16	5	7	6	1	3	2	8	4
17	6	7	4	3	2	1	5	8
18	5	6	4	3	2	1	8	7
19	4	5	6	3	2	1	8	7

Based on AHP results, the most important NWFPs were the honey (that recorded the highest score in 8 out of 19 criteria), followed by the common pheasant and the representatives of genus *Boletus*, while the less important ones were the European elderberry and peppermint (fig. 2).

Honey is one of the most dense food in nature (Skinner, 1991), and it contains about 80-95% sugar, being a concentrated source of fructose and glucose (Bogdanov *et al.*, 2008; Murray *et al.*, 2001, White *et al.*, 1962). It also contains a large amount of essential vitamins and minerals (Iskander *et al.*, 1995; Terrab *et al.*, 2004) and components that act as preservatives, including ascorbic acid, flavonoids,

glucose oxidase, catalase and peroxidase (Crane, 1975; Ferreres *et al.*, 1993; Nagai *et al.*, 2006).

As regards the birds of hunting interest from Romania, the common pheasant is one of the most important one due to its population size and its distribution range, as well as to the favorable outlook for the growth of this species in an intensive system (Scărlătescu, 1977). In a similar study done for Bihor County, the pheasant ranked also on the second position (Timiș-Gânsac *et al.*, 2018), while in the case of Prahova County, it ranked on the third place (Enescu *et al.*, 2018a).

The mushroom's mycelium (vegetative stage) is very important in the ecosystem as the substratum might start biodegrading and residues might be used for the agricultural production. The fructiferous body (reproductive stage) is also very sought after for its texture and taste, as well as for its chemical and nutritional characteristics (Manzi *et al.*, 1999).

Furthermore, mushrooms are also useful from a therapeutic point of view, especially for treating diseases such as hypertension, cholesterol excess and cancer (Bobek and Galbavy, 1999; Bobek *et al.*, 1995). These characteristics are mainly caused by dietetic fibres, namely chitin (Manzi *et al.*, 1999), a polizaharid structure of cellular walls, beta-glucans (Manzi and Pizzoferrato, 2000; Mullins, 1990) human and hetero glucans with $\beta(1-3)$, $\beta(1-4)$ and $\beta(1-6)$, with glucose links.

The quality of mushrooms is influenced by certain parameters such as the development stage or the conditions recorded before and after harvesting.

Penny bun is considered to be an absolute market leader, being one of the most widespread non-timber forest products that is harvested for marketing purpose throughout the world (Sitta and Floriani, 2008; de Roman and Boa, 2006; Garibay-Orijel *et al.*, 2007; Mitchell and Hobby, 2007; Pilz and Molina, 2002). The importance of this species of edible mushroom for Romanian culture and gastronomy also resides in a large number of localities in our country for which their names are derived from the popular name of penny bun (Dincă *et al.*, 2016), but also for the very large harvested quantities (Vasile *et al.*, 2015). Penny bun also ranked first in a similar study done for Maramureș County (Enescu *et al.*, 2017).

Peppermint is one of the most commonly harvested plants in our country (Vasile *et al.*, 2015). In the eastern part of Romania, peppermint ranks among the first seven species of medicinal plants as regards the harvested quantity (Vasile *et al.*, 2018). Linden flowers are harvested from Moldovan woods. The perception of their usefulness places them in the middle of the ranking made up of all NWFPs in the case of Iași County, as it was the case also for Timis County (Enescu *et al.*, 2018b).

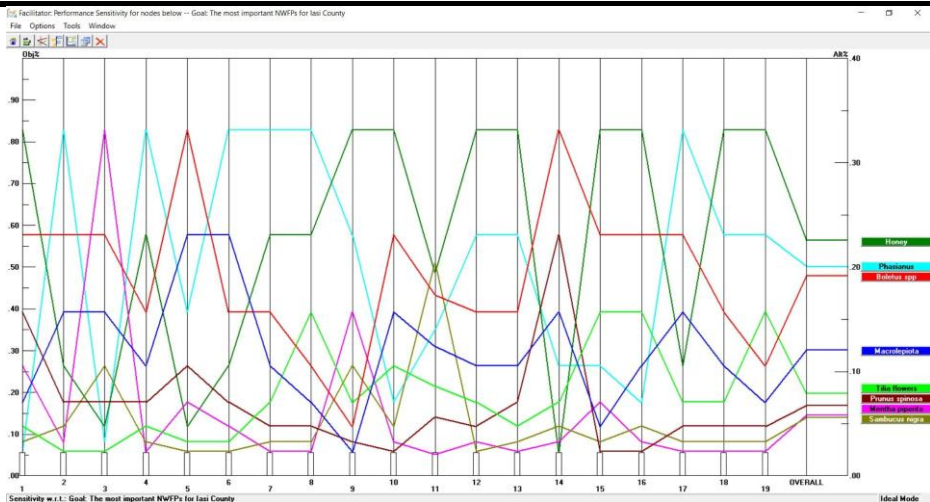


Fig. 2 The ranking of the non-wood forest products

Prunus spinosa L. is a wild shrub (Reynders-Aloisi and Grellet, 1994) frequently found in our broad-leaved forests. The species is pollinated by insects, while the seed's dispersion is realized with the help of mammals and birds (Yeboah and Woodell, 1987; Guitian, Guitian and Sa'nchez, 1993). It can also grow on calcareous, dry and cold soils. The leaves and fruit extract medicinal properties are recommending it for preparing ayurvedic remedies.

Sambucus nigra L., (elderberry), is a widespread species that develops well in sunny areas from most part of Europe, Asia, North Africa and the United States. It is a broad-leaved shrub, that can reach a height of 6 meters, with small white hermaphrodite flowers that bloom at the beginning of summer. The fruits are dark purple, almost black, with a diameter of maximum 6 mm that bloom at the end of summer. The elderberry extracts are used as drinks or food flavours (Christensen *et al.*, 2007). The fruits are regularly used as drugs or food supplement (Dawidowicz *et al.*, 2006; Lee and Finn, 2007).

Infusions from *Sambucus nigra* flowers are well known as traditional remedies for different types of diseases (Kohlmünzer, 1998). Their pharmacological properties result amongst others from the presence of flavonoids.

CONCLUSIONS

1. The diversity and the harvested quantities of NWFPs in Iasi County are not so high, mainly due to low forested area and its uneven distribution range. Even so, the honey was the most important non-wood forest product in the case of Iasi County. This means that if a forest contains all the selected NWFPs and a manager or an owner will take into account the proposed criteria, one of the best management measures will be to focus on harvesting and marketing of honey.

2. The combination between Analytic Hierarchy Process and Expert Choice Desktop software package proved to be a good choice if someone wants to choose a certain non-wood forest product, based on the criteria taken into account. The more the hierarchy has been done more correctly, based on serious documentation and analysis, the more accurate the results are.

3. By taking into account the economic situation from Iasi County, we believe that local projects and policies aimed at encouraging the harvesting and marketing of NWFPs are needed, especially in rural and poor communities throughout the county. Of course that not only the economic target should be prioritized, but also the social and environmental aspects as well.

4. In conclusion, in our opinion, the results of this research should be regarded as an incipient step in analyzing the potential of certain forest products. Different stakeholders may want to use this multi-criteria decision model in the future when they will have to take important decisions that will be focus on economic, social and environmental aspects at local or national level.

REFERENCES

1. **Barbir C.F., Negrea B.M., 2014** - *The forestry sector acting as a basis for local and regional entrepreneurial initiative like beekeeping, on the path towards reaching sustainable rural development in Iași county, Romania*. Advances in Environmental Sciences, 6(3), p. 235-242.
2. **Bogandov S., Jurendić T., Sieber R., Gallman P., 2008** - *Honey for nutrition and health: A review*. American College of Nutrition, 27(6), p. 677-689.
3. **Cioacă L., Enescu C.M., 2018** - *What is the potential of Tulcea County as regards the non-wood forest products?* Current Trends in Natural Sciences, 7(13), p. 30-37.
4. **Christensen L.P., Knaack K., Frette X.C. 2007**- *Selection of elderberry (Sambucus nigra L.) genotypes best suited for the preparation of elderflower extracts rich in flavonoids and phenolic acids*. European Food Research and Technology, 227 (1), pp. 293-305
5. **Crane E., 1975** - *Honey: A comprehensive survey*. London: Heinemann in cooperation with IBRA.
6. **de Roman M., Boa E., 2006** - *The Marketing of Lactarius deliciosus in Northern Spain*. Econ Bot, 60, p. 284-290.
7. **Dawidowicz A.L., Wianowska D., Baraniak B. 2006** - *The antioxidant properties of alcoholic extracts from Sambucus nigra L. (antioxidative properties of extracts)*. Food Science Technology, 39 (3), pp. 308-315.
8. **Dincă L., Enescu C.M., Dincă M., Cântar I.C., 2016** - *Mushrooms in Romanian toponymy, vocabulary and literature*. JOURNAL of Horticulture, Forestry and Biotechnology, 20(3), p. 119- 125.
9. **Enescu C.M., Dincă L., Vasile D., 2017** - *Importance of non-wood forest products for Maramureș County*. Revista de Silvicultură și Cinegetică, 40, p. 92-97.
10. **Enescu C.M., Dincă L., Crișan V., 2018** - *The most important non-wood forest products from Prahova County*. Revista Pădurilor, 1, p. 45-51.
11. **Enescu C.M., Dincă L., Cântar I., 2018** - *Which are the most common non-wood forest products in Timis County?* Research Journal of Agricultural Science, 50(1), p. 51-56.
12. **Ferreres F., Garcavioguera C., Tomaslorente F., Tomasbarberan F.A., 1993** - *Hesperetin C a marker of the floral origin of citrus honey*. Journal of the Science of Food and Agriculture, 61, p. 121-123.

13. **Garibay-Orijel R., Caballero J., Estrada-Torres A., Cifuentes J., 2007** - *Understanding cultural significance, the edible mushrooms case*. Journal of Ethnobiology and Ethnomedicine, 3, p. 1-4.
14. **Guitian J., Guitian P., and Sanchez J. M., 1993**- *Reproductive biology of Prunus species (Rosaceae) in the northwest Iberian Peninsula*. Plant Systematics and Evolution 185: 153–165.
15. **Iskander F.Y., 1995** - *Trace and minor elements in four commercial honey brands*. Journal of Radioanalytical Nuclear Chemistry, 201, p. 401-408.
16. **Janse G., Ottitsch A., 2005** - *Factors influencing the role of Non-Wood Forest Products and Services*. Forest Policy and Economics, 7, p. 309-319.
17. **Kohlmünzer, S. 1998** - *Farmakognozja. Podręcznik dla studentów farmacji* (pp. 163–176). Wydawnictwo Lekarskie PZWL, Warszawa.
18. **Manzi P., Aguzzi A., Vivanti V., Paci M., Pizzoferrato L., 1999** - *Mushrooms as a source of functional ingredients*. Euro Food Chem X. European Conference on: Functional foods. A new challenge for the food chemist. 22-24 sept. Budapest, Hungary, Vol. I, p.86-93.
19. **Manzi P., Pizzoferrato L., 2000** – *Beta glucans in edible mushrooms*. Food Chemistry, 68, 315-318.
20. **Mitchell D., Hobby T., 2010** - *From rotations to revolutions: Non-timber forest products and the new world of forest management*. BC Journal of Ecosystems and Management, 11, p. 27-28.
21. **Mohammadi Z., Limaei S.M., 2018** - *Multiple Criteria Decision-Making Approaches for Forest Sustainability (Case Study: Iranian Caspian Forests)*. Forest Res 7: 215. doi: 10.4172/2168-9776.1000215.
22. **Mullins J.P. 1990** – *Regulatory mechanism of β glucan synthetases in bacteria, fungi and plants*. Physiological Plantaurm, 78, 309-314.
23. **Murray S.S., Schoeninger M.J., Bunn H.T., Pickering T.R., Marlett J.A., 2001** - *Nutritional composition of some wild plant foods and honey used by Hadzaforagers of Tanzania*. Journal of Food Composition and Analysis, 14, p. 3-13.
24. **Nagai T., Inoue R., Kanamori N., Suzuki N., Nagashima T., 2006** - *Characterization of honey from different floral sources. Its functional properties and effects of honey species on storage of meat*. Food Chemistry, 97, p. 256-262.
25. **Pilz D., Molina R., 2002** - *Commercial harvests of edible mushrooms from the forests of the Pacific Northwest United States: issues, management, and monitoring for sustainability*. Forest Ecol Manag, 155, p. 3-16.
26. **Reynders-Aloisi, S., and Grellet F. 1994**- *Characterization of the ribosomal DNA units in two related Prunus species (P. cerasifera and P. spinosa)*. Plant Cell Reports 13: 641–646
27. **Scărlătescu G.M., 1977** - *Studiul populațiilor de fazan din principalele făzănării din România*. St. Cerc. Cinegetică, ICAS, vol. 35, ser. I, București, p. 7-15.
28. **Sitta N, Floriani M., 2008** - *Nationalization and Globalization Trends in the Wild Mushroom Commerce of Italy with Emphasis on Porcini (Boletus edulis and Allied Species)*. Econ Bot, 62, p. 307-322.
29. **Skinner M., 1991** - *Bee brood consumption: An alternative explanation for hypervitaminosis A in KNM-ER 1808 (Homo erectus) from Koobi Fora, Kenya*. Journal of Human Evolution, 20, p. 493-503.
30. **Terrab A., Hernanz D., Heredia F.J., 2004** - *Inductively coupled plasma optical emission spectrometric determination of minerals in thyme honey and their contribution to geographical discrimination*. Journal of Agricultural Food Chemistry, 52, p. 3441-3445.

31. **Timiș-Gânsac V., Enescu C.M., Dincă L., Oneț A., 2018** - *The management of non-wood forest products in Bihor County*. Natural Resources and Sustainable Development, 8(1), p. 27-34.
32. **Vasile D., Dincă L., Voiculescu I., 2015** - *Collecting medicinal plants from spontaneous flora of forest fund managed by National Forest Administration Romsilva*. Revista de Silvicultură și Cinegetică, 20 (37), p. 88-94.
33. **Vasile D., Enescu C.M., Dincă L., 2018** - *Which are the main medicinal plants that could be harvested from Eastern Romania?* Scientific papers series Management, Economic Engineering in Agriculture and Rural Development, 18(1), p. 523-528.
34. **White J.W.J., Riethof M.L., Subers M.H., Kushnir I., 1962** - *Composition of American Honeys*. Washington, DC: U.S. Government Printing.
35. **Yeboah G. K., and Woodell S. R. J., 1987**- *Flowering phenology, flower colour and mode of reproduction of Prunus spinosa L. (blackthorn); Crataegus monogyna Jacq. (hawthorn); Rosa canina L. (dog rose); Rubus fruticosus L. (bramble) in Oxfordshire*. Functional Ecology 1: 261–268