Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 1, 2020
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

AVANTGUARD OF ROMANIAN RESEARCH: *MURRAYA KOENIGII* L. - AN AMAZING FLOWER AND MEDICINAL PLANT

Mariana TOMA[1, 2], Vasilica LUCHIAN[2], Dorel HOZA[2]

[1]Institute of Research and Development for Processing and Marketing of Horticultural Products - "Horting"; 5N Drumul Gilaului, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, Bucharest, Romania

Corresponding author email: mtoma.horticulture@gmail.com

Abstract

Murraya koenigii L. (Rutaceae), known as the curry leaf tree is native to the Indian subcontinent and cultivated in tropical and subtropical regions. The fresh and roasted leaves of the curry tree are widely used in the Asiatic cuisine for seasoning different dishes. The essential oil can be extracted from its flowers and leaves and used in the cosmetic industry. The Ayurvedic medicine uses the leaves of Murraya koenigii, due to their high therapeutic properties. The curry leaf tree can grow very well in our climate but must be protected from freezing. The research pointed out that the bioactive principles of analyzed curry tree plants are highly valuable for medicinal purposes. The morphological analyses showed that the leaves are pinnate, with 11-25 leaflets, each leaflet 2-4 cm long and 1-2 cm broad. The anatomical analyses of the leaf showed a cuticularized upper & lower epidermis and a biseriate palisade & spongy parenchyma.

Key words*: curry tree, therapeutic proprieties, plant morphology, leaf anatomy.*

INTRODUCTION

Murraya koenigii belongs to family *Rutaceae* which has 150 genera and over 1600 species. It is a tropical to sub-tropical evergreen shrub or small tree native of India where is called "sweet neem" or "kadi patta" and Sri Lanka and widely distributed in South-East Asia, Australia and the Pacific Islands (Jain et al., 2012). It can grow up to 4-6 m in height and diameter is about 15-40 cm with short trunk. The foliage is the real standout and is arranged alternately on the stem. The mature leaves are pinnate and 15-30 cm long, with 11-25 leaflets, each leaflet length is about 2-4 cm and breadth is of 1-2 cm; margins irregularly create, petioles 2-3 mm long (Chauhan, 1999). Curry leaf plant has an upright, open growth appearance, aromatic and pungent leaves. Its flowers are bisexual, complete, sweetly scented, white, stalked, regular with the diameter of fully opened flower being in average of 10-12 cm inflorescence, terminal cymes each bearing 60-90 flowers (Saini & Reddy, 2013). The flowers are followed by green pea sized berry-like fruits which turn into black shiny when ripe. The fruit is edible, but the seed is poisonous and should be removed prior to use. *Murraya koenigii* leaves are highly aromatic and very valued for seasoning various dishes. Curry tree has been used in cooking for hundreds of years. Curry tree leaves are a section of the Indian seasoning called curry which is a compilation of many herbs and spices. In India, Thailand and other Asian countries, curry leaves are an essential ingredient of sauces, soups, stews, fish curries (Malaysia, Indonesia), rice, potatoes, etc., but they play a more delicate, aromatic role in the background of the flavor profile. Curry leaves have the strongest aroma and most pronounced flavor when used freshly picked, but they retain their flavor even after drying. In their fresh form, they have a short shelf life and they do not keep well in the refrigerator (Hema et al., 2011). Relating the curry leaf tree uses, its flowers are used in the parfum & cosmetics industry and to religious ceremonies. The wood of curry tree is highly valued to handcraft and tools making. *Murraya koenigii* is also called "the magic plant of the Indian Sub-Continent" thanks to its culinary and medicinal properties. In the Ayurvedic medicine, the root, bark and

leaves of *Murraya koenigii* are used from centuries to treat and prevent different diseases and body disorders (Muthulinggam & Subramanian, 2015; Parrota, 2001). The bioactive compounds of curry tree are used in many tribal and villages communities by traditional medical practi-tioners, but nowadays these compounds are widely used in pharmaceutic industry, as well (Shyamapada, 2016; Harish et al., 2012). The leaves of *Murraya koenigii* have amazing medicinal properties, such as: anti-diabetic (Arunselvan et al., 2006; Achyut et al., 2005; Grover et al., 2003; Yadav et al., 2002; Khan et al., 1995), antioxidant (Arunselvan et al., 2007; Baliga et al., 2003; Deshmukh et al., 1986; Singh & Sharma, 1978), antimicrobial (Dheeraj et al., 2014; Vinuthan et al., 2004; Goutam & Purohit, 1974;), anti-inflammatory (Mathur et al., 2011; Muthumani et al., 2009), analgesic (Das & Biswas, 2012; Gupta et al., 2011), hepato-protective (Roy et al., 2014; Pande et al., 2009), anti-hypercholesterolemia (Khan et al., 1996) and anti-atherosclerotic (Vinuthan et al., 2007), anti-mutagenic (Zahin et al., 2013), anti-anxiety and anti-depressant (Sharma et al., 2017). *Murraya koenigii* leaves have cancer fighting properties (Ghasemzadeh et al., 2014; Iyer et al., 1990). They have the ability to control diarrhea, dysentery, indigestion (Adebajo et al., 2004). The fresh juice of curry leaves is also used as eye treatment for certain eye disorders, especially in arresting the development of cataract (Surbhi & Meenakshi, 2016). Using curry leaves for hair problems, such as dandruff, hair fall and greying hair can be extremely beneficial (Saini, 2013). The stems are used as anthelmintic, febrifuge, foul ulcer (Sharma et al., 2011), in treatment of vomiting and flatulence (Kumar et al., 1999; Nadkarni, 1995; Parmar & Kaushal, 1982); they are very popular for strengthening the gums and teeth (Sivakumar & Meera, 2013). The bark and the roots are used as a stimulant, cure eruptions and against fungi (Das et al., 1965) and bites of poisonous animals (Rao et al., 2013; Shivkanya et al., 2009). Leaves are rich in many bioactive compounds like, alkaloids (Chakrabarty et al., 1997), volatile oils (Chowdhury et al., 2008), furocoumarins, terpenoids, tannins, glycosides, polyphenols and flavonoids (Adebajo & Reisch, 2000). In addition, leaves are also rich in fibers, minerals and vitamins, such as calcium, carotene, vitamin A, phosphorous, calcium, iron, vitamin B2, niacin and vitamin C (Narendhirakannan et al., 2005). The two carbazole alkaloids namely mahanimbine and koenigine found in these leaves showed higher antioxidant activities (Singh, 2014; Kale & More, 2014). Mahenine, a carbazole alkaloid isolated from curry leaf, has been reported to induce apoptosis in human myeloid HL-60 cancer cells by down regulating cell survival factors and disrupting the cell cycle progression (Bhattacharya et al., 2010; Parmar et al., 2010; Roy et al., 2004). Anti-tumorigenic activity of a curry leaf extract against MCF-7 breast cancer cells has been reported by Handral et al. (2012) and Kok et al. (2012). Antioxidant effect of curry leaf powder in chicken and goat meat products has also been reported (Devatkal et al., 2012; Biswas et al., 2006). *Murraya koenigii* bio-active compounds showed a real inhibition of *Staphylococcus epidermidis*, *Streptococcus uberis*, *Pseudomonas aeruginosa*, *Escherichia coli, Corynebacterium gravis* and *Bacillus cereus* on different studies applied to human-beings and animals, as well (Mathur et al., 2010).

MATERIALS AND METHODS

Curry leaf plants (*Murraya koenigii* L.) originated from Hyderabad, India were taken into cultivation last 3 years in our country. They grew as potted plants outdoor between May and October and indoor in the cold season. Fresh leaves & leaflets, rachis and stem fragments were anatomically studied. The material was sectioned manually using razor blades in order to obtain semi-permanent and permanent slides for microscopic study. The sections were clarified with chloral hydrate for 24 hours, then washed and stained with carmine alaunate and green iodine (Luchian & Teodosiu, 2019; Georgescu et al., 2015; Savulescu & Hoza, 2010). The anatomical analyses were performed at the University of Agronomical Sciences and Veterinary Medicine of Bucharest and the bio-chemical analyses were performed at "Chem-Analyst" Laboratory, district 6, Bucharest. The pictures and measurements were made using Leica

DM1000 LED, Leica DFC295 Video Camera, Leica S8 APO Stereo Microscope, Optika Microscope and Sony photo camera. The pictures were taken using light microscope with different magnifications. *Murraya koenigii* leaves have been studied by various authors (Mohammad et al., 2013; Syed et al., 2015).

RESULTS AND DISCUSSIONS

There are three varieties of *Murraya koenigii*: regular, dwarf and gamthi. The regular type has a fast growing; it is tall and the most culinary used. The dwarf variety is 25-30 cm in height and it's not typically grown to use culinary, but as a decorative plant or ground cover. The gamthi curry plant is only 15-20 cm in size, being the most fragrant and flavorful and grows the slowest of the three. As concern the growing conditions, all three varieties of *Murraya koenigii* are frost tender. In the experiment were used plants of *M. koenigii* belonging to regular variety (Figures 1-3).

Figure 1. *Murraya koenigii* seedlings - year 2018

Figure 2. Plants of *Murraya koenigii* - year 2019

Figure 3. Regular variety of *M. koenigii* - year 2020

In cold countries, tropical species need protection from freezing. As an indoor plant in temperate areas, curry leaf develops and flowers from spring till autumn. During the resting period in the winter months, the curry tree leaves might turn yellow and drop off; this generally means that the plant is about to go dormant (Figure 4). In the cold season, *M. koenigii* needs full sunlight or partial shade and a bright windowsill away from any draughts or radiators where the temperature range stays above at least 12°C. The plants can tolerate a temperature range up to 37°C, but below 16°C their growth is affected.

Figure. 4. Mature plants of *Murraya koenigii* affected by winter rest (downward foliage dropping) - year 2020

A real problem with indoor cultivation of *Murraya koenigii* is represented by the air dryness mixed with a warm temperature which encourage the attack of red spider mite and specific pathogens, such as mildew (Figures 5 and 6).

Figure 5. Plants of *M. koenigii* slightly attackedby mildew and red spider mite - year 2020

Murraya koenigii needs and a rich, well-draining soil. Curry leaf tree can be cultivated in a wide range of soils. Red sandy loam soil is ideal for curry leaf cultivation. *Murraya koenigii* plants don't need a particular soil pH level to survive. It doesn't require much in terms of water and it is semi - drought tolerant.

Figure 6. *Murraya koenigii* plants at the end of the winter - year 2020

Three years after sowing, *Murraya koenigii* started to bloom (Figure 7). Daily 1-2 flowers of its inflorescence were fully opened and their fragrance could be smelled from few metres distance. The flowers of *Murraya koenigii* don't produce any allergic reaction. For this reason, curry leaf tree doesn't represent any risk to children or animals, but a sharp attention must be paid to its seeds which are poisonous.

Figure 7. Inflorescences of *Murraya koenigii* - springtime of the year 2020

Staking could be necessary if planted in a windy location. The trees sucker vigorously, so a limited space is a good option. They grow well in a pot and they are very attractive plants for verandas, balconies, terraces or backyards.

M. koenigii propagation is mainly through cuttings or seeds. For raising seedlings, well-ripe fruits are collected from high-yielding curry leaf plants. Within three to four days of fruits collection, the seeds should be pulped and sown in nursery beds or poly bags filled with a mixture of 1:1:1 sand, soil and farmyard manure. Seeds germinate in three weeks. One-year-old seedlings are planted in a pot. Growing *M. koenigii* from seed is not an easy task because the germination process is fickle. For propagating curry tree through cuttings, will be selected a branch or a stem which is neither flexible or nor stiff, means semi-hard. The cutting must be of 5 mm in diameter and about 8-10 cm long with 4 to 5 leaflets. In about ten days, the cutting will produce new buds. Curry leaf can also be propagated by root suckers process. It is very important to start pruning curry leaf tree early in its growth stage. In order to keep plant tight, compact and producing the greatest amount of tasty foliage, is recommended pruning it annually, removing near 1/3 from the top/branches. Within a few weeks, the plant will generate side shoots and fill out into a mini-grove of numerous bushy stalks with pointed leaves. That is a sign that curry leaf plants are healthy and thriving. Curry leaves are picked or harvested 15 months after planting. Commercial harvest can be started from three-year-old plants.

Macroscopic determinations

Murraya koenigii is semi deciduous, unarmed aromatic shrub. Curry leaves are shiny and smooth with paler undersides, having characteristic aroma. Mature leaves are pinnate, estipulate, having reticulate venation and having ovate lanceolate with an oblique base with 11-21 leaflets which are short stalked, alternate, gland dotted and having 0,5 cm long petiole. The young stems are green in color with sweet aromatic odor and characteristic taste. The outer surface is smooth, soft and glabrous.

The mature stems of *M. koenigii* are dark brown (unpeeled) and yellow-brown (peeled) in color with slight aromatic odor and specific taste. The outer surface is smooth and hard. The fracture of bark is splintery.

During three years (2018-2020) was analyzed the growth of *Murraya koenigii* plants, by measuring yearly their height, number of

pinnate leaves and leaflets. As regard the number of leaves and leaflets, in the Table 1, is observed that every year their number is increased averagely with near 50%, to all variants of the experience. Following this rate, in 2020, the number of leaves and leaflets has become double than in 2018. Relating the height of *Murraya koenigii* plants, their size increased yearly with 20-25 %, as is showed in Figures 8 and 9. *Murraya koenigii* grows slowly at seedling stage and 2-3 years after sowing and is a sensitive plant to the attack of different pathogens. Starting with 2019, the curry leaf plants were fertilized twice a month with *Cropmax* and *Vitaflora* (alternatively) - both fertilizers containing macro and micronutrients. This slow growth rate of curry leaf in our country is due to the metabolic adjustments to stressors, mainly the weather conditions (temperature and humidity fluctuations, light intensity). Due to these aspects, *Murraya koenigii* requires a professional care and a strict pest control.

Microscopic determinations

Sections of leaf, midrib, rachis and stem of *Murraya koenigii* L. were analyzed using optic and electronic microscopes.

Leaf anatomy

The presence of the following was observed: epidermis (upper and lower), mesophyll with palisade & spongy parenchyma, epidermal cells, stomata, vascular bundle and epidermal trichomes (Figures 10, 11, 12 and 13).

Table 1. Pinnate leaves and leaflets number of *Murraya koenigii* L. between the years 2018-2020

Variant / Average	Number of pinnate leaves 2018	Number of pinnate leaves 2019	Number of pinnate leaves 2020	Number of leaflets/plant 2018	Number of leaflets/plant 2019	Number of leaflets/plant 2020
V1	4	7	11	25	58	103
V2	5	9	14	32	81	119
V3	4	8	13	29	76	110
V4	6	11	16	38	97	152
V5	13	18	22	107	145	188
V6	14	18	23	116	141	199
V7	14	19	25	113	148	215
V8	15	22	27	127	185	232
V9	14	21	28	119	167	239
V10	16	23	31	144	196	263
Average	**10.5**	**15.6**	**21.0**	**85.0**	**129.4**	**182.0**

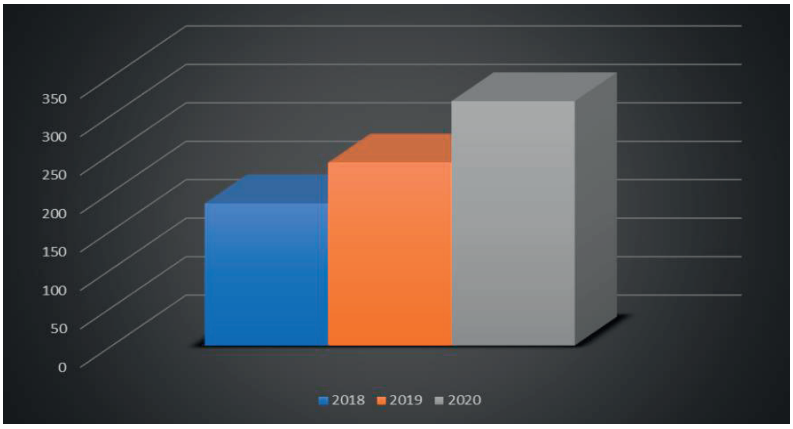

Figure 8. Average yearly increase of *Murraya koenigii* plants

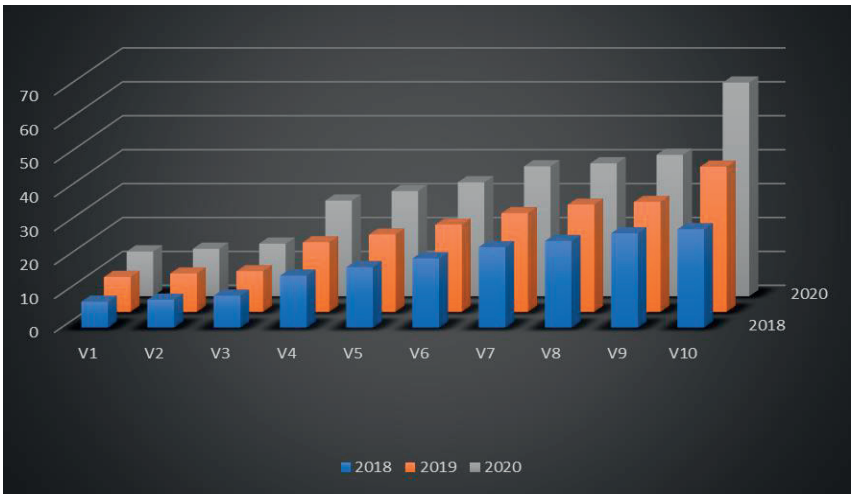

Figure 9. Growth dynamics of *Murraya koenigii* plants

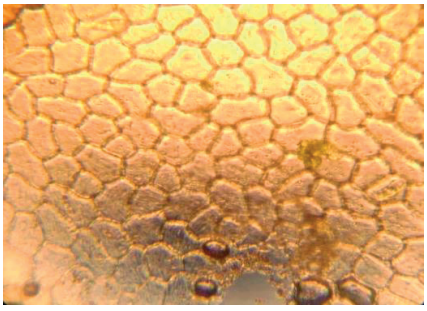

Figure 10. Upper epidermis

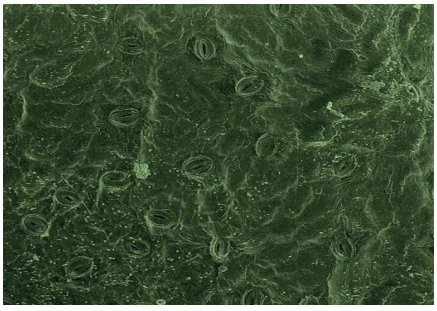

Figure 12. Lower epidermis viewed at SEM

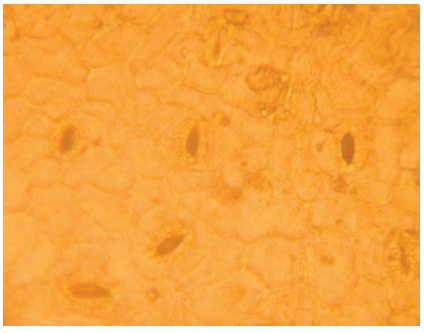

Figure 11. Lower epidermis with stomata

Figure 13. Lower epidermis with trichomes (SEM)

The epidermis presents a layer of rectangular cells. The upper epidermis is covered with cuticle. The lower epidermis presents stomata. The mesophyll presents a palisade tissue with 2 layers of cells (Figure 14).

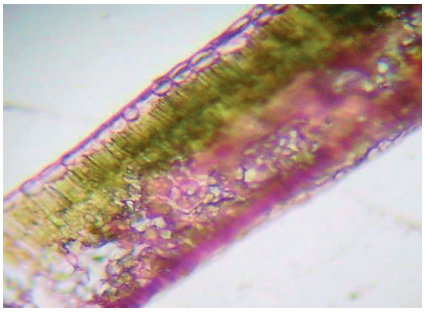

Figure 14. Cross section of *Murraya koenigii* leaf

The ground tissue is oval to polygonal. The parenchyma cells present chlorophyll contents and vascular bundle. Towards the vascular bundles, a bundle of fibers is present on the upper side. The xylem and phloem portions of vascular bundle consist of their basic elements. The leaf shows the presence of non-glandular trichomes (with higher density on the mid - vein of the abaxial leaf surface), parenchymatous pith in petiole, long pericyclic fibers in the midrib (Jain et al., 2017). Trichomes distribution on the leaf was restricted predominantly to the mid-vein and edges, only one type of long, slender non-glandular trichomes was observed on the leaf and stem. The trichomes are vital to the survival of the plant and collectively provide an adaptive edge to the plant by regulating evapotranspiration, shielding from harmful rays and deterring insects and predators. The trichomes play a key role in plant defense, especially with regard to phytophagous insects, avoiding insect feeding & oviposition responses and the nutrition of larvae (Fahn, 2000; Duke, 1994; Thomas, 1991).

Midrib anatomy

The leaf through midrib region flattens towards upper and lower epidermis; unicellular, non-glandular trichomes arise from the abaxial epidermis; adaxial and abaxial hypodermis bi or tri seriate, composed of isodiametric collenchy-matous cells with calcium oxalate crystals; vascular bundle forms an arch with the adaxial xylem and the abaxial phloem (Figure 15).

Figure 15. Midrib of curry tree leaf - cross section

Rachis anatomy

The epidermis of curry tree rachis has a single layer of isodiametric cells which are covered with a thick cuticle; unicellular, non-glandular, curved, cortex many-layered, parenchymatous, hypodermal cortical cells are smaller, isodiametric, intercellular spaces; abundant pyramidal calcium oxalate crystals, present in cortical cells; cortex in the hypodermal region is traversed by lysigenous cavities; vascular bundle is encircled by a ring of 2 or 3 layered sclerenchymatous pericycle, xylem parenchyma and xylem fibers with thick walls; phloem is situated towards the periphery of xylem ring and contains sieve tubes, companion cells, phloem parenchyma and phloem fibers; medullary rays are uniseriate; the cells contain calcium oxalate crystals; the pith is large containing parenchymatous cells (Duartea & Deburb, 2005), as are showed in the Figures 16 and 17.

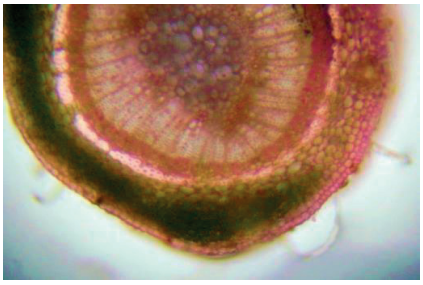

Figure 16. Rachis of curry tree

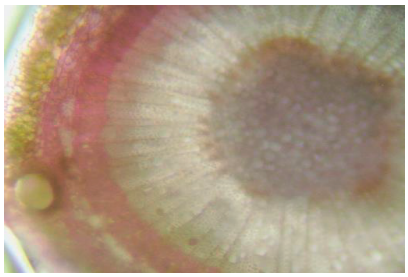

Figure 17. Rachis of *M. koenigii* with oil gland

Stem anatomy

The cross section of *Murraya koenigii* stem (Figure 18) presents: uniseriate epidermis covered with a thick cuticle; it presents trichomes. The cortex is composed by 3-6 layers of cells. It presents oil glands (Figure 19), positioned just below the epidermis, a vascular. Bundle and pith in the center. In the cortex was observed a sclerenchymatic ring composed by 2-3 layers of cells (Jarald et al., 2008).

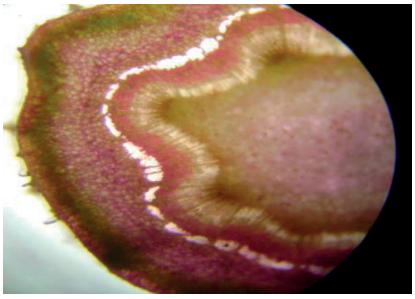

Figure 18. *Murraya koenigii* stem - cross section

The sclerenchymatic cells concentration is effective in withstanding environmental pressures, such as damage by wind and to fend off herbivores (Metcalfe & Chalk, 1988).

The pith consists of walled polygonal, parenchy-matous cells bearing starch grains - clearly showed at the transverse section of *M. koenigii* pith. The pith serves also to produce crystals and other ergastic substances (Dutta, 2001). The vascular system consist of a cylinder of xylem produced towards the inside and a cylinder of phloem outward. Vascular bundles are of collateral, conjoint and open type.

Figure 19. *Murraya koenigii* stem with oil gland

Biochemical compounds analyses

Fresh leaves of Murraya *koenigii* L. were collected in March 2020 from the plants taken into the experience. The biochemical analyses were done at "Chem-Analyst" private laboratory, 101 L Timisoara Avenue, district 6, Bucharest. Total polyphenol (TPP) content was determined using Folin - Ciocalteu method (Johansen, 1940), as modified by Yi and Wetzstein (2010), Vaidya et al. (2013) and further modified by Meena et al. (2017). The analyses showed that, at the humidity of 11.24%, the total content of polyphenols, expressed in gallic acid was of 1259.61 mg %; the flavones content, expressed in rutin was of 0.30 mg %; caffeic acid 1.97 g %; carotene 0.043 g %; calcium 42.03 mg/kg; iron 129.43 mg/kg; magnesium 23.89 mg/kg; zinc 55.33 mg/kg.

The antioxidants reduce the risk of cancer and heart diseases (Lafuente et al., 2009) and enhance immunity; therefore, it is imperative that they should be supplied to body through external sources (Ganesan et al., 2013). Plant-based antioxidants block free radicals produced through oxidation, thus inhibiting chain reactions that could lead to degradation and death of cells in human body. Antioxidants are marketed as beneficial to us by protecting the skin, supporting digestion and the immune system (Das et al., 2011).

The total phenols of *Murraya koenigii* leaves showed an amount with ~ one quarter higher than the polyphenols amount contained in fresh fruits of *Aronia melanocarpa* L. (black chokeberries) - recognized to be very rich in polyphenols, as is shown in the study of Toma (Singh) et al. (2019).

The flavonoids (including the flavones) are precious for their antioxidative, antimicrobial, anticancer and cardio protective effects. Rutin

also strengthens the capillaries, and, therefore, can reduce the symptoms of hemophilia. It also may help to prevent venous edema of the legs. Rutin, as ferulic acid, can reduce the cytotoxicity of oxidized LDL cholesterol and lower the risk of heart disease. The amount of rutin found in *M. koenigii* leaves was near similar to that existing in the fruits of *Aronia melanocarpa*, well known for its high number of flavonoids, as is shown in the study of Atanassova & Bagdassarian (2009).

The amount of caffeic acid (a very important antioxidant) found *in Murraya koenigii* leaves was ~ four times larger, in comparison with the amount of caffeic acid found in the leaves of *Psidium guajava* (guava), a tropical plant very rich in antioxidants which was studied in Romania mainly for its pharmacological potential, as is mentioned in the scientific paper of Toma (Singh) and Luchian (2019). Caffeic acid is considered to have many health benefits, including anti-inflammatory, anticancer and antiviral properties. It may help boost the performance of athletes and improves significantly the hair health & growth (In resources for authors: Caffeic acid. (n.d.) Healthline. Retrieved from: https://www.health-line.com/health/caffeic-acid). Curry tree leaves contained high values of carotene, calcium, magnesium, iron and zinc, with a real contribution to the health. Thus, the beta- carotene is an antioxidant that converts to vitamin A and plays a very important role to improve cognitive function, promote good skin health, reduce macular degeneration, contribute to lungs health, prevent cancer, etc. (In resources for authors: Benefits of Beta Carotene and How to Get It. (n.d.) Healthline. Retrieved from: https://www.healthline.com/health/betacaroten-benefits). Calcium is important for overall health. Almost every cell in our body uses calcium in some way. Some areas where our bodies use calcium is in our nervous system, muscles, heart and bones (In resources for authors: Why is Calcium Important. (n.d). Medicine.wisc.edu. Retrieved from: https://www.medicine.wisc.edu/rheumatology/why - calcium - important). Magnesium helps to maintain normal nerves and muscles function, supports a healthy immune system, keeps the heartbeat steady and helps bones remain strong. It also helps adjust blood glucose levels. Magnesium aids in the production of energy and protein. Diets high in protein, calcium or vitamin D will increase the need for magnesium (In resources for authors: Magnesium in diet. (n.d.). Medline Plus. Retrieved from: https://medlineplus.gov/ency/article/002423/magne -sium-in-diet). Iron is the mineral responsible for the production of hemoglobin, the substance in red blood cells that helps blood carry oxygen throughout the body. If the amount of iron is not enough, then is installed the anemia which determines the following effects: tiredness, lack of concentration, breathing problem, dizziness, headache, feeling cold (In resources for authors: Why is Iron Important in My Diet? (n.d.). Med.umich.edu. Retrieved from: http://www.med.umich.edu/cancer/files/why-is-iron-important.pdf). Zinc is needed for the body's defensive (immune) system to properly work.

It plays a role in cell division, cell growth, wound healing and the breakdown of carbohydrates. Zinc is also needed for the senses of smell and taste (In resources for authors: Zinc in diet. (n.d.). Medline Plus. Retrieved from: https://medline-plus.gov/ency/article/002416/zinc-in-diet.) It is essential for bones, skin, nails and hair beauty, as well. Polyphenols & flavonoids activity at *Murraya koenigii* was studied by many researchers, such as Ghasemzadek et al. (2014), Rani et al. (2012), Ningappa et al. (2008), Tachibana et al. (2003), Middleton et al. (2000). The bio-compounds analyses of potted curry tree plants grown in our country revealed quite similar values of them cultivated or growing wildly in their origin places. It points out that the pharmacologic potential of *Murraya koenigii* is very precious, making this plant a possible solution for preventing and treating a large range of diseases and body disorders.

CONCLUSIONS

In Romania, *Murraya koenigii* L. cultivation represents an avantguard research.

Curry leaf tree has showed a good adaptability in our country.

In the climate of Romania, *Murraya koenigii* needs protection from freezing.

The curry tree grew very well as potted plant outdoor between May and October and indoor in the cold season.

Murraya koenigii started to bloom three years after sowing.

The plants can tolerate a temperature range up to 37°C, but below 16°C their growth is affected.

During three years (2018-2020) was analyzed the growth of *Murraya koenigii* plants, by measuring yearly their height, number of pinnate leaves and leaflets.

Every year the number of leaves and leaflets have increased averagely with near 50%, to all variants of the experience.

The height of *Murraya koenigii* plants has increased yearly with 20-25%.

Murraya koenigii grows slowly at seedling stage and 2-3 years after sowing.

The slow growth rate of curry leaf in our country is due to the metabolic adjustments to stressors, mainly the weather conditions, such as temperature & humidity fluctuations and light intensity.

A special attention to *Murraya koenigii* care and pest control must be paid.

Curry leaf plants cultivated indoor in the cold period have faced a medium attack of red spider mite and a slight attack of mildew.

Sections of leaf, midrib, rachis and stem of *Murraya koenigii* L. were anatomically studied. The microscopic analyses showed that the growth and development of potted curry tree plants follows the same dimensions and characteristics as those of their origin places.

The bio-compounds analyses of potted curry tree plants grown in our country revealed quite similar values of them cultivated or growing wildly in their native areas.

The study points out that the pharmacologic potential of *Murraya koenigii* L. is very precious, making this plant a possible solution for preventing and treating a large range of diseases and body disorders.

REFERENCES

Achyut, N. K., Gupta, R. K., Watal, G. (2005). Hypoglycemic effects of *Murraya koenigii* on normal and alloxan-diabetic rabbits. J. of Ethnopharm: 97, 247.

Adebajo, C.A., Reisch, J. (2000). Minor furocoumarins of *M. koenigii.* Fitoterapia, 71: 334-337. Cross Ref.

Adebajo, C.A., Gbola, O., Eugen, V.J., Ezekiel, O.I., Omisore, N.O.A., Dieter, B., Vijaya K., Kolawole, A.S. (2004). Evaluation of the ethnomedical claims of *Murraya koenigii.* Pharm. Biol., 42: 610-620.

Arulselvan, P., Senthilkumar, G.P., Sathish Kumar D., Subramanian, S. (2006). Anti-diabetic effect of Murraya koenigii leaves on streptozotocin induced diabetic rats. Pharmazie 61 (10): 874–7.

Arulselvan, P., Subramanian, S.P. (2007). Beneficial effects of *Murraya koenigii* leaves on antioxidant defense system and ultra-structural changes of pancreatic beta-cells in experimental diabetes in rats. Chem Biol. Interact., 165(2):155-64.

Atanassova, M., Bagdassarian, V. (2009). Rutin content in plant products J.of the University of Chemical Technology and Metallurgy, 201-203, Bulgaria.

Baliga, M.S., Jagetia, G.C., Rao, S.K., Babu, K. (2003). Evaluation of nitric oxide scavenging activity of certain spices *in vitro*: a preliminary study. Nahrung: 47(4), 261.

Bhattacharya, K., Samanta, S. K., Tripathi, R. (2010). Apoptotic effects of mahanine on human leukemic cells are mediated through crosstalk between Apo-1/Fas signaling and the Bid protein and via mitochondrial pathways. *Bioch. Ph.*, vol. 79, 361–372.

Biswas, AK, Kondaiah, N, Anjaneyulu, A.S.R. (2006). Effect of spice mix and curry leaf powder (*Murraya koenigii*) on the quality of meat and precooked chicken patties during refrigeration storage. J. Food Sci Technol., 43: 438-441.

Chakrabarty, M., Nath, A.C., Khasnobis, S. (1997). Carbazole alkaloids rom *Murraya koenigii.* Phytochemistry, 46: 751-755.

Chauhan, N.S. (1999). Medicinal and aromatic plants of Himachal Pradesh: Indus Publishing.

Chowdhury, J. U., Bhuiyan, M., Mohammed, N.I.Y. (2008). Chemical composition of the leaf essential Oils of *Murraya koenigii* (L.) Spreng and *Murraya paniculata* (L.).

Das, A.K., Rajkumar, V., Dwivedi, DK. (2011). Antioxidant effect of curry leaf (*Murraya koenigii*) powder on quality of ground and cooked goat meat. Int Food Res J., 18: 559-565.

Das, B.N, Biswas, B.K. (2012). Analgesic activity of the leaf extract of *Murraya koenigii*. Int J Compr. Pharm., 3: 1–3.

Das, K.C., Chakraborty, D.P., Bose, P.K. (1965). Antifungal activity of some constituents of *Murraya koenigii*. Experimentia, 21(6): 340.

Deshmukh, S. K., Jain, P. C., Agarwal, S.C. (1986). Antimicrobial activity of the essential oil of the leaves of *Murraya koenigii* (Linn) Spreng (Indian curry leaf). Fitoterapia, 57, 295.

Devatkal, S.K, Thorat, P.R, Manjunatha, M. (2012). Comparative antioxidant effect of aqueous extracts of curry leaves, fenugreek leaves and butylated hydroxytoluene in raw chicken patties. J. Food Sci. Tech., 49(6): 781-785.

Dheeraj, K., Gahlawat, S., Jakhar, S., Dahiya, P. (2014). *Murraya koenigii* (L.) Spreng: an ethnobotanical, phytochemical and pharmacological review Journal of Pharmac. and Phytochemistry, 3(3): 109-119.

Duartea, M.R., Deburb, M.C. (2005). Stem and leaf

morphoanatomy of Murraya koenigii. Fitoterapia, 76: 41-49. CrossRef.
Duke, S.O. (1994). Glandular trichomes, a focal point of chemical and structural interactions. Int J Plant Sci. 154: 107-118.
Dutta, A.C. (2001). Botany. Oxford University Press, Kolkata, India.
Fahn, A. (2000). Structure and function of secretory cells. Adv Bot Res., 31: 37-75.
Ganesan, P., Phaiphan, A., Murugan, Y., Bahariu, B.S. (2013). Comparison study of bioactive compounds in curry and coriander leaves - an update. J. of Chemical and Pharmac. Research, 5: 590-594.
Georgescu, M.I., Savulescu, E., Dobrescu, E., Muşat, M. (2015). *Seseli gigantissimum,* Ciocarlan – anatomy of leaves. Scientific Papers- Series B, Horticulture, (59), 347-349.
Ghasemzadeh, A., Jaafar, H.Z., Rahmat, A. (2014). Evaluation of bioactive compounds, pharmaceutical quality and anticancer activity of curry leaf (*Murraya koenigii* L.). Evidence based Comp Alternative Med.
Goutam, M.P., Purohit, R.M. (1974). Antimicrobial activity of essential oils of the leaves of *Murraya koenigii* Spreng. Indian J. of Pharmaceuticals: 36, 11.
Grover, H., Yadav, S.P., Vats, V. (2003). Effect of feeding *Murraya koenigii* and *Brassica juncea* on kidney functions and glucose levels in streptozotocin diabetic mice. J. Ethno-pharmac.85:1-5.CrossRef.
Gupta, S., George, M., Singhal, M, Sharma, GN, Garg, V. (2011). Leaf extract of *Murraya koenigii* Linn. for anti-inflammatory and analgesic activity in animal models. Journal of Advanced Pharmaceutical Technology and Research 2011; 1:68-77.
Handral, H.K, Pandith, A., Shruthi, S.D (2012). A Review on *Murraya koenigii*: Multipotential Medicinal Plant. Asian J Pharm Clin Res., 5(4): 5-14.
Harish, M., Anup, P., Shiruthi, S.D. (2012). A review on Murraya koenigii: multipotential medicinal plant. Asian J. Pharmac. and clinical Research, 5(4): 5-14.
Hema, R., Kumaravel, S., Alagusundaram, K. (2011), GC/MS Determination of Bioactive Components of *Murraya koenigii,* J. of American Sci., 7(1).
Iyer, U.M., Mani, U.V. (1990). Studies on the effect of curry leaves supplementation (*Murraya koenigii*) on lipid profile, glycated proteins and amino acids in non-insulin dependent diabetic patients. Plants and Food in Human Nutrition, 40, 275.
Jain, M., Gilhotra, R., Singh, R.P. (2017). Curry leaf (*Murraya koenigii*): A spice with medicinal property. MOJ Biol Med., 2(3): 00050.
Jain, N, Munira, M, Kirti, L. (2012). *Murraya koenigii*, an update review. International Journal of Ayurvedic and Herbal Medicine, 2(4): 607-627
Jarald, E.E., Sheeja, E., Parial, S. (2008). Morphoanatomy of stems of *Murraya koenigii* Spreng. J Biol Sci. 8(3): 654-658.
Johansen, D.A. (1940). Plant Micro technique. McGraw-measurement with the Folin phenol reagent. J Hill Book Co. New York: 523.
Kale, NV., More, G.S. (2014). Biochemical, antimicrobial and organoleptic analysis of curry leaf. Plant Science Feed, 4: 6-9.
Khan, AB, Annie, A, Leelamma, S. (1995). Hypoglycemic action of *Murraya koenigii* and *Brassica juncea:* Mechanism of action. Indian Journal of Biochemistry and Biophysics, 32(2): 106-108,
Khan, B. A., Abraham, A., Leelamma, S. (1996). *Murraya koenigii and Brassica juncea* alterations on lipid profile in 1-2 dimethyl hydrazine induced colon carcinogenesis. Investigational New Drugs, 14, 365.
Kok, YY., Mooi, LY., Ahmad, K., Sukari, MA., Mat, N., Rahmani, M. (2012). Anti-tumor promoting activity and antioxidant properties of girinimbine isolated from the stem bark of *Murraya koenigii S*. Molecules 14(17):4651-4660.
Kumar, V.S., Sharma, A., Tiwari, R., Kumar, S. (1999). *Murraya koenigii*: A review. Journal of Medicinal and Aromatic Plant Science, 2(1): 1139-1144.
Lafuente - Garcia, A., Guillamón, E., Villares, A., Rostagno, M.A., Martínez, J.A. (2009). Flavonoids as anti-inflammatory agents: implications in cancer and cardiovascular disease. *Inflammation Research*, vol. 58, no. 9, pp. 537–552.
Luchian, V., Teodosiu (Iordache), G. (2019). Research results regarding the anatomy of some medicinal plants of *Cucurbitaceae*. Scientific Papers. Series B, Horticulture. Vol. LXIII, No.1, Bucharest, RO.
Mathur, A., Dua, V.K., Prasad, G. (2010). Antimicrobial activity of Leaf Extracts of *Murraya koenigii* against Aerobic Bacteria Associated with Bovine Mastitis. Int. J. of Chemical Environmental and Pharmaceutical Research. Vol. 1, No. 1, 12-16.
Mathur, A, Prasad, G., Dua V. (2011). Anti-inflammatory activity of leaves extracts of *Murraya koenigii* L. International J. of Pharma and Bio Sciences, 2(1).
Meena, S., Sarma, R.K., Dwivedi V. (2017). Trans-criptomic insight into terpenoid and carbazole alkaloid biosynthesis and functional characterization of 2 terpene synthases in curry tree Sci. Rep. 7:44126.
Metcalfe, C.R., Chalk, L. (1988). Anatomy of Dicoty-ledons. 2nd Edn., Oxford University Press, USA., Oxford, pp: 97-177.
Middleton, E., Kandaswami, C., Theoharides, TC. (2000). The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease and cancer. Pharmacol Rev., 52: 673-751.
Mohammad, A., Liman, M.L., Atiku, S. (2013). *Murraya koenigii c*hemical composition of the methanolic leaf and stem bark extracts of *Senna siamea* lam. Journal of pharmacognosy and phytotherapy, 5(5): 98-100.
Muthulinggam, N., Subramanian, P. (2015) - *Murraya Koenigii* - A review on its potential, International J. of PharmTech Research, Vol.7, No.4, Malaiezia.
Muthumani, P., Venkatraman, S., Ramseshu, K.V., Meera, R., Devi, P., Kameswari, B., Eswarapriya, B. (2009). Pharmacological studies of anticancer, anti-inflammatory activities of *Murraya koenigii* (Linn) Spreng in experimental animals J. Pharm. Sci. & Res. Vol.1 (3), 137-141.
Nadkarni, K.M. (1995). The Indian Materia Medica.

3rd Edn, Popular Prakashan, Mumbai, India.
Narendhirakannan, R.T., Subramanian, S., Kandaswamy, M. (2005). Mineral content of some medicinal plants used in the treatment of diabetes mellitus. Biol. Trace Element Res., 103: 109-115.
Ningappa, M.B., Dinesh, B.R., Srinivas, L. (2008). Antioxidant and free radical scavenging activities of polyphenols-enriched curry leaf (*Murraya koenigii*) extracts. Food Chemistry, 106: 720-728.
Pande, M.S., Gupta, S.P.B.N., Pathak, A. (2009). Hepatoprotective activity of *Murraya koenigii* Linn. Bark. J. of Herbal Med. and Toxicology, 3(1), 69-71.
Parmar, C., Kaushal, M.K. (1982). Wild Fruits. Kalyani Publishers, New Delhi, India.
Parmar, S.A., Gangwal, A., Sheth, N. (2010). Mast cell membrane stabilization and anti-histaminic actions possible mechanism of action of anti-inflammatory action of *Murraya koenigii*. *Journal of Current Pharmaceutical Research*, vol. 2, no. 1, pp. 21–25.
Parrota, J.A. (2001). Healing plants of peninsular India. CABI Pub, U.S.A. : 639.
Rani, U., Verma, R.N., Batra, A. (2012). Total phenolic (flavonoids) contents and antioxidant capacity of different *Murraya koenigii* extracts. International Journal of Medicinal Plant Research 1: 124-128.
Rao, B.R.R., Rajput, D.K., Mallavarapu, G.R. (2013). Chemical diversity of curry leaf (*Murraya koenigii*) essential oil. Food Chemistry 126: 989-994.
Roy, A., Bhoumik, D., Sahu, R.K., Dwivedi, J. (2014). Medicinal Plants Used in Liver Protection - A Review. UK Journal of Pharmaceutical and Biosciences. 2(1): 23-33.
Roy, M. K., Thalang, V.N., Trakoontivakorn, G., Nakahara, K. (2004). Mechanism of mahanine-induced apoptosis in human leukemia cells (HL-60), *Biochemical Pharmacology*, vol. 67, no. 1, 41-51.
Saini, S.C., Reddy, GBS. (2013). *Murraya koenigii*. IOSR J. of Pharmacy and Biological Sciences 7(6): 15-18.
Savulescu, E., Hoza, G. (2010). Research results regarding the anatomy *of Momordica charanthia L*. species Scientific works. USAMV Bucharest, Series B, Vol. LIV, 694-700.
Sharma, P., Gali, V., Bhandari, A., Singh, S., Ghule, S., Agrawal, S. (2011). Antiulcer activity of leaves extract of *Murraya koenigii* in experimentally induced ulcer in rats. Pharmac. online; 2:818-824.
Sharma, S., Handu, S., Dubey, A.K., Sharma, P., Mediratta, P., Ahmed, O.M. (2017). Anti-anxiety and Anti-depressant Like Effects of *Murraya koenigii* in experimental Models of Anxiety and Depression. Enc. Sci. Life., 36(4): 215-219.
Shivkanya, J., Pahwa, S., Kumari, S., Fuloria, N. (2009). Pharmacognostical studies and antibacterial activity of the leaves *of M. koenigii* Pharmacog. J. 210-214.
Shyamapada, M. (2016). Curry plant (*Murraya koenigii)* an indigenous spice plant with versatile medicinal property. A mini review. International Journal of Clinical and Experimental Physiology 3(2): 59-65.
Singh, L., Sharma, M., (1978). Antifungal properties of some plant extracts. Geobios 5, 49.
Singh, S, More, P.K., Mohan, S.M. (2014). Curry leaves (*Murraya koenigii* Linn. Spreng.) - A miracle plant. Indian J. Sci. Res.4 (1):46-52.
Sivakumar, C.V, Meera, I. (2013). Antioxidant and biological activities of three monotype of *M. koenigii* from Uttarakhand. J. Food Process Tech., 4: 2-7.
Surbhi, S., Meenakshi, B. (2016). A review on *Murraya koenigii* (curry plant) - meethi neem. World Journal Pharmacy and Pharmaceutical science, 5(8): 397-408.
Syed, M.N, Aamir, S., Masood, S.B., Mohammad, I.K., Mahwish, T. (2015). Phytochemical profiling of curry (*Murraya koenigii*) leaves and its health benefits. Pakistan Journal of Food Science, 25(4): 204-215.
Tachibana, Y., Kikuzaki, H., Lajis, N.H., Nakatani, N. (2003). Comparison of Anti oxidative properties of Carbazole Alkaloids from *Murraya koenigii* Leaves. J. of Agricultural & Food Chemistry, 51: 6461-6467.
Thomas, V. (1991). Structural, functional and phylogetic aspects of the colleter. Ann Bot., 68(4): 287-305.
Toma (Singh), M., Luchian, V. (2019). Morphological and anatomical study of *Psidium guajava Linn*. (guava) -a new fruit tree and medicinal plant researched in Romania. Scientific Papers, Series B, Horticulture. Vol. LXIII, No.1, Bucharest, RO.
Toma (Singh), M., Popescu, S., Moise, D. (2019). Preliminary results regarding classical and innovative dehydration methods of organic black chokeberries (*Aronia melanocarpa* L.), International Symposium "Agricultural and mechanical engineering ISB- INMATEH", Bucharest, RO.
Vaidya, B.N., Brearley, T.A., Joshee, N. (2013). Antioxidant capacity of fresh and dry leaf extracts of sixteen *Scutellaria* species. J. Med Active Plants., 2(3): 42-49.
Vinuthan, M. K., Kumar, V., Ravindra, J.P., Narayana, K. (2004). Effect of extracts of *Murraya koenigii* leaves on the levels of blood glucose and plasma insulin in alloxan induced diabetic rats. Indian J. Physiology Pharmacol., 48, 348.
Vinuthan, M.K., Kumara, G., Narayanaswamya, M., Veenab, T. (2007). Lipid lowering effect of aqueous leaves extract of *M. koenigii* (curry leaf) on alloxan-induced male diabetic rats. Pharmacog. 3:112–115.
Yadav, S., Vats, V., Dhunnoo, Y., Grover, J.K. (2002). Hypoglycemic and antihyperglycemic activity of *Murraya koenigii* leaves in diabetic rats. J. Ethnopharmacol. 82, 111.
Yi, W., Wetzstein, H. (2010). Biochemical, biological and histological evaluation of some culinary and medicinal herbs grown under greenhouse and field conditions. J. Sci. FoodAgric., 90: 1063-1070.
Zahin, M., Aqil, F., Husain, F.M., Ahmad, I. (2013). Antioxidant capacity and anti-mutagenic potential of *M. koenigii.* Biomed Res Int. 263-509.
https://www.healthline.com/health/beta-caroten.
https://www.healthline.com/health/caffeic-acid.
https://medlineplus. gov/ency/ article/002416.htm).
https://medlineplus.gov/ency/ article/002423.htm.
http://www.med.umich.edu/cancer/files/ why-is-iron- important.pdf.