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PLANT BIODIVERSITY IN THE ETHNOPHARMACOLOGY OF SALENTO. BIBLIOMETRIC NETWORKS FOR ITS RE-EVALUATION

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Abstract

This study explores the historical evolution of ethnopharmacology, a discipline rooted in the earliest stages of human civilisation and still practiced globally. Central to this field is humanity's deep understanding of plants—used for nourishment, healing, and toxicity—and the transmission of this knowledge across generations. In the Salento region, the rich biodiversity of native flora has long supported diverse therapeutic applications, with traditional methods of medicinal preparation preserved to the present day. Recent bibliometric analyses highlight a significant surge in scientific interest in ethnopharmacology, particularly in the search for novel bioactive compounds that enhance the pharmacological value of indigenous plant species To re-evaluate this local knowledge, bibliometric analysis was applied to three key Salento species: borage (*Borago officinalis* L.), sea fennel (*Crithmum maritimum* L.), and poppy (*Papaver rhoeas* L.). Scientific investigation confirmed traditional uses while revealing a high number of secondary metabolites. Noteworthy findings include borage's high γ-linolenic acid content, sea fennel's potent antioxidant and cytotoxic activity, and the reclassification of poppy as a biocide plant.

Keywords

Bibliometric networks, biodiversity, ethnopharmacology, medicinal plants

1 *Introduction*

Man has always sought remedies for his ailments in nature. Meadows, woods and marshes were his first pharmacies, and he interpreted the medicinal powers of plants as expressions of the supernatural. Over time, knowledge of plant morphology was handed down with increasingly precise instructions on how to harvest and use them. The earliest Egyptian papyri, Chinese illustrated herbals, and Indian medical texts date back to the 5th-4th centuries BC and contributed to the birth of phytotherapy.

In the 19th century, about twelve Egyptian medical papyri were discovered and translated. The oldest is the Smith Papyrus (c. 3000 BCE), while the comprehensive is the Ebers Papyrus (c. 1550 BCE), which contains numerous recommendations for treating diseases with plant-based medicines, as well as techniques and preparations for mummification. Access to these texts was restricted to high priests, who were responsible for studying the papyri and administering medicines (Capasso, 2006; Atanasov et al. 2015).

In Greece, the first official texts on medicinal plants emerged during the early period of Aristotelian philosophy, which brought together physician-philosophers and scientists to approve rudimentary remedies. Hippocrate (c. 460-377 BCE) laid the foundation formedical science by researching the therapeutic properties and appropriate dosages for approximately 250 plant species. Theophrasto (c. 372-287 BCE), in his Historia Generalis Plantarum, collected all known information of the time, including guidance on harvesting and preserveing drugs and medicinal preparations.

In De Materia Medica, Dioscoride (1st century BC) described around 600 medicinal plants and their properties. His work was transmitted throughout the Middle Ages and remained influential until the Renaissance. The Arabs introduced new medicinal plant species to Europe, such as cinnamon, nutmeg and tamarind, as well as new pharmaceutical preparations like syrups and distillates, facilitated by increasingly precise chemical instruments. The Salerno Medical School was established and produced numerous scientific studies and discoveries over the centuries. In 1231, Frederick II founded the University of Medicine in Naples and, through the edict of 1242, formalized the role of the medicine preparer.

During the Middle Ages, interest in herbal medicine grew. Dante Alighieri, in his Divine Comedy, illustrated and described medicinal plants with admirable verses and subtle details, reflecting both his extensive knowledge and his deep respect for nature, viewed through the lens of a researcher and naturalist (Valzano & Sartor, 2021).

Dante drewupon personal experience, classical Latin sources such as Virgil, Horace, and Ovid, Pliny's Naturalis Historia (77-78 AD or CE), Albertus Magnus' De Vegetalibus et plantis (1250), considered a significant contribution to medieval botany, and contemporary herbals.

Dante's references to plants provide valuable insight into their regional and national presence, as well as their uses, consumption, and cultivation methods (Valzano, Sartor, Romani, & Accogli, 2022).

In monasteries, learned monks, proficient in Latin and Greek, translated and preserved a vast corpus of manuscripts on the virtues of plants. Monastic schools developed cloistered gardens and Giardini dei Semplici (Gardens of Simples), which served not only as cultivation sites but also as centers for experimentation and advanced education (Capasso, 2006; Lanzara, 1978; Ranfa, 2004). Collections of medicinal plants became increasingly important in university curricula, leading to the establishment of the first botanical gardens in Pisa, Padua, and Florence (Garbari, 1996; Meda, 1996).

Paracelsus (1493-1541) proposed that plants act through a "fifth essence" that can be extracted and used medicinally, thereby advancing distillation and extraction techniques. In the early 18th century, active ingredients in medicinal plants were identified and isolated, culminating in the synthesis of the first alkaloid, coniine, in 1889 (Capasso, 2006; Lanzara, 1978).

2 *Ethnopharmacology in Salento*

Situated between two seas and near the center of the Mediterranean Basin, Salento is characterized by remarkable plant biodiversity, shaped through slow and continuous co-evolution with other life forms, including animals, fungi, bacteria, and protists. The region's flora comprises approximately 1,540 species (Marchiori & Tornadore, 1988; Mele et al., 2006), many of which remain in active use across Salento in diverse traditional and contemporary applications. Interest in the use of wild plants has increased significantly in this third millennium, likely driven by increased awareness of the relationship between diet and health. Wild herbs are valued not only for their nutritional properties but also for their therapeutic potential, often blurring the distinction between food and medicine.

Over the centuries, Salento has preserved a rich body of ethnobotanical knowledge shaped by daily life, historical events, and geographical and anthropological transformations. This knowledge, though often marginalized or diminished by changing cultural contexts, continues to reflect the deep connection between local communities and their natural environment (Accogli et al., 2007). Given the number of plant species present, the region harbors an extensive and largely untapped reservoir of primary and secondary metabolites—many of which are synthesized only under specific environmental conditions. This biochemical diversity positions Salento's flora as a valuable resource for the development of pharmaceutical, nutritional, cosmetic, and dietary products (Accogli, 2009).

In line with national and global trends, Salento has begun to reexamine its ethnobotanical heritage and folk pharmacopoeia. Efforts are underway to recover ancient remedies once prepared by "expert women" using wild plants to treat burns, skin conditions, respiratory and gastrointestinal disorders, joint pain, and other ailments (Accogli & Marchiori, 2010). Contemporary scientific research is increasingly focused on validating these traditional practices. Bibliographic reviews and field interviews conducted in the region have documented therapeutic and nutritional uses for over 800 plant species (Accogli et al., 2007; Accogli & Marchiori, 2010; Accogli & Medagli, 2014; Biscotti, 2018; Guarrera, 2006; Nardone et al., 2012; Palombi, 2005).

Many of these plants exhibit perennial root systems that store precious bioactive compounds, while their aerial parts regenerate annually. Dietary habits and therapeutic practices have often been transmitted to the present day in a somewhat ambiguous manner, as many herbs used for food can also be curative. Traditionally, grandmothers adjusted the plant ingredients in their recipes according to the seasons and local availability. These dishes were believed to promote well-being by purifying the bloodstream and enhancing diuresis. Consequently, knowlwdgeable women meticulously studied different plant species to identify effective remedies.

Information on the therapeutic use of plants highlights that, in the past, they were commonly found near human settlements and were readily available. For example, plants and their fruits were used in infusions and decoctions to treat bronchial catarrh, coughs, fever, intestinal disorders, and circulatory ailments. Cattail (*Thypha latifolia* L.) and common centaury (*Centaurium erythraea* Rafn) were regarded as miraculous when applied to wounds sustained during fieldwork, as were poulices prepared from the bulbs of sea squill (*Charybdis maritima* (L.) Speta), which were ground into a pulp and applied to joints to treat bruises or arthritis (Accogli & Marchiori, 2010).

3. International bibliographic sources

The search for recent scientific bibliographic sources was carried out using PubMed, a free database and search interface for scientific literature in the biomedical and life sciences fields, developed by the National Centre for Biotechnology Information (NCBI) of the US National Library of Medicine (NLM). PubMed collects biomedical scientific literature from 1949 to the present, containing millions of citations and abstracts from scientific journal articles and collections. It is a widely used and valuable bibliographic resource among researchers. The database provides access to MEDLINE, the main bibliographic database of the NLM, as well as to information and full text articles from other databases.

To search for bibliographic sources on a specific species, the scientific name can simply be entered into the database, which will immediately display a list of articles published in numerous indexed international scientific journals. Specialised data analysis and visualisation software, such as VOSviewer, can then be used to process all the retrieved articles by constructing and visualising bibliometric networks, including co-authorship, citation, and co-occurrence networks.

4 Biodiversity and bibliometric networks

Bibliometric networks are graphical representations of the relationships among scientific publications, authors, institutions, and keywords.

These networks can be used to analyse the structure of scientific knowledge in a specific field, identify the most influential authors and institutions, and trace the evolution of scientific ideas and concepts.

Bibliometric networks are increasingly employed to analyse research on biodiversity and to identify trends and gaps in scientific knowledge.

Thus, bibliometric analysis contributes to a better understanding of the structure of scientific knowledge on biodiversity and helps to identify research areas that require greater attention.

5. Research objectives

The effectiveness of bibliometric networks analysis was evaluated for three species: borage (*Borago officinalis* L.), sea fennel (*Crithmum maritimum* L.), and poppy (*Papaver rhoeas* L.). The objective was to compile a botanical data sheet for each species, comparing properties reported in traditional pharmacopoeia with information validated by recent scientific studies.

Each data sheet includes:

- botanical and ecological caracteristics;
- information derived from local ethnobotanical sources;
- information obtained from scientific sources indexed in PubMed.

Regarding botanical aspects, information on the taxonomy of each species was considered, including the scientific binomial, common name, and family, as well as data on ecological requirements, habitat, and chorology (global distribution). Ethnobotanical information was synthesized to summarize the therapeutic properties reported in local sources.

The selection of species studied was based on their differing ecological characteristics and their strong connection with the food traditions of Salento.

The map generated using VOSviewer enabled the visualization of relationships among elements and clusters of interest.

5.1 *Borago officinalis* L. - Borage

Borago officinalis is a winter-spring species that prefers cultivated gardens rich in humus and moisture, and can be found for an extended period throughout the year (Fig. 1).

Fig. 1: *Borago officinalis* L. - Borage

Borage is one of the best-known wild species, renownwd for its therapeutic properties, handed down through popular pharmacopoeia, and for its use in numerous local recipes. It is harvested before flowering, and the tender leaves are used either cooked or raw as an ingredient in many traditional dishes. The fresh flowers are added to vegetable salads, used to decorate sweet and savoury foods, or infused in alcohol to produce wines and liqueurs.

In folk medicine across various Italian regions, borage is known for its therapeutic effects on several organs and systems of the human body. The young leaves and flowers are used to prepare decoctions, infusions or compresses, and juices are obtained by pressing the plants.

Borage has been recommended for respiratory disorders, as an expectorant and anti-bronchial agent; to support the digestive and circulatory systems, as a laxative and purifier of the blood and liver; for urinary tract disorders, as a diuretic and anti-nephritic agent; and as a diaphoretic and sudorific to aid the excretory system. It has also been used in cases of depression, nervous exhaustion, and acute pain caused by arthritis or rheumatism, as well as for eczema and skin abscesses (Accogli & Medagli, 2014; Atzei, 2017; Ballerini, 2009; Boni & Patri, 1980; Gastaldo, 1987; Ditonno et al., 1997; Nardone et al., 2012; Palombi, 2005).

The ancient Greeks used its flowers and leaves in wine infusions to obtain a drink that Homer described as a remedy "that calmed anger and pain, oblivion of all suffering". The hydroalcoholic infusion of borage was said to induce cheerfulness and courage; according to tradition, gladiators, slaves, and Crusaders drank it to face death, and many artists and writers suffering from melancholy used it to recover their good spirits. For centuries, its exhilarating effects have been celebrated by the saying "*Ego borago gaudia semper ago*!", which continues to encourage its use today (Ballerini, 2008).

The therapeutic potential of borage, documented by ethnobotany, has driven scientific research in the biomedical field, particularly in the last decade, resulting in the publication of hundreds of articles worldwide.

Our PubMed search identified 198 scientific articles published in high-impact international journals over the past fifty years. Analysis using VOSviewer software revealed multiple correlations among these studies, highlighting bioactive compounds and their applications in clinical, agronomic, environmental, and health-related fields.

The network analysis identified five clusters, 373 links, and a total link strength of 1180, with over 600 related keywords (Fig. 2).

Recent research has not only confirmed the properties reported by ethnobotany and folk pharmacopoeia but also identified numerous secondary metabolites extracted from the species.

The well-known therapeutic effects of borage oil, recognized since ancient times, are attributed to its high γ-linolenic acid content (≥20%), which has been investigated for use in several "new generation" diseases, including multiple sclerosis, cancer, autoimmune disorders, cardiovascular disease, premenstrual syndrome, and diabetes mellitus (Samani et al., 2014; Baharvand-Ahmadi et al., 2016; Ghasemian et al., 2016).

Dietary consumption of *B. officinalis* has been shown to play an important role in cancer prevention (Lozano-Baena et al., 2016), and the juice of the fresh plant is effective in the green synthesis of stable silver nanoparticles (AgNPs), with strong anticancer potential. This eco-friendly synthesis minimises the harmful by-products associated with conventional chemical and physical nanotechnological methods (Singh et al., 2017).

id	keyword	id	keyword	id	keyword
12	adolescent	226	fatty acids, unsaturated	433	Obesity
13	adult	228	female	436	oils, volatile
14	aged	230	fish oils	437	oleic acid
25	alpha-tocopherol	233	flowers	446	oxidoreductases
30	amino acid sequence	250	free radical scavengers	455	phenols
37	animals	257	gamma-linolenic acid	461	phylogeny
43	anti-inflammatory agents	258	gas chromatography-mass spectrometry	462	phytochemicals
55	antioxidants	260	gene expression	464	phytotherapy
75	biomarkers	278	guinea pigs	465	picrates
77	biphenyl compounds	296	humans	470	plant extracts
84	boraginaceae	299	hydrogen-ion concentration	471	plant leaves
85	borago	315	inflammation	472	plant oils
111	cells, cultured	318	inhibitory concentration 50	474	plant preparations
126	chromatography, high pressure liquid	326	iran	476	plants
131	cinnamates	328	italy	477	plants, edible
155	cytochromes b5	345	linoleic acid	478	plants, genetically modified
163	depsides	346	linoleic acids	479	plants, medicinal
171	diet	347	linolenic acids	497	pyrrolizidine alkaloids
177	dietary supplements	348	linoleoyl-coa desaturase	503	randomized controlled trials as topic
181	disease models, animal	349	lipase	504	rats
200	echium	351	lipid peroxidation	507	rats, wistar
201	eicosapentaenoic acid	367	magnoliopsida	530	seeds
210	epidermis	369	male	532	sequence alignment
213	ethnobotany	377	medicine, traditional	554	spectrometry, mass,
220	fatty acid desaturases	388	mice	568	tandem mass spectrometry
221	fatty acids	395	microsomes	576	tobacco
222	fatty acids, essential	397	middle aged	588	triglycerides
224	fatty acids, omega-3	404	molecular sequence data	598	vegetables
225	fatty acids, omega-6	405	molecular structure	605	young adult

Fig. 2: keywords related for Borage

Recent studies have also demonstrated the hypoglycaemic activity of *B. officinalis*, whose active ingredients are particularly useful in the treatment of diabetes mellitus, a metabolic disorder characterised by chronic hyperglycaemia and associated organ dysfunction (Rodríguez-Magaña et al., 2019). Its properties in the treatment of gastrointestinal, respiratory and vascular disorders (Gilani et al., 2007), atopic dermatitis (Foster et al., 2010), melanogenesis regulation and melanoma prevention (Shin et al., 2020), and skin regeneration after photodamage (Seo et al., 2018) have been confirmed. Additionally, its role as a biostimulant in agricultural crops (Bulgari et al., 2017) and its larvicidal activity against *Anopheles gambiae* (Kweka et al., 2012) have been established.

5.2 Crithmum maritimum L. – Sea fennel

Sea fennel is a perennial species typical of coastal habitats, with a spring-summer growth cycle (Fig. 3).

Historically, it was used by populations engaged in coastal economic activities. Scientifically, it remained relatively understudiuied until the last two decades, but it is now considered a species of significant therapeutic interest.

Since antiquity, fresh sea fennel has been valued for its purifying, aperitif, tonic, diuretic, and purgative properties and was also used as an antiscorbutic. The fruits are known to reduce fermentation and intestinal spasms.

Fig. 3: *Crithmum maritimum* L. - Finocchio marino

In maritime territories, it remains a popular culinary ingredient for side dishes and as a flavouring for fish-based preparations. Even today, in late spring, the tender apical portions of the stems are harvested along the coast and preserved in jars. The main active componentrs include essential oils, vitamins, and mineral salts (Accogli & Medagli, 2014; Atzei, 2017; Ballerini, 2008; Boni & Patri, 1980; Gastaldo, 1987; Ditonno et al., 1997; Nardone et al., 2012; Palombi, 2005).

Research on PubMed revealed that scientific attention towards sea fennel has increased since 2000, with 101 publications indexed in PubMed, reaching a peak of 18 articles in 2023. VOSviewer analysis identified three clusters, 44 links, and a total link strength of 120, with over 200 related keywords.

The traditional properties of sea fennel - purifying, diuretic, aperitif and laxative - have been complemented by discoveries of additional activities, including antioxidant, vasodilator, antibacterial, cytotoxic, and cholinesterase-inhibiting effects (Mekenic et al., 2016; Gil et al., 2019; Meot-Duros et al., 2009; Jallali, 2014). Its dermatological potential has been confirmed , particularly its antibacterial action and skin-regenerating capacity (Lequeux et al., 2011). Recent studies also demonstrate that ethyl acetate extracts of sea fennel inhibit the growth of hepatocellular carcinoma (Beeby et al., 2020; Gnocchi et al., 2020; Gnocchi et al., 2021).

Moreover, sea fennel extracts have shown biocidal activity, including acaricidal effects against *Dermanyssus gallinae* (Tabari et al., 2020), nematicidal activity against *Bursaphelenchus xylophilus*, and insecticidal activity against *Tribolium castaneum* (Barbosa et al., 2010; Mustapha et al., 2020).

Recent literature also highlights its reintroduction as a food plant of nutritional value (Pereira et al., 2017; Pereira et al., 2020) and its potential as an emerging crop (Renna, 2018; Ventura, 2014), suitable for dryland farming and green roof cultivation (Azeñas et al., 2018).

5.3 Papaver rhoeas L. - Poppy

Papaver rhoeas is an annual herbaceous species with a winter-spring cycle, typically found for about nine months each year in cereal fields and along rural roadsides (Fig. 4).

The poppy's properties have been celebrated since Babylonian times. The Greeks depicted Hypnos, the god of sleep, crowned with poppies, and the Romans used it as a milder substitute for opium poppy (*Papaver somniferum* L.) in a beverage called *cocetum*, known for its sedative properties.

Fig. 4: *Papaver rhoeas* L. - Poppy

The plant has a sweetish taste and can be eaten raw in salads or cooked (boiled or sautéed with oil, garlic and chilli). Its consumption is therapeutic, as folk medicine attributes to it astringent, analgesic, antispasmodic, anti-inflammatory, and expectorant properties. It was also used to relieve toothache, gout, and shingles.

Among the first alkaloids extracted from plants in the early 20th century was readine, responsible for its sedative and narcotic effects, present in high concentrations in the petals and mature capsules. Other alkaloids acting synergistically with readine include reaginine, protopine, coptisine, cheletrine, and sanguinarine, which may cause gastrointestinal disturbances if consumed in excess.

The plant also contains resins, pigments, and mucilage, used in traditional remedies for skin and dental inflammations.

Interest in the poppy as a food plant has persisted, and the traditional "*fritta*" or "*paparena*" dish continues to be prepared and appreciated for its flavour and health benefits (Accogli & Medagli, 2014; Atzei, 2017; Ballerini, 2008; Boni & Patri, 1980; Gastaldo, 1987; Ditonno et al., 1997; Montefusco et al., 2015; Nardone et al., 2012; Palombi, 2005; Ranfa, 2004).

Research on PubMed has shown steady but moderate interest in *P. rhoeas*, with 196 publications over the last fifty years. Scientific output was limited until 2002 (two articles), later peaking at twelve articles in 2011, 2015, and 2019.

VOSviewer analysis revealed five clusters, 464 links, and a total link strength of 1142, with over 500 related keywords (Fig. 5 and Fig. 6), underscoring the diversity of bioactive molecules that make it a plant of considerable clinical interest. Furthermore, its allogamous nature has

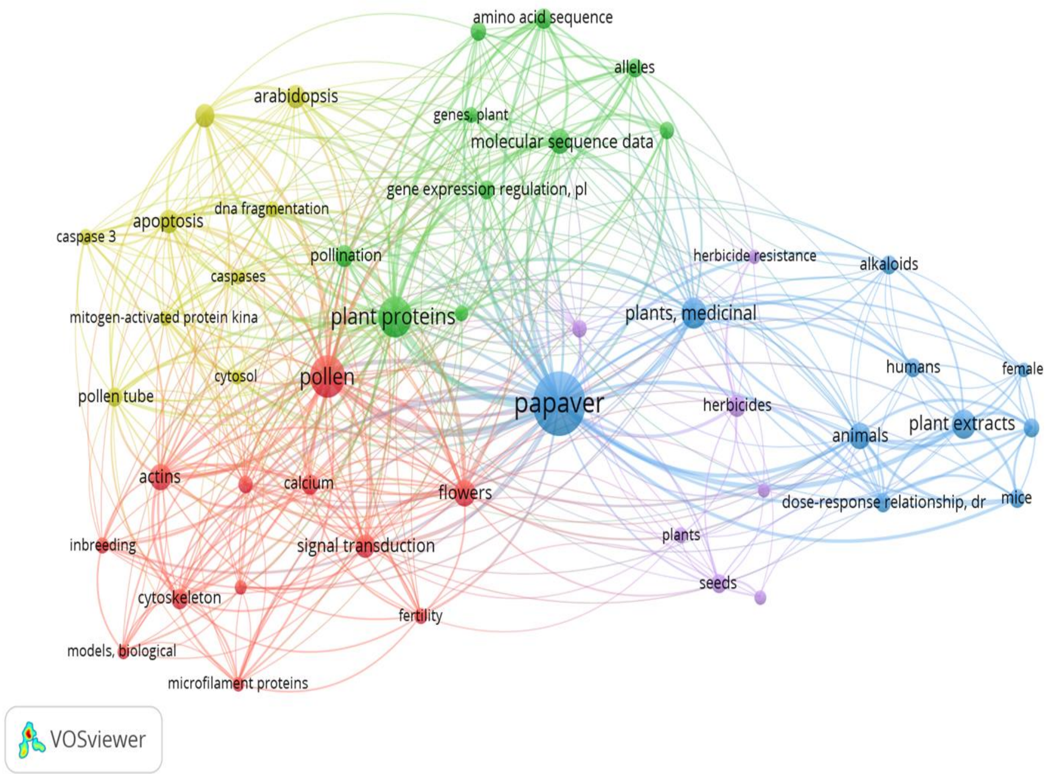

Fig. 5: Bibliometric network – *Papaver rhoeas L.*

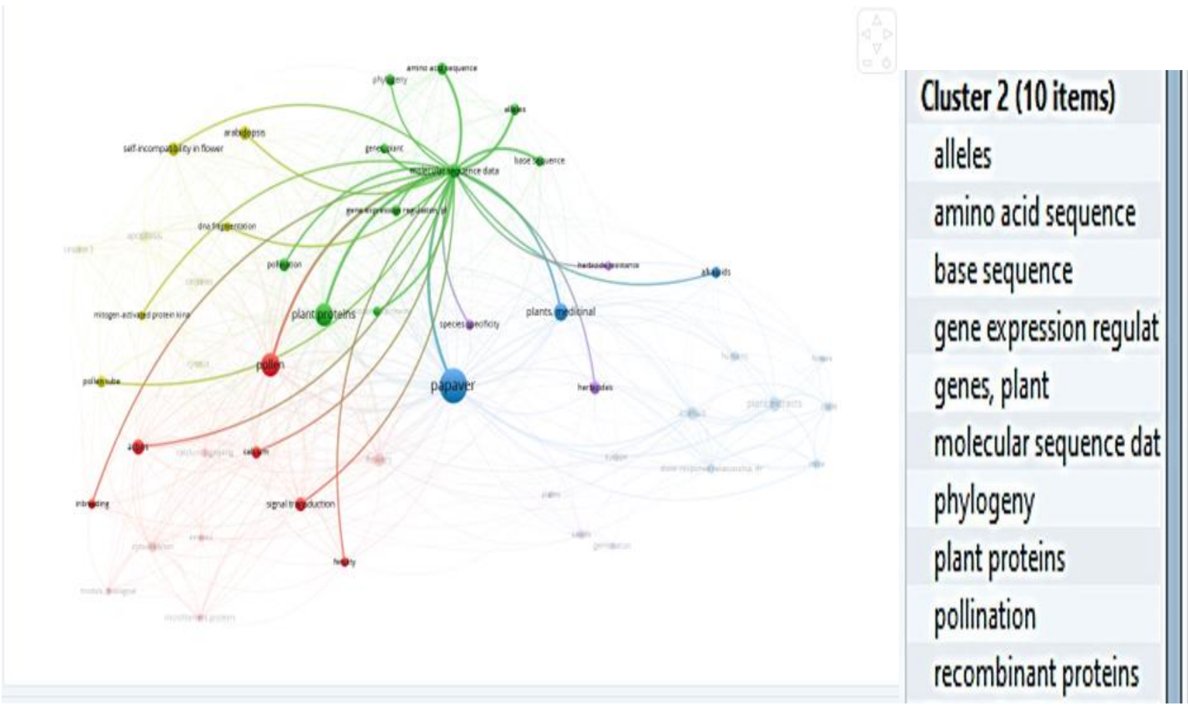

Fig. 6 Cluster 2: (10 items) network highlighted in green

drawn attention to its cellular biology, leading to discoveries that position it among biocidal plants with potential new applications.

6. Conclusions

In addition to confirming the information preserved in traditional pharmacopoeia, the scientific literature provides a comprehensive and updated understanding of *B. officinalis*, *C. marinum,* and *P. rhoeas*.

The availability of online databases and analytical software enables real-time visualization of research trends and relationships guiding investigations towards priority areas such as novel therapeutic approaches, functional food production, low-impact agricultural practices and environmental restoration using native species with minimal cultivation requirements.

Traditional knowledge, transmitted orally or in writing, remains a valuable foundation for scientific inquity, not merely for verification, but as a source of insight and practical solutions beneficial to the community.

The scope of investigation extends beyond the therapeutic potential of plant species to include their ecological roles and the interactions among organisms and regulatory substances within ecosystems.

The growing reliance on natural phytochemicals underscores the need for comprehensive knowledge of local flora, enabling targeted and suitable use of natural resources. The information gathered on these three species contributes to an updated understanding of the health-promoting properties of Salento’s native flora, with international scientific relevance.

The creation of a catalogue of Salento species, each accompanied by a glossary of health properties supported by objective, current, and accessible data, represents an important future objective.

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