

The Fascinating History of Bergamot (*Citrus Bergamia* Risso & Poiteau), the Exclusive Essence of Calabria: A Review

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Abstract: The bergamot (*Citrus bergamia* Risso et Poiteau), a citrus fruit growing almost exclusively in the South Italy, is considered the “prince of citrus” for its storical role in the perfume industry due to its essential oil, a product in great demand of a pleasant and refreshing scent. Recently, analgesic, anxiolytic, neuroprotective consistent effects have been ascribed to bergamot essential oil when it is used in aromatherapy, for the relief of pain and symptoms associated with stress-induced anxiety and depression. Moreover, today, bergamot fruit due to a considerable abundance and variety of nutraceutical compounds which are present in its juice, is becoming increasingly important also in the food, pharmaceutical and confectionery industries. In this review, it is discussed that the literature on *C. bergamia*, focusing on the several studies performed with the experimental data, and recently accumulated, may form the rational basis for further development.

Key words: Bergamot (*Citrus bergamia* Risso & Poiteau), essential oil.

1. Introduction

1.1 Origins

The bergamot (*Citrus bergamia* Risso & Poit., syn.: *Citrus aurantium* L. subsp. *bergamia* (Risso et Poit.) Wight et Arn. Engl.) is an aromatic citrus fruit resembling in size, an orange with a yellow color, similar to a lemon. It belongs to the Rutaceae family of the *Citrus* genus and it was mentioned by Ferrari, for the first time, in 1646, in his monography *Hesperides sive de malorum aureorum cultura et usu*, as an “aurantium stellatum et roseum”; only later, in 1708, it was described in detail by Volkamer, in his *Nurnbergische Hesperides*, as “gloria limonum fructus inter omnes nobilissimus” who reported the

distinctive and desirable characteristics of its essential oil [1]. Bergamot has been known, in the Mediterranean, for several centuries, as the distinctive and desirable characteristics of its oil having been recognized, as early as 1750. Until now, both the centre of origin and the significance of its name are unknown. Almost all citrus species, are believed to be originated from several thousand years ago, in the tropical and subtropical regions of Southeast Asia and then they spread globally, following ancient land and sea routes [2]. The lineages that gave rise to most modern cultivated varieties, have been lost in undocumented antiquity and their identities remain controversial [3, 4]. It is not an easy task to trace back the path which led to their worldwide diffusion principally, because *Citrus* has a long history of cultivation (more than 4,000 years) and a wide dispersion [5]. Presumably, *C. bergamia* originated as

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seedling, in Southern Italy [6]. It is an hybrid of *C. aurantium* x *C. medica* [7] whose the sour orange (*C. aurantium* L.) is the maternal parent, and citron (*C. medica* L.) is the paternal one [8]. The origin of the name and its significance is a matter of conjecture; there is general agreement, that it derived from Turkish word “*beg-a-mudi*” which means “Pears of the Prince”, due to its certain resemblance to the bergamot pear, represented in a painting of B. Bimbi of 1715 [9, 10]. However, since the beginning of the sixteenth century, the bergamot was known only, as ornamental plant that decked the gardens of the aristocratic Italian families. Later, due to a Sicilian gentleman, Francis Procopius who around 1686, introduced in France, the “*bergamot water*”, a very fine essence obtained from the peel of bergamot fruit, it became the more precious component of the most charming perfumes. Almost at the same time, in the Cologne town, another Italian emigrant, Paolo Feminis, developed the “*cologne water*” (eau de cologne), perhaps the most widely used toilet water that was commercialized, in the same town, by his son-in-law, Gian Maria Farina. Its manufacture dates back to 1709 [11]. The essence was utilized with success also, in beauty and toilette treatment and quickly, its European demand grew very much. So, in 1750, near Reggio Calabria town, in the Giunchi Feudal Estate, the first known bergamot orchard, was planted by the owner Nicola Parisi. Later, the *C. bergamia* growing increased and expanding rapidly along the Straits of Messina area [12, 70].

1.2 Essence History

The first extraction essence of *C. bergamia* was obtained by manual pressure of the peel of the fruit and absorbed by natural sponge placed on special cups, called “*concoline*”; the complete process that was described, by Domenico Sestini, in 1780, was carried on, often at night-time, by expert workmen, the “*sfumatori*” [13]. In 1844, with the invention of the “*Calabrian Machine*” by N. Barillà, the first real

industrialization of the extraction process of the essence, took place that was able to assure, in short time, not only a high output but also an excellent quality of the essential oil. Nowadays, the natural essence is extracted from the peel by a cold-pressing procedure [14]. Later, in 1908, because of the dramatic earthquake that razed the Reggio Calabria town, the bergamot growing stopped suddenly; only, in the 1960, it reached the maximum economic expansion (4,000 hectares) but then, it slowly decreased, until the end of last century, due to the housing boom and the diffusion of synthetic essences [15]. Since the eighteenth century, this crop has been cultivated, almost exclusively, in the Calabria region, in the province of Reggio Calabria, in a narrow strip of land, about a hundred kilometers long, between Villa San Giovanni and Gioiosa Ionic towns, on a surface of 1.200 ha. This stretch of coast, is the exclusive productive area able to provide more of 90% of the world bergamot production with a crop of 250 q/ha, to produce 100.000 kg of essence. To obtain one kilogram of essence, about 200 kg of fruits are necessary [16]. The very exclusive microclimate of this small area, due to alluvial and argillaceous soils rich of mineral salts and geographical exposition, with rainy winters and warm-humid summers, favors the optimum development and production of the bergamot plant. This citrus is very sensitive to the thermal shock and the spring mists, and it is resistant to the breezes, because it needs to reduce the fungus infections. We can find that, also in some areas of Africa (Costa d’Avorio, Mali, Cameroun, Guinea) and of South America (Argentina and Brazil), *C. bergamia* growing but the concentration of the compounds of its rind oil, is highly variable and therefore, unprofitable [17]. The collecting of suitable fruits for the essential oils extraction, is carried out from December to the end of February, by skilled workers [18]. Bergamot is a middle-sized plant; its productivity lasts up to 25 years. It generally, develops slower than other citrus species with regular and symmetrical foliage. The tree

is moderately vigorous, at full maturity, it is medium-small to medium in size. The leaves are large and somewhat like the lemon in color, form and emargination, although the blades are sharper-pointed and the petioles are longer and more broadly winged. The flower buds and flowers are medium-large and pure white. The small to medium large lemon—yellow-colored fruits are hesperidium with an average weight of 150 gr. and usually, have a persistent style. They present an *exocarp*, an external part with a lot of utricles full of essential oil, a spongy *monocarp* and an *endocarp*. The rind is medium-thin with a smooth to moderately rough surface, commonly ridged and adherent. The segments are numerous and the core solid. The flesh is moderately firm, pale greenish-yellow, and highly acid with a faint bitter aftertaste. The highly monoembryonic seeds, comparatively few and sometimes none, often are not well developed. The cotyledons are white or faintly green. A distinctive characteristic of both foliage and fruits, is the strongly pungent and agreeably aromatic oil, which is similar to that of the sour orange leaf, though the rind oil of the latter is different. The flowering time is between the end of the March and the half of May while the harvesting comes from November to March [19]. There are currently three distinct cultivars of *Citrus bergamia*: “*Femminello*”, “*Castagnaro*” and “*Fantastico*”. The “*Femminello*” cultivar is a fast-growing plant that is not very developed with lanceolate leaves, spherical fruit and a thin exocarp rich in essential oils; it is the more aromatic, and it is therefore, preferred to the other cultivars. It is also, the earliest because the harvest begins in early October. The “*Castagnaro*” cultivar is a rustic plant, resistant to strong winds and long-lived, with large and lanceolate leaves and globular fruit with exocarp of medium thickness; it has an average content of essential oils. The harvest begins in November. The “*Fantastico*” cultivar is rustic and highly productive plant with very large leaves, globular, pear-shaped fruit and oil with an

excellent aroma. Although it has been introduced more recently, it constitutes the largest percentage of fruit production. The harvest-time is between November and December [20].

2. Bergamot Uses

2.1 Cosmetic Use

The bergamot essence belongs to essential oils which are volatile, natural, limpid complex compounds characterized by a strong odor; they are produced by various aromatic plants, as secondary metabolite and usually, obtained by steam or hydro-distillation; each essential oil, is a very complex mixture of molecules which contains between 20 and 70 components, with low molecular weight and at different concentrations. Most molecules are present in traces while two to three, are often the most representative components, accounting for 20-70% of the whole oil and responsible for determining its biological activities [21]. There is a high variation in the chemical profile of essential oils depending on the extraction methods, organ used, age and vegetative stage of the plant, the time of the harvest and the soil composition [22, 23]. Bergamot oil, is one of the most important perfume materials; its pleasant refreshing scent, blends into almost, any perfume composition so that, today, there is not a perfume which does not contains BEO (Bergamot Essential Oil). It imparts delicate top notes and at the same time, strength and body to the perfume. Phytochemical, essential oils, have been considered attractive, for their wide variety of bioactivities. About 3,000 essential oils, are known of which 300 are very important for pharmaceutical, cosmetic and perfume industries [24]. The bergamot essence is a clear yellow-green liquid, obtained by cold pressing of epicarp and partly, of the mesocarp, of the fresh fruit. It consists of a volatile (93-96% of total) and a non volatile (4-7% of total) fraction; the former contains monoterpene and sesquiterpene hydrocarbons such as limonene (40%) and oxygenated derivatives such as linalool (8%) and linalyl acetate

(28%). The hydrocarbon fraction does not have a fundamental role, in determining the olfactory character of the essence, but oxygenated compounds mark the flavor [25]. Monoterpenes are the most abundant constituents and often, the antitumor activity of the essential oil, has been related to their presence in the phytocomplex [26]. The non-volatile residue contains waxes and polymethoxylated flavones, coumarins and psoralens (bergapten (5-methoxypsoralen), bergamottin (5-geranyloxypsoralen)) which influence the olfactory properties of the essence. A large body of experimental data, accumulated during the last 20 years, have stressed that the psoralens, among other uses, are employed in therapy of psoriasis and vitiligo [27]. In addition, experimental evidence demonstrates that the phytocomplex may interfere with the receptor-mediated mechanisms of regulation of synaptic levels of amino acid neurotransmitters [28]. Then, the bergapten compound binding to DNA under ultraviolet A light exposure, produces compounds which are cytotoxic and highly mutagenic [29, 30]. So, bergamot essence was restricted or banned in many countries, because of certain adverse effects, due to photosensitive and melanogenic properties of bergapten; in fact, the bergapten-free extract of the essence are prepared by extractive industries for perfumery and cosmetic uses. In addition, recent experimental evidence, demonstrates that the bergamottin might be endowed with Ca⁺⁺ antagonist properties “*in vitro*” [31, 32]. The nonvolatile fraction is a natural odor fixative, which influences the olfactory properties of the oil. However, the bergamot essence constitutes the base of cologne water (eau de cologne) and of the most widely perfumes, due to its ability to fix and amalgamate different fragrances, in the unique bouquet. It also, gives substance to soaps, tooth-pasts and deodorants and it is an important component of tanning creams, due to the presence of photodynamic compounds as fucumarins and terpenes [33-37]. However, there are other types, of very

valuable bergamot essence: the “petit grain” extracted from the leaves and tender branches, which are very useful to impact a strong refreshing note; the “bergamottella essence” from immature fruits and the “neroli”, a highly esteemed, very expensive, extract that is obtained from the flowers.

2.2 Medicinal Use

The use of essential oils, as antimicrobial agents for topical treatment of infections, is well known in popular tradition. Recently, the potential antimicrobial effects of certain plant oil have attracted serious attention within the scientific community [38]. It has always attributed anti-infective properties to bergamot oil but its medicinal effects have received only limited attention [39, 40]. Its efficacy and safety have been validated, by means of consistent clinical and accurate testing [14]. Recent studies indicated that bergamot oil was active, *in vitro*, against several common species of dermatophytes, suggesting its potential use as antibacterial and antiseptic in gynecology and dermatology [41]. Also, in preservation of fresh fruit quality and safety, during postharvest cold storage, is recommended chitosan (CH) coating with bergamot oil because of its highest antimicrobial activity [42].

Moreover, bergamot essence, as well as other essential oils, obtained from a range of aromatic plants, are used increasingly, in aromatherapy, a specialized form of phytotherapy [43]. It is highly diffused, in the industrialized countries, as an adjuvant treatment in cancer care, for the management of some symptoms of dementia, acute and chronic pain, depression and anxiety [44, 45]. This therapy is a natural way of healing a person’s mind, body and soul. Many ancient civilizations, like Egypt, China and India, have used it as a popular complementary and alternative therapy from at least 6,000 years [46]. Aromatherapy that uses natural essential oils was found to be superior when compared to synthetic odors which generally contain irritants, like solvents and propellants causing irritation in some people [47]. Only recently, a

growing of scientific studies investigated the neurobiological effects of the essential oil, enlightening on the cellular targets of the different active ingredients of the phytocomplex [48, 49]. Aroma components are therapeutically effective, for their psychological effects due to a direct action to cortical areas and their ability to cross blood brain barrier [50]. The penetration potential of the oil to reach the subcutaneous tissues is one of the important characters of this therapy. The mechanism of this action involves integration of essential oil into a biological signal of the receptor cells in the nose, when inhaled. The signal is transmitted to limbic and hypothalamus parts of the brain, via olfactory bulb. These signals cause brain to release neuron messengers like serotonin, endorphin and noradrenalin, to link our nervous and other body systems assuring a desired change and to provide a feeling of relief [46]. In fact, there is an increased trend to use this therapy in the treatment of sleep disorder [51, 52]. Finally, a recent study reported that exposure of human SH-SY5Y neuroblastoma cells to 0.02% and 0.03% bergamot essential oil significantly reduced cell viability inducing both necrotic and apoptotic cell death cytotoxicity [53]. Really, it is demonstrated that only, the combination of limonene and linalyl acetate of the fitocomplex, was able to induce cell death [54].

Also, the bergamot juice that is considered a waste of the essential oil production, contains a considerable amount and variety of compounds, flavonoid and flavonoid glycosides, having important health implications [55]. There is great interest, in the possibility that the antioxidant potential of plant-derived phenolic compounds, such as flavonoids, may have beneficial effect on the human health [56]. As everybody knows, these nutrients are important for limiting damaging oxidative reactions in the cells, which may predispose the development of major clinical conditions, such as heart disease and cancer. Recently, it is demonstrated that the flavonoid components of juice, naringin, neoriotricin and

neohesperidin, reduce “*in vitro*” the carcinogenic cells growth in the human neuroblastoma and its metastasis [57, 58]. Moreover, rare higher molecular weight flavonoids which play a well known role, in the local folk medicine, in anticholesterolemic activity, are also found in bergamot fruit albedo [59]. These compounds which are flavonoid diglycosides, and called *HMG-flavonoids* carrying the 3-hydroxy-3-methylglutaric acid (HMG) moiety, are brutieridin and melitidin. They are absent in other citrus species (only a very few amounts in *C. myrtifolia* Raf.) and posses statin-like activity. In fact, they inhibit the production of cholesterol in blood thus determining the triglycerides and carbohydrates level and providing beneficial effects also, in the fight against hepatic steatosis and diabetes [60, 61].

2.3 Other Uses

The bergamot fruit juice is also used as flavouring, in gastronomy and the confectionery industry, for the preparation of fresh and dry pastries, sweets, candied peel, ice-cream and sorbets, as well as in soft drinks, cocktails and liqueurs (the well-known ‘*Bergamino*’, typical product of Reggio Calabria town, is exported to all over the world) [62, 63]. Moreover, this juice that has not reached the popularity of other citrus juices, in the daily diet, for its organoleptic properties, is used in industrial preparations, to fortify fruit juice in place of synthetic additives [59, 64]. In addition, another bergamot product, the “*pastazzo*”, which is constituted by pulp and peel of the fruits, and obtained after the extraction process of the essence, is a good soil improver [65, 66]. It is also used, either fresh or dried, as energy and desirability source in daily ration of animal feed [67, 68]. Finally, the dry peel of bergamot fruits is utilized to make some snuff-boxes and original souvenirs [69].

3. Conclusion

Above all, the bergamot fruit is cultivated for its essential oil, and it is a product that is in great demand,

in the perfumery and cosmetic industries. The European Union has recognized the bergamot essence of Reggio Calabria, as a product of DOP (Protected Denomination of Origin). Many legislative efforts have been done to protect this geographical brand that it is not the arrival point of the effective marketing politics but it represents the foundation for the development and exploitation of organized and stable production. So the Calabrian Regional Board has delegated the “Bergamot Consortium” to guarantee both the purity of the essence and its continuous availability. In fact, as a widely used and highly competitive article, bergamot oil is frequently, adulterated. Because of the great variety of natural isolates and terpenes, from the other citrus oils, it is relatively simple to sophisticate bergamot oil in such a way that moderate additions of these products, cannot be detected in the course of routine analysis. Moreover, the abundance of nutraceutical compounds which are present in the juice and pulp of the bergamot have attracted serious attention, within the scientific community. Actually, there is great interest, in the antioxidant potential of plant-derived phenolic compounds because of their beneficial effects, on human health. Recent studies have found that, although bergamot essential oil have been used, for centuries reputedly effectively as a traditional medicine, there is very little verified scientific evidence to support this use. Particularly, the pharmacology of essential oil and/or their single chemical constituents remains largely to be discovered. To conclude, the data reported herein, emphasize the therapeutic and dietetic potential of the bergamot fruit that appears to be of great importance for the human health. And further studies are needed to better define the medicinal effects of its phytocomplex, that have received, only limited attention, also if the essential oils have been used in traditional medicine since ancient time. So, the bergamot growing is an important pillar of positive economic reality of Calabria region. It needs safeguarding because the

research on its biological activities is still in its growing state and a systematic and rigorous approach to the study of potential phytotherapeutics was an achievement in the last decades.

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