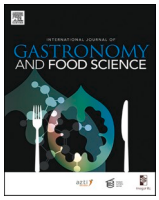
International Journal of Gastronomy and Food Science 36 (2024) 100927

Contents lists available at ScienceDirect

International Journal of Gastronomy and Food Science

journal homepage: www.elsevier.com/locate/ijgfs



Sweet basil: An increasingly popular culinary herb

Charles Spence *

Department of Experimental Psychology, University of Oxford, UK

ARTICLE INFO

Keywords:
Herbs
Culinary
Medicinal
Sensory history
Essential oil

ABSTRACT

Sweet basil (*Ocimum basilicum* L.), of the Lamiaceae family, has long been a popular culinary and medicinal herb. However, the composition of the essential oil varies markedly between different varieties, meaning that the aroma/flavour profile can also vary significantly from one cultivar or hybrid to the next. Some of the key aromatic volatiles in basil essential oil include eugenol, methyl eugenol, linalool, methyl chavicol (also known as estragole), and methyl cinnamate. As highlighted by this narrative historical review, while fresh basil is nowadays often associated with tomato-based dishes and sauces in Italian cuisine, it was rarely used as a culinary herb in countries such as the US, Britain, or even, in fact, Italy prior to the twentieth century. The herb is consumed fresh, dried (though lacking the perfumed top notes), and as a paste (i.e., in the Mediterranean pesto and pistou). Sweet basil may also be one of the few herbs/spices to have been integrated into cuisine simply because it tastes good (i.e., because of its highly-pleasant aromatic flavour profile). There are also a number of important non-culinary uses for basil, based on its highly fragrant aroma, not to mention its antimicrobial properties, including in a ritualistic setting in countries such as Greece and Bulgaria.

1. Introduction

This narrative historical review (see Ferrari, 2015; Furley and Goldschmied, 2021, on the strengths and appropriateness of this style of review; i.e., in contrast to the systematic reviews that are more commonly used in medicine) is designed to bring together a wide range of historical sources (including cookbooks both old and new, as well as a wide range of other historical sources) together with contemporary findings from flavour chemistry, and consumer food trends, in order to explain this fragrant herb's recent growth in popularity in a culinary context. The future potential developments in basil's usage are also touched on briefly.

While it has often been suggested that many herbs and spices were initially eaten out of necessity (herbs), or as an ostentatious sign of luxury (as in the case of exotic spices; Bourdieu, 2005; Spence, 2021), commentators have sometimes been minded to suggest that basil may have been consumed simply because of its very-pleasant aromatic flavour profile). For instance, at one point in their influential article, Sherman and Hash (2001, p. 158) write that: "We speculate that people initially used pungent plant materials either because their flavors were appealing (e.g., cinnamon, basil) or they caused pleasurable psychological sensations" (see also Darrah, 1974). Similarly, Sherman and Billing (1999, p. 460) mention how: "some spices are initially appealing (e.g. cinnamon, basil, and thyme)". Meanwhile, in *The Flavour Thesaurus*, Niki Segnit (2010, p. 213) is similarly effusive, writing that: "Sweet basil is the warmest, most fragrant, beautiful, fresh and irritatingly likeable of herbs. It has strong notes of spice – clove, cinnamon, anise, and tarragon – combined with a minty grassiness that's particularly noticeable when it is pulverised in quantity to make pesto."

1.1. Basil: a very brief history

Sweet basil (*Ocimum basilicum* L.), of the Lamiaceae family, has long been used in medicinal, ritual, and more recently in culinary settings (e.g., Allen, 2012; Arrowsmith, 2009; Bernhardt et al., 2015; De Baggio and Belsinger, 1996; Ivanova et al., 2023; Sutton, 2023).[1] Harold McGee

* Department of Experimental Psychology, New Radcliffe House, University of Oxford, Oxford, OX2 6BW, UK.
E-mail address: charles.spence@psy.ox.ac.uk.

[1] At the same time, however, basil's frequent appearance in literature, poetry, and art hints at the herb's historic cultural importance and symbolism (e.g., Allen, 2021; Kalogeris, 2001; see also Darrah, 1972).

https://doi.org/10.1016/j.ijgfs.2024.100927
Received 18 July 2023; Received in revised form 10 March 2024; Accepted 26 March 2024
Available online 30 March 2024

Table 1
Some of the major species of basil. Taxonomically, only two of these species have produced numerous cultivars: *O. basilicum* and *O. sanctum*, and only the former present confusion in North America (Darrah, 1974; McGee, 1984/2004).

Common name	Latin name/Classification	Morphology & Flavour profile
Sweet basil	*Ocimum basilicum* L.	Very variable essential oil mixtures, most commonly containing linalool, methyl chavicol, & eugenol with many other constituents usually present
	O. basilicum cv. Genovese Gigante	Methyleugenol & eugenol (Miele et al., 2001), dominant variety used in pesto
	O. basilicum crispum	Curled dentate leaves, typical sweet basil flavour, sometimes anise
	O. basilicum lactucaefolium	Lettuce leaf basil, broad leaves, typical sweet basil flavour, sometimes anise
	O. basilicum purpurascens	Purple color, typical sweet basil flavour
	O. basilicum [dark opal]	Lobed leaf purple color, sweet basil plus clove flavour
Thai lemon basil	*O. basilicum citriodorum*	Citrus (cf. Orange blossom) flavour
	O. citriodorum Vis.	Citrus aroma and distinct balm-like flavour
	O. basilicum from Nigeria	Anise flavour
	O. basilicum from Mexico	Short branched inflorescence, typical sweet basil flavour
	O. basilicum minimum	Strong, pungent odour, bitter taste, unlike sweet basil; geranyl acetate (69.5%; Özcan and Chalchat, 2002)
Thai basil	*O. basilicum and tenuiflorum*	Tends toward anise-like camphoraceous
Indian holy basil (Tulsi)	*O. tenuiflorum* L.=	Dominated by eugenol; though also contains
	O. sanctum L.	citral, & methyl chavicol
	O. canum Sims.	Perennial variety from Asia; Citral, camphor, & methyl cinnamate
	O. americanum L.	in varying proportions (Bernhardt et al., 2015)
Camphor Basil	*O. kilimandscharicum Guerke*	Perennial variety from Africa (Charles and Simon, 1992)
Wild basil	*O. suave Willd.*	p-cymeme (59%), α-thujene (10%), myrcene (7%), & thymol (7%; Kéita et al., 2000)
	O. gratissimum L.	Thymol (46%), p-cymeme (12%), γ-terpene + t-sabiene hydrate (17%; Kéita et al., 2000)

(1984/2004, p. 402) suggests that the tropical genus *Ocimum*[2] probably originated in Africa,[3] and was thereafter domesticated in India (Hooker, 1885; Muenschler and Rice, 1955; see also Gebrehiwot et al., 2015; McGee, 1984). Due to its naturalization on every continent except Antarctica,[4] it is now a common ingredient in many cultural foodways (Allen, 2021).[5] Livarda (2018, p. 183) notes that archaeobotanical analysis reveals that basil is rarely found in Ancient Roman sites, and first appears in the middle Roman period. Basil was not considered to be a digestive plant it ancient Rome (Baker, 2018; Rudolph, 2018). Gebrehiwot et al. highlight how basil is widely incorporated into contemporary Italian cuisine (often paired with tomato), while also playing a major role in the Northeast Asian cuisine of Taiwan, tropical parts of Africa, and the Southeastern Asian cuisines of Indonesia, Thailand (Thompson, 2002), Vietnam, Cambodia, and Laos (Sullivan, 2009). Over the centuries, many different species/cultivars of basil have been grown as medicinal plants, culinary herbs, and as insect-controlling agents. Basil is rightly famous for its therapeutic potential and preservative effects. For instance, basil has traditionally been used therapeutically to help treat brain fog, anxiety, and stress (de la Forêt, 2017). Basil is often referred to as the "king of herbs," relating to the Greek word for "king," *basileus* (Allen, 2021; Makri and Kintzios, 2008).

2. Basil: varieties, commercial considerations, and yield

While basil is native to India, it is grown commercially all over the Mediterranean as well as in California (Heath, 1981). At the turn of the century, the export market for fresh basil from Israel was estimated to be worth 4 million dollars (see Paton and Putievsky, 1996). At the time, France, Hungary, the USA, and Yugoslavia were the major producing countries (Peter, 2000). The herb is rich in essential oils (Chenni et al., 2016; Simon et al., 1990). According to Lawrence (1992), at the time he was writing, around 100 tonnes of essential oil were produced from the genus *Ocimum* around the world with around half (42.5 tonnes) coming from *Ocimum basilicum* L. and its close relatives. Nowadays, *Ocimum* is widely cultivated as a culinary pot herb (Darrah, 1980), as well as a popular ornamental plant. Typically, the leaves and terminal shoots of this annual or perennial small bushy plant (Darrah, 1974) are consumed (see Peter, 2000), though occasionally the seeds may also be also used; this contrasts with a number of other herbs (such as lovage and coriander) where the roots, seeds, fruits and/or flowers are also eaten (e.g., see Spence, 2023a, b).

The genus *Ocimum* contains around 30 species native to the tropics and subtropics of the Old and New World, with some species also being cultivated in temperate areas (Paton 1992). As many as 60 named varieties of *Ocimum basilicum* were known to 19th-Century English and French gardeners. However, many of these varieties are no longer cultivated, nor were herbarium specimens necessarily preserved, thus in many cases we are left with only vague descriptions in the published horticultural literature (Darrah, 1974; see Table 1 for some of the currently popular species/cultivars of basil from around the world). Note that when particular cultivars of *Ocimum* species have an unusually high content of one or two of the volatiles in the essential oil, and are lacking in others, interesting and easily identifiable forms are produced, with names such as lemon basil, spice basil, and anise basil. The basil varieties that are currently sold to gardeners in the West include cinnamon basil, camphor basil, anise basil, and spice basil; the latter has a very pleasant, complex, and warm flavour (Albuquerque, 1996; Darrah 1974; Morales and Simon, 1997; Phippen and Simon, 1998; Simon et al., 1999).

As is the case for many other herbs, the taste/flavour/aroma profile of basil depends on the growing conditions (i.e., organic vs. conventional; Kandil et al., 2009; Klimánková et al., 2008; Wang et al., 2013) and the stage at which the plant is harvested (McGee, 1984/2004; Miele et al., 2001). The specific make-up of the essential oil can also differ as a function of the region in which the basil is grown (Akgül, 1989; Brophy and Jogia, 1986; Fleisher, 1981; Gebrehiwot et al., 2015; Kéita et al., 2000; Özcan and Chalchat, 2002; Telci et al., 2006; Vieira and Simon, 2000; Viña and Murillo, 2003; Woliso et al., 2022). The high chemical

[2] *Ocimum*, the genus of basil, is derived from the Greek *ozo*, meaning "to smell," likely related to the strong scent emitted by the plant (Allen, 2021; McIntosh, 1853, p. 237).

[3] According to Manniche (1989), the species was known in Egypt at the time of the pharaohs.

[4] Though, EDEN ISS researchers have been exploring how to grow basil, cilantro, chives, and mint in Antarctica in preparation for a possible future mission to Mars (Wilhelm, 2018; see also Lang, 1998).

[5] For example, according to Albuquerque (1996), *Ocimum* species were introduced into Brazil through the Portuguese colonizers initially (and more recently by other European immigrants), and also via the slave trade from Africa.

variation in the composition of the essential oil of various basil cultivars also reflects the result of interspecific hybridization. Taken together, therefore, various factors such as genetic background, ontogenesis, morphogenesis, abiotic factors, method of essential oil extraction, [6] drying, and storage, can all contribute to the composition of the essential oil of any given basil cultivar (Bernhardt et al., 2015). At the same time, drying, packaging, and storage conditions can all affect the quality of basil (Baritaux et al., 1992). Indeed, both the odour and taste of freeze-dried basil are very sensitive to the storage conditions. Nevertheless, according to research from Paakkonen et al. (1990), the quality of dried basil could be maintained for two years in airtight packages at room temperature. However, drying the leaves tends to lead to the loss of the beautiful perfumed top notes. Regardless of the variety, dried basil leaves tend to be much less aromatic than fresh ones. According to several researchers, deep-freezing may offer the best means of preserving the herb.

Basil's fresh aromatic leaves are used as flavourings or spices in sauces, stews, salads, pickled vegetables, vinegar, aromatic oils as well as in "Bouquet garni" (David, 1955, pp. 64–65). Restaurateurs (at least those in California) apparently appreciate the leaves and flowers of differently-coloured cultivars are preferred in for decorating various dishes (Brown, 1991). That said, there may be a danger of some customers confusing the purple herb for others, such as sage. Basil took root in Liguria (North-Western Italy) and Provence (France), where it has been incorporated into the well-known basil pastes, pesto and pistou (see McGee, 1984/2004, p. 402). Typically, pesto is made from *Ocimum basicilcum* cv. Genovese Gigante, garlic, pine nuts, and Parmigiano-Reggiano or pecorino Romano hard cheese (Belsinger, n.d.; McGee, 1984). (The hard cheese is typically replaced by walnuts in vegan pesto.) Pistou also contains basil and garlic, and possibly also cheese but, crucially, no pine nuts.

2.1. On the many types of basil and the difficulties in classifying them

Linneaus first described the genus *Ocimum* in 1753, suggesting that it consisted of five species (Bast et al., 2014).[7] The genus *Ocimum* L. (Lamiaceae; mints) comprises around 30 species of annual and perennial aromatic herbs and shrubs which are found in both tropical and subtropical/warm temperate regions of the old world (Lal et al., 2018; Paton, 1992). Depending on the source one reads, there may, however, be as many as 250 species in the genus *Ocimum*, of which several are eaten (McGee, 1984/2004, p. 402). The genus is characterized by a great variability of both morphology and chemotypes due to the ease of cross-pollination that has given rise to a large number of interspecific hybrids, subspecies, varieties, and forms, with very divergent essential oil compositions (Bernhardt et al., 2015; Grayer et al., 1996). This has undoubtedly led to a great deal of difficulty/confusion in terms of naming and classification, with morphology and phenotype, not to mention sensory qualities, sometimes crossing in unpredictable ways (Marotti et al., 1996; Paton and Putievsky, 1996; see also Paton et al., 2004, 1999).

Different phenotypes can be established amongst the cultivars on the basis of the size of the leaf, shape, and color and plant height, weight, branching, and leafing. In terms of contemporary commercial cultivars: Several basil varieties that differ in terms of the size, shape, aroma, and color of their leaves are to be found in the marketplace in many countries. Nowadays, commercial basil cultivars display a wide diversity in growth habit, flower, leaf, and stem colours (see Lal et al., 2018), and aroma. Many of the cultivars evaluated belong to the 'sweet' basil group with 'Genovese,' 'Italian large leaf,' 'Mammoth,' 'Napoletano,' and 'Sweet' dominating the American fresh and dry culinary herb markets (Lal et al., 2018; though see also Simon et al., 1999). Wild basil populations also differ in terms of their essential oil composition (Ryding, 1994). Over the years many different chemocultivars (varying in their aroma profile/essential oil composition) have been selected, or bred, by crossing with other cultivars or closely related species. As such, the relationship among different forms of *O. basilicum* has been described as reticulate, meaning that the taxonomy of the group is difficult to ascertain, with new varieties continuing to emerge (Morales and Simon, 1997).[8]

3. Flavour profile and flavour chemistry

Fresh basil leaves have a strong and characteristic aroma. According to McGee (1984/2004, p. 402), most sweet basil varieties are dominated by flowery and tarragon notes. The Genoa variety of basil contains both the mildly spicy methyl eugenol, and the clove-like eugenol (Chartier, 2012; McGee, 1984/2004).[9] Depending on the species and cultivar, the leaves may taste of anise, with a strong, pungent, and often sweet smell (Gebrehiwot et al., 2015). Anise-flavoured compounds that may be found in basil include anethole, estragole, eugenol, and menthol are sometimes found in the fresh herb (McGee, 1984). Several different flavour varieties of basil have been developed, including lemon, lime, cinnamon, anise and camphor (McGee, 1984/2004, p. 402). Harold McGee (1984, pp. 254–256) has highlighted the important aromatic differences between some common varieties of basil (see Table 2). Ornamental basils that have been selected (and named) for their characteristic aroma include 'Anise' (methyl chavical), 'Cinnamon' (methyl cinnamate; Majdi et al., 2020), 'Licorice' (methyl chavicol), and 'Spice' (bisabolene; Albuquerque, 1996; Darrah, 1972; Simon et al., 1999). Meanwhile, lime basil and another lemon basil (*O. americanum*) have a very pure and fresh lemon aroma (Morales and Simon, 1997). In addition to the 'Mediterranean type' of basil that is most common in the West, a plethora of other varieties or cultivars expressing different flavours, many of which are hybrids, are available. For instance, India has 'sacred basil' (*O. sanctum* = *O. tenuifolium*) with an intense, somewhat pungent smell, while Thailand has a sweet basil with a licorice aroma. These species have a strong, but less pleasant flavour, and hybrids between them and Mediterranean basil are a recent innovation with a novel appearance and flavour that have enjoyed a growing popularity over recent decades (Darrah, 1972).

3.1. Flavour chemistry

Plants of *O. basilicum* typically have an aniseed-like aroma and sweet taste. The essential oil that is thought to be responsible for these features is methyl chavicol (estragole; Hussain et al., 1990; Sheen et al., 1991 see also Javanmardi et al., 2002; Peter, 2000), which has a sweet taste (Arctander 1969; Furia and Bellanca 1975). Gas-chromatography (GC)

[6] The relative percentages of different essential oil constituents is also affected by the extraction method: See, for example, Charles and Simon (1990) for a comparison of hydrodistillation, steam distillation, and organic solvent extraction.

[7] Three sections are currently recognized within this genus, namely, *Ocimum Benth.* (with appendiculate posterior stamens, comprised of *basilicum*, *gratissimum*, and *americanum*), *Hierocymum Benth.* (with fascicles of hairs at the base of posterior stamens, comprised of *tenuiflorum*) and *Gymnocymum Benth.* (with glabrous posterior stamens, comprised of *campechianum*; see Paton, 1992).

[8] For instance, Morales and Simon (1997) describe the new cultivar, 'Sweet Dani' as being distinguished by the high concentration of citral in its essential oil.

[9] Methyl eugenol and eugenol are the main components of the *Ocimum basicilcum* cv. Genovese Gigante that is normally used to make pesto. However, although chemically similar to eugenol, methyl eugenol has been shown to be carcinogenic in the animal model at higher concentrations. According to research from Miele et al. (2001), as the plant grows over 10 cm in height, the percentage of methyl eugenol declines while the percentage of eugenol increases.

Table 2
Some common varieties of basil, their distinctive component aronas, and the molecules responsible. Table adapted from McGee (1984, pp. 255–256).

Basil variety	Component aromas	Molecules
Holy, tulsi (*Ocimum tenuiflorum*)	Clove or cinnamon + clove	High eugenol or methyl eugenol
African, clove (*O. gratissimum*)	Thyme or clove	High thymol or eugenol
Thai (*O. basilicum* var. thyrsiflora)	Tarragon, anise	High estragole
Mexican, cinnamon (*O. basilicum*)	Fruity, strawberry, cinnamon	High methyl cinnamate
Lemon or sweet Dani (Ocimum x citriodora)	Lemony, floral	High neral & geranial
African blue (*O. basilicum* Dark Opal x O. kilimandsharicum)	Camphor, medicinal	High camphor
Ruffled, anise types (*O. basilicum*)	Tarragon, anise	High estragole
Standard; small-leaf bush types (*O. basilicum*; *O. minimum*)	Floral, eucalyptus, clove, tarragon	Linalool, eucalyptol, eugenol, estragole
Genovese types (*O. basilicum* cv. Genovese gigante)	Floral, eucalyptus, clove	linalool, eucalyptol, eugenol

analysis of the essential oil of basil typically yields approximately 1% volatile chemicals (e.g., Bagamboula et al., 2004; Lee et al., 2005; see also Zheljazkov et al., 2007). Various analyses of the essential oil of basil have revealed a number of aromatic compounds, including 30 monoterpenes, 14 sesquiterpenes, 20 aromatic compounds, 8 alcohols, 4 aldehydes, 7 ketones and esters, and 3 other miscellaneous compounds. Despite the fact that the compositions of essential oils vary in different basil cultivars, the main components are oxygenated monoterpenes and phenylpropane derivates (Bernhardt et al., 2015).

Intriguingly, over 85% of the total volatiles quantified in one study were found to originate from just five compounds, namely linalool (39.8%), methyl chavicol (otherwise known as estragole; 20.5%), methyl cinnamate (12.9%), eugenol (9.1%), and 1,8-cineole (2.9%; Charles and Simon, 1990; Grayer et al., 1996; Hasegawa et al., 1997; Qasem et al., 2023). Other fragrant volatiles that are sometimes detected in basil essential oil include geraniol, geranial, and neral (Grayer et al., 1996). According to Coucquyt et al. (2020, p. 73): "*Ocimum basilicum* leaves contain six key compounds that are largely responsible for the aroma profile of basil: citrusy linalool, the camphoraceous eucalyptol and the woody, pine-scented alpha-pinene, plus three different spicy volatiles – the peppery beta-myrcene, clove-scented eugenol and estragole with its anise-like notes."

On the basis of more than 200 analyses of oils in O. *basilicum,* Lawrence (1992) recognized a number of major essential oil chemotypes in this species (each with a number of small variants). These included three that are high in linalool: 'linalool' (see also Ravid et al., 1997), 'linalool and methyl chavicol' (characteristic of European basil; Akgül, 1989), and 'linalool and eugenol', along with methyl cinnamate basil which, as its name suggests, is rich in methyl cinnamate (cf. Viña and Murillo, 2003). Meanwhile, exotic or Reunion basil is rich in methyl chavicol (Sheen et al., 1991), while eugenol basil oil contains a high percentage of eugenol (Sheen et al., 1991). As was mentioned earlier, methyl eugenol and eugenol are the main components of the *Ocimum basicilcum* cv. Genovese Gigante used to make pesto (Miele et al., 2001). Grayer et al. (1996) note that the major essential oil components (i.e. those which comprised 20% or more of the total in at least one genotype), were especially variable in occurrence and concentration among the different accessions, ranging from absent in some genotypes to more than 90% of the total essential oil composition in others.

Seasonal factors have also been identified as playing a role (Hussain et al., 2008), with those samples collected in winter being richer in oxygenated monoterpenes (69%), while those of summer tend to be higher in sesquiterpene hydrocarbons (24%). At the same time, however, it is also interesting to note how many of the volatile compounds that are found in basil also appear in a number of other herbs and spices (see Table 3).

It is also interesting to consider basil's position in flavour networks (Ahn and Ahnert, 2013; Ahn et al., 2011). Indeed, according to theory of molecular flavour pairing, strawberries share aromatic compounds with chocolate, basil and balsamic vinegar – which may explain why they complement each other (Coucquyt et al., 2020; though see Spence, 2020). At the same time, however, one needs to be cognizant of the profound aromatic/flavour differences that exist between different basil varietals. Consider here only how the European Community has granted an official Protected Designation of Origin on the basil variety *Ocimum basilicum* cv. Genovese gigante (otherwise known as basilica Genovese),

Table 3
Major components (>2%) of basil essential oil (%) recovered by either hydrodistillation (HD) or steam distillation (SD) of basil (fresh or dry samples), along with sensory descriptors associated with compound.

Compound	Charles and Simon (1990); HD	Bagamboula et al. (2004); SD	Sensory Analysis
Estragole (Methyl chavicol)	31.6	20.5	Anisic-type odour & licorice-type flavour; Phenolic aroma akin to tarragon; strong, sweet, basil, tarragon anise-like aroma
Linalool	48.2	16.1	Sweet lavender with a touch of citrus; Also found in tomato
β-caryophyllene	1.7		This terpene has a spicy or peppery smell; v (Compound also found in black pepper)
Methyl cinnamic acid		8.6	Flavour is fruity & strawberry-like; the odour is sweet & fruit-like
Eucalyptol (1,8-cineole)	7.4 (+limonene)	8.3	Fresh camphor-like odour; spicy, cooling taste slightly-woody, refreshing aroma
Eugenol		3.9	Powerful, warm-spicy, rather dry and almost sharp odour Warm-spicy taste, main component in clove
Methyl cinnamate		8.6	Sweet, balsamic and fruity odour, reminiscent of cinnamon and strawberry
Methyl eugenol		8.0	Clove-like aroma; spicy earthy odour; bitter taste
α-Bergamotene		2.9	Smell like pepper with woody and spicy undertones. Taste reminiscent of citrus

given that it expresses a distinctive set of volatiles (including a pronounced floral linalool note in the absence of estragole), which has been deemed appropriate for pesto alla Genovese. As Harold McGee (1984, p. 256) notes: "As plant breeders at the University of Bologna put it, estragole gives "a typical mint/anise flavour that is considered anomalous and this undesirable in 'Genovese,' and not appreciated by the Italian consumers."" Finally, here, it is worth remembering that fresh basil leaves are also used in a number of popular cocktails and mixed drinks (see Hoffman, 2020).

4. Medicinal/health properties/qualities

Basil has long played an important role in many indigenous systems of medicine (see Paton and Putievsky, 1996). For instance, it is used in a number of traditional Iranian medicines (Javanmardi et al., 2002; Prakash and Gupta, 2005). Meanwhile, an English book published at the end of the 16th century recommended basil for toothache (A.T., 1596). However, in *The English Physitian,* the herbalist Nicholas Culpeper considered basil to be dangerous, writing at one point that: "To conclude; It expels both birth and after-birth; and as it helps the deficiency of Venus in one kind, so it spoils all her actions in another. I dare write no more of it." (Culpeper, 1653). Culpeper mentions basil as a herb of Venus. In fact, basil is still known as a herb of love in some parts of the world: In Italy, for instance, it is known as 'little love' or 'kiss-me--Nicholas', whereas in Romania/Moldavia it is given to one's love interest. Culpeper's statement may thus perhaps be triggered by (his) conflicting ideas on 'love washed with tears' (see Oakley Harrington, 2020).

Traditionally, basil has been used as a medicinal plant in the treatment of a wide range of conditions, including headaches, coughs, diarrhoea, constipation, warts, worms, painful postnatal uterine contractions, and kidney malfunction (e.g., Fatope and Takeda, 1988; Purushothaman et al., 2018; Simon et al., 1999). Basil possesses antimicrobial properties (Bagamboula et al., 2004; Chukwuma et al., 2023; Gebrehiwot et al., 2015; Sakkas and Papadopoulou, 2017; Wan et al., 1998), and also serves a preservative function (Lachowicz et al., 1998).[10] Basil, like several other culinary herbs, is also antifungal (Bozin et al., 2006; Dube et al., 1989), containing antioxidants (Bozin et al., 2006; Javanmardi et al., 2003; Lee et al., 2005; Nadeem et al., 2022), as well as various compounds that act as effective insecticidal agents (e.g., Shaaya et al., 1991). In Kenya, for example, basil is used to make brooms to sweep chicken coops and rid them of fleas and as an insecticide on maize cobs (Arrowsmith, 2009, p. 86).[11]

Tulsi (*Ocimum sanctum* Linn), has long been an important herb within Ayurveda (Hemphill & Cobiac, 2006; see Cohen, 2014, for a review). Tulsi (in Hindi) is an aromatic shrub in the basil family Lamiaceae (tribe ocimeae) that likely originated in north central India and now grows native throughout the eastern tropics (Bast et al., 2014). Within Ayurveda, tulsi is known as "The Incomparable One," "Mother Medicine of Nature" and "The Queen of Herbs." Holy basil also has anti-carcinogenic properties, due to the presence of compounds such as eugenol (see Hasan et al., 2023, for a recent review). In fact, some of the oldest documented medicinal uses of basil can be found in the Rigvedas, Ayurvedic texts dated to 3500-1600 BCE (Allen, 2021).

4.1. Health uses of basil

Basil provides a good source of β-carotene, magnesium, as well as iron, calcium, potassium, and vitamin C (e.g., Gebrehiwot et al., 2015; Lal et al., 2018). That said, people typically do not eat herbs in sufficient amounts to provide a significant source of vitamins or minerals in the daily diet (Mäkinen and Pääkkönen, 1996) – though basil is sometimes consumed as a tincture, where the concentration of specific compounds is likely going to be higher (see Lopresti et al., 2022). Furthermore, the Lamiaceae family, which includes basil, sage, and thyme, has also long been recognized as a rich source of diverse and unique anthocyanins, with the deep purple pigmented basils of the ornamental and herb trade provide a potential new source of anthocyanins (Phippen and Simon, 1998). The important (health) role played by various culinary herbs in the management of gut microbiota has recently also been acknowledged (Dahl et al., 2023; Vita et al., 2022). However, a survey of 500 top restaurateurs in southern California revealed that few of them (21%) used culinary herbs such as basil for their putative health benefits (Brown, 1991).

5. Ritualistic uses of basil

Basil serves a ritualistic function in some countries/cultures (e.g., Bulgaria and Greece; Cristea et al., 2008; Ivanova et al., 2023; Sutton, 2023). For instance, David Sutton (2023, p. 296) highlights the use of basil in grave adornment, religious ceremony, and also as a scented garland held by the dead prior to burial. Sutton also describes how basil-scented water is used in other religious ceremonies, and basil is touched prior to shaking hands when people engage in introductory handshake. Pots of basil are apparently also used to help deodorize Greek offices. Greeks love the smell of basil, and it is seen as representing home to them – One famous Greek folklorist even went so far as to suggest that: "A flowerport of basil can represent the soul of a people better than a drama of Aeschylus." (Dragoumis, 1976). According to Sutton, consideration of the cultural meaning and symbolic associations of herbs such as basil helps emphasis: "the importance of recognizing the embeddedness of taste in specific cultural contexts" (Sutton, 2023, p. 296).

6. Culinary uses

Although basil was known to the Greeks and Romans (McGee, 1984/2004), it is only mentioned once in Apicius (see Apicius, 1936; see Albala, 2021). Despite the herb's contemporary popularity in the cuisines of many countries (i.e., Italy, US, UK, and Australia), it was not always widely used (in a culinary context). For instance, basil appears in only 2.7% of the recipes in Pellegrino Artusi's, *Science in the Kitchen and the Art of Eating Well,* first published in 1891 (Artusi, 2003). Nowadays, however, basil is one of the most popular culinary herbs, especially in the context of tomato-based dishes. Basil's widespread incorporation into Italian cuisine would appear to have taken place at some point during the 20th century. The recipe for Pesto Genovese first appeared in print in 1865 (per Via Verdi). As with most modern European food, there is an ancient equivalent: In particular, the two ancestors of pesto are moretum and agliata (Cashman, 2022). In other words, the history of this bright green, fragrant paste can, in some sense at least, be traced back through the centuries to Roman times.

Basil is rarely mentioned in early English cookbooks. There is, for example, no mention of the herb in the English professional cook's Robert May's (1660) *The accomplisht cook or, The art & mystery of cookery.* Contrast that with the 501 mentions of pepper, 284 mentions of ginger and 'cinamon' (sp.), 168 mentions of parsley, 68 mentions of 'garlick', and 22 of coriander that appear in the digital version of the book.[12] Meanwhile, basil is only mentioned once in John Evelyn's

[10] A couple of decades ago, Suppakul et al. (2003) even suggested the intriguing possibility that the antimicrobial properties of basil might make it relevant to the enhanced design of functional food packaging.

[11] In a historical context, basil was also used as one of the strewing herbs for Henry VIII's strewer, Thomas Tuser, who compiled a list of sixteen sweet-smelling herbs and flowers, including basil that would have been spread across the floor of the castle, creating a sweet aroma from being crushed under people's feet (see Allen, 2012, p. 35).

[12] Though lovage isn't mentioned in May's (1660) cookbook either.

(1699/2005) *Acetaria: A discourse of sallets*: "Baſil, *Ocimum* (as *Baulm*) imparts a grateful Flavour, if not too ſtrong, ſomewhat offenſive to the Eyes; and therefore the tender Tops to be very ſparingly us'd in our *Sallet*." Isabella Beeton (1861), author of the famous British cookery guide, mentions basil at several points, writing that: "As fresh green basil is seldom to be procured, and its fine flavour is soon lost, the best way of preserving the extract is by pouring wine on the fresh leaves."[13] It appears in the recipe for mock turtle: "BASIL.–This is a native of the East Indies, and is highly aromatic, having a perfume greatly resembling that of cloves. It is not much employed in English cookery, but is a favourite with French cooks, by whom its leaves are used in soups and salads." Meanwhile, Francatelli's (1861) cookbook, originally published in the same year as Beeton's work, includes basil in just two recipes (one of which also happens to be a recipe for mock turtle soup). Augustin de Candolle, the Swiss botanist, does not mention basil in his *Origin of cultivated plants* either (de Candolle, 1885).[14]

The English cookery book writer Elizabeth David incorporates basil in a number of the recipes in her Mediterranean-inspired *Summer Cooking* (David, 1955). She was clearly a huge fan of basil, writing in the Introduction to her book that: "… because somebody long ago discovered that basil works some sort of spell with tomatoes ….while basil enhances almost anything which it is cooked" (David, 1955, p. 1). David goes on to note that: "In England basil is one of the traditional herbs for turtle soup, and it is well known that it brings out the flavour of tomato salads and sauces; although it was common at one time in English kitchen gardens it is now extremely hard to lay hands on fresh basil, a state of affairs which should be remedied as fast as possible, for, with its highly aromatic scent, it is one of the most delicious of all herbs." (David, 1955, p. 2).[15] "Once you have become a basil addict it is hard to do without it … …all the dishes with tomato sauces need basil as a fish needs water, and there is no substitute" (David, 1955, p. 2).[16] Though, as Coucquyt et al. (2020, p. 73) note: "High temperatures will destroy the delicate flavour of basil, so only add the fresh leaves to your dish at the very last moment."

Hard though it may be to believe today, basil was hardly known in the US until the 1970s (McGee, 1984/2004, p. 402). Nevertheless, by 1991, a survey of 500 top restaurants (of all types) in southern California reported by Brown (1991), revealed that 79% reported using sweet basil (either fresh, frozen, or dried; Hiltunen and Holm, 1996, p. 57). In fact, basil was by far the most commonly used herb (with thyme and cilantro tied for second place, with 32% each), regardless of restaurant type. The vast majority of respondents (97%) responded that used fresh herbs in the preparation or presentation food: 94% used fresh herbs to add flavour to a dish; Many also use herbs for the aroma (74%), and almost as many (68%) use fresh herbs for garnishing. The results of the survey indicated that almost 40% of restaurateurs increased their use of fresh herbs over the preceding year. Interestingly, the majority of responding chefs and restaurant managers (90%) also thought that the culinary use of herbs would continue to grow in the coming years. Indeed, the only potential limitations to continued growth in the use of fresh culinary herbs such as basil identified by the respondents in Brown's study was considered to be the high price and limited storage life (Brown, 1991). Meanwhile, according to data from Parker (2004), the amount spent by Australians on sales of fresh herbs and spices in major supermarkets suggest that the fourth most popular by weight after garlic, ginger, and chilli, was basil.

7. Conclusions

Basil (*Ocimum basilicum* L.) has a long history as a medicinal, insect-controlling agent and ritual herb in certain countries (cf. Ivanova et al., 2023; Sutton, 2023). Basil's use as a culinary herb is much more recent, starting to gain in popularity in Italian cuisine around the start of the twentieth century. Indeed, until the 20th century, the fresh leaf was not commonly used in a culinary setting in Italy, the UK, the USA, and Australia. That said, and as highlighted by this narrative historical review, it has undoubtedly become an increasingly popular culinary herb in recent decades in the west (e.g., Brown, 1991; McGee, 1984/2004; Miele et al., 2001; Parker, 2004). Nowadays, the leaves of the aromatic herb are commonly used fresh, dried, and as a paste (pistou & pesto). Basil provides a rich source of bioactive compounds (Romano et al., 2022) and is used extensively to add aroma and flavour to food (i.e., it is used as a culinary ingredient in different cultures). While once a popular companion for mock turtle soup (in Britain), the fresh herb is now widely seen as an ideal accompaniment for tomato-based Italian dishes (e.g., David, 1955).[17] One might, then, consider it as a prime example of the success of Italian (food) marketing (Zancani, 2019). However, given the recency of the herbs ascendency in international cuisine (specifically in the case of tomato-based dishes), one might consider introducing lovage as a possibly less-overpowering match.

It is also worth considering what impact this powerfully aromatic herb may have on diners when experienced as an ambient odour, in terms of promoting specific appetite, biasing people towards possibly congruent food choices, and ultimately potentially impacting their food intake (e.g., Morquecho-Campos et al., 2020; Ouyang et al., 2018; see Zhang and Spence, 2023, for a review). This can be seen as linking back to basil's use as a fragrant strewing herb in the time of Henry VIII (see Allen, 2012, p. 35), as well as its use to mask the smell of death with basil fronds adorning the recently deceased before their burial (Sutton, 2023). At the same time, however, basil would appear to be less often found in aromatherapy and other ambient scenting applications (e.g., contrasting with herbs such as lavender, say).

The many edible varieties of basil provide a surprisingly wide range of flavour profiles (referred to as chemotypes). Some of the key aromatic volatiles that have been identified in basil essential oil include eugenol, methyl eugenol, linalool, methyl chavicol (also known as estragole), and methyl cinnamate (see able 3). Given the many different kinds of basil that have been identified, it can sometimes be difficult to know exactly which type is being referred to in written sources/previous studies/recipes. At the same time, however, it is interesting to note how many of the volatile aroma compounds (such as linalool) that are often found in

[13] Such observations seemingly contradicting Parrish's (2021) claim that basil was an endemic English herb in earlier centuries.

[14] It is interesting to note that according to Parrish (2021, p. 273): "Rather than succumb to the temptations of exotic spices like ginger, Puritans like Busy encouraged the women of their communities to be content with native English herbs like basil, rosemary, and thyme, in order that women might 'improve the godliness of the broader community', with the understanding that native herbs were all the godly Englishman required for virtuous eating (see also La Cerva, 2021)."

[15] The marked downturn in the consumption of spices after the Second World War may have affected the consumption of herbs such as basil as well. Indeed, according to one report from the Food and Agriculture Organization (FAO) of the United Nations, there was a decline of 20% worldwide, and an almost 50% decline across most of Europe following the war (FAO, 1962). As David (1955, p. 9) notes: "Fresh basil, so rare in this country, is too precious for so much as one leaf to be allowed to go to waste."

[16] Informal taste tests as Worton Kitchen Garden, a largely organic restaurant and kitchen garden on the outskirts of Oxford (https://wortonkitchengarden.com/) would appear to suggest that people find lovage to be a surprisingly good match for tomato-based dishes with the customers (see Spence, 2023b). In fact, customers are often surprised as to how good a match lovage and tomato make, given the more widespread combination of tomato and basil. Cross-cultural research would be needed to assess the generalizability of such anecdotal observations.

[17] Indeed, it is interesting to consider how this herb has become one of essential ingredients that is expected to be found in, and helps the consumer to identify, the cuisine as coming from a particular region (Rozin, 1983). These 'flavour principles' are the distinctive seasoning combinations which characterize many cuisines.

basil also appear in a number of other herbs and spices (see Raguso and Pichersky, 1999). Indeed, Coucquyt et al. (2020, p. 72) even include a recipe for basil oil without basil that includes: coriander seeds, bay leaf, thyme, tarragon, cardamom, clove cinnamon, ginger, and olive oil.

Looking to the future, there is interest in the use of controlled mechanical stimuli to enhance the sensory quality of basil (Herdenstam et al., 2022; Seeburger et al., 2023; though see Califano et al., submitted). Furthermore, basil is currently one of the herbs that is being assessed as a possible future food for the first manned mission to Mars (Wilhelm, 2018; see also Lang, 1998).

8. Implications for gastronomy

Sweet basil (*Ocimum basilicum* L.) has long been a popular culinary herb. It is consumed fresh, dried, and as a paste (i.e., in the Mediterranean pesto and pistou). While basil leaves are often associated with tomato-based dishes and sauces in Italian cuisine nowadays, it was rarely used as a fresh culinary ingredient in countries such as the US, Britain, or even, in fact, Italy prior to the twentieth century. The herb is often used in the cuisines of Taiwan, tropical Africa, and Southeastern Asian cuisines of Indonesia, Thailand, Vietnam, Cambodia, and Laos. The composition of the essential oil varies markedly between different varieties, meaning that the aroma/flavour profile varies significantly from one cultivar or hybrid to the next. Interestingly, sweet basil is one of the few herbs/spices that may originally have been integrated into cuisine simply because it tastes good. Culinary surveys suggest that the fresh herb has become increasingly popular in the west in recent decades, and was by far the most frequently used culinary herb in a 1991 survey of top Californian restaurateurs (used in almost 80% of dishes across all styles of restaurant). There is a resurgence of interest in the use of this fragrant herb, including its use as an ambient scent.

CRediT authorship contribution statement

Charles Spence: Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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