



# Ginger: The pungent spice

Charles Spence \*

Department of Experimental Psychology, University of Oxford, UK

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## ABSTRACT

Ginger (*Zingiber officinale* Roscoe) has long been a popular ingredient in both medicinal and culinary settings. However, while ginger, and the related galangal, were once both popular ingredients in Britain (e.g., from roughly the 9th to the 17th centuries), they essentially disappeared from savoury culinary recipes thereafter, as spiced foods fell out of fashion (though the dried spice continued to be used in sweet baked products). However, the desirable pungency and flavour attributes of ginger, together with renewed interest in the spice's medicinal properties, combined with the growing popularity of Asian cuisines that make extensive use of ginger (in savoury recipes), has resulted in a recent resurgence in sales of this once popular spice. From a culinary perspective, the volatiles in ginger help to lift the taste of the dishes to which they are added while the spice's pungency may offer a means of substituting for some of the less healthy ingredients currently in our food.

## 1. Introduction

Ginger (*Zingiber officinale* Roscoe) has long been a popular ingredient in both medicinal and culinary settings, with some commentators even going so far as to refer to the spice as 'natural gold' (Ghosh et al., 2011). According to Shivakumar (2019), ginger is the third most important spice used for its medicinal properties in day to day life. Looking back in time, ginger was one of most important spices in medieval Europe (see Klug et al., 2021, for an analysis of the use of ginger and other spices in medieval German recipes). Ginger was also used to flavour beer throughout the Middle Ages (McGee, 2004). In fact, it was such a highly-valued trade item in 13th and 14th century England that one pound of the spice was once said to be worth as much as a sheep.<sup>1</sup>

Medieval writings suggest that ginger was a standard ingredient in both kitchen and apothecary recipes (Bhatt et al., 2013). For example, Alexander Neckham's 12th Century *De Utensibiles* [Treatise on Kitchen Utensils] incorporates ginger into a number of the recipes. In medieval Europe, the richest members of society were able to enjoy roast meats accompanied by spicy dipping sauces (e.g., Spencer, 2003; Tannahill, 1973): For instance, yellow sauce was made by combining ginger and saffron, while green sauce involved a combination of ginger, cloves, cardamom, and green herbs. Meanwhile, the recipe for the carmeline

sauce mentioned in *Le Viandier de Taillevent* (Tirel, 1375) starts with the instruction to pound ginger (see also Smith, 2007, p. 239). The mixing of cinnamon and ginger was a favourite of French medieval cooking, and thus is found in most recipes of the time. By contrast, cinnamon appears in less than 10% of English recipes during the same period (Lauriou, 2021). Smith (2007 p. 243) goes on to note that: "The English seem, by contrast, to have been the exception to the rule. While heavily reliant on meat, and, according to works such as *Ancient Cookery* (1381) and *Form of Cury* (c.1390), apparently connoisseurs of lesser known spices such as mace, cubeb, galangal, and cinnamon flowers".<sup>2</sup>

Spencer (2003, p. 50) writes of the 12-14<sup>th</sup> Century in Britain that: "Both white and black peppercorns were undoubtedly the favourite spice, but ginger came a close second, then grains of paradise which look like grey peppercorns but have a slight gingery taste. Next came an enthusiasm for cinnamon and cloves ...". Indeed, Spencer (2003, p. 41) is struck by the impressive amounts of ginger and sugar that were called for, though the fact that no measures of the amount needed was provided in early recipes makes an exact assessment of consumption of this spice impossible to determine. Smith (2007, p. 239) highlights the fact that: "Ginger figures in as many as 70 per cent of Pierre Pidoult's (Pidoux) recipes in his *Le fleur det toute cuisine* of 1543". Gervase Markham's, *The English Huswife* (Markham, 1683), a domestic manual

\* Department of Experimental Psychology, New Radcliffe House, University of Oxford, Oxford, OX2 6BW, UK

E-mail address: [charles.spence@psy.ox.ac.uk](mailto:charles.spence@psy.ox.ac.uk).

<sup>1</sup> According to Smith (2007, p. 249): "... after a day's work, a manual worker in Soissons in 1543 would have been able to afford precisely three ounces of ginger, that is, less than one hundred grams."

<sup>2</sup> Note that both *Ancient Cookery* (1381) and *Form of Cury* (c. 1390) were published by G. Brander in *The Forme of Cury: A Roll of Ancient English Cookery* (London, 1780).

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attests to the use of foreign seasonings such as ginger in his gingerbread recipe, under the assumption that this spice would have been available to upper- and upper-middle class women (see Parrish, 2021).<sup>3</sup> Ginger is mentioned 284 times in the English professional cook's Robert May's (1660) *The accomplisht cook or, The art & mystery of cookery*. However, ginger, along with many other once popular spices, largely disappeared from European cooking during the 17th century (perhaps as a result of the rise of Puritanism; Smith, 2007; see also Evans, 2011). At one point, Smith (2007, p. 250) suggests that, in the latter half of the 17th century, the French culinary establishment pushed "the 'choleric' spices such as pepper, but also the favoured ginger and saffron, to the rubbish bin of defunct medieval culture." Smith (2007, p. 248) also highlights how: "The relative abundance of pepper, as well as ginger, cinnamon, and saffron, all except cinnamon indispensable to medieval cooking – as we find in the mid-fourteenth-century German *Buck von guter Speise* – led to the phenomenon of their being snubbed in the households of the noblemen in favour of more exotic and expensive spices." It is relevant here to note that the price of ginger declined in England in the opening decades of the 17th century, as supply switched from India to the Caribbean (Lloyd, 2015, ps. 120, 127). According to Aram (2015), Caribbean ginger would have been five times less expensive than that from India in the opening years of the 17th century.

Nowadays, though, ginger has seen something of a resurgence of popularity in a culinary setting, being associated with a wide range of both savoury and sweet dishes/foods (Saveur, 2019). McGee (2004, p. 426) draws attention to the spice's remarkable culinary range, being used to flavour everything from sausages to fish dishes, and from sodas to sweets, bakery, confectionary, pickles, condiments, and sauces (see also Coucquyt et al., 2020; Shahrajabian et al., 2019). Dried ginger has also long maintained an association with 'fairings' (Mabey, 1978).<sup>4</sup> Note that the fact that crystallized ginger and other spices were sometimes eaten by themselves at the end of a meal (Rabelais, 1962; Smith, 2007) also argues against the suggestion that the role of spices was merely to mask off-taints in food (see Spence, 2021, for a review). The latter suggestion sometimes crops up in wider discussions of why it should be that people chose to eat spices, many of which initially have a pungent, piquant, and/or unpleasant taste (e.g., Cole 2007; Govindarajan 1985).

Ginger is an ancient medicinal plant belonging to the *Zingiberaceae* family originating from south-east Asia (i.e., Indo-Malaysia; Purseglove, Brown, Green and Robbins, 1981, p. 457). Ginger is a 2–4 foot tall herbaceous perennial with grass-like leaves up to a foot long. The underground root or rhizome (Vasala, 2000)<sup>5</sup> has a wide range of both culinary and medicinal uses (Deng et al., 2022; Zadeh and Kor, 2014). Ginger was first documented by van Rheede in 1692. In 1807, the English botanist William Roscoe named the plant *Zingiber officinale*. The name of the genus originates from the Greek word 'zingiberis', itself derived from the Sanskrit term 'shringavera', meaning 'shaped like a deer's antlers' (Sharma, 2017). Meanwhile, *officinale* pertains to the medicinal properties of the rhizomes (often incorrectly referred to as 'roots'; Elzebroek and Wind, 2008).

According to Syafitri et al. (2018), there are three main types of ginger: Giant ginger or white ginger (*Zingiber officinale* var. Roscoe), small white ginger or ginger *emprit* (*Zingiber officinale* var. Amarum), and red ginger (*Zingiber officinale* var. Rubrum) (see Fig. 1). Plant species of the *Zingiberaceae* family are widely distributed in both tropical and subtropical regions around the world (e.g., Delin and Larsen, 2000;



Fig. 1. Rhizome of *Zingiber officinale* var. Amarum (left), *Zingiber officinale* var. Roscoe (center), and *Zingiber officinale* var. Rubrum (right). [Figure from <https://manfaatjahemerah.com/perbedaan-jahe-merah-jahe-gajah-dan-jahe-emprit/>, as presented in Syafitri et al., 2018).].

Kantayos and Paisooksantivatana, 2012). *Zingiberaceae* can be found in South and South-East Asia, particularly in humid lowland habitats as well as at higher altitudes (Larsen and Larsen, 2006). *Zingiberaceae* comprises more than 50 genera (approximately 1500 species in total; Sirirungsa, 1998), of which 26 genera and 300 species are found in Thailand, while 22 genera and 178 species have been identified in India (Jain and Prakash, 1995; see also Burt and Smith, 1972; Kress et al., 2002), and 150 species belonging to 23 genera in Peninsular Malaysia (Sukari et al., 2008; see also Sirirungsa, 1998). The main genera of these species are *Zingiber* (49 spp.), *Kaempferia* (17 spp.), *Hedychium* (22 spp.), *Curcuma* (34 spp.), *Globba* (42 spp.), *Alpinia* (17 spp.), *Amomum* (16 spp.), *Etingera* (12 spp.), and *Caulokaempferia* (14 spp.).

Ginger is thought to have been domesticated in southern Asia in prehistoric times (see McGee, 2004, p. 426; Sutarno et al., 1999; Vasala, 2000). According to Reay Tannahill (1973, p. 38), the population in the city of Rehman Dehri on the Indus plains, may well already have been using ginger and turmeric as a seasoning for their food as far back as the fourth millennium B.C. Ginger was certainly one of the first oriental spices to have been introduced to Northern Europe by Arab traders (Shahrajabian et al., 2019), and was brought in dried form to the Mediterranean by classical Greek times. Indeed, the plant was well-known to the Greeks and was mentioned by the Ancient Greek physician, botanist, and apothecary Dioscorides (40–90 A.D.) in his works (Elzebroek and Wind, 2008).<sup>6</sup> The Roman writer, naturalist, and philosopher Plinius Secundus (23–79 A.D.), known as Pliny the Elder, describes the medicinal uses of ginger in his *Naturalis Historia* (Elzebroek and Wind, 2008). That said, according to van Rheede, 1692, p. 60, only 3% of the recipes in Apicius (1936) include ginger as compared to 81% that call for black pepper (cf. Spence, submitted).<sup>7</sup> According to Tannahill (1973, p. 87), ginger was being traded along the Silk Road from China to Rome by the second century.

By the 9th century, the medicinal properties of ginger were also becoming known in Germany and France (Bhatt et al., 2013). Meanwhile, the Venetian merchant and explorer Marco Polo first came across ginger while visiting China (Peking) and Sumatra (in Indonesia) in the 13th century (1271–1295), and had some sent back to Europe. The Arabs introduced ginger to East Africa from India in the 13th and 14th Centuries. It was introduced to West Africa by the Portuguese in the 16th

<sup>3</sup> Ironically, though, not all early recipes actually included ginger, as highlighted by Freedman (2008). He cites a recipe for "gyngerbrede" in a mid-15th-century English cookbook manuscript, which does not call for ginger.

<sup>4</sup> Fairings (i.e., fairground, or festival foods) incorporating dried ginger were, for instance, documented at the Malborough Mop fair in 1970s (see Mabey, 1978). Cornish fairing, which also incorporated ginger powder as a kind of ginger biscuit, was also connected with festivals (see Mason and Brown, 2006).

<sup>5</sup> Strictly-speaking, the roots emerge from the rhizome.

<sup>6</sup> After an orgy/feast, the Greeks would apparently eat ginger wrapped in bread to combat nausea (Bhatt et al., 2013).

<sup>7</sup> While ginger is mentioned in the Koran (76: 15–17), it does not appear in the Bible.

century.<sup>8</sup> The Mexican cultivation of ginger was initiated by the Spaniard, Francisco de Mendoza (Elzebroek and Wind, 2008; Semwal et al., 2015; Shahrajabian et al., 2019), while later being introduced to Jamaica as well (Aram, 2015).<sup>9</sup> The plant's introduction to South America and the West Indies by the Spanish was intended to improve this spice's availability. In 2016, global production was 3.3 million tonnes (FAO, 2017), up from an estimated 1.4 million tonnes in 2007 (Camacho and Brescia, 2009). India is both the largest producer (with 34% of the world total; FAO, 2017; see also FAO, 2019) and also the largest consumer of ginger, contributing roughly a third of total global production; Next comes China, followed by Nepal, Indonesia, Nigeria, and Thailand (Bag, 2018; Dhanik et al., 2017; Vasala, 2000). Ginger is currently also grown commercially in Jamaica (cf. Rose, 2018), Mexico, Australia (Camacho and Brescia, 2009), and Hawaii (Nishina et al., 1992) as well (Zadeh and Kor, 2014).

## 2. Medicinal uses of ginger

Ginger has been used in traditional Chinese and Indian medicine for more than 2500 years (Zadeh and Kor, 2014). Indeed, the clinical and health-related benefits associated with *Zingiber officinale* appear in both traditional Chinese medicine and modern industry (Chrubasik et al., 2005; Khodaie and Sadeghpoor, 2015; Liu et al., 2019; Malhotra and Singh, 2003; Shahrajabian et al., 2019; Waggas, 2009; White, 2007). Ginger is sometimes referred to as a nutraceutical (e.g., Semwal et al., 2015; Singh et al., 2017).<sup>10</sup> A large body of empirical research has documented an impressive range of medicinal benefits associated with ginger (e.g., see Afzal et al., 2001; Ali et al., 2008; Awang, 1992; Bag, 2018; Bode and Dong, 2011; Ghayur et al., 2005; Gupta and Sharma, 2014; Kumar et al., 2011; Moghaddasi and Kashani 2012; Rahmani et al., 2014). For instance, ginger has been demonstrated to constitute an effective treatment for pregnancy-induced (and postoperative) nausea and vomiting, acting directly on the gastrointestinal tract (e.g., Jewell and Young, 2003; Langner et al., 1998; Marx et al., 2015; Mowrey and Clayson, 1982; Palatty et al., 2013; Ryan et al., 2012; Wood et al., 1988).<sup>11</sup> By contrast, the evidence for the spice's role in treating motion sickness and seasickness remains much less certain (see Ernst and Pittler, 2000; White, 2007).

As is the case for a number of other spices, ginger essential oil (*Zingiberis aetheroleum*) acts as an insecticide (Nour et al., 2017; see also Wang et al., 2015). Ginger essential oils are also used as an ingredient in perfumery (Zachariah and Gopalam, 1987). Apparently, the Romans added ginger to their oil lamps in order to fragrance the atmosphere (Bhatt et al., 2013). And, as with so many other herbs and spices, ginger has a range of antimicrobial (Guptha and Ravishankar, 2005; Stoyanova et al., 2013), antibacterial (Malu et al., 2009), anti-fungal,

anti-inflammatory (Grzanna et al., 2005), chemopreventative (Baliga, Haniadka, Pereira, D'Souza, Pallaty, Bhat and Popuri, 2011), and anti-oxidant properties (Aeschbach et al., 1994; El-Baroty et al., 2010; Hiroe and Nobuji, 1993; Jelled et al., 2015; Kantayou and Painsooksantivatana, 2012; Mao et al., 2019; Shirin Adel and Prakash, 2010; Zadeh and Kor, 2014).<sup>12</sup> According to the research, ginger may be beneficial in terms of reducing the pain and disability experienced by osteoarthritis patients (Bartels et al., 2015).<sup>13</sup> Here, though it is important to note that the form in which ginger (fresh, dried, as ginger powder, as a ginger capsule, or as an increasingly popular ginger gummies) is taken is likely to impact its medicinal effectiveness, in part because of the differing proportions of gingerols and shogaols, which are two of the key bioactive ingredients (Sang et al., 2020). According to the latest research, [6]-Gingerol puts the human immune (white blood) cells on high-alert (Andersen et al., 2023).

Ginger has been shown to exert a psychophysiological effect on human alertness/vigilance (and possibly also cognition and attention). In one study where such alerting effects were demonstrated, the participants had to consume 500 mg per day for five days (Al-Kuraishy, 2015), while in another, the participants simply inhaled the essential ginger oil for a few minutes instead (Stappen et al., 2016; cf. Heuberger et al., 2008). In the 17th century, ginger also held other associations, at least according to an analysis of the pungent spice's frequent appearance in Jonson's *Bartholomew Fair* (1614; see Jonson, 2004; Parrish, 2021).<sup>14</sup> One might consider the extent to which ginger's alerting/arousing properties match the intention of the other sensory elements of the fairground experience (see Spence, 2022, for a review).

## 3. On the culinary uses of ginger

While the rhizome is typically used in both medicinal and culinary settings, the flowers of selected members of the ginger family are also consumed in certain parts of the world (e.g., in Thailand), and provide a source of potassium and calcium (see Rachkeeree et al., 2018). The rhizome is consumed in several different forms/preparations: Namely as crystallized ginger (*gingebras*; Smith, 2007), syruped ginger (Brown, 1969), as fresh ginger, and as dried ginger powder (Camacho and Brescia, 2009). Nowadays, ginger is frequently used in soft drinks (e.g., ginger beer, ginger ale, ginger wine, ginger tea),<sup>15</sup> in baking (ginger biscuits and cakes), and in the meat processing industry as a tenderizer (e.g., Maiti et al., 2008; Naveen and Mendiratta, 2001; Olorunsanya and Omiyale, 2009; Saranya et al., 2016). The consumption of ginger may also help to promote salivation (O'Hara et al., 1998).

It is sometimes suggested that ginger isn't much used in cooking in

<sup>8</sup> According to Dalby (2000), it is uncertain whether ginger was transplanted from South Asia to East Africa and/or Arabia before subsequently dying out.

<sup>9</sup> Aram (2015, p. 410) writes that: "Ginger smuggled out of Asia flourished on the Caribbean islands of Hispaniola and Puerto Rico during the late sixteenth and early seventeenth centuries. The oriental root, whose migration and transplantation Spanish sovereigns sought to stimulate, enjoyed more of a market in England and the Low Countries than in Castile. A differentiated demand for ginger in northern and southern Europe, documented in archival and literary sources, reflected the principles of humoral medicine and influenced trade."

<sup>10</sup> Nutraceuticals refer to those foodstuffs, such as fortified foods or dietary supplements that provides health benefits in addition to its basic nutritional value.

<sup>11</sup> Though, as is nearly always the case, these researchers argue that more research is needed (see also Shahrajabian et al., 2019). In particular, they conclude by suggesting that "ginger is a promising antiemetic herbal remedy, but the clinical data to date are insufficient to draw firm conclusions. Further rigorous studies are needed to establish whether ginger is efficacious for clinical nausea and vomiting." (Ernst and Pittler, 2000, p. 370).

<sup>12</sup> The phenolic compounds in ginger, such as the gingerols and shogaols, which are VR1 vanilloid agonists, are thought to play an important role in determining the spice's medicinal properties (Dedov et al., 2002; Ho et al., 2013; Mao et al., 2019).

<sup>13</sup> The culinary appropriation of combinations of medicinal ingredients is mentioned by Segnit (2010, p. 312). At one point, she suggests that: "The combination of ginger and rhubarb came about because it was considered good for the bowels, which may go some way to explaining why they're still paired when to my mind the two flavours seem a little annoyed with each other." Many people find the sharpness of rhubarb to perfectly complement the warming pungency of ginger. For those in South America, where rhubarb tends to be harder to come by, the lulo fruit (*Solanum quitoense*) makes a surprisingly good replacement.

<sup>14</sup> As Parrish (2021, pp. 274–275) writes: "As Jonson's play demonstrates, 'hot' spices were not without their controversy (despite their popularity as ingredients), particularly when one considers the rising support Puritans and their strict, temperate ideology garnered in the decades leading to the English Civil War; over the next century spices like ginger and cinnamon decreased significantly in popularity in part because of cultural shifts."

<sup>15</sup> Canada Dry Ginger Ale was patented in 1907 by Canadian pharmacist John J. McLaughlin. It became a popular beverage in America during prohibition.

the USA, Canada, and UK (Bag, 2018; see also Govindarajan, 1982a, Table 13a, for a comparison of patterns of ginger consumption by country in 1954–1958 as compared to in 1975).<sup>16</sup> Indeed, there was a very marked downturn in the consumption of spices after the Second World War, perhaps linked to decolonization (Pearson, 1996, p. xvii). According to one report published by the Food and Agriculture Organization (FAO) of the United Nations (Food and Agriculture Organization of the United Nations, 1962), there was a decline of 20% worldwide, and an almost 50% decline across most of Europe following the Second World War (FAO, 2019). At the same time, however, such claims for the limited use of ginger would appear to contradict the following suggestion from Segnit (2010, p. 308): “Popular the world over as both a sweet and a savoury ingredient, ginger is available fresh, dried, ground, glacé, pickled preserved in syrup, juiced and in both soft and alcoholic drinks.” Meanwhile, in their book *Tastes of Britain*, Mason and Brown (2006, p. 418) note that ginger appears as an ingredient in the following popular, and often historic, dishes: ginger beer, ginger cake, ginger drops, ginger jam, ginger marmalade, ginger snap (or brandy snap; see Spence et al., 2019, for early recipes for this fairings food), ginger wine, gingerbread, and Yorkshire parkin.

While the culinary use of ginger has undoubtedly risen and fallen over the centuries, the spice’s popularity would appear to have been on the rise in Western countries once again in recent decades. For instance, according to Parker (2004), the most popular fresh herbs and spices by amount spent by Australian shoppers in major supermarkets (by weight) were garlic, ginger, and chilli. In part, this increase in popularity may be linked to the growing interest (in the West) in Asian (i.e., Thai and Chinese food; where the ginger, garlic, and scallion combination is popular, see Stuckey, 2012, p. 166), these being cuisines that both make extensive use of ginger. Whatever the cause, the global production of ginger has certainly risen markedly in recent decades (see Table 1).

### 3.1. Gingerbread men

Dried ginger is often used in baking in Western cuisine, particularly in traditional baked goods like gingerbread, parkin, pecan pie, spices biscuits and Caribbean rum cake (Coucquyt et al., 2020, p. 140).<sup>17</sup> Queen Elizabeth I’s reign (in the 16th-century) was famous for the elaborate royal dinners that would include marzipan shaped like fruit, castles and birds. Intriguingly, the queen’s retinue at the time also included a royal gingerbread maker.<sup>18</sup> At one famous banquet, the queen had gingerbread men made to represent foreign dignitaries as well as those at her court (see Levin, 2001). It has been suggested that this represents the start of figurative biscuit making (Franklin, 1998, p. 183; Lach, 2010, p. 442).

During this period, gingerbread men would have been dished out by folk-medicine practitioners, often described as witches or magicians, who created them as love tokens for young women. According to Carole Levin (quoted in Waxman, 2016): “If they could get the man of their choice to eat the gingerbread man that had been made for them, the idea was the man would then fall in love with the young woman”. According to Michael Kronld, “The popularity of gingerbread during the holidays can, at least in part, be attributed to the belief that spices heated you up

<sup>16</sup> Though, back in the 19th century, the hugely successful, Mrs. Beeton (1861) includes a recipe for a gingery tomato sauce. In fact, the word ‘ginger’ appears 136 times in the Gutenberg version of her text, suggesting it was still a popular spice in the 19th century. By contrast there are only 12 mentions in Hazlitt’s (1902) cookery book.

<sup>17</sup> Intriguingly, however, neither Chartier (2012) nor Segnit (2010) mention the wondrous combination of honeydew melon (*Cucumis melo*) and dried ginger that I grew up with as a child.

<sup>18</sup> In Shakespeare’s comedy play, *Love’s Labour’s Lost* (dated to 1594–1595), the clown Costard quips “An I had but one penny in the world, thou shouldst have it to buy ginger-bread”.

**Table 1**

Descriptive sensory assessment of different ginger varieties as a function of where it is grown. Sensory descriptions taken from Vasala (2000), Segnit (2010, p. 308), McGee (1984/2004), & Coucquyt et al. (2020, p. 140). Production figures for 1999 taken from Vasala (2000), and from Dhanik et al. (2017) for 2017, except for Australian figures which are taken from Camacho and Brescia (2009).

Origin of ginger (and 'type')	Production (in tonnes)		Sensory & quality description where available
	2000	2017	
India ('Cochin' or 'Calicot')	235,000	683,000	Superior quality, lemon-like aroma
China	157,000	425,000	
Nepal	3,200	235,000	Characterized by its richness, pungency, & a coarser camphorous odour that distinguishes it from the more lemony varieties, & betrays its relation to cardamom
Indonesia	80,500	232,700	
Jamaican (grown in Nigeria)	80,000	160,000	
Thailand		140,000	
Bangladesh	39,000	69,000	The lemoniest of all, having a greater percentage of lemon-scented citral
Australian (Queensland & recently-developed 'Buderim Gold')	6,100		
Japan		57,800	
Cameroon		46,350	
Philippines		28,200	
Jamaican (from Jamaica)	620		

in the winter,” (see Kronld, 2016; quoted in Waxman, 2016).<sup>19</sup> (see Fig. 2 for a depiction of a gingerbread vendor from 1902).<sup>20</sup>

### 3.2. On the culinary use of ginger in other parts of the world

The focus in this review has been very much centred on the use and consumption of ginger in Europe and the Commonwealth. One might also want to know about its culinary use elsewhere in the world. Here, though, it is interesting to note that even eminent food historians such as Rachel Laudan, have little to say concerning the historical use of ginger in Latin America (Laudan, 2012). While according to the McCormick Spice Institute website: “In Thailand, it is an essential ingredient in many curry dishes. In India, ginger is an essential flavor in the vast majority of dishes as well as the popular hot beverage masala chai (milky black tea with aromatic spices). In Japan, pickled ginger (gari) is served with sushi as a palette cleanser.”<sup>21</sup>

### 3.3. Related spices

Ginger is closely related to two other culinary spices, namely turmeric (*Curcuma longa* L., otherwise called red ginger) and cardamom (*Elettaria cardomum* (L.) Maton; Vasala, 2000; Zadeh and Kor, 2014).<sup>22</sup>

<sup>19</sup> Mother Ginger also appears in Act II of Tchaikovsky’s *The Nutcracker* (1892), which is set on Christmas Eve.

<sup>20</sup> Intriguingly, no VAT is charged for gingerbread men with just two chocolate spots for eyes in the UK. However, 20% VAT is added on the sale of any gingerbread man dressed with any other chocolate-based additions (Anon., n.d.).

<sup>21</sup> <https://www.mccormickscienceinstitute.com/resources/culinary-spices/herbs-spices/ginger#:~:text=Culinary%20Uses&text=In%20Thailand%2C%20it%20is%20an,sushi%20as%20a%20palette%20cleanser>.

<sup>22</sup> As Segnit (2010, p. 309) notes: “Cardamom is a member of the ginger family, a relationship that is more detectable to the nose and mouth than the eye. Both have warming properties with a distinctive citric note.”



Fig. 2. Gingerbread vendor portrayed in 1902. [After Carle Vernet - Internet Archive, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=36244823>.].

which are also part of the zingiberoideae subfamily of Zingiberaceae. Zingiberaceae is divided into 4 tribes: Hedychieae, Zingibereae, Alpinieae, and Globbeae (Sirirungsa, 1998). Galangal is the name for two Asian ginger relatives, *Alpinia galena* (or greater galangal, sometimes called Thai ginger), and *Aplinia officinarum* (or lesser galangal). Ginger and galingal (historically referred to as galingale in old English recipes; e.g., see the Food of Cyprus dish mentioned in Spencer, 2003, that incorporates both ground ginger and galingale). Galangal tends to impart a more austere taste/flavour than ginger (Wong et al., 2006); It is pungent, with overtones of eucalyptus, pine, clove, and camphor, but none of ginger's lemony character (Hasegawa et al., 2016). From a culinary perspective, therefore, it is interesting to note how galangal is often combined with lemongrass in S. E. Asian (e.g., Thai) recipes.

#### 4. Ginger flavour chemistry

The non-volatile gingerols (also shogaols, paradols, and zingerone), which all have antioxidant properties (Coucquyt et al., 2020; Kulka, 1967) constitute the major active components in the fresh ginger rhizome and gingerol (5-hydroxy-1-(4-hydroxy-3-methoxy phenyl) decan-3-one) is the most abundant constituent in the gingerol series (Zadeh and Kor, 2014; see also Govindarajan, 1982a, b). The powdered rhizome contains 3–6% fatty oil, 9% protein, 60–70% carbohydrates, 3–8% crude fibre, about 8% ash, 9–12% water and 1–3% volatile oil by weight (Sultan et al., 2005; see also Kamaliroostaa et al., 2013; Sharma, 2017). The volatile oil consists mainly of mono and sesquiterpene hydrocarbons; camphene,  $\beta$ -phellandrene, curcumene, cineole, geranyl acetate, terphineol, terpenes, borneol, geraniol, limonene, linalool (Wu et al., 2006),  $\alpha$ -zingiberene (30–70%),  $\beta$ -sesquiphellandrene (15–20%),

$\beta$ -bisabolene (10–15%) and  $\alpha$ -farnesene (see Table 2). According to Vasala (2000), the pleasant aroma of ginger is comprised of more than 70 constituent molecules, while Liu et al.'s (2019) literature review identified almost 200 compounds in the volatile oil of ginger (along with a further 85 types of gingerol, and 28 types of diaryheptanoids), including  $\beta$ -sesquiphellandrene (27%), caryophyllene (15%), zingiberene (14%),  $\alpha$ -farnesene (11%) and AR-curcumin (7%; see also Deng et al., 2022; El-Baroty et al., 2010; Kizhakkayil & Sasikumar, 2011).

Ginger provides a source of minerals such as potassium, phosphorous, sodium, and iron (Bhatt et al., 2013; Vasala, 2000) as well as trace amounts of vitamin C, thiamine, riboflavin, and niacin (see Bag, 2018; Shirin Adel and Prakash, 2010). Ginger oleoresin contains 4–7.5% of dried powder, incorporating pungent substances namely gingerol, shogaol, zingerone, and paradol<sup>23</sup> (Singh et al., 2008). The oleoresin also contains zingiberol, the principal aroma contributing component as well as zingiberene, gingediol, diarylheptanoids, vitamins and phytosterols.

##### 4.1. Shogaol: the pungent ingredient in dried ginger

One of the reasons as to why ginger is such an interesting spice is because of the fact that dried ginger contains different 'zingy' compounds than the fresh rhizome. Shogaol a dehydrated product of gingerol (Zadeh and Kor, 2014), is the predominant pungent constituent dried ginger powder. According to McGee (2004, p. 426), when ginger is dried, its gingerol molecules lose a small side group of atoms and are

<sup>23</sup> Paradol has a peppery taste that is also found in guinea pepper (see Spence, submitted).

**Table 2**

Some of the key aromatic compounds present in the essential oil of ginger. Data compiled from several sources including: Pino et al., 2004; Sultan et al. (2005); Singh et al. (2008); Kamaliroostaa et al., 2013; Stappen et al. (2016); Vedashree et al. (2020). Percentages refer to proportion of ginger essential oil (>1%). It should, however, be noted that, the colour, aroma, and taste of ginger differ depending on the origin of cultivation, the cultivar, growing conditions etc. (see McGee, 1984/2004). Note that the maturity of the rhizome has also been shown to affect chemical composition (Vedashree et al., 2020).

Chemical compound	Pino et al. (2004)	Sultan et al. (2005)	Singh et al. (2008)	El-Baroty et al. (2010)	Kamaliroostaa et al. (2013)	Stappen et al. (2016)	Aroma description (where available)
		Thai (Chinese)					
$\beta$ -Sesquiphellandrene		30.8 (8.0)		25.1	15.6	6.7	Terpene, almond
( $\alpha$ -)Zingiberene	11.7		9.5	14.0	31.8	17.4	Spicy yet sweet aroma
AR-Curcumene	22.1		6.6	6.6	15.9	5.6	Tumeric-like
(trans,trans)- $\alpha$ -Farnesene			7.6	10.5	5.7	6.8	Green apple, herbal, ginger, and hint of citrus
Cis-Caryophyllene				15.3			Woody, spicy, clove-like
$\beta$ -Bisabolene	11.2				9.3	5.8	Balsamic, sweet, myrrh, orange flower
$\alpha$ -Eudesmol					3.2		Mildly sweet & primarily woody aroma.
Geranial			25.9			10.5	Yuzu-like flavour
Neral			7.6			9.1	Sweet floral scent with citrus undertones
Candina-1.4 diene	12.5						Sweet lemon aroma
1,8-cineole		3.9 (2.4)				3.6	Eucalyptus-like odour; Sweet, citrus-like
p-cymene							Smells citrusy (lemon & bergamot) & fresh
Citral		5.4 (4.5)		4.4			Characteristic lemon scent (as in lemongrass)
Linalyl acetate							Floral, sweet, & citric
$\alpha$ -pinene		3.6				3.0	Pine-like or rosemary scent
Camphene						7.8	Woody-like aroma (fir needles)
Myrcene		4.6 (4.8)				1.4	Eucalyptus-like, fresh & gripping
Limonene				5.1		1.3	Earthy, fruity, & clove-like
$\beta$ -phellandrene		2.8 (1.0)				2.2	Pleasant, lemon-orange smell
$\alpha$ -phellandrene							Peppery-minty & slightly citrusy
$\gamma$ -cadinene					3.6	3.1	Herbaceous, woody, minty, & mildly citrus
(trans)-nerolidol					2.0	1.2	Woody aroma
$\gamma$ -terpinene		2.5 (2.9)				2.5	Woody, rose-apple, floral aroma
$\alpha$ -terpinene		6.5					Refreshingly herbaceous-citrusy odour
Germacrene B					1.1		Lemony aroma
4,5-Dimethyl-11-Methylene Tricycl <sup>*</sup>					2.4		
7- $\alpha$ -(1-Hydroxyl-1-Methylethyl					2.0		

transformed into shogaols. Shogaols are about twice as pungent, thus meaning that dried ginger is stronger than fresh (McGee, 2004, p. 426). Shogaol activates the TRPV1 receptor (Dedov et al., 2002), as do the ginger extracts zingerone and gingerol, as well as the nutmeg and clove oil constituent eugenol.<sup>24</sup> Cooking tends to reduce ginger's pungency by transforming some gingerols and shogaols into zingerone, which is only slightly pungent and has a sweet-spicy aroma (Dugasani et al., 2010; see also Coucquyt et al., 2020, p. 140). Of course, in a culinary context, one should also consider the stability of pungent compounds such as gingerol and shogaol in aqueous solution (Bhattarai et al., 2001).

## 5. Sensory qualities of dried and fresh ginger

Back in 1945, Crocker (1945, p. 46) wrote that: "Gingerroot contains a peppery-tasting, non-volatile oleoresin and a fragrant essential oil." Interestingly, 'peppery' does not appear as a descriptor for gingers

<sup>24</sup> Stuckey (2012, p. 98) suggests that the chemesthetic stimulation provided by gingerols (Silver, 1987) should be termed 'irritate'.

sensory qualities thereafter.<sup>25</sup> Several decades later, Grant and Lutz (2000) characterized ginger as 'spicy' and 'hot'. Meanwhile, according to Segnit (2010, p. 308): "In general, fresh ginger is lemony, woody, and earthy with a kick of heat." Coucquyt et al. (2020, p. 141) suggest that: "The aroma profile of fresh root ginger is dominated by lemony, citrus scented geraniol and linalool, which also has a floral nuance." (see also Onyenekwe and Hashimoto, 1999). Chartier (2012) describes linalool as smelling like lavender and lily of the valley. Descriptors like 'citrusy' and 'spicy' are commonly used (Coucquyt et al., 2020, p. 140) but the actual flavour is much more complex. Zingiberene gives ginger its distinct flavour, while gingerol compounds pack a sharp pungency and floral citrusy volatiles (Coucquyt et al., 2020).

<sup>25</sup> That being said, it is perhaps worth noting that there may be some salient individual differences in the perception of bitterness from zingerone. In particular, Green and Hayes (2004) document how when the irritants Capsaicin (and its congeners) piperine, and zingerone were swabbed directly onto the circumvallate papillae, a bitter taste sensation elicited in only half of the participants.

At the same time, ginger can add freshness to food in a way that is unmatched by other spices (Bag, 2018). Bag suggests that ginger imparts a warm spicy flavour to food and drink. Ginger essential oil smells lemon-like with a hot and pleasant, mild-balsamic note (Menon, 2007; Stoyanova et al., 2013). According to Harold McGee (2004, p. 426), ginger has something of the quality of lemon juice in that it adds a refreshing, bright aroma—from fresh, floral, citrus, woody, and eucalyptus notes—and mild, pepper-like pungency that complements other flavours without necessarily dominating them. Visual inspection of Table 2 highlights how fresh ginger contains a number of volatile compounds that are capable of imparting a citrus-like aroma.

Ginger rhizomes sourced from different parts of the world have different sensory qualities (see McGee, 2004, p. 426; Segnit, 2010, p. 308; Tan, 2011).<sup>26</sup> For instance, Chinese ginger is primarily pungent; South Indian and Australian gingers have a notable quantity of citral<sup>27</sup> and hence a more distinctly lemony aroma (see also Connel and Jordan, 1971; Smith et al., 2004); Jamaican ginger is said to have a delicate and sweet taste/flavour, African ginger has been described as penetrating, pungent, and/or coarse (see Table 1), with Onyenekwe and Hashimoto (1999) highlighting the high concentration of terpenoids such as zingiberene (29.5%) and  $\beta$ -sesquiphellandrene (18.4%) in Nigerian samples (see also Anand, 1982; Ekundayo et al., 1988; Okwuowulu, 2005). Sukari et al. (2008) evaluated the essential oils of four *Zingiberaceae* species from Indonesia using gas chromatography-mass spectrometry (GC-MS). These researchers found the major constituent of *Zingiber officinale* var. *rubrum* to be E-citral (21.0%, along with 22.0%  $\beta$ -citronellol, and 6.9% *trans*-geraniol), zerumbone (40.7%) in *Zingiber amaricans*, p-methoxycinnamate (58.5%) in *Kaempferia galangal*, and camphor (58.0%) in *Boesenbergia pandurata*. Sultan et al. (2005) evaluated the quality of ginger rhizomes imported from China and Thailand, on the basis of their essential oil, and reported that the latter was better quality due to it having a higher percentage of essential oil (1.58% as compared to 0.98% for the Chinese sample). Though, even within China, marked differences between samples grown in different regions have been documented (Xuan et al., 2008). Perhaps unsurprisingly, similarly differences have also been reported in India (Kizhakkayil & Sasikumar, 2011), and elsewhere (Ravindran et al., 2005; Sukari et al., 2008).

Several hybrid varieties of ginger are grown in South and South-East Asia (e.g., Holtum, 1950; Kizhakkayil & Sasikumar, 2011; Ridley, 1912; Singh et al., 1999). Although ginger is sterile, plenty of cultivars exists around the world (Kizhakkayil & Sasikumar, 2011). However, at least to a certain extent, their sensory properties depend upon the climate, soil, and local growing conditions (Kamaliroostaa et al., 2013), including the shade conditions (Ajithkumar and Jayachandran, 2003; Aly et al., 2019). In fact, when the rhizome is picked in the growing season can also make a difference. While they are normally farmed after five months, the longer it is left in the ground, the more pungent the rhizome becomes (Coucquyt et al., 2020, p. 140). Vedashree et al. (2020) note that zingiberene increased with an increase in days of maturity (from 150 to 270 days), while ar-curcumin decreased on maturation (2.5% to 18.2% with an increase in maturity days, whereas ar-curcumin decreased from 12.6% to 3.8%). When ginger is harvested also depends on the eventual use of the product. Confectionary ginger products is typically harvested after 5 to 6 months, while ginger for fresh consumption is generally harvested after 6 to 18 months (Camacho and Brescia, 2009). Different drying regimes can also exert an impact on the rhizome (An et al., 2016; Kamal et al., 2023; see also Bartley and Jacobs, 2000; Cherrat et al., 2019). At the same time, however, it is important to note that how the

ginger is prepared/cooked/treated (e.g., fresh, dried, stir-frying and carbonized) likely also exerts a not insignificant effect on the chemical characterization and antioxidants activities (Li et al., 2016).

## 6. Conclusions

There is growing interest in the potential use of herbs and spices as a means of reducing the salt, sugar, and fat content in our foods (see also Tapsell et al., 2006). Pungent spices such as ginger (as well as chile pepper and black pepper) may have a particularly important role to play in this regard (e.g., Scott et al., 2019; Spence, 2018, submitted). Ginger is an especially interesting ingredient, given the wide range of both savoury and sweet foods and drinks in which both the fresh and dried spice appear (see McGee, 2004; Shahrajabian et al., 2019). Ginger is a culinary spice with both medicinal (neutraceutical) and psychophysiological (i.e., alerting) properties (e.g., Al-Kuraishy, 2015; Stappen et al., 2016). At the same time, however, from a culinary perspective, the addition of ginger to a dish can also help to add freshness, lifting the tasting experience in much the same way that a squirt of lemon juice does. Ginger is also used as a meat tenderizer.

Taken together, therefore, it is easy to see why researchers describe ginger as ‘a wonderful spice’ (Gupta, 2008) and as ‘a natural gold’ (see Ghosh et al., 2011). There is even some evidence to suggest that the daily consumption ginger may help in the prevention of chronic diseases in adults (Wang et al., 2017; see also Teschke and Xuan, 2018). It would appear that the consumption of ginger in the West, one of the most important of tropical spices (Lawrence, 1984), will continue to rise in the years ahead.

## 7. Implications for gastronomy

Ginger has long been an important culinary and medicinal spice. However, its popularity in European kitchens has waxed and waned as the centuries have passed by. As one of a number of pungent spices (along with black pepper and chile pepper), it may have an important role to play in the near-future in terms of helping to reformulate those foods that are high in sugar, salt, and fat without necessarily having to compromise too much on taste/flavour. Ginger may be especially well-placed in this regard given its remarkable culinary range, appearing in a wide range of both savoury and sweet dishes, as well as in a number of popular drinks. Many chefs appreciate the spice’s ability to lift a dish and provide freshness. While it was once described as peppery, researchers nowadays typically emphasize the spicy, citrus, and floral notes that ginger imparts instead. Importantly, however, the balance between pungency and citrusy aromatic notes depends on where the ginger is sourced from, as well as on growing conditions etc. The many beneficial culinary and medicinal properties that have been associated with ginger over the millennia help to explain its title as a ‘natural gold’.

## 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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<sup>26</sup> Note that even more marked differences have been identified when *Costus speciosus* (wild ginger) and *Zingiber officinale* (ginger) rhizome from India were compared (Kala et al., 2016).

<sup>27</sup> According to Chartier (2012), citral is found in lemongrass, verbena, oranges, and lemons.  $\alpha$ -citral (or geraniol) has a strong lemon scent, while  $\beta$ -citral (or neral) has a softer lemon scent.

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