GINGER, FROM THE DINING TABLE STRAIGHT TO THE PHARMACY

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Obr. 1. ***Zingiber officinale***

Ginger (*Zingiber officinale* Roscoe) is a perennial tropical plant (Fig.1, ref[1]), grown in the Orient under various names, namely ada, adrak, aradraka, adu, ale, allamu, gyin, halia bara, ingiver, inchi, inji, sonthi. In Czech zázvor, in German Ingwer. It is from the family Zingiberaceae together with turmeric, cardamom or galangal. Its rhizome is used, as a food and a medicinal drug, whether fresh, pickled, candied, or ground dried, or as oil and resin (oleoresin) obtained from it, the latter two with the attribute GRAS (Generally Recognized As Safe)[2]. It is necessary to distinguish it from ginger-grass (*Cymbopogon martinii*) or black ginger (*Kaempferia parviflora*).

It has been grown in the world since time immemorial, producing more than 4 million tons per year, mostly in India. Productivity is around 3.5 t/ha (ref.[3]), whereas its production is known to be increasingly threatened by fungal infestation[4]. They mention it as a useful medicinal plant 4,000 years ago also the Vedas[5], TCM[6], Dioscorides[7] a Matthioli[8]. The chemical literature shows a growing interest in this drug, when in 2021 the Chemical Abstracts Service registered 351 citations, as shown in the graph in Fig. 2.

Ginger is one of the most commonly consumed herbal drugs with significant pharmacological and physiological activities. It is widely used in folk medicine, for various diseases, including chronic diseases such as diabetes in general[10,11], diabetic nephropathy[12], diabetic retinopathy[13], type 2 diabetes (ref.[14]), many types of tumours[15–19], ulcers[20,21], Alzheimer disease[22,23], cardiovascular disease[24,25], pulmonary fibrosis[26], arthritic pain, poisoning[6], viroses[27], a depressions[28]. The beneficial effect of ginger in these diseases lies primarily in its antioxidant[29,30], antimicrobial[31], fungicidal[32] and anti-inflammatory properties[33] and, among other things, it reduces the problems of kinetosis[34], migraine[35], lowers lipid levels[36], mild nausea and vomiting, a property of which is used e.g. even when administering chemotherapeutics[37], mild cramps and sore throat[38], and promotes digestion[39]. Its use as an aphrodisiac is known[40], according to the Qur'an, it will be used by the orthodox in paradise[41]. It is a natural product with as powerful biological properties as those we are trying to describe in this journal, e.g.[42–44], in a series of articles we launched 15 years ago[45].

The sharp aroma and taste of fresh ginger rhizome are due to the mixture of bioactive volatile oils [46] or lipophilic extract[47] (e.g. gingerols, shogaols, paradol and zingerone), which account for about 1-3% of its weight. [6]-Gingerol ((5*S*)-5-hydroxy-1-(4-hydroxy-3-methoxyphenyl)decan-3-on) is considered the main pungent and main bioactive compound in fresh ginger[48]. [4]-, [8]-, [10]-, and [12]-gingerols are present in smaller quantities[49]. In addition, ginger also contains mono and sesquiterpenes[50], several important antioxidant compounds such as vitamin C, vitamin E, niacin, β-carotene, pantothenic acid, lutein, lycopene, quercetin, genistein and tannin[15,51]. In addition, ginger contains essential elements such as potassium, magnesium, phosphorus, calcium, manganese, copper, selenium and zinc[15,51]. In addition, ginger has been found to contain small amounts of toxic elements such as cadmium, lead and nickel[52].

The PubChem database states that [6]-gingerol has been associated in the literature with a number of diseases, such as neoplasms, cancers, metastases, hyperplasia, complications associated with diabetes, glucose intolerance, keratosis, diarrhoea, bleeding, prostate diseases, teratozoospermia, testicular diseases, pathological weight changes[53],

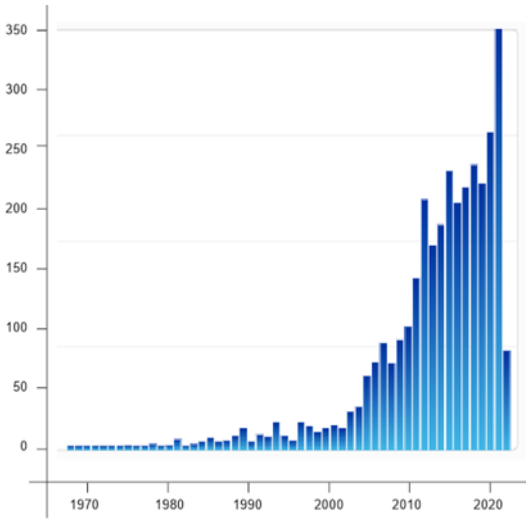
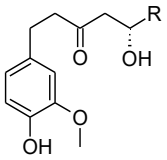
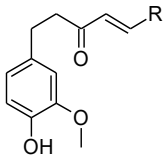
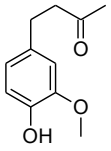
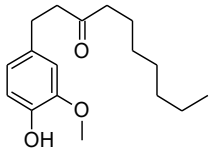


Fig. 2. **The growing trend in the number of publications on ginger (1969–2022)[9]**









[6]-gingerol	[6]-shogaol	R – $(CH_2)_4CH_3$	zingeron	[6]-paradol
[8]-gingerol	[8]-shogaol	R – $(CH_2)_6CH_3$		
[10]-gingerol	[10]-shogaol	R – $(CH_2)_8CH_3$		
[12]-gingerol	[12]-shogaol	R – $(CH_2)_{10}CH_3$		

The number in square brackets indicates the number of carbons in the side chain after the α-carbon next to the carbonyl carbon.

the same database states that it is irritating and toxic (LD_{50}/mice/*p.o.* 250 mg/kg, ref.[54]). Unlike the previous one, the GRAS status for the products it contains and e.g. also a study stating that the metabolism of gingerols and shogalols was studied in healthy volunteers[15] with doses *p.o.* up to 2 g. [6]-Gingerol can be dissolved 80 mg in a litre of water[55] but its solubility can be increased by complexation with β-cyclodextrin[56] min. 4×.

Gingerols and shogaols are metabolised to glucuronides and sulphates after ingestion and are thus easily eliminated[15].

When researching the biological properties of ginger and its components, we encounter difficulty. Gingerols, the main compounds in fresh ginger, are prone to dehydration and conversion to shogaols, the main compounds in dried ginger, due to the instability of β-hydroxy ketone when exposed to the mild heat and/or acidic conditions[57]. The heat treatment of ginger transforms gingerol into zingerone, which is less pungent and has a spicy-sweet aroma, by reversing the aldol reaction.

Department of Complementary and Alternative Medicine, John A. Burns School of Medicine, University of Hawai'i, USA, after evaluating the available studies, divides the results into 'suggestive' (eg short-term use of ginger for safe relief of pregnancy-related nausea and vomiting), 'mixed' (eg use for travel sickness, nausea after chemotherapy or surgery) and 'unclear' (e.g. treatment of rheumatoid arthritis, osteoarthritis or joint and muscle pain)[58].

We bring this paper again as a textbook describing various interesting aspects of the chemistry of natural substances (cf.[59,60]), also because we want to respond in this way to the number of ideas, half-truths and nonsense that are spread around natural compounds today. We are pleased to find a natural substance that, moreover, has negligible toxicity, almost zero contraindications and which has been used by mankind for thousands of years.

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Abstract

Common food and spice, ginger contains a plethora of biologically active compounds that may serve as a basis for pharmaceutical exploitation.

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