Eberhard Teuscher

Medicinal Spices

A Handbook of Culinary Herbs, Spices, Spice Mixtures and Their Essential Oils




With contributions from
Ulrike Bauermann,
Monika Werner

Josef A. Brinckmann
Michael P. Lindenmaier
(Translators)

medpharm Scientific Publishers Stuttgart

CRC Press
Taylor & Francis Group

Medicinal Spices

A Handbook of Culinary Herbs, Spices, Spice Mixtures and Their Essential Oils

Eberhard Teuscher, Triebes, Germany

With contributions from
Ulrike Bauermann, Bergholz-Rehbrücke, Germany
Monika Werner, Montjoi, France

Translated from German by
Josef A. Brinckmann, Sebastopol, USA
Michael P. Lindenmaier, Eugene, USA

With a foreword by
James A. Duke, Fulton, USA

173 full color illustrations
36 black-and-white illustrations
498 chemical structures

medpharm
Scientific Publishers Stuttgart

CRC Press
Taylor & Francis Group

Preface to the English Edition

For good reason, there exists a popular German folk saying: *The seasoning makes the roast*. Besides visual appearance, odor and taste play the most important role in terms of acceptance and wholesomeness of foods. Nutritious food products are often rejected by people if they are not enjoyable. Therefore, we zest the foods. Spices do not only add to the enjoyment of foods and increase the love of life, they can also be beneficial to human health if they are used appropriately within a reasonable dosage range.

Hundreds of books on culinary herbs and spices as well as spice mixtures are currently on the market. This indicates that the ancient art of seasoning is still popular and continues to gain momentum.

The aim of this book is to present the scientific and medical aspects of culinary herbs and spices, and among others to work up our knowledge of botany, cultivation of spice plants and the production of culinary herbs and spices, their chemistry, and the analysis of their constituents, physiological effects as well as their toxicology and medicinal application. In order to fascinate the reader about the fine art of seasoning, this book also includes information about the cultivation of culinary herbs in the garden or on the balcony, their commercial forms as well as their storage and use in cooking. The use of spices can be a special event particularly if the fragrances of exotic foods are captured at home. In order to give the reader the possibility to appreciate the value of culinary herbs and spices, in many of the monographs simple recipes for experimenting and aroma testing are included. An attempt has been made to choose those types of dishes, which only include one type or just a few culinary herbs and spices in order to demonstrate the typical flavor of an herb or spice. Try yourself!

The book is divided into 2 parts, a general section and the specific monographs. The general section provides an overview of facts about herbs and spices that can be generalized; it also should contribute to a better understanding of the specific monographs. The monograph section describes the most important culinary herbs and spices. Many monographs are followed by short supplementary paragraphs describing herbs and spices, which are only used rarely or not at all in Central Europe. Since thousands of plants are used as spices, the list is, of course, not exhaustive. Evaluated were scientific papers that were found through literature research of periodicals relevant for this particular field, from the author's own file of references and from Hager's Handbook of Pharmaceutical Practice (4th edition, 5th edition and subsequent volumes), as well as from references of the last 5 annual volumes of Chemical Abstracts, internet literature, specialty literature and cook books (→ Index of books and monographs used as general references at the back of this book) and the secondary literature cited in the aforementioned publications. Not all of the publications cited were read by the author in their original form. Sometimes facts were taken from abstracts or review papers. Hence, the page numbers are not always noted. The literature list is structured in such a way that the reader can access it in order to solidify his/her knowledge and possibly conduct one's own investigations. The book also tries to verify relevant findings. A complete verification was of course not possible since the literature list would have become far too large. The individual herbs and spices were investigated quite differently by various international research groups. An internet search for soybean generated about 35,000 hits for literature citations; for garlic, there were about 1,300 citations. For a few other herbs and spices, relevant literature citations were not available; the selection and "omission" criteria were difficult for the author, particularly for the well-researched spices (e.g. garlic, paprika, pepper, and soy bean).

This book is intended primarily for pharmacists, physicians, biologists, and interested students and laypersons, but also for food scientists who are interested in the chemical and pharmacological-toxicological aspects of culinary herbs and spices.

The color illustrations should familiarize the reader with the appearance of herbs and spices and their plant sources. Pictures of comminuted herbs and spices were not included since they are only of minor importance for the consumer. Line drawings of microscopic images are only shown if the powder shows conspicuous features or if they are significant for trade and as a component of spice mixtures. Only relevant microscopic features are shown; atypical powder components, e.g. parenchymatic, sclerenchymatic and vascular tissue, starch, etc., are mentioned in the text. Chemical structures are only shown for selected substances that contribute to the odor, taste or color, or in some cases to the therapeutic and toxicological effects. The more important structures of chemicals, which are typical for a specific culinary herb or spice, are reproduced in the individual monographs. Chemical structures of common essential oil components are compiled in chapter 2.2, mostly without indicating their steric structures; individual components can be found using the subject index. From compounds with unequivocal rational names chemical structural formulae (chemical structure diagrams) are not drawn.

I am especially grateful to Prof. M. Wichtl, Mödling (Austria), who inspired me to

write this book, and I also would like to thank Dr. K.G. Brauer, Medpharm Scientific Publishers, Stuttgart (Germany), for accepting me as an author. I am also thankful to the staff of Medpharm Scientific Publishers, particularly Dr. E. Scholz, for his cooperative effort preparing the design of the book.
Many thanks also go to Mrs. U. Bauermann, Potsdam-Rehbrücke (Germany) and Mrs. M. Werner, Montjoi (France), for their contributions and support. My thanks also go out to all of my colleagues who placed their photos at my disposal for illustration of the book.
Constructive discussions and valuable advice from many colleagues helped the author to write this book, above all agronomist Dipl. Ing. P. Achermann, Basel (Switzerland), Dr. M. Börnchen, Drensteinfurt (Germany), Dr. Ch. Rotta, Stuttgart (Germany), apothecary Mr. K.H. Schnitter, Oberwolfach (Germany), Mrs. I. Schönfelder and Prof. P. Schönfelder, Regensburg (Germany), Mrs. A. Teige, Gera (Germany), Dipl. pharm. S. Tiemann and Dr. D. Tiemann, Dassow (Germany), as well as Mrs. Dr. W. Wichtl and Prof. M. Wichtl (Austria); I would like to express my gratitude to all of them. For providing the specimens of dried culinary herbs and spices, I would like to thank the companies Caesar and Loretz GmbH, Hilden (Germany), Gera Gewürze GmbH, Gera (Germany), Hamburger Gewürzmühle GmbH, Hamburg (Germany), and especially the firm SUNDAVital OHG, Wolfach (Germany).
I am also very grateful to my wife, Dr. G. Teuscher, in her tireless effort to proofread the German manuscript and galley proof.
I express my gratitude to Josef A. Brinckmann, Sebastopol (California, USA) and Michael P. Lindenmaier, Eugene (Oregon, USA), translators and specialists, for the translation of the sometimes very difficult texts and for good cooperation with the author.
Due the diversity of the presented data, and the inherent possibilities for errors, I am grateful for any critical suggestions and advice on the content and layout of the book.

Triebes, Thuringia, Germany, Winter 2005
Eberhard Teuscher

Table of Contents

Monographs of spice plants and culinary herbs

Spice Mixtures

Indexes

Garlic

Fig. 1: Garlic bulb and cloves of garlic

Plant source: *Allium sativum* L. var. *sativum.*

Taxonomic classification: The species *Allium sativum* L. can be subdivided into the following varieties:
Allium sativum L. var. *sativum*, common garlic,
Allium sativum L. var. *ophioscordum* (also *ophioscorodon*) (LINK) DÖLL, serpent garlic, rocambole (see below: Similar culinary herbs),
Allium sativum L. var. *pekinense* (PROKH.) MAEKAWA apud MAKINO, Peking garlic (see below: Similar culinary herbs).

Family: Allium plants (Alliaceae; in older literature this species was placed in the lily family, Liliaceae).

Common names: Engl.: garlic, common garlic; Fr.: ail, ail blanc; Ger.: Knoblauch, Knobl, Knoblich, Knofel, Kofel, Knufloch, Windwurzel, Weingartenknoblauch.

Description: Perennial herb, 25 cm to 90 cm in height, with mostly composite bulbs, offset bulbs (cloves) oblong-ovoid (*A. s.* var. *sativum*) or roundish ovoid (*A. s.* var. *ophioscordum*), enclosed by a thin, skin-like membrane which is white, greenish, pink, purple or violet. Leaves are gray-green to bluish gray, flat, broadly linear, acuminate, with a keel below, somewhat grooved, with a rough margin (in *A. s.* var. *ophioscordum* not grooved, with a more or less smooth margin), up to 2 cm wide (in *A. s.* var. *pekinense* more than 2 cm wide). Stalk with inflorescence round, bearing leaves up to the mid-section. Sheath monophyllous with a long beak-like projection; inflorescence is a pseudoumbel with few flowers but bearing numerous, ovoid brood bulbs, up to 1 cm in diameter.


Fig. 2: Garlic (*Allium sativum* L. var. *sativum*)

Flowers with 6 perigone leaves, reddish-white or greenish and 6 stamina, shorter than the perigone, the inner ones with a short, blunt, tooth-like appendix on each side; sterile (only a few Asian cultivars produce viable seeds). Flowering period is July to August [Ü42].

Native origin: Probably native to central Asia, secondarily the central Mediterranean region, and from there it has spread through cultivation almost worldwide. Today, garlic is not known in the wild.

Main cultivation areas: China, India, Thailand, Egypt, South Korea Spain, Turkey, USA (California), Republics of the former Yugoslavia, Italy, and France.

Main exporting countries: Italy, Spain, Hungary, Czech Republic, the Balkan countries, Russian Federation, and Egypt. China is the main exporter of dried garlic.

Cultivation: Garlic prefers loamy-humus, deep, nutrient-rich soil in sunny locations. It is winter hardy. Due to its self-incompatibility, garlic or other Allium species should not be planted again in the same location for at least 5 years. Propagation is carried out vegetatively by planting cloves (separated from the bulb) or brood bulbs (secondary cloves formed in the umbel) in September until mid October, spaced at about 25 × 8 cm, at a depth of 3.5 to 5.0 cm. Garlic that is grown from brood bulbs will produce in the first year rounds (small bulbs without cloves) which can be used for planting in the autumn [Ü21, Ü96]. Cultivars include, among others, 'Stamm' (high allicin content), 'Thüringer' (without brood bulbs, it does not produce shoots), 'Burgenland', 'Mako' and 'Ungarisher' (Hungarian) [22, Ü21].

Culinary Herb

Commercial forms: Garlic: whole, fresh bulbs, loose, or the tops tied in bundles or woven into braids (garlic braids), summer garlic products (unripe bulbs with green, whole or shortened leaves), dried or freeze-dried flakes, slices, granulated or powdered bulb, garlic juice, puréed garlic, garlic dry extract (spray-dried onto a carrier), garlic salt (mixture of 40% powdered garlic and 60% common salt), garlic essential oil (obtained by steam distillation), and garlic oleoresin. Smoked garlic bulbs are also commercially traded, which, due to the loss of their ability to germinate, have a longer shelf life than non-smoked bulbs. Garlic that is cultivated in southern latitudes is more aromatic than garlic grown in Central Europe.

Production: The ripe bulbs are harvested when the upper third of the of leaves have withered and the cloves begin to fill the skins (beginning of July to beginning of August). If harvested later than this, the bulbs begin to disintegrate in the cloves. In industrial farming, garlic is harvested using bulb diggers, digger-shakers, or other mechanical garlic harvesters (scooping, uprooting, stalk cutting), or plowshares with attached loaders. After field drying, the tops should be cut at 1 cm, the outer skin should be removed and the bulbs should then be cured in a well-ventilated room. In the retail trade, garlic is offered by small producers bundled or with the leaves woven into braids [Ü21]. Powdered- or granulated garlic is produced by cutting the cloves into slices and dehydrating in a tunnel dryer. Lyophilization is also practiced. By adding calcium stearate (flow agent), the free-flowability of powdered- or granulated garlic is improved [Ü93].

Forms used: Fresh garlic cloves, dried or freeze-dried preparations made from garlic cloves (powder, granules, flakes, garlic salt), and garlic purée.

Storage: The bulbs with a dried surface can be stored in a well-ventilated, dry location between 0 and 2 °C (also in attics; stored garlic is frost-resistant). Winter garlic (planted in fall, harvested in July) can be stored until February. Spring garlic (planted in spring, harvested in August) can be stored until May. In order to prevent the bulb from drying out, the producers sometimes coat the bulbs with paraffin.

Description. Whole bulb (Fig. 1): Spherical to ovoid, composite bulb, diameter about 4 cm. The bulb consists of a hard, flattened base with root fibers on the lower end, and situated on top, a longish main bulb, surrounded by 8 to 20 longish and bent, somewhat angular secondary bulbs (cloves). The main and secondary bulbs are each enclosed by white to reddish, paper-like membranes. The entire bulb-aggregate is covered by several, dry whitish skins [EB 6].

Cut dried pieces: Horn-like, transparent, strongly hygroscopic disks or fragments.

Powdered garlic: Light yellow to light ochre-colored powder; microscopic examination of the chloral hydrate slide preparation reveals the numerous parenchyma fragments as well as groups of spiral and annular vessels, closely associated with thin-walled parenchyma. Numerous oxalate crystals in form of prisms are also present. Negative reaction for starch with iodine-solution [87, Ph Eur].

Odor: Fresh, uncut bulbs odorless, characteristic garlic odor when cut or crushed; the powder has only a faint, garlic odor.

Taste: Pungent, burning, and characteristic.

History: The origin of garlic cultivation was probably in southwestern Asia, about 6,000 years ago; it is one of the oldest cultivated plants. Since about 2000 BCE, garlic has been cultivated in Egypt. It is common knowledge that garlic played a significant role in promoting the health of slaves working on the great pyramids. Due to its antiseptic effects, garlic was used as a component for filling the body cavities of mummies. Garlic is also an important plant in the mythology of many cultures and peoples [48, Ü92].

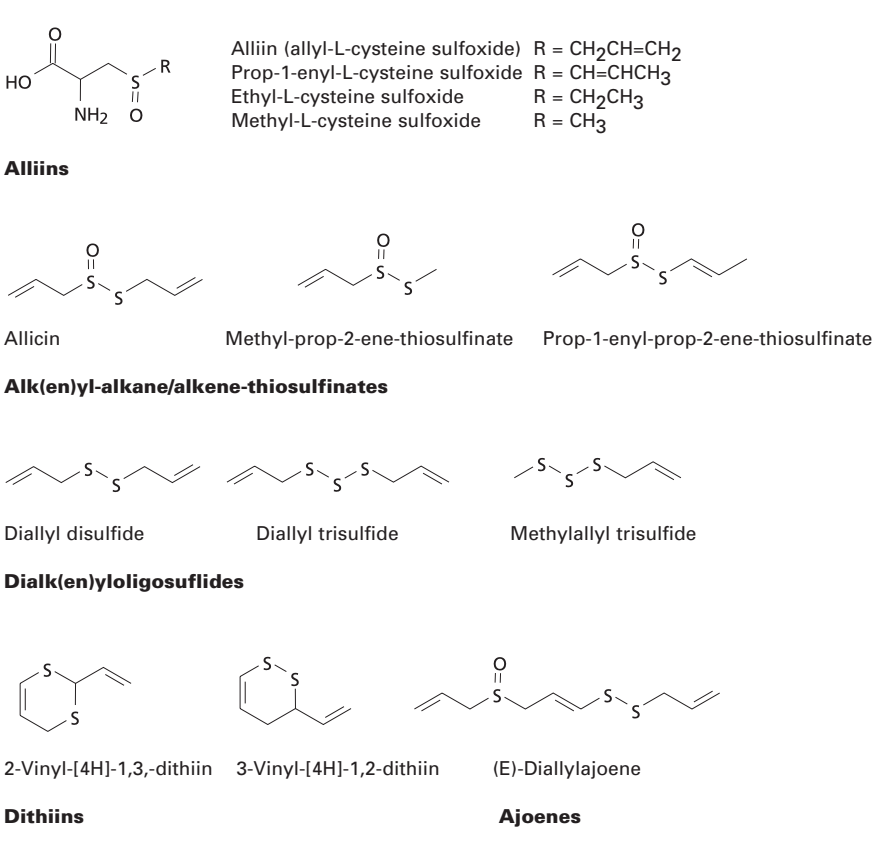
Constituents and Analysis

DIN- and ISO-Standards: DIN-Standard 5560 (Dried garlic, trade specification), ISO-Standard 6663 (Garlic, cold storage).

Constituents

- Alliins (*S*-alk(ene)ylcysteine sulfoxides): 0.5 to 1.3% in the fresh bulbs, less in the leaves: (+)-*S*-Allyl-L-cysteine sulfoxide (alliin, about 1%), *trans*-(+)-*S*-(prop-1-enyl)-L-cysteine sulfoxide, (+)-*S*-ethylcysteine sulfoxide and (+)-*S*-methyl-L-cysteine sulfoxide [71, 108].
- Alliaceous oils: The non-volatile alliins come into contact with the enzyme alliinase after tissue damage and are then transformed to the volatile alk(ene)-sulfenic acids, which spontaneously convert to compounds with characteristic garlic aroma, the alk(en)yl-alkane/-alkenethiosulfinates (Figs. 10 and 11, General Part 2.3.4). 10 Dialkylthiosulfinates (0.5 to 1.0%) have been detected including, among others, allicin (allyl-prop-2-ene-thiosulfinate), methyl-prop-2-enethiosulfinate and prop-1-enyl-prop-2-enethiosulfinate [20, 44, 65, 77, 88].
- As decomposition products of the thiosulfinates arising during steam distillation, boiling or frying of garlic: Dialk(ene)oligosulfides, including diallyl-, methylallyl- as well as dimethyl-sulfides and –oligosulfides; they include compounds with 1 (3%), 2 (40%), 3 (37%), 4 (20%), 5 or 6 sulfur atoms, particularly diallyl trisulfide, diallyl disulfide, methylallyl trisulfide and diallyl sulfide, in addition to sulfur-free constituents such as propene and acetaldehyde, which quickly evaporate [1, 54, 112, 123, Ü83]. After steam distillation, a number of hydrophilic constituents have been isolated from the water phase, e.g. 3,5-diethyl-1, prop-2-ene-1-ol and 2,4- [123].
- If comminuted garlic is non-polar solvents, for ex oil maceration, the thios allyl functionality are vinyldithiins (about 70%, 1,3-dithiin and 3-vinyl-[4H and ajoene (12% *cis*- and dialkyldi- and –trisulfid been detected. Extraction mostly yields diallyl-trisu lallyl-trisulfide and ajoene
- The human organism me thiosulfinates to the c alk(ene)yl mercaptans (all methyl mercaptan) and into allylmethyl sulfide a fide. These compounds eliminated through respi the skin and mucous mem are finally metabolized to CO_2 [78, 84, 110, for a re macokinetics, see Lit. 62 also be transformed to al fides by intestinal flora [1
- γ-Glutamylpeptides (abou cursors of alliins, in the b Glutamyl-*S*-allylcysteine 0.56%), γ-glutamyl-*S*-*tran* cysteine (0.35 to 0.47%), methylcysteine (0.06 to glutamylmethionine [42, 8
- Allithiamine (adduct of allicin with full vitamin B_1
- Adenosine: about 0.05% |
- Polysaccharides, oligosac monosaccharides: Particu (about 50%, neokestose- rose, scorodose, glucose, [15, 64, 82].
- Steroid saponins, triterp Including, among others, -R1, -R2, protoeruboside [63].
- Flavonoids (traces): Qu kaempferol glycosides [42
- Trace elements: Selenium um [74].

Tests for Identity: TLC, acc Ü102, Ph Eur].



Quantitative assay: The content of alliin and allicin can be determined with TLC [56, 87]; alliin levels can be evaluated with HPLC [86–88] or, after derivatization, with GC [71]. Another method for alliin quantification is the detection of ammonia, which develops after cleavage with immobilized alliinase [57, 70], and the HPLC determination of the allicin and other thiosulfinates after fermentation of garlic biomass [86–88, 115, 119, Ph Eur], as well as GC [86, 87] or headspace-GC analyses [46, 67]. The alk(en)ylsulfides and thiosulfinates are assayed with HPLC [78]; the former can also be detected in steam-distilled garlic oil by GC/MS or GC/FTIR [54, 123]. The sulfur content is determined according to [20], the steam-volatile constituents are quantified volumetrically [DAB], and the proteins are assessable via SDS-PAGE [85].

Adulterations, Misidentifications and Impurities can be excluded due to the typical appearance, taste and odor of garlic.

Actions and Uses

Actions: Garlic not only has appetite stimulant and digestion promoting effects, but also antilipidemic, antiatherosclerotic and antihypertonic action, thrombocyte aggregation inhibiting effects, and it stimulates fibrinolysis, in this way preventing infarction. Furthermore, it increases blood circulation in peripheral vessels, reduces the risk of tumor formation, activates thyroid gland activity, and has antihepatotoxic activity. Almost all of these effects can be attributed to the antioxidative effect of alliaceous oils. Additionally, garlic has also shown, among other activities, antimicrobial, anthelmintic, insecticidal and immune stimulant activity. The number of publications that have reported on the pharmacological actions of garlic is so great, that in the following section, there is only room for an overview of the exemplary literature. For the most part, results from in vitro studies have been left out.

Lowering of lipid levels in the blood: Garlic has been observed to show a lipid-lowering effect in numerous clinical studies [for an overview of studies up until 1989 see Lit. 75; additional findings reported in Lit. 24, 27, 51, 52, 81, 98, 104, 116]. Daily oral ingestion of 5 g fresh garlic for three weeks as part of a controlled standard diet led to a lowering of total cholesterol by 13% and triglycerides by 25% in healthy volunteers [52]. In a 16-week double blind, placebo-controlled study with hypercholesterolemic patients, a daily dose of 600 mg garlic powder tablets (standardized to 1.3% alliin) led to a 12% reduction of cholesterol concentration in serum in the experimental group and a 17% reduction of triglycerides concentration. [81]. In a randomized, double-blind, placebo-controlled study involving patients with primary hypercholesterolemia, given 0.9 g garlic powder/day (standardized to 1.3% alliin) for 4 months, a decrease of cholesterol level of 21% occurred [27]. In another study involving patients with primary hypercholesterolemia, after six months total cholesterol levels dropped by an average of 14%, triglyceride levels dropped by an average of 20%, LDL-values dropped by about 19% and HDL-values increased by about 18% following daily administration of an enteric coated garlic oil preparation (5 mg oil bound to beta-cyclodextrin, b.i.d.; main constituents diallyl disulfide and diallyl trisulfide) [98]. A meta-analysis of 16 studies found that one-month garlic powder therapy (600 to 900 mg daily) resulted in a lowering of total cholesterol levels by about 12%, which persisted for a minimum of 6 months. Lowered triglyceride levels were also observed [104]. A subsequent meta-analysis confirmed a "modest" lowering of total cholesterol levels (5.8%) due to the influence of dietary supplementation with garlic, however the authors doubt that this small lipid-lowering effect has clinical significance [107]. An anti-hypercholesterolemic effect has also been observed in animal experiments wherein garlic powder was added to feed with concomitant ingestion of a cholesterol rich diet [6, 50].

These observations stand in contrast to other study results [16, 17, 49, 80, 89, 105]. In a randomized, double-blind, placebo-controlled study involving patients with hyperlipoproteinemia, no significant changes in total serum cholesterol, HDL or LDL were observed following ingestion of 198 mg or 450 mg garlic, t.i.d. [80]. Likewise, no effect was attained in similarly designed studies with dried garlic powder in enteric-coated tablets at a dosage of 300 mg, t.i.d., for 12 weeks [49, 105]. Also, the application of garlic essential oil (5 mg oil bound to beta-cyclodextrin, b.i.d.) in a randomized, placebo-controlled study had no influence on serum lipoproteins, cholesterol absorption, or cholesterol synthesis [16].

Antiatherosclerotic effect: Garlic has demonstrated antiatherosclerotic effects in animal- and human studies. Ingestion of garlic powder (300 mg/d, 2 years) in seniors resulted in the maintenance of the arterial elasticity (measured by pulse wave velocity) [26]. In a randomized, double blind, placebo-controlled study, enteric-coated garlic powder tablets were administered to patients with advanced atherosclerotic plaque (300 mg, t.i.d.). In the garlic group, the reduction of the increase of atherosclerotic plaque volume in carotid and femoral artery (assessed by high-resolution ultrasound) ranged from 5 to 18% within the observation period of 48 months, and in a few cases there was even a decrease in plaque volume [69].

The antiatherosclerotic effect of garlic appears not only to be dependent upon the antilipidemic action, but rather it probably takes place, mainly due to a protection of blood lipids, especially LDL (see Chapter 4.8), from oxidative changes. Evidence for that theory is found in a study of mice fed a high-cholesterol diet supplemented with allicin solution (9 mg/kg body weight) for 15 weeks. The allicin-treated group had significantly lower atherosclerotic changes in the aortic sinus compared to the control group that was fed only a high-cholesterol diet. There were no significant differences between blood lipid profiles of either group [2]. Similar results have been attained in studies with rabbits [92]. In an ex-vivo study, LDL isolated from patients who took an aged garlic extract (2.4 g/day) for 7 days was significantly resistant to Cu2+-mediated oxidation [89].

Antihypertensive effect: Blood pressure lowering effects of 5 to 10% following ingestion of garlic have been observed in a few studies [for an overview of studies up until 1989 see Lit. 75; additional findings in Lit. 14, 58, 75, 81]. An antihypertensive effect has also been determined in animal studies [4, 6]. It has been deduced from rat studies that garlic exhibits a vasodilatative effect by modulation of the production and function of relaxing- and contracting factors of endothelial cells [59].

Inhibition of thrombocyte aggregation: This effect has been demonstrated in clinical studies [for an overview of studies up until 1989 see Lit. 75; additional findings in Lit. 5, 7, 47, 58, 94, 116]. In a double blind, placebo-controlled study involving subjects with elevated spontaneous thrombocyte platelet aggregation, after 4 weeks administration of 800 mg garlic powder (400 mg, t.i.d.; standardized to 1.3% allin), decrease of circulating platelet aggregates in the blood, of thrombocyte aggregation tendency and of plasma viscosity was observed [58, 116]. Oral administration of one garlic clove per day (about 3 g) for 26 weeks reduced thromboxane B_2 levels in serum [58]. An ex-vivo study in humans showed that the administration of 5 ml of an aged garlic extract for 13 weeks delayed the ADP-induced platelet aggregation and diminished the total percentage of platelet aggregates in the blood though without significant changes in plasma level of thromboxane B_2 [94]. In rats, thromboxane B_2 levels in serum were significantly decreased by administration of an aqueous extract of garlic. Boiling the extract diminished its activity [25].

Enhancement of fibrinolytic activity: [For an overview of studies up until 1989, see Lit. 75; additional findings in Lit. 23, 32, 52]. Daily ingestion of 5 g fresh garlic by healthy volunteers for 3 weeks led to an increase of fibrinolytic activity from 77 units to 94.5 units (measurement of euglobulin lysis time) [52]. In a group of 50 patients with myocardial ischemia, fibrinolytic activity increased 6 hours after ingesting a dose of 500 mg fresh or baked garlic by 63% or 72%. After ingestion of the same daily dose for 4 weeks, at the end of the study period activity increased by 85% or 72% [32].

Lowering the risk of infarction: As proof of the speculation that antiatherosclerotic, antilipidemic and antihypertensive effects of garlic contribute to lowering the risk of infarction, a study involving 432 patients after cardiac infarction was carried out. They were treated with encapsulated garlic essential oil (0.1 mg/day) or placebo. After 3 years, blood pressure and blood cholesterol levels in the verum group were significantly lower than those in the placebo group and the number of re-infarctions in the verum group was reduced about 50% [23].

Antimicrobial action: In the agar diffusion test, fresh pressed juice of garlic inhibited the growth of both gram-negative and gram-positive bacteria and was also active against some antibiotic-resistant strains. 20 mg of the pressed garlic juice had the same effect as 10 µg of ampicillin [100]. Garlic powder, garlic oil, allicin or diallyl trisulfide have shown antibiotic effects against, among other species, *Helicobacter pylori* [30, 90, 106], *Staphylococcus aureus*, *Escherichia coli*, *Listeria monocytogenes* [72], *Staphylococcus epidermidis*, *Salmonella thyphi*, yeasts [12, 33], *Cryptococcus neoformans* [34] and *Giardia intestinalis* [8, 10, 12, 19, 29, 30, 33, 34, 72, 95, 100, 101, 106, 116, 120-122]. In vivo, the number of streptococcal bacteria and total coliforms in the intestinal flora of rats was reduced by garlic extract (1 g/rat for 3 days, activity equivalence with 8 mg tetracycline hydrochloride) to 1% of the original count, and lactobacillus to 10% [101].

A Chinese epidemiological study indicated that garlic consumption may protect against *Helicobacter pylori* infection and therefore may also protect against stomach ulcers and gastric cancer [122]. The same opinion is also shared by other authors [106].

The growth of pathogenic dermatophytes has also been strongly inhibited in the agar diffusion test or by topical application on rabbit skin (but not with oral administration) [8].

An antimicrobial effect in the blood and urine has also been demonstrated following ingestion of garlic [29].

Immune stimulating action: Garlic stimulates the production of cytokines (IL-2, TNF, and interferon-gamma) and the proliferation of macrophages, NK-cells and T-cells [73, 76].

Prevention against the induction of malignant tumors: There are numerous indications that garlic may prevent malignant tumors. Epidemiological studies in Japan and China have shown that increased consumption of garlic (as well as, among others, onion and Chinese leek) decreased the risk of occurrence of stomach- or esophagus cancer [19, 45]. In epidemiological studies in France, it was demonstrated that the probability of women getting breast cancer decreased with an increased consumption of garlic or onions (as well as fiber from cereals) [31]. An earlier, extensive study in Holland does not corroborate these results [39]. A meta-analysis of epidemiological studies carried out up to year 2000 showed, however, that for persons who regularly take garlic, the risk of intestinal cancer lowered from 1 to 0.69, and for stomach cancer from 1 to 0.53 [96]. Similar results are found in another meta-analysis [43].

Indications of the tumor preventing action of garlic arose also from experiments with animals. It has been shown that tumors induced by carcinogens (e.g. benzopyrene, 7,12-dimethyl benzanthracene, *N*-methyl-*N*-nitrosourea, dimethylhydrazine, nitrosomethylbenzylamine, diethylnitrosamine) can be inhibited by preparations made from raw garlic or some by its genuine isolated constituents (e.g. *S*-allyl cysteine) [for an overview of studies up until 1989, see Lit. 109, up to 1996, Lit. 117].

Administration of an aqueous garlic extract (250 mg/kg body weight, orally) effectively suppressed 7,12-dimethylbenzanthracene(DMBA)-induced carcinogenesis in the buccal pouches of male Syrian hamsters [14]. Garlic powder (1 to 4% in feed) prevented DMBA-induced breast cancer in rats [79], and the incidence of mammary tumorigenesis induced by *N*-methyl-*N*-nitrosourea in female rats was reduced by supplementation with garlic powder (20 g/kg body weight, a very high

dose), *S*-allyl cysteine (57 µmol/kg body weight) or diallyl disulfide (57 µmol/kg body weight) by 76, 33 or 53%, respectively [97]. The incidence of colorectal adenocarcinoma in mice induced by 1,2-dimethylhydrazine was strongly reduced by gavage administration of diallyl sulfide [118].

The formation of carcinogenic substances by chemical reaction can also be inhibited by constituents of garlic and their degradation products. Diallyl disulfide inhibited the formation of carcinogenic heterocyclic aromatic amines in boiled pork juice [111], and *S*-allyl cysteine inhibited the formation of carcinogenic nitrosamines in the stomach [37].

In Mexico, in some Central- and South-American countries, and in Spain and India, garlic is used as an oxytocic agent, for dysmenorrhea and as an abortive. In animal experiments, estrogenic and ACTH-like effects have been shown [35, 36, 60].

Toxicology: Based on existing data, there is no acute or chronic toxicity in healthy people with the regular use of garlic as a spice or herbal remedy. Particularly in sensitive individuals, high doses of raw garlic, garlic powder, garlic juice or garlic oil can lead to stomach complaints, heart burn, nausea, vomiting, bloating, colic, diarrhea, micturition, cystitis and even fever. Raw garlic is contraindicated in stomach and duodenal ulcers. Since the alliaceous oils pass into breast milk, they can cause bloating in babies and hence, nursing mothers should avoid garlic or preparations thereof. With external use of garlic or garlic oil, skin irritation with blistering can occur, especially in children [36, 61, 75, 93, 103, Ü58].

In animals (rats, cats, dogs), which were fed high doses of garlic juice over a few weeks time, reduced body weight was observed, as well as damage to the gastric mucosa or anemia; at levels of 5 ml/kg body weight, a few laboratory rats died. The LD_{50} for garlic extracts is at 0.5 up to or exceeding 30 ml/kg body weight [21, 36, 41, 102].

The sensitization potential is moderate. The main allergen is diallyl sulfide but antibodies against a macromolecular antigen (12 kDa) from garlic have also been detected. Eczema of the hands and more rarely conjunctivitis, runny nose or asthma (particularly with contact of airborne garlic dust) have been observed, particularly in kitchen personnel, vegetable venders and housewives as well in workers of the pharmaceutical industry. Cross reactions with onions are possible [9, 13, 28, 36, 40, 53, 61, 65, 91, Ü39].

Culinary use: The culinary use of garlic is highest in eastern and southeastern Asia, followed by the Mediterranean countries and South America. But also in Europe, following the end of the 2nd world war, it became more and more integrated partly from the adoption of exotic dishes and cooking traditions.

Sometimes it is just used to produce a delicate aroma of garlic, e.g. for salads and in some vegetable dishes (spinach, chard, zucchini, vegetable fennel) that are served in a bowl that has been rubbed with cut pieces of fresh garlic or with cloves of garlic that have been lightly browned in oil. Rubbing garlic over roasted meat is also practiced. If one desires a strong garlic taste, it is best to use the fresh cloves with the paper-like skin removed, chopped, in thin slices or cut into spikes (for larding), chopped in a garlic dicer or in a mortar (best with some salt) or squeezed through a garlic press. For garlic bulbs that have already begun to sprout, the green shoots should be removed. The serving size for Central European eating habits is 1 to 2 cloves, but in southern Europe up to 40 cloves are used for a meal that serves 4 persons. Flavor intensity can be varied depending on the point at which garlic is added to the meal, at the beginning or at the end of cooking. Adding it to hot oil destroys its aroma. Fresh garlic is preferable over dried products or other prepared forms [Ü2, Ü55, Ü91].

Garlic serves as a spice in meat dishes (roasted with, especially mutton, lamb, pork, calf, rabbit, chicken, goose), of sausages (salami, garlic sausage, ringed garlic sausage, garlic sausage for heating in water), fish dishes (e.g. zarzuela, a Spanish seafood casserole), rice dishes, fried potatoes (one should avoid over browning of roasted garlic), egg dishes (e.g. omelets), salads (e.g. tomato salad, tsatsiki, mushroom salad, and garlic honey in fruit salads), of sauces, mayonnaises or dips (e.g. aioli sauce, a Provençal garlic mayonnaise, and skordalia, a Greek garlic mayonnaise) for noodles, fish, sea foods, poultry, game or vegetables, for salad dressings (e.g. as a component of garlic honey), quark, soups (e.g. potato soup) and vegetables [Ü2, Ü13, Ü23, Ü53, Ü55, Ü65, Ü74, Ü79, Ü91, Ü95]. Steamed in butter, garlic can be eaten as a vegetable [48].

Garlic is also popular as a bread topping. For this, one rubs peeled garlic cloves onto toasted white bread and then spreads butter over it. In the English literature, the preparation of garlic baguettes (garlic bread) is described. To prepare, the baguette is cut in two, lengthwise, and a mixture of about 80 g butter and 1 to 2 peeled, crushed garlic cloves (sometimes also with chopped parsley) is spread on the baguette pieces, which are then wrapped in aluminum foil and baked at about 180 ºC for 10 to 15 minutes. It is served hot [Ü65, Ü79].

Garlic plants that have not formed bulbs, or fresh garlic herb can be used, chopped, like chives, as a bread and butter topping.

Garlic butter is an essential addition to escargot, shellfish, and fish filets [Ü68].

Garlic herb oil can be added to soups and pot roast dishes. It is made by pickling the whole, peeled cloves of 4 to 8 garlic bulbs for 1 to 2 months in 600 ml olive oil along with thyme- and rosemary branches as well as a few bay leaves. Prior to pickling the garlic cloves, they are brushed with olive oil, wrapped in aluminum foil, and baked in the oven at 190 ºC for about 15 minutes [Ü47].

Peeled, garlic cloves, pickled in vinegar, are used as a side dish for noodle dishes, baked chicken or cold meats [Ü55]. In Russian cooking, garlic is also used in the pickling of mushrooms and vegetables [Ü81].

Likewise, garlic can be used as a flavor component of alcoholic beverages (e.g. garlic vodka, garlic punch).

Combines well with: Basil, chillies, coriander, fresh ginger, lemongrass, onion, paprika, parsley, pepper, and watercress.

As a component of spice mixes and preparations: → A.1. Sauce, → Barbecue spice, → Bomboe, → Café de Paris spice mix, → Cajun spice, → Chemen, → Chili con carne spice, → Chili powder, → Fish spice, → Garlic salt (40% garlic powder + 60% cooking salt), → Green masala, → Gremolata, → Hamburger meat spice, → Harissa, → Herb butter, → Herb vinegar, → Lemon pepper, → Masala, → Meat spice, → Nam prik, → Persillade, → Pesto, → Pizza spice, → Quark spice, → Sambal badjak, → Sauce spice, → Soup spice, → Tai-ping China, → Tandoor, → Tika paste, → Tomato ketchup, → Tunisian spice blend, → Venison spice, → Zhug.

Other uses: In the rearing of young pigs, garlic was successfully employed to reduce the frequency of diarrhea thus increasing the growth performance [55].

Medicinal herb

Herbal drugs: Allii sativi bulbi pulvis, Garlic Powder [Ph Eur] contains not less than 0.45% allicin or Powdered Garlic [USP-NF] contains not less than 0.3% alliin and not less than 0.1% γ-glutamyl-(*S*)-allyl-L-cysteine), Powdered Garlic Extract [USP-NF] contains not less than 4.0% alliin, Garlic Fluidextract [USP-NF], Allii sativi aetheroleum, Distilled Garlic Oil (obtained by steam distillation of cut fresh, fermented garlic bulbs).

Indications: As adjunctive therapy to dietetic measures for hyperlipidemia and for prevention of age-related vascular changes. The recommended daily dose according to Germany's Commission E monograph (1988) is 4 g fresh garlic bulb (corresponding to about 1.3 g garlic powder) or equivalent preparations [68]. More recently, lower dosage levels have been shown to be sufficient [103].
In folk medicine, garlic is used for gastrointestinal disorders, among other conditions, especially for flatulence and colic, as a cholagogue, for high blood pressure, as an antiatherosclerotic remedy, for bronchitis, menopausal conditions and as an anthelmintic. Dosage forms include fresh garlic, fresh pressed juice, dried powder, oily macerate of fresh homogenized garlic (usually in soft-gel capsules or in β-cyclodextrin coated dragées), garlic oil, obtained by steam distillation, and also rarely in the form of garlic tincture and garlic dry extract. Garlic juice, crushed garlic cloves or garlic slices are used applied externally for treatment of wounds, warts, corns, muscle pains, neuralgia and rheumatic diseases [3, Ü37, Ü60].
It should not be underestimated that garlic also plays a large role in the prevention of intestinal infections, especially in warmer climates.
There are some pharmaceuticals that release an insufficient quantity of allicin [11], so it is advisable to take preparations of garlic with sufficient allicin-forming potential, fresh garlic or garlic oil.

Similar culinary herbs

Serpent garlic (rocambole, sand leek, → Pearl onion, see: → Onion; Similar Allium species)**,** *Allium sativum* L. var. *ophioscordum* (LINK) DÖLL, is cultivated nearly worldwide, and its bulbs and bulbils are used the same as garlic or also pickled in vinegar similar to pearl onions [Ü61, Ü74].

Peking garlic, *Allium sativum* L. var. *pekinense* (PROKH.) MAEKAWA apud MAKINO, is grown in gardens, predominantly in China and Japan. The bulbils are used as a spice [Ü61].

Twisted leaf garlic, *Allium obliquum* L., is cultivated in North- and Central Asia, Romania, and Siberia, and is used in the same way as garlic [Ü98].

Long-stamen onion, *Allium macrostemon* BUNGE, is native to Mongolia, China, Japan, Korea, and the eastern part of the Russian Federation, is cultivated and wild collected in Southeastern Asia, and used in the same manner as garlic, especially in China and in the Republic of Georgia [Ü85].

Long-pointed leek, *Allium longicuspis* REGEL, is native to Central Asia, cultivated in Kazakhstan, and is used in the same way as garlic [Ü61].

Garlic Spread

1 small can of anchovies, 30 peeled garlic cloves, 1 bunch of parsley, 2 tablespoons of soft butter, 5 tablespoons of olive oil, some olive oil for roasting.

Drain the anchovies, rinse and mash them with a fork. Squeeze 15 garlic cloves in a garlic press, remove the parsley leaves from the thick leaf stalks and mince very finely. Mix the ingredients and process the mixture to obtain a paste. Dice the remaining garlic cloves, fry the pieces with a bit of olive oil until golden-brown and mix them with the paste [Ü53].

Literature

[1] Abraham K.O. et al., Lebensm. Wiss. Technol. 9(4):193–200 (1976).
[2] Abramovitz D. et al., Coron. Artery Dis. 10(7):515–519 (1999).
[3] Agarwal K.C., Med. Res. Rev. 16(1): 111–124 (1996).
[4] Al-Qattan K.K., A.M. Alnaqeeb, J. Ethnopharmacol. 66(2):217–222 (1999).
[5] Ali M. et al., Prostaglandins Leukot. Ess. Fatty Acids 60(1):43–47 (1999).
[6] Ali M. et al., Prostaglandins Leukot. Ess. Fatty Acids 62(4):253–259 (2000).
[7] Ali M., M. Thomson, Prostaglandins Leukot. Ess. Fatty Acids 53(3):211–222 (1995).
[8] Amer M. et al., Int. J. Dermatol. 19: 285–287 (1980).
[9] Anibarro B. et al., J. Allergy Clin. Immunol. 100(6 Pt):734–738 (1997).
[10] Ankri S., D. Mirelman, Microbes. Infect. 1(2):125–129 (1999).
[11] Anonym, Dtsch. Apoth. Ztg. 132(13): 643 (1992).

[12] Arora D.S., J. Kaur, Int. J. Antimicrob. Agents 12(3):257–262 (1999).
[13] Asero R. et al., J. Allergy Clin. Immunol. 101(3):427–428 (1998).
[14] Balasenthil S. et al., Cancer Detect. Prev. 23(6): 534–538 (1999).
[15] Baumgartner S. et al., Carbohydr. Res. 328(2):177–183 (2000).
[16] Berthold H.K. et al., J.A.M.A 279(23): 1900–1902 (1998).
[17] Berthold H.K., T. Sudhop, Curr. Opin. Lipidol. 9(6):565–569 (1998).
[18] Bitsch R., I. Bitsch, Dtsch. Apoth. Ztg. 129:65–68 (1989).
[19] Block E., Angew. Chem. 104:1158–1203 (1992).
[20] Block E., Dtsch. Apoth. Ztg. 129 (Suppl. 15):3–4 (1989).
[21] Bogin E. et al., J. Food Protection 47:100–101 (1984).
[22] Bomme U. et al., Arznei- und Gewürzpflanzen 1(2):55–60 (1996).
[23] Bordia A., Dtsch. Apoth. Ztg. (Suppl. 15):16–17 (1989).
[24] Bordia A., Am. J. Clin. Nutr. 34: 2100–2103 (1981).
[25] Bordia T. et al., Prostglandins Leukotrienes Fatty Acids 54(3):183–186 (1996).
[26] Breithaupt-Grögler K. et al., Circulation 96:2649–2655 (1997).
[27] Brosche T., D. Platt, Fortschr. Med. 108:703–706 (1990).
[28] Burden A.D. et al., Contact Dermatitis 30(5):299–300 (1994).
[29] Caporaso N. et al., Antimicrob. Agents Chemother. 23:700–702 (1983).
[30] Cellini L. et al., FEMS Immunol. Med. Microbiol. 13(4):273–277 (1996).
[31] Challier B. et al., Eur. J. Epidemiol. 14(8):737–747 (1998).
[32] Chutani B.K., A. Bordia, Atherosclerosis 38:417–421 (1981).
[33] Dankert J. et al., Zentralbl. Bakteriol. (Orig. A) 245(1/2):229–239 (1979).
[34] Davis L.E. et al., Planta Med. 60(6): 546–549 (1994).
[35] De Montellano B.A., C.H. Browner, J. Ethnopharmacol. 13:57–88 (1985).
[36] De Smet P.A.G.M. et al. (Eds.), in: Adverse Effects of Herbal Drugs, Springer Verlag Berlin, Heidelberg, New York 1992, Bd. 1, p. 91–95.
[37] Dion M.E. et al., Nutr. Cancer 28(1):1–6 (1997).
[38] Dorant E. et al., Gastroenterology 110(1): 12–20 (1996).
[39] Dorant E. et al., Breast Cancer Res. Treat 33(2):163–170 (1995).
[40] Eming S.A. et al., Br. J. Dermatol. 141(2):391–392 (1999).
[41] Farkas M.C., J.N. Farkas, J. Am. Anim. Hosp. Ass. 10:65 (1974).
[42] Fenwick G.R. et al., CRC Crit. Rev. Food Sci. Nutr. 22:199–377 (1985).
[43] Fleischauer A.T. et al., Am. J. Clin. Nutr. 72(4):1047–1052 (2000).
[44] Freeman G.G., R.J. Whenham., J. Sci. Food Agric. 26:1869 (1975).
[45] Gao C.M. et al., Jpn. J. Cancer Res. 90(6):614–621 (1999).
[46] Graham D.Y. et al., Am. J. Gastroenterol. 94(5) :1200–1202 (1999).
[47] Grünwald J., Dtsch. Apoth. Ztg. 131 (Suppl. 24):16–20 (1991).
[48] Hale S.: Knoblauchküche, Könemann Verlagsges mbH Köln, Lizenzausgabe einer engl. Ausgabe (Quintet Publishing Limited, London) 1995.
[49] Isaacsohn J.L. et al., Arch. Intern. Med. 158(11):1189–1194 (1998).
[50] Ismail M.F. et al., Pharmacol. Res. 39(2): 157–166 (1999).
[51] Jain A.K., Am. J. Med. 94:632–635 (1993).
[52] Jain R.C., Am. J. Clin. Nutr. 30:1380–1381 (1977).
[53] Jappe U. et al., Am. J. Contact Dermatitis 10(1):37–39 (1999).
[54] Jinovetz L. et al., Z. Lebensm. Unters. Forsch. 194:363–365 (1992).
[55] Jost M., Agrarforschung 3:479–481 (1996).
[56] Kappenberg F.J., H. Glasl, Pharm. Ztg.-Wissensch. 135(5):189–193 (1990).
[57] Keusgen M., Planta Med. 64(8):736–740 (1998).
[58] Kiesewetter H. et al., Clin. Pharm. Ther. Toxicol. 29:151–155 (1991).
[59] Kim-Park S., D.D. Ku, Clin. Exp. Pharmacol. Physiol. 27(10):780–786 (2000).
[60] Koch H.P., Z. Phytother. 13(6):177–188 (1992).
[61] Koch H.P., Dtsch. Apoth. Ztg. 132(27): 1419–1428 (1992).
[62] Koch H.P., Z. Phytother. 13(3):83, (1992).
[63] Koch H.P., Dtsch. Apoth. Ztg. 133(41): 3733–3743 (1993).
[64] Koch H.P. et al., Phytother. Res. 7:387–389 (1993).
[65] Koch H.P., G. Hahn: Knoblauch – Grundlagen der therapeutischen Anwendung von Allium sativum L., Urban & Schwarzenberg, München 1988.
[66] Koch H.P., W. Jäger, Dtsch. Apoth. Ztg. 128:993–995 (1988).
[67] Koch J. et al., Planta Med. 55:327–331 (1989).
[68] Kommission E beim BfArM., BAnz. 122 vom 06.07.88.
[69] Koscielny J. et al., Atherosclerosis 144(1): 237–249 (1999).
[70] Krest I., P. Milka, M. Keusgen, Pharm. Pharmocol. Lett. 7(4):145–147 (1997).
[71] Kubec R. et al., J. Chromatogr. A 862(1):85–94 (1999).
[72] Kumar M., J.S. Berwal, J. Appl. Microbiol. 84(2):213–215 (1998).
[73] Lamm D.L., D.R. Riggs, Urol. Clin. North Am. 27(1):157–162 (2000).
[74] Larner A.J., Med. Hypothesis 44(4): 295–297 (1995).
[75] Lau B.H.S.: New Protective Roles for Selected Nutrients, Allan R. Liss, Inc. 1989, p. 295–325.
[76] Lau B.H.S. et al., Mol. Biother. 3(2): 103–107 (1991).
[77] Lawson L.D., Dtsch. Apoth. Ztg. 131 (Suppl. 24):10–12 (1999).
[78] Lawson L.D. et al., Planta Med. 57(4): 363–370 (1991).
[79] Liu L. et al., Carcinogenesis 13(10): 1847–1851 (1992).
[80] Luley C. et al., Arzneim. Forsch. 36:766–768 (1986).
[81] Mader F.H., Arzneim. Forsch. 40:1111–1116 (1990).
[82] Matsuura H. et al., Planta Med. 62(1): 70–71 (1997).
[83] Michahelles E., Über neue Wirkstoffe aus Knoblauch (Allium sativum L.) und Küchenzwiebel (Allium cepa L.), Dissertation Ludwig-Maximilians-Universität München 1974 (1974).
[84] Minami T. et al., J. Food Sci. 54:763–765 (1989).
[85] Mochizuki E. et al., J. Assoc. Off. Anal. Chem. Int. 79(6):1466–1470 (1996).
[86] Müller B., R.D. Aye, Dtsch. Apoth. Ztg. 131 (Suppl 24):8–10 (1991).
[87] Müller B., A. Ruhnke, Dtsch. Apoth. Ztg. 133(24):2177–2187 (1993).
[88] Müller B.H., Beitrag zur Charakterisierung und Analytik von Alliin und Allicin in Knoblauch und seinen Zubereitungen, Dissertation Universität Erlangen-Nürnberg 1991.
[89] Munday J.S. et al., Atherosclerosis 143(2):399–404 (1999).
[90] O'Gara E.A. et al., Appl. Environ. Microbiol. 66(5):2269–2273 (2000).
[91] Peret-Pimiento A.J. et al., Allergy 54(6): 626–629 (1999).
[92] Prasad K. et al., J. Cardiovasc. Pharmacol. Ther. 2(4):309–320 (1997).
[93] Rafaat M., A.K. Leung, Pedriat. Dermatol. 17(2):475–476 (2000).
[94] Rahman K., D. Billington, J. Nutr. 130(11):2662–2665 (2000).
[95] Ross Z.M. et al., Appl. Environ. Microbiol. 67(1):475–480 (2001).

[96] Samaranayake M.D. et al., Phytother. Res. 14(7):564–567 (2000).
[97] Schaffer E.M. et al., Cancer Letters 102(1/2):199–204 (1996).
[98] Schiewe F.P., T. Hein, Z. Phytother. 16(6):343–348 (1995).
[99] Sendl A. et al., Planta Med. 58(1):1–7 (1992).
[100] Sharma V.D. et al., Indian J. Exp. Biol. 15:466–468 (1977).
[101] Shashikanth K.N. et al., Food Microbiol. 29:348–352 (1984).
[102] Shashikanth K.N. et al., Nutr. Rep. Int. 33:313–319 (1986).
[103] Siegers C.P., Dtsch. Apoth. Ztg. 129 (Suppl. 15):13–15 (1989).
[104] Silagy C., A. Neil, J.R. Coll. Physicians Lond. 28(1):39–45 (1994).
[105] Simons L.A. et al., Atherosclerosis 113(2):219–295 (1995).
[106] Sivam G.P. et al., Nutr. Cancer 27(2): 118–121 (1997).
[107] Stevinson C. et al., Ann. Intern. Med. 133(6):420–429 (2000).
[108] Sticher O., Dtsch. Apoth. Ztg. 131 (Suppl. 24):3–4 (1999).
[109] Sumiyoshi H., M.J. Wargovich, Asia Pacific J. Pharmacol. 4:133–140 (1989).
[110] Tamaki T., S. Sonoki, J. Nutr. Sci. Vitaminol. (Tokyo) 45(2):213–222 (1999).
[111] Tsai Sh-J. et al., Mutagenesis 11(3): 235–240 (1996).
[112] Velisek J. et al., Spec. Publ-R. Soc. Chem. 197 (Flavour Science):258–261 (1996), ref. CA: 126:237607m.
[113] Virtanen A.I., Phytochemistry 4:207–228 (1965).
[114] Vorberg G., B. Schneider, Natur Ganzh. Med. 3:62–66 (1990).
[115] Wagner H. , A. Sendl, Dtsch. Apoth. Ztg. 130(33):1809–1815 (1990).
[116] Walper A., Dtsch. Apoth. Ztg. 131 (Suppl. 24):20–25 (1991).
[117] Wargovich M.J., Biochem. Soc. Trans. 24(3):811–814 (1996).
[118] Wargovich M.J., Carcinogenesis 8(3): 487–488 (1987).
[119] Winkler G. et al., Dtsch. Apoth. Ztg. 132(43):2312–2317 (1992).
[120] Yin M.C., W.S. Cheng, J. Food Prot. 61(1):123–125 (1998).
[121] Yin M.C., S.M. Tsao, Int. J. Food Microbiol. 49(1/2):49–56 (1999).
[122] You W.C. et al., Int. J. Epidemol. 27(6):941–944 (1998).
[123] Yu T.H. et al., J. Agric. Food Chem. 37(3):725–730 (1989).

Literature references identified by Ü can be found in the general listing of books and monographs at the back of this book.

Ginger

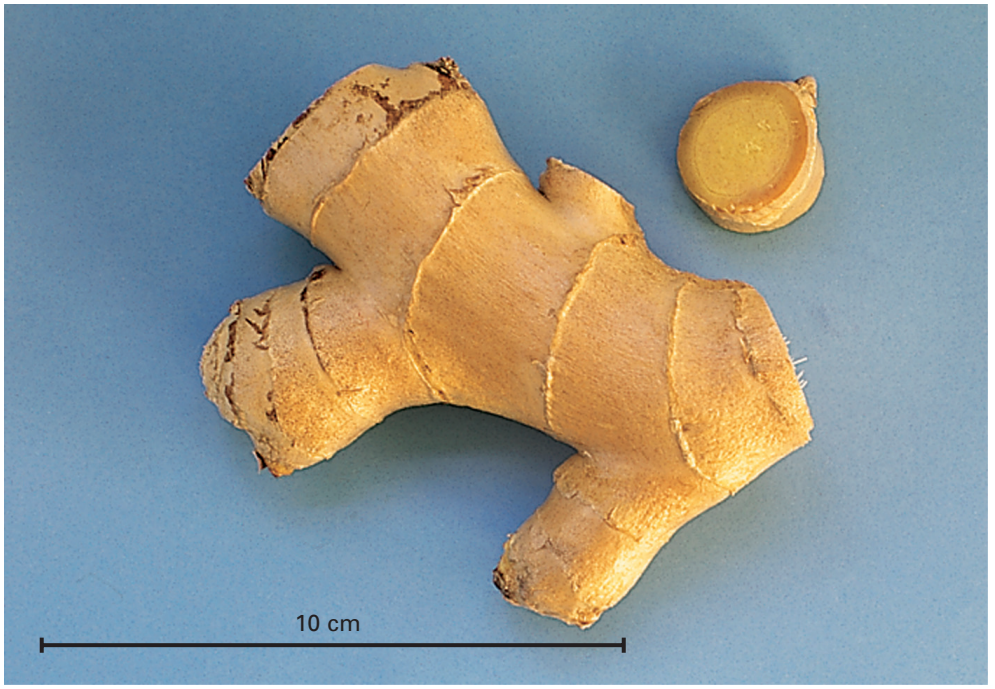


Fig. 1: Fresh, unpeeled ginger

Fig. 2: Ginger (*Zingiber officinale* L.)

Plant source: *Zingiber officinale* L.

Synonym: *Amomum zingiber* L.

Family: Ginger family (Zingiberaceae).

Common names: Engl.: ginger, common ginger; Fr.: gingembre; Ger.: Ingwer, Echter Ingwer, Ingber, Immerwurzel, Schnapswurzel.

Description: Rhizomatous perennial with horizontal creeping rhizome, antler-like branched and bulbous thickened, somewhat flattened, with annular leaf scars and filiform roots. The up to 1 m high pseudostems are formed from the long sheaths of the reed-like leaves with longish-lanceolate, entire-margined lamina. The flowering stalks are growing up to 30 cm in length, bearing densely arranged sheath-like leaves. The inflorescences are spicular, ovoid, with about 5 cm long, single flowers situated in the axils of the bracts. The calyx is whitish, corolla yellow, with 3 clefts. The 3 stamina of the outer whorl form a petal-like, purple colored, yellowish punctate lip, within the inner whorl only 1 stamen is fertile. Inferior ovary, 3-chambered, developing into a fleshy, berry-like capsule. Flowers and seeds are rare.

Native origin: Ginger is not known to occur in the wild, and it probably originated in India.

Main cultivation areas: Cultivated in many tropical countries, especially in India (over 20 varieties), Southern China, Malaysia, Nigeria and Sierra Leone, followed by, among others, Taiwan, Japan, Thailand, Sri Lanka, Vietnam, Jamaica, Hawaii, Indonesia, Australia (Queensland), and Brazil.

Main exporting countries: Predominantly China and Brazil, followed by Nigeria, Indonesia, Singapore, and West Malaysia.

Cultivation: The cultivation of ginger requires a tropical climate with high humidity and without large fluctuations in temperature as well as light but humus, sufficiently damp soil in half-shaded locations. Propagation is carried out vegetatively with pieces of rhizome [Ü89]. For growing ginger in pots, they must overwinter completely dry and not be exposed to temperatures below 10 ºC [Ü56].

Culinary herb

Commercial forms: Ginger (ginger root): fresh, unpeeled rhizome (Fig. 1, green ginger), unpeeled or partially peeled only on the flattened sides (unpeeled ginger, coated ginger, black ginger), decorticated and dried (white ginger, peeled ginger, uncoated ginger), whole, cut ("sliced"), covered in sugar syrup or candied (Chylon ginger) or ground, dried and rarely unpeeled, treated with lime and/or sulfurized. In China and Japan, slices of the rhizome are preserved by pickling in brine, rice wine or rice vinegar (due to the pink color, which is often strengthened by synthetic food coloring substances, also described as red ginger, pickled in sweet vinegar as beni shoga [30].

Ginger is also described according to its origin: **Jamaican ginger** (light, pale yellow, peeled, fracture fibrous, pieces up to 12 cm long and up to 2 cm wide, very good quality, aromatic-pungent, with a citrus-like flavor, corresponds to the requirements of the German pharmacopoeia, top product "peeled bold", never treated with lime or bleached, **Indian ginger** (Bengal-, Cochin-, Calicut-, Malabar-ginger, bleached or unbleached, decorticated or partially peeled only on the flattened sides, Bengal-ginger, fine-aromatic, best Indian variety, Cochin-ginger is light brown to yellowish, burning-pungent, good quality Calicut-ginger is reddish-brown, moderately pungent, and smells lemony), **Chinese ginger** (unpeeled, pale brown, mild, often in slices, mostly traded in crystallized candied form or in a sugar solution), **Australian ginger** (light brown, peeled or unpeeled, moderately pungent, citrus-like aroma, mostly traded in preserved or crystallized form), **West African ginger** (very dark, usually unpeeled, with wrinkled cork tissues, sometimes also unpeeled or longitudinally split, very pungent, camphoraceous odor, inferior quality, usually only used in the meat processing industry and for the manufacture of oleoresins or essential oils), **Brazilian ginger** (unpeeled, giant variety, very large rhizome, usually traded fresh, plus chaipira variety).

Also commercially traded are **ginger essential oil** (ginger oil) and **ginger oleoresin** (golden brown, highly viscous oil, main components are essential oil (20 to 40%), pungent compounds (25 to 30%), in addition to, among others, triacylglycerols and waxes) [Ü37, Ü92, Ü98].

Production: For the production of dried ginger, the rhizomes are harvested about 8 to 10 months after planting, after the aerial parts of the plant have wilted. To obtain a less fibrous rhizome, e.g. for the fresh ginger market or for the production of candied ginger for ginger confectionery, the rhizomes are harvested earlier, after about 5 to 6 months. The washed rhizome, sometimes soaked over night in water, also often immersed briefly in hot water or hot water is poured over it, is broken into suitable sized pieces, freed from the roots and cork by scraping, rarely peeled with a bamboo knife (using a metal knife would spoil the taste), and dried. The removal of the cork layer must be done very carefully, because the secretion cells are situated, in part, directly below the cork layer. The rhizome may be coated with lime, especially in some parts of India (Kerala). For this purpose the rhizome is soaked and cleaned several times, in baskets submerged in lime milk, then dried. The process can be repeated several times. In addition, the rhizome is sometimes sulfurized. Decorticated ginger can also be treated in this way (bleached ginger). Lime and sulfurizing serve to beautify the product and protect it against infestations by insects or microorganisms. Rarely the rhizome is dried unpeeled, with only the cork of flanks removed or longitudinally split. In Australia, the fresh rhizome is dried in cut slices. Ginger is usually packed in jute sacks [35, Ü37].

To produce candied ginger, the rhizome is washed, hot water is poured over it and then soft-boiled. It remains in cold water for up to 3 days, and then boiling, concentrated sugar syrup is poured over it. After draining, the procedure is repeated, followed by drying (candied ginger) or coating in sugar syrup (Chylon, cut into plum-shaped pieces = plum ginger). Sometimes it is brightened up with rice flour.

Ginger can also be cut into thin slices and pickled (beni shoga).

Forms used: The fresh rhizome, decorticated and scraped or finely chopped, the peeled or unpeeled dried, ground rhizome, the candied, peeled rhizome, ginger essential oil, and ginger oleoresin.

Storage: The fresh rhizome can be preserved for several weeks in the refrigerator wrapped with paper towels and tightly packed in a plastic bag. Ginger can also be stored in the deep freezer and, upon demand, peeled and sliced while still frozen. It is also used pickled with vinegar, rice wine, salt brine or candied and coated with syrup, respectively; after opening, these products need to be refrigerated as well. The dried rhizomes are stored in well-closed containers protected from light, heat, moisture and insect infestation. During storage, the gingerols are slowly converted to shogaols. Elevated shogaol levels indicate excessive storage or thermal stress.

Description. Whole rhizome (Fig. 3): Antler-like (sympodial), planar branched, somewhat flattened, up to 12 cm long, up to 4 cm wide pieces; unpeeled ginger is light to red-brown, yellowish-gray pieces if peeled ("claw" or "hand", for the colors of different varieties, see: Commercial forms) [DAB].

Cut rhizome consists of whitish to light-yellow slices or cubiform pieces. The cross

Fig. 3: Decorticated, dried ginger

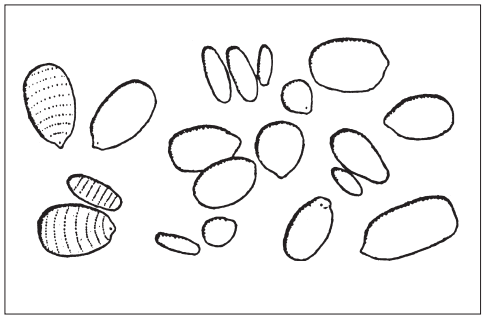


Fig 4: Starch grains from ginger [Ü37]

section shows, below the periderm, a narrow, somewhat dark parenchyma of the cortex, which is separated by a circular endodermis from the rather large and oval central stele. Numerous vascular bundles are scattered in the cortex and central stele. Cork or fragments thereof can be present [DAB].

Powdered rhizome: Light-yellow to yellowish-brown. Microscopic examination shows predominantly the characteristic, single, ovate to drop-shaped, flat, indistinctly layered, 20 to 25 µm long and 18 to 20 µm wide starch grains (Fig. 4) as well as the colorless fragments of parenchyma with partially intact oil cells with yellow content and tiny crystals. Also present are scalariform and reticulate vessels and non-ligneous, lightly thickened fibers, which, if viewed from the side, are on one side lobed in an arch-like fashion. In the unpeeled or partially peeled material, cork shreds with thick-walled cork cells are present [11, Ü37, Ü49].

Taste: Aromatic, more or less pungent and slightly bitter, **Odor:** Aromatic; in Indian, Chinese and Australian ginger with a lemon-like note.

History: Cultivation and use were already described in the oldest Chinese and early Indian (Sanskrit) texts. Ginger was introduced to Mediterranean regions by the Arabs and was used by the Greeks and Romans. Dioscorides (second half of the 1st century) and Plinius the Elder (23–79 CE) described its aromatic properties. The Roman cookbook "De re coquinaria" (10 volumes), which appeared under the name of Apicius in the 3rd century, mentions ginger as a valuable spice for meat and poultry sauces (see: Asafetida, footnote). Its application in Central Europe as a culinary spice was first mentioned in the 11th century. At that time, the monastery Hirschau already documented ginger as a common spice. Its use as a valuable aphrodisiac has also been noted. In the 13th century, the Arabs brought it to East Africa. In the 16th century, ginger was introduced to Western Africa by the Portuguese and to the West Indies during the Spanish conquests. In Australia, it has been cultivated since about 1940. In the 18th century, ginger almost disappeared from European cuisine, but today, with the new trend in East Asian cooking, it has found its way back as a popular kitchen spice [30, Ü92].

Constituents and Analysis

DIN- and ISO-Standards: DIN-Standard 10201 (Ginger, technical specifications), ISO-Standard 13 685 (Ginger and its oleoresins: Determination of the most pungent components: gingerols and shogaols).

Constituents

- Essential oil: 1 to 4.3%, 160 components have been identified to date; the composition strongly depends on the origin. Usually, the main components are sesquiterpenes, including, among others:
  - Sesquiterpene hydrocarbons (–)-zingiberene (7 to 50%), (–)-β-sesquiphellandrene (2 to 12%, both components decline during storage), *ar*-curcumene (0.2 to 19%, increases during storage), (–)-β-bisabolene and (*E*)-α-farnesene,
  - Sesquiterpene alcohols such as sesquiphellandrol and zingiberol (isomeric mixture of *cis*- and *trans*-β-eudesmol, which significantly contributes to the odor,
  - Monoterpenes, including, among others, 1,8-cineole (traces to 13%), *p*-cymene (0.2 to 11%), nerolidol, (traces to 9%), α-pinene (1.8 to 4.2%), linalool (1.0 to 5.5%), furthermore, borneol, β-pinene, camphene, geraniol, citral (a high content causes a lemon-like aroma),
  - Aliphatics, among others, nonanol (2 to 8%), propanal, (0.1 to 3.1%) [5, 10, 14, 17, 29, Ü37].

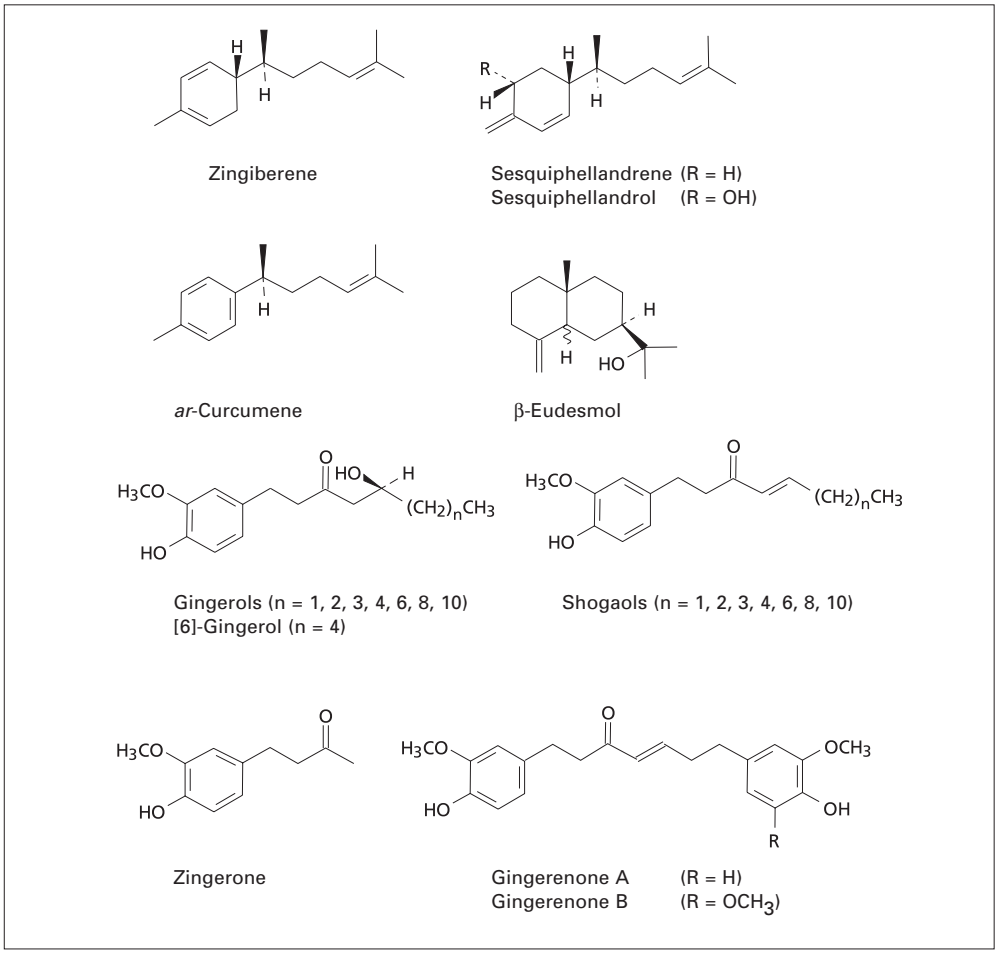
  In a ginger variety of Indian origin, the main components were found to be *ar*-curcumene (about 19%), β-sesquiphellandrene (about 12%); the content of zingiberene was only at 7% [10]. The dried rhizome of another variety from Sri Lanka ("Sidda") contained mostly β-bisabolene (about 45%) and *ar*-curcumene (about 27%) [31]. Australian ginger contains mostly monoterpenes, particularly camphene (about 14%) and β-phellandrene (about 12%), in addition to 1,8-cineole (about 7%) and citral (geranial about 5% + neral about 4%) [10]. Ginger rhizomes from Madagascar also contained predominantly monoterpenes, including camphene (about 31%), γ-terpinene (about 12%) and geranial (about 10%), as well as, among others, α-pinene (about 7%), β-phellandrene (about 6%), 1,8-cineole (about 5%) and neral (about 4%), with only 2% zingiberene [33].
- Monoterpene glycosides: (+)-Angelicoidenol-2-*O*-β-D-glucoside [53].
- Phenylethyl-*n*-alkyl-ketones (phenylalkanones) and their derivatives:
  - Gingerols (phenylalkanones), about 25% of the oleoresin, particularly [6]-gingerol (pungent tasting), furthermore [3]-, [4]-, [5]-, [8]-, [10]-, [12]-gingerol ([n] = amount of C-atoms from the fatty acid residues which biosynthetically are linked with a cinnamic acid derivative),

methyl gingerols (methylation at the asymmetrical C-atom or at the phenolic OH-group),
- Shogaols (5-desoxy-4,5-dehydro-gingerols), which are artifacts from the drying process and storage, developing from the gingerols by dehydration, especially [6]-shogaol (more pungent than [6]-gingerol, thus the pungency of the rhizomes is increasing during storage), as well as methylshogaols,
- Paradols (5-deoxy-gingerols): [6]-Paradol (only in traces),
- Gingerdiones, 1- and 5-dehydro-gingerdiones: particularly [6]-dehydrogingerdione,
- 6-Gingesulfonic acid,
- Zingerone (phenylethyl-methylketone-derivatives, arising from the gingerols during storage; elevated levels are indicative of inferior quality) [6, 9, 14, 53].

- Gingerdiols (3-deoxy-3,5-dihydroxy-gingerols), particularly [6]-gingerdiol, its glycosides, as well as [6]-methylgingerdiol, [6]-gingerdioldiacetate and [6]-methylgingerdioldiacetate [4, 21, 22, 42].
- 1,7-Diarylheptanoids (curcuminoids) including, among others, hexahydrocurcumin (diarylheptandione), diarylheptanones (e.g. gingerenones A, B and C, isogingerenone B), diarylheptanonols, diarylheptanediols, cyclic diarylheptanoids and their acetates and diacetates [9, 21, 23, 24].
- Diterpenes: Galanolactone, (*E*)-8-β,17-epoxylabd-12-ene-15,16-dial; only present in the Japanese ginger variety "Kintoki", from *Z. officinale* ROSCOE var. *rubens* MAKINO, [18]).
- Ginger glycolipids A, B, C (monoacyldigalactosylglycerols) [53].
- Starch (about 50%).

Tests for Identity: With organoleptic, macroscopic and microscopic analysis as well as TLC, according to Ph Eur or USP-NF (see also Lit. [13]; for identity tests using micro-TLC, see Lit. [50]).

Quantitative assay: The content of essential oil can be determined volumetrically with steam distillation and xylol in the graduated tube [Ph Eur]. HPLC determination of the gingerols and total pungent compounds according to USP-NF or [39].



Adulterations, Misidentifications and Impurities: Japanese ginger (see below) can be recognized by its different aroma (reminiscent of bergamot oil) as well as by the occurrence of composite aleuron grains and oxalate druses. The rhizomes of other types of ginger are considerably larger. Addition of lime to improve appearance can be detected with acetic acid (bubbling due to the presence of $CaCO_3$).

Actions and Uses

Actions: Ginger rhizome, essential oil and oleoresin, due to their aromatic odor and aromatic-pungent taste, stimulate the flow of saliva, the secretion of gastric juices and intestinal motility, and therefore they have appetite stimulating and digestion promoting action. In animal experiments, after several weeks administration increased activity of various digestive enzymes was shown, e.g. intestinal lipase-, saccharase-, maltase-, trypsin- and chymotrypsin activity [11, 28, 36, 37, Ü37]. Ginger also stimulates choleresis. [6]-Gingerol has been shown to be the most active choleretic substance of ginger [52].

Ginger has anti-ulcerogenic activity. Aqueous dry extracts, that probably contain no essential oil, have caused a reduction in gastric juice production in animal tests. The extracts protect against ulcerogenic noxa (hydrochloric acid, indomethacin, acetylsalicylic acid, among others). As anti-ulcerogenic substances, [6]-gingerol, [6]-gingesulfonic acid, [6]-shogaol and zingiberene have been isolated [14, 21, 38, 51, 53, Ü37].

Ginger has antiemetic action, which has been demonstrated in animal studies and in numerous clinical studies [overviews found in Lit. 8, 11, 14, 19, Ü37]. Some constituents of ginger probably have a 5-HT_3-antagonistic action [46].

Ginger has antihyperlipidemic activity. In cholesterol fed rabbits, an ethanolic extract of ginger (200 mg/kg body weight, p.o.) significantly reduced elevated levels of serum cholesterol, triglycerides, lipoproteins and phospholipids. The severity of atherosclerotic lesions in the animals receiving ginger extract was also much lower [2]. In animal experiments, elevated cholesterol excretion and a lowering of serum cholesterol levels after administration of ginger oleoresin have been observed [14, 15, 43]. In mutant apolipoprotein E- deficient (E(0)) mice, ginger extract (250 µg/day, p.o., 10 weeks) led to a reduction of aortic atherosclerotic lesion areas by 44%, plasma triglycerides by 27% and plasma cholesterol by 29%. There was a 76% reduction of the cellular cholesterol biosynthesis rate in peritoneal macrophages and the capacity to oxidize LDL was reduced by 60%. The macrophages had a lower capacity to take up oxidized LDL (by 47%) [12].

In humans, ginger inhibits thrombocyte aggregation at high doses (10 g powder as single-dose) [3].

Ginger has antitumorigenic activity. Ginger extracts, in vitro in non-cytotoxic doses, inhibited Epstein-Barr-virus activation in Raji cells induced by 12-O-tetradecanoyl phorbol-13-acetate (TPA) [48] and pre-application of a ginger extract protected against skin tumors in mice after topical application of cocarcinogen TPA together with 7,12-dimethylbenz(a)anthracene [20]. In animal tests, [6]-gingerol and [6]-paradol showed antitumor promotional and antiproliferative effects [47].

Ginger potentiates the antioxidative defense system of the organism. In rats, ginger (1% in the feed) significantly lowered lipid peroxidation and significantly increased the blood glutathione content [1].

Dry extracts of ginger have antimicrobial, nematocide, molluscicidal and antischistosomal action [16, Ü37]. Components of the essential oil, especially β-sesquiphellandrene and zingiberene, inhibit the replication of rhinoviruses [7].

Ginger extracts and the polar constituents of ginger rhizome, especially [6]-gingerol and shogaol, have antiphlogistic and antiedematic action [20]. In clinical studies, improvements of rheumatic complaints have been shown following oral administration [46]. The antiphlogistic effect occurs possibly through inhibition of cyclooxygenase and lipoxygenase [25].

In the Ayurvedic system of medicine, ginger is used for treatment of migraine headaches. Studies have shown a preventive effect with the addition of uncooked ginger with meals (decrease in frequency of episodes), and a symptomatic effect with migraine attacks 30 minutes after ginger is taken orally (500 to 600 mg powder in water). Additional doses are taken every 4 hours for 3 to 4 days [34].

A detailed overview of pharmacological actions and clinical studies on ginger can be found in Lit. 8 and 14.

Toxicology: Based on existing data, there is no acute or chronic toxicity with regular use of ginger as a spice [8]. At higher doses (single dose above 4 to 6 g), ginger can irritate the mucosa of the stomach. Contact allergies can occur in sensitive people [13].

Culinary use: In Indian and oriental cooking, ginger is combined mainly with fish. In Indonesian, Japanese and Chinese cooking, it is often used in combination with soy sauce and garlic, as a seasoning in meat-, fowl-, fish- and vegetable dishes. Chinese specialties prepared in a wok are hardly imaginable without ginger. Ginger is also very popular in Russian cooking. In Russia, and in other countries, ginger is a component of refreshing beverages (sbiten) with kvass and honey.

Due to the pleasant aroma, fresh ginger is preferred over dried ginger. In cooked dishes, ginger should be added about 20 minutes before the end of cooking time, and in sweet dishes as well as sauces about 1 to 5 minutes before finishing and for pastry it is mixed with the other ingredients. Due to its strong spice intensity, it should be measured carefully.

Fresh ginger, with its cork layer scraped off, in grated form or in the form of juice made by squeezing grated or diced ginger through a garlic press is used as an ingredient in fruit desserts, salads (fruit salads, especially those that contain apples and/or bananas, and sweet-sour salads, e.g. carrot-, cucumber- or rice salad), sauces (e.g. tomato sauce), marinades, chutneys or pickles. Ginger is often used for canning pears and pickling cucumbers or pumpkins. As a spice for meat dishes (especially beef), vegetable dishes (e.g. red cabbage, celery puree), fish dishes (e.g. red bass) and rice dishes as well as crabs and prawns, fresh, peeled ginger, and ginger cut in slices or strips can be added to the dish and removed after finished cooking [26, Ü2, Ü13, Ü55, Ü59, Ü73, Ü95].

Dried, ground ginger is used especially as an ingredient in sweet baked goods (ginger biscuits, ginger cakes, ginger bread, ginger buns) and in puddings, and less often as a spice in soups, sauces, fish, meat, especially fowl dishes, and fruit salads as well as compotes. It is an integral component of many spice mixes (see below). In tropical countries (e.g. Saudi Arabia, Yemen), ginger is added to coffee (gahwa) or tea (Ü13, Ü55, Ü73].

Ginger syrup serves primarily as a component of fruit desserts, marmalades, sauces or chutneys. Candied ginger is used the same as fresh ginger in the bread- and confectionery industries (e.g. for the production of ginger chocolate, ginger jelly). Ginger confectionery, with chocolate-coated bars of candied ginger, is a popular sweet. Ginger jam with orange peels ("chow-chow") is very popular not only in China, but also in England [Ü55, Ü59, Ü73, Ü95].

Ginger oleoresin and ginger essential oil are used especially in the beverage industry, e.g. in bitter liqueurs such as angostura and Boonekamp, but also in the confectionery industry.

Ginger beer and ginger ale are well known and popular, mainly in the Anglo-Saxon countries. Ginger beer is a top-fermented beer with a high content of extract, for which commercially available industrially

manufactured ginger extracts are used. Non-brewed ginger beer (Gingerade) can be made in a bottling factory by diluting commercial ginger beer concentrate with carbonated water. Its alcohol content is adjusted to 2%. Ginger lemonade (Ginger Ale) is alcohol-free and is produced from ginger concentrates mixed with lemon- and other fruit juices, capsicum extracts as well as frothing agents [Ü93].
English ginger bread is prepared with shredded wheat, butter and eggs and spiced with ginger, cinnamon and clove as well as honey [49].

Combines well: In salty dishes with black pepper, chillies, clove, coriander, cumin, garlic, onions, paprika, and soy sauce, and in sweet dishes with cardamom, cinnamon, and citrus fruits.

As a component of spice mixes and preparations: → Chat masala, → Chilli sauce, → Curry powder, → Fish spice, → Five-spice-mix, → Gingerbread spice, → Green masala, → La kama, → Masala, → Pastry spice, → Pickling spice, → Plum jam spice, → Poultry spice, → Quatre épices, → Ras el hanout, → Salsa comum, → Sausage spice, → Scappis spice mix, → Stollen spice, → Tandoori, → Tika paste, → Tomato ketchup, → Tridschataka.

Other uses: Ginger oil is used in the perfume industry as a component of heavy, oriental perfumes, and as a bath additive [30].

Medicinal herb

Herbal drug: Zingiberis rhizoma, Ginger rhizome, contains not less than 15 ml/kg of essential oil [Ph Eur].

Indications: Ginger is used for digestive problems, loss of appetite, nausea, symptoms of motion sickness, nausea following minor surgical procedures and Roemheld's syndrome. The single dose is 0.3 to 1.5 g, and daily dose is 2 to 4 g dried rhizome or equivalent preparations. Preferred dosage forms are powdered rhizome, ginger tincture (20 to 30 drops in some water, one half-hour before meals) or fluidextracts as a component of prepared medicines [8, 27]. For treatment of symptoms of motion sickness, 0.5 to 2 g of powdered ginger is taken 30 minutes before departure time and then every 4 hours another 0.5 to 2 g. Ginger is recommended for nausea and vomiting during the clinical course of cytostatic-therapy [44]. The essential oil can be incorporated in cough ointments.
In folk medicine, ginger tea is used for soothing stomachaches, dysmenorrhea and blood circulation problems. Ginger tincture is applied externally for treatment of rheumatic complaints and for pulled muscles. The essential oil, added to a fatty base (e.g. butter; 5 drops/100 g), is used as an external rub for coughs. Ginger mulled wine (5 slices fresh ginger rhizome, juice of half a lemon, a shot of red wine, honey and hot water) is a home remedy for treatment of influenza infections with moderate fever [49].

Similar culinary spices

Japanese ginger (myoga ginger), *Zingiber mioga* (Thunb.) Roscoe (Zingiberaceae), native to Japan and China, cultivated in Japan, China and Hawaii, the material of commerce is usually peeled and treated with lime, more pungent than Jamaican ginger, the young leaves and shoots are also used [Ü61].

Martinique ginger (zerumbet ginger, wild ginger), *Zingiber zerumbet* (L.) Roscoe (Zingiberaceae), is not known in the wild and is cultivated in Sri Lanka, India and Thailand. The essential oil in the rhizome has a race-specific composition with the main components being either zerumbone (ca. 36%, sesquiterpene), α-caryophyllene (humulene, ca. 17%) and camphene (ca. 16%) or α-terpineol (ca. 45%), myrcene (ca. 22%) and γ–terpinene (ca. 10%) [Ü43]. The rhizome is used the same as ginger, especially as a spice in unsweetened rice dishes as well as in fowl- and meat dishes. The leaves are eaten as a vegetable. The essential oil is used in the cosmetics industry [40, 41, Ü61].

Yellow zitwer (also known as Indian ginger or Bengal ginger), *Zingiber cassumunar* Roxb. (*Z. purpureum* Roscoe, Zingiberaceae), is probably native to India, and is cultivated in many parts of tropical Asia. The main components of the essential oil in the rhizome are sabinene and terpinenol-4, and furthermore, among others, α- and β-pinene, myrcene, α-terpinene, limonene, terpinolene and *p*-cymene [32, Ü43]. The rhizome is used the same as ginger [Ü61, Ü92].

Mango ginger, *Curcuma amada* Roxb. (Zingiberaceae), is native to India, and cultivated in India and Pakistan. The rhizome is used similar to ginger and contains ca. 1 to 3% essential oil composed mainly of *ar*-curcumene (ca. 28%), camphor (ca. 11%), β-curcumene (ca. 11%), curzerenone (ca. 7%) and 1,8-cineole (ca. 6%) [45, Ü61].

Ginger Cake Slices

(For the Christmas Holiday season)
250 g butter, 250 g sugar, 6 eggs, 250 g ground hazelnuts, 250 g rubbed bittersweet chocolate, 100 g flour, 100 g finely diced, candied ginger, 250 g confectioner's sugar, juice of one lemon.

Preheat the oven to 180 °C. In a large bowl, mix the butter, sugar and eggs until foamy and continuously add the hazelnuts, bittersweet chocolate and flour; at the end, fold in the ginger. Butter a baking tin with a high rim and spread the cake mixture about 2 cm thick onto it. Bake for 25 min. Before removing from the oven, check with a tooth pick if the cake is done. Cut the cake while still hot into squares or triangular pieces and let them cool. Spread the frosting made from confectioner's sugar and lemon juice evenly over the slices. Before eating, store the ginger cake slices for 1 to 2 weeks in a well-closed tin-box [30].

Literature

[1] Ahmed R.S. et al., Indian J. Exp. Biol. 38(6):604–608 (2000).
[2] Bhandari U. et al., J. Ethnopharmacol. 61(2):167–171 (1998).
[3] Bordia A. et al., Prostaglandins Leukot. Ess. Fatty Acids 56(5):379–384 (1997).
[4] Charles R. et al., Fitoterapia 71(6): 716–718 (2000).
[5] Chen Ch.Ch., Ch.T. Ho, J. Agric. Food Chem. 36:322–328 (1988).
[6] Connell W.D., M.D. Sutherland, Austr. J. Chem. 22:1033–1043 (1969).
[7] Denyer C.V. et al., J. Nat. Prod. 57:658–662 (1994).
[8] ESCOP, ESCOP Monographs Zingiberis rhizoma, Ginger (1996).
[9] Endo K. et al., Phytochemistry 29(3): 797–799 (1990).
[10] Erler I. et al., Z. Lebensm. Unters. Forsch. 186:231–234 (1988).
[11] Falch B. et al., Dtsch. Apoth. Ztg. 137: 4267–4278 (1997).
[12] Fuhrman B. et al., J. Nutr. 130(5):1124–1131 (2000).
[13] Futrell J.M., R.L. Rietschel, Cutis 52(5): 288–290 (1993).
[14] Germer S., G. Franz, Dtsch. Apoth. Ztg. 137:4260–4266 (1997).
[15] Gujral S. et al., Nutr. Rep. Int. 17:183–189 (1978).
[16] Habsah M. et al., J. Ethnopharmacol. 72(3):403–410 (2000).
[17] Harvey D.J., J. Chromatogr. 212:75 (1981).
[18] Huang Q. et al., Chem. Pharm. Bull. 39:397–399 (1991).
[19] Jaspersen-Schib R., Dtsch. Apoth. Ztg. 132(13):621–625 (1992).
[20] Katiyar S.K. et al., Cancer Res. 56(5): 1023–1030 (1996).
[21] Kikuzaki H. et al., Phytochemistry 30(11): 3647–3651 (1991).
[22] Kikuzaki H. et al., Phytochemistry 31(5): 1783–1786 (1992).
[23] Kikuzaki H. et al., Chem. Pharm. Bull. 39(1):120–122 (1991).
[24] Kikuzaki H., N. Nakatani, Phytochemistry 43(1):273–277 (1996).
[25] Kiuchi F. et al., Chem. Pharm. Bull. 40: 387–391 (1992).
[26] Knieriemen H., Natürlich 16(3):39–43 (1996).
[27] Kommission E beim BfArM, BAnz-Nr. 85 vom 05.05.88, Berichtigung am 13.03.90 und am 01.09.90.
[28] Langner E. et al., Balance 1:5–16 (1997).
[29] Lawrence B.M., Perfumer and Flavorist 9:1–40 (1984).
[30] Lorenz B.: Leckere Gerichte mit Ingwer, Mary Hahn Verlag in der FA Herbig Verlagsbuchhandlung, München 1998.
[31] MacLeod A.J., N.M. Pieris, Phytochemistry 23:353–359 (1983).
[32] Masuda T., A. Jitoe, Phytochemistry 39(2):459–461 (1995).
[33] Möllenbeck S. et al., Flavour Fragrance J.12(2):63–69 (1997).
[34] Mustafa T., K.C. Srivastava, J. Ethnopharmacol. 29:267 (1990).
[35] Nair M.K. et al. (Eds.): Processings of the National Seminar on Ginger and Turmeric, Central Plantation Crops Research Institute, Kasaragod, India, 1980, p. 253.
[36] Platel K., K. Srinivasan, Int. J. Food Sci. Nutr. 47(1):55–59 (1996).
[37] Platel K., K. Srinivasan, Nahrung 44(1): 42–46 (2000).
[38] Sakai K. et al., Chem. Pharm. Bull. 37: 215–217 (1989).
[39] Sane R.T. et al., Indian Drugs 35(1):37–44 (1998).
[40] Seidemann J., Drogenreport 13(23):65–68 (2000).
[41] Seidemann J., Dtsch. Lebensm. Rdsch. 89:117–120 (1993).
[42] Sekiwa Y. et al., J. Agric. Food Chem. 48(2):373–377 (2000).
[43] Sharm I. et al., Phytotherapy Res. 10:517–518 (1996).
[44] Sharma S.S. et al., J. Ethnopharmacol. 57(2):93–96 (1997).
[45] Srivastava A.K. et al., J. Ess. Oil Res. 13:63–64 (2001).
[46] Srivastava K.C.T., T. Mustafa, Med. Hypotheses 39:342–348 (1992).
[47] Surh Y., Mutat. Res. 428(1/2):305–327 (1999).
[48] Vimala S. et al., Br. J. Cancer 80(1/2): 110–106 (1999).
[49] Vonarburg B., Natürlich 17(6):61–63 (1997).
[50] Wolf J., Pharm. Ztg. 140:4142 (1995).
[51] Yamahara J. et al., J. Ethnopharmacol. 23:299–304 (1988).
[52] Yamahara J. et al., J. Ethnopharmacol. 13:217–225 (1985).
[53] Yoshikawa M. et al., Chem. Pharm. Bull. 42:1226–1230 (1994).

Literature references identified by Ü can be found in the general listing of books and monographs at the back of this book.