Peer-reviewed | Manuscript received: : April 15, 2016 | Revision accepted: August 1, 2016

Herbs and spices

Overview on possible health-promoting effects

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Summary

In traditional folk medicine, herbs and spices have been used for centuries against diseases of all kinds. However, their contribution to the promotion and maintenance of health has yet hardly been considered due to the usually low consumption levels. Yet they contain a variety of bioactive ingredients (e. g. polyphenols), which can counteract cardiovascular diseases due to their antioxidant potential. This article presents the current state of research on the influence of selected herbs and spices on important cardiovascular risk factors (hypertension, oxidative stress, inflammation, type 2 diabetes mellitus and hyperlipidemia). In addition, studies on chemopreventive effects are considered.

Keywords: herbs, spices, hypertension, atherosclerosis, inflammation, oxidative stress, diabetes mellitus type 2, hyperlipidemia, cancer

Citation:
Fischer S, Glei M (2016) Herbs and spices. Overview on possible health-promoting effects. Ernahrungs Umschau 63(11): 222–227; 63(12): 228–236

This article is available online:
DOI: 10.4455/eu.2016.047

Introduction

Herbs and spices are understood in general as plants or parts of plants, which are used either fresh or dried for food preparation because of their odor or flavoring properties [1]. Despite them being used for medical purposes for centuries, their health-promoting contribution to nutrition has received little attention so far, due to their low consumption levels [1, 2].
Herbs and spices contain a number of bioactive ingredients which are potentially antioxidative, anti-inflammatory or anti-cancerogenic (◆ Table 1). It is therefore assumed that they may possibly contribute to the prevention of cardiovascular diseases, whose origin, for example, are inflammatory and oxidative processes [3].
While the detection of potentially health promoting ingredients and properties of these plants appears to be relatively simple, the assessment of possible health benefits when using them as food components is particularly challenging because of their low consumption levels.
This article summarizes the current state of research on the relevance of important herbs and spices (oregano, rosemary, thyme, turmeric, ginger, garlic and cinnamon) for health. The selection of the species took place in consideration of both the eating habits prevailing in Germany [4] and the currently available data on this topic. Furthermore, this article focuses on cardiovascular risk factors (hypertension, oxidative stress, inflammation, hypercholesterolemia, type 2 diabetes mellitus) and the chemopreventive potential.
When evaluating the findings, it should be noted that these studies did mostly not use the herbs and spices in usual dosages and preparation forms.

Hypertension

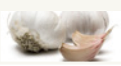
Hypertension is one of the most important, susceptible cardiovascular risk factors. A sustained increase in blood pressure (systolic: ≥ 140 mm Hg, diastolic ≥ 90 mm Hg) is associated with structural changes in blood vessels and overstressed kidneys, which can lead to increased cardiovascular morbidity and mortality [5]. Hypertension should therefore be avoided.
Different herbs and spices are attributed with the capability to normalize the blood pressure (◆ Table 2). This applies, inter alia, to oregano, rosemary and thyme, which

are derived of the *Lamiaceae* family and contain bioactive components with hypotensive properties. Thus, a blood pressure lowering effect of rosmarinic acid and caffeic acid was observed in *in vitro* studies as well as in animal experiments with rats using rosemary and oregano extracts [6–8]. *Kwon* et al. showed a strong inhibitory effect of aqueous rosemary extract on angiotensin I converting enzyme (ACE) *in vitro*, which may help reducing blood pressure [8]. Carvacrol, a substance derived from oregano, also caused hypotensive effects in animal models [9]. Although these findings seem promising, there is no evidence of efficacy in humans so far. Ginger also exerted hypotensive effects in animal experiments. Using a ginger extract resulted, for example, in a dose-dependent reduction (0.3–3 mg/kg) of the arterial blood pressure in anesthetized rats [10]. Additionally, it was also shown that the vasodilatory effect can probably be attributed to a blockade of voltage-dependent calcium channels. Moreover, an ACE-inhibitory effect was demonstrated using ginger extract on rat hearts [11]. But there is still a lack of comparative studies with humans, nevertheless.

Abbreviations

ACE	angiotensin I converting-enzyme
BAK	Bcl-2 homologue antagonist
BAX	Bcl-2-associated X protein
CAC	coronary artery calcium
CAT	catalase
CETP	cholesterol ester transfer protein
CI	confidence interval
COX2	cyclooxygenase 2
CRP	c-reactive protein
DMT2	diabetes mellitus type 2
EGF	epidermal growth factor
GSH	flutathione
HbA_{1c}	hemoglobin A_{1c}
HDL-C	high density lipoprotein-cholesterol
HMG-CoA-Reductase	3-hydroxy-3-methyl-glutaryl coenzyme A reductase
HOMA-Index	homeostasis model assessment
IL-6	interleukin-6
LDL-C	low density lipoprotein-cholesterol
MDA	malondialdehyde
MeS	metabolic syndrome
NfκB	nuclear factor of kappa light polypeptide gene enhancer in B-cells
NO	nitrogen monoxide
OR	odds ratio
ox-LDL	oxidized LDL
PGE2	prostaglandin E2
PPARγ	peroxisome proliferator activated receptor γ
ROS	reactive oxygen species
SOD	superoxide dismutase
TC	total cholesterol
TG	triglyceride
TNFα	tumor necrosis factor α
VEGF	vascular endothelial growth factor

There is more evidence for hypotensive effects of garlic and cinnamon. The consumption of 300 mg/day of dried garlic powder led to a significant reduction in blood pressure (systolic: -6.6 ± 2.3 mm Hg; diastolic: -4.6 ± 1.5 mm Hg) in hypertensive subjects compared

Plant	Botanical name	Selection of known bioactive components	Polyphenol content (mg/100 g)	
			fresh	dry
Ginger  © Diana Taliun/iStock/Thinkstock	*Zingiber officinale* Roscoe	gingerol, zingeron	205	474
Garlic  © Marc-Dietrich/Fotolia	*Allium sativum*	alliin, allicin, S-allyl-L-cysteine	n. s.	293
Turmeric  © Sunisa Chukly/123rf.com	*Curcuma longa* L.	curcuminoids	n. s.	2,117
Oregano  © dionisvero/iStock/Thinkstock	*Origanum vulgare* L.	carvacrol, rosmarinic acid, thymol	935	6,367
Rosemary  © anna1311/iStock/Thinkstock	*Rosmarinus officinalis* L.	carnosol, naringin, rosmarinic acid, caffeic acid	1,082	2,518
Thyme  © Marika/iStock/Thinkstock	*Thymus vulgaris* L.	carvacrol, rosmarinic acid, thymol	1,173	1,815
Cinnamon  © Shawn Hempel/123rf.com	*Cinnamomum verum*	caffeic acid, cinnamon aldehyde	n. s.	9,700

Tab. 1: **Bioactive ingredients and total polyphenol content of selected herbs and spices** (after [1])
n. s. = not specified

Herbs/Spices	Study type	Parameter	Results	Author [source]
Oregano/ Rosemary/ Thyme	*In vitro*	ACE-inhibiting potential of oregano-and rosemary extracts via enzyme tests	both extracts inhibit ACE; effect of rosemary extract greater	Kwon [8]
	In vivo	100 mg/kg bw aqueous thyme extract hypertensive rats	SBD ↓, DBD ↓ peripheral vessel resistance ↓	Mihailovic-Stanojevic et al. [6]
		10 mg/kg bw rosmarinic acid insulin resistant rats	systolic BD ↓	Karthik et al. [7]
		100 µg/kg bw carvacrol anesthetized rats	SBD ↓, DBD ↓, pulse ↓	Aydin et al. [9]
Ginger	*In vitro*	25–125 µg/mL aqueous ginger extract rat heart	dose-dependent ACE-inhibiting effect	Akinyemi et al. [11]
	In vivo	0,3–3 mg/kg bw ginger anesthetized rats	dose-dependent reduction of arterial BP	Ghayur et al. [10]
Garlic	Human study	300 mg/day garlic powder; 12 weeks 47 men and women with mild hypertension	SBD ↓, DBD ↓	Nakasone et al. [12]
		meta-analyses: 2 studies, 87 men and women	200 mg/day garlic SBD ↓, DBD ↓	Stabler et al. [13]
		meta-analyses: 20 studies, 970 men and women	garlic powder, -oil, -extract SBP ↓, DBD ↓	Ried et al. [14]
		meta-analyses: 7 studies, 391 hypertensive men and women	garlic powder, -oil, -extract SBD ↓, DBD ↓	Xiong et al. [15]
Cinnamon	Human study	1 200 mg/day cinnamon, 12 weeks 59 men and women with DMT2	SBD ↓	Wainstein et al. [17]
		2 g/day cinnamon, 12 weeks 58 men and women with DMT2	SBD ↓, DBD ↓	Akilen et al. [18]
		500 mg/day cinnamon extract, 12 weeks 22 men and women with MeS	SBD ↓	Ziegenfuss et al. [19]

Tab. 2: **Influence of selected herbs and spices on biomarkers of blood pressure**
↓ = significantly reduced
ACE = angiotensin I-converting enzyme; BP = blood pressure; bw = body weight; DBP = diastolic blood pressure; DMT2 = diabetes mellitus type 2; MeS = metabolic syndrome; SBP = systolic blood pressure

to the control group [12]. This antihypertensive effect was also confirmed in several meta-analyses [13–15]. Stabler et al. found a regular consumption of 200 mg of garlic powder per day to significantly reduce the systolic and diastolic blood pressure (systolic: -12 ± 11.4 mm Hg; diastolic: -9 ± 6.5 mm Hg) [13]. Slightly lower effects were observed in the meta-analyses of Ried et al. (systolic: -5.1 ± 2.2 mm Hg; diastolic: -2.5 ± 1.6 mm Hg) [14] and Xiong et al. (systolic: -6.7 ± 5.7 mm Hg, diastolic: -4.8 ± 1.8 mm Hg) [15]. These hypotensive effects were interestingly independent of the consumed amount (200–3,050 mg/day) or type of supplementation (garlic powder, -oil, -extract). The effects shown are, in particular, attributed to the bioactive sulfur component allicin which is formed from the garlic component alliin during preparation. It can stimulate the production of vasodilatory effective factors such as nitrogen monoxide (NO) and reduce the formation of vasoconstrictive factors such as endothelin and angiotensin II [16].

Antihypertensive effects have also been observed in studies with regular cinnamon intake. For example, in 59 subjects with diabetes mellitus type 2 (DMT2), a daily consumption of 1,200 mg of cinnamon led to a reduction of the systolic blood pressure by 3.4 ± 11.4 mm Hg compared to the control group [17]. A similar effect has been reported by Akilen et al. in 58 subjects with DMT2 (2 g/day cinnamon, 12 weeks) [18]. Here, the systolic (by 4.0 ± 1.8 mm Hg) as well as the diastolic blood pressure (by 4.0 ± 4.2 mm Hg) were reduced. The hypotensive effect was more pronounced in people with already elevated blood pressure at the beginning of the study, though. This observation was also supported by Ziegenfuss et al. [19]. The regular consumption of an aqueous extract of cinnamon (500 mg/day, 12 weeks) led to a significant reduction of the systolic blood pressure by 3.8% in individuals with metabolic syndrome (MeS). However, as the underlying mechanisms of action are

Herbs/Spices	Study type	Parameter	Results	Author [source]
Turmeric	Human studies	intervention study: 1 g/day curcuminoids + 10 mg/day piperin, 8 weeks 117 men and women with MeS meta-analysis: 8 studies 562 men and women	intervention study: SOD ↑, MDA ↓, CRP ↓ meta-analysis: Serum-CRP ↓	PANAHI et al. [24]
		1 g/day curcuminoids + 10 mg/day piperin, 10 weeks 30 men and women with MeS	improved prooxidant-antioxidant-balance	SAHEBKAR et al. [26]
		80 mg/day curcumin, 4 weeks 38 men and women	enzyme activity CAT ↑, antioxidative capacity of saliva ↑	DI SILVESTRO et al. [27]
Oregano, Rosemary, Thyme	*In vitro*	intrinsic antioxidative capacity of rosmarinic acid via enzyme tests	rosmarinic acid has antioxidative capacity	MUNOZ-MUNOZ et al. [32]
	In vivo	100 mg/kg bw carvacrol; male mice	IL-1β ↓	LIMA et al. [28]
		50 mg/kg bw carvacrol rats with induced inflammation	KAT ↑, SOD ↑, GSH ↑, lipid peroxidation ↓	ARIGESAWAN et al. [29]
		10 mg/kg bw rosmarinic acid, male rats	leukocyte migration ↘	GAMARO et al. [31]
		2 mg/rat rosmarinic acid, 3 days rats with induced pneumonia	IL-1β ↓, ROS ↘	SANGBONIG et al. [32]
	Human studies	300 or 600 mg/day oregano extract 4 weeks, 45 men	n. c.	NURMI et al. [33]
		75 mL/day thyme extract, 3 months 48 men and women with hyperlipidemia	paroxonase-activity ↑, serum-CRP ↓	ÖZDEMIR et al. [34]
		25 mL olive oil + 250 mg/kg thyme-polyphenols 3 weeks 12 men and women with hypercholesterolemia	serum-ox-LDL ↓	MARTIN-PELÁES [35]
Ginger	*In vitro*	antioxidative activity of methanol-extract of ginger via enzyme tests	extract has high antioxidative activity	GHASEMZADEH et al. [37]
	In vivo	5% of daily food as ginger powder rats with and without diabetes	MDA ↓, antioxidative capacity in plasma ↑	AFSHARI et al. [36]
		500 mg/kg bw ginger, 4 weeks, rats	PGE2 ↓	THOMSON et al. [39]
Garlic	Human studies	4 mL/day dry garlic extract, 1 year, 23 men and women	CAC-progression ↓	BUDOFF et al. [42]
		250 mg/day garlic extract + vitamins B_{12}, B_6, folic acid and L-arginine, 1 year 65 men and women	CAC-progression ↓	BUDOFF et al. [43]
		1.2 g/day dry garlic extract + 120 mg coenzyme Q10, 1 year, 65 men	CAC-progression ↓	ZEB et al. [44]
Cinnamon	*In vivo*	20–500 mg/kg bw cinnamon extract male mice	TNFα ↓, IL-6 ↓	HONG et al. [50]
	Human studies	10 mg/day cinnamon, 10 days, 18 men and women	lipid peroxidation ↓	RANJBAR et al. [48]
		52 mL/day aqueous cinnamon extract, 12 weeks 22 overweight people	antioxidative capacity in plasma ↑, MDA ↓	ROUSSEL et al. [49]

Tab. 3: **Influence of selected herbs and spices on antioxidative and anti-inflammatory biomarkers**
↓ = significantly reduced; ↑ = significantly increased; ↘ = non-significantly reduced
bw = body weight; CAC = coronary artery calcium; CAT = catalase; CRP = C-reactive protein; GSH = glutathione; IL-1β = interleukin-1β; IL-6 = interleukin-6; MDA = malondialdehyde; MeS = metabolic syndrome; n. c. = no change; ox-LDL = oxidized low density-lipoprotein; PGE2 = prostaglandin 2; ROS = reactive oxygen species; SOD = superoxide dismutase; TNFα = tumor necrosis factor α

currently considered unexplained, it is assumed that the hypotensive effects can be retraced to a vasodilatory effect [20] mediated by the cinnamic aldehyde contained therein [21].

Atherosclerosis

The development of cardiovascular diseases can be fostered by oxidative stress and chronic inflammatory reactions. Oxidative processes can lead to the formation and deposition of oxidized lipoproteins (e. g. oxidized low density lipoprotein [ox-LDL]) in vessel walls. These changes affect the endothelial function (e. g. decreased vascular flexibility due to reduced NO production) and promote further inflammatory processes which may lead to the accumulation of immune cells (macrophages) and the storage of minerals which favors the formation of atherosclerotic plaques [22, 23]. In order to assess the risk for atherosclerotic processes, various inflammatory (C-reactive protein [CRP]), oxidative (ox-LDL) or vascular biomarkers (E-selectin, NO) can be determined.

Antioxidant and anti-inflammatory effects of turmeric, oregano, thyme and ginger

Herbs and spices may exert antioxidative and anti-inflammatory potential, due to their high content of polyphenols (◆ Table 3), which in turn could help reducing atherosclerotic processes. Thus, the in this regard often observed effects of curcuminoids derived from turmeric are also attributed to their basic polyphenolic structure. According to *in vitro* studies, they can scavenge reactive oxygen species (ROS), reduce lipid peroxidation and promote the formation of antioxidant enzymes. The mechanism of action is also based on the inhibition of the transcription factor NfκB which reduces the formation of proinflammatory cytokines (e. g. IL-6, TNFα) (overview in [24]).

Curcumin is poorly bioavailable in humans. Only about 0.01% are absorbed in the intestine and rapidly metabolized in the small intestine and liver [25]. In order to investigate potential effects on health-related biomarkers, curcumin is therefore often supplemented in combination with other substances that improve the bioavailability (e. g. piperine, lipids). By using such curcumin preparations, positive effects on certain antioxidants and anti-inflammatory biomarkers were determined in various studies examining people with metabolic syndrome (MeS). Thus, an intervention with a curcuminoid piperine supplement (1 g/day curcuminoids + 10 mg/day piperine) resulted in significant improvement of parameters of the antioxidant capacity (superoxide dismutase [SOD]), lipid peroxidation (malondialdehyde [MDA]) and inflammation (CRP) in patients with MeS [24]. Using the same supplement resulted furthermore in significantly reduced systemic oxidative stress among people with metabolic risk, which was demonstrated by an improvement of the prooxidant-antioxidant-balance [26]. A meta-analysis of eight studies with a total of 562 subjects bearing different metabolic diseases revealed that supplementation of curcumininoids in different concentrations (80 mg–6 g/day) leads to significantly reduced serum-CRP concentrations (-2.20 mg/L, confidence interval [CI]: -3.96 to -0.44) [24]. In addition, a positive effect on the antioxidant capacity of the saliva as well as a significant increase in plasma-catalase (CAT) activity was observed in healthy people after the consumption of 80 mg/day of curcumin lipid supplements [27].

Thus, high-bioavailable curcuminoids appear to exert a favorable influence on inflammatory and antioxidant biomarkers, especially in people with metabolic diseases. However, according to current knowledge, it is questionable whether such an effect can also be obtained by regular consumption of turmeric, due to the comparably low bioavailability and lower intake levels.

Besides turmeric, oregano, rosemary and thyme also contain bioactive components with anti-inflammatory and antioxidant potential [8]. The polyphenol carvacrol, contained in thyme and oregano, showed inhibitory effects on inflammatory messengers (e. g. interleukin-1β) in mice [28] and promoted the formation of antioxidative enzymes in rats (e. g. CAT, SOD, glutathione [GSH]). Lipid peroxides were also significantly reduced [29]. Furthermore, there is *in vitro* evidence for antioxidant effects of the polyphenol rosmarinic acid [30] and anti-inflammatory effects have been observed in animal experiments with rats [31], which are probably caused by the inhibition of lipoxygenase and cyclooxygenase as well as the inhibition of pro-inflammatory cytokines [31, 32]. Previous results from human studies vary depending on the chosen subjects and substances used. Thus, no effects of a mango-orange juice enriched with oregano extract (300 mg or 600 mg) on biomarkers of lipid peroxidation were detected in healthy men [33]. But a thyme extract (25 mL/day) resulted in increased activity of the antioxidative enzyme paraoxonase as well as reduced serum-CRP concentrations in 32 volunteers with hyperlipidemia [34] and the consumption of 25 mL of olive oil enriched in 250 mg/kg of thyme polyphenols significantly reduced the serum concentration of ox-LDL in 12 subjects with hypercholesterolemia compared to the control group (olive oil) [35].

Ginger also contains various antioxidant phytochemicals (e. g. zingeron and gingerol). *In vitro* studies and animal experiments have shown that these components can scavenge free radicals, reduce lipid peroxidation and promote antioxidant protective mechanisms (e. g. CAT, SOD) [36–38]. Ginger extracts are also anti-inflammatory. They were found to inhibit the formation of pro-inflammatory prostaglandins and cytokines as well as the expression of NFκB (overview in [38]). Thus, a daily dose of 500 mg/kg ginger (4 weeks) resulted in significantly reduced prostaglandin E2 (PGE2) concentrations in rats [39]. However, whether a regular consumption of ginger also has beneficial anti-inflammatory and antioxidant effects in man cannot be evaluated to date.

Hence, there are indications for turmeric, oregano, thyme, rosemary and ginger containing various effective bioactive components. Yet there is no evidence so far for cardioprotective effects through regular consumption of herbs or their essential ingredients in humans.

Garlic and cinnamon show antioxidant and anti-inflammatory potential

Garlic contains a number of bioactive components, which may also contribute to reducing atherosclerotic processes. It was shown that the contained sulfur components alliin or allicin, which is formed when cutting garlic, exert antioxidative and anti-atherosclerotic effects, for example, by scavenging ROS, inducing the formation of endogenous antioxidants (e. g. GSH) and inhibiting platelet aggregation (overview in [16]). Furthermore, garlic and aqueous garlic extracts increased the serum concentration of the antioxidative enzymes GSH-peroxidase and CAT in mice and where shown to absorb exogenous ROS in a dose-dependent manner (overview in [40]).

Potentially anti-atherosclerotic effects were also observed in human studies. For example, different studies investigated the influence of garlic on the progress of atherosclerotic processes by measuring the calcium content in the coronary artery (CAC) associated with atherosclerotic plaques [41]. Budoff et al. observed a significantly reduced CAC progress in the subjects consuming garlic extract for one year compared to the control group (7.5% vs. 22.2%) [42]. They confirmed this in another study and found that the effect is more pronounced when the garlic extract is combined with vitamins and arginine (6.8% vs. 26.5%) [43].

Zeb et al. showed that the consumption of 1.2 g garlic dry extract + 120 mg coenzyme Q10 was associated with a 4-fold reduction in CAC progress compared to the control group [44]. The underlying mechanisms of action are not yet fully understood. However, there is a correlation between oxidative stress and calcium deposition (CAC) [45], so garlic may prevent atherosclerosis through antioxidant effects.

Cinnamon can also induce antioxidant effects [46–49]. In 18 subjects, daily consumption of cinnamon (10 mg/day, 10 days) led to a significant reduced plasma concentration of lipid peroxides (5.3 ± 0.5 vs. 3.2 ± 0.3 nmol/mL) which was attributed to the phenolic antioxidants (e. g. rosmarinic acid, tannins, procyanidines) contained in cinnamon [48]. A daily consumption of 25 mL of an aqueous cinnamon extract resulted after 12 weeks in significantly increased plasma antioxidant capacities in 22 overweight individuals with impaired glucose metabolism and significantly reduced concentrations of the lipid peroxidation product MDA (2.7 ± 0.2 vs. 2.2 ± 0.1 µmol/L) [49]. Anti-inflammatory effects were also observed in mice after regular administration of aqueous cinnamon extract [50]. Hong et al. observed significantly reduced serum concentrations of proinflammatory cytokines (TNFα and IL-6) as well as an inhibited TNFα-mRNA expression *in vitro* [50]. This effect was also attributed to the polyphenolic components of the extract.

Although current studies are promising regarding antioxidant and anti-inflammatory effects of garlic and cinnamon, there is nevertheless a lack of studies confirming these effects in humans to date.

The continuation of this article is to be found in the next issue of Ernährungs Umschau (number 12/2016).

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Conflict of Interest
The authors declare no conflict of interest.

The references of this article are to be found online in Ernährungs Umschau issue 11/2016.

DOI: 10.4455/eu.2016.047