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REVIEW ARTICLE

GINSENG PHARMACOLOGY: MULTIPLE MOLECULAR TARGETS AND RECENT CLINICAL TRIALS

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SUMMARY

Ginseng has been used as a folk medicine in Far East Asian countries for several thousand years. Recently, its use has also expanded to Western countries. A number of studies provide evidence for its various pharmacological properties, including antifertility, antidiabetic, antiobesity, antibacterial, antifungal, antiviral, antiulcer and neuroprotective effects. Ginseng and its constituents have demonstrated the ability to interact with multiple molecular targets affecting multistep processes in many diseases. Research revealed that ginseng and its constituents bind to a variety of proteins and inhibit the activity of various kinases. Ginseng also modulates the activity of various transcription factors, enzymes, receptors, ion channels, antiapoptotic proteins, adhesion molecules and others, including different cyclins. Various beneficial in vitro and in vivo effects in different pathological conditions have encouraged researchers to design clinical trials to investigate the safety, efficacy and pharmacokinetics of ginseng. The clinical trials have provided encouraging results, and a number of other trials are in progress. This study aims to review the various beneficial effects of ginseng in different pathological conditions. The multiple molecular targets for ginseng published in the literature during the past few years are included. Similarly, the completed or ongoing clinical trials for ginseng and its constituents are also summarized.

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INTRODUCTION

Ginseng, a member of the Araliacea family, is a slow-growing perennial herb with fleshy roots. Eleven major species of this plant have been reported in the literature (1). However, the majority of studies are concerned with the constituents from three common species, *Panax ginseng* (Asian ginseng), *Panax quinquefolius* (American ginseng) and *Panax japonicus* (Japanese ginseng) (2). Ginseng root has been used as a folk medicine in Far East Asian countries for several thousand years, with the belief that it cures all diseases (3). During the last few decades, its use has extended to Western countries for the improvement of various conditions.

The bioactive constituents isolated from various ginseng species include ginsenosides, polysaccharides, peptides, nucleic acids, alkanes, alkynes, sterols, monoterpenes, sesquiterpenes, phenylpropanoids, chromones, amines, flavonoids, organic acids, vitamins, enzymes, inorganic compounds, polyacetylenic alcohols and fatty acids (1, 3). Among these, ginsenosides are considered to be the main constituents responsible for various molecular actions of ginseng. There is a wide variation in the relative abundance of ginsenoside content in various ginseng species. To date, more than 100 bioactive compounds have been reported from different ginseng species (4).

Research has revealed that ginseng has a wide array of pharmacological properties, including antioxidant, anticancer, anti-inflammatory, antiapoptotic, antihepatotoxic, antimutagenic, antifertility, antidiabetic, antibacterial, antifungal, antiviral, antiulcer and neuroprotective effects. During the last decade, there has been additional interest in studying the molecular pharmacology of ginseng and its constituents using various modern biological methods, including molecular, biochemical and electrophysiological techniques. These studies have demonstrated that ginseng has multiple actions through direct and indirect interaction with various molecular players (5). Numerous molecular targets for ginseng have been identified using these techniques. Recently, it has been demonstrated by our group that ginseng extracts improved visual sensitivity and may have beneficial effects in ophthalmic diseases (6). As ginseng has shown promising results in in vitro and in vivo preclinical studies,

several trials were initiated to address the safety, efficacy and pharmacokinetics of ginseng at the clinical level.

The purpose of this article is to review the beneficial in vitro and in vivo effects of ginseng in different pathological conditions. Numerous molecular targets for ginseng identified through extensive molecular research are summarized. The clinical studies conducted over the past few years are also highlighted.

BIOLOGICAL AND PHARMACOLOGICAL EFFECTS OF GINSENG

In folk medicine, ginseng and its constituents have been used as therapeutic preparations over the past few thousand years in different parts of the world. In the traditional Chinese medical book, *Shen Nong Ben Cao Jing*, ginseng has well-documented pharmacological properties, such as curative, stimulant and antiaging effects, as well as a long list of other activities. A full discussion of the traditional medicinal uses of ginseng is beyond the scope of this review.

Recent investigation suggests that ginseng has modulatory effects in various diseases (Fig. 1). Since the anticancer, antiapoptotic, antimutagenic, neuroprotective and central nervous system (CNS) effects of ginseng have been well documented in other review articles, these will not be discussed here.

Effects on gastrointestinal and cardiovascular systems

P. ginseng has been reported to exhibit gastroprotective activity in peptic and chronic ulcer models (7). Later, it was found that ginsenoside Rb1 is the main constituent responsible for the antiulcer activity of ginseng through an increase in mucus secretion (8). Ginseng and ginsenosides improve the accelerated movement of the small intestine and contribute to the action of Dai-kenchu-to on small intestinal transit (9). Additionally, ginseng has shown antihepatotoxic effects in vitro and in vivo (10).

The beneficial effects of ginseng in cardiovascular diseases are well documented. Ginseng and its main active constituents exhibit a variety of cardiovascular actions, including antihypertensive, negative chronotropic, negative inotropic, vasorelaxant and antiarrhythmic effects, and protection against ischemia/reperfusion injury. Moreover, ginsenosides protect against myocardial infarction (11, 12).

Antibacterial, antifungal and antiviral effects of ginseng

A pilot study on standardized G115 ginseng extract revealed its beneficial effects on the reduction in bacterial counts in the bronchial system of patients with acute attacks of chronic bronchitis (13). In another study, ginseng treatment reduced bacterial load in chronic *Pseudomonas aeruginosa* pneumonia in rats (14).

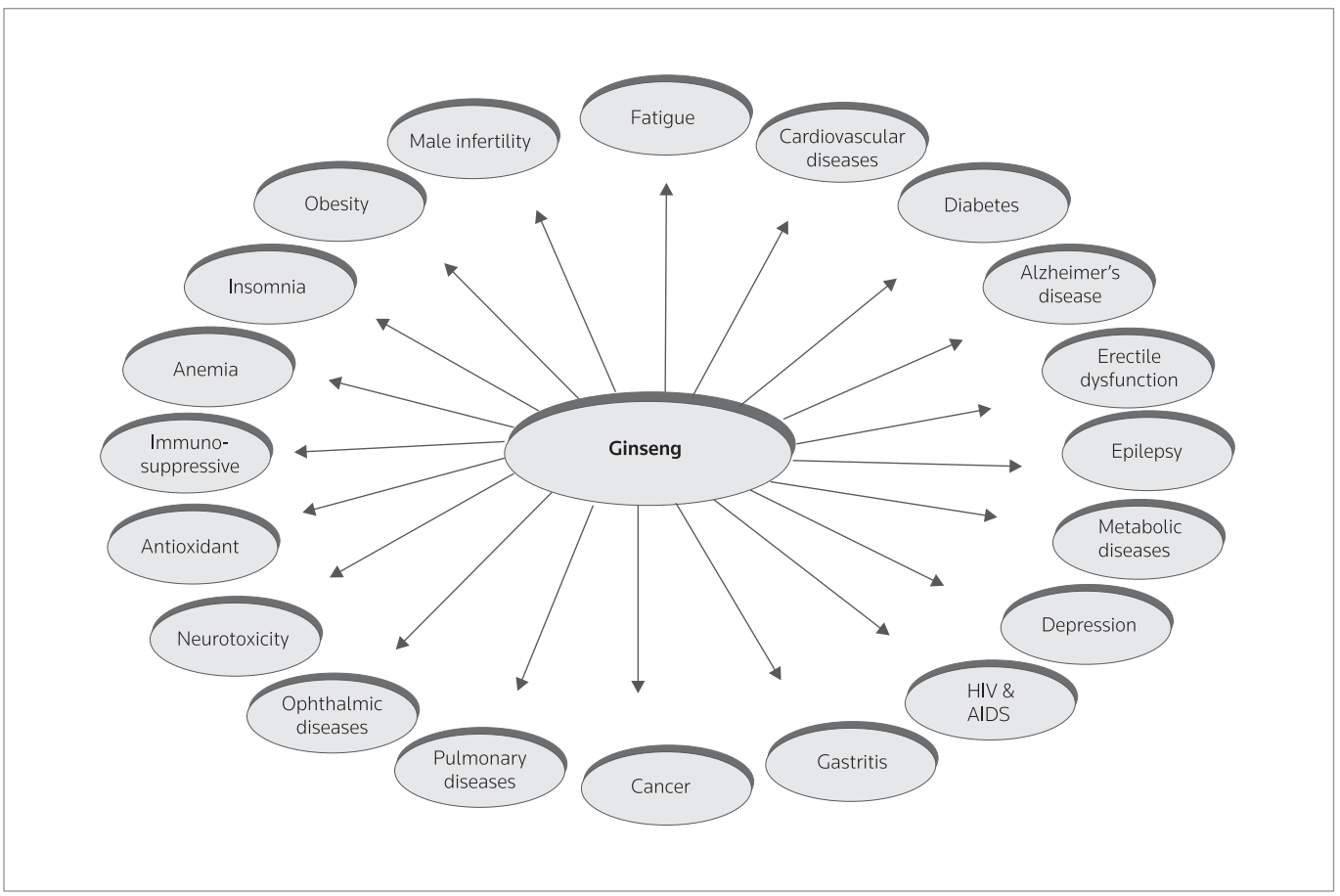

Figure 1. Various diseases in which ginseng has beneficial effects (for references see text).

The antifungal activity of ginseng has recently been investigated. *Panax notoginseng* RNase exhibits antifungal activity against *Physalospora piricola* and *Coprinus comatus* (15). Recent investigations suggest that ginsenosides exert considerable antifungal activity by disrupting the structure of the cell membrane (16).

Ginseng and its constituents have also been shown to have antiviral activity. In an early study, *P. ginseng* extract was found to be effective against experimental Semliki Forest virus infection in mice (17). In a more recent report, it was observed that panaxagin, a protein from Chinese ginseng, exhibits antiviral activity (18); panaxagin exerted its activity through inhibition of the HIV reverse transcriptase enzyme. In 2004, a study reported that ginsenoside Rb1 from *P. ginseng* demonstrated antiviral activity at a concentration of 100 μM (19). Most importantly, clinical studies have revealed that Korean red ginseng delays disease progression in HIV-1-infected patients (20).

Antifertility, antidiabetic and antiobesity effects of ginseng

There is evidence that ginseng has a potent effect on fertility functions (21, 22), as well as beneficial effects on erectile dysfunction and premature ejaculation (22, 23). *P. ginseng* extract showed an improvement in spermatozoa number/mL and progressive oscillating motility, an increase in plasma total and free testosterone, dihydrotestosterone, follicle-stimulating hormone and luteinizing hormone levels (24). Another study revealed that diabetic rats with decreased erectile function showed better erectile responses to cavernosal nerve stimulation upon treatment with Korean red ginseng (23).

Ginseng has been widely studied for the treatment of diabetes and obesity in animal models and human patients. Ginseng and its constituents have beneficial effects in the regulation of blood glucose and blood pressure. Intriguingly, in addition to ginseng root, ginseng berry and leaf were also shown to reduce blood glucose and body weight in models of diabetes and obesity (25). In diabetic (*ob/ob*) mice the berry ginseng extract produced a significant reduction in hyperglycemia and fasting and postprandial insulin levels, while glucose tolerance was markedly improved. It was also found that ginseng berry extract reduced food intake, decreased body weight and enhanced energy expenditure, as indicated by increased body temperature (26). The efficacy of berry extract was also examined in *db/db* mice, and good results were observed on glucose and energy metabolism. The extract also reduced body weight in lean littermates, indicating that ginseng has beneficial effects in both lean and genetically obese mice (27).

Another study compared the effects of ginseng root and ginseng berry on metabolic syndrome in *ob/ob* mice (28). The results suggested that ginseng berry has more potent effects than ginseng root in decreasing blood glucose, increasing glucose tolerance and lowering body weight. Ginseng leaf also has antidiabetic and antiobesity effects, as demonstrated in *ob/ob* mice (29). It was found that the leaf extracts lower blood glucose levels, raise body temperature and reduce body weight after injections over 12 days.

Anti-inflammatory activity of ginseng

Several investigators used ginseng or its active constituents to treat inflammation in animals and humans. Published results revealed that ginseng could effectively inhibit inflammation. The anti-inflammatory role of ginseng might be due to the effects of ginsenosides, as they target different levels of immunological activity, and so contribute to the diverse actions of ginseng in humans (30). A recent study concluded that ginseng has potential analgesic and anti-inflammatory activities. The results confirmed the pharmacological effects of ginseng for the relief of pain and inflammation. This study also suggested that the anti-inflammatory activity of ginseng may be due to inhibition of cyclooxygenases and/or lipoxygenases (31).

MULTIPLE MOLECULAR TARGETS OF GINSENG

Ginseng has a diverse range of molecular targets, which include transcription factors, growth factors and their receptors, genes regulating cell proliferation and apoptosis, cytokines, enzymes, ion channels and neuronal receptors (Table I).

It can be concluded from published results that ginseng and its constituents are effective inhibitors of the activation of various transcription factors, including nuclear factor NF-κB, transcription factor AP-1, signal transducer and activator of transcription (STAT) proteins, peroxisome proliferator-activated receptor PPARγ and β-catenin (32-34). The aforementioned transcription factors regulate the expression of genes that play an important role in tumorigenesis, cell survival, invasion, cell proliferation, inflammation and angiogenesis.

The misregulation of a variety of tyrosine and other kinases has been found to contribute to the development of various disease conditions. Experimentally, it was shown that ginseng and its constituents regulate the activity of various tyrosine-protein kinases. Ginseng treatment attenuated the expression of epidermal growth factor receptor (EGFR, erbB-1), erbB-2 (HER2) and apoptosis regulator Bcl-2, as well as the phosphatidylinositol 3-kinase (PI3K)/Akt pathway, serine/threonine-protein kinase Akt and extracellular signal-regulated kinase (ERK) signaling pathways (32-35). Ginseng also modulated the activity of other kinases, including phosphorylase kinase, protein kinase C (PKC), protamine kinase, autophosphorylation-activated protein kinase and tyrosine-protein kinase Src (36-38). It was reported that ginseng can completely inhibit the activity of various protein kinases, including EGFR, ERK, PKA, PKB, PKC and Janus kinase (30, 39). On the other hand, it activates the c-Jun *N*-terminal kinase and mitogen-activated protein kinase (MAPK) (32).

Ginseng can interact and alter the activities of various growth factors. Ginseng and its constituents especially target EGF, fibroblast growth factor (FGF), platelet-derived growth factor (PDGF), transforming growth factor-β (TGF-β) and many others that are linked with growth signaling and cell proliferations (34, 40). Ginseng can induce apoptosis through decreased expression of proapoptotic proteins, particularly vascular endothelial growth factor (VEGF) (41).

It has been reported that ginsenosides increase DNA polymerase activity 2.2-fold in a concentration-dependent manner (42). Other studies have provided evidence that ginseng and its constituents have the ability to interact with other enzymes, including cyclooxygenase-2 (COX-2), lipoxygenase (LOX), nitric oxide synthase (NOS), heme oxygenase 1 (HO-1), and others that are necessary for the normal activity of cells and tissues (5, 30, 31, 34, 43).

Table I. *A list of multiple molecular targets of ginseng.*

Molecular targets	Reference
Transcriptional factors	
Transcription factor AP-1	32, 36
β-Catenin	33
CREB-binding protein	65
Hypoxia inducible factor 1	41
Nuclear factor NF-κB	34
Peroxisome proliferator-activated receptor PPARγ	34, 66
Signal transducer and activator of transcription STAT-1, -3, -4 and -5	40, 67
Kinases	
Autophosphorylation-activated protein kinase	36
c-Jun *N*-terminal kinase	30
Epidermal growth factor receptor	39
Extracellular signal-regulated kinase	39
Focal adhesion kinase	68
IL-1 receptor-associated kinase	30
Janus kinase	30
Mitogen-activated protein kinase	68
Phosphorylase kinase	36
Protamine kinase	37
Protein kinase A, B and C	30
Tyrosine-protein kinase Src	38
Growth factors	
Connective tissue growth factor	69
Fibroblast growth factor	70
Hepatocyte growth factor	71
Nerve growth factor	72
Platelet-derived growth factor	69
Transforming growth factor-β	34, 70
Vascular endothelial growth factor	41
Enzymes	
ATPase	5
Cyclooxygenases	34
DNA polymerase	5
Gluthathione *S*-transferase	73
Glutamate-cysteine ligase	74
Glutamyl cysteine ligase	75
Heme oxygenase-1	30
Inducible nitric oxide synthase	43
Lipoxygenase	31
Matrix metalloproteinase	30
Ornithine decarboxylase	76
Telomerase	77
Cytokines	
Interleukins	41
Monocyte chemoattractant protein	30
Migration inhibitory protein	71
Tumor necrosis factor TNF-α	34
Receptors	
Androgen receptor	70
Aryl hydrocarbon receptor	78
Death receptor 5	79
Epidermal growth factor receptor	80, 81
Estrogen receptor	70
Fas receptor	79
Glucocorticoid receptor	70
Histamine H_2 receptor	81
Inositol 1,4,5-triphosphate receptor	82
Integrin receptor	70
Progesterone receptor	70
Urokinase plasminogen activator surface receptor	70

Continued

Table I. *Cont. A list of multiple molecular targets of ginseng.*

Molecular targets	Reference
Adhesion molecules	
Endothelial leukocyte adhesion molecules	70
Intercellular adhesion molecule 1	70
Vascular cell adhesion protein 1	70
Proteins	
Apoptosis regulator Bcl-2	35
Bcl-X(L)	35
High-density lipoprotein	70
Low-density lipoprotein	70
Uncoupling protein 2	45
Ion channels	
GABA receptor channels	47
Glucocorticoid receptor channels	5
Glycine receptor α1 receptor channels	48
Human 5-HT_{3A} receptor channels	48
Nicotinic acetylcholine receptor channels	46
NMDA receptor channels	48
Sodium, potassium and calcium voltage-gated channels	46
Other	
Cyclin D1, E and cyclin-CDK complex	35, 36
Glutamate-induced neurodegeneration	48
Heat shock proteins	83
Kainate-induced cell damage	48
Multidrug resistance protein	70
p53 and p21	34, 36
Retinal neuronal antagonist	6
Urokinase-type plasminogen activator	70

In addition, ginseng effectively regulates the activity of various hormones. An investigation suggested that ginseng inhibits cytokine-induced apoptosis in β-cells (44). In a mouse model, ginseng modulated Th1-like immune responses in mice with *Pseudomonas aeruginosa* lung infection (45). Furthermore, higher levels of interferon gamma (IFN-γ) and TNF-α and lower levels of interleukin-4 (IL-4) cytokines were observed after ginseng treatment. Other studies reported that ginseng can effectively interact with and modulate the activity of various inflammatory cytokines, including interleukins IL-1, -2, -5, -6, -8, -12 and -18 (41).

Recent electrophysiological studies suggested that ginseng and its constituents bind and regulate the activity of a variety of ion channels and receptors. It was reported that ginseng can attenuate the sodium, potassium and calcium voltage-gated ion channels (46). It can alter ligand-gated ion channels such as nicotinic acetylcholine, glucocorticoid, GABA, glycine receptor α1 and 5-HT_{3A} receptors and NMDA receptor channel activity (46-48). Additionally, a recent study by our group has shown that ginseng possesses retinal neuronal antagonist activity (6).

It can be concluded that the diverse in vitro and in vivo pharmacological activities of ginseng might be due to its ability to mediate multiple molecular targets. Additionally, the multiple molecular targets and multifaceted pharmacological functions of ginseng combined can explain its role in different diseases. Thus, these properties made ginseng a desirable choice for clinical use in the treatment of various diseases.

GINSENG IN HUMAN CLINICAL TRIALS

In response to the increasing in vitro and in vivo evidence for the beneficial effects of ginseng and its constituents, a number of clinical studies have been carried out to address its safety, efficacy and pharmacokinetics. Promising results have been reported in patients treated with ginseng extract, isolated fractions or pure constituents. These trials assessed the effects of ginseng on physical and psychomotor performance, cognitive function, type 2 diabetes, obesity, upper respiratory infection, allergic conditions, various types of cancer and immunomodulation. Diseases in which the beneficial effects of ginseng have been evaluated in the past few years are summarized in Table II. Early trials were focused on the efficacy of ginseng, while the current studies are also exploring the safety and pharmacokinetics (49).

Clinical studies on the effects of ginseng on physical and psychomotor performance and cognitive function showed controversial results. Therefore, further pilot and well-controlled studies are needed to fully evaluate the efficacy of ginseng in the above-mentioned diseases (33, 50). Clinical results for immunomodulation were encouraging. Results from a study in 60 volunteers showed enhancement of chemotaxis, phagocytosis, total lymphocyte count and numbers of T helper cells after 8 weeks of treatment with G115 extract at a dose of 100 mg twice daily (51). In a pilot study, 36 patients with newly diagnosed non-insulin-dependent diabetes were subjected to 8 weeks of ginseng treatment at a dose of 100 or 200 mg. Results showed improvement in psychophysical performance and reduction in fasting blood glucose and body weight. Additionally, elevated mood and other favorable symptoms were also observed after ginseng treatment (52).

Ginseng also displayed promising results in other clinical studies, such as increasing the energy level in cancer patients and other patients. Although most of the results published in the literature regarding the efficacy of ginseng are encouraging, there are also studies which did not achieve the goal for ginseng therapy. Despite intense research efforts, only little is known about the safety and pharmacokinetics of ginseng. However, it may be a prime time for

Table II. *A list of completed and ongoing clinical trials of ginseng.*

Disease	Study type/design	No. of patients	Start date and present condition	Trial site	ClinicalTrials.gov Identifier*
Alzheimer's disease, Memory decline	(Phase I&II), nonrandomized	?	April 2004 completed October 2005	Seoul National University Hospital, KR	NCT00391833
Breast cancer	(Phase II), nonrandomized	50	February 2008 and ongoing	Simmons Cooper Cancer Institute, SIU School of Medicine, US	NCT00631852
Cancer survivor, Infertility, Reproductive issues, Solid tumors	Randomized	186	May 2007 and ongoing	US-based locations National Cancer Institute	NCT00459134
Diabetes type 2	Phase II, randomized	120	September 2008 and ongoing	Clinical Nutrition and Risk Factor Modification Centre, Toronto, CA	NCT00728403
Diabetes	(Phase 0), randomized	19	September 2003 completed September 2008	Washington University School of Medicine, St. Louis, US	NCT00781534
Fatigue, Solid tumors	Randomized	280	October 2005	National Cancer Institute	NCT00182780
Healthy volunteers	(Phase IV), randomized	150	January 2005 completed September 2009	National Institutes of Health Clinical Center, Bethesda, US	NCT00103012
Healthy volunteers	(Phase II), randomized	60	March 2020 completed March 2005	University of Kansas Medical Center, Kansas City, US	NCT00029692
Hypertension, Blood pressure, Endothelial function	Phase II, randomized	17	November 2007	St. Michael's Hospital, Toronto, CA	NCT00728221
Hypertension	(Phase III), randomized	52	April 2001 completed October 2003	St. Michael's Hospital, Toronto, CA	NCT00219960
Hypertension	(Phase II), randomized	18	June 2007 completed March 2008	St. Michael's Hospital, Toronto, CA	NCT00730951
Hyperglycemia	(Phase III), randomized	12	June 2005 completed July 2005	St. Michael's Hospital, Toronto, CA	NCT00367926
Ischemic stroke	(Phase II), randomized	199	September 2005 completed September 2006	Xijing Hospital, Xi'an, CN	NCT00591084
Ischemic stroke	(Phase III), randomized	390	September 2006 completed September 2008	Xijing Hospital, Xi'an, CN	NCT00815763

Continued

Table II. *Cont. A list of completed and ongoing clinical trials of ginseng.*

Disease	Study type/design	No. of patients	Start date and present condition	Trial site	ClinicalTrials.gov Identifier*
Leukemia	(Phase III), nonrandomized	336	September 2008 and ongoing	130 worldwide locations National Cancer Institute	NCT00752895
Multiple sclerosis	Phase II, randomized	56	September 2005 and ongoing	Oregon Health & Science University, Portland, US	NCT00754832
Multiple cancer types, Fatigue	(Phase III), randomized	360	October 2008 and ongoing	313 worldwide locations National Cancer Institute	NCT00719563
Memory, Learning, Attention, Cognition, Well-being	(Phase II), randomized	72	Completed	Edmonton, CA	NCT00527969
Postoperative ileus	(Phase II), randomized	24	December 2005 completed January 2008	Washington University School of Medicine, St. Louis, US	NCT00266461
Periodontitis	(Phase II), randomized	?	Completed	The Oregon Health Sciences University, Portland, US	NCT00010634
Schizophrenia, Schizoaffective, Tardive dyskinesia, Insulin resistance, Obesity	(Phase I&II), randomized	60	December 2002 completed April 2007	Regional Mental Health Care London, St. Thomas, CA Queen's University, Kingston, CA Northwick Park Hospital, UK Northern Ontario Medical School, Thunder Bay, CA	NCT00401089
Seasonal allergic rhinitis	(Phase II), randomized	200	May 2008 and ongoing	Edmonton, Alberta, CA	NCT00726401
Upper respiratory tract infection	(Phase II), randomized	75	November 2005 completed April 2006	Misericordia Child Health Clinic and Stollery Children's Hospital, Edmonton, CA	NCT00255307
Upper respiratory tract infection	(Phase IV), randomized	327	June 2005 completed June 2007	Two General Outpatient Clinics, Hong Kong, CN	NCT00887172
Xerostomia	Phase IV, randomized	100	September 2007 completed December 2008	Kyung Hee East-West Neo Medical Center, Seoul, KR	NCT00911768

*http://clinicaltrials.gov

ginseng research to succeed on the back of remarkable in vitro, in vivo and clinical results.

GINSENG INTERACTIONS, SIDE EFFECTS AND LIMITATIONS

As discussed in earlier sections, ginseng has the ability to interact directly and indirectly with various molecular targets and modulate their activity. Therefore, ginseng may also interact with other conventional drugs and result in serious side effects. Ginseng is generally considered to be a stimulant; therefore, care should be taken if an individual is using caffeine, pseudoephedrine or other stimulants (53). It has been reported that vitamin C can interact with and may increase the absorption of ginseng (54). Studies have also demonstrated that ginseng increases the activity of warfarin through various mechanisms. Therefore, ginseng should not be used by patients receiving oral anticoagulant and/or antiplatelet medications (55, 56). Phenelzine is commonly used as an antidepressant and anxiolytic. It has been reported that ginseng interacts with phenelzine and their simultaneous use may decrease blood concentrations of alcohol and warfarin, and may cause mania (53, 57). Ginseng has been reported to have an adverse interaction with amlodipine (58) and it can also interfere with digoxin pharmacodynamics (59). It is believed that ginseng may interact with opioids and in some cases inhibits the analgesic effects of such drugs (60). Some of the possible interactions of ginseng with other conventional drugs are summarized in Table III.

Ginseng appears to be quite safe when properly used; however, high doses or long-term use may cause some adverse effects. Moreover, ginseng interaction with other drugs may also lead to side effects. Some of the commonly reported side effects include reactions such as nervousness, restlessness, excited feeling, trouble sleeping, gastrointestinal problems, headache, insomnia, anxiety, breast soreness or tenderness, skin rashes, asthma attacks, increased blood pressure, diarrhea, euphoria, skin eruptions, heart palpitations or postmenopausal uterine bleeding (61, 62). A study reported with some level of uncertainty that ginseng may intensify seizures (63). Some of the commonly observed side effects are summarized in Table III.

Ginseng (and other herbal medicines) is associated with other limitations and problems. Consistency in chemical composition and pharmacological properties is fundamental for the safe and effective use of herbal drugs; however, ginseng and other herbal products frequently fail to meet this standard. Ginseng extracts vary in composition depending on genetic variability, harvesting season, locality and other environmental factors (1, 4).

Table III. *A summary of ginseng interactions with other drugs and side effects.*

Ginseng interactions/side effects	Reference
Drugs with which ginseng may interact	
Amlodipine	58
Caffeine, pseudoephedrine or other stimulants	53
Digoxin	59
Opioids	60
Phenelzine	58
Vitamin C	54
Warfarin	53, 55, 57
Ginseng side effects	
Asthma attacks and diarrhea	61, 62
Breast soreness or tenderness	61, 62
Gastrointestinal problems	61, 62
Headache, insomnia and anxiety	61, 62
Increased blood pressure and heart palpitations	61, 62
Nervousness, restlessness and excited feeling	61, 62
Skin rashes and skin eruption	61, 62

Poor extraction methods constitute another problem concerning ginseng and other herbal research. Chromatographic techniques and marker compounds are commonly used for the standardization of herbal products, but this does not guarantee consistent pharmacological activity or stability. In a study on ginseng preparations, the amount of ginsenosides varied from 11.9% to 327.7% of the label claim (64). Lack of standardization of ginseng preparations is another serious problem for researchers and thus they cannot rely on commercially available herbal products for their research studies. Despite the fact that unregulated and inappropriate use of ginseng may have serious side or toxic effects, based on laboratory and clinical studies it would be safe and effective if used in consultation with licensed and experienced herbalists or health specialists. Moreover, the use of high-quality and regulated brands of ginseng preparations may also ensure its safety and efficacy to a certain extent.

DISCLOSURES

The authors state no conflicts of interest.

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