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Review Article

Schisandra chinensis, Five Flavor Berry, a Traditional Chinese Medicine and a Super-Fruit from North Eastern China

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ABSTRACT

Introduction: The aim of this review was to summarize the most important traditional and modern health benefits of *Schisanda* berry. **Methods:** We used PubMed, Science Direct and Google to search for and collect scientific publication for a full evaluation of current evidence in the literature indicating the potential role of *Schisanda* berry. **Results:** The traditional Chinese medicine (TCMs) is essential components of alternative medicines. *Schisandra* berry (*Schisandra chinensis* (Turcz.) Baill. (Magnoliaceae) or Wu-Wei-Zi, which means the fruit of five tastes is a commonly used herb in traditional Chinese medicine (TCM). The five tastes of *Schisandra* berry refer to its influence on the five visceral organs in the body. It is one of the oldest medicinal plants used in East of Asia, especially traditional Chinese medicine. *S. chinensis* is mainly distributed in provinces in northern China including Heilongjiang, Jilin and Liaoning. *S. chinensis* can treat lung-Qi and kidney-Yin deficiencies, relieve coughs and asthma and stop persistent diarrhea. *S. chinensis* has been used to treat sleep disorder in traditional Chinese medicine and a tonic for kidney and brain in traditional Chinese medicine. Its extracts may apply as a preservative and as an additive to increase the flavor, taste and nutritional value of food. The five important components of *S. chinensis* are Schisandrol B, Schisandrin A, γ-Schisandrin, Gomisin N and Schisandrin C. **Conclusion:** The most important pharmacological effects of Schisandrol B are anti-allergy, liver protection and anticarcinogenic effects; Schisandrin A has role in liver protection and anti-carcinogenic effect; γ-Schisandrin has liver protection and anti-carcinogenic effect, Gomisin N has anti-proliferative, pro-apoptis HepG2 cells, anti-hepatitis, anti-HIV, anti-carcinogenic effect; and Schisandrin C has protect liver, anti-HIV, anti-catchinogenic effect and anti-hepatitis. The treatment with natural herbal medicine which are also super-fruit and non-synthetic drug is recommended.

Key words: Traditional Chinese Medicine, *S. Chinensis*, Gomisin, Schisandrin, Lignans, Polysaccharides.

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INTRODUCTION

Herbal medicines are medicinal products contain active ingredients aerial, underground parts of plants or/and other plant materials,[1-5] and herbal medicines contain variety of pharmacologically active plant constituents.[6-13] The genus of *Schisandra* (Schisandraceae) comprising 23 species which have been distributed in East of Asia. *Schisandra chinensis* has been used because of multiple pharmacological activities alone or in the combination with other drugs for many years.[14,15] It is one of the oldest medicinal plants used in East of Asia, especially traditional Chinese medicine.[16-18] Chinese magnolia vine (*Schisandra chinensis*) is used in both traditional and modern Chinese medicine.[19,20] It is calledomiza in Korean, gomishi in Japanese and wu wei zi in Chinese because it has five tastes, namely salty, sweet, sour, astringent and bitter.[21,22] *S. Chinensis* is mainly distributed in provinces in northern China including Heilongjiang, Jilin and Liaoning.[23-25] It was registered in the list of health foods by the Ministry of health of the People's Republic of China in 2002 as it was increasingly used as food stuff.[26,27] It can use as both medicine and food.[28] It is listed in the Chinese Pharmacopeia and indexed as a tonic and sedative and also listed in the Shen Nong Ben Cao Jing book, year 1596 (2697 BC) as the important drug which helps in coughs and prevents asthma.[28-30] It is with high safety and is officially listed as health food by State Food and Drug Administration (SFDA).[31] It was abundant in orient with related records traced back before Christ.[32,33] It is round or oblate in shape and 5-8 mm in diameter and the surface of the fruit is red or dark red in color, wrinkly and glossy and the pulp is very soft, faint in smell and sour in taste.[34] The most important information about its characteristics is shown in Table 1. In this review-article, we try to show the importance of *S. Chinensis* and survey on chemical constituents, traditional health benefits and modern pharmaceutical benefits of it.

CHEMICAL CONSTITUENTS

The main active chemical constituents of Schisandra include lignans and polysaccharides.[36-39] Sovova *et al.*[40] Reported that lignans of dibenzo[a,c] cyclooctadiene type (gomisins), are present in all parts of the plant especially in seeds which is up to 5% dry weight. Nine compounds were isolated from the supercritical CO_2 extraction of Schisandra chinensis and their structures were identified as chrysophanol, schisandrin B, β-sitosterol, schisandrin C, schisandrol A, angeloylgomisin H, daucosterol, 1,5-dimethyl citrate and shikimic acid.[41] Dai *et al.*[42] isolated Five compounds were from the fruits of *Schisandra chinensis*. Their structures were established as dihydrophaseic acid-3-O-β-D-glucopyranoside (I), benzyl alcohol-O-β-D-glucopyranosyl (1→6)-β-D-glucopyranoside (II), benzyl alcohol-O-β-D-glucopyranosyl (1→2)-β-D-glucopyranoside (III), (+)-isoscoparin (IV) and quercetin-3-O-β-L-rhamnopyranosyl (1→6)-β-D-glucopyranoside (V) based on the analysis of spectral data of IR, FAB-MS and NMR. The most important ingredients of the drug are vitamins C and E, essential oil and lignans found especially in the seeds and these compounds are responsible for various pharmaceutical activities.[43] Choi *et al.*[44] found that phytochemical investigation of the fruits of *Schisandra chinensis* led to the isolation of 13 lignans including schisandrene (13), a new lignin based on a dibenzocyclooctadiene backbone with an exocyclic double bond. On the basis of their research, the structure-activity relationships of the dibenzocyclooctadiene lignans showed that the exocyclic methylene functionality was essential for antioxidant activity. Essential oils, triterpenoids, polysaccharides, vitamins, bioelements, phytosterols and organic acids are other important ingredients of this traditional medicinal plant.[45,46] The presence of gentisic acid and flavonoids: hyperoside, isoquercitrin, rutin and quercetin also reported.[47] The two

Table 1: Information about characteristics of *S. chinensis*.[35]

Alias	Wuweizi, Beiwuweizi
Shape of fruit	Irregular round or oblatoid
Surface	Soft and glossy
Diameter of single fruit	6-8 mm
Color of fruit	Vivid red, with white-frost on its surface
Fruit maturation period	July-October
Distribution	Northern or northeastern China and eastern Asia.

Table 2: The five important components from *S. chinensis* fruit.[55]

Name	Formula	Molecular weight	Melt point
Schisandrol B	$C_{23}H_{28}O_7$	416	80°C
Schisandrin A	$C_{24}H_{32}O_6$	416	114 °C
γ-Schisandrin	$C_{23}H_{28}O_6$	400	126 °C
Gomisin N	$C_{23}H_{28}O_6$	400	126 °C
Schisandrin C	$C_{22}H_{24}O_6$	384	122 °C

most important lignin analogs isolated from *Schisandra chinensis* are gomisin C (GC) and gomisin G (GC) which can reach up to 0.79 mg/g and 0.69 mg/g, respectively.[48] Schisandrin and schisandrin B are the most abundant lignin constituents in the berries. Among the phenolic acids that have been detected in *S. chinensis* fruit dominate derivatives of benzoic acid.[49] Gao *et al*.[50] introduced Schisandrin, Schisandrol B, Deoxyschisandrin, Gomisin H and Schisandrin B as the five major lignans in *S. Chinensis* oils. Ma *et al*.[51] Identified seven compounds including schizandrin, schisandrol B, Schisantherin B, schisantherin A, schisanhenol, deoxyschizandrin and schisandrin B as the main antioxidants in *Schisandra chinensis*. Chemical structure of Gomisin C (GC) and Gomisin G (GG) is shown in Figure 1. They have same molecular weight and similar chemical structures. They possess a bulky benzoyl at the same position, while the methylenedioxy group locates at different positions.[52] Chemical structure of Gomisin C and Gomisin G are shown in Figure 1. Chemical structures of shizandrin and gomisin A are indicated in Figure 2. Chemical structures of dibenzocyclooctadiene lignans a) schisandrin, b) schisandrin B and c) schisandrin C are presented in Figure 3. Chemical structure of phytosterols components identified in *S. chinensis* oil are shown in Figure 4. Chemical structure of Deoxyschisanrin is indicated in Figure 5. The five important components from *S. chinensis* fruit are shown in Table 2. Chemical composition of the fruit essential oil from *Schisandra chinesis* (Turz.) Baill is shown in Table 3. Mineral analysis of *S. chinensis* by inductive coupled plasma optical emission spectrometer (ICP-OES) is shown in Table 4.

Baek *et al*.[58] reported that the complete mitochondrial genome sequence of *S. chinensis* was 946,141 bp in length and a phylogenetic tree based on the mitochondrial genome demonstrated that *S. chinensis* was most closely related to *Schisandra sphenanthera* of the Schisandraceae family. Phylogeny of *S. chinensis* and 11 related species based on their mitochondrial genome sequences.

Table 3: Chemical composition of the fruit essential oil from *Schisandra chinesis* (Turz.) Baill.[56]

Limonene
β-Phellandrene
p-Cymene
γ-Terpinene
Terpinolene
Terpinen-4-ol
Thymol methyl ether
Bornyl acetate
Cycloisosativene
Ylangene
α-Cubebene
β-Bourbonene
Sativen
β-Elemene
α-Santalene
Bicyclo[4.4.0]dec-1-ene,2-isopropyl-5-methyl-9-methylene
α-Gurjunene
β-Farnesene
Caryophyllene
γ-Cadinene
α-Cedrene
α-Bergamotene
Epizonarene
Bicyclogermacrene
α-Muurolene
γ-Muurolene
2-tert-butyl-1,4-dimethoxybenzene
β-Chamigrene
α-Himachalene
α-Chamigrene
Acoradiene
β-Cadinene
Isoledene
Cuparene
β-Himachalene
Nerolidol
β-Neoclovene
δ-Cadinene
Tricyclo[4.4.0.0(2,7)]dec-3-ene-3-methanol,1-methyl-8-(1-methylethyl)-
Longipinene
Calamenene
Total identified
Monoterpene hydrocarbons
Oxygenated monoterpenes
Sesquiterpene hydrocarbons
Oxygenated sesquiterpenes

HEALTH BENEFITS IN MODERN AND TRADITIONAL SCIENCE TRADITIONAL MEDICINE

In traditional medicine, the berry extracts of *S. chinensis* are considered as both tonic and liver protective agents and they are currently referred as adaptogens.[59] In Traditional Chinese Medicine (TCM), *schisandra* berries are plants that belong to the 'Herbs that stabilize and bind' category. This category of herbs is used for treating abnormal discharges and displacement of organs. This includes conditions such as diarrhea, discharges from the vagina, penis or rectum as well as prolapse of the uterus or rectum. It is important to note that herbs in this category only treat symptoms, so one should also use herbs to treat the underlying Deficiency. Moreover, *schisandra* berries are plants that are Warm in nature. This means that *schisandra* berries tend to help people who have too much "cold" in their body, although with less effect than a plant that would be Hot in nature. Balance between Yin and Yang is a key health concept in TCM. Those who have too much cold in their body are said to either have a Yin excess (because Yin is Cold in nature) or a Yang deficiency (Yang is Hot in Nature). Depending on your condition schisandra berries can help restore a harmonious balance between Yin and Yang. *Schisandra* berries also taste Sour and Sweet. The so-called "five elements" theory in Chinese Medicine states that the taste of TCM ingredients is a key determinant of their action in the body.[60] Sour ingredients like *schisandra* berries help with digestion and restrain abnormal discharges of fluids from the body, such as diarrhea or heavy sweating. On the other hand Sweet ingredients tend to slow down acute reactions and detoxify the body. They also have a tonic effect because they replenish Qi and Blood. It has been reported in both Chinese traditional medicine, it has been used to treat diabetes, palpitation, insomnia, nocturnal enuresis, dysentery, cough, asthma, phlegm and jaundice. In Korea, Schizandrae fructus has been used to make tea or liquor because of its five-kind flavors of pungency, sweetness, sourness, bitterness and saltiness.[61] *S. Chinensis* can treat lung-Qi and kidney-Yin deficiencies, relieve coughs and asthma and stop persistent diarrhea.[62] *S. chinensis* has been used to treat sleep disorder in traditional Chinese medicine. Hu *et al*.[63] also mentioned the positive influence of *S. chinensis* as a tonic for kidney and brain in traditional Chinese medicine. Sun *et al*.[64] introduced *Schisandra chinensis* as a traditional Chinese medicine and Schisandra red pigment as an important antioxidant helpful in anti-aging study. Schisanda berries have mainly been used for the lungs and kidneys as an astringent tonic and also as antihepatotoxic, antiasthmatic, antitussive, sedative and tonic medicine. Nowak *et al*.[65] reported that *S. chinensis* extract may apply as a preservative and as an additive to increase the flavor, taste and nutritional value of food.

Common TCM formulas in which Schisandra berries are used:

a) For impotence, spermatorrhea, premature ejaculation, weak and low sperm count combine *schisandra* berries with plantain seeds (Che Qian Zi), cuscuta seeds (Tu Si Zi), goji berries (Gou Qi Zi) and palmleaf raspberries (Fu Pen Zi).

b) For symptoms of exhaustion and fatigue with shortness of breath,

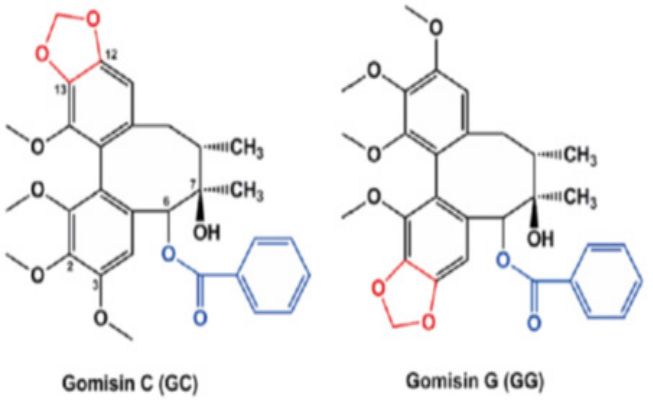

Figure 1: Chemical structure of Gomisin C (GC) and Gomisin G (GG).[52]

Table 4: Mineral analysis of *S. chinensis* by inductive coupled plasma optical emission spectrometer (ICP-OES) (μg/g).[57]

Mineral	*S. chinensis* (μg/g)
B	209.0
Ca	12000.0
Co	1.1
Cr	24.9
Cu	11.5
Fe	983.0
Mg	1220.0
Mn	644.0
Ni	14.3
Pb	1.0
Se	0
Sr	99.3
Zn	175.0

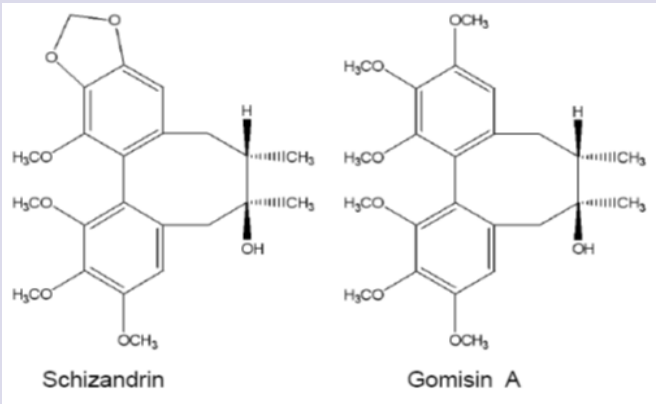

Figure 2: Chemical structures of shizandrin and gomisin A.[53]

Table 5: The most important pharmacological effects of *S. chinensis* fruit.

Name	Pharmacological impacts
Schisandrol B	Anti-allergy; liver protection; anticarcinogenic effects
Schisandrin A	Liver protection anti-carcinogenic effect
γ-Schisandrin	Liver protection; anticarcinogenic effect
Gomisin N	Anti-proliferative, pro-apoptis HepG2 cells, anti-hepatitis; anti-HIV; anticarcinogenic effect
Schisandrin C	Protect liver; anti-HIV; anticatcinogenic effect, anti-hepatitis

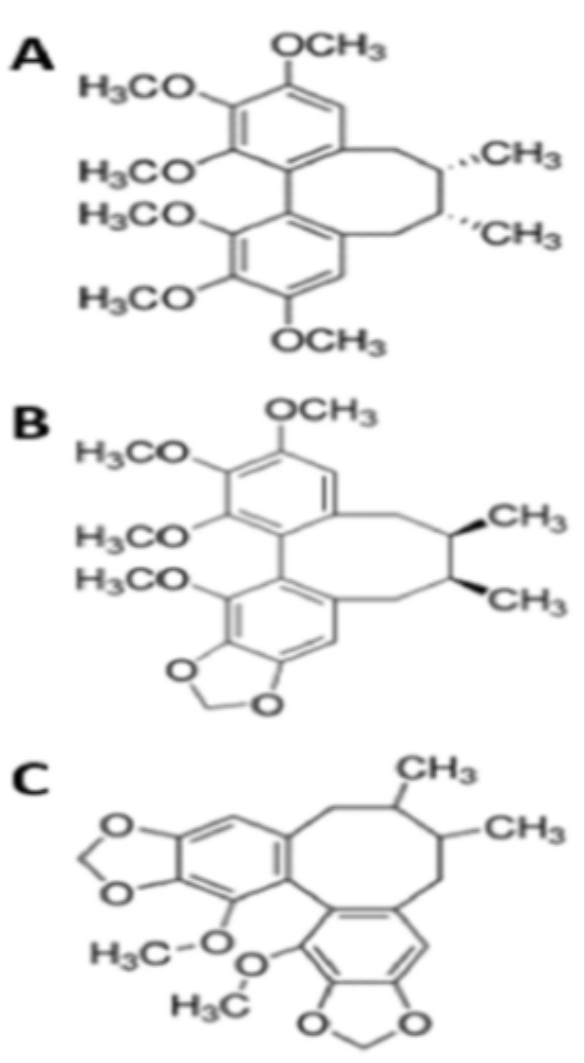

Figure 3: Chemical structures of dibenzocyclooctadiene lignans a) schisandrin, b) schisandrin B and c) schisandrin C.

excessive perspiration and thirst combine *schisandra* berries with ginseng (Ren Shen) and dwarf lilyturf roots (Mai Dong).

c) For asthma, cough combine *schisandra* berries with lingzhi mushroom (Ling Zhi), codonopsis roots (Dang Shen), prepared aconite (Zhi Fu Zi) and crow-dipper rhizomes (Ban Xiao).

d) For fluid accumulation with cough, wheezing combine *schisandra* berries with coltsfoot flowers (Juan Dong Hua) and crow-dipper rhizomes (Ban Xia).

MODERN PHARMACEUTICAL SCIENCE

The most important pharmacological lignans activities of this plant include neuro-effects, cardio- and hepatoprotective effects and anti-cancer activities.[66,67] Lignans also can ameliorate learning and memory deficits.[67] Zhang *et al.*[69] reported that lignin and triterpenoid compounds in *S. chinensis* have biological activities on diseases related to aging and cancer. It has been reported that dibenzocyclooctene lignans, such as schisandrol A, deoxyschizandrin, schisantherin A, schisandrin B and schisandrin C are the key bioactive constituents for hepatoprotective, anticancer, antiasthmatic, anti-inflammatory, sedative, hypnotic, anxiolytic effects and one of the best preventive for Alizheimer 's disease.[70,71] Polysaccharides modulate immune function and increase antioxidant activities, contributing directly to the therapeutic impacts of *Schisandra chinensis*. Schisandrin B has been reported to protect murine brain against beta amyloid toxicity,[72] protect liver against chemically induced toxicity,[73] inhibits cortical neuronal damage in a rat stroke model. α-cubebnoate is a natural compound of *S. chinensis* which is a powerful potential anti-septic agent. Lee *et al.*[74] indicated that α–Cubebenoate has an inhibitory influence on allergic inflammation and could be utilized as an agent for the treatment of asthma. Choo *et al.*[75] concluded that *S. chinensis* extract has a dose relaxation impact on human prostate tissue and additive influence with tamsulosin. *S. chinensis* may be effective as a complementary medicine in Cyclophosphamide treatment. Gomisin G showed the most anti-HIV pharmacological activity with an EC_{50} value of 0.006 μg/ml among all other natural dibenzocyclooctadiene lignans which have been isolated from *Schisandra chinensis*.[76] Yang *et al.*[77] stated that *Schisandra chinensis* polysaccharide (SCP) revealed considerable potential in clinical applications because of excellent immunostimulatory effects on the ompA-Fc vaccine and promoting macrophages activity. Chung *et al.*[78] suggested that *Schisandra chinensis* berry ethanol extract (SCE) has potential to consider as a novel therapeutic agent for the prevention of steatosis. Park *et al.*[79] indicated that *Schisandra chinese* (SC) extracts showed preadipocyte differentiation and adipogenesis in cultured cells which may lead to decrease body weight and fat tissue in rats. Park *et al.*[80] also showed the role of SC as a medical herb for treatment of cardiovascular symptoms associated with menopausal symptoms. *S. Chinensis* polysaccharide (SCAP) has a therapeutic impact on streptozotocin (STZ) and this protective influence maybe mediated via preventing the apoptosis of β-cells by inhibiting the expression of phosphor C-Jun N-terminal kinase (JNK) and related apoptotic proteins.[81] Modern pharmacological research has demonstrated that most of the biological actions and pharmacological effects of Wuweizi can be attributed to its lignan constituents, particularly the dibenzocyclooctadiene-type lignans, which can lower the serum glutamate-pyruvate transaminase (SGPT) level, inhibit platelet aggregation and show antioxidative, calcium antagonism, antitumor-promoting and anti-HIV (human immunodeficiency virus) effects.[82] Rybnikar *et al.*[83] found that their activity has been investigated in hundreds of studies that have confirmed adaptogenic effects, central nervous system stimulation, hepatoprotective effects and potential anticancer potential. Jang *et al.*[84] confirmed that *S. Chinensis* may be useful as a pharmacological agent for protection against Endoplasmic reticulum (ER) stress-induced human diseases. Wang *et al.*[85] found that *Schisandra chinensis* has ability to resist acetaminophen-induced hepatotoxicity by protecting mitochondria and lysosomes which provides a novel application of it against acetaminophen-induced acute liver failure. Kang *et al.*[86] found that α-Cubebnoate may act as an anti-fatigue constituent of *Schisandra chinensis* through anti-inflammation and it can be considered as a treatment for inflammatory diseases. Lee *et al.*[87] discovered that α-iso-cubebene should be useful for the development of an immune-modulating agent. Chun *et al.*[88] reported that *S. Chinensis* extract has vasorelaxant, anti-fibrotic and anti-oxidant effect, Schisandrin B has vasorelaxant, anti-fibrotic, anti-inflammatory, anti-oxidant and anti-apoptotix, Gomisin has anti-oxidant and anti-apoptotic effects, both Schisandrin A and Schisandrin C has anti-oxidant impacts. Mu *et al.*[89] stated that Wu Wei Zi (*Schisandra chinensis*) increased the metabolism of the coadministered warfarin, reinforcing concerns involving the safe use of herbal medicines and other nutraceuticals to avoid PXR-mediated drug-drug interactions. The most important pharmacological effects of *S. chinensis* fruit is shown in Table 5. The most important health benefits of *Schisandra* berries is presented in Table 6.

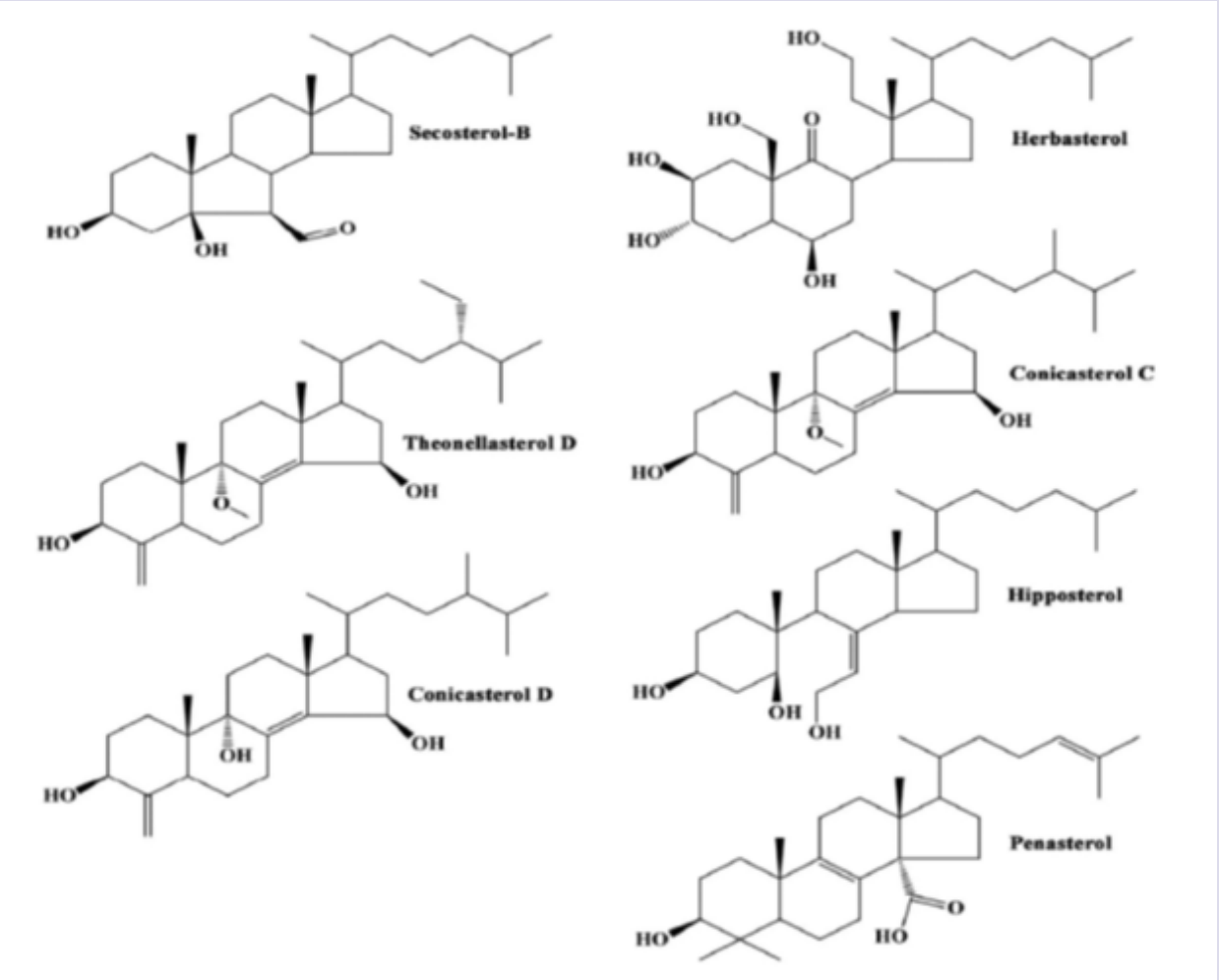

Figure 4: Chemical structure of phytosterols components identified in S. chinensis oil.[54]

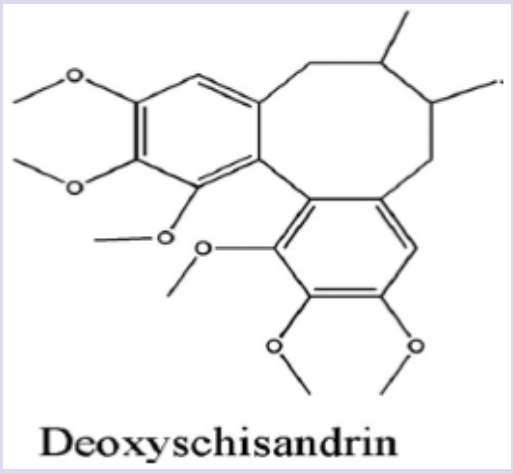

Figure 5: Chemical structure of Deoxyschisanrin.

Table 6: The most important health benefits of *Schisandra* berries.

Anti-inflammatory
Increasing energy
Improving vision
Boosting muscular activity
Improving cellular health and preventing premature aging
Liver disease (Hepatitis, cirrhosis)
Protection against radiation
Diabetes and regulation of blood glucose levels
Motion sickness.
Modulating blood pressure.
Preventing infection.
Improving digestion.
Decreasing night sweats and spontaneous sweating.
Improve physical exhaustion.
Decrease excessive urination.
Improve mental health (Depression, Brain fog, Concentration).

CONCLUSION

Schisandra chinensis (*S. Chinensis*) is a famous traditional Chinese medicine, which was recorded first in Shennong Bencao Jing. It has a long therapeutic history for thousands years and is currently serving in many countries, especially Asian countries. *Schisandra chinensis* is a famous traditional Chinese medicine and has been used in China for thousand years. A native of Asia, *Schisandra* is a woody vine that produces bright red fruits at the end of summer; the fruits are then harvested and utilized for their extensive medicinal properties. The Chinese call it ***wu wei zi*** or "fruit of five flavors", which means that *Schisandra* incorporates all of the five tastes (sour, salty, bitter, sweet and pungent). Because of this distinctive quality it was thought to be an especially important tonic medicine. Based on the "Five-Element" theory in TCM, while the "five tastes" of Schisandra berry refer to its influence on the five visceral organs in the body, ancient Chinese herbalists specifically trumpeted the berry's beneficial effect on the "Qi" of the five visceral organs. The five important components of *S. chinensis* are Schisandrol B, Schisandrin A, γ-Schisandrin, Gomisin N and Schisandrin C. The most important pharmacological effects of Schisandrol B are anti-allergy, liver protection and anticarcinogenic effects; Schisandrin A has role in liver protection and anti-carcinogenic effect; γ-Schisandrin has liver protection and anti-carcinogenic effect, Gomisin N has anti-proliferative, pro-apoptis HepG2 cells, anti-hepatitis, anti-HIV, anti-carcinogenic effect; and Schisandrin C has protect liver, anti-HIV, anti-catchinogenic effect and anti-hepatitis. The most important health benefits of Schisandra berries are anti-inflammatory, increasing energy, improving vision, boosting muscular activity, improving cellular health and preventing premature aging, liver disease, protection against radiation, diabetes and regulation of blood glucose levels, motion sickness, modulating blood pressure, preventing infection, improving digestion, decreasing night sweats and spontaneous sweating, improve physical exhaustion, decrease excessive urination and improve mental health. All in all, in conclusion *S. chinensis* can promote good health as a modern medicine with considering its important traditional pharmaceutical usages.

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Disclosure

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

Authors' Contribution

All authors equally contributed to this study.

ABBREVIATIONS

TCMs: Traditional Chinese Medicine; **SFDA:** State Food and Drug Administration; **GC:** Gomisin C; **ICP-OES:** Inductive Coupled Plasma Optical Emission Spectrometer; **SCP:** Schisandra Chinensis Polysaccharide; **SCE:** Schisandra Chinensis Extract; **SC:** Schisandra chinese; **SCAP:** S. Chinensis Polysaccharide; **JNK:** C-Jun N-terminal Kinase; **SGPT:** Serum Glutamate-Pyruvate Transaminase; **ER:** Endoplasmic reticulum.

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SUMMARY

- *Schisandra chinensis* (*S. chinensis*) is a famous traditional Chinese medicine, which was recorded first in Shennong Bencao Jing.
- It has a long therapeutic history for thousands years and is currently serving in many countries, especially Asian countries.
- *Schisandra chinensis* is a famous traditional Chinese medicine and has been used in China for thousand years.
- A native of Asia, Schisandra is a woody vine that produces bright red fruits at the end of summer; the fruits are then harvested and utilized for their extensive medicinal properties.
- It was thought to be an especially important tonic medicine. Based on the "Five-Element" theory in TCM, while the "five tastes" of Schisandra berry refer to its influence on the five visceral organs in the body, ancient Chinese herbalists specifically trumpeted the berry's beneficial effect on the "Qi" of the five visceral organs.
- The five important components of *S. chinensis* are Schisandrol B, Schisandrin A, γ-Schisandrin, Gomisin N and Schisandrin C.
- The most important pharmacological effects of Schisandrol B are anti-allergy, liver protection, and anticarcinogenic effects; Schisandrin A has role in liver protection and anti-carcinogenic effect; γ-Schisandrin has liver protection and anti-carcinogenic effect, Gomisin N has anti-proliferative, pro-apoptis HepG2 cells, anti-hepatitis, anti-HIV, anti-carcinogenic effect; and Schisandrin C has protect liver, anti-HIV, anti-catchinogenic effect and anti-hepatitis.
- The most important health benefits of Schisandra berries are anti-inflammatory, increasing energy, improving vision, boosting muscular activity, improving cellular health and preventing premature aging, liver disease, protection against radiation, diabetes and regulation of blood glucose levels, motion sickness, modulating blood pressure, preventing infection, improving digestion, decreasing night sweats and spontaneous sweating, improve physical exhaustion, decrease excessive urination and improve mental health.

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PICTORIAL ABSTRACT