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A Comprehensive Review of Malinzi: Botany, Medicinal Uses, Phytochemistry, and Pharmacological Properties

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ABSTRACT

Malinzi, the dried mature seed of Iris lactea Pall. var. chinensis (Fisch.) Koidz, is a traditional medicinal plant with considerable potential for development and utilization. Research has identified 31 compounds in Malinzi, including flavonoids, quinones, oligostilbenes, and other bioactive constituents. Contemporary pharmacological studies indicate that Malinzi exhibits notable anti-tumor, radiosensitizing, immunomodulatory, antioxidant, antifertility, and glucolipid metabolic effects. This paper reviews both domestic and international studies on Malinzi, summarizing its traditional applications, chemical composition, and pharmacological properties, aiming to provide a theoretical foundation for future in-depth research and practical use.

Keywords: Pharmacological activities, Chemical constituents, Traditional uses, Malinzi

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Introduction

Traditional Chinese medicine (TCM) has been practiced for millennia and continues to play an important role in modern healthcare. Iris lactea Pall. var. chinensis (Fisch.) Koidz, a perennial herb of the Iridaceae family [1], represents a valuable medicinal plant resource. Its natural distribution spans northwest, northern, eastern, and northeastern China, as well as parts of central and western Asia, Russia, Mongolia, and Korea [2]. The species typically grows in degraded grasslands, roadsides, hillsides, and saline-alkali areas affected by overgrazing, and is also found along coastal regions in China and Korea. Thanks to its high salt tolerance and vigorous reproductive capacity, it can thrive in shaded roadside areas and is sometimes cultivated in seaside gardens [3].

Malinzi, the dried mature seed of Iris lactea Pall. var. chinensis (Fisch.) Koidz, usually appears as an irregular polyhedron with a reddish-brown, slightly glossy surface. Historically known as Lishi in Shennong Ben Cao Jing [4], it was later referred to as Malinzi in the Tang Materia Medica [5]. In TCM, Malinzi is described as having a pungent-sweet flavor and neutral properties, acting on the lung, spleen, stomach, and liver meridians. Traditionally, it has been employed to clear heat, remove dampness, detoxify, disperse lumps, stop bleeding, and eliminate parasites. Its therapeutic applications include treating jaundice, urinary difficulties, intestinal abscesses, parasitic infections, malaria, rheumatic conditions, throat obstruction, toothache, gastrointestinal bleeding, abnormal uterine bleeding, scrofula, genital disorders, hemorrhoids, burns, and snakebites. Recent pharmacological research has focused on its chemical profile and biological effects, including the use of irisquinone capsules from its seed coat as a radiosensitizer, which is now incorporated into the Chinese New Drug Conversion Standard.

This review aims to summarize current knowledge of Malinzi, covering its botanical characteristics, traditional uses, medicinal applications, chemical constituents, and pharmacological activities, providing a foundation for further research, development, and practical utilization.

Botany

Iris lactea Pall. var. chinensis (Fisch.) Koidz is a herbaceous perennial reaching 40–60 cm in height, with a thick, lignified, and slightly ascending rhizome, complemented by long yellowish-white fibrous roots. Its leaves are tough, upright, and clustered, with long, narrow laminae measuring 40–50 cm in length and 4–6 mm in width, tapering to pointed tips. The flowers are bluish to purplish, 5–6 cm in diameter, with six perianth segments arranged in two whorls. The fruit is a long cylindrical capsule, 4–6.3 cm long and 1–1.3 cm wide, featuring six longitudinal ridges and a beaked apex **(Figure 1a)**, while the seeds are irregular polyhedra with a dark brown hue **(Figure 1b)** [6].

The plant is widespread across northern and eastern China and extends to parts of central and western Asia, Russia, Mongolia, and Korea [2, 7]. It thrives mainly in grasslands, with limited presence in forests and deserts, and can grow on poor soils, including wastelands, roadsides, natural grasslands, and saline-alkali coastal areas [8]. In China, salinized meadows containing this species cover approximately 398,700 hectares [8]. The species possesses a robust root system and exhibits strong tolerance to cold, drought, pests, and salinity, allowing growth in arid hills, alpine meadows, wastelands, and wetlands [9–11]. As a result, it is widely used in environmental restoration, greening projects, soil and water conservation, and the rehabilitation of saline-alkali lands, desertified areas, and dry climates in northern China. Shi reported its ability to mitigate soil erosion, shallow landslides, and related geological hazards [12], and Sun explored how different low-temperature treatments and rhizome ramet counts influence its reproductive capacity [13].

a) b)

Figure 1. (a) Iris lactea Pall. var. chinensis (Fisch.) Koidz, (b) Malinzi

Herbal medicine authentication

Due to the large variety of plants in nature, many Iridaceae species exhibit similar external characteristics, which can make distinguishing authentic Malinzi challenging. Its wide sources, diverse specifications, and the prevalence of counterfeits make accurate identification critical. Current methods for confirming Malinzi authenticity primarily involve chemical and microscopic analyses. Each method has its unique advantages and may be used independently or in combination to achieve reliable identification. Continuous refinement of these techniques has improved the accuracy of verifying Malinzi's origin and established a solid foundation for further research and development.

Microscopic identification

The seed coat epidermis consists of neatly arranged rectangular cells with thickened walls, interspersed with reddish-brown granules and a cuticle layer on the outer wall. Beneath this are 5–7 layers of shrunken parenchyma cells, while the innermost layer contains 3–4 rows of orderly brown flattened cells. Endosperm cells are rounded or oblong with thickened walls and contain aleurone granules.

Powdered Malinzi appears tan. Epidermal cells of the seed coat are oblong, round, or polygonal with thick walls and brown-red granules. Cells within the seed coat are irregularly shaped, yellow, and exhibit tumor-like wall thickening. The endosperm cells are round to oblong, thick-walled, and contain both aleurone granules and lipid droplets.

Chemical identification

To prepare the test solution, 0.5 g of Malinzi powder is combined with 25 mL of ether, sonicated for 20 minutes, filtered, and evaporated to dryness. The residue is then dissolved in 1 mL of ether. A reference sample is prepared using the same procedure. For thin-layer chromatography (TLC), 2 μL of each solution is applied to a silica gel plate. Petroleum ether (60–90 °C) and diethyl ether (3:1) serve as the developing solvent. After development, the plate is dried and examined under sunlight and UV light (365 nm). The test solution is confirmed when spots or fluorescent bands match the positions and colors of the reference material.

Medicinal applications

Traditional uses

Malinzi has been utilized in TCM for over two millennia. It possesses a pungent-sweet flavor and neutral properties, acting on the lung, spleen, stomach, and liver meridians. Traditionally, it is used to clear heat, remove dampness, detoxify, disperse lumps, stop bleeding, and eliminate parasites. Malinzi was first documented in Shennong Bencao Jing [4], where it was described as regulating cold and heat in the skin, stomach heat, wind-cold-dampness, strengthening muscles and bones, enhancing appetite, and supporting weight management with long-term use. Mingyi Bielu [14] reported its ability to relieve restlessness, promote urination, and encourage healthy skin growth. The Tang Materia Medica [5] recorded its applications in controlling bleeding and treating abscesses, while Rihuazi Bencao [15] detailed its use for regulating women's blood and qi, alleviating postpartum dizziness, controlling abnormal bleeding, reducing sores and swelling, preventing nosebleeds, detoxifying alcohol, curing jaundice, and treating snake and polyp toxins. Furthermore, the Compendium of Materia Medica [16] noted its use for abdominal hernia pain, intra-abdominal cold accumulation, and dysentery. According to the Medical and Forestry Compilation [17], it is also employed to soften hardness and resolve blood stasis. To date, 24 classical TCM texts have recorded Malinzi's traditional therapeutic applications **(Table 1)**.

Table 1. Key Traditional Applications of Malinzi in China

Form	Ingredients	Therapeutic Use	Reference
Single herb	Malinzi 9 g, boiled in water	Jaundice with yellow, scanty urine	*Handbook of Ningxia Chinese Herbal Medicine*
Formula	Malinzi 9 g, Inula 15 g, decoction	Jaundice with yellow, scanty urine	*Hubei Chinese Herbal Medicine*
Formula	Malinzi 60 g, rock sugar 15 g, stewed	Gonorrhea	*Folk Practical Herbal Medicine*
Formula	Malinzi 6 g, Plantago ovata 9 g, decoction	Difficult urination	*Handbook of Shandong Chinese Herbal Medicine*
Formula	Malinzi 25 g, knotgrass 10 g, Mucuna pruriens 10 g, decoction	Difficult urination	*Jilin Chinese Herbal Medicine*
Formula	Malinzi 9 g, knotgrass 9 g, plantain 9 g, decoction	Difficult urination	*Handbook of Ningxia Chinese Herbal Medicine*
Formula	Malinzi 9 g, Huangra bark 9 g, decoction	Early-stage dysentery	*Xining Chinese Herbal Medicine*
Single herb	Malinzi 49 seeds, pounded and ingested with water	Laryngeal paralysis	*Taiping Holy Prescriptions for Universal Relief*
Formula	Malinzi 2.4 g, Burdock 1.8 g, powdered, taken with water	Throat swelling and pain	*Guang Ji Fang*
Formula	Chuan Sheng Ma 50 g, Malinzi 100 g, dispersed, 3.75 g per dose	Throat swelling and pain	*Taiping Holy Prescriptions for Universal Relief*
Formula	Malinzi 6 g, White Fescue Root 30 g, Xianhecao 15 g, decoction	Nosebleeds, vomiting blood	*Handbook of Shandong Chinese Herbal Medicine*
Single herb	Malinzi 30 g, fried black, 6 g per dose	Nosebleeds	*Jilin Chinese Herbal Medicine*
Formula	Malinzi 9 g, cumin 6 g, neem 9 g, decoction	Painful hernia	*Handbook of Liaoning Chinese Herbal Medicine*
Single herb	Malinzi 9 g, fried in vinegar, decoction	Cold hernia	*Anhui Chinese Herbal Medicine*
Formula	Malinzi 18 g, Douluo 24 g, decoction	Uterine cancer	*Tianjin Chinese Herbal Medicine*

Formula	Malinzi 9 g, Douluo 15 g, Bei Chonglou 15 g, ground, 9 g per dose	Uterine cancer	*Handbook of Plateau Chinese Herbal Medicine Treatment*
Formula	Malinzi 6 g, Amaranthus officinalis 30 g, Dandelion 30 g, decoction	Canker sores, boils	*Handbook of Qingdao Chinese Herbal Medicine*
Single herb	Malinzi roasted with fragrant oil	Canker sores, boils	*Tianjin Chinese Herbal Medicine*
Single herb	Malinzi fried and dried, powdered, 5–7 g per dose	Bone tuberculosis	*National Chinese Herbal Medicine*
Single herb	Malinzi boiled with flour, ingested with hollow rice	Dysentery	*Zhang Wenzhong Formulary for Emergency*
Formula	Malinzi, dried ginger, Huang Lian, boiled in soup	Dysentery	*Zhang Wenzhong Formulary for Emergency*
Formula	Malinzi 500 g, ground, soaked in wine with realgar and orpiment 200 g each, formed into pills	Intestinal bleeding	*Prescriptions for Universal Relief*
Formula	Chuan Sheng Ma 50 g, Malinzi 100 g, dispersed, 3.75 g per dose	Throat paralysis and swelling	*Taiping Holy Prescriptions for Universal Relief*
Formula	Malinzi 9 g, Malus officinalis 9 g, Pomegranate peel 12 g, ground	Excessive menstruation	*Handbook of Xinjiang Chinese Herbal Medicine*
Single herb	Malinzi 10 g, boiled with flour	Cold hernia with poor appetite	*Yao Sengyuan Ji Yan Fang*
Single herb	Malinzi 3–9 g, decoction	Painful hernia	*National Chinese Herbal Medicine*

Patent medicines containing malinzi

Malinzi is incorporated into several traditional patent medicines in both Tibetan and Chinese medicine. Shiliuweimalinziwan, a Tibetan formulation, combines Malinzi with 15 other herbs including Przewalskia tangutica Maxim. and cardamom [18]. This pill is traditionally employed for its astringent and anti-inflammatory properties, supporting respiratory health, promoting mucosal recovery, alleviating cough, and reducing phlegm. Modern pharmacological analysis indicates that gallic acid is a key bioactive component responsible for these effects [19].

Another preparation, Shisanwei Malin San, integrates 13 ingredients such as Malinzi, R. tibetica Hook.f., Ficus benghalensis secretion, Symplocos caudata Wall. ex G.Don, crab, Przewalskia tangutica, Veronica eriogyne, Canavalia gladiata, Mangifera indica seeds, Syzygium jambos, Caesalpinia bonduc, lapis micae aureus, and sal ammoniac [20]. The resulting powder is purple, aromatic, and has a slightly spicy-bitter taste. Clinically, it is utilized to manage inflammation, support diuresis, and address testicular swelling [21].

Nine-Flavored Ciwujianhua Powder is a multi-herb TCM formula designed to strengthen kidney yin, nourish essence and marrow, and regulate internal homeostasis. Its composition includes nine botanical ingredients such as Cistanche deserticola, Salvia miltiorrhiza, wolfberries, Chinese dates, Chinese yam, black sorghum, cabbage, and Silvianthus bracteatus Hook. f. [22–24]. This formula is particularly indicated for patients with kidney yin deficiency manifesting as impotence, nocturnal emissions, or generalized weakness following illness [25, 26].

Anka (Irisquinone capsules) has been developed as a radiosensitizing agent. Research demonstrates that Anka can enhance the therapeutic effects of radiotherapy for cancers such as lung and esophageal tumors, promoting faster lesion reduction and higher rates of complete remission [27, 28]. Irisquinone, the principal active component, has been quantified through RP-HPLC and single-sweep oscillopolarography, and its effective concentration range has been established [29, 30]. Efforts to improve irisquinone's solubility and bioavailability led to the formation of a hydroxypropyl-β-cyclodextrin (HP-β-CD) inclusion complex. This modification substantially increases intestinal absorption and enhances bioavailability to 133.9 % [31].

Chemical profile of malinzi

Extensive phytochemical investigations have identified 31 distinct compounds from Malinzi. These can be grouped into flavonoids (compounds 1–6), quinones (7–11), oligostilbenes (12–20), and miscellaneous constituents (21–31). Among these, flavonoids and benzoquinones are considered the primary active agents. Different extraction methods were employed to isolate these compounds, including NaOH aqueous solution (4

compounds), 85 % ethanol (4), ethyl acetate (5), 95 % ethanol (5), petroleum ether (7), and ether (6) **(Tables 2 and 3; Figures 2 and 3)**.

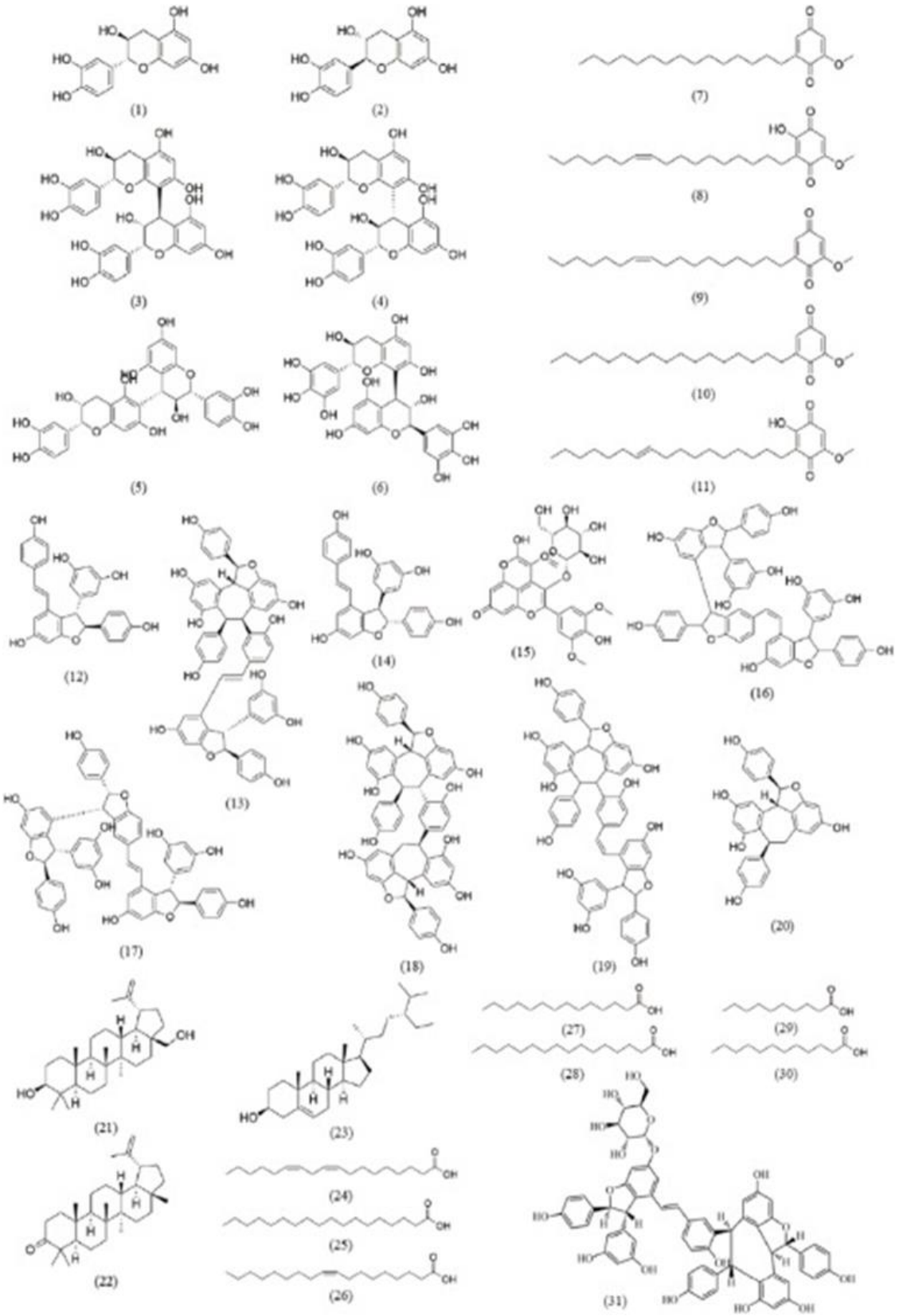

Figure 2. Molecular structures of the 31 distinct compounds extracted from Malinzi (labeled 1–31).

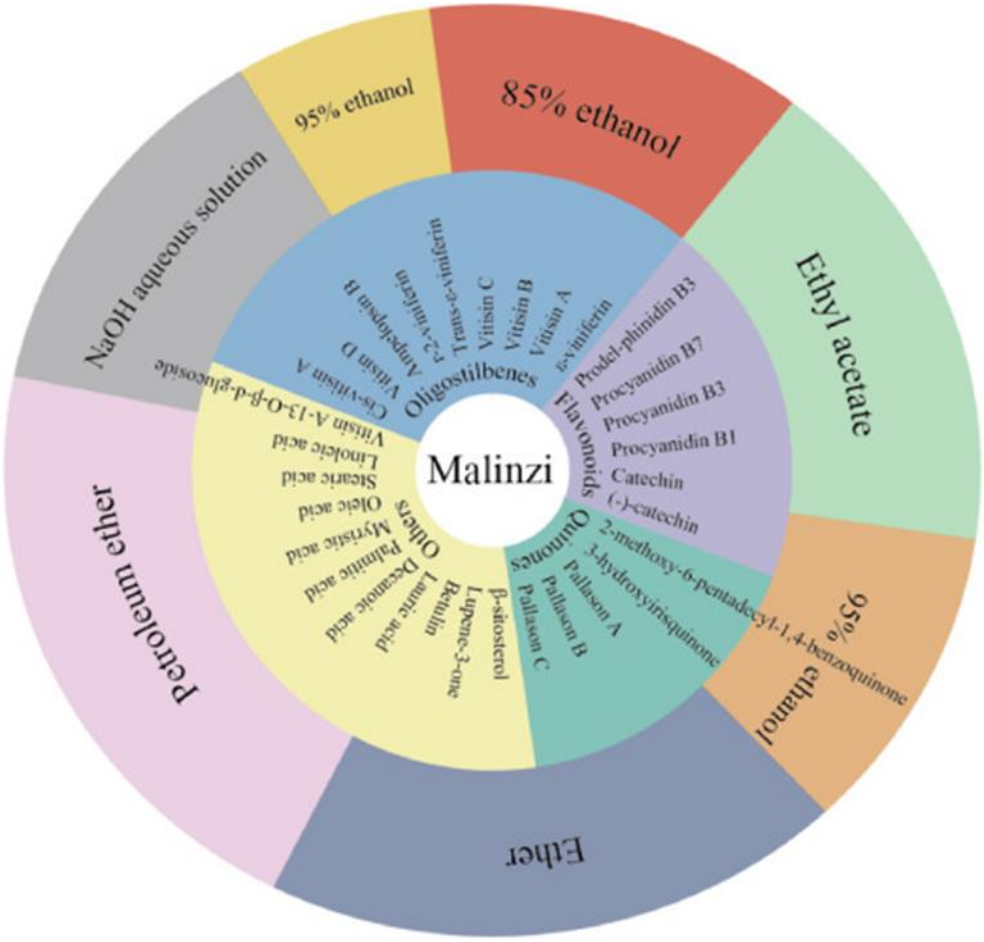

Figure 3. Circular representation of the 31 compounds isolated from Malinzi, with the inner ring indicating their chemical classification and the outer ring specifying the type of extraction solvent used.

Table 2. The parts of compounds isolated from Malinzi.

Type	No.	Name	Source	References
Flavonoids	1	Catechin	Ethyl acetate	[32]
	2	(−)-catechin	95 % ethanol	[33]
	3	Procyanidin B1	Ethyl acetate	[32]
	4	Procyanidin B3	Ethyl acetate	[32]
	5	Procyanidin B7	Ethyl acetate	[32]
	6	Prodel-phinidin B3	Ethyl acetate	[34]
Quinones	7	2-methoxy-6-pentadecyl-1,4-benzoquinone	95 % ethanol	[33]
	8	3-hydroxyirisquinone	95 % ethanol	[33]
	9	Pallason A	Ether	[35]
	10	Pallason B	Ether	[36]
	11	Pallason C	Ether	[36]
Oligostilbenes	12	*Trans*-ε-viniferin	95 % ethanol	[37]
	13	r-2-viniferin	95 % ethanol	[37]
	14	ε-viniferin	85 % ethanol	[38]
	15	Vitisin A	85 % ethanol	[38]
	16	Vitisin B	85 % ethanol	[38]

	17	Vitisin C	85 % ethanol	[38]
	18	Vitisin D	NaOH aqueous solution	[39]
	19	*Cis*-vitisin A	NaOH aqueous solution	[39]
	20	Ampelopsin B	NaOH aqueous solution	[39]
Others	21	Betulin	Ether	[40]
	22	Lupene-3-one	Ether	[40]
	23	β-sitosterol	Ether	[40]
	24	Linoleic acid	Petroleum ether	[41]
	25	Stearic acid	Petroleum ether	[41]
	26	Oleic acid	Petroleum ether	[41]
	27	Myristic acid	Petroleum ether	[41]
	28	Palmitic acid	Petroleum ether	[41]
	29	Decanoic acid	Petroleum ether	[41]
	30	Lauric acid	Petroleum ether	[41]
	31	Vitisin A-13-*O*-β-*d*-glucoside	NaOH aqueous solution	[42]

Table 3. Statistical summary of pharmacological activities of Malinzi

Pharmacological Effect	Active Component	Model/Cell Line/Patients	Observed Effect	Reference (s)
Anti-tumor	Pallasone A	H22-bearing mice	Enhanced immune response and reduced VEGF expression and microvessel density in tumors	[43]
Anti-tumor	Pallasone A	SMMC-7721, LOVO, A549, BGC-823, MCF-7 cells	Modulated cell cycle and induced apoptosis	[44]
Anti-tumor	Pallasone A	COC1/DDP cell line	Disrupted intracellular GSH/GST detoxification pathways	[45]
Anti-tumor	Pallasone A	CNE2, SUNE1, Fadu cells	Exhibited cytotoxic effects	[46]
Anti-tumor	Pallasone A	K562 cells	Increased G0/G1 phase cell proportion, decreased S phase compared to controls	[47]
Anti-tumor	Pallasone A	NCI–H1975 cells	Suppressed IAP family proteins	[48]
Anti-tumor	Pallasone A	PANC-1 cells	Inhibited proliferation, migration, and invasion	[49]
Anti-tumor	2-r-viniferin	HepG2 cells	Triggered apoptosis via G2/M phase arrest and elevated intracellular ROS	[33]
Anti-tumor	Trans-ε-viniferin	HepG2 cells	Demonstrated anti-proliferative activity against liver cancer cells	[37]
Anti-tumor	Viniferin	HepG2 cells	Arrested cells at G2/M transition in cell cycle	[50]
Immune enhancement	Pallasone A	KM mice with U14 tumors	Boosted delayed-type hypersensitivity and overall cellular immunity	[51]
Radio-sensitization	Pallasone A	Patients with advanced esophageal cancer	Improved half-dose radiotherapy effectiveness and complete remission rates	[52]
Radio-sensitization	Pallasone A	Patients with NSCLC, esophageal, head & neck, and nasopharyngeal cancers	Tumor elimination rate higher after 40 Gy compared to controls	[52]
Radio-sensitization	Pallasone A	CHO cells	Increased radiosensitivity of hypoxic cells by 59%	[53]
Radio-sensitization	Pallasone A	58 nasopharyngeal cancer patients	Significant therapeutic improvement with Pallasone A plus radiotherapy	[54]

Radio-sensitization	Pallasone A	34 esophageal cancer patients	CR & PR rates: 88.24% (treatment) vs. 86.67% (control)	[55]
Radio-sensitization	Pallasone A	145 nasopharyngeal carcinoma patients	Primary focus ER: 1.17 vs 1.07; Metastatic focus ER: 1.20 vs 1.05 (treatment vs control)	[56]
Radio-sensitization	Pallasone A	New Zealand rabbits	1 & 2 h T/M ratios and RIs decreased with 12–18 Gy radiation, while increasing in controls	[57]
Radio-sensitization	Pallasone A	C6 rat glioma cells	Downregulation of HIF-1 identified as main radiosensitization mechanism	[58]
Radio-sensitization	Pallasone A	MDA-MB231 cells and BALB/c nude mice	18F-FLT microPET/CT validated radiosensitization effects in breast cancer model	[59]
Radio-sensitization	Pallasone A	MDA-MB231 cells	Inhibited Warburg effect via HKII gene downregulation	[60]
Immune enhancement	Pallasone A	Mice	Stimulated phagocytic activity of liver reticuloendothelial system	[61]
Immune enhancement	Pallasone A	Mice	Improved normal immune cell function and modulated humoral immunity	[62]
Antioxidant	Malinzi oil	DPPH, FeSO4 assays	14 mg/mL: 71.42% DPPH scavenging; 168 mg/mL: 0.4207 mmol/L FeSO4 equivalent	[63]
Anti-fertility	Malinzi alcoholic extract	Mice	Seed coat exhibited anti-fertility and anti-germinal effects; seed kernel showed no effect	[64]
Glucolipid metabolism	Vitisin B	3T3-L1 cells	Decreased PPARγ, C/EBPα, and aP2 protein expression	[65]
Glucolipid metabolism	Oligostilbenes from Malinzi	HFD/STZ diabetic mice & 3T3-L1 cells	Modulated expression of C/EBPβ and PPARγ	[66]
Glucolipid metabolism	Oligostilbenes from Malinzi	C2C12 cells	Suppressed lipogenesis and enhanced lipolysis via PKA/HSL pathway during adipogenic transdifferentiation	[67]

Flavonoids

Malinzi is rich in flavonoids, and recent studies have focused on isolating and characterizing various flavonoids with novel structures. Wei Hou [33] extracted (−)-catechin (2) from Malinzi using 95% ethanol, followed by petroleum ether extraction. Huanhuan *et al*. separated the seed coat using ethyl acetate, n-butanol, and water; the ethyl acetate fraction was further purified via silica gel column chromatography, and high-speed countercurrent chromatography (HSCCC) yielded Catechin (1), Procyanidin B1 (3), Procyanidin B3 (4), and Procyanidin B7 (5) [32], with further isolation leading to Prodelphinidin B3 (6) [34].

Quinones

Quinones represent another major bioactive group in Malinzi, demonstrating pharmacological effects such as anti-tumor, anti-radiation, and modulation of cell proliferation. Wei Hou [33] obtained 2-methoxy-6-pentadactyl-1,4-benzoquinone (7) and 3-hydroxyirisquinone (8) from the 95% ethanol extract. Wu *et al*. [35] isolated Pallasone A (9) from ether extracts of the seed coat, identical to irisquinone reported earlier. Subsequently, Wu identified two additional novel quinones, Pallasone B (10) and Pallasone C (11), from ether extracts [36].

Oligostilbenes

Oligostilbenes are bioactive compounds in Malinzi with antioxidant, anti-tumor, hepatoprotective, and neuroprotective properties [50, 68–70], and are increasingly studied for therapeutic potential [71]. Wei Hou [37] refluxed Malinzi powder in 95% ethanol for 12 hours to isolate trans-ε-viniferin (12) and r-2-viniferin (13). Huanhuan Lv *et al*. [38] used HSCCC with a two-phase solvent system to separate four oligostilbenes: the first fraction contained vitisin A (15) and ε-viniferin (14), while the second fraction yielded vitisin B (16) and vitisin C (17). Later, Huanhuan *et al*. [39] applied alkaline extraction–acid precipitation to isolate vitisin D (18), cis-vitisin HSCCC fraction a (19), and ampelopsin B (20) from the seed kernel.

Volatile components

Li *et al*. [72] employed GC-MS to analyze ethyl ether extracts from the seed coat and identified 26 peaks using NIST libraries and reference standards, with high levels of Pallasone A, (E)-irisquinone isomer, and Pallasone B. Major volatile components included saturated and unsaturated fatty acid esters, fragrance esters, organic acids, and alkaloids. Luan *et al*. [73] optimized Malinzi oil extraction and characterized its chemical composition using GC–MS, identifying oleic acid (34.74%), linoleic acid (41.31%), and docosahexaenoic acid (3.18%) as the main fatty acids.

Other constituents

Beyond flavonoids, quinones, and oligostilbenes, Malinzi contains numerous fatty acids and trace elements. Wu [40] extracted the crude powder with ether reflux, isolating betulin (21), lupene-3-one (22), and β-sitosterol (23). Zang *et al*. [41] obtained Malinzi oil from petroleum ether extraction of seed kernels, isolating linoleic acid (24), stearic acid (25), oleic acid (26), myristic acid (27), palmitic acid (28), decanoic acid (29), and lauric acid (30). Liping *et al*. [74] detected Cr, Zn, Cu, Tl, Sb, and Cd using ICP-OES with microwave digestion. Additionally, Malinzi macerated in 5% NaOH followed by alkaline-acid extraction yielded vitisin A-13-O-β-D-glucoside (31) via semi-preparative HPLC [42].

Pharmacological activities

Modern pharmacological research has shown that Malinzi exhibits diverse biological activities, including anti-tumor, radio-sensitization, immune enhancement, antioxidant, anti-fertility, and modulation of glucolipid metabolism **(Figure 4)**. Radio-sensitization has been extensively studied, with Pallasone A identified as the most potent bioactive component. **Table 3** summarizes the pharmacological effects of Malinzi constituents and extracts. According to traditional Chinese medicine, Malinzi also possesses antispasmodic and analgesic effects, relieving pain and spasm associated with inflammation or cancer, and potentially controlling disease progression. Contemporary studies confirm that certain Malinzi compounds can enhance anti-cancer activity and immunity, bridging traditional use with modern scientific validation.

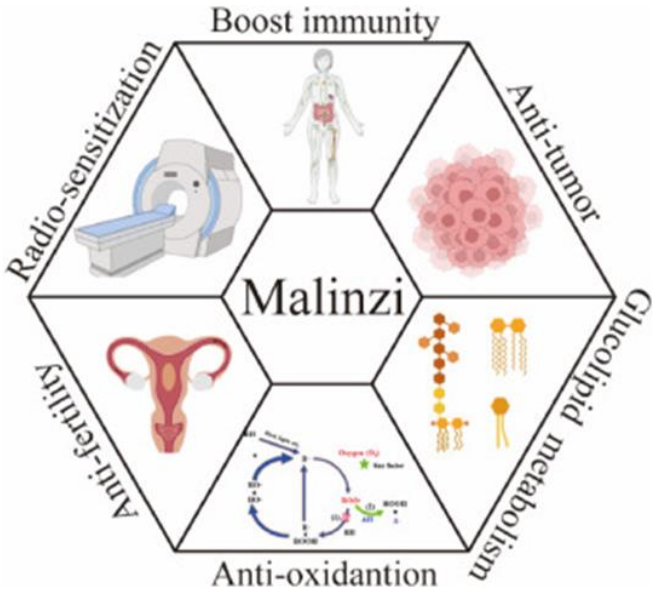

Figure 4. Statistical chart of the pharmacological activities of Malinzi (Adapted from "Gut-Brain Axis Regulators," by BioRender.com, 2022. Retrieved from https://app.biorender.com/biorender-templates).

Anti-tumor

Pallasones are benzoquinone derivatives isolated from Malinzi, representing natural anti-tumor agents with high efficacy and low toxicity [75, 76]. They have demonstrated therapeutic effects against a variety of cancers, including lung, head and neck, nasopharyngeal, esophageal, liver, and ovarian cancers [77, 78]. Pallasone A is the principal active component responsible for Malinzi's anti-cancer effects. In tumor-bearing animals, Pallasone A inhibits lung metastasis by enhancing cellular immunity while decreasing tumor vascular endothelial growth factor (VEGF) expression and microvessel density [43].

When combined with chemotherapeutic agents, Pallasone A can regulate the cell cycle and induce apoptosis, thereby markedly suppressing tumor cell proliferation [44]. Li *et al*. confirmed that Pallasone A can reverse cisplatin resistance in the ovarian cancer cell line COC1/DDP, increasing intracellular cisplatin levels and significantly lowering the IC50, potentially through interference with the intracellular GSH/GST detoxification system [45]. Cai *et al*. observed cytotoxic effects of Pallasone A on multiple nasopharyngeal cancer cell lines, inducing apoptosis in CNE2, SUNE1, and Fadu cells [46].

Pallasone A also exhibits broad in vitro anticancer activity. In K562 leukemia cells, it induces apoptosis and alters the cell cycle, increasing the proportion of cells in the G0/G1 phase while significantly decreasing those in the S phase [47]. Additionally, Pallasone A inhibits proliferation and promotes apoptosis in NCI–H1975 human non-small cell lung adenocarcinoma cells, potentially via suppression of the IAP family of proteins [48]. It further blocks Rho signaling-mediated epithelial–mesenchymal transition (EMT), preventing PANC-1 cells from proliferating, migrating, and invading [49].

Beyond pallasones, other compounds in Malinzi contribute to its anticancer properties. Viniferins are potent antioxidants, free radical scavengers, and anti-tumor agents. Wei Hou first isolated trans-ε-viniferin and r-2-viniferin from Malinzi. Trans-ε-viniferin was shown via MTT assay to inhibit HepG2 liver cancer cell proliferation [37], while 2-r-viniferin promotes apoptosis by increasing intracellular reactive oxygen species (ROS) and reducing mitochondrial membrane potential, likely through G2/M phase arrest [33]. Colin *et al*. also reported that viniferin and its polymeric forms exhibit antiproliferative effects on HepG2 cells [50].

Since tumor initiation and progression are closely linked to impaired immune surveillance, particularly reduced cellular immunity [79], immunotherapy aimed at enhancing the body's anti-cancer defenses has become a central strategy in modern oncology [80]. Li Weimin [51] demonstrated that oral or intraperitoneal administration of Pallasone A, either as an emulsion or powder, enhances delayed-type hypersensitivity responses in tumor-bearing mice and improves cellular immunity at appropriate doses.

Radio-sensitization

Solid tumors are known to harbor a large number of hypoxic cells, which are typically resistant to radiotherapy and chemotherapy [81]. This resistance can compromise short-term treatment outcomes and allow residual hypoxic cells to drive tumor recurrence [82]. Pallasone A, an active compound in Malinzi, has been identified as a bioreductive tumor radiosensitizer [83]. Experimental studies show that Pallasone A is metabolized and activated by reductases in vivo, enhancing the radiosensitivity of hypoxic cells and facilitating their elimination [84]. Consequently, it improves radiotherapy efficacy, lowers tumor recurrence, and increases overall cancer cure rates [85].

Recent research demonstrates that combining Pallasone A with radiotherapy effectively treats liver, lung, esophageal, nasopharyngeal, and cervical cancers with minimal toxicity [52–56, 86, 87]. Xu *et al*. evaluated the radiosensitizing effect of Pallasone A on rabbit VX2 lung transplant tumors using ^{18} F-FDG PET/CT imaging [57]. Wang *et al*. reported that Pallasone A enhanced radiosensitivity in C6 rat glioma cells both in vitro and in vivo, primarily through downregulation of HIF-1 [58]. Furthermore, Irisquinone, another Malinzi constituent, exhibited radiosensitizing activity in breast cancer models, assessed via ^{18}F-FLT microPET/CT [59]. Irisquinone increases MDA-MB231 breast cancer cells' sensitivity to radiotherapy by suppressing the Warburg effect through downregulation of the HKII gene [60].

Boost immunity

Traditional Tibetan medicine studies [61] showed that, 3 minutes after administration of colloidal Au, radioactive intensity in the mouse liver was significantly higher than in controls, indicating that Pallasone A enhances phagocytosis by the liver's reticuloendothelial system. Wang *et al*. further demonstrated that Pallasone A increases serum IL-2 levels in normal mice in a dose-dependent manner, while reducing sIL-2R levels, suggesting enhanced immune function and regulation of humoral immunity [62].

Anti-oxidation

Excessive free radical accumulation from metabolic processes is implicated in various diseases. Malinzi oil, obtained via subcritical fluid extraction, is rich in polyphenols and exhibits strong antioxidant activity. At a concentration of 14 mg/mL, Malinzi oil achieved a maximum DPPH free radical scavenging rate of 71.42%, while the total antioxidant capacity peaked at 168 mg/mL, equivalent to 0.4207 mmol/L FeSO4 [63].

Anti-fertility

Oral administration of Malinzi alcoholic extract in mice demonstrated anti-fertility and anti-implantation effects. The seed coat was responsible for these effects, whereas the seed kernel showed no impact [64].

Glucolipid metabolism

Proanthocyanidins from Malinzi seed coat and oligomeric stilbenes from the seed kernel can modulate lipid metabolism. Vitisin B reduces expression of PPARγ, C/EBPα, and aP2 in 3T3-L1 cells, decreasing lipid droplet accumulation, and simultaneously activates AMPK to enhance GLUT4 expression, promoting glucose uptake without increasing lipid storage [65]. Other oligostilbenes inhibit adipogenesis and adipocyte differentiation, improving lipid metabolism. Vitisin A, Vitisin B, and cis-Vitisin A strongly downregulate PPARγ and related adipocyte-specific genes during adipogenesis [88]. Tie *et al*. observed lipid-lowering effects of Malinzi oligostilbenes in HFD/STZ-induced diabetic mice and suppression of adipogenesis/lipogenesis in 3T3-L1 cells via modulation of C/EBPβ and PPARγ [66]. Additionally, five oligostilbenes were tested for regulating adipogenic transdifferentiation in C2C12 myoblasts: VitAOG, VitA, and Hop inhibited adipogenic differentiation by downregulating PPARγ, FABP4, and C/EBPβ, while VitD and Isohop promoted it by upregulating PPARγ and FAS [67].

Malinzi, a traditional Chinese herbal medicine, has been employed for centuries in East Asia to treat a wide range of ailments, demonstrating considerable clinical value. In recent years, its traditional applications have attracted renewed attention in modern research. This review summarizes the current understanding of Malinzi, encompassing its botanical characteristics, traditional medicinal uses, chemical constituents, and pharmacological activities.

Literature analysis indicates that Malinzi exhibits multiple pharmacological effects, including anti-tumor, radio-sensitization, immune enhancement, antioxidant activity, anti-fertility effects, and regulation of glucolipid metabolism. Its chemical profile comprises flavonoids, quinones, oligostilbenes, and other compounds, which appear to contribute synergistically to its bioactivities. However, only 31 constituents have been definitively isolated and characterized, suggesting that many metabolites remain unidentified. Systematic isolation and structural elucidation of these compounds has become a central focus in current research, though the complexity and diversity of traditional Chinese medicine components make this a challenging and labor-intensive task.

At present, most pharmacological studies on Malinzi have concentrated on Pallasone A, with limited investigation into the activities of other constituents. While traditional use points to broad therapeutic potential, the pharmacologically active ingredients beyond Pallasone A remain largely unexplored. Moreover, many identified compounds have only been evaluated in vitro, and their in vivo pharmacodynamics and molecular mechanisms have not been sufficiently studied. Such evaluations are critical for integrating traditional knowledge with modern drug development.

Future research on Malinzi should focus on three key directions: first, systematic isolation and identification of its chemical components to enable detailed analysis of their pharmacodynamic properties; second, expanding pharmacological studies beyond Pallasone A to assess the effects of other bioactive compounds; and third, deepening pharmacological investigations using multi-omics approaches and evaluating bioavailability to clarify mechanisms of action scientifically.

Conclusion

In conclusion, Malinzi remains a widely used folk medicine in China and other parts of Asia. A comprehensive understanding of its traditional applications, phytochemical composition, and pharmacological properties is essential for rational clinical use. Advancing research on its unexplored chemical constituents and biological activities will help fully realize the medicinal potential of Malinzi and support its broader, evidence-based application in clinical practice.

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