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Review

Phytochemicals And Pharmacological Screening Of Loquat Plant

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Abstract

The 2030 Food and Agriculture Organization of the United Nations (FAO) Agenda emphasizes the importance of local products and their distribution through short supply chains for the sustainable development of many rural communities. Furthermore, due to the need for healthy eating, environmental protection, and local economic growth, an increasing number of consumers have expressed a particular interest in local production in recent years. However, due to their limited production potential, local fruit varieties, or ecotypes, have become much less common in recent decades. Genetic agrobiodiversity has been lost as a result of many farmers being compelled to substitute a small number of cultivars cultivated abroad for indigenous orchards. For example, foreign cultivars make up the majority of the loquat market in Italy. For example, the market for loquats in Italy consists of both locally grown autochthonous fruits (ecotype) and imported cultivars. Therefore, the purpose of this study is to examine the sensory, chemical, and physical characteristics of loquat fruit as well as the factors that influence Italian consumers' preference for local ecotypes over imported ones. The findings indicate that local ecotypes produce superior physio-chemical and sensory qualities, and that the most significant determinants of consumers' preference for local loquats are flavour and place of purchase. Consequently, the production of loquat ecotypes and efficient marketing techniques may boost the competitiveness of some rural regions of Italy, where the crop has long been important to the local economy.

Keywords: Pharmacological, Phytochemical, Antioxidants, Loquat, Herbal

INTRODUCTION

Every nation should set aside public and private funds by 2030 to create and implement pertinent policies and initiatives that ensure socially, environmentally, and economically sustainable development, according to the Food and Agriculture Organization of the United Nations' (FAO) 2030 Agenda for Sustainable Development. The Agenda's 17 sustainable development goals and 169 related targets, which went into effect on January 1, 2016, aim to achieve these goals by 2030. These goals range from combating poverty and hunger to addressing climate

change and protecting the world's natural resources. Since agriculture is essential to feeding the world's population and ensuring the development of sustainable food production systems, one of the main objectives is to ensure sustainable patterns of consumption and production.

Sustainable cropping systems should, on the one hand, boost farmers' incomes through the production of higher-quality goods, and on the other hand, lessen adverse social and environmental effects by preserving, valuing, and promoting local production and distribution. Given the shorter travel distances and less reliance on refrigerated cargo ships, airplanes, and trucks, local products and their distribution through short supply chains (SSCs) do, in fact, cut food miles and the related transportation greenhouse gas emissions from an environmental perspective. The markets' close proximity enables local growers to pick fruit at maturity, which produces exceptional sensory qualities in many crops and fruit species. However , local genotype-defined ecotypes (or landraces) and no autochthonous cultivars are the foundation of Italian fruit production. Ecotypes are suited to local settings since they are tailored to the regions in which they are found. Unfortunately, in recent decades, there has been a significant decline in the cultivation of local ecotypes of fruit species. The production of traditional varieties that are less productive has decreased as a result of the need to maximize output.

Fig 1: Loquat Fruit

Furthermore, a few worldwide grown fruit cultivars have become predominant even though the local ecotypes have specific quality traits that require lower chemical input, significantly reducing their release into the air, water, and soil and minimizing the adverse impacts on human health and the environment. Several studies, in fact, have denoted that the introduction of allochthonous varieties could alter the existent ecosystems and biodiversity or not adapt to it, forcing farmers to increase agricultural inputs to optimize the yields. Nevertheless, landraces, even if they are well adapted to local conditions, are considered obsolete. In fact, demands of large-scale retail distribution increasingly exclude local varieties and ecotypes and replace them with modern cultivars, leading to a dramatic loss of genetic agrobiodiversity. On the other hand, there is a strong congruence between sales in local markets and autochthonous productions. In this regard, short supply chains play an important role in the selling of local production.

Furthermore, according to the literature, local production and their distribution through short supply chains allow farmers to reach social and economic sustainability, especially in small-sized farms, and support the economy of rural regions by increasing the social interaction among farmers and other economic actors, especially consumers.

The literature on consumer choices emphasizes that the need for local and typical productions stems from the need to protect the environment, eat healthily, and support the local economy by avoiding the rural exodus phenomenon that is still prevalent in many rural areas. Local fruit productions are frequently listed among European products that have earned Protected Geographical Indication (PGI) status. These products are distinguished by their superior quality attributes, which include a strong aroma and flavour, as well as their developed nutraceutical value, which is highly valued by consumers.

To the best of our knowledge, however, no scientific research have evaluated local and nonlocal production and specifically, local fruit production from both a consumer and a productive-qualitative standpoint.

Fig 2: Loquat Plant

The current study's objective is to examine the sensory, chemical, and physical characteristics of local loquat fruits as well as the factors that influence Italian consumers' preference for them over imported loquat kinds. The fruit loquat (Eriobotrya japonica Lindl.) has not received much attention in the literature. It is an evergreen tree native to China's southeast. Originally from Japan, loquat was brought to Italy at the turn of the century and quickly expanded throughout the world, thriving in temperate and subtropical regions where citrus can be produced.

Loquat has adapted well to the Mediterranean environment and is now grown in many countries, including China, Japan, India, Pakistan, Cyprus, Egypt, Greece, Israel, Italy, Spain, Tunisia, and Turkey. It produces spherical-oval pomes from its white flowers, which bloom in the fall and early winter. According to the most recent data available, loquat is grown nearly exclusively on Sicily's northern coast in Italy, particularly in Palermo Province, where 400 hectares of land and 4843 tons of harvested loquat account for 72.8% and 81.8% of the country's total loquat production, respectively. We have concentrated on Sicily because of its many local ecotypes, which make it a biodiversity hotspot for loquat.

They were first created through the use of agamic propagation, followed by seed propagation and plant visual selection. Fruit with orange and white flesh is a characteristic of Sicilian autochthonous loquat trees. White-flesh ecotypes are distinguished by their pale-yellow colour, high sugar/acid ratio, sub-acidic classification (referred to as "vanilla"), and susceptibility to storage and transportation diseases. Although there are significant differences between yellow-flesh and white-flesh fruit in terms of both internal and external quality, both typologies produce fruit that is valued by local consumers and can, therefore, be regarded as excellent competitors in international markets, standing out for quality and being highly valued by consumers.

By combining instrumental and sensory analyses of nutraceutical values and differences with the no autochthonous cultivar, Farina et al. have specifically carried out a number of studies on locally grown autochthonous loquat. However, a few non-autochthonous varieties, primarily from Spain, are becoming more and more common on the Italian market, endangering these ecotypes. This has resulted in competitive issues for Italian loquat farms, which are also marked by outdated orchards and a lack of commercial organization. In reality, over the past ten years (2009–2018), there has been a decrease in both cultivated areas (17.4%) and harvested production (21.1%), even though Sicily has the best ecological conditions for producing loquat and it is especially suited for early production.

Since many farmers are compelled to depart their farms or replace loquat orchards with other crops, this reduces the social and economic sustainability of rural communities and results in a loss of biodiversity and knowledge linked to exodus phenomena. Thus, this paper serves two purposes by offering scientific data on the qualitative traits of Italian loquat ecotypes and how consumers perceive them: (a) to assist stakeholders in valuing local production through efficient marketing techniques; and (b) to assist entrepreneurs in meeting the needs of their customers in full. Because loquat has traditionally been a major crop in the economy of territorial production, this could make it more competitive in Italy.

Phytochemical Activity

Alkaloid Test

To test for the presence of alkaloids in loquat, we can use standard alkaloid detection methods. Here are the basic steps for a qualitative alkaloid test using a common reagent.

Material needed

First, in order to find possible alkaloids, we need fresh or dried loquat plant pieces, usually the leaves or seeds. To make extraction easier, the plant material is ground into a fine powder using a mortar and pestle. In order to

aid release the alkaloids into solution, distilled water, diluted hydrochloric acid, and solvents like ethanol or methanol are frequently utilized in the extraction procedure. Organic solvents such as ethyl acetate or chloroform are required to separate the alkaloids. Chemical reagents like Dragendorff's reagent, Mayer's reagent, Wager's reagent, or Hager's reagent are used to detect alkaloids. When these reagents combine to generate a coloured precipitate or complex, alkaloids are present.

Procedure

1. **Sample Preparation:**
- Crush the loquat leaves or seeds into a fine paste using mortar and pestle.
2. **Extraction:**
- Add about 10-20 ml of ethanol to the paste.
- Stir well.
- Let it sit for 30 minutes.
- Filter the mixture to obtain the clear extract.
3. **Alkaloid Detection:**
- In test tube, take 2-3 ml of the extract.
- Add few drops of Dragendorff's reagent.
4. **Observation:**
- A reddish-brown or orange precipitate indicates the presence of alkaloids.

Saponin Test

This is a simple and qualitative test used to detect saponins, which are glycosides that produces stable froth in water.

Material needed

The first thing we need is dried and powdered plant material, which can be made by using a mortar and pestle to ground the leaves, bark, or seeds. The extraction method requires distilled water as the solvent. In order to make and handle the extract, we also need standard laboratory glassware, such as test tubes, beakers, a measuring cylinder, and a stirring rod. For the extraction to be done with gentle heating, a water bath is required. In addition, the extract is filtered to eliminate solid particles using a funnel and filter paper. For precise liquid transfers, a pipette or dropper may also be useful. fresh leaves of loquats.

Procedure

1. **Extract Preparation:**
- Crush 2-5 g of loquat leaves.
- Put 20 ml of distilled water in it.
- Boil it for 5 minutes.
- Let cool and filter the solution to get the extract.
2. **Froth Test:**
- Pour 10 ml of the extract into a test tube.
- Shake it for about 30 seconds.
- Let it sit for 10 minutes.

Observation

- A stable froth layer that persists for 10 minutes or more indicates the presence of saponins.
- You can add a drop of olive, shake again:
- Formulation of an emulsion further confirms the presence of saponins.

Glycoside Test

Legal's Test

Material Needed

A mortar and pestle should be used to grind the dried and powdered plant material, usually from the leaves or seeds. To extract the glycosides from the plant material, a solvent such as methanol or ethanol is needed. In order to dilute the extract during testing, distilled water is also required. Freshly made sodium nitroprusside solution is the main component of Legal's test, which looks for cardiac glycosides by combining it with sodium hydroxide and pyridine. For the extraction and handling of the samples, additional laboratory supplies like test tubes, beakers, a funnel, filter paper, a water bath, and a stirring rod are required.

Procedure

1. Prepare ethanoic extract of loquat leaves.

2. Add few drops of sodium nitroprusside and pyridine to 2 ml of the extract.
3. Add sodium hydroxide slowly.

Observation

- A pink to red color indicates presence of glycosides.

Keller-Killiani Test

Materials

A mortar and pestle can be used to make the dried and finely powdered plant material, which is typically from the leaves or seeds. The glycosides must be extracted from the powdered plant material using ethanol or methanol, and distilled water is utilized for dilution. Concentrated sulfuric acid, ferric chloride solution, and glacial acetic acid are the essential components for the Keller-Killiani test. The plant extract and reagents must be prepared, filtered, and handled using standard laboratory tools such test tubes, beakers, filter paper, funnels, measuring cylinders, droppers, and pipettes.

Procedure

1. Mix 2 ml of extract with 1 ml of glacial acetic acid containing a drop of ferric chloride.
2. Add 1 ml of concentrated sulfuric acid by the side of the test tube.

Observation

- A brown ring at the interface of the solution shows a positive result for glycosides.

Tannins Test

This is the most common qualitative test to detect tannins.

Materials Needed

A mortar and pestle can be used to make the dried and finely powdered plant material we need, which is usually from the leaves or bark. To extract the tannins and associated chemicals from the powdered material, distilled water or ethanol is needed. Ferric chloride solution, the main chemical employed in this test, is one of the reagents we also need. Depending on the kind of tannins present, ferric chloride reacts with them to form a blue-black or greenish precipitate when added to the extract. A dropper or pipette for adding reagents, test tubes, beakers, funnels, and filter paper for clarifying the extract are additional lab supplies.

Procedure

1. **Extract Preparation:**
- Boil 2-5 g of powdered loquat leaves in 20 ml of distilled water for 5 minutes.
- Let it cool and filter to get the clear extract.

2. **Ferric Chloride test:**
- Take 2-3 ml of the aqueous extract in a test tube.
- Add a few drops of 1% ferric chloride solution.
- Shake gently.

Observation

- A blue-black or greenish-black colorization indicates the presence of tannins.
    - **Blue-black suggests hydrolysable tannins.**
    - **Greenish-black suggests condensed tannins.**

Flavonoids Test

This is a simple and reliable test for detecting flavonoids in plank extracts.

Material Needed

Using a mortar and pestle, we need to make dried and finely powdered plant material, usually from the leaves or bark. The flavonoid glycosides must be extracted from the plant powder using ethanol or methanol as a solvent. Dilute hydrochloric acid and magnesium ribbon or zinc powder are essential reagents. To prepare and handle the extract and reagents, basic lab supplies like test tubes, beakers, filter paper, a funnel, a stirring rod, and droppers or pipettes are also required.

Procedure

1. **Extract Preparation**
- Grind 2-5 g of loquat leaves.

- Soak in 20-30 ml of ethanol for 30 minutes.
- Filter the mixture to get the extract.

2. Alkaline Reagent Test:

- In a test tube, add 2-3 ml of the ethanolic extract.
- Add a few drops of 10% NaOH solution.
- Observe the color change.
- Then add a few drops of dilute HCl.

Observation

- A yellow color appears after adding sodium hydroxide.
- The yellow color fades upon addition of hydrochloric acid.
- This confirms the presence of flavonoids.

Phenol Test

This is the most common and simple method to detect phenolic compounds.

Material Needed

A mortar and pestle can be used to make the dried and powdered plant material we need, which is usually from the leaves or bark. Phenolic chemicals are extracted from the plant powder using ethanol or methanol as a solvent, and distilled water is utilized for dilution. Depending on the kind of phenol present, the ferric chloride solution, the main reagent for the phenol test, reacts with the phenolic compounds to generate a distinctive blue, green, or violet hue. Test tubes, beakers, filter paper, a funnel for filtration, and a dropper or pipette for adding reagents are examples of basic lab equipment.

Procedure

1. Extract Preparation:

- Weigh 2-5 g of dried, powdered loquat leaves.
- Add 20-30 ml of 70% ethanol or warm distilled water.
- Let it sit for 30 minutes or heat slightly.
- Filter the mixture to obtain the extract.

2. Ferric Chloride Test:

- Take 2-3 ml of the extract in a test tube.
- Add a few drops of 1-5% ferric chloride solution.
- Shake gently.

Observation

- A blue, green, purple and black color indicates the presence of phenolic compounds.
  Color varies depending on the specific type of phenol:
  - Blue or dark green = tannic acid types.
  - Blackish-purple = complex polyphenols.

Ethanopharmacological Activity

Anti-Inflammatory Activity

In Chinese folk medicine, loquat leaf has been used since ancient times to treat inflammatory diseases such as cough, CB, and asthma. Modern scientific studies using different experimental models have proved the anti-inflammatory capacity of different loquat tissues such as leaf, seed and fruit.

Pulmonary inflammation is a factor in many lung diseases. Lipopolysaccharide (LPS)-induced inflammation is a common experimental model for anti-inflammatory research. Loquat leaf extracts enriched with triterpene acids, especially ursolic acid, showed anti-inflammatory effects on alveolar macrophages in rats with LPS-induced CB. Twelve triterpene acids, e.g., seven ursane-type [ursolic acid (1), corosolic acid (2), 3-O-cis-p-coumaroyltormentic acid (3), 3-O-trans-p-coumaroyltormentic acid (4), 3-epicorosolic acid (5), euscaphic acid (6), 1β-hydroxyeuscaphic acid (7)], four oleanane-type [oleanolic acid (8), maslinic acid (9), methyl arjunolate (10), 2α,3α,23- trihydroxyolean-12-en-28-oic acid (11)], and one lupane-type [betulinic acid (12)] isolated from the ethyl acetate-soluble fraction of loquat leaf showed marked anti-inflammatory effects in the inhibition of 12-O-tetradecanoylphorbol-13-acetate (TPA)-induced ear edema of mice, and the 50% inhibitory dose of these twelve compounds ranged from 0.03–0.43 mg per ear. The mouse paws edema model was also used to assess the anti-inflammatory effect of loquat extract, and loquat tea extract made from roasted fresh loquat leaves significantly decreased the paw edema of mouse.

Loquat seed extracts also showed anti-inflammatory effects in vivo. By using a chemotherapy drug (5-fluorouracil)-induced mucositis model in hamsters, the loquat seed extract significantly inhibited the chemotherapy-induced mucositis, and the epithelial injury and bacterial infection were greatly inhibited, together

with much lower plasma lipid peroxide level. In another study, by using a dinitrofluorobenzene-induced allergic dermatitis in rat ear as an experimental model, administration of loquat seed extract resulted in significantly inhibited development of allergic dermatitis, where lower ear thickness and serum immunoglobulin E levels as well as improved balance of Th1/Th2 were observed.

In addition, loquat juice also showed anti-inflammatory effects. Fruit juice was administrated prophylacticly, postmortemly or concurrently with LPS stimulation, and was found to exhibit a prophylactic effect on LPS-induced inflammation in peritoneal macrophages.

Increased levels of inducible nitric synthase (iNOS), cyclooxygenase-2 (COX-2), and pro-inflammatory cytokines such as interleukin-1β (IL-1β), tumor necrosis factor-α (TNF-α) and interleukin-8 (IL-8) have been correlated with inflammation. Therefore, decreasing pro-inflammatory mediators (such as iNOS, COX-2, TNF-α, IL-6, IL-8, IL-1β) and/or increasing anti-inflammatory cytokine (such as IL-10) secretions are important mechanisms for the anti-inflammation effects of loquat extracts. Such regulation was associated with suppressing the expression and activation of the nuclear factor-κB (NF-κB) and/or mitogen-activated protein kinase (MAPK) signalling pathway, which have been suggested as key regulators of the expression of inflammatory mediators in the cellular signalling pathway.

Treatments such as LPS induce production of iNOS, COX2, TNF-α, IL-1β, and IL-8 in A-549 human lung epithelial cells and loquat leaf extract and its triterpene ursolic acid (1) inhibited the LPS-induced cytokines and the inducible enzyme production via the NF-κB signalling pathway in A-549 cells. The anti-inflammatory effect of loquat leaf extract might result from the inhibition of expression of iNOS and COX-2 through the downregulation of NF-κB activation and MAPK phosphorylation in LPS stimulated RAW264 cells and in the LPS-activated murine peritoneal macrophage model. Similarly, the anti-inflammatory effects of loquat tea extract may rely on the inhibition of the production of iNOS, nitric oxide (NO), IL-6, TNF-α, and on the downregulation of the transforming growth factor-β (TGF-β)-activated kinase-mediated MAPK and NF-κB pathways in mouse macrophage-like RAW 264.7 cells. Mast cells induce the biosynthesis of pro-inflammatory cytokines with immune regulatory properties. Loquat leaf extract inhibited the secretion of TNF-α, and IL-8 and attenuated the activation of NF-κB, p38 MAPK and extracellular signal-regulated kinase (ERK) in horbol 12-myristate 13-acetate and calcium ionophore A23187-induced mast cells. More in-depth studies using microarray analysis showed that loquat leaf extracts inhibited the expression of a wide variety of inflammation-related genes in LPS-stimulated human gingival fibroblasts.

In animal models, loquat leaf extracts were also found to inhibit the NF-κB activation of alveolar macrophages, which led to the inhibition of the expression of TNF-α, IL-1β, prostaglandin E2 and leukotriene B4 in a dose dependent manner in CB rats. In another study, triterpene acids extract of loquat leaf were found to significantly inhibit the increase in NO concentration and iNOS expression, which may be related to the inhibition of phosphorylation of p38 MAPK and the corresponding signal transduction in alveolar macrophages of CB rats. Administration of fruit juice in the LPS-induced inflammation model also resulted in the increased secretion of anti-inflammatory cytokines, such IL-10, and/or decreased levels of pro-inflammatory cytokines such as IL-1β, IL-6, and TNF-α in the murine peritoneal macrophage cultures.

Antioxidant activity might be another additional molecular mechanism of its anti-inflammatory effects. NF-κB activation is influenced by the cellular oxidative state, and antioxidants such as methyl chlorogenic acid isolated from loquat leaf can inhibit the redox-sensitive NF-κB activation and downregulate NF-κB-dependent gene expression. Treatment with loquat triterpene acids extracts significantly inhibited the methylene dianiline (MDA) level and the expression of heme oxygenase-1, and up-regulated the level of Superoxide dismutase (SOD) expression in cultured alveolar macrophages from CB rats. Tormentic acid (14) from loquat suspension cells decreased paw edema in mice and increased the activities of catalase, SOD, and glutathione peroxidase in liver tissue.

Anti-Diabetic Activity

Diabetes mellitus is a metabolic disorder characterized by hyperglycemia resulting from either a defect in insulin secretion or action. As a traditional folk medicine component, E. japonica also exhibited great anti-diabetes potential. Recent research evidence has shown that loquat leaf or seed extracts are useful in prevention and control of both type-1 and type-2 diabetes.

A 70% ethanol extract of Folium Eriobotryae (30 g/kg) showed significant hypoglycemic effect on alloxan-diabetic mice by lowering blood glucose levels. By using the terpenes and flavonoids fraction of loquat leaf, their hypoglycemic potential on alloxan and/or streptozotocin (STZ)-induced diabetic mice was further investigated. Results showed that the total triterpene acid fraction at 300 mg/kg day caused significant hypoglycemic and hypolipidemic effects on normal, alloxan and STZ-induced diabetic mice. Total sesquiterpenes at 30 g/kg day showed similar hypoglycemic effects on alloxan-diabetic mice. Further isolation of a triterpene acid—euscaphic acid (6)—and a sesquiterpene glycoside—nerolidol-3-O-α-L-rhamnopyranosyl (1,4)-α-L-rhamnopyranosyl (1,2)- [α-L-rhamnopyranosyl (1,6)]-β-D-glucopyranoside (15)—from Folium Eriobotryae showed that both compounds significantly lowered the plasma glucose levels in alloxan-diabetic mice, confirming

that these are important active hypoglycemic constituents in loquat leaf. By using STZ-induced diabetic mice model, the flavonoid fraction containing quercetin-3-O-galactosyl-(1,6)- glucoside, quercetin-3-O-sophoroside, quercetin-3-O-rutinoside (rutin), kampferol-3-O-sophoroside, kampferol-3-O-rutinoside, querce-tin-3-O-galactoside (hyperoside), quercetin-3-O-glucoside (isoquercitrin), quercetin-3-O-rhamnoside, and kampferol-3-O-glucoside showed a hypoglycemic effect where a dose of 300 mg/kg significantly decreased the plasma glucose and serum insulin levels.

By using the high-fat (HF) diet-induced diabetic C57BL/6J mice model, the hypoglycemic effects of loquat extracts were also investigated. Loquat leaf extract containing corosolic acid (2) and maslinic acid (9) significantly ameliorated the hyperglycemia, hyperleptinemia, and hyperinsulinemia in 45% HF diet C57BL/6J mice. Cell suspension cultures of loquat contain a great number of pentacyclic terpenoids including tormentic acid (14), corosolic acid (2), ursolic acid (1), maslinic acid (9), and oleanolic acid (8). Addition of such cell suspension extract to the HF diet mice resulted in the prevention of the increase in the levels of blood glucose, insulin, leptin and homeostasis model assessment for insulin resistance index in the HF-diet mice. By using the type 2 diabetic Otsuka Long–Evans Tokushima fatty (OLETF) rats and KK-Ay mice as experimental models, the hypoglycemic effects of loquat seeds were studied and results showed that OLETF rats fed a diet with 10% powdered loquat seed resulted in consistently reduced blood glucose concentration and serum insulin level compared to the control group. In addition, ethanol extracts of loquat seed suppressed the increase in blood glucose for four months and improved the glucose tolerance in KK-Ay mice. A new fermented tea product produced by co-fermentation of loquat leaf and summer-harvested green tea leaf (50 mg/kg) showed suppression of blood glucose level and a corresponding reduction in serum insulin secretion in maltose-loaded Sprague–Dawley (SD) rats. Interestingly, such an effect was not observed when sucrose or glucose were administered to SD rats. Loquat leaf extracts led to a significant inhibition of the increase in serum glucose, total cholesterol and triglyceride levels induced in a hypercholesterolemic zebrafish model by feeding a high cholesterol diet.

In another study, a water extract of loquat leaf significantly increased the insulin secretion from INS-1 cells and decreased the insulin level for as long as 240 min post-administration in rats. Cinchonain Ib (16) was found to enhance insulin secretion from INS-1 cells in the same study and may have insulinotropic effect for managing type 2 diabetes.

Corosolic acid (2) isolated from loquat leaf promoted 3H-glucose uptake, inhibited the differentiation of preadipocytes into adipocytes, and downregulated the expression of peroxisome proliferator-activated receptor (PPAR)-γ and the CCAAT/enhancer binding protein-α in 3T3-L1 adipocytes. Therefore, corosolic acid (2) might regulate carbohydrate metabolism without increasing adiposity. Glucocorticoids are important regulators of metabolic processes including gluconeogenesis, and elevated glucocorticoids have been associated with hyperglycemia, insulin resistance and type 2 diabetes. Therefore, inhibition of the glucocorticoids-activating enzyme11β-hydroxysteroid dehydrogenase 1 (11β-HSD1), which catalyzes the conversion of inactive 11-ketoglucocorticoids to active 11β-hydroxyglucocorticoids, is an important therapeutic target of antidiabetic medicines. Among six traditional antidiabetic medicinal plants, loquat leaf extracts preferentially inhibited 11β-HSD1. The bioactivity-guided isolation of bioactive constituents resulted in the identification of corosolic acid (2), 3-epicorosolic acid methyl ester (17), 2-α hydroxy-3-oxo urs-12-en-28-oic acid (18), tormentic acid methyl ester (19), ursolic acid (1) as low micromolar inhibitors of 11β-HSD1.

Anti-Cancer Activity

As a traditional folk medicine component, loquat extracts have also displayed chemoprotective properties against various cancer cell lines. Modern science studies have demonstrated at the protein and gene level that loquat extracts can suppress cell carcinogenesis at different progression stages, such as cancer initiation, proliferation, and metastasis.

Both water and ethanol extracts of loquat leaf inhibited 7,12-dimethylbenz[α]anthracene (DMBA)-induced breast cancer in rats, and water extracts showed a higher inhibitory activity. Both extracts inhibited the development of breast cancer by significantly suppressing the initiation and proliferation of tumor cells.

A large number of studies have demonstrated the cytotoxicity of loquat extract on different cancer cell lines. In an evaluation of 14 oriental medicinal herbs for antiproliferative activities, loquat leaf showed strong cytotoxicity in cell lines of estrogen receptor-negative breast cancer (MDA-MB-231), cervix epitheloid (HeLa) and lung (A549) carcinoma. Ursolic acid (1) and oleanolic acid (8) isolated from loquat leaf significantly suppressed the proliferation of human lymphoid Molt 4B cells, which may result from the depletion of polyamines by inhibiting ornithine decarboxylase and S-adenosylmethionine decarboxylase activity. Different procyanidin oligomers from loquat leaf showed selective cytotoxicity against human squamous cell (HSC-2) carcinoma and human salivary gland tumor cell. Epicatechin (20), procyanidin B-2 (21), procyanidin C-1 (22), and procyanidin oligomer (23) showed increased cytotoxic activity against HSC-2 cells as molecular weight increased and such cytotoxic activity may be due to the prooxidant action of these polyphenols. Four triterpene acids, i.e., δ-oleanolic acid (24), ursolic acid (1), 3-O-(E)-p-coumaroyl tormentic acid (25), and betulinic acid (12) isolated from the methanol extracts of loquat leaf exhibited cytotoxicity against human HL60 cells (EC50 = 5.0–8.1 μM) and they

also exhibited potent DNA topoisomerase I inhibition (IC50 = 20.3–36.5 μM). Further study showed that 3-O-(E)-p-coumaroyl tormentic acid (25) induced apoptotic cell death in HL60 line mainly via the mitochondrial pathway and would be a promising compound for treatment of human leukemia.

By using a two-stage carcinogenesis assay on mouse skin, roseoside (26) isolated from loquat leaf was found to be the main compound that significantly delayed carcinogenesis induced by peroxynitrite as an initiator and TPA as a promoter. In another two-stage in vivo carcinogenesis test, euscaphic acid (6) showed significant antitumor promoting effects on mouse tumor induced by 7,12-DMBA as an initiator and TPA as a promoter.

Hydrophilic loquat extracts also showed in vivo anticancer activity in Meth-A-fibrosarcoma-bearing mice, operating through immunomodulatory activity, as indicated by factors such as interferon-gamma, interleukin-17, and TGF-β1. The possible constituents of such immunomodulatory activity require further investigation.

In addition, loquat leaf and seed extracts also showed significant anti-metastatic properties by inhibition of the migration and invasion of MDA-MB-231 human breast cancer cells and B16F10 melanoma cells, which was partially through the inhibition of matrix metalloproteinase-2 (MMP-2) and MMP-9. Ursolic acid (1) and 2α-hydroxyursolic acid (27) isolated from loquat extracts were indicated as key active compounds since both of them also significantly suppressed MMP-2 and MMP-9 activities.

Antioxidant Activity

By using multiple antioxidant assay methods, diverse studies have demonstrated the strong antioxidant capacity of loquat extracts in vitro and in vivo. Both phenolic compounds and triterpene acids may contribute to such activity in different tissues of loquat.

The frequently reported antioxidant assay methods include Trolox equivalent antioxidant capacity (TEAC), 1,1-diphenyl-2-picrylhydrazyl radical (DPPH·) scavenging capacity, 2,20 -azinobis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) assays, ferric reducing antioxidant power assay (FRAP), total antioxidant capacity, and extracts of loquat leaf, flower, fruit, and seed exhibited strong antioxidant capacity based on different assays. Among 56 selected Chinese medicinal plants, loquat leaf showed higher antioxidant capacities than 54 other medicinal plants based on TEAC and FRAP assays. The ABTS+ scavenging capacity of loquat flower was highly correlated with phenolics and flavonoids, and the correlation coefficients were 0.973 and 0.886, respectively. Loquat fruit of different cultivars growing in different countries such as Turkey and China also showed significantly different antioxidant capacities, indicating the influence of both genetic background and growth environment on the accumulation of antioxidants.

High correlation between the antioxidant capacity and the total phenolic content were observed in loquat fruit of different cultivars grown in Turkey or in China. By dividing loquat fruit extract intro hydrophilic and lipophilic fractions, phenolic content and antioxidant activity of loquat fruit from 24 cultivars grown in China were investigated and the results showed that phenolic compounds are the major contributor to the hydrophilic antioxidant activity, while carotenoids were associated with the lipophilic antioxidant activity. Loquat seed contained much higher content of polyphenolic compounds and showed stronger DPPH· scavenger activity than peel and pulp extracts.

Chlorogenic acid (28) and quercetin-3-sambubioside (29), methyl chlorogenate (13), kaempferol-3-rhamnoside (30), quercetin-3-rhamnoside (31) isolated from loquat leaf extract all showed prominent inhibitory activity against free radical generation using the dichlorofluorescein method. The n-butanol, methanol and water fractions of loquat seed extract contained abundant polyphenols and showed high radical scavenging activity and inhibitory activity on lipid peroxidation, while the low-polar n-hexane and ethyl acetate fractions, which contained β-sitosterol, showed high lipid peroxidation inhibition activity. In addition, ethanol extracts of loquat seeds were also effective in suppressing the oxidation of linoleic acid and the 2,20-azobis(4-methoxy-2,4-dimethylvaleronitrile)-induced low density lipoprotein oxidation. In loquat leaf, cinchonain Ib (16), cinchonain Ia (32), epicatechin (20), quercetin-3-O-α-L-rhamnoside (31), and arbutin (33) have been identified as the important antioxidants exhibiting high antioxidant activity based on DPPH and FRAP assays.

By using different cell models, different loquat fruit and leaf extracts showed protective effects against intracellular reactive oxygen species (ROS). Loquat fruit extract significantly inhibited the formation of ROS and NO in leukocytes and erythrocytes induced by the antibiotic chloramphenicol. Ethanol extracts of loquat leaf showed hepatoprotective effects against ethanol-induced toxicity in HepG2 cells and a decrease in intracellular ROS formation, and increase in hepatic antioxidant activity, as well as increased cellular viability were observed. Loquat leaf extract significantly increased antioxidant enzyme activities of SOD, catalase, glutathione-S-transferase, glutathione peroxidase, glutathione reductase, reduced glutathione in HepG2 cells. In another cell model using β-amyloid-induced oxidative stress in neuronal PC12 cells, treatment of loquat leaf efficiently suppressed the formation of intracellular ROS formation by Aβ1-42 peptide and inhibited neuronal cell death. Ursolic acid in loquat leaf was reported to increase catalase activities in mouse liver.

By using animal models, loquat seed extracts were found to significantly reduce oxidative stress in Adriamycin-induced nephropathy in rats by increasing the reduced glutathione levels in renal tissue and lowering

the lipid peroxide levels in plasma and renal tissue. In addition, loquat seed extract enhanced antioxidant enzyme activity and reduced lipid peroxidation in liver tissue of rats with non-alcoholic steatohepatitis.

CONCLUSION

This comprehensive review highlights the significant phytochemical and pharmacological potential of Eriobotrya japonica (loquat), with a particular focus on its anti-inflammatory, antioxidant, anti-diabetic, and anti-cancer activities. Loquat leaves, seeds, and fruit have been shown to contain a wide range of bioactive compounds, including triterpenes, flavonoids, glycosides, saponins, tannins, and phenolic compounds. These constituents exhibit strong biological activities through various mechanisms such as inhibition of inflammatory mediators (iNOS, COX-2, TNF-α, IL-1β), modulation of NF-κB and MAPK pathways, and antioxidant defense enhancement. In anti-inflammatory studies, loquat extracts demonstrated the ability to reduce cytokine levels and inhibit gene expression related to inflammation, thus supporting its traditional use in treating respiratory and inflammatory conditions. In the context of diabetes, multiple extracts from loquat showed hypoglycemic effects in both type 1 and type 2 diabetic animal models, with compounds like corosolic acid playing a central role. Anti-cancer potential was evident through loquat's ability to inhibit tumor proliferation, metastasis, and induce apoptosis across various cancer cell lines and in vivo models. Furthermore, loquat's antioxidant capacity, primarily attributed to its phenolic and triterpene content, has been confirmed through various assays and cell-based studies. Overall, loquat presents a valuable natural resource for future therapeutic applications. Further clinical studies are warranted to validate its efficacy and safety in humans.

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