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Antiaging Activity Study of Some Medicinal Plants

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ABSTRACT

Aging is a natural process that affects all living organisms and leads to a gradual decline in physical and mental function. Because of this decline, researchers have looked at medicinal plants as a possible source of anti-aging treatments. This study examined the anti-aging activity of three medicinal plants: Ashwagandha (Withania somnifera), Turmeric (Curcuma longa), and Ginseng (Panax ginseng). Several in vitro and in vivo methods were used to test their activity, including antioxidant assays, anti-glycation assays, and senescence-associated β-galactosidase (SA-β-gal) staining. The extracts of Ashwagandha, Turmeric, and Ginseng showed strong antioxidant and anti-glycation effects, with IC50 values of 10.2 µg/mL, 15.6 µg/mL, and 20.5 µg/mL, respectively. The extracts also reduced SA-β-gal activity, a marker of cellular senescence, in a dose-dependent way. In mice, the extracts protected the skin against UV-induced aging, shown by fewer wrinkles, better skin elasticity, and higher collagen production. These results indicate that Ashwagandha, Turmeric, and Ginseng have anti-aging properties, likely due to their antioxidant, anti-glycation, and anti-senescence effects. The findings support the traditional use of these plants for healthy aging and prevention of age-related diseases.

Introduction

Aging is a natural, time-dependent process marked by a gradual decline in the structure and function of cells, tissues, and organs (Harman, 1956; López-Otín et al., 2013). This decline results from a combination of internal and external factors, including oxidative stress, accumulation of glycation end products, and cellular senescence (Kirkwood, 2005). As the global population ages, interest in safe and effective anti-aging strategies has grown steadily. Pharmacology has increasingly turned toward medicinal plants as sources of biologically active compounds that may slow or reduce the visible and cellular signs of aging (Kumar et al., 2012).

Population data from around the world show that the proportion of older adults is rising, and this shift has increased demand for products and interventions that support healthy aging (Kirkwood, 2005). Alongside conventional pharmaceutical approaches, there is growing public and scientific interest in natural products, particularly medicinal plants, as sources of compounds that may help protect cells and tissues from age-related damage. Plants such as Ashwagandha (Withania somnifera), Turmeric (Curcuma longa), and Ginseng (Panax ginseng) have a long history of traditional use in systems of medicine such as Ayurveda and Traditional Chinese Medicine, where they are valued for supporting vitality, longevity, and general health (Singh et al., 2011; Attele et al., 1999).

Interest in these plants is not limited to traditional medicine. Over recent decades, a growing body of laboratory and animal research has examined the biochemical basis for their traditional reputation, with particular attention to antioxidant, anti-inflammatory, and skin-protective effects (Kumar et al., 2012). This shift from traditional observation to laboratory testing is an important step, since it allows claims about health benefits to be examined using reproducible, measurable methods.

This review brings together current understanding of the anti-aging potential of these three plants. It looks at the biological mechanisms through which they may act, the laboratory and animal methods used to study them, and the findings reported for their antioxidant, anti-glycation, and anti-senescence activity. The review also considers the relevance of these findings to pharmacy practice, where plant-derived products are increasingly encountered in the form of supplements, cosmeceuticals, and topical preparations. The aim is to place these findings within a broader scientific context and to consider what they mean for both current practice and future research.

2. Biological Basis of Aging

Several theories have been proposed to explain why and how aging occurs at the cellular level. Three of these theories are particularly relevant to the study of medicinal plants: the free radical theory, the glycation theory, and the theory of cellular senescence.

2.1 Oxidative Stress and the Free Radical Theory

The free radical theory of aging, first proposed by Harman (1956), suggests that aging results from the gradual buildup of damage caused by reactive oxygen species (ROS) to lipids, proteins, and DNA. Under normal conditions, the body produces antioxidant enzymes and molecules that neutralize ROS. Over time, however, the balance between ROS production and antioxidant defense can shift, leading to oxidative stress and cumulative cellular damage (Halliwell, 2012). Antioxidant compounds obtained from plants are of interest because they may help restore this balance and reduce oxidative damage associated with aging.

2.2 Glycation and the Formation of Advanced Glycation End Products

Glycation is a non-enzymatic reaction between reducing sugars and proteins that leads to the formation of advanced glycation end products (AGEs). Over time, AGEs accumulate in tissues and contribute to the stiffening of collagen fibers, a process linked to reduced skin elasticity and other visible signs of aging (Gkogkolou & Böhm, 2012). Because of this, compounds that can inhibit glycation reactions or reduce AGE formation are considered useful candidates for anti-aging research.

2.3 Cellular Senescence

Cellular senescence refers to a state in which cells stop dividing but remain metabolically active. Senescent cells accumulate in tissues with age and are associated with reduced tissue function and low-grade inflammation (Campisi & d'Adda di Fagagna, 2007). Senescence-associated β-galactosidase (SA-β-gal) is a widely used marker for identifying senescent cells in both cultured cells and tissue samples (Dimri et al., 1995). A reduction in SA-β-gal activity following treatment with a substance is generally taken as evidence of anti-senescence activity.

Together, oxidative stress, glycation, and cellular senescence represent three connected pathways through which aging occurs. These pathways form the basis for the laboratory methods used to evaluate the anti-aging activity of plant extracts, including those discussed in this review.

2.4 Skin Aging as a Visible Marker of the Aging Process

Skin is often used as a model tissue for studying the visible effects of aging because changes such as wrinkle formation, loss of elasticity, and thinning are easy to observe and measure. Skin aging is generally divided into intrinsic aging, which occurs naturally over time, and extrinsic aging, which results mainly from environmental exposure such as ultraviolet (UV) radiation (Pittayapruek et al., 2016). Both forms of skin aging involve oxidative stress and the breakdown of structural proteins such as collagen and elastin. Because of this, skin aging models provide a useful way to connect the cellular mechanisms described above, namely oxidative stress, glycation, and senescence, with visible, measurable outcomes such as wrinkle depth and skin elasticity.

3. Medicinal Plants Studied

This review focuses on three medicinal plants with a long history of traditional use: Ashwagandha, Turmeric, and Ginseng. Each plant is described below in terms of its traditional use and its main active constituents.

3.1 Ashwagandha (Withania somnifera)

Ashwagandha, also known as Indian ginseng or winter cherry, is a shrub used widely in Ayurvedic medicine. Its roots contain a group of steroidal lactones called withanolides, which are considered responsible for many of its pharmacological effects (Mishra et al., 2000). Ashwagandha has traditionally been classified as an adaptogen, a substance believed to help the body cope with physical and mental stress (Singh et al., 2011). Modern research has examined its antioxidant, anti-inflammatory, and neuroprotective properties, all of which are relevant to processes involved in aging (Kulkarni & Dhir, 2008).

3.2 Turmeric (Curcuma longa)

Turmeric is a rhizome used both as a spice and as a medicinal plant across South Asia. Its main active component, curcumin, has been studied extensively for its antioxidant and anti-inflammatory properties (Aggarwal & Harikumar, 2009). Curcumin is reported to scavenge free radicals directly and to support the activity of endogenous antioxidant enzymes such as superoxide dismutase and catalase (Menon & Sudheer, 2007). These properties make turmeric a reasonable candidate for reducing the oxidative damage associated with aging.

3.3 Ginseng (Panax ginseng)

Ginseng is a root used widely in Traditional Chinese Medicine and is recognized for its adaptogenic properties. Its main active constituents, ginsenosides, have been reported to have antioxidant, anti-inflammatory, and immune-modulating effects (Attele et al., 1999). Ginseng has also been studied for its potential role in skin health, including its possible influence on collagen synthesis and skin barrier function (Kim et al., 2013).

3.4 Common Features Among the Three Plants

Although Ashwagandha, Turmeric, and Ginseng belong to different plant families and contain different classes of active compounds, namely withanolides, curcuminoids, and ginsenosides, they share a number of features relevant to aging research. Each plant has a long history of traditional use as a general health tonic rather than as a treatment for a single disease. Each also contains compounds capable of neutralizing free radicals, and each has been studied, to varying degrees, for effects on inflammation and skin health. These shared features make the three plants a reasonable group for comparison in a review focused on anti-aging activity.

4. Methods Used to Evaluate Anti-Aging Activity

Anti-aging research on plant extracts typically combines in vitro assays with in vivo animal models. Each method addresses a different aspect of the aging process, from free radical scavenging to visible changes in skin structure.

4.1 In Vitro Antioxidant Assays

Antioxidant activity is commonly assessed using assays such as DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging and ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)) assays. These methods measure the ability of a plant extract to neutralize free radicals under controlled laboratory conditions and are usually expressed as IC50 values, meaning the concentration required to inhibit 50 percent of radical activity (Sharma & Bhat, 2009). A lower IC50 value indicates stronger antioxidant activity.

4.2 Anti-Glycation Assays

Anti-glycation activity is typically measured by incubating a protein, such as bovine serum albumin, with a reducing sugar in the presence or absence of a plant extract. The extent of AGE formation is then measured using fluorescence or spectrophotometric methods (Wu & Yen, 2005). A reduction in AGE formation in samples treated with the extract indicates anti-glycation activity.

4.3 Senescence-Associated β-Galactosidase Staining

SA-β-gal staining is a standard method for detecting senescent cells in culture. Senescent cells show increased β-galactosidase activity at pH 6, which can be visualized using a specific staining reagent (Dimri et al., 1995). A decrease in the number of SA-β-gal-positive cells after treatment with a plant extract suggests that the extract has anti-senescence activity.

4.4 In Vivo UV-Induced Skin Aging Models

In vivo studies of skin aging often use mice exposed to ultraviolet (UV) radiation, which produces changes similar to those seen in human photoaging, including wrinkle formation, loss of elasticity, and reduced collagen content (Pittayapruek et al., 2016). Treating animals with a plant extract before or during UV exposure allows researchers to observe whether the extract offers protection against these structural and functional changes in the skin.

Outcomes in these models are usually assessed using a combination of visual and instrumental methods. Wrinkle formation can be scored visually or measured using replica imaging of the skin surface. Skin elasticity is often measured using a cutometer, an instrument that applies gentle suction to the skin and records how quickly it returns to its original shape. Collagen content is typically measured in skin biopsy samples using histological staining or biochemical assays. Using more than one method in the same study allows researchers to check whether visible improvements in the skin, such as fewer wrinkles, are matched by measurable changes at the tissue level, such as increased collagen content.

4.5 Value of Combining In Vitro and In Vivo Methods

No single test can capture every aspect of the aging process, which is why anti-aging research generally combines several methods. In vitro assays such as DPPH, ABTS, and anti-glycation assays are useful because they are quick, inexpensive, and allow direct comparison of different plant extracts under the same conditions. However, these assays are performed outside a living system and cannot fully represent what happens in skin or other tissues. In vivo models, such as the UV-induced skin aging model, provide information that is closer to how a plant extract might behave in a whole organism, but they are more time-consuming and raise additional questions about dosing, absorption, and safety. Using both types of methods together, as was done in the present study, provides a more complete picture of anti-aging activity than either approach alone.

5. Anti-Aging Activity of the Studied Plants

5.1 Antioxidant and Anti-Glycation Activity

Extracts of Ashwagandha, Turmeric, and Ginseng showed clear antioxidant and anti-glycation activity when tested using the methods described above. The reported IC50 values for antioxidant activity were 10.2 µg/mL for Ashwagandha, 15.6 µg/mL for Turmeric, and 20.5 µg/mL for Ginseng. Since a lower IC50 value reflects stronger activity, these results suggest that Ashwagandha had the strongest radical scavenging effect among the three plants under the conditions tested, followed by Turmeric and then Ginseng. A similar pattern was observed for anti-glycation activity, supporting the view that all three plants can reduce oxidative and glycation-related damage linked to aging.

5.2 Effect on Cellular Senescence

Treatment with extracts of the three plants was linked to a dose-dependent reduction in SA-β-gal activity, pointing to a decrease in the number of senescent cells. This finding suggests that these plants may help delay or reduce cellular senescence, one of the central mechanisms behind tissue aging.

5.3 Protection Against UV-Induced Skin Aging

In mice exposed to UV radiation, treatment with the plant extracts was associated with reduced wrinkle formation, improved skin elasticity, and increased collagen synthesis compared to untreated animals. These outcomes fit with the antioxidant and anti-glycation properties described above, since both oxidative stress and AGE accumulation are known to contribute to collagen breakdown and loss of skin elasticity (Gkogkolou & Böhm, 2012).

6. Discussion

The findings summarized in this review support the traditional use of Ashwagandha, Turmeric, and Ginseng in relation to aging and skin health. Each plant appears to act through more than one pathway, including direct radical scavenging, inhibition of glycation reactions, and reduction of cellular senescence markers. This overlap between pathways may help explain why traditional medicine systems have used these plants for general health maintenance rather than for a single, narrowly defined condition.

The agreement between the in vitro results, namely the antioxidant and anti-glycation assays, and the in vivo results from the UV-induced skin aging model strengthens the overall conclusion that these plants have measurable anti-aging activity. At the same time, the strength of this activity differed among the three plants, with Ashwagandha showing the lowest IC50 value and therefore the strongest antioxidant activity under the conditions tested in this study. This does not necessarily mean that Ashwagandha is the most effective plant overall, since factors such as extract concentration, preparation method, and the specific assay used can all influence the results.

It is also worth noting that antioxidant activity, anti-glycation activity, and anti-senescence activity, although related, are not identical measures. A plant extract could show strong activity in one assay and weaker activity in another, depending on which compounds are present and how they interact with the specific biological target being tested. The fact that Ashwagandha, Turmeric, and Ginseng each showed activity across all three types of assay in this study, rather than in only one, supports the idea that their anti-aging effects are not limited to a single mechanism.

The improvement in skin parameters observed in the UV-induced mouse model, namely reduced wrinkle formation, better elasticity, and increased collagen synthesis, is consistent with what would be expected if the extracts were acting through the antioxidant and anti-glycation pathways described earlier in this review. Reduced oxidative damage would be expected to limit the breakdown of collagen and elastin, while reduced glycation would be expected to limit the stiffening of existing collagen fibers. Taken together, the cellular-level findings and the tissue-level findings in this study point in the same direction and support each other.

7. Relevance to Pharmacy Practice

From a pharmacy perspective, these findings are relevant to the growing interest in plant-based cosmeceuticals and nutraceuticals aimed at supporting healthy aging. Pharmacists are often the first point of contact for patients asking about dietary supplements and topical products that contain plant extracts. A clear understanding of the scientific basis behind the anti-aging claims associated with Ashwagandha, Turmeric, and Ginseng allows pharmacists to give patients accurate, balanced information rather than relying only on marketing claims.

This understanding also supports the development of standardized plant-based formulations with defined antioxidant and anti-glycation activity, which is an important step toward making such products more consistent and reliable. Product quality is a particular concern for plant-derived supplements and cosmeceuticals, since the concentration of active compounds such as withanolides, curcuminoids, and ginsenosides can vary depending on the plant source, growing conditions, and extraction method. Pharmacists are well placed to advise patients on choosing products from manufacturers that provide clear information on standardization and quality control.

In addition, pharmacists can play a role in counseling patients about realistic expectations for plant-based anti-aging products. While the laboratory and animal findings reviewed here are encouraging, they do not by themselves prove that a given commercial product, at the dose typically used by consumers, will produce the same effects in humans. Communicating this distinction clearly, without dismissing the potential value of these plants, is an important part of responsible pharmacy practice.

8. Limitations and Future Directions

While the results reviewed here are encouraging, several limitations should be kept in mind. Much of the anti-aging research on these plants relies on in vitro assays and animal models, and further studies in humans are needed to confirm whether the same effects occur under real-world conditions. Differences in extraction methods, plant sources, and dosing can also affect reported activity, which makes direct comparison between studies difficult.

Future research should focus on standardizing extraction and testing methods so that results can be compared more reliably across studies. Identifying the specific active compounds responsible for the observed anti-aging effects would also help in developing targeted formulations. Finally, well-designed clinical trials in humans are needed to establish the safety and efficacy of these plants before firm recommendations can be made for their use in anti-aging products.

Safety is another area that deserves attention in future work. Although Ashwagandha, Turmeric, and Ginseng have long histories of traditional use, this does not automatically guarantee safety at the higher or more concentrated doses that may be used in modern extracts or supplements. Long-term safety data, as well as information on possible interactions with common medications, would strengthen the case for these plants as reliable anti-aging agents. Attention should also be given to the possibility that combining these plants, either with each other or with other active ingredients, could produce effects different from those seen when each plant is tested on its own.

9. Conclusion

This review has brought together available evidence on the anti-aging activity of Ashwagandha, Turmeric, and Ginseng, with attention to their antioxidant, anti-glycation, and anti-senescence properties. Results from in vitro assays and an in vivo UV-induced skin aging model, including reduced wrinkle formation, improved elasticity, and increased collagen synthesis, provide scientific support for the traditional use of these plants in promoting healthy aging. Further clinical research is needed to translate these findings into standardized, evidence-based therapeutic and cosmeceutical products.

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