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REVIEW

Pharmacological Activity of Chemical Compounds of Potato Peel Waste (*Solanum tuberosum* L.) in vitro: A Scoping Review

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Introduction: The potato (*Solanum tuberosum L.*) is a short-lived tuber plant with a round to oval shape and varying colors, depending on the variety. It is known that only the inside of the potato is used, while the peel is generally discarded. However, recent studies have shown that potato peels contain many health-beneficial compounds.

Purpose: This study aimed to investigate the compounds present in potato peels and their in vitro activities.

Methods: A scoping review following the PRISMA guidelines was conducted. The selection process involved identifying articles of in vitro research published within the last 10 years (2012–2022). Electronic searches were conducted using the portals Scopus, ScienceDirect, EBSCOhost, and Portal Garuda by using the keywords "potato" or "Solanum tuberosum" and "peel" or "skin". The search was limited to articles in English with full text availability.

Results: The screening process resulted in a total of 4773 articles from the four search engines; 14 articles were obtained that met the requirements for the review, most of which use extract preparations in their research. Extracts of flavonoids, phenols, and glycoalkaloids are the most frequently studied compounds, and their antioxidant and anti-inflammatory activity have undergone extensive research.

Conclusion: The potential compounds contained in potato peels, including flavonoids, phenols, and glycoalkaloids, are highly abundant and offer numerous benefits. Provides opportunities for further research to prove the potential pathway activity of the compound. These compounds have been the subject of extensive research, suggesting their significance in the context of health and nutrition.

Keywords: flavonoid, peel, antioxidants, anti-inflammatory

Introduction

Potato *(Solanum tuberosum L.)* is a member of the Solanaceae family of short-lived tuber plants, exhibiting varying shapes that range from round to oval. Additionally, the color of potatoes varies depending on the variety. Worldwide, there are approximately 5000 varieties of potatoes, and Indonesia alone has 34 types, including Granola, Atlantic, Cipanas, and Margahayu, among others.[1,2] Apart from being a source of 80% carbohydrates and one of the most consumed types of food by the world population, potatoes contain essential compounds crucial for maintaining good health. Notably, the composition of the compound depends on variety and growing conditions. They are rich in flavonoids and vitamin C, which function as antioxidants.[3–6] Additionally, potatoes contain anthocyanin, which functions as an antioxidant, anti-inflammatory, and antimicrobial. Potatoes are used as traditional herbal medicine in Indonesia, but there are no references written about them.[7]

Despite the general practice of discarding potato peels and utilizing only the inner part, a recent study has reported that potato peels are rich in polyphenol compounds, surpassing the content found in the flesh. Understanding the

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pharmacological properties of these compounds could open up new avenues for utilizing potato peels in food and medicine, promoting more sustainable and beneficial practices. This study aims to conduct an extensive review of various publications that investigate the in vitro content of potato peel compounds and their pharmacological potencies in the last ten years, so that it can provide information for further research because there have been no articles reviewing in vitro potato peel research before.

Materials and Methods

Protocol and Eligibility Criteria

This scoping review was conducted following the *Preferred Reporting Items for Scoping Reviews and Meta-Analyses* (PRISMA) method (Figure 1). The research questions were formulated using the *Population, Intervention, Comparison, and Outcome* (PICO) method. Specifically, the population of interest was focused on potato peels; the intervention under

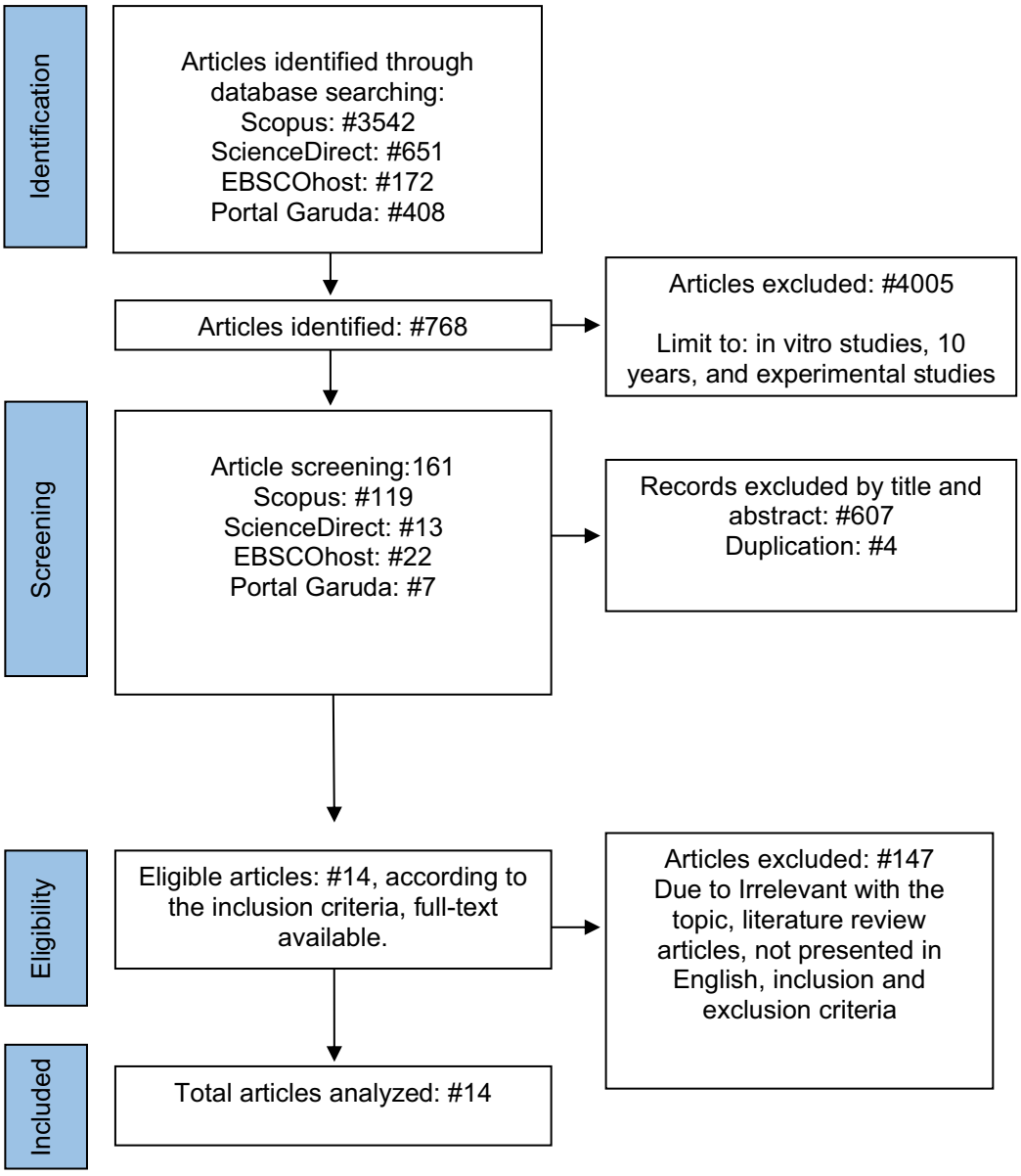

Figure 1 Flowchart of Preferred Reporting Items for Scoping Reviews and Meta-Analyses (PRISMA).

investigation involved compounds derived from potato peels; the comparison was made against a placebo; and the primary outcome of interest was the pharmacological activity of these compounds.

The inclusion criteria for this scoping review included research articles published within the last 10 years (2012–2022), in vitro research involving potato peel compounds, articles indexed in Indonesian or English, and English full-text availability. Based on these inclusion criteria, clinical research studies with only abstracts available were excluded, as they may not provide enough comprehensive data on the specific in vitro content and pharmacological activity of potato peel compounds.

Article selection and data extraction, according to the inclusion criteria, were carried out meticulously to ensure the integrity and comprehensiveness of the scoping review by two reviewers independently. The results of their evaluations were recorded in a table for further analysis. Journal articles were obtained through electronic searches as well as manual searching. The data obtained went through several stages of review. In the preliminary stage, abstracts were selected based on the relevance of the title and abstract to the research topic. The second stage involved further selection based on the content of the articles and adherence to the inclusion and exclusion criteria. Finally, the selected data from the eligible articles was extracted and processed for analysis.

Information Resources and Search

The article search strategies employed a comprehensive approach to gather relevant research articles. Relevant keywords such as "potato" or "Solanum tuberosum" and "peel" or "skin" were used, and advanced search techniques with "AND" and "OR" operators were utilized to refine the search results. The search was focused on electronic resources, including Scopus, ScienceDirect, EBSCOhost, and Portal Garuda. To ensure up-to-date information, the search was limited to articles published between 2012 and 2022. Portal Garuda, an online library in Indonesia, played a crucial role in the search as it houses research conducted in Indonesia and publishes it in Science and Technology Index (SINTA)-accredited journals. Articles sourced from Portal Garuda were considered to be from reputable journals, as SINTA is a journal accreditation issued by the Indonesian Ministry of Research and Technology.

Results

The PRISMA (Figure 1) diagram illustrates the systematic article selection process for the scoping review. Initially, a total of approximately 4773 articles were obtained from four search engines: Scopus, ScienceDirect, EBSCOhost, and Portal Garuda. After undergoing screening and selection based on inclusion and exclusion criteria, a total of 14 articles were deemed suitable for a review. Subsequently, the 14 selected articles were thoroughly read and analyzed to extract the relevant data. This data was then organized and recorded in Table 1.

Among these articles, 12 utilized potato peel extract preparations in their research, while two articles used potato peel fraction preparations. Additionally, six articles provided information on the specific varieties of potato peel used in the research, whereas the remaining articles referred to potato peels without specifying the variety. The majority of researchers focused on utilizing potato peel extract for its antioxidant and anti-inflammatory properties. Some studies also examined additional aspects such as antioxidant and antibacterial or antioxidant and antiviral properties. Moreover, anti-aging and anti-hyperglycemic properties were explored in certain studies, along with anti-viral effects.

Discussion

The analysis of potato peel content revealed the presence of phenolic compounds, flavonoids, and anthocyanins, with higher levels of flavonoids observed in potato peels compared to the flesh itself. The reviewed articles predominantly reported on the antioxidant activity of potato peel extract preparations.[8–16] The high antioxidant activity of potato peels can be attributed to the presence of vitamin C, flavonoids, polyphenols, and anthocyanins.[4–6] Vitamin C is an antioxidant that produces collagen, which is vital for maintaining skin health and facilitating wound healing by stimulating fibroblast formation. Increased fibroblast activity can accelerate the wound healing process.[17] The polyphenolic compound in potato peels can help prevent cell mutations that may lead to malignancy, while the antioxidant in potato peels can counteract the effects of free radicals.[16] Flavonoids, as reported in the research, exhibit antioxidant, *anticarcinogenic, antibacterial, anti-inflammatory, anti-allergic, analgesic*, and antiviral properties.[12,18] Flavonoids act as antioxidants by

Table 1 Characteristic Distribution of Articles on Potato Peel

No	Author/ Year	Title	Variant	Form Preparation	Chemical Compound	The Study Animals Involvement	Activity of the Potatoes Peel Extract/ Fraction	The Doses of the Potatoes Peel Extract/ Fraction
1	Sampaio et al, 2021.[8] Greece	Phenolic composition and cell-based biological activities of ten colored potato peels	*Rosemary, Red Cardinal, Red Emmalie, Purple, Kafermarkter Blaue, UACH 0917, Salad Blue, Blaue aus Finnland, Shetland Black, Violetta*	Potato peel ethanol extract	Anthocyanins, (non-anthocyanins) phenolic compounds, flavonoids, caffeic, caffeoylquinic acids, kaempferol	No (antioxidant and antitumor activity)	Anti-oxidant activity with cell based in vitro, anti-inflammatory activity with mouse macrophage RAW 264.7 and cytotoxic activity with cancer cell line	Significant effect as an anti-oxidant and antitumor, Rosemary extract is the best anti-oxidant (IC_{50}=26 µg/mL), cytotoxic (IG_{50}=304 µg/mL), and anti- inflammatory (IC_{50} =141 µg/mL)
2	Ansari et al, 2020.[9] India	Nutritional and pharmacological potential of potato peels: A valuable multifunctional waste food industry	Lady Rosetta (LR) red skin and FT-1533 (brown skin)	Potato peel ethanol extract	Phenol and flavonoid compounds.	No (antioxidant activity)	Anti-oxidant activity with radical scavenging assay (RSA) DPPH (40 µL) and ferric reducing anti-oxidant power (FRAP) (0.1 µL)	Lady Rosetta (LR) having higher anti-oxidant (RSA= 63, 32) activity and nutritional content than FT-1533. Doses for RSA 40 µL and 0.1 µL for FRAP
3	Wahyudi et al, 2020.[18] Indonesia	Analgesic, anti-inflammatory, and anti-biofilm-forming activity in potato peel extract	*Solanum tuberosum*	Potato peel ethanol extract	Phenol and flavonoid compounds	Yes (anti-inflammatory activity) No (anti-biofilm activity)	Analgesic activity with Wistar rats by placing at hotplate 60°C, anti- inflammatory activity with Wistar rats induced by 1% carrageenan, anti-biofilm activity with streptococcus ATCC 25175.	Significant as anti- inflammatory, anti-biofilm, and analgesic Analgesic uses 50, 100 and 200 mg/kg. Anti- inflammatory 100, 200, and 400 mg/kg. Anti-biofilm using 5%, 10%, and 20% extract
4	Verma et al, 2017.[19] India	Anti- inflammatory activity of *Solanum tuberosum* Peel extracts on carrageenan-induced raw paw edema	*Solanum tuberosum*	Potato peel 70% ethanol extract	Flavonoid and phenols compounds	Yes (anti-inflammatory activity)	Anti- inflammatory activity with Wistar rats induced by 0.1% carrageenan	In doses 100 and 200 mg/kg of potato peel ethanol extract has an anti- inflammatory effect in rats induced by edema
5	Kenny et al, 2013.[20] Ireland	Anti-inflammatory Properties of potato glycoalkaloids in stimulated Jurkat and Raw 264.7 mouse macrophages	*Solanum tuberosum*	Ethyl acetate fraction and methanol fraction	Glycoalkaloid compounds by Waters acquity method	No (anti-inflammatory activity)	Anti-inflammatory activity with human Jurkat T cell and RAW 246.7 mouse macrophages by biomarker IL2 and IL8	Using doses 5, 10, 25 µ/mL Glycoalkaloid Compounds from the potato peel fraction have anti-inflammatory effects, for example, diosgenin which can inhibit the inflammatory response
6	Helal et al, 2020.[10] Egypt	Evaluation of potato peel extract as a source of anti-oxidant and antimicrobial substances	*Solanum tuberosum*	Water, methanol, and ethanol (80 and 100%) extracts from potato peels	Phenol and flavonoid compounds (vanillic and hesperidin)	No (anti-microbial and anti-oxidant activity)	Anti-oxidant activity with DPPH and anti-microbial with Bacillus subtilis ATCC 6633, Staphylococcus aureus ATCC 29213, E. coli ATCC 25922, Salmonella t. ATCC14028, and C. albicans ATCC 10231	Dose 70 µL (200 and 400 ppm), potato peel methanol extract 400 ppm was more effective in inhibiting gram-positive, gram-negative bacteria and *Candida albicans* than ampicillin (control)

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7	Chauhan, 2014.[11] India	Study of anti-oxidant potential of *Solanum tuberosum* peels extract	*Solanum tuberosum*	Ethyl acetate and methanol extract from potato peel	Phenolic compounds (gallic acid)	No (anti-oxidant activity)	Anti-oxidant activity with DPPH method and Nitric oxide activity.	The phenolic content of the ethyl acetate extract was higher than the methanol extract; the anti-oxidant capacity of the ethylacetate extract was better than the methanol extract with DPPH and Nitric oxide activity in doses (0.2; 0.4; 0.6; 0.8; 1 mg/mL)
8	Amanpour et al, 2015.[28] Iran	Anti-bacterial effects of *Solanum tuberosum* peel ethanol extract in vitro	*Solanum tuberosum*	Ethanol extract 80%	Flavonoid Compounds	No (anti-bacterial activity)	Anti-bacterial activity with (S. pyogenes PTCC 1447, S. aureus PTCC 1113, P. aeruginosa PTCC 1430, K. pneumonia PTCC 1053)	30 µL of extract contains phenolic compounds, anthocyanins, and flavonoids in potato peel extract provide anti-bacterial effects, especially in gram-positive bacteria
9	Silva-Beltran et al, 2017.[12] Mexico	Phenolic compounds of potato peel extracts: their anti-oxidant activity and protection against human enteric viruses	*Solanum tuberosum* Fianna variety	Ethanol extract and water extract	Phenolic and flavonoid compounds (quercetin and gallic acid)	No (anti-oxidant and anti-viral activity)	Anti-oxidant and antiviral activity (Bacteriophages Av-05 and MS2 and host E. coli ATCC 4076)	With concentration 1, 3, 5 mg/mL. phenol and flavonoid compounds from ethanol extract and their derivatives can inhibit the replication of MS2 and Av-05 phage viruses (viruses found in food) and showed anti-oxidant activity.
10	Suto et al, 2019.[29] Japan	A potato peel extract stimulates type I collagen synthesis via Akt and ERK signaling in normal human dermal fibroblasts	*Solanum tuberosum* Kitahime variety	Ethanol extract 50%	Phenolic and flavonoid compounds	No (anti-aging activity)	Anti-aging activity with normal human dermal fibroblasts (NHDF) cell.	COL 1A1 and COL 1A2 mRNA expression increases and promotes collagen synthesis through the signaling pathways Akt/PI3K and MAPK/ERK with doses 5, 10, 15 µg/mL of extract ethanol.
11	Friedman et al, 2017.[13] USA	Glycoalkaloid, phenolic, and flavonoid content and anti-oxidative activities of conventional non-organic and organic potato peel powders from commercial Gold, Red, and Russet potatoes	*Solanum tuberosum* Gold, Red, and Russet varieties (Organic and non-organic)	Extract with acetate acid 5% and ultrasonic method	Phenolic compounds, flavonoids, and glycoalkaloids	No (anti-oxidant activity)	Anti-oxidant activity with 3 method (DPPH), ferric reducing (FRAP), scavenging of ABTS radical)	Doses 0.8 µL, 10 µL and 60 µL for each method. The anti-oxidant activity of organic potato peel compounds was higher than non-organic or conventional ones but not significantly
12	Arun et al, 2015.[14] India	A comparative evaluation of anti-oxidant and anti-diabetic potential of peel from young and matured potato	*Solanum tuberosum*	Hexane, ethyl acetate, methanol extract	Polyphenolic compounds	No (anti-oxidant and anti-diabetic activity)	Anti-oxidant activity with DPPH, nitric oxide and anti-diabetic activity with L6 (rat skeletal myoblast) cell line	Concentration of extract 1, 10 and 100 µL/mL. Young potato anti-oxidant and anti-diabetic activity were better than mature potatoes. Ethyl acetate extract has the highest phenol content among all solvents

(*Continued*)

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Table 1 (Continued).

No	Author/ Year	Title	Variant	Form Preparation	Chemical Compound	The Study Animals Involvement	Activity of the Potatoes Peel Extract/ Fraction	The Doses of the Potatoes Peel Extract/ Fraction
13	Albishi et al, 2013.[15] Canada	Phenolic content and anti-oxidant activities of selected potato Varieties and their processing by products	*Solanum tuberosum* Yellow, Innovator Russet, and Purple varieties	Phenolic fractions	Polyphenolic compounds, anthocyanins	No (anti-oxidant activity)	Anti-oxidant activity with Trolox (TEAC), DPPH and oxygen radical absorbance (ORAC)	The highest total phenolic (7.2 mg/g peel) and anti-oxidant activity was found in purple potato peel compared to other varieties
14	Gebrechristos et al, 2020.[16] China	Potato peel extracts as an antimicrobial and potential anti-oxidant in active edible film	*Solanum tuberosum*	Ethanol potato peel extract	Phenol and flavonoid compounds	No (anti-oxidant and anti-bacterial activity)	Anti-bacterial activity with E. coli ATCC 25922, S. enterica ATCC 1311, K. pneumonia ATCC 2473, S. aureus ATCC 6538, L. monocytogenes ATCC 19115 and Anti-oxidant activity with DPPH	Potato peel extract (10 mg/mL) has anti-bacterial activity (MIC 7.5, 5.8 and 4.7mg/mL) and anti-oxidant activity, its phenolic compounds can inhibit lipid oxidation and inhibit bacterial

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neutralizing *reactive oxygen species (ROS)*. Free radicals suppress the level of antioxidants, which leads to oxidative instability, known as oxidative stress. This condition is characterized by an increase in lipid peroxidation, as measured by the marker *malondialdehyde*, due to an excess of lipid peroxidase. Flavonoids exhibit antioxidant activity by binding to free radical ions and preventing the formation of singlet oxygen. With multiple phenol groups (–OH and aromatic groups) and double bonds, flavonoids can counteract free radicals by donating one –OH hydroxyl group.[14] The mechanism can occur directly or indirectly. In indirect action, flavonoids donate one hydroxyl ion to bind to free radicals and neutralize their toxic effects. Indirectly, flavonoids increase the expression of endogenous antioxidants by activating nuclear factor-erythroid 2 related factor 2 (Nrf2) genes, which are involved in the synthesis of endogenous antioxidant enzymes such as superoxide dismutase (SOD).[14]

Potato peel chemical compounds also have anti-inflammatory properties.[8,18–20] Anti-inflammatory activity is the second most prominent after antioxidants. Several researchers have conducted studies simultaneously on anti-inflammatory and antioxidant effects, carried out by Wahyudi (2020) and Sampaio (2021). These studies reported that potatoes contain anthocyanin compounds besides flavonoids, which act as both antioxidants and anti-inflammatory agents. In other studies, anthocyanins have been found to contribute to the inhibition of collagen aging by preventing cell damage, promoting vascularization, initiating DNA synthesis, and playing a role in fibronectin and fibroblast synthesis, suggesting their potential in the wound healing process.[7,18,21] The anti-inflammatory mechanism of flavonoids involves the inhibition of the cyclooxygenase and lipoxygenase pathways, as well as the inhibition of histamine and leukocyte accumulation, which are crucial in overcoming inflammation and allergic symptoms. Flavonoids can also suppress the secretion of arachidonic acid and lysosomal enzymes.[22–25] According to al-Kayri (2022), flavonoids target the NF-κB, MAPK, ERK, and Akt pathways to reduce inflammation and oxidative stress. Furthermore, anthocyanins and flavonoids have been shown to reduce proinflammatory cytokines such as TNF-α, IL-6, IL-8, IL-1β, IL-17, and IFN-γ.[22,25,26]

The antibacterial activity of potato extract has been investigated in studies conducted by Amanpour (2015), Gebrechristos (2020), and Helal (2020). Potato peel extract has been shown to effectively inhibit the growth of Propionibacterium, gram-positive and gram-negative bacteria, and *Candida albicans*.[10,16,27] Amanpour's research (2015) specifically indicates that potato peel extract has a greater impact on gram-positive than gram-negative bacteria.[28] Flavonoids, anthocyanins, solasodine, and solanidine in potato peel extract exhibit strong antimicrobial and antioxidant properties. Silva's study (2017) found that derivatives of phenolic compounds, namely chlorogenic and caffeic acids, have a role in antiviral and antimicrobial activity.[12,16] Phenolic derivatives of potato peel extract, such as quercetin, interfere with the processing of retroviral (RV) polyproteins by RV proteases, which are essential for the inactivation of RNA polymerase. Consequently, these compounds can interfere with viral replication through multiple mechanisms. Caffeic and chlorogenic acids inhibit viral capsids, and this activity may stem from the presence of free hydroxyl and ester groups.[12,16] The higher effectiveness of antimicrobial activity against gram-positive bacteria can be attributed to the differences in cell wall structure, with gram-negative bacteria possessing a layered cell wall compared to gram-positive bacteria.[16]

Another benefit of potato peel extract is its anti-aging activity. The extract activates PI3K/Akt and MAPK/ERK signaling through TGF-β receptors, which then stimulate type I collagen synthesis by fibroblasts.[29] Previous studies have also reported that ascorbic acid, various phenolic compounds, and flavonoids stimulate type I collagen synthesis in the dermis.[29]

Glycoalkaloid compounds and flavonoids present in potato peels also possess antihyperglycemic properties.[6] Quercetin, a type of flavonoid, plays a role in maintaining the normal function of pancreatic beta cells, thereby controlling fasting blood sugar levels and postprandial hyperglycemia. Additionally, quercetin can also inhibit the α-glucosidase enzyme and inhibit glucose transport by GLUT2. GLUT2 (*Glucose Transporter 2*) is responsible for carrying glucose from the digestive tract into the bloodstream, and inhibiting this transporter helps regulate blood sugar levels.[14,27] Arun (2015) reported that ethyl acetate extract from potato peel increased glucose absorption in the blood through the GLUT4 transporter in skeletal muscle and adipose cells.[14]

Conclusion

Potato peels are rich in potential compounds that offer various health benefits, particularly in young potato peels. Flavonoids, phenolic compounds, and glycoalkaloids have been extensively studied for their antioxidant and anti-inflammatory activities, primarily in the form of ethanol extracts. Further research is needed to understand the specific

mechanism of action for each compound in potato peels and explore their potential for other pharmacological activities beyond antioxidation and anti-inflammation.

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Disclosure

The authors report no conflicts of interest in this work.

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