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REVIEW

Anti-Inflammatory and Anticancer Potential of *Solanum tuberosum* L. Bioactive with Proposed Mechanisms in Oral Squamous Cell Carcinoma: A Scoping Review

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Abstract: *Solanum tuberosum* L. (potato) contains various bioactive compounds with health-promoting properties. Its extracts are composed of multiple classes of phytochemicals, among which two are of particular interest, anthocyanins, a subclass of polyphenols, and steroidal glycoalkaloids. The predominant glycoalkaloids, α-solanine and α-chaconine, along with anthocyanins, exhibit potent antioxidant, anti-inflammatory, and anticancer activities. Both α-solanine and α-chaconine have demonstrated pro-apoptotic, anti-proliferative, and anti-inflammatory effects in various cancer models. These compounds have been shown to modulate inflammation-associated pathways implicated in carcinogenesis. However, their relevance to inflammation-driven oral malignancies, particularly oral squamous cell carcinoma (OSCC), remains unclear. This scoping review followed PRISMA-ScR guidelines. A systematic search of PubMed and Scopus was conducted for articles published up to December 2024 using predefined keywords. Eligible studies investigated the anticancer or anti-inflammatory effects of glycoalkaloids or anthocyanins from *S. tuberosum* in vitro or in vivo. Eighteen studies met the inclusion criteria: 12 in vitro, 2 in vivo, and 4 combining both. Most studies focused on colorectal (n = 6), breast (n = 4), and lung (n = 3) cancers. Treatments with glycoalkaloids (1–50 μM) or anthocyanins (10–200 μg/mL) demonstrated pro-apoptotic, anti-proliferative, and anti-angiogenic effects. However, no study evaluated these compounds in OSCC models. Glycoalkaloids and anthocyanins from *S. tuberosum* exhibit promising anticancer and anti-inflammatory properties in various types of cancer. The absence of OSCC-focused research highlights a significant gap and the need for future studies in this context.

Keywords: anticancer, anthocyanins, glycoalkaloids, oral squamous cell carcinoma, *Solanum tuberosum* L

Introduction

Solanum tuberosum L., commonly known as the potato, is one of the world's most important food crops, originating in the Andes Mountains in Peru and Bolivia. It belongs to the *Solanaceae* family, which includes other widely consumed edible species such as tomato (*Solanum lycopersicum*) and eggplants (*Solanum melongena*), while peppers belong to the related genus Capsicum.[1,2] The *Solanum* genus is rich in bioactive compounds, including phenolic compounds, alkaloids, saponins, terpenes, and lipids, making it a valuable source for medicinal applications.[3,4] *Solanum tuberosum* L. refers to the potato plant. *S. tuberosum* extract refers to any preparation derived from the plant's tubers, peel, or sprouts. These extracts contain numerous bioactive compounds, which fall into distinct chemical classes. Glycoalkaloids are nitrogen-containing steroidal secondary metabolites; the most abundant in potatoes are α-solanine and α-chaconine. Anthocyanins, found in pigmented potato varieties, are a subclass of flavonoids, which are themselves a class of polyphenols.[4,5]

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Among the numerous phytochemicals present, steroidal glycoalkaloids (α-solanine and α-chaconine) and, in pigmented varieties, polyphenolic anthocyanins have garnered significant scientific interest for their potent biological activities.[4] These compounds are particularly concentrated in the tuber skin and sprouts and are considered primary contributors to the bioactivity discussed in this review.[6] The primary glycoalkaloids found in cultivated potatoes are α-solanine and α-chaconine, which together constitute over 95% of the total glycoalkaloid content and are the focus of the majority of toxicological and pharmacological research.[5] These bioactive have demonstrated antirheumatic, antimicrobial, and antitumor properties, with their potential anticancer effects garnering particular interest.[4]

Oral cancer, of which over 90% is oral squamous cell carcinoma (OSCC), represents a significant global health burden, with 389,846 new cases and 188,438 deaths reported worldwide in 2022, making it one of the most common and lethal head and neck malignancies globally.[7,8] OSCC is primarily associated with risk factors such as smoking and alcohol consumption, which act synergistically. Other contributing factors include chronic trauma, genetic predisposition, and dietary influences.[9,10] Despite advances in surgery, radiotherapy, and chemotherapy, the 5-year survival rate for OSCC has remained stagnant at approximately 50% for several decades, often due to late diagnosis, recurrence, and significant therapy-associated morbidity.[11] This highlights an urgent need for novel preventive and therapeutic strategies, particularly those that can target the chronic inflammation underpinning the disease.

Recent studies have developed predictive inflammatory trajectory models to describe how inflammation and immune responses change over time in oral tissues. These models help explain the connection between immune activity, tissue injury, and cancer development. For example, dynamic mucositis prediction models have been used to monitor inflammation and healing during cancer treatments.[12] Such approaches show that persistent inflammation can be tracked to predict changes in oral tissue and recovery. Including this perspective helps strengthen the scientific rationale for studying anti-inflammatory compounds, such as glycoalkaloids and anthocyanins from *S. tuberosum*, in oral cancer prevention and therapy.

It is now well-established that chronic inflammation is a key driver of OSCC initiation and progression, a feature that sets OSCC apart from many other epithelial cancers.[13] Key signaling pathways, including nuclear factor-kappa B (NF-κB), the Interleukin-6 (IL-6)/JAK/STAT3 axis, and mitogen-activated protein kinase (MAPK) pathways, are constitutively active in OSCC, promoting cell proliferation, survival, and immune evasion.[14–16] Given that potato-derived glycoalkaloids and anthocyanins have been shown to modulate these exact inflammatory pathways in other cancer models, a compelling rationale exists to investigate their potential therapeutic utility in OSCC, a research area that remains completely unexplored.[5]

In this scoping review, we summarize the current evidence on the anticancer and anti-inflammatory properties of *S. tuberosum* bioactive compounds and explore their potential implications for OSCC prevention and treatment. Unlike previous reviews that broadly examined *Solanaceae* or potato phytochemicals in cancer, this review uniquely emphasizes the proposed mechanisms relevant to OSCC and highlights critical gaps to guide future research.

Materials and Methods

This scoping review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for Scoping Reviews (PRISMA-ScR) guidelines to ensure methodological transparency and systematic reporting.[17] The study design was based on the Arksey and O'Malley framework, with refinements based on the recommendations of Levac et al.[18] A PRISMA-ScR checklist was utilized to ensure completeness in study selection, data extraction, and synthesis. The completed PRISMA-ScR checklist is provided as a supplementary file.

To ensure that the molecular pathways addressed in this review were translationally relevant to OSCC, evidence from validated OSCC experimental models was also considered. Specifically, NF-κB inhibitor assays conducted in established OSCC cell lines (eg, SCC-9, HSC-3, CAL-27) were reviewed to confirm the pathway's relevance to inflammation-driven tumorigenesis.[19] This evidence supported the inclusion of NF-κB as a mechanistic reference framework in this review.

The study was structured using a Population, Intervention, Comparison, and Outcome (PICO) framework.

- Population (P): Studies involving in vivo (human participants or animal models), or in vitro cell lines in which *S. tuberosum* or its bioactive compounds were assessed in cancer research.

- Intervention (I): Use of *S. tuberosum* extracts, glycoalkaloids (α-solanine and α-chaconine), anthocyanins, or any derived formulations for cancer-related applications.
- Comparison (C): Control groups treated with a placebo, untreated cells/animals, or standard treatment.
- Outcome (O): Evaluation of anticancer effects, including apoptosis induction, tumor growth inhibition, angiogenesis suppression, oxidative stress modulation, and immune response regulation.

A systematic literature search was conducted using PubMed and Scopus, covering peer-reviewed publications without time restrictions. The search period spanned December 16, 2024, to December 21, 2024, with a final update on December 21, 2024. The search strategy incorporated Boolean operators, truncation, and Medical Subject Headings (MeSH) terms to retrieve relevant studies. The primary search terms included ("Solanum tuberosum L." OR "potato extract") AND ("cancer" OR "tumor" OR "neoplasm" OR "malignancy"). A secondary search included ("Solanum tuberosum L.") AND ("oral cancer" OR "OSCC" OR "head and neck cancer"). Given that no studies focusing on OSCC were identified, a broader search was conducted to evaluate the anticancer effects of *S. tuberosum* on epithelial malignancies, such as colorectal, breast, prostate, and lung cancers, to determine its potential relevance. The reference lists of selected articles were manually screened to identify additional relevant studies.

The study selection followed a three-stage process and was conducted independently by two reviewers (A.L. and S. A.) to ensure rigor and minimize bias. The initial stage involved screening titles and abstracts to exclude non-relevant articles. The second stage involved a full-text review based on the eligibility criteria. The final selection included studies that met all the criteria, with discrepancies resolved through discussion or consultation with a third reviewer (I.S). The PRISMA-ScR flow diagram (Figure 1) outlines the identification, screening, and selection of the studies.

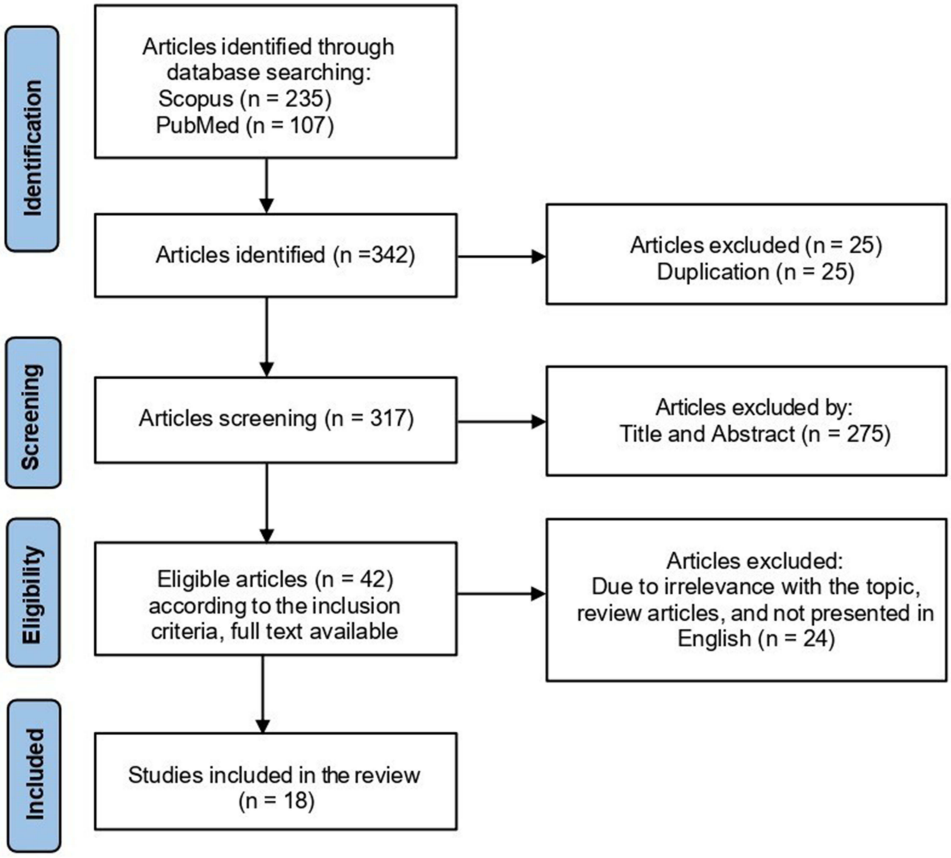

Figure 1 Flowchart of Preferred Reporting Items for Scoping Review and Meta-analysis (PRISMA).

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Data were extracted using a standardized form to ensure consistency across studies. The extracted variables included publication details, study design (in vitro, animal, or human), type of cancer investigated, form of *S. tuberosum* used, bioactive compounds, mechanisms of action, dosage, treatment regimen, and key findings. Owing to the heterogeneity of the study design, a meta-analysis was not performed, and findings were summarized narratively.

All studies investigating *S. tuberosum* in oral and precancerous cancers were considered potentially admissible. No restrictions were applied for the publication year. Language restrictions were not imposed, provided that an English abstract was available.

Results

A comprehensive search of Scopus and PubMed identified 342 articles that investigated the anticancer potential of *S. tuberosum* extracts. After removing duplicates, 186 studies were screened based on title and abstract relevance. Following full-text assessment and application of the eligibility criteria, 18 studies met the inclusion criteria and were included in this review. The study selection process followed the PRISMA guidelines as illustrated in Figure 1 (PRISMA Flow Diagram).

Among the 18 included studies, 12 were in vitro, 2 used animal models, and 4 employed both in vitro and in vivo assessments. The primary bioactive compounds investigated were glycoalkaloids (α-solanine and α-chaconine) and anthocyanins. The studies primarily focused on epithelial cancers, with colorectal cancer, breast cancer, lung cancer, and prostate cancer being the most studied models.

The in vitro studies predominantly utilized well-established epithelial cancer cell lines, with colorectal cancer (HT-29, Caco-2), breast cancer (MCF-7, MDA-MB-231), and prostate cancer (DU145) being the most frequent models. In vivo studies primarily employed xenograft models in mice. Dosages varied significantly depending on the preparation, with isolated glycoalkaloids often tested in the micromolar (μM) range in vitro and at doses around 5 mg/kg in animal models, while whole potato extracts were incorporated into diets at concentrations of 10–20% (w/w). Despite extensive investigations into the anticancer properties of *S. tuberosum* bioactives, no studies have directly evaluated their effects on OSCC or other head and neck cancers. This gap is particularly relevant given the strong inflammatory component of OSCC pathogenesis.

The reviewed studies identified three primary mechanisms through which *S. tuberosum* extracts exert anticancer effects: (1) induction of apoptosis; (2) inhibition of proliferation and cell cycle arrest; and (3) suppression of invasion, metastasis, and angiogenesis. Glycoalkaloids were found to activate apoptotic pathways by triggering caspase activation and disrupting the mitochondrial membrane potential. Moreover, *S. tuberosum* bioactive suppresses tumor growth by modulating cell cycle checkpoints and downregulating MAPK signaling. Furthermore, the inhibition of MMP-2/9 activity and vascular endothelial growth factor (VEGF) expression suggests a role in preventing tumor invasion and angiogenesis.

These findings highlight the therapeutic potential of potato-derived bioactive compounds in epithelial cancers. The evidence summarized in Table 1 demonstrates the anticancer properties of potato-derived bioactives across various epithelial malignancies. Despite this, their role in OSCC remains largely unexplored. Given the inflammatory nature of OSCC and the ability of glycoalkaloids and anthocyanins to modulate inflammation, oxidative stress, and apoptotic pathways, we hypothesize that these compounds could target critical molecular drivers of OSCC progression. This concept is illustrated in Figure 2.

Discussion

The potential role of *S. tuberosum* in cancer therapy has garnered considerable attention owing to its rich phytochemical content and safety profile as a dietary supplement. This review synthesizes evidence primarily from studies on epithelial cancers, including colorectal, breast, and lung cancer. These studies consistently report that glycoalkaloids (eg, α-solanine and α-chaconine) and anthocyanins exhibit anti-proliferative, pro-apoptotic, antiangiogenic, and antimetastatic properties. Importantly, many of these effects are considered to be mediated via the modulation of inflammatory pathways and oxidative stress responses, which are increasingly recognized as key drivers of cancer development and progression.[5,20,38]

Table 1 Summary of Included Studies on the Anticancer Activities of *S. tuberosum* Bioactives

No	Author/Year	Form Preparation	Key Bioactives	Study Type	Cancer Model (Cell Line/Animal)	Activity	Doses Tested	Outcome/Main Findings
1	Kowalczewski et al (2023)[20]	Enzyme-digested potato juice	Glycoalkaloids, phenolic acids	In vitro	Digestive system cancer cells	Cytotoxic to digestive system cancer cells	Dose-dependent	Concentration-dependent cytotoxicity of solanine and chaconine on gastric and colon cancer cells; chaconine was more toxic
2	Nielsen et al (2019)[21]	Resistant starch	Butyrate	In vivo	Rat model	Reduced oncogenic miRNA expression in colon tissue	10% substitution in diet	Oncogenic miRNAs in colon tissue were markedly downregulated in vivo
3	Sido et al (2017)[22]	Purple-fleshed potatoes in a high-calorie diet	Anthocyanins	In vivo	Mouse model	Suppressed IL-6 signaling pathways	10% w/w in diet	IL-6 signaling was suppressed, and systemic inflammation was reduced in obese mice
4	Pan et al (2016)[23]	Glycoalkaloid (α-solanine)	α-Solanine	In vitro and in vivo	DU145 (prostate); Nude mice	Suppressed tumor growth via ROS/P38 pathway activation	NS	DU145 tumor growth was significantly reduced in nude mice via ROS/p38 activation
5	Singh et al (2016)[24]	Potato peel extracts	α-Solanine, α-chaconine	In vitro	Various cancer cells	Demonstrated cytotoxicity against cancer cells	NS	Broad-spectrum cytotoxic effects were observed on multiple cancer cell lines
6	Charepalli et al (2015)[25]	Baked potato extract	Anthocyanins	In vitro and in vivo	Colon cancer stem cells; Mouse model	Reduced colon cancer stem cells and suppressed tumor incidence	20% w/w in diet	Colon tumor incidence and stem cell fraction were lowered after dietary anthocyanin intake
7	Bontempo et al (2015)[26]	Anthocyanin extracts	Anthocyanins	In vitro	MCF-7, MDA-MB-231 (breast)	Modulated cell cycle regulators and induced apoptosis	NS	Breast cancer cells showed cell cycle arrest and expressed apoptosis markers
8	Sun et al (2014)[27]	Glycoalkaloid (α-solanine)	α-Solanine	In vitro and in vivo	Panc-1 (pancreatic); Xenograft in mice	Inhibited pancreatic cancer growth by promoting apoptosis	NS	Pancreatic cancer growth was inhibited in the xenograft model through apoptosis
9	Mohsenikia et al (2013)[28]	Glycoalkaloid (α-solanine)	α-Solanine	In vitro and in vivo	4T1 (breast); BALB/c mice	Reduced tumor size and weight; enhanced apoptosis	5 mg/kg	Breast tumor weight decreased by >40% with histological evidence of apoptosis

(*Continued*)

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Table 1 (Continued).

No	Author/Year	Form Preparation	Key Bioactives	Study Type	Cancer Model (Cell Line/Animal)	Activity	Doses Tested	Outcome/Main Findings
10	Madiwale et al (2012)[29]	Processed colored potatoes (baked/chipped)	Anthocyanins	In vitro	HT-29 (colon)	Induced apoptosis in human colon cancer cells	NS	Clear apoptotic morphology was observed in HT-29 colon cancer cells
11	Ombra et al (2015)[30]	Anthocyanin extracts	Anthocyanins	In vitro	Caco-2 (colon)	Inhibited cancer cell proliferation and induced apoptosis	Dose-dependent	Proliferation was reduced and apoptosis was enhanced in Caco-2 colon cancer cells
12	Hayashi et al (2010)[31]	Purple and red anthocyanins	Anthocyanins	In vitro	Various cancer cells	Induced apoptosis in cancer cells without toxicity to normal cells	Dose-dependent	Apoptosis was induced in cancer cells without damaging normal cells
13	Lu et al (2010)[32]	Glycoalkaloid (α-solanine)	α-Solanine	In vitro	A2058 (melanoma)	Reduced MMP-2/9 activities, inhibited metastasis	NS	Melanoma metastasis was suppressed by inhibiting MMP-2 and MMP-9 activity
14	Yang et al (2006)[33]	Glycoalkaloid extract	α-Chaconine	In vitro	HT-29 (colon)	Induced apoptosis in colon cancer cells via caspase-3 activation	Time- and concentration-dependent	Apoptosis in colon cancer cells was linked to caspase-3 activation
15	Langner et al (2009)[34]	Heated potato fiber (Potex)	Melanoidins, fibers	In vitro	HT-29 (colon), MCF-7 (breast)	Decreased motility and induced apoptotic death in tumor cells	NS	Cell motility was reduced, and apoptotic features were increased in breast and colon cancer cells
16	Bontempo et al (2013)[35]	Crude anthocyanin extract	Anthocyanins	In vitro	MCF-7, T47D (breast)	Anti-proliferative and pro-apoptotic activity in cancer cells	Dose-dependent	Breast cancer cell growth was suppressed with upregulated apoptotic markers
17	Friedman et al (2005)[36]	Isolated glycoalkaloids	α-Solanine, α-Chaconine	In vitro	HeLa (cervical), HepG2 (liver), AGS (stomach)	Inhibited growth of cervical, liver, and stomach cancer cells	Dose-dependent	Marked inhibition of cervical, liver, and gastric cancer cell proliferation was observed
18	Zargarani et al (2025)[37]	Solanine-loaded niosome nanoparticles	α-Solanine	In vitro	MCF-7 (breast)	Induced apoptosis and arrested G0/G1 cell cycle in MCF-7 cells	IC_{50} values reported	MCF-7 cells showed G0/G1 arrest and dose-dependent apoptosis (IC_{50} reported)

Abbreviations: NS, Not Specified (the original study did not report the exact dose or concentration tested); w/w, weight/weight; IC_{50}, Inhibitory Concentration 50%.

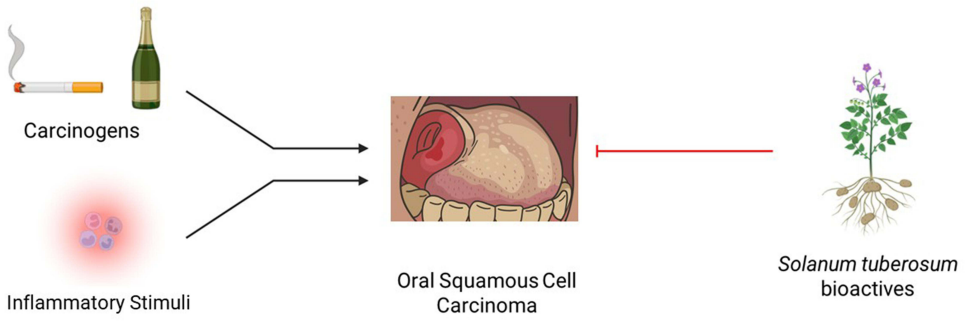

Figure 2 Conceptual overview. Exogenous carcinogens and inflammatory stimuli converge on oral squamous cell carcinoma (OSCC). *S. tuberosum bioactives* act as inhibitors of these drivers.

Recent OSCC-specific transcriptomic studies have identified novel immune-related biomarkers that provide deeper insight into tumor progression. In particular, cuproptosis-associated long non-coding RNAs (lncRNAs) have been linked to oxidative metabolism and immune infiltration patterns that predict OSCC prognosis.[39] While the direct influence of anthocyanins on these pathways has not yet been examined in OSCC, their capacity to regulate mitochondrial redox balance and inflammation in epithelial cancers suggests potential relevance. Integrating these emerging biomarker findings with phytochemical modulation could therefore refine the mechanistic framework for future OSCC-specific investigations.

Mechanistic Links Between S. tuberosum Bioactives and OSCC Inflammatory Pathways

The induction of apoptosis is one of the most notable mechanisms reported in the reviewed studies. Glycoalkaloids, such as α-solanine and α-chaconine, reportedly activate caspases 9 and 3, triggering mitochondrial apoptosis and leading to cancer cell death.[5,23,27] Notably, α-solanine-induced apoptosis occurs independently of p53, a finding particularly relevant for OSCC, where p53 mutations and inflammation-induced genomic instability are frequently observed.[23,27] Given that chronic inflammation in OSCC often contributes to therapy resistance by evading apoptosis, glycoalkaloids may offer an alternative strategy to overcome inflammation-associated chemoresistance.

Another key mechanism involves the inhibition of cancer cell proliferation and cell cycle progression. Several studies have reported that glycoalkaloids and anthocyanins effectively modulate cyclin-dependent kinase expression and induce G2/M phase arrest, thereby suppressing tumor growth. *S. tuberosum* extracts were found to downregulate CDK1 and cyclin B, leading to cell cycle arrest.[35,38] Additionally, modulation of the MAPK pathway suggests that potato-derived bioactive compounds can interfere with ERK1/2 and JNK phosphorylation, both of which are critical regulators of inflammation-driven OSCC proliferation.[14,30,32] These kinases are often upregulated in response to pro-inflammatory cytokines, linking cell proliferation directly with tumor-associated inflammation.[16] Given the high proliferative and inflammatory activities of OSCC tumors, targeting these pathways with *S. tuberosum* compounds could represent a promising anti-inflammatory and anti-proliferative therapeutic strategy.

The reviewed studies also provided strong evidence that glycoalkaloids and anthocyanins inhibit tumor invasion and metastasis, processes that are exacerbated by chronic inflammation. α-Solanine and α-chaconine reportedly downregulate MMP-2 and MMP-9, key enzymes involved in extracellular matrix degradation, which is often upregulated by pro-inflammatory mediators such as interleukin (IL)-6 and tumor necrosis factor (TNF)-α.[16,34] Furthermore, anthocyanins were shown to reduce VEGF secretion and endothelial cell migration, thereby limiting tumor vascularization, another hallmark of inflammation-induced cancer progression.[20,22,29] Because an inflammatory microenvironment frequently facilitates OSCC progression, these findings suggest that *S. tuberosum* bioactive compounds may suppress OSCC progression not only via direct cytotoxicity but also by inhibiting inflammation-associated metastatic signaling.

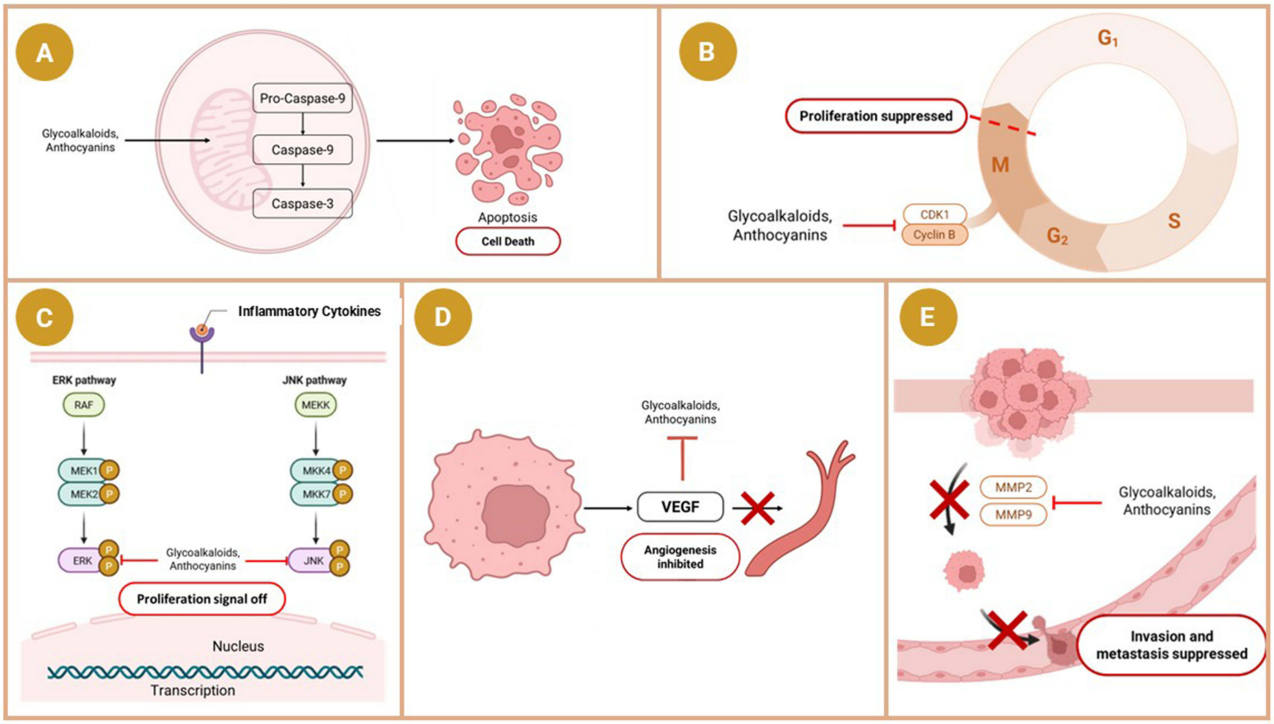

Figure 3 Proposed mechanisms of *S. tuberosum* bioactives in OSCC. (**A**) Induction of intrinsic apoptosis via mitochondrial activation of caspase-9 followed by caspase-3, culminating in programmed cell death; (**B**) Suppression of proliferation through inhibition of the CDK1–Cyclin B complex and down-modulation of Cyclin D1 and PCNA, resulting in checkpoint arrest; (**C**) Attenuation of inflammation-driven MAPK signaling with reduced TNF-α/IL-1 inputs to Raf–MEK–ERK and JNK and a diminished nuclear proliferation programme; (**D**) Anti-angiogenesis via decreased VEGF signaling and limited endothelial sprouting; (**E**) Anti-invasion and anti-metastasis via down-regulation of MMP-2 and MMP-9 and reduced extracellular-matrix degradation.

Figure 3 illustrates the proposed mechanisms through which *S. tuberosum* bioactives, particularly glycoalkaloids and anthocyanins, may inhibit OSCC progression by modulating inflammatory pathways, inducing apoptosis, and suppressing tumor growth and metastasis.

Bioavailability, Toxicity, and Clinical Translation Considerations

Despite the promising preclinical findings, the translation of potato-derived bioactives, particularly glycoalkaloids, into clinical applications faces significant hurdles related to their bioavailability and inherent toxicity. Glycoalkaloids are known to be toxic at high concentrations, with symptoms ranging from gastrointestinal distress to severe neurological disorders and, in extreme cases, death.[38,40] The European Food Safety Authority (EFSA) has identified a Lowest Observed Adverse Effect Level (LOAEL) for total potato glycoalkaloids of 1 mg/kg of body weight per day, primarily based on acute gastrointestinal symptoms.[40] This establishes a narrow therapeutic window, as the doses required for potential anticancer effects could overlap with those causing toxicity.

Furthermore, the oral bioavailability of α-solanine and α-chaconine is relatively low, though they are systemically absorbed. Human pharmacokinetic studies have reported long serum half-lives for these compounds, suggesting a potential for accumulation with daily consumption, which could increase the risk of toxicity over time.[41] This presents a paradox: while chronic, low-dose exposure might be desirable for chemoprevention by modulating inflammation, the risk of accumulation must be carefully managed. The aglycone, solanidine, appears to have slow blood clearance, further complicating the toxicokinetic profile.

These challenges suggest that the clinical application of glycoalkaloids is unlikely to involve the simple consumption of high-glycoalkaloid potato extracts. Instead, future research must focus on strategies to overcome these limitations. This could involve the purification of specific compounds and their formulation into advanced drug delivery systems, such as nanoparticles, to enhance tumor-specific targeting and reduce systemic exposure.[37] Alternatively, research could

focus on identifying non-toxic doses that exert a sufficient anti-inflammatory effect for chemoprevention rather than cytotoxic effects for treatment. For anthocyanins, bioavailability is also a concern, though their safety profile is much more favorable.[20]

Research Gaps and Future Directions

This review provides a novel perspective by connecting evidence from epithelial cancer models to OSCC-specific pathways, an area that has not been systematically addressed in previous literature. By synthesizing mechanistic insights and identifying translational gaps, it establishes a foundation for future OSCC-focused studies on potato-derived bioactives. The most notable limitation identified in this review is the complete absence of OSCC-specific studies, making it difficult to directly extrapolate findings from other cancer models. This represents a critical research gap that needs to be addressed.

Comparative insights from structural-bioactivity studies of polysaccharide-based antitumor agents may also guide future investigations of glycoalkaloids. Recent findings show that detailed physicochemical and conformational analyses of bioactive polysaccharides can help clarify how molecular configuration and glycosidic linkages influence anticancer activity.[42]

To strengthen translational relevance, future studies on *S. tuberosum* bioactives should adopt standardized structural elucidation and anti-inflammatory characterization workflows routinely used in plant-derived compound research. These include bioactivity-guided fractionation, sequential extraction, and advanced spectroscopic analyses such as nuclear magnetic resonance (NMR) and mass spectrometry (MS) for compound identification, purity confirmation, and mechanistic validation.[43] Applying such validated analytical approaches could help elucidate how variations in glycosidic or steroidal backbones determine the bioefficacy and safety of *S. tuberosum*-derived compounds in oral cancer models.

In addition, studies on immune-modulatory polysaccharides offer valuable methodological frameworks relevant to glycoalkaloid investigations. Techniques such as chromatographic purification and structural validation have been successfully used to isolate active polysaccharide fractions and define their immunomodulatory effects.[44] Adopting similar strategies could enhance the standardization and translational potential of *S. tuberosum* bioactives in OSCC models.

Comparative insights from synthetic anticancer scaffolds may also guide future studies on natural bioactives. s-Triazine derivatives show reproducible and quantifiable antitumor effects across cancer models, with clinically used examples such as altretamine.[45] Structural optimization of *S. tuberosum* glycoalkaloids may improve efficacy and safety, while tailored formulations could further enhance the clinical potential of anthocyanins in oral cancer therapy.

Future research should prioritize in vitro experiments using established OSCC cell lines (HSC-3, SCC-9, and CAL-27) to elucidate the cytotoxic, anti-inflammatory, and mechanistic effects of *S. tuberosum*. Additionally, in vivo animal studies should assess tumor regression, angiogenesis inhibition, and metastasis prevention while also examining the modulation of key inflammatory markers such as TNF-α, IL-6, cyclooxygenase-2, and NF-κB. Exploring combination therapies by integrating *S. tuberosum* compounds with chemotherapy, radiotherapy, or immunotherapy may provide insights into their synergistic anticancer and anti-inflammatory effects. Clinical trials are necessary to establish the translational potential of potato-derived bioactive compounds for the treatment and prevention of OSCC, particularly by targeting chronic inflammation within the tumor microenvironment.

Conclusion

This scoping review highlights the potential anticancer and anti-inflammatory roles of glycoalkaloids (α-solanine and α-chaconine) and anthocyanins derived from *Solanum tuberosum*. Among the 18 included studies, most used epithelial cancer cell lines such as colorectal (Caco-2, HT-29), breast (MCF-7), and lung (A549), while animal studies primarily employed murine xenograft models. Treatments involved purified compounds or potato-derived extracts, with glycoalkaloid concentrations ranging from 1–50 μM and anthocyanin doses between 10–200 μg/mL, over 24–72 hours in vitro and up to four weeks in vivo. These interventions consistently demonstrated pro-apoptotic, anti-proliferative, and anti-angiogenic effects across different cancer types. Importantly, no study to date has explored these effects in OSCC,

revealing a significant research gap. Given the strong inflammatory component of OSCC, further studies are warranted to investigate the therapeutic and preventive potential of these compounds in oral cancer.

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Disclosure

The authors report no conflicts of interest in this work.

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