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Review Article

Nutritional composition and action mechanism of *Channa striata* meat in wound healing: A systematic review

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Abstract

Wound healing is a complex biological process requiring adequate nutritional support, particularly proteins, amino acids, fatty acids, and essential minerals. Snakehead fish (*Channa striata*) has been traditionally consumed in Southeast Asia to accelerate recovery after surgery and childbirth. Emerging evidence suggests that its nutritional composition plays a pivotal role in tissue repair. The aim of this systematic review was to consolidate evidence on the nutritional composition of *C. striata* and elucidate its mechanisms of action in wound healing based on preclinical and clinical studies. A systematic search was conducted across PubMed, ScienceDirect, ProQuest, and Google Scholar for studies published between 2000 and 2023, following PRISMA 2020 guidelines. Eligible studies included biochemical analyses, in vitro and in vivo preclinical studies, and clinical trials assessing the wound-healing effects of *C. striata*. Data extraction covered nutrient composition, study design, wound-healing parameters, and mechanistic pathways. Out of 2898 identified studies, 22 of them met the inclusion criteria: ten biochemical composition studies, nine preclinical investigations, and four clinical trials. *C. striata* extract demonstrated high levels of albumin (0.76–10.73 g/100 g), essential and non-essential amino acids (notably glutamic acid, arginine, and glycine), fatty acids (palmitic, arachidonic, linoleic), and minerals such as zinc and copper. Preclinical models consistently showed enhanced fibroblast proliferation, epithelialization, tensile strength, and collagen deposition. Clinical studies in post-cesarean patients reported significant improvements in wound healing scores, uterine involution, pain reduction, and biomarker modulation (VEGF, IL-6, MMP-9). In conclusion, *C. striata* exhibits promising wound-healing potential attributable to its rich nutrient profile and multi-pathway mechanisms involving collagen synthesis, angiogenesis, and immunomodulation. However, the limited number of clinical trials underscores the need for larger, well-designed studies to confirm its translational efficacy in human wound care.

Keywords: Wound healing, *Channa striata*, mechanical action, nutrition, systematic review

Introduction

Cutaneous wound healing is a highly complex and energy-demanding process that involves intricate interactions among multiple factors cooperating to restore the integrity of injured skin. Physiologically, the healing process encompasses four overlapping and dynamic phases: hemostasis, inflammation, proliferation, and remodeling. This cascade is typically observed in superficial wounds. However, aberrant wound healing may occur and is commonly associated

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with underlying conditions such as diabetes, cancer, or malnutrition, which prolong the healing time and lead to suboptimal recovery [1].

Between 2014 and 2019, the number of Medicare beneficiaries worldwide receiving wound treatment increased from 8.2 million to 10.5 million, corresponding to the prevalence of wounds increasing from 14.5% to 16.4%, likely reflecting an aging population, a higher burden of surgical and dermatologic conditions (including arterial ulcers) in younger beneficiaries [2]. In developed countries, it is estimated that approximately 3% of individuals over 65 years experience a wound at any given time, while 1–2% of the general population will develop a chronic wound at some point in their lifetime [3].

Among the underlying conditions, malnutrition is recognized as one of the most common risk factors for impaired wound healing [4,5,6]. Malnutrition is defined as a state in which deficiencies or imbalances in energy, protein, or other nutrients exert measurable adverse effects on tissue structure and function, ultimately leading to unfavorable clinical outcomes. Nutrient deficiencies are frequently observed in patients with cutaneous wounds, a situation that further compromises recovery. Specifically, malnutrition can impair healing by prolonging the inflammatory phase, reducing fibroblast proliferation, and disrupting collagen synthesis, thereby decreasing wound tensile strength and increasing susceptibility to infection [7].

Specialized nutritional supplementation, when provided as an adjunct to standard wound care, has been shown to enhance the healing process [8]. Proteins are essential for the development and activity of cells involved in wound repair, and protein loss can compromise immune function [3]. Energy deficiency resulting from inadequate protein intake may reduce fibroblast activity, delay angiogenesis, and impair collagen formation during the proliferative and remodeling phases [3]. In addition to proteins, carbohydrates, and fats contribute to meeting the elevated energy demands of wound healing by supporting inflammatory responses, cellular activity, angiogenesis, and collagen deposition throughout the proliferative phase [5]. Micronutrients, such as amino acids, are also involved in the wound healing process. Certain amino acids, like arginine, glycine, aspartic acid, and glutamine, are known to play an important role in the inflammatory process of wound healing [9]. Vitamins (A, B, and C) and some minerals may also account for wound healing as the structural factor for enzymes and antioxidants [5].

One of the excellent sources of protein and micronutrients is fish. Snakehead fish (*Channa striata),* also called striped murrel, is a specific local fish in Indonesia, the second largest country producing fishery products. Snakehead fish are spread throughout Indonesia and known by various regional names, such as *kutuk* (Jawa), *gabus* (Betawi dan Sunda), *haruan* (Kalimantan Selatan), *behau* (Kalimantan Tengah), *deleg* (Sumatra), *bale salo* (Sulawesi), and *ikan gastor* (Papua). This fish is the most popular commodity for consumption in Indonesia as a traditional food, particularly by Indonesian women after giving birth through normal or cesarean operation, aimed at faster recovery [10,11]. Post-operative patients are also encouraged to consume *C. striata* to speed up wound healing and reduce pain [10,11].

The efficacy of *C. striata* in wound healing has been scientifically proven [12-13]. Consumption of the meat of the fish increases the albumin level and thereby accelerates the process of wound healing [12]. The meat of *C. striata* has been shown to contain essential amino acids and fatty acids that have been reported to accelerate wound healing [13]. Other biochemical components, such as arachidonic acid, polyunsaturated fatty acids, and docosahexaenoic acid, are also important [9]. Each component has a different and unique mechanism in the healing process. However, despite numerous reports on the composition of *C. striata*, no systematic review has yet examined the relationship between its nutritional constituents and the mechanisms of action involved in the wound healing process.

In this review, a wide range of primary studies investigating the composition and mechanisms of *C. striata* in wound healing were systematically evaluated to provide a comprehensive understanding of its therapeutic potential. Accordingly, this review aims to (1) consolidate validated composition data for albumin, amino/fatty acids, and minerals in *C. striata*; and (2) map these constituents to the mechanism of actions along the hemostasis–inflammation–proliferation–remodeling cascade, using evidence from in vitro, in vivo, and clinical studies. It is anticipated that the findings will offer valuable insights for future research and the development of novel wound care products.

Methods

Study design

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines to ensure methodological transparency and reproducibility. A comprehensive search strategy was employed to identify relevant studies that reported the nutritional composition of *C. striata* and its mechanism in wound healing. The review protocol included predefined eligibility criteria, systematic screening of titles and abstracts, and full-text evaluation of potentially relevant articles.

Literature search strategy

An online literature search was conducted to identify relevant studies published between 2000 and 2023. The following electronic databases were systematically searched: PubMed, ScienceDirect, ProQuest, and Google Scholar. The search was restricted to articles published in English or Indonesian. Various combinations of keywords and text words related to *C. striata* and wound healing were applied to optimize retrieval. All identified records were imported into Zotero reference management software for organization and duplicate removal.

Selection criteria of studies

The literature search targeted studies reporting significant findings on the wound-healing effects of *C. striata* in both preclinical and clinical settings. Eligible articles included those that described the biochemical composition of *C. striata* as determined by standard chemical analyses, as well as studies exploring its potential mechanisms of action in wound healing. Studies with titles and abstracts deemed irrelevant to *C. striata* in the context of wound healing were excluded. All publications categorized as reviews, editorials, book chapters, letters, or case reports were also excluded.

Data extraction

Data extraction was performed using a standardized form. The extracted information included: (1) bibliographic details (first author, year of publication, publication status); (2) study objective or aim; (3) fish body part analyzed; (4) type of biochemical analysis performed; and (5) outcomes of interest related to wound healing.

Results

Study selection

The process of study identification, screening, eligibility assessment, and final inclusion is summarized in the PRISMA 2020 flow diagram (**Figure 1**). The records identification from four electronic databases yielded 2,898 results (PubMed (n=12), ScienceDirect (n=124), ProQuest (n=1,471), and Google Scholar (n=1,291)). All identified records were exported to Zotero for reference management and duplicate removal. An initial 2,318 duplicate entries were excluded, leaving 580 unique records.

Subsequently, 580 records consisting of book chapters, conference abstracts, letters, commentaries, encyclopedia entries, and other non-peer-reviewed articles were removed, resulting in 580 articles eligible for screening. Titles and abstracts were screened, and 515 records deemed irrelevant to *C. striata* and/or wound healing were excluded. A total of 65 full-text articles were retrieved for detailed assessment, of which 26 were evaluated for eligibility. After excluding four review articles, 22 studies met the inclusion criteria and were included in this systematic review (**Figure 1**).

Characteristics of the studies

Of the 22 articles reviewed, ten studies [14-23] examined the chemical composition of *C. striata* extract, including its amino acid, fatty acid, mineral, and albumin content. Nine studies [9,20,25-31] were preclinical investigations conducted in vitro and in vivo, while four studies [32-35] were clinical trials in humans. The biochemical composition of *C. striata* extract is summarized in **Tables 1–4**. Summaries of characteristics and significant findings of the selected pre-clinical and clinical studies are shown in **Table 5** and **Table 6**.

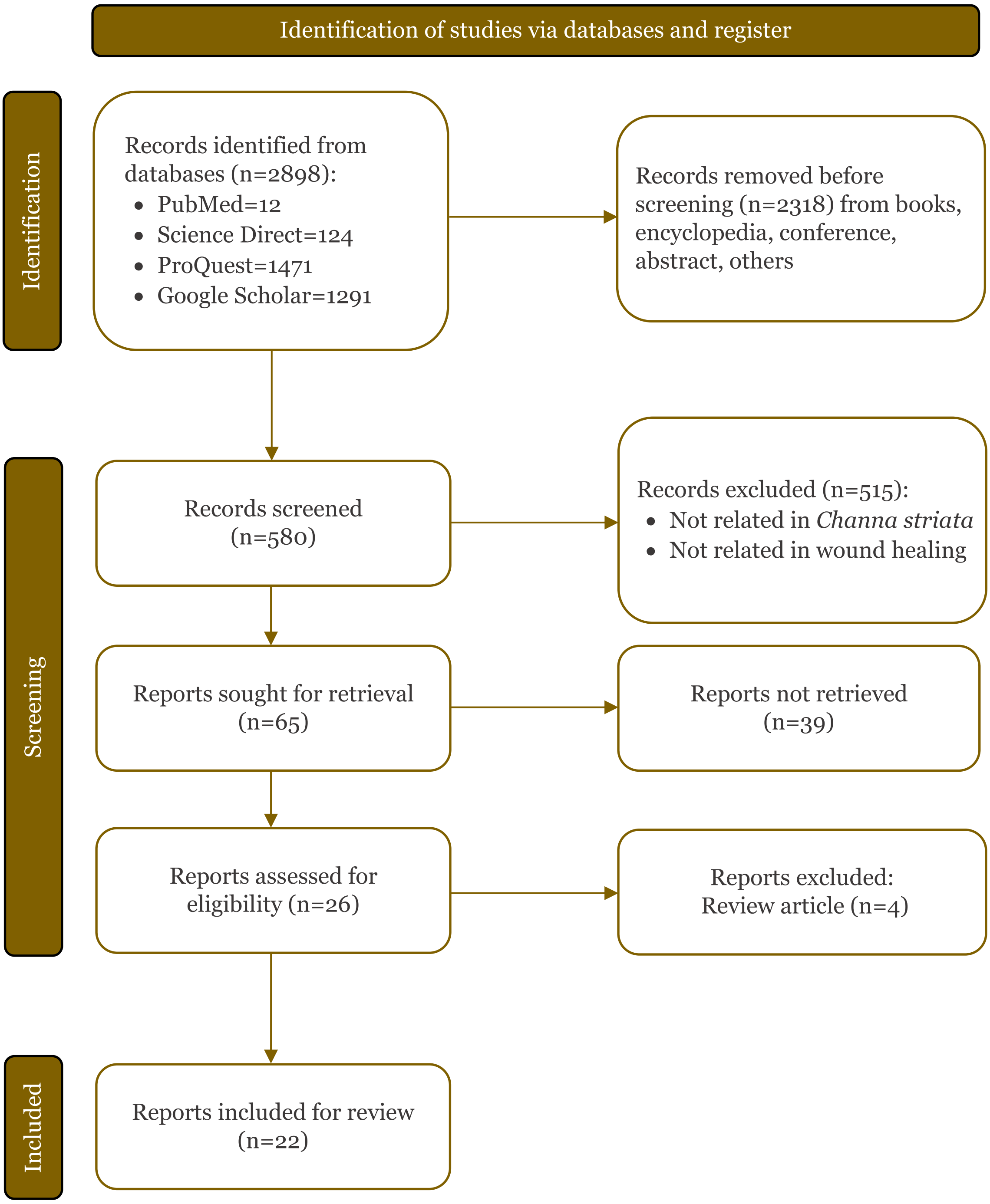

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta Analysis (PRISMA) flow diagram of the study.

Composition of *Channa striata*

The quantity of albumin is an important determinant of the quality of *C. striata* as a raw material for health supplements or functional food. Serum albumin levels are significantly correlated with the rate of wound healing. The albumin content of *C. striata* ranges from 0.76 to 10.73 g/100 g, as presented in **Table 1** [14-19]. Variations in albumin levels have been observed between native and cultured snakehead fish, as well as among fish from different geographical regions.

Table 1. Albumin content of *Channa striata* extract

Source	Albumin (g/100 g)
Mustafa *et al.* [14]	2.17±0.14
Siswanto *et al.* [15]	3.55
Nurfaidah *et al.* [16]	2.63±0.15
Susilowati *et al.* [17]	
West Java	1.07
Central Java	0.76
East Java	0.91
Khasani and Astuti [18]	
South Kalimantan	2.6±0.4
Sumatera	2.4±0.3
Java	2.2±0.4
Chasanah *et al.* [19]	
Native from Yogyakarta	7.579±0.9
Native from Malang	9.11±2.4
Native from Blitar	7.01±1.80
Native from Parung	10.73±0.32
Rearing	6.34±0.93
Cultured	6.67±0.38

The nutrients in *C. striata* extract, particularly amino acids and fatty acids, play key roles in collagen fiber synthesis during wound healing. The total protein content ranges from 5.524 to 44.9 g/100 g of *C. striata*. Amino acids are classified into essential and non-essential categories, with their composition presented in **Table 2** [14,17,19-22]. Lysine, leucine, and histidine constitute the dominant essential amino acids, whereas glutamic acid, arginine, and glycine are the most abundant non-essential amino acids in *C. striata* extract.

The fatty acid composition of *C. striata* extract is presented in **Table 3**. Palmitic acid is the predominant fatty acid, followed by arachidonic and linoleic acids [20,23]. In addition, *C. striata* extract contains several essential minerals, including zinc, iron, copper, sodium, potassium, and calcium (**Table 4**).

Effect of *Channa striata* on wound healing

A comprehensive overview of the diverse and significant findings on *C. striata* in wound healing, as reported in preclinical studies (both in vitro and in vivo) [9,20,25-31], is presented in **Table 5**. The in vitro studies [20,31] primarily employed 3T3 fibroblast cells derived from Swiss albino mice and the EA.hy926 endothelial cell line. In the in vivo studies [9,20,25,26,27,28,29,30], Wistar rats were predominantly used, with one study utilizing Sprague-Dawley (SD) rats. Sample sizes varied from 6 to 96 animals, with the majority being male. *C. striata* extract was administered both orally and topically, and in one study [30], the efficacy of pure *C. striata* extract was compared with formulations containing cetrimide.

The summaries of clinical studies in human subjects are presented in **Table 6**. Three studies [32,33,35] were conducted in women following lower segment cesarean section (LSCS), where *C. striata* extract was administered orally in tablet form (500 mg). In one additional study, *C. striata* extract was applied topically as a spray [34].

Table 2. Amino acid composition of *Channa striata* extract

Composition	Rahayu *et al.* [20]	Mustafa *et al.* [14]	Zuraini *et al.* [21]	Lay-Harn Gam *et al.* [22]	Susilowati *et al.* [17]	Chasanah *et al.* [19]	
						Native	Cultured
Total protein content (g/100 g)		5.524±0.02	23.0±0.7	36.4–44.9	18.31± 0.34	NA	NA
Essential amino acid							
Histidine	0.78	0.405±0.0006	1.2±0.02	2.49–3.06	0.3	0.000±0.00	0.083±0.00
Isoleucine	0.99	0.558±0.0003	3.8±0.25	4.49–5.23	0.8	0.017±0.01	0.576±0.26
Leucine	2.01	0.956±0.0002	7.5±0.85	8.35–8.87	1.5	0.004±0.00	0.022±0.02
Lysine	1.16	1.152±0.0006	NA	NA	2.5	0.001±0.00	0.549±0.01
Methionine	1.07	0.343±0.0008	3.4±0.11	3.14–3.92	0.8	0.017±0.01	0.012±0.00
Phenylalanine	1.64	0.453±0.0004	4.3±1.2	4.64–5.09	0.75	0.002±0.00	0.363±0.00
Threonine	0.90	0.551±0.003	4.2±0.06	5.15–5.50	0.8	NA	NA
Tryptophan	1.91	0.159±0.0002			0.2	0.000±0.00	0.015±0.00
Valine	0.96	0.606 ±0.0009	4.2±0.06	4.67–5.14	0.8	NA	NA
Non-essential amino acid							
Arginin	1.74	0.624±0.0002	5.9±0.15	8.39–9.18	1.2	NA	NA
Glycine	1.29	0.567±0.001	4.3±0.19	4.55–5.97	0.6	0.034±0.01	0.241±0.01
Glutamic acid	1.90	1.494±0.004	21.7±0.9	13.42–14.57	3.5	0.012±0.01	0.113±0.01
Serine	0.37	0.447±0.002	4.8±0.03	4.70–5.23	0.6	NA	NA
Proline	1.05	0.312±0.003	3.2±0.21	3.58–4.08	0.5	0.131±0.11	0.227±0.11
Tyrosine	1.00	0.414±0.0004	3.6±0.14	4.02–4.31	0.5	0.006±0.00	0.012±0.00
Cystein	2.26	NA	0.9±0.15	0.88–1.64	NA	0.000±0.00	0.011±0.01
Alanine	0.81	0.725±0.0005	5.8±0.73	5.78–6.04	1.0	0.001±0.01	0.335±0.13
Aspartic acid		0.911±0.010	11.4±0.12	8.36–9.37	2.0	0.006±0.01	0.293±0.03

Table 3. Fatty acid composition of *Channa striata* extract

Composition	Rahayu *et al.* [20]	Zuraini *et al.* [21]	Zakaria *et al.* [23]
Fatty acid (mg/100 g)			
Palmitic acid	124.31	30.39±0.23	35.93±0.63
Oleic acid	0.8	12.04±0.54	22.96±0.40
Stearic acid	33.95	15.18±0.15	15.31±0.33
Linoleic acid	5.24	8.34±1.01	11.45±0.31
Arachidonic acid	0.7	19.02±0.78	7.44±0.83
Decosahexaenoic acid	0.23–0.76	15.18±1.12	NA
Eicosapentaenoic acid	0.41–0.72	NA	NA
Heptadecanoic acid	NA	NA	2.90±0.56
Myristic acid	NA	NA	2.15±0.11
Palmitoleic acid	NA	NA	1.86±0.32

Table 4. Mineral composition of *Channa striata* extract

Composition	Chasanah *et al.* [19]		Mustafa *et al.* [14]	Siswanto *et al.* [15]	Zuraini *et al.* [21]
	Native	Cultured			
Mineral (mg/100 g)					
Zinc	0.36±0.03	0.45±0.02	0.41±0.01	0.58	4.92
Copper	NA	NA	0.01±0.001	NA	4.67
Sodium	18.35±3.04	34.82±2.65	NA	NA	NA
Iron	0.17±0.01	0.71±0.08	0.01±0.001	58.9	4.67
Potassium	283.00±18.38	389.83±17.37	5.78±0.015	0.13	NA
Calcium	12.15±2.33	73.23±36.86	NA	NA	NA

Table 5. Effects of *Channa striata* extract on wound healing based on pre-clinical studies

Reference	Disease model	Dosage *Channa striata* extract	Wound healing parameter	Primary outcomes	Mechanism of action
Baie and Sheikh [9]	Wounded Wistar rats, male (n=96)	Concentration 1%	Uronic acid, protein, glycosaminoglycans and wound contraction	• A marked increase in uronic acid and dermatan sulfate content was observed on Day 3 in Group 1 (combination with cetrimide) compared with Group 2 (*C. striata* extract), Group 3 (cetrimide), and the control group ($p<0.05$) • Protein levels were higher in Groups 1, 2, and 3 compared with the control group	• The increased uronic acid content in *C. striata*–treated wounds suggests enhanced synthesis of glycosaminoglycans (GAGs), which are among the first extracellular matrix components synthesized during the wound-healing process • The substantial increase in dermatan sulfate observed in *C. striata*–treated wounds represents a key factor in the accelerated healing process. This finding underscores the close association between dermatan sulfate and collagen fibers, a critical element of wound repair
Pasha *et al.* [25]	Malnourishment rats, male (n=40)	100 mg/100 g BW	• Tensile strength of the wound (kg/cm²) • Epithelial and fibroblast cell count	• The treated group demonstrated greater tensile strength, with a mean difference of 1.151 kg/cm² on Day 7 post-laparotomy ($p<0.001$) • The treated group showed a significantly higher epithelial cell count (100 cells/mm³ vs 83 cells/mm³), with a mean difference of 16 cells/mm³ on Day 7 ($p<0.001$) • Fibroblast counts were significantly higher in the *C. striata*–treated group (336 cells/mm³) compared with the control group	• The increase in tensile strength observed with *C. striata* treatment has been attributed to the action of polypeptides formed through the combination of amino acids such as glycine, aspartic acid, and glutamine, in the presence of leucine, methionine, alanine, and arginine • *C. striata* also provides an immediate source of macro- and micronutrients, thereby accelerating healing by promoting fibroblast proliferation

Reference	Disease model	Dosage *Channa striata* extract	Wound healing parameter	Primary outcomes	Mechanism of action
Rahayu *et al.* [20]	3T3 fibroblast cell of the Swiss albino mouse	0–50 mg/mL	3T3 cells growth	• Striatin promoted 3T3 cell proliferation in a dose-dependent manner. At the maximum tested concentration of 50 mg/mL, 3T3 cell growth was nearly doubled compared with the control group	
Rahayu *et al.* [20]	Wounded Wistar rats, female (n=6)	5 mL/kg BW 2×/day orally for 15 days	• The wound area • Serum albumin level	• The wound area in the striatin-treated group was significantly reduced after 8 days ($p<0.05$) • A significant difference in wound size was observed between the striatin-treated and control groups ($p<0.05$)	• Striatin contains 214.81 mg/g of protein and 21.84% specific amino acids, which play an important role in wound healing • The vitamin A content of striatin (27 mg/100 g) contributes to scar tissue strength and is essential for an adequate inflammatory response • Striatin also contains vitamin B6 (72.18 mg/100 g), which is involved in the inflammatory response and participates in the conversion of tryptophan to niacin, thereby supporting the wound-healing process
Oentaryo *et al.* [26]	Wounded Wistar rats (n=20)	10 mg/kgBW/ day *C. striata* extract	• The number of fibroblasts • Fibroblast growth factor-2 (FGF-2) expression	• On Day 5, a significant increase in fibroblast counts was observed in the groups treated with *C. striata* extract at concentrations of 25%, 50%, and 100% compared with the control group • The highest expression of fibroblast growth factor-2 (FGF-2) was detected in the group treated with 50% *C. striata* extract	• *C. striata* extract contains copper, which enhances FGF-2 expression, thereby promoting fibroblast proliferation • Increased FGF-2 expression subsequently stimulates fibroblast proliferation and upregulates type I collagen expression, accelerating tissue repair during wound healing
Atmajaya *et al.* [27]	Extraction of teeth of Wistar rats, male (n=20)	0.1 mL gel 10%, topical	• The number of fibroblasts (histopathological examination)	• Significant increases in the number of fibroblasts during tooth extraction in the group given 100% *C. striata* extract	• Albumin plays a role in increasing the proliferation of fibroblasts, which in turn increases the synthesis, accumulation, and remodeling of collagen • Copper minerals contained in *C. striata* increase and produce fibroblast growth factor (FGF), which leads to an increase in fibroblast cells

Reference	Disease model	Dosage *Channa striata* extract	Wound healing parameter	Primary outcomes	Mechanism of action
Hendriati *et al.* [28]	Incision wounded Wistar rats (n=6)	350 mg emulgel 10%, topical, 2×/day	• The wound length • The number of neutrophils, macrophages, and fibroblasts	• Significant reduction after Day 3 in the wound length treated *C. striata*. • Significant difference in the number of neutrophils and fibroblast cells on Day 7 in the group treated with C. striata • The number of macrophages in the Day 7 *C. striata* group was much greater than either the positive or the negative control	• Albumin plays a role in the growth of granulation tissue, including fibroblasts, collagen formation, and collagen strength • Albumin and Zn work in remarkable synergy to contribute to cell development and the formation of new cell tissue. Zn, a crucial element, is particularly needed for collagen synthesis during the proliferation and maturation phase
Rama dhanti *et al.* [29]	Wounded Wistar rats, male (n=27)	5 mL/100 g per day	• The average number of macrophages • The number of blood vessels	• Treatment group with 100% extract of *C. striata* resulted in the lowest average number of blood vessels	• Fewer macrophages are migrating into the tissue during the inflammatory phase when using *C. striata* extract because various substances contained in *C. striata* could inhibit vasodilation of blood vessels • The decrease in the number of blood vessels in the treatment group due to the decrease in the VEGF, TGF-β, & basic fibroblast Growth Factor
Yuliana *et al.* [30]	Wounded Wistar rats, male	Concentration 1%, 3% and 5%	• Wound size • % Wound healing (the wound after treatment /the initial wound length) • Albumin content (UV-Vis spectrophotometry	• Significant difference in the formula 3% and 5% for wound healing activity (p<0.05) • The formula 5% shows the highest rate in wound healing (58%) on Day 8	• Albumin activates epidermal growth factor receptor (EGFR) expression and upregulates NF-κB signaling. The activation of EGFR could accelerate epithelialization
Kwan *et al.* [31]	EA. hy926 endothelial cell line and ex vivo aortic ring	100 and 200 µg/mL of freeze-dried water extracts (FDWE) and spray-dried water extracts (SDWE) of *C. striata*	• Cell proliferation activity • Maximal microvessel length (Lmax) and area covered by the newly formed blood vessels	• SDWE showed a significant change in the cell proliferation activity, whereas FDWE showed no significant proliferative activity observed in the cells at a low level of concentration (6.25–12.5 µg/mL) • The growth promoted by both FDWE and SDWE showed positive activity on cell proliferation	• *C. striata* FDWE and SDWE protein fractions contain bioactive proteins that are highly similar to human proteins and thus can be involved in the wound healing process via specific biological pathways

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Table 6. Effects of *Channa striata* extract on wound healing based on clinical studies

Paper	Disease model	Dose *Channa striata* extract	Wound healing parameter	Primary outcomes	Proposed mechanism of action
Bakar *et al.* [32]	Women after lower segment cesarean section (LSCS) (n=66)	500 mg, oral, daily dose	• The anteroposterior (AP) measurements of the uterus • The pulsatility index (PI) and resistance index (RI) of the uterine and superficial skin wound arteries	• AP measurements of the uterus in the longitudinal and oblique transverse planes were significantly lower in the *C. striata* group compared with the placebo group ($p<0.05$ and $p<0.001$, respectively) • No significant differences were observed in the pulsatility index (PI) or resistance index (RI) of the uterine and superficial skin wound arteries between the *C. striata* and placebo groups • *C. striata* extract demonstrated a significant effect on uterine involution following lower segment cesarean section (LSCS) compared with placebo	• The increased tensile strength may be attributed to polypeptide formation arising from the combination of glycine with aspartic and glutamic acid, in the presence of leucine, methionine, alanine, and arginine • The effectiveness of *C. striata* as a wound-healing agent is also influenced by its high content of specific amino acids, such as glycine, and fatty acids, such as arachidonic acid
Wahab *et al.* [33]	Women after lower segment cesarean section (LSCS) (n=76)	500 mg for 6 weeks	• Numeric pain rating scale (NRS) • Wound evaluation scale (WES) • Visual analog scale (VAS) scores • Patient satisfaction score (PSS) • Safety profiles (adverse events)	• A greater reduction in NRS and WES scores was observed in the *C. striata* group compared with the placebo group; however, the difference was not statistically significant • VAS and PSS scores were significantly improved in the *C. striata* group compared with the placebo group ($p<0.001$) • Study participants reported no adverse events	• Specific amino acids, such as glycine, and fatty acids, such as arachidonic acid, present in *C. striata* are believed to promote wound healing by initiating a series of mechanisms, including collagen remodeling, re-epithelialization, and induction of wound contraction
Sahid *et al.* [34]	Postoperative patients (n=102), prospective randomized controlled trial	Spray, daily dose	• Visual analog score (VAS) • Visual analog pain score (VAPS) • Visual analog cosmetic scale (VACS) • Wound evaluation scale (WES) • Vancouver scar scale (VSS)	• A significant difference in the estimated marginal means of VAS was observed at Weeks 2, 4, and 6 between the *C. striata* spray and placebo groups ($p<0.001$) • A significant difference in patient-reported pain scores based on VAPS was found between the *C. striata* spray and placebo groups ($p<0.05$) • A significant difference in VACS scores for estimated improvement was observed between Weeks 4 and 6 of follow-up ($p<0.001$) • A significant difference in mean wound healing based on WES was observed	• The proposed mechanism suggests that lipoamino acid and N-arachidonoyl glycine suppress pain sensation by modulating pain neurotransmitters within the synaptic cleft • *C. striata* extract has been reported to enhance the analgesic activity of morphine

Paper	Disease model	Dose *Channa striata* extract	Wound healing parameter	Primary outcomes	Proposed mechanism of action
				between the *C. striata* spray and placebo groups ($p<0.05$). • A significant difference in mean resultant scar outcomes based on VSS was observed between the *C. striata* spray and placebo groups ($p<0.05$)	
Omar *et al.* [35]	Women post lower segment cesarean section (LSCS)	500 mg daily for 6 weeks	IL-6, VEGF and MMP-9 (from blood sample)	Between-group comparisons demonstrated significant differences ($p<0.05$) in IL-6 and MMP-9 at Weeks 4 and 6, whereas VEGF showed significant differences ($p<0.05$) at Day 1, Day 3, Week 4, and Week 6	• *C. striata* extract enhances and stimulates multiple biological pathways by upregulating cytokines and growth factors in response to tissue injury • The extract increases VEGF levels up to Week 6, indicating its effectiveness in promoting wound healing. From Week 4 onwards, VEGF production rises markedly during the proliferative and remodeling phases • The high amino acid and fatty acid content of *C. striata* further contributes to VEGF production, mediated in part through interleukin-6 (IL-6), which regulates VEGF expression

Discussion

Wound healing is a complex process involving a series of biological and molecular events, including coagulation and hemostasis, inflammation, cell migration and proliferation, and tissue remodeling [35]. Optimal wound repair requires adequate nutritional status. Previous studies have demonstrated that patients with good nutritional status exhibit enhanced growth hormone activity and collagen production, which improve tensile strength and reduce the risk of wounds progressing to chronic states [38-40].

Nutrition plays a pivotal role in modulating the wound healing process. Proteins, essential for cellular formation and function, also contribute significantly to immune responses. Protein deficiency can hinder the transition from the inflammatory to the proliferative phase, thereby delaying tissue repair [3]. Carbohydrates and fats serve as major energy sources to support the inflammatory response, cellular metabolism, and collagen deposition during the proliferative phase. Fatty acids, in addition to their role as structural components of cell membranes, are actively involved in regulating inflammatory processes [39]. Furthermore, minerals such as zinc, iron, copper, sodium, potassium, and calcium are indispensable for sustaining the inflammatory response and promoting collagen synthesis [14,15,19-21].

Dietary proteins must be efficiently digested and absorbed to exert their physiological benefits. Among dietary protein sources, fish protein is particularly well absorbed and is considered of high quality due to its balanced composition of essential amino acids. Fish containing more than 15% protein are classified as high-protein species [8], with the highest total protein content reported in *C. striata* [14,17,19,21,22].

Albumin, the predominant plasma protein (accounting for 50–60% of total plasma protein), plays a critical role in maintaining osmotic pressure, thereby ensuring adequate delivery of nutrients and oxygen to tissues. Evidence from our systematic review indicates that *C. striata* is a rich source of albumin [14-19]. Hypoalbuminemia is frequently observed in patients with severe wounds, and albumin has been shown to facilitate wound healing by activating epidermal growth factor receptor (EGFR) expression and upregulating Nuclear Factor kappa-light-chain-enhancer of activated B cells (NF-κB) signaling pathways [31]. The albumin content in fish is influenced by intrinsic factors such as species, size, and maturity, as well as extrinsic factors including environmental conditions, habitat, diet, and seasonality [13]. Notably, wild-caught *C. striata* exhibit the highest albumin levels, followed by cultured and reared fish [19].

Essential amino acids modulate the wound healing process by reducing the activation of inflammatory cells. This attenuation of pro-inflammatory activity creates a more favorable microenvironment for fibroblast proliferation, thereby promoting collagen synthesis during the proliferative phase. The accelerated deposition of a dense collagen fiber network ultimately strengthens the wound. Our systematic review identified glutamic acid as the most abundant amino acid in wild-type *C. striata*, followed by aspartic acid, lysine, arginine, leucine, alanine, valine, threonine, and glycine, in descending order of concentration [22]. Among the essential amino acids, leucine, lysine, and histidine were the most prevalent, whereas glutamic acid, arginine, and glycine were the predominant non-essential amino acids (**Table 2**). Notably, glutamine and arginine are categorized as conditionally essential amino acids, as their plasma concentrations decline under metabolic stress conditions such as injury [38]. Glutamine, the most abundant amino acid in human plasma, serves as a critical energy source for proliferating cells. It also confers protection against inflammatory injury by inducing the expression of heat shock proteins, which safeguard cells during states of inflammation, injury, and physiological stress [41].

Arginine plays a pivotal role in wound healing through multiple mechanisms, including the stimulation of growth hormone and insulin-like growth factor 1 (IGF-1) secretion, the generation of nitric oxide (NO) and polyamines, and the enhancement of proline and hydroxyproline synthesis [42,43]. Metabolically, arginine serves as a precursor for proline and ornithine, both of which are essential for polyamine and NO synthesis. Proline and NO, in turn, are critical mediators of collagen deposition during wound repair. Another bioactive compound, the human tripeptide glycine-histidine-lysine (GHK), has also been shown to accelerate wound healing. Evidence from comprehensive studies suggests that GHK promotes tissue regeneration and exhibits anti-inflammatory and antioxidant properties [40].

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Our systematic review further identified palmitic acid as the most abundant fatty acid in *C. striata* extract, followed by arachidonic acid and linoleic acid (**Table 2**). Fatty acids contribute significantly to wound healing by regulating the production of pro-inflammatory cytokines, including interleukin-1 (IL-1), IL-6, and tumor necrosis factor-α (TNF-α), via their bioactive metabolites such as leukotrienes, prostaglandins, and thromboxanes. Through these pathways, fatty acids exert potent anti-inflammatory effects that facilitate tissue repair [42].

Fatty acids derived from *C. striata* play complementary roles in modulating the wound healing process. Palmitic acid has been reported to regulate immune cell activity and to influence cytokine and growth factor signaling, both of which are central to wound repair and fibrosis. Its anti-inflammatory properties are particularly critical during granulation tissue formation and the remodeling phase, where it inhibits lipopolysaccharide (LPS)-induced secretion of TNF-α) [43,44]. Arachidonic acid, as a precursor in prostaglandin and thromboxane biosynthesis, contributes to the analgesic and anti-inflammatory properties of *C. striata* oil, thereby facilitating the resolution of pain and inflammation during tissue recovery. Linoleic acid further complements these effects by promoting macrophage chemotaxis, a key process in regulating fibrinolytic system activity and collagenase production. It also enhances neutrophil infiltration into the wound bed and decreases necrotic layer thickness, accelerating the transition to tissue regeneration [44]. Collectively, these fatty acids orchestrate a coordinated response that balances inflammation, matrix remodeling, and tissue regeneration, ultimately supporting effective wound healing.

The presence of zinc and copper in *C. striata* is not incidental but represents a critical factor influencing wound healing. Zinc is essential for numerous enzymatic functions and plays a central role in plasma zinc transport, thereby accelerating the repair process. Copper, likewise, contributes significantly to wound healing by modulating cytokine activity and upregulating vascular endothelial growth factor (VEGF) expression in the wound microenvironment, which enhances angiogenesis [45]. During the proliferative phase, multiple cell types act in concert to restore the epidermal and dermal layers, culminating in complete wound closure.

Our systematic review revealed that fibroblast proliferation is frequently used as a key parameter in preclinical studies of wound healing. Histological evidence demonstrates that wound repair can be evaluated by the density of collagen fibers synthesized by fibroblasts within newly formed connective tissue during the proliferative phase [25-29]. Fibroblasts typically appear within 2–3 days post-injury, coinciding with the formation of new capillaries that provide an adequate nutrient supply to support continued cell proliferation.

In the clinical setting, *C. striata* extract demonstrated notable efficacy in enhancing wound healing, particularly among women who had undergone lower segment cesarean section. In several cultural and clinical contexts, postpartum mothers traditionally consume *C. striata* to accelerate recovery. This effect may be attributed not only to enhanced wound repair but also to the extract's ability to increase uterine contractility and promote rapid uterine involution. Mechanistically, *C. striata* extract has been shown to improve wound healing by increasing tensile strength at the wound site [24].

Despite these promising findings, this systematic review is limited by the scarcity of clinical studies evaluating wound-healing outcomes. The majority of available evidence is derived from in vitro or animal models, which, while informative, do not fully reflect the complex physiological dynamics of human wound healing. Consequently, the generalizability of the current evidence to clinical practice remains uncertain. Well-designed, adequately powered clinical trials are needed to confirm the translational relevance of *C. striata* extract for wound healing in humans.

Conclusion

This review synthesized evidence from 21 studies investigating the biochemical mechanisms underlying the wound-healing effects of *C. striata*. Among these, nine were preclinical studies (in vitro and in vivo), four were clinical studies, and ten focused on the chemical composition of *C. striata* extracts. Notably, only a limited number of studies comprehensively evaluated both the compositional profile and mechanism of *C. striata* in wound healing. The wound-healing potential of *C. striata* has been attributed to its rich nutritional profile, which includes amino acids (particularly glutamic acid, followed by aspartic acid, lysine, arginine, leucine, alanine, valine, threonine, and glycine), albumin, fatty acids (notably palmitic acid, arachidonic acid, and linoleic acid), as well as essential trace minerals such as zinc and copper. Mechanistically, these bioactive components contribute to wound repair by promoting collagen and elastic tissue synthesis, supporting immune system function, enhancing epidermal growth, and facilitating keratinization. The wound-healing efficacy of *C. striata* has been demonstrated across multiple outcome measures, including reductions in wound area, increased tensile strength, elevated fibroblast and epithelial cell counts, and enhanced VEGF production.

Ethics approval

Not required

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization, or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

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