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Review

In vivo effects of *Channa striatus* on humans and animals: a systematic review

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Abstract

Channa striatus contains biochemical components and albumin, which elicit beneficial effects to the consumers. This review aimed to clarify the effects of *Channa striatus* consumption on humans and animals in *in vivo* studies. A systematic search in four electronic databases namely ProQuest, EBSCOhost, PubMed, and SpringerLink was performed to choose the studies on *Channa striatus* as the interventions, and its effects on animals and humans. The intervention involved: (i) *Channa striatus* with placebo-controlled, (ii) *Channa striatus* pre-treated and treated with drugs, (iii) *Channa striatus* with the combination of Chronic Unpredictable Mild Stress (CUMS), and (iv) *Channa striatus* pre-treated with amino acids and methylene blue. Thirteen animal studies and seven human studies were included in the final analysis. They investigated the effects of *Channa striatus* on wound healing, anti-depressant-like effects, anti-inflammatory effects, and effects on human diseases. Consumption of *Channa striatus* supplements was found in seven studies to benefit wound healing processes due to the contents of amino acids and fatty acids found in *Channa striatus* extract. Two studies were found regarding *Channa striatus* lipid decreased the corticosterone level and nuclear factor-kappa B, while two studies reported of DHA content in Channa striatus inhibited the production of inflammatory mediators. *Channa striatus* elicits a positive effect on the wound healing process and enhanced antidepressant-like and anti-inflammatory effects due to its high content of amino acids and fatty acids.

Introduction

Channa striatus, or snakehead fish, is a freshwater, air-breather, and carnivorous fish indigenous to many tropical countries (Baie and Sheikh, 2000a). *Channa striatus* is known locally to the Malays as *ikan haruan*, and widely consumed in Malaysia and other Southeast Asian countries (Zakaria *et al*., 2005a). This snakehead fish belongs to the Channidae family. There are 30 species of snakehead fish in the Channidae family reported worldwide, and eight of them are found in Malaysia. Other species of the Channidae family are also found in Myanmar, Thailand, Laos, Cambodia, Vietnam, Brunei, Philippines, Indonesia, and Singapore (Ali Khan *et al.,* 2014). *Channa striatus* is a wild species and a top predator in shallow and slow-moving waters with temperatures between 20 - 30°C. It is also a good survivor in tough environment with low dissolved oxygen and turbidity (Shafri and Abdul Manan, 2012).

Several previous studies showed that *Channa striatus* contains biochemical components such as essential amino acids and fatty acids (Baie and Sheikh, 2000b; Laila *et al.,* 2011; Sahid *et al.,* 2018), and also glycine, a non-essential amino acid (Zakaria *et al.,* 2007) in *Channa striatus* extract. Moreover, Dahlan-Daud *et al.* (2010) mentioned that there are other non-essential amino acids discovered such as glutamic acids, arginine, and aspartic acid. Other than that, amino acids such as glutamic acid, glycine, leucine, aspartic acid, proline, alanine, and arginine have been reported with values 1.87 - 43.13, 21.80 - 80.85, 7.85 - 40.19, 13.85 - 44.07, 9.49 - 45.46, 11.38 - 35.25, and 5.99 - 21.79 mg/g, respectively. *Channa striatus* has high contents of arachidonic acid and polyunsaturated fatty acids that can accelerate prostaglandin synthesis (Jais and Manan, 2007; Shafri and Abdul Manan, 2012), which plays a crucial role in wound healing. Zakaria *et al.* (2005a) mentioned that the entire fish could be a dietary medicine, consumed by grilling, dry-frying, or boiling in porridge for wound healing. The typical contents of *Channa striatus* is shown in Table 1.

Among freshwater fishes, *Channa striatus* appears to have a medium level of antioxidant activities, possibly contributed by albumin, which acts

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Table 1. Typical contents of *Channa striatus*.

Amino acid (g/100 g) (Gam *et al.*, 2005)	
Glutamic acid	13.42 - 14.57
Aspartic acid	8.36 - 9.37
Lysine	8.61 - 9.13
Arginine	8.39 - 9.18
Leucine	8.35 - 8.87
Alanine	5.78 - 6.04
Valine	5.14 - 4.67
Threonine	5.15 - 5.50
Serine	4.70 - 5.23
Phenylalanine	4.64 - 5.09
Glycine	4.55 - 5.97
Isoleucine	4.49 - 5.23
Tyrosine	4.02 - 4.31
Proline	3.58 - 4.08
Methionine	3.14 - 3.92
Histidine	2.49 - 3.06
Cysteine	0.88 - 1.64
Fatty acid (%) (Zakaria *et al.*, 2007)	
Palmitic acid (C16:0)	35.93 ± 0.63
Oleic acid (C18:1)	22.96 ± 0.40
Stearic acid (C18:0)	15.31 ± 0.33
Linoleic acid (C18:2)	11.45 ± 0.31
Arachidonic acid (C20:4)	7.44 ± 0.83
Heptadecanoic acid (C17:0)	2.90 ± 0.56
Myristic acid (C14:0)	2.15 ± 0.11
Palmitoleic acid (C16:1)	1.86 ± 0.32
Mineral (mg/kg) (Paul *et al.*, 2013)	
Calcium (Ca)	5279
Magnesium (Mg)	276
Zinc (Zn)	8.30
Iron (Fe)	4.93
Lead (Pb)	0.06
Mercury (Hg)	0.01
Chromium (Cr)	0.01
Nutrient (g/100 g) (Mustafa *et al.*, 2012)	
Protein	3.36 ± 0.29
Albumin	2.17 ± 0.14
Fat	0.77 ± 0.66
Glucose	0.07 ± 0.02

as a radical scavenger (Dahlan-Daud *et al.,* 2010; Suhartono *et al.,* 2013). Albumin contains many sulfhydryl groups (-SH) that can serve as a radical binder and plays an important role in inhibiting free radical production by polymorphonuclear leukocytes. The antioxidants present in *Channa striatus* are lipophilic antioxidants, which represent powerful defence tools particularly against oxidative stress, malondialdehyde (MDA), and reactive oxygen species (ROS) (Suhartono *et al.,* 2013). Thus, exogenous antioxidant supplements such as *Channa striatus* can be a suitable non-invasive tool in reducing oxidative stress.

Channa striatus extract has also been shown to increase the tensile strength of the surgically stitched wound (Baie and Sheikh, 2000a) but mostly involved animals such as rabbits and rats. In human studies, *Channa striatus* extract was used to treat symptoms of knee osteoarthritis in older patients (Kadir *et al.,* 2014; Azidah *et al.,* 2017), reducing pain (Bakar *et al.,* 2015; Wahab *et al.,* 2015), and chronic inflammation (Zuraini *et al.,* 2006) after post-caesarean in women, and also inducing cytokine conversion in pulmonary tuberculosis patients (Paliliewu *et al.,* 2013). A previous study by Michelle *et al.* (2004) also found that *Channa striatus* could reduce soft tissue swelling and synovial inflammation, and significantly improved the density of PGP 9.5-immunoreactive nerve fibres in the synovial membrane.

Hence, the main aim of this systematic review was to clarify the findings of published research studies that primarily focus on the effects of *Channa striatus* consumption on humans and animals' studies.

Materials and methods

Data sources

A comprehensive review on all *in vivo* studies on *Channa striatus* was performed using databases such as ProQuest, EBSCOhost, PubMed, and SpringerLink. A comprehensive search of the databases was performed using the keywords #*Channa striatus* AND #human OR #animal. A cross-referencing on the related published studies was also performed to obtain additional articles. Peer-reviewed articles in English language from January 2000 until December 2019 were used. No attempts were made to contact authors for further information. Comparable searches were done for other databases.

Study selection

The search was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. The keywords used during the search were #*Channa striatus* AND #humans OR #animals. Studies were screened to choose *Channa striatus* as the interventions, and its effects on animals or humans as the outcome measures. Laboratories studies and randomised controlled trials were included in this review. The intervention involved: (i) *Channa striatus* with placebo-controlled, (ii) *Channa striatus* pre-treated and treated with drugs, (iii) *Channa striatus* with the combination of Chronic Unpredictable Mild Stress (CUMS), and (iv) *Channa striatus* pre-treated with amino acids and methylene blue. The authors evaluated the methodological quality of each paper by using the Physiotherapy Evidence Database Scale (PEDro) for randomised controlled trials (Sherrington *et al.,* 2000). The PEDro scale consists of 11 scored yes-or-no questions. The first statement pertains to the external validity of the study, and was not included in computing the final score. The high quality of the study was achieved when the PEDro scored a value of 6 and above, whereas a score of 5 and below represented a low quality of the study. Differences in opinion on any PEDro item scores were resolved through discussion until a consensus was attained.

Data extraction

The specified criteria were used when reviewing the titles and abstracts of retrieved articles to determine whether full texts were required for further analysis. Each full-text manuscript was evaluated systematically according to (1) objectives, (2) study design, participants or model, age, and sample size, (3) intervention contents (intervention types and length of intervention), (4) targeted outcomes, and (5) main findings. The outcomes extracted from those studies were not combined, reanalysed, or altered due to the nature of this systematic review.

Results

Search results

The initial search from the databases identified 1,038 potential articles. After filtered only for full-text articles from January 2000 until December 2019, 581 articles were found. A total of 554 articles were excluded because they did not investigate *Channa striatus* on humans and animals. After a detailed analysis of the 27 full-text articles, only 20 articles were included in this systematic review. The excluded articles were duplicated articles. Figure 1 illustrates the PRISMA flow diagram for the study selection.

From the 20 studies reviewed, 13 studies were conducted on animals, while the remaining seven studies were conducted on humans. The scope of the study from those retrieved articles was primarily on the effects of *Channa striatus* extract on wound healing. Secondarily, a few animal studies investigated the effects of *Channa striatus* extract on antinociceptive activity, antidepressant-like effect, and antiulcer activity. One of these studies investigated more than one measurement combination which are antinociceptive activity, anti-inflammatory, and antipyretic properties. In addition, some studies were done on humans where it investigated the effectiveness of *Channa striatus* on osteoarthritis, allergic rhinitis, and tuberculosis.

The amount of *Channa striatus* presented was ranged between 10 to 1,000 mg/kg/bw (body weight) in animal studies, while most studies (Wahab *et al.,* 2015; Bakar *et al.,* 2015; Shukkoor *et al.,* 2016; Shafii *et al.,* 2017; Azidah *et al.,* 2017; Sahid *et al.,* 2018; Susibalan *et al.,* 2018; Azemi *et al.,* 2018; Ma'rufi *et al.,* 2019) prescribed 500 mg per day of *Channa striatus* in human studies. Calculation of the human dosage was based on animal studies by using the formula below (Shin *et al.,* 2010):

$$\text{Human Equivalent Dose } \left(\text{HED in } \frac{\text{mg}}{\text{kg}}\right) = \frac{\text{animal dose } \frac{\text{mg}}{\text{kg}} \times \text{animal Km}}{\text{Human Km}} \quad \text{(Eq. 1)}$$

In animals, the standard dose for the administration of *Channa striatus* extract is 10 mL/kg. Based on 10% (w/v) or 0.8 g/kg, the animal dose was 80 mg/kg. Therefore, the dose in human can be calculated as below (Shin *et al.,* 2010):

$$\text{Human Equivalent Dose } \left(\text{HED in } \frac{\text{mg}}{\text{kg}}\right) = \frac{80 \frac{\text{mg}}{\text{kg}} \times 3 \text{ mice Km}}{37 \text{ Human Km}} = 6.49 \text{ mg/kg} \quad \text{(Eq. 2)}$$

According to Human Equivalent Dose (HED; in mg/kg) equation, for humans with an average weight of 70 kg, the therapeutic amount of *Channa striatus* aqueous extract is 64.9 mg/kg × 70 kg = 454.3 ~ 500 mg. Based on the calculation, the calculated dose for humans based on 20% (w/v), or 1.6 g/kg in the animal, would be 1,000 mg/day for humans with an average weight of 70 kg.

Eight studies used multiple dosages of *Channa striatus* supplementation based on the standard dose administration. Meanwhile, there were four studies combining *Channa striatus* extract with other components namely cetrimide (Baie and Sheikh, 2000a; 2000b), 12-0-tertradecanoylphorbol-13-acetate (TPA) (Isa *et al.,* 2016), and fusidic acid (Laila *et al.,* 2011). There was a study that pre-treated the experimental animals with certain drugs such as prazosin, yohimbine, *p*-chlorophenylalanine methyl ester (PCPA), (R)-(+)-7-chloro-8-hydroxy-3-methyl-1-phenyl-2,3,4,5-tetrahydro-1H-3-benzazepine hydrochloride (SCH23390), sulpiride, and fluoxetine (Saleem *et al.,* 2013). In addition, some were pre-treated with naloxone, and an antagonist (atropine, mecamylamine, phenoxybenzamine, pindolol, haloperidol, methysergide, and bicuculline) also had been used in the study by Zakaria *et al.* (2005a). One study combined the Chronic Unpredictable Mild Stress (CUMS) protocol which was designed to develop depressive symptoms in animals with the *Channa striatus* supplementation (Shukkoor *et al.,* 2016).

Based on the retrieved articles, some studies used *Channa striatus* in both tablet and extract forms

Table 2. Studies of *Channa striatus* in animals.

No.	Author and year	Study target / target population	*Channa striatus* dosage	Intervention	Outcome measure	Main finding	Comment
1	Ali Khan *et al.* (2014). Gastroprotective effect of freeze-dried striped snakehead fish (*Channa striata* Bloch.) aqueous extract against aspirin induced ulcerogenesis in pylorus ligated rats.	30 antiulcer property, male albino Wistar rats randomised into five different groups of six rats each. Group I is a negative control group and received vehicles. Group II, III, and IV received aqueous extract of *Channa striatus* (AECS) at 30, 40, and 50% (w/v) concentrations. Group IV received standard drugs (Ranitidine).	10 mg/kg/bw	Aspirin suspended in 1% CMC in water was administered orally at a dose of 50 mg/kg in 12-h fasted rats. The test was extracted, and Ranitidine treatment was done 30 min prior to the administration of aspirin. Then, the pyloric ligation surgery was performed after 30 min.	Volume and pH of gastric juice, free and total acidities, ulcer index (UI), catalase (CAT), superoxidase dismutase (SOD), and malondialdehyde (MDA).	40 and 50% (w/v) of AECS showed significantly decreased volume of gastric juice and increased level of catalase. There was a significant decrease in free and total acidities, and an increase in superoxide dismutase was noticed in 50% (w/v) AECS solution and standard drugs. Meanwhile, all test doses of AECS solutions significantly decreased the UI and SOD compared to standard drugs. However, 30% (w/v) of AECS did not show any significant values on volume and pH of gastric juice, free and total acidities, catalase, and superoxide dismutase.	AECS is devoid of gastric acid neutralising effects but possesses potent antisecretory and antiulcer properties.
2	Azemi *et al.* (2018). Antiulcer activity of methanol-chloroform extract of *Channa striatus* fillet.	For untreated rats, 20 male Sprague Dawley rats were divided into negative control (10% DMSO) group, positive control (Ranitidine) group, and three doses of chloroform: methanol *Channa striatus* fillet (CMCS) group. In pre-treated rats, 30 rats were used and was divided six in each group. The rats were pre-treated with normal saline, L-NAME, and NEM.	50, 250, and 500 mg/kg/bw	Untreated rats fasted for 24 h before oral administration of 10 mL/kg of 10% DMSO, 100 mg/kg of ranitidine, and 50, 250, and 500 mg/kg of CMCS. Pre-treated rats were treated with normal saline, L-NAME, and NEM. After 30 min, the rats received an oral dose of 10% DMS0, 1,000 mg/kg carbenoxolone, 500 mg/kg of CMCS, and 70 mg/kg L-arginine only for normal saline and L-NAME groups. After 1 h, all rats were treated with 1 mL of absolute ethanol to induce gastric ulceration.	Antiulcer activity, volume and pH of gastric juice, total acidity, and antiulcer activity.	CMCS showed significant ($p < 0.05$) antiulcer activity. CMCS also did not change the volume and pH but reduced total acidity. Besides, CMCS demonstrated that antiulcer activity was reversed by NEM but not affected by L-NAME.	CMCS shows that antiulcer activity is modulated via its cytoprotective, but not in antisecretory effect; and in the presence of sulfhydryl compounds, not nitric acid.
3	Baie and Sheikh (2000b). The wound healing properties of *Channa striatus*-cetrimide-wound contraction and glycosaminoglycan measurement.	96 male Sprague Dawley rats were divided into four groups in both sets of the experiment (normal rats and diabetes rats): Group 1: Wounds treated with cream containing cetrimide and Haruan extract, Group 2: Wounds treated with cream containing cetrimide, Group 3: Wounds treated with cetrimide cream, and	Local application that enough to cover the wound (concentration of extract is 1%)	Excision was created on experimental rats. The cream was applied to the wound. Then, rats were sacrificed at intervals 3, 6, 9, and 12 days after wound creation.	Hexosamines, protein, uranic acid, glycosaminoglycans, and wound contraction were determined.	For hexosamine and protein determination, Groups 1 to 3 showed higher hexosamine content compared to Group 4 in both normal and diabetic rats. Groups 1 to 3 also showed higher values of uranic acid compared to Group 4 in the normal rat. The diabetic rats followed the same sequences of uranic acid synthesis but at slower rates. In addition, the level of glycosaminoglycan was higher in the treated group compared to the controlled group on all alternates in normal rats as compared to the diabetic rats. For wound	The enhanced level of glycosaminoglycan may help in the formation of a resistant scar, and enhanced wound contraction represents the positive influence of Haruan.

		Group 4: Wounds untreated (control group).				contraction, Group 1 showed a maximum on day 9 (65%) in normal rats ($p < 0.05$) compared to diabetic rats. On day 6, wound contraction in all normal groups higher than diabetic rats ($p < 0.01$).	
4	Baie and Sheikh (2000a). The wound healing properties of *Channa striatus* cetrimide cream-tensile strength measurement.	40 male adult Sprague-Dawley rats were divided into four groups: Group 1: Wounds treated with cream containing *Channa striatus* and cetrimide, Group 2: Wounds treated with *Channa striatus* cream, Group 3: Wounds treated with cetrimide cream, and Group 4: Wounds untreated served as control.	Local application (5 - 10 mg)	Incision wound was made on the rats. The wound was closed with interrupted sutures. Rats were sacrificed on the 7th post-operative day.	Tensile strength measured by TA.XT2 texture analyser.	Groups 1 to 3 showed a significant increase in tensile strength ($p < 0.05$) compared to the control group (Group 4).	*Channa striatus* helps in wound healing, which may be due to an increase in tensile strength.
5	Isa *et al.* (2016). *Channa striatus* cream down-regulates tumour necrosis factor (TNF)-alpha gene expression and alleviates chronic-like dermatitis in the mouse model.	30 male ICR mice randomised into six groups with five mice in each group: (1) acetone (vehicle), (2) TPA alone (negative control), (3) TPA + Haruan 1%, (4) TPA + Haruan 5%, (5) TPA + Haruan 10%, and (6) TPA + H-Cort (positive control).	10 mg/kg/bw/day	All groups were subjected to the TPA application except for the vehicles that received acetone only for three consecutive days. For Haruan treatment, Haruan cream was applied on the ear surface twice per day after 1 h of TPA application and 6 h after the first treatment with Haruan cream. The mice were assessed on day 10 after 24 h of application with TPA.	Mouse ear oedema assessment, histopathological analysis, and regulation of gene expression of inflammatory cytokines.	Topical application of Haruan cream had reduced the mouse ear thickness compared to the positive control group. There was also a significant reduction ($p < 0.001$) of mice ear thickness by Haruan 1, 5, and 10% compared to the TPA alone group. In addition, the histopathological comparison had shown reduction in various parameters of cutaneous inflammation including dermal oedema, inflammatory cells infiltration, and proliferation of epidermal keratinocytes. TPA application resulted in the up-regulation of TNF- gene expression by 353-fold, which subsequently down-regulated by the Haruan cream (34 to 112-fold)	Haruan is an effective topical anti-inflammatory agent in this mouse model of chronic-like dermatitis.
6	Laila *et al.* (2011). Wound healing effect of Haruan (*Channa striatus*) spray.	Incision wound model: 72 Sprague-Dawley rats randomised into three groups with 24 rats for each group, (1) wound treated with blank formula, (2) wounds treated with formula P1 (Haruan water extract), and (3) wound treated with P2 (Haruan extract with fusidic acid). Burn wound model: 24 adult female Sprague-Dawley rats divided into four groups with six rats in each group, (1) control group, (2) treated with formula P, (3) treated with	Local application that enough to cover the wound.	Rats for incision wound model were euthanised at intervals of 3, 6, 9, and 12 days after wounds creation, and the analysis was performed on the same day. Rats for the burn wound model were treated for 21 days to see the wound contraction.	Primary irritation test, intracutaneous test, systemic injection test, tensile strength test, and wound contraction.	The Haruan spray-on treated rats gave no significant responses to the primary irritation, intracutaneous, and systematic injection test. Tensile strength test showed no significant difference between the groups treated with P, P1, and P2. However, all groups showed an increase in tensile strength from day 6 to 9. On day 4, P1 treatment significantly showed a higher percentage of wound closure compared with the control group. In the first ten days, P1 treatment gave a higher percentage of wound closure compared with the other group.	Haruan water extract spray formula was effective and safe for application on both incision and burn wounds.

		formula P1, and (4) treated with formula P2.					
7	Oentaryo *et al.* (2016). Acceleration of fibroblast number and FGF-2 expression using *Channa striatus* extract induction during the wound healing process: *in vivo* studies in Wistar rats.	20 Wistar rats were randomised into four groups with five per each group, (1) control group, (2) treatment group with a concentration of 25% CS, (3) treatment group with a concentration of 50% CS, and (4) treatment group with a concentration of 100% CS.	10 mg/kg/bw/day	Wound creation was made on lower lips using a heated scalpel, and the histopathological was examined on day 3, 5, and 7.	The number of fibroblast and FGF-2 expression.	On day 3, the number of fibroblasts in all *Channa striatus* treatment groups was higher compared to the control group. The highest number of fibroblasts found in the treatment group with *Channa striatus* extract at concentrations of 100% ($p < 0.05$). In addition, all the *Channa striatus* treated groups showed higher FGF-2 expression compared to the control group. The highest expression of FGF-2 was found in the treated rats with concentration at 50% of *Channa striatus* ($p < 0.05$).	*Channa striatus* extract increases the number of fibroblasts and FGF-2 expression in the mucosa wound healing process.
8	Saleem *et al.* (2013). Involvement of monoaminergic system in the antidepressant-like effect of aqueous extract of *Channa striatus* in mice.	36 males of ICR mice were divided into six groups pre-treated by PCPA, prazosin, yohimbine, SCH23390, sulpiride, and fluoxetine. There were six mice in each group.	10 mg/kg/bw/day	For the role of serotonergic system assessment, mice were pre-treated with PCPA for four consecutive days. After 24 h with the last PCPA injection, the mice were treated with 20% (w/v) of AECF, fluoxetine, or vehicle. In order to assess the role of noradrenergic and dopaminergic systems, an independent group of mice was pre-treated with a vehicle, or prazosin, or yohimbine, or SCH23390, or sulpiride, respectively. Mice received 20% (w/v) of AECSF or vehicles. Tail suspension tail (TST) tested after 30 min later for both assessments.	Tail suspension test (TST)	Pre-treatment with PCPA showed a significantly prevented decrease in immobility time induced by AECSF ($p < 0.05$) compared to their respective groups. Moreover, pre-treatment with prazosin ($p < 0.001$) and yohimbine ($p < 0.01$) significantly prevented the decrease in immobility time induced by AECSF treatment when compared to pre-treatment with a vehicle.	The antidepressant-like effect of AECSF may be mediated through the serotonergic and noradrenergic systems, and not through the dopaminergic systems.
9	Shukkoor *et al.* (2016). Antidepressant-like effect of lipid extract of *Channa striatus* in chronic unpredictable mild stress model of depression in rats.	46 male Sprague-Dawley rats randomly assigned to different groups: 1. No stress ($n = 8$), 2. CUMS control ($n = 7$), 3. CUMS + fluoxetine 10 mg/kg ($n = 7$), 4. CUMS + lipid ext 125 mg/kg (n =,6) 5. CUMS + lipid ext 500 mg/kg ($n = 6$), 6. no stress + lipid ext 250 mg/kg ($n = 6$)	250 and 500 mg/kg/bw/day	All animals were subjected to the Chronic Unpredictable Mild Stress (CUMS) protocol for six weeks except for animals belonging to the no-stress + vehicle group, and no stress + lipid extract 250 mg/kg group.	Forced swimming test (FST), open field test, and biochemical assay.	The lipid extract of *Channa striatus* (125, 250, and 500 mg/kg) significantly ($p < 0.05$) reversed all the parameters in rats subjected to CUMS, thus exhibiting the antidepressant-like effect. CUMS protocol increased plasma corticosterone, decreased levels of monoamines, and increased interleukin-6 in the hippocampus and prefrontal cortex, and increased factor-kappa B in the prefrontal cortex, not in the hippocampus.	The mechanism was found to be mediated through a decrease in plasma corticosterone, increased in serotonin levels in the prefrontal cortex, increased in dopamine and noradrenaline level in hippocampus and prefrontal cortex, increased in BDNF in the hippocampus and prefrontal cortex, and decreased in IL-6 and NF-κB in the prefrontal cortex.

10	Shukkoor *et al.* (2017). Antidepressant-like effect of lipid extract of *Channa striatus* in a postpartum model of depression in rats.	48 female Sprague-Dawley rats were divided into eight different groups, with six rats in each group. 1. Normal control, 2. Sham control, 3. Positive control, 4. Ovariectomised vehicle group, 5. Ovariectomised with hormone simulated pregnancy control group, 6. Ovariectomised + HSP + lipid extract 125 mg/kg, 7. Ovariectomised + HSP + lipid extract 250 mg/kg, and 8. Ovariectomised + HSP + lipid extract 500 mg/kg.	125, 250 and 500 mg/kg/bw/day	The rats were ovariectomised and treated with a high dose of progesterone and estradiol benzoate for 23 d to have hormone-simulated pregnancy. Day 24 onwards was considered as the postpartum period. On postpartum day 15, the animals were tested in FST, OFT, and followed by biochemical analysis.	Forced swimming test (FST), Open field test (OFT), and Biochemical analysis.	In FST, all doses of lipid extracts ($p < 0.001$) and positive control fluoxetine ($p < 0.01$) showed a significantly decreased in the duration of immobility when compared to the HSP control group. Meanwhile, in OFT, the lipid extract at doses 125 and 250 mg/kg ($p < 0.01$) and fluoxetine ($p < 0.05$) showed a significantly decreased number of squares crossed when compared to the HSP control group. Meanwhile, lipid at dose 125 mg/kg ($p < 0.05$) significantly decreased the number of rearing compared to the HSP control group.	The mechanism of antidepressant-like effect may be mediated through the decrease in plasma corticosterone, an increase in plasma oxytocin, and a decrease in nuclear factor-kappa B in the prefrontal cortex of rats.
11	Zakaria *et al.* (2007). Amino acid and fatty acid compositions of an aqueous extract of *Channa striatus* (Haruan) that exhibits antinociceptive activity.	72 male ICR mice were divided into six groups, with 12 mice per group. Control group, aspirin-treated group, 100% aqueous extract of Haruan (ASH), and three extract-treated groups (25, 50, and 100% ASH).	10 mg/kg/bw/day	All the mice were administered with the respective doses to their group. The mice were then left to rest for 30 min before being given acetic acid. All solutions were administered in a volume of 10 mL/kg.	Antinociceptive activity of the aqueous extract of Haruan.	Groups treated with aqueous extract of Haruan showed a dose-dependent increase in inhibition of abdominal constriction to approximately 23, 51, 76, and 81% of control respective to the strength of doses.	The aqueous extract of *Channa striatus* contains all important amino acids but only some of the important fatty acids that are suggested to play a key role in the antinociceptive activity of the extract.
12	Zakaria *et al.* (2005a). Effects of various antagonists on the *Channa striatus* fillet extract antinociception in mice.	Male ICR Balb-C mice were equally divided into 33 groups of ten mice each. There were control groups that received distilled water. Test groups were treated with an antagonist, pre-treated groups with naloxone, and the rest is only 100% concentration of ASH used.	10 mg/kg/bw/day	All groups received the respective antagonist followed by the ASH 10 min later. After administering dH_2O, aspirin, or ASH, the mice were left to rest for 30 min before subjected to antinociceptive assay.	Antinociceptive activity.	The ASH showed significant ($p < 0.001$) concentration-dependent antinociception, which compared to aspirin-produced antinociception. However, the lowest naloxone used exhibited a significant ($p < 0.05$) decreased in the number of abdominal constrictions, indicating the presence of antinociception. In addition, pre-treatment with atropine, phenoxybenzamine, methysergide, or bicuculline produced a significant ($p < 0.001$) reduction in ASH inhibitory effects on nociception. Atropine and bicuculline caused the highest reversal of ASH antinociception with the lowest analgesia.	Aqueous extract of Haruan possessed only a peripheral antinociceptive activity.
13	Zakaria *et al.* (2005b). The effects of L-arginine, D-arginine, L-name, and methylene blue on *Channa striatus*-induced peripheral antinociception in mice.	All male Balb-C mice were divided into 25 groups of ten mice each. Five groups were pre-treated with dH_2O, followed 5 min later by treatment with dH_2O, ASA, or ASH (0.107, 0.426, and 1.074 mg/kg), respectively. Other 20 groups were pre-treated with 20 mg/kg L-arginine, D-arginine, L-NAME, or MB followed 5 min later by treatment with dH_2O, ASA, or ASH (0.107, 0.426, and 1.074 mg/kg), respectively.	10 mg/kg/bw/day	All mice were administered with their respective treatment. 30 min after administering the respective dH_2O, ASA, or ASH (0.107, 0.426, and 1.074 mg/kg), respectively, the mice were injected with 0.6% acetic acid intraperitoneally.	Antinociceptive activity.	Administration of ASH alone showed exhibited dose-dependent antinociception while the L-arginine and MB exhibited significant both nociception and antinociception. Moreover, pre-treatment with L-arginine and MB found significantly reverse the three respective doses of ASH antinociception, while L-NAME only significantly increased the 0.170 and 0.426 mg/kg ASH antinociception.	Aqueous supernatant of Haruan (ASH) antinociception involves the nitric oxide. The presence of nitric oxide was found to reverse ASH antinociceptive activity.

AECS = aqueous extract of *Channa striatus*; DMSO = dimethyl sulfoxide; CMCS = chloroform methanol *Channa striatus*; L-NAME = NG-omega-nitro-L-arginine methyl ester; NEM = N-ethylmaleimide; H-Cort = hydrocortisone 1%; TPA = 12-0-tetradecanoylphorbol-13-acetate; SCH_23390 = halobenzazepine; ASH = aqueous solution Haruan; and dH2O = distilled water.

which were administered orally to the subjects (Saleem *et al.,* 2013; Ali Khan *et al.,* 2014; Wahab *et al.,* 2015; Bakar *et al.,* 2015; Oentaryo *et al.,* 2016; Shukkoor *et al.,* 2016; 2017; Azidah *et al.,* 2017; Shafii *et al.,* 2017; Azemi *et al.,* 2018; Sahid *et al.,* 2018; Susibalan *et al.,* 2018; Ma'rufi *et al.,* 2019). Meanwhile, in studies done by Baie and Sheikh (2000a; 2000b) and Isa et al. (2016), *Channa striatus* cream was applied on wounds, whereas *Channa striatus* spray was described by Laila *et al.* (2011).

In vivo Channa striatus studies on animals

Table 2 summarises the studies done on animals. Three studies conducted on rats and mice with a local application of 5 to 10 mg *Channa striatus* cream (Baie and Sheikh, 2000a; 2000b; Isa *et al.,* 2016) showed a significant increase in tensile strength, enhanced wound contraction, and reduced ear oedema thickness. Another three studies done by Zakaria *et al.* (2005a; 2005b; 2007) found that mice orally administered with 10 mg/kg/bw of *Channa striatus* aqueous extract showed dose-dependent antinociception and a decrease in the number of abdominal constrictions. Meanwhile, Laila *et al.* (2011) reported that wounds of mice treated with *Channa striatus* spray showed a higher percentage of wound closure as compared to the untreated group in the first ten days.

Saleem *et al.* (2013) and Shukkoor *et al.* (2017) investigated *Channa striatus* supplementation of 10 mg/kg/bw on antidepressant-like effect. The authors reported that the *Channa striatus* group showed a significantly decreased mobility duration in the forced swimming test (FST) and the number of squares crossed in the open field test (OFT). However, pre-treatment with *p*-chlorophenylalanine (PCPA), prazosin, and yohimbine significantly prevented the decrease in immobility time (reversed the antidepressant-like effect) of *Channa striatus* aqueous extract in tail suspension test (TST). Meanwhile, Shukkoor *et al.* (2016) reported that a combination of *Channa striatus* extract administration (250 and 500 mg/kg/bw) with CUMS significantly reversed the FST and OFT parameters, thus exhibiting the antidepressant-like effect.

There are two studies that investigated the effects of *Channa striatus* on antiulcer properties. Ali Khan *et al.* (2014) evidenced that rats treated with aqueous extract of *Channa striatus* (10 mg/kg/bw) significantly decreased the volume of gastric juice, ulcer index, and superoxidase dismutase. The study also found an increased level of catalase. However, Azemi *et al.* (2018) found that antiulcer activity was reversed by pre-treated N-ethylmaleimide (NEM). A study done by Oentaryo *et al.* (2016) found that *Channa striatus* administration to the rats increased the number of fibroblasts and FGF-2 expression as compared to the control group during wound healing.

In vivo Channa striatus studies on humans

Table 3 shows the summaries of studies on humans. There are three studies conducted on post Lower Segment Caesarean Section (LSCS) women. According to Bakar *et al.* (2015), LSCS women supplemented with *Channa striatus* tablet of 500 mg per day for six weeks showed a decrease in measurements of a longitudinal and oblique transverse plane on the uterus as compared to the placebo group. The uterus involute was faster in the *Channa striatus* groups, which significantly enhanced healing.

Wahab *et al.* (2015) reported significant improvement in visual analogue scale (VAS) scores and patient satisfaction score (PSS) in the *Channa striatus* group, when consumed 500 mg per day of *Channa striatus* for six weeks. The consumption of *Channa striatus* marked a difference in terms of wound cosmetic appearance and PSS towards the wound appearance in this study. Meanwhile, a study done by Shafii *et al.* (2017) reported that the *Channa striatus* group and placebo group had an equivalent effect on the reactive protein (hsCRP), total white cell counts (TTWC), and platelets counts from day 1 to 3. However, there were no positive effects found on both groups on day 3, postoperatively. That study claimed that *Channa striatus* supplementation at day 3 yielded no changes in inflammatory markers during wound healing in post LSCS.

There was one study done on osteoarthritis patients by Azidah *et al.* (2017). This study showed that the treatment group supplemented with 500 and 1,000 mg/day of *Channa striatus* for six months exhibited greater decreases in WOMAC physical function and stiffness score as compared to a placebo group. Other than that, a study conducted by Ma'rufi *et al.* (2019) on tuberculosis patients reported the acceleration of tuberculosis treatment by *Channa striatus* supplement at week 4, where it accelerated bacterial clearance.

Sahid *et al.* (2018) investigated the application of *Channa striatus* spray on wound in patients who underwent clean elective surgery, and found significant differences in the visual analogue cosmetic score, Vancouver scar scale, visual analogue pain score, and wound evaluation scale between treatment and placebo groups. Susibalan *et al.* (2018) reported improvement in nasal blockage, nasal and eyes itchiness, and general symptoms among allergic rhinitis subjects who took 500 mg per day of *Channa striatus* tablet for six weeks. Serum Ig E was also

Table 3. Studies of Channa striatus in humans.

No.	Author and year	Study target / target population	*Channa striatus* dosage	Intervention	Outcome measure	Main finding	Comment
1	Azidah *et al.* (2017). A randomised, double-blind study comparing multiple doses of *Channa striatus* supplementation for knee osteoarthritis.	A randomised, double-blind, placebo-controlled 3-arm trial. n = 120 primary knee osteoarthritis patients. Six months of intervention: Placebo, *Channa striatus* 500 mg, and *Channa striatus* 1,000 mg.	500 and 1,000 mg/day	Consumption of *Channa striatus* supplement for the *Channa striatus* group and corn starch capsule for the placebo group for 6 months.	WOMAC pain score, WOMAC stiffness score, WOMAC physical function score, analgesic score, and serum COMP.	Pain score markedly decreased in all treatment groups (*Channa striatus* 1,000 mg, 52.5%; and *Channa striatus* 500 mg, 49.2%) after six months treatment duration compared to placebo (30.4%). *Channa striatus* 1,000 mg ($p < 0.05$) and *Channa striatus* 500 mg ($p < 0.05$) had significantly higher value compared to the placebo group. In addition, the physical function score was significantly lowered in the *Channa striatus* 1,000 mg ($p < 0.05$) and *Channa striatus* 500 mg ($p < 0.05$) compared to the placebo subjects. No significant difference in analgesic scores and serum COMP within group analysis.	Both doses of *Channa striatus* showed similar efficacy and were more effective than placebo in treating the symptoms of knee osteoarthritis.
2	Bakar *et al.* (2015). Randomised controlled trial on the effect of *Channa striatus* extract on measurement of the uterus, pulsatility index, resistive index of uterine artery, and superficial skin wound artery in post lower segment of caesarean section women.	A randomised, double-blind, placebo-controlled study. n = 66 women after LSCS. Six weeks of intervention: placebo and *Channa striatus* group.	500 mg/day	*Channa striatus* group consumed 500 mg daily of *Channa striatus* tablet, and the placebo group consumed 500 mg daily of maltodextrin for six weeks from three days after LSCS.	Pulsatility index (PI), Resistive index (RI) of the uterine, and superficial skin wound arteries.	There were no significant differences in PI and RI of the uterine, and superficial skin wound arteries between *Channa striatus* and the placebo group. However, the anterior posterior (AP) measurements of the uterus on the longitudinal ($p < 0.05$) and oblique transverse plane ($p < 0.001$) were significantly lower in the *Channa striatus* group compared to the placebo group.	Daily intake of *Channa striatus* supplement results in marked differences compared to placebo in terms of uterine involution and recovery of women in post LSCS.
3	Ma'rufi *et al.* (2019). *Channa striata* (Ikan Gabus) extract and the acceleration of tuberculosis treatment: a true experimental study.	The new positive pulmonary tuberculosis patients were voluntarily involved and randomised into the control and intervention group (n = 200).	500 mg/ day	The control group performed standard antibiotic treatment and placebo supplementation, while the intervention group performed not only antibiotic treatment for TB but also *Channa striatus* supplementation for four weeks.	Sputum test of tuberculosis	There was a significant difference between *Channa striatus* supplementation and the acceleration of tuberculosis treatment among patients at week 3 ($p < 0.05$). At week 4, respondents classified in the negative category of tuberculosis level in the intervention group is higher than the control group.	*Channa striata* in this study significantly related to the acceleration of tuberculosis recovery.
4	Sahid *et al.* (2018). Snakehead consumption enhances wound healing? From tradition to modern clinical practice: a prospective randomised controlled trial.	A randomised, double-blind, placebo-controlled study. n = 81 patients underwent clean elective surgery. Six weeks of intervention: treatment group and placebo group	unknown	The treatment group was sprayed with *Channa striatus* extract, and the placebo was sprayed without *Channa striatus* extract daily for six weeks.	Visual analog cosmetic score (VACS), Vancouver scar scale (VSS), visual analog pain score (VAPS), and wound evaluation scale (WES).	There was significant difference in VAPS ($p < 0.05$), VACS ($p < 0.001$), VSS ($p < 0.05$), and WES ($p < 0.05$) between treatment and placebo group.	Application of *Channa striatus* extracts sprayed on clean wounds showed a significantly better pain score result and cosmetic outcome compared to placebo.

5	Shafii *et al.* (2017). Changes in the inflammatory markers with supplementation of *Channa striatus* extract in post lower segment caesarean section.	A randomised, double-blinded, placebo-controlled study. *n* = 60 patients who undergone LSCS. There were *Channa striatus* group and placebo group.	500 mg/day	*Channa striatus* group consumed 500 mg daily (2 capsules) of freeze-dried *Channa striatus* extract, and the placebo group consumed 500 mg daily (2 capsules) of maltodextrin per day for three days.	High sensitivity C-reactive protein (hsCRP), total white cell counts (TWCC), and platelets count.	Within *Channa striatus* group, there were significant reduction in hsCRP ($p < 0.001$) and TWCC ($p < 0.001$) whereas platelet counts increased significantly ($p < 0.001$). A similar pattern of changes was observed within the placebo group. However, group comparison at day 3 reported no significant difference in hsCRP, TWCC, and platelet count between *Channa striatus* and placebo groups.	There were no significant differences in the inflammatory markers during wound healing in post LSCS women for three days.
6	Susibalan *et al.* (2018). Efficacy of snakehead fish (*Channa striatus*) in subjects with allergic rhinitis: a randomised controlled trial.	A randomised, double-blind, placebo-controlled trial. *n* = 70 subjects with allergic rhinitis. Six weeks of intervention: *Channa striatus* group and placebo group.	500 mg/day	*Channa striatus* group orally administered 500 mg daily of freeze-dry *Channa striatus* extract, and the placebo orally took 500 mg daily maltodextrin for six weeks.	Allergic rhinitis symptoms (nasal symptoms and non-nasal symptoms) and serum Ig E.	*Channa striatus* group showed significant improvement in nasal blockage ($p < 0.05$), nasal itchiness ($p < 0.05$), eye itchiness ($p < 0.001$), and general symptoms ($p < 0.05$) compared to the placebo group. Meanwhile, serum Ig E showed significantly lowered in the *Channa striatus* group compared to the placebo. There were no significant differences between the groups in terms of nasal discharge, sneezing, palate itchiness, and smell score.	*Channa striatus* has a beneficial role in improving nasal symptoms and reduction in serum Ig E in allergic rhinitis patients.
7	Wahab *et al.* (2015). The effect of *Channa striatus* (Haruan) extract on pain and wound healing of post-lower segment caesarean section women.	A randomised, double-blind, placebo-controlled study. *n* = 76 subjects with post lower segment caesarean section women. Six weeks of intervention: treatment group and placebo group.	500 mg/day	The treatment group orally took 500 mg daily of freeze-dried *Channa striatus* extract, and the placebo group consumed 500 mg daily maltodextrin for six weeks.	Wound evaluation scale (WES), visual analogue scale (VAS) scores, patient satisfaction score (PSS), and safety profile.	There were significant differences in VAS and PSS in the treatment group compared to placebo ($p < 0.001$). However, there were no significant differences in postoperative pain, WES, and safety profile between the groups.	Six weeks of supplementation of 500 mg of *Channa striatus* extract showed marked differences in wound cosmetic appearance, patient's satisfaction, and is safe for human consumptions.

LSCS = lower segment caesarean section; WOMAC = The Western Ontario and McMaster Universities Arthritis Index; COMP = cartilage oligomeric matrix protein; PI = pulsatility index; RI = resistive index; VACS = visual analog cosmetic score; VSS = Vancouver scar scale; VAPS = visual analog pain score; WES = wound evaluation scale; and hsCRP = high sensitivity C-reactive protein.

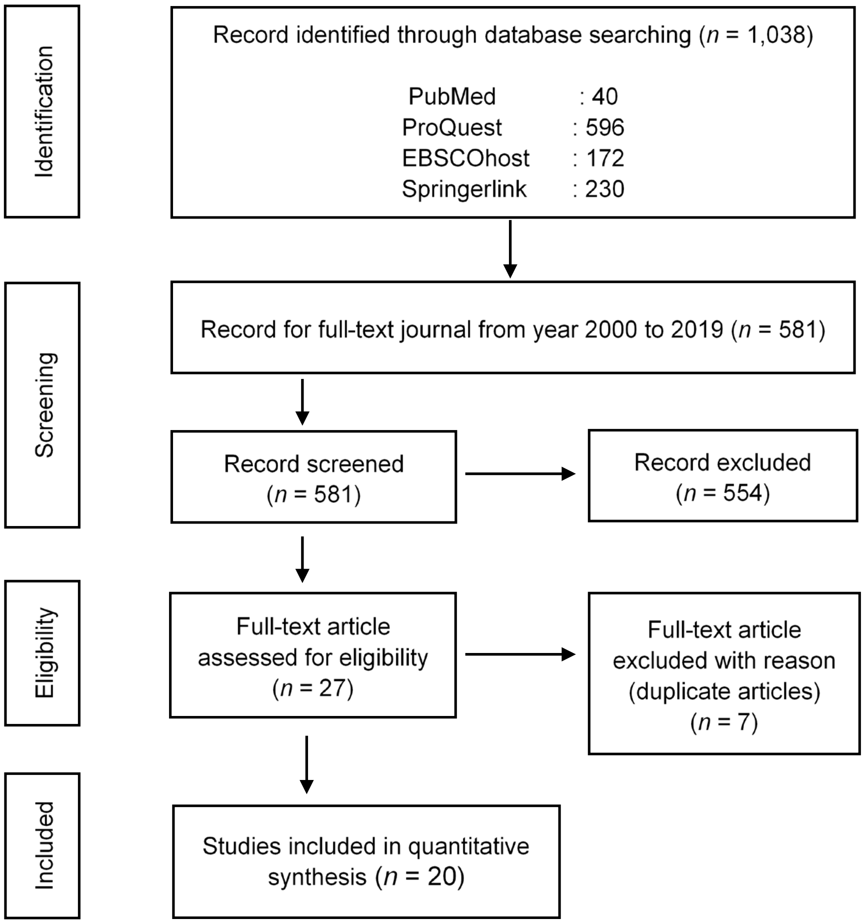

Figure 1. PRISMA flow for study selection.

found to be lowered in the treatment group as compared to a placebo group.

Studies methodological quality

Out of the 20 studies, 13 animal studies were not scored using the PEDro scale since there was no randomisation in animal studies. The average score obtained was 9.3 for the remaining seven studies (Table 2 and 3).

Discussion

Effects of Channa striatus on wound healing

Seven studies had reported on wound healing; three studies were on humans, while the other four studies were on animals. The studies on humans were conducted on women with post LSCS (Bakar *et al.,* 2015; Wahab *et al.,* 2015) and patients who underwent clean elective surgery (Sahid *et al.,* 2018). Meanwhile, the studies on animals were conducted on rats with excision wounds (Baie and Sheikh, 2000b), incision wounds (Baie and Sheikh, 2000a; Laila *et al.,* 2011), and wound creation on lower lips (Oentaryo *et al.,* 2016).

Wound healing is a complex process involving several overlapping stages that include inflammation, granulation tissue formation, reepithelialisation, matrix formation, and scar contraction with remodelling. The collagen determines strength and structure in normal tissues. Therefore, collagen is one of the essential components contributing to the tensile strength of the wounded skin (Laila *et al.,* 2011). According to Steed (2003), adequate nutrition intake is required to enhance fibroblast cell proliferation to produce collagen fibre network in wound healing.

Consumption of *Channa striatus* supplement was beneficial for wound cosmetic enhancing and wound healing processes. According to Baie and Sheikh (2000a), the two components in *Channa striatus*, which are amino acids (such as glycine) and fatty acids (such as arachidonic acid), have been implicated in enhancing wound healing by the initiation of a series of mechanisms involving collagen remodelling, wound reepithelialisation, and induction of wound contraction. Glycine is the most important component of human skin collagen, and combines with aspartic and glutamic acid which act synergistically with the presence of other essential amino acids such as proline, alanine, arginine, leucine, isoleucine, phenylalanine, and methionine to form a polypeptide that is responsible for tissue repair and healing (Baie and Sheikh, 2000a; Witte and Barbul, 2002; Shafri and Abdul Manan, 2012; Wahab *et al.,* 2015).

After delivery, the collagen content of the uterus rapidly decreases, which is a noticeable feature of post-partum involution. Most of the collagen bundles are degraded extracellularly (Roh *et al.,* 2000). A study done by Bakar *et al.* (2015) found that *Channa striatus* extract consumption increased the uterus involution rate by enhancing the wound healing process and increasing the contractile activity of the uterus. According to a study done by Baie and Sheikh (2000a), *Channa striatus* extract increased the rate of the wound healing process by increasing the tensile strength of the wound. This finding is in line with the study done by Laila *et al.* (2011), in which they mentioned that an increase in tensile strength could be related to the collagen structure changes on that wound, which depends on the high-level amount of specific amino acids such as glycine and fatty acids such as arachidonic acid present in the *Channa striatus* extract. According to Monaco and Lawrence (2003), after collagen molecules are formed, they are secreted into the cells' wound site to become cross-linked, thus forming fibres.

The wound healing process can also be enhanced by increasing the number of fibroblasts (Oentaryo *et al.,* 2016). Fibroblasts enter the wound area two to five days after an injury occurred. Fibroblasts begin to secrete collagen at the end of the first week for reinstating the tensile strength of the wound (Pasha *et al.,* 2015). A previous study by Oentaryo *et al.* (2016) reported that an increase in the number of fibroblasts is due to the effects of content in the *Channa striatus* extract. The authors also mentioned that copper (Cu) content in the extract triggered the increased number of fibroblasts. The proliferation of fibroblasts in the wound area triggered by Cu plays a vital role in the growth and replication of cells. This is in line with Siswanto *et al.* (2016), which mentioned that albumin, zinc (Zn), copper (Cu), and iron (Fe) found in the *Channa striatus* extract are an important substances for the wound healing process.

Channa striatus exhibits an antidepressant-like effect

The mechanism of antidepressant effect may be mediated by an increase in plasma corticosterone and interleukin-6 in the hippocampus and prefrontal cortex, and a decrease in monoamines and nuclear factor-kappa B (NF-κB) in the prefrontal cortex (Koo *et al.,* 2010). A study done by Shukkoor *et al.* (2017) reported that lipid extract with the dosage of 125 and 500 mg/kg/day had decreased the level of plasma corticosterone. Their earlier study supported this finding. The authors mentioned that the *Channa striatus* lipid extract exhibited a significant effect on the hypothalamic-pituitary-adrenal axis, mainly by decreased level of plasma corticosterone.

Monoamines are believed to be linked with depression. Elhwuegi (2004) and Krishnan and Nestler (2008) mentioned that monoamines such as noradrenaline, serotonin, and dopamine are involved in depression pathogenesis. The administration of lipid extract on the depressed rats showed that it increased the serotonin level in the prefrontal cortex but not in the hippocampus, thus creating a dose-dependent relationship with hippocampal noradrenaline and both prefrontal cortex and hippocampal dopamine level (Shukkoor *et al.,* 2016). This finding implied that *Channa striatus* lipid extract had a significant effect on brain monoamine levels.

It is also believed that chronic stress promotes the activation of NF-κB in response to inflammatory stimuli (Koo *et al.,* 2010). Shukkoor *et al.* (2017) reported that consumption of 125, 250, and 500 mg/kg of Haruan lipid extract significantly decreased the NF-κB level in the prefrontal cortex due to the docosahexaenoic acid content. A study done by Shukkoor *et al.* (2016) combined CUMS with an intake of lipid extract of *Channa striatus*. That study found that lipid extract with 500 mg dose inhibited the activation of NF-κB and subsequently reduced the IL-6 in the prefrontal cortex and increased the serotonin level. This finding is in line with Zúñiga *et al.* (2011) which mentioned that □-3 fatty acids inhibited the NF-κB.

Effects of Channa striatus on anti-inflammatory

A study by Isa *et al.* (2016) found that the application of Haruan cream could reduce the thickness of mouse ear, down-regulation of TNF-α gene expression level, and suppression of histological features of cutaneous inflammation. However, there were no significant changes found in inflammatory markers with the consumption of 500 mg *Channa striatus* due to the short period of consumption, *i.e.,* three days (Shafii *et al.,* 2017).

Zuraini *et al.* (2006) mentioned that the DHA content in Haruan contributed to the anti-inflammatory mechanism. Moreover, DHA also inhibits the production of inflammatory mediators such as TNF-α (James *et al.,* 2000; Isa *et al.,* 2016). Abedi *et al.* (2012) mentioned that the bioactive substances in *Channa striatus* cream such as linoleic acid, oleic acid, and stearic acid could give an anti-inflammatory effect that suppresses the myeloperoxidase (MPO) activity (pro-inflammatory enzyme) during inflammation.

Effects of Channa striatus on human diseases

Tuberculosis (TB), although largely a curable disease, remains a major cause of morbidity and mortality worldwide. There were nine million new cases and 1.4 million deaths in 2010 (WHO, 2013). According to the study done by Ma'rufi *et al.* (2019), consumption of *Channa striatus* for four weeks showed a significant effect on the acceleration of tuberculosis recovery among patients. The extract of *Channa striatus* consists of a high amount of amino acids and fatty acids which could control the antifungal activities in a restricted spectrum (Mat Jais *et al.,* 2008), and possessed a concentration-dependent antinociceptive activity (Zakaria *et al.,* 2007).

Allergic rhinitis (AR) is an inflammatory disorder of the nasal mucous membrane that can be characterised by nasal obstruction, watery nasal discharge, pruritus, and sneezing (Blaiss *et al.,* 2018). A study done by Susibalan *et al.* (2018) reported that the consumption of 500 mg/day of *Channa striatus* for six weeks resulted in improvement in nasal blockage, nasal itchiness, eye itchiness, and general symptoms. *Channa striatus* extract elicited beneficial effects on AR through its anti-inflammatory properties (Abedi *et al.,* 2012) and antioxidant properties (Radzak *et al.,* 2014). This finding is in line with a previous study done by Thien *et al.* (2002), which found that the content of omega-3 fatty acids in the *Channa striatus* could reduce inflammation of airways and bronchoconstriction.

Knee is the most affected joint associated with osteoarthritis (OA). Azidah *et al.* (2017) found that the consumption of 500 and 1,000 mg/day of *Channa striatus* for six months in knee OA patients showed significant improvement in OA symptoms. This finding was supported by Kadir *et al.* (2014) which reported that the pain and symptoms of knee OA patients were significantly improved in the *Channa striatus* group as compared to the placebo group. *Channa striatus* has been reported to elicit anti-inflammatory effects on OA. Isa *et al.* (2016) mentioned that the EPA and DHA found in the *Channa striatus* have involved with the anti-inflammatory action by reducing the pro-inflammatory production. Moreover, the high amount of amino acids in *Channa striatus* could promote collagen remodelling by synthesising protein linking (Baie and Sheikh, 2000a; 2000b) which is important in the healing process and tissue repairing.

Limitation of this review

This systematic review only examined publications from the years 2000 to 2019, and only those in the English language were considered. Hence, there are possibilities that few related publications might have been excluded.

Conclusion

This review reported seven studies that have investigated the effects of *Channa striatus* on wound healing. Three studies investigated the antidepressant-like effects with consumption on *Channa striatus*, and another three studies were on anti-inflammatory effect. Meanwhile three studies have reported the effects of *Channa striatus* on diseases. It can be concluded that *Channa striatus* elicits a positive effect on the wound healing process, enhanced antidepressant-like, and anti-inflammatory effect due to its high content of amino acids and fatty acids.

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