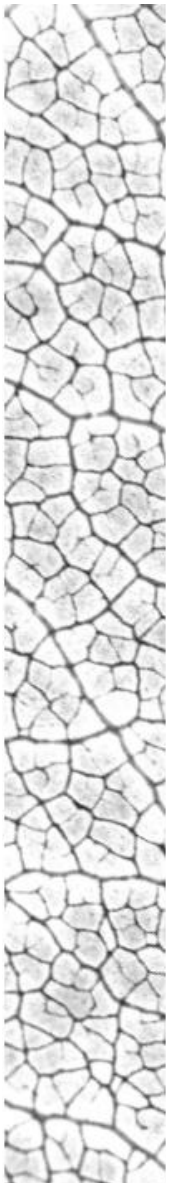

EurAsian Journal of BioSciences
Eurasia J Biosci 14, 4527-4533 (2020)

Snakehead fish extract (*Channa striata*): A review of pharmacological activity

Andi Suhendi [1,2*], Hesti Pawarti [1], Abdul Rohman [3], Djoko Wahyono [4], Arief Nurrochmad [4]

[1] Pharmaceutical Chemistry Department, Faculty of Pharmacy, universitas Muhammadiyah Surakarta, INDONESIA
[2] Doctoral Student of Pharmaceutical Science, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, INDONESIA
[3] Pharmaceutical Chemistry Department, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, INDONESIA
[4] Pharmacology and Clinical Pharmacy Department, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, INDONESIA
*Corresponding author: Andi Suhendi

Abstract
Snakehead fish extract contains nutrients and minerals with pharmacological activities that support the therapeutic handling of several diseases. Albumin is the major nutrient content in snakehead fish extract. In addition, snakehead fish extract also contains amino acids, fatty acids, and minerals. From 21 references, it was found that the active compounds of snakehead fish extract have various pharmacological activities such as antioxidant, complementary therapy of anti-tuberculosis (supportive therapy), anti-inflammation, anti-diabetes, and antihypertensive. Besides, various processing techniques and types of solvents have also become one of the determinants for the quality of snakehead fish extract produced. Most of the literature reported that the active compound responsible for the pharmacological activities of snakehead fish extract is albumin. This review aims to provide a summary of the latest research regarding the pharmacological activities of snakehead fish extract. In this review, the data presented were obtained from the latest online literature between 2015 to 2020 including journals and scientific articles, both national and international publications consisted of in vitro, in vivo, and clinical experiments.

Keywords: snakehead fish extract, activity, pharmacology

Suhendi A, Pawarti H, Rohman A, Wahyono D, Nurrochmad A (2020) Snakehead fish extract (*Channa striata*): A review of pharmacological activity. Eurasia J Biosci 14: 4527-4533.

INTRODUCTION

The use of snakehead fish extract is currently increasing with the various experiment conducted in vitro, in vivo, and clinical experiments both in single preparation form and in combination with other compounds. The snakehead fish extract reported from various experiments were proved to have various benefits such as medical therapy of diseases with various pharmacological activities. The pharmacological activities of snakehead fish extract as therapy of several diseases depend on the active compounds contained. The active compounds of snakehead benefit in supporting the medical therapy by having treats such as antioxidant (Kurnianto and Retnaningsih, 2017; Hidayati et al., 2018; Chasanah et al., 2018; Suhendi et al., 2020), complementary therapy of anti-tuberculosis (Pratama et al., 2016; Maarufi et al., 2019; Mirzaie, 2018), anti-inflammation (Muhtadi and Ariyati, 2017; Muhtadi et al., 2019; Chasanah et al., 2015; Suharjono et al., 2016; Hartini et al., 2015; Maharani and Muhtadi, 2017; Agustin et al., 2016; Wahab et al., 2015; Rahayu et al., 2016), anti-diabetes (Prastari et al., 2017; Muhtadi et al., 2019; Muhtadi et al., 2018), and antihypertensive (Chasanah et al., 2015; Budiari et al., 2018; Fidelis et al., 2019).

As the main food daily consumed by the community, snakehead fish extract is one of the safest and best sources of protein to consume. Snakehead fish extracts are produced from the extraction using various solvents such as water and ethanol. However, several articles (Suhendi et al. (2020); Kurnianto and Retnaningsih, (2017); Pratama et al. (2016); Maarufi et al. (2019); Maarufi et al. (2020); Wahab et al. (2015)) did not mention how to produce snakehead fish extracts because the preparations used were ready-to-use powder preparations obtained from the producing company. Good processing techniques in producing snakehead fish extract will determine the nutrients produced (Chasanah et al., 2018; Ahmadinejad and Talebi Trai, 2019). The research conducted by Salmatia

Received: November 2019
Accepted: March 2020
Printed: October 2020

et al. (2020) supported the research conducted by Chasanah et al. (2018) stating that the method of boiling and steaming snakehead fish can significantly affect albumin levels. The fresh snakehead fish group has high albumin levels. The high levels of albumin in the fresh fish group are due to the absence of heat treatment so that the albumin levels are not affected. Direct heating of snakehead fish in water media will cause damage to albumin in snakehead fish.

The research conducted by Chasanah et al. (2015) reported that the snakehead fish extract obtained from cultivation and nature had almost the same protein content, but differed in water, ash, and fat content. The results of the research were reported that there was no significant difference because the snakehead fish were given feed in the form of pellets which had been designed in such a way as to meet the needs that support the growth process of snakehead fish. The pellet composition was designed to meet the protein needs of snakehead fish so that it was not significantly different from the feed from its natural habitat. The snakehead fish extract in this research was extracted using a distilled water solvent. The snakehead fish extract obtained from natural habitat has higher albumin levels compared to cultivated products and has potential as an antihypertensive. The high use of snakehead fish extract in the health environment was also reported in the research conducted by Chasanah et al. (2015). Therefore, a literature review from various results of recent research between 2015-2020 regarding the active substance content of snakehead fish extract which has pharmacological activity as therapeutic handling of various diseases is needed.

RESULTS AND DISCUSSION

Based on research conducted by (Chasanah et al., 2015), it is stated that the largest content of snakehead fish extract is albumin. Albumin is one of the determinants of snakehead fish extract quality as a raw material for making supplements or as a support in the health sector. The largest albumin content in snakehead fish extract based on research conducted by Asikin and Kusumaningrum (2017) was found in fish weighing 600-900 grams of 17.85%. Snakehead fish body weight affects the quality of albumin produced. In addition, the research conducted by Hidayati et al. (2018) stated that snakehead fish extract in storage must also concern with the temperature factor to obtain the maximum pharmacological effect. The temperature factor in the storage of snakehead fish extract affects shelf life. A good temperature for storing snakehead fish extract is at a temperature of 30^{o}C.

In this literature review, the pharmacological activity of snakehead fish extract in terms of active compound in the form of albumin, striatin, and snakehead fish extract in a whole. The main topic in this review is snakehead fish extract as an antioxidant complementary therapy (supportive therapy), anti-inflammation, anti-diabetes, and antihypertensive therapy which is considered the most experiment carried out according to the author in this review literature. The review presented discusses the activity of snakehead fish extract from various studies conducted in vitro, in vivo, and clinical experiments. Following the data presented on Tabel 1 the pharmacological activity of snakehead fish extract and the active compounds in a role from various experiment results:

In writing this literature review, the pharmacological activities of snakehead fish extract are reviewed from the active compounds of snakehead fish extract in the form of albumin, striatin, and snakehead fish extract powder as a whole. The main topic in this literature review is divided into five topics, namely the pharmacological activity of snakehead fish extract as an antioxidant, complementary therapy of anti-tuberculosis (supportive therapy), anti-inflammatory, anti-diabetic, and antihypertensive therapy whose research are considered the most often conducted research according to the author of this review literature. This review discusses the pharmacological activity of snakehead fish extract according to various research conducted in vitro, in vivo, and clinical trials. The following shown in **Table 1** is the pharmacological activity of snakehead fish extract and the active compounds that play a role in it according to various research results:

Antioxidant

Snakehead fish extract as an antioxidant reported by the research conducted by Hidayati et al. (2018) was proven by how it reacts with the free radical reagent TMAMQ (Tetramethoxy azobismethylene quinone). The test results showed that there was a process of free radical withdrawal by the snakehead fish extract given. Snakehead fish extract has been shown to have a higher antioxidant activity than ascorbic acid, which was around 5.7 times. Besides, the research carried out by Chasanah et al. (2018) also proved the existence of free radical scavenging activity by snakehead fish extract which was reacted with DPPH (2,2-diphenyl-1-picrylhydrazyl). The results of this research indicated specifically that the highest antioxidant activity produced by snakehead fish extract was found in the snakehead fish eggs, and the other parts, namely meat, gills, and skin, respectively. The higher the concentration of snakehead fish extract, the better its activity as an antioxidant.

The research carried out by Suhendi et al. (2020) stated that snakehead fish extract has pharmacological activity by reducing MDA (Malondialdehyde) levels. MDA is one of the parameters for liver damage, which indicates the presence of excess free radicals in the body. MDA levels of rats in the experiment increased

Table 1. Pharmacologycal activities of snakehead fish extract

Activity	Type of extract	Type of experiment	Active compound	Reference
Antioxidant	Water	*In vitro* (free radical scavenging with TMAMQ)	Whole extract	Hidayati *et al.,* 2018
	Water	*In vitro* (free radical scavenging with DPPH)	Whole extract	Chasanah *et al.,* 2018
	Ready to be use powder	*In vivo* (rats)	Whole extract	Suhendi *et al.,* 2020
	Ready to be use powder	Clinical experiment (acute ischemic stroke with a history of hypertension patients)	Whole extract	Kurnianto and Retnaningsih, 2017
Complementary therapy of TB	Ready to be use powder	Clinical experiment (TB patients)	Albumin	Pratama *et al.,* 2016
	Ready to be use powder	Clinical experiment (TB patients)	Whole extract	Maarufi *et al.,* 2019
	Ready to be use powder	Clinical experiment (pasien TB)	Whole extract	Maarufi *et al.,* 2020
Anti-inflammation	Water	*In vitro* (3T3 fibroblast cell) *In vivo* (rats)	Whole extract	Rahayu *et al.,* 2016
	Water	*In vivo* (rats)	Whole extract	Muhtadi and Ariyati, 2017
	Water	*In vivo* (rats)	Whole extract	Muhtadi *et al.,* 2019
	Air	*In vivo* (rats)	Whole extract	Hartini *et al.,* 2015
	Air	*In vivo* (rats)	Whole extract	Maharani and Muhtadi, 2017
	Air	*In vivo* (rats)	Whole extract	Agustin *et al.,* 2016
	Ready to be use powder	Clinical experiment (patients with caesarean)	Whole extract	Wahab *et al.,* 2015
Anti-diabetes	Water	*In vivo* (rats)	Whole extract	Muhtadi *et al.,* 2018
	Water	*In vivo* (rats)	Whole extract	Muhtadi *et al.*, 2019
Anti-hypertensive	Water	*In vitro* (ACE enzyme)	Whole extract	Chasanah *et al.,* 2015
	Water	*In vitro* (ACE enzyme)	Whole extract	Chasanah *et al.,* 2018
	Water, ethanol	*In vitro* (ACE enzyme)	Whole extract	Budiari *et al.,* 2018

when there was damage to liver cells as the result of an increase in free radicals due to the administration of the rifampin-isoniazid combination. Albumin and Zn are active compounds of snakehead fish extract which act as antioxidants. This snakehead fish extract supplementation serves to assess its effectiveness as an antioxidant. The treatment towards snakehead fish extract at a dose of 54 mg/200 g BW/day using rats induced with rifampicin and isoniazid was proven to reduce MDA levels in the blood and liver.

The effect of snakehead fish extract as an antioxidant was also reported by Kurnianto and Retnaningsih (2017) in acute ischemic stroke patients with a history of hypertension who were undergoing treatment at dr. Kariadi Central Hospital, Semarang. Acute ischemic stroke patients with a history of hypertension have low SAT (Total Antioxidant Status) levels, so they need external antioxidants to ward off free radicals. The research subjects were 29 people with 13 people given snakehead fish extract and 16 others given a placebo. Patients with stroke onset of 48-72 hours showed a decrease in SAT levels in the body. In that research, it was stated that the content of snakehead fish extract was able to significantly increase SAT in patients with acute ischemic stroke who also had a history of hypertension at a dose of 3 x 5 g / day. SAT measurements in the research serve to assess free radical activity in the body. Reduced SAT (Total Antioxidant Status) levels in stroke patients depend on both decreased activity and levels of SOD (Superoxide Dismutase). Snakehead fish extract supplementation in acute ischemic stroke patients who have a history of hypertension has been shown to have increased SAT. The increase of SAT levels in that research indicated an improvement in the patient's condition.

Complementary therapy of Antituberculosis

Based on the research carried out by Pratama et al. (2016) that conducted a clinical trial on patients in six health centers in Jember Regency, stated that tuberculosis can cause malnutrition caused by disruption of albumin synthesis and an increase in REE (Resting Energy Expenditure). Snakehead fish extract supplementation was needed to treat malnutrition. In malnutrition condition, the BMI (Body Mass Index) of patients with TB (Tuberculosis) has decreased. The low BMI in patients with TB in this research was one of the factors influencing the effectiveness of decreasing IFN-in the body. In tuberculosis conditions, the body will release IFN-γ (Interferon-gamma) in response to infection by Mycobacterium tuberculosis. The treatment group in this research was given snakehead fish extract 3 x 500 mg/day. The results showed a decrease in IFN-γ levels. Snakehead fish extract has an activity approach to reduce the level of IFN-γ in the body which indicates an improvement in the condition of patients with TB against infections caused by Mycobacterium tuberculosis. This causes the number of ESAT (Early Secretory Antigenic Target) and CFP-10 (Culture Filtrate Protein) antigens to decrease. This antigen plays a role in releasing IFN-γ so that by decreasing ESAT and CFP-10 levels, it can also reduce IFN-γ levels which indicates an improvement in the condition of patients with TB.

The research conducted by Maarufi et al. (2019) has shown that snakehead fish extract supplementation accelerated healing in patients with TB. The research was conducted in a clinical trial on patients with TB in Jember and Situbondo. The research subjects were given snakehead fish extract at a dose of 3 x 500 mg/day. 500 mg of snakehead fish extract supplementation contains 90% snakehead fish extract and 10% contains other mixtures. Patients in the research had their sputum taken from week 0-4 for analysis at the Jember Pulmonary Hospital. The results showed that there was an acceleration in the healing of TB in the treatment group that received snakehead fish extract supplementation. The use of this supplementation can help in recovering from

malnutrition in patients with TB. This is also supported by the results of the research carried out by Maarufi et al. (2020) which also states that tuberculosis patients experience malnutrition which affects their low BMI. The research states that BMI will increase rapidly with the provision of snakehead fish extract. The BMI of a total of 200 respondents was measured for one month after being given snakehead fish extract supplementation. Snakehead fish extract supplementation has been shown to increase the BMI of patients with TB. The treatment group that received snakehead fish extract experienced an average BMI increase of 0.79 kg/m2 compared to the control group.

Anti-inflammation

Based on in vivo research carried out by Muhtadi and Ariyati (2017), the activity of snakehead fish extract as an anti-inflammatory can be seen from the result of a decrease in edema volume of 42.27 ± 7.20% when combined with the ethanol extract of bitter melon (Momordica charantia L.) with a ratio of 1:1 (dose of 150 mg/kg body weight). The research was conducted on rats induced with carrageenan suspension of 0.2 mL on the soles of the feet subplantary as an inflammatory agent. The test animals were then treated with snakehead fish extract and bitter melon fruit ethanol extract. The effectiveness of the combination of snakehead fish extract with bitter melon fruit produced a stronger effect when compared to a single dose supplementation. Meanwhile, in the research conducted in vivo by Muhtadi et al. (2019) indicated that the combination of snakehead fish extract with Lempuyang Gajah extract (Zingiber zerumbet) showed no synergistic effect and had almost the same value as giving diclofenac sodium which is a conventional anti-inflammatory drug. The two research above indicate that the combination of snakehead fish extract with other compounds that also have pharmacological activity as anti-inflammatory does not always produce a synergistic effect.

Another pharmacological activity of snakehead fish extract as an anti-inflammatory was also reported in an in vivo research conducted by Hartini et al. (2015) that was indicated by an increase in the number of macrophages. The number of macrophages in the research increased due to tissue damage in injured rats. The injured area will show improvement due to an increase in the number of macrophages that move towards the injured area to form blood clots. Snakehead fish extract contains an active compound in the form of albumin which is the largest content in the research, namely 7.568 mg/L, Zn of 6.7 mg/L, Fe of 0.72 mg/L, and Cu of 0.47 mg/L contents. The 10 mg/kg BW dose of snakehead fish extract with a concentration of 50% in the research was reported to be able to inhibit vasodilation of blood vessels on day 1 to day 5 so that the process of macrophage migration into the tissue will be less. The length of days in observing rats' wounds affected the acceleration of wound healing. The test results showed decreased levels of macrophages which indicated wound improvement in the test animals.

Based on the research carried out by Maharani and Muhtadi (2017), the albumin content of snakehead fish extract and zerumbon compounds contained in the ethanol extract of Lempuyang Gajah (Zingiber zerumbet) each have pharmacological activity as an anti-inflammatory. The research was conducted in vivo by inducing male wistar rats using carrageenan as an inflammatory mediator. The research was divided into three treatment groups, namely snakehead fish extract with concentrations of 150, 300, and 600 mg/kg BW. Positive control in this research used diclofenac sodium of 0.9 mg/ 200g. The results of the research indicated that the difference in the concentration of snakehead fish extract did not show a significant increase. Thus, the smallest dose that could cause an effect was chosen, namely 150 mg/kg BW. The combination of snakehead fish extract and Lempuyang Gajah ethanol extract in the research showed there was no increase in anti-inflammatory activity compared to its use as an anti-inflammatory in a single dose preparation. The snakehead fish extract in this research had an anti-inflammatory activity of 35.25 ± 8.48 while Lempuyang Gajah ethanol extract had an anti-inflammatory activity of 40.01% ± 7.19. The combination of snakehead fish extract with Lempuyang Gajah ethanol extract was equivalent to that of diclofenac sodium which was a positive control in the research, which was 36.56 ± 7.22.

The finding of the effectiveness of snakehead fish extract in the inflammatory healing process was shown by the research carried out by Agustin et al. (2016) conducted in vivo with a test animal model of male wistar rats with injuries to the buccal mucosa. Snakehead fish extract acted as a treatment group compared to ibuprofen as a positive control and distilled water as a negative control. The results of this research indicated that the rats that suffered wounds after being given snakehead fish extract with three different concentrations, namely 25%, 50%, and 100% showed an improvement on the 3rd day with the best results in the 100% extract treatment group.

The ability of snakehead fish extract to accelerate wound healing was also reported by Rahayu et al. (2016) in vitro using 3T3 fibroblast cells and in vivo experiments using injured rats. The in vitro experiment using 3T3 fibroblast cells served to confirm the effect of striatin in the proliferation phase. Striatin is a bioactive protein fraction isolated from snakehead fish in the form of a purified extract which is useful in the process of wound healing after surgery or childbirth and can increase albumin levels in the body. Striatin contains 214.81 mg/g protein and amino acids (21.84%) which function in the wound healing process. Striatin contains 235 mg/100 g of fatty acids and 33% carbohydrates

which can help in accelerating the wound healing process. According to the experiment on the 10th day after the rats were treated with striatin, the wounds of the rats experienced significant improvement compared to the control group. Albumin levels in the body increased after striatin was induced. The results of similar research were confirmed in clinical trials carried out by Wahab et al. (2015) regarding the effectiveness of snakehead fish extract in the wound healing process. It showed that the use of snakehead fish extract at a dose of 500 mg/day can accelerate the wound healing process of patients with cesarean section.

Supporting research conducted by Suharjono et al. (2016) reported that patients with burn injuries experienced a hypoalbumin condition. The research was conducted on patients with burn injuries at Burn Unit GBPT of dr. Soetomo General Hospital, Surabaya reported that the highest incidence rate was caused by thermal sources of 80.8%. Patients with burn injuries were measured for their albumin levels after 6 hours of albumin infusion. Albumin infusion was administered by drip infusion to recover hypoalbumin conditions in the burn patients. The results of the research indicated an average increase in the patient's albumin levels up to 0.83 g/dL. The administration of albumin infusion in burns can reduce patient mortality by up to 65%. Patients who have been recovered or experienced the improvement, their conditions become more stable and there has been a decrease in the area of the body burned. Through this research, it provides an overview of the administration of snakehead fish extract which contains albumin functioning to recover from inflammatory conditions.

Antidiabetic

Snakehead fish extract as an antidiabetic was reported from the results of the research carried out by Muhtadi et al. (2018) which indicated that snakehead fish extract with albumin content combined with rambutan (Nephelium lappaceum) peel extract can reduce blood glucose levels to 123.3 ± 15.5 mg/dL. The research was conducted in vivo using alloxan-induced rats. The ratio of the dose of snakehead fish extract with rambutan peel extract was 1:1 (300 mg/kg BW). The study indicated significant results in lowering blood glucose levels in rats compared to the control group.

Another research conducted by Muhtadi et al. (2019) regarding the snakehead fish extract as an antidiabetic also tried to find out the synergistic effect of the combination of snakehead fish extract with Lempuyang Gajah (Zingiber zerumbet) ethanol extract with a dose ratio of 1: 1 (300 mg/kg BW). The active compounds of snakehead fish extract in this research, namely albumin, arginine, and leucine were thought to have pharmacological activity to reduce blood glucose levels. The research was undertaken using male albino wistar rats with an average weight of 150-220 g induced by alloxan as a diabetes agent. The administration of a single dosage of snakehead fish extract was able to reduce the blood glucose levels of rats by 142.3 ± 515 mg / dL, while the combination of snakehead fish extract and Lempuyang Gajah ethanol extract could reduce the blood glucose levels of rats to 128.7 ± 72.3 mg / dL. The research demonstrated a synergistic effect on the combination of snakehead fish extract and Lempuyang Gajah ethanol extract.

Based on the results of research from both articles, it can be concluded that not all compounds that also have pharmacological activity as antidiabetic will produce a synergistic effect when combined with snakehead fish extract. The resulting effect could be better or the same as the single dosage form of snakehead fish extract. Thus, it is necessary to confirm the combination of snakehead fish extract with various other compounds that also have pharmacological activity as antidiabetic.

Anti-hypertensive

Based on the research carried out by Chasanah et al. (2015) snakehead fish extract has potential as antihypertensive with ACE (Angiotensin Converting Enzyme) inhibitory activity of 90.32% in vitro. The research compared the snakehead fish extract obtained from nature and cultivated products. Both snakehead fish obtained from nature and cultivation showed activity in ACE inhibition of 1/10 of the dose of captopril which is an antihypertensive drug on the market. Another in vitro research conducted by Budiari et al. (2018) indicated that the ethanol extract of 50% snakehead fish had a better ability to inhibit ACE than water extract. The results of both research conducted in vitro showed that snakehead fish extract had ACE inhibitory activity. Those two research were carried out by comparing the snakehead fish extract as a treatment group with captopril which is an anti-hypertensive drug on the market.

The results of a recent in vitro research carried out by Chasanah et al. (2018) also showed the potential of snakehead fish extract as anti-hypertensive through the increase of the snakehead fish extract dose to 10 mg/mL. Snakehead fish extract as an antihypertensive was thought to have an activity approach to inhibit the conversion of angiotensin I to angiotensin II. This increase in dosage had the same properties as the use of captopril which is an antihypertensive drug on the market. The differences in processing methods or processing methods of snakehead fish affected their pharmacological activity. The oven method was the best method to produce snakehead fish extract that can serve as an ACE inhibitor compared to the boiling method. The boiling method can reduce ACE inhibitory activity by 23%, while indirect heating and dry heat were considered better with a decrease in ACE inhibitory activity by 6%. This was due to indirect heating and the dry heat of the snakehead fish did not directly come into

contact with water so that it did not damage the protein content.

REFERENCES

Agustin R., Dewi N. & Rahardja S.D., 2016, Efektivitas Ekstrak Ikan Haruan (Channa striata) dan Ibuprofen terhadap Jumlah Sel Neutrofil pada Proses Penyembuhan Luka Studi in Vivo pada Mukosa Bukal Tikus (Rattus norvegicus) Wistar, Dentino (Jur. Ked. Gigi), 1 (1), 68–74. http://dx.doi.org/10.20527/dentino.v1i1.424

Ahmadinejad, N., Talebi Trai, M. (2019). Computational NQR−NBO Parameters and DFT Calculations of Ampicillin and Zwitterion (Monomer and Dimer Structures). Chemical Methodologies, 3(1), 55-66. http://www.chemmethod.com/article_68823.html

Asikin A.N. & Kusumaningrum I., 2017, Karakteristik Ekstrak Protein Ikan Gabus Berdasarkan Ukuran Berat Ikan Asal DAS Mahakam Kalimantan Timur, Jurnal Pengolahan Hasil Perikanan Indonesia, 21 (1), 137. https://doi.org/10.17844/jphpi.v21i1.21462

Budiari S., Chasanah E., Suhartono M.T. & Palupi N.S., 2018, Angiotensin Converting Enzyme (ACE) Inhibitory Activity of Crude and Fractionated Snakehead Fish (Channa striata) Fillet Extract, Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology, 13 (2), 57–67. http://dx.doi.org/10.15578/squalen.v13i2.345

Chasanah E., Budiari S., Thenawijaya M. & Palupi N.S., 2018, ACE Inhibition and Antioxidant Activity of Different Part of Channa striata Prepared by Various Cooking Method, Dalam IOP Conference Series: Earth and Environmental Science, Institute of Physics Publishing, pp. 1–7. https://doi.org/10.1088/1755-1315/139/1/012044

Chasanah E., Nurilmala M., Purnamasari A.R. & Fithriani D., 2015, Komposisi Kimia, Kadar Albumin dan Bioaktivitas Ekstrak Protein Ikan Gabus (Channa striata) Alam dan Hasil Budidaya, JPB Kelautan dan Perikanan Vol., 10 (2), 123–132. http://dx.doi.org/10.15578/jpbkp.v10i2.364

Fidelis, G., Louis, H., Tizhe, T., Onoshe, S. (2019). Curcumin and Curcumin-based derivatives as anti-cancer agents: Recent Nano-Synthetic Methodologies and Anti-cancer Therapeutic Mechanisms. Journal of Medicinal and Chemical Sciences, 2(2), 59-63. http://www.jmchemsci.com/article_79588.html

Hartini P.S., Dewi N. & Hayatie L., 2015, Esktrak Ikan Haruan (Channa striata) Menurunkan Jumlah Makrofag pada Fase Inflamasi Proses Penyembuhan Luka, Dentofasial, 14 (1), 6–10. DOI:10.15562/jdmfs.v14i1.417

Hidayati D., Faizah A., Prasetyo E.N., Jadid N. & Abdulgani N., 2018, Antioxidant Capacity of Snakehead Fish Extract (Channa striata) at Different Shelf Life and Temperatures, Dalam Journal of Physics: Conference Series, Institute of Physics Publishing, pp. 1–5. https://doi.org/10.1088/1742-6596/1028/1/012021

Kurnianto A. & Retnaningsih R., 2017, Pengaruh Pemberian Ekstrak Ikan Gabus terhadap Status Antioksidan Total pada Pasien Stroke Iskemik Akut dengan Riwayat Hipertensi, Medica Hospitalia : Journal of Clinical Medicine, 3 (1). https://doi.org/10.36408/mhjcm.v3i1.206

Maarufi I., Ali K., Jati S.K., Sukmawati A., Ardiansyah K. & Ningtyias F.W., 2020, Improvement of Nutritional Status among Tuberculosis Patients by Channa striata Supplementation: A True Experimental Study in Indonesia, BioMed Research International, 1–9. https://doi.org/10.1155/2020/7491702

Maarufi I., Ali K., Sedemen I.A., Purwanto P. & Khoiri A., 2019, Channa striata (Ikan Gabus) Extract and the Acceleration of Tuberculosis Treatment : A True Experimental Study, Interdisciplinary Perspectives on Infectious Diseases, 2019, 1–7. https://doi.org/10.1155/2019/8013959

Maharani N. & Muhtadi M., 2017, Aktivitas Antiinflamasi Kombinasi Ekstrak Etanol Lempuyang Gajah (Zingiber zerumbet) dan Serbuk Ikan Gabus (Channa striata) terhadap Udem Telapak Kaki Tikus Putih Jantan Galur Wistar, Dalam THE 5 TH URECOL PROCEEDING UAD Yogyakarta, pp. 152–160.

Mirzaie, A. (2018). A density functional theory study on the effect of size on the ionization potential of different carbon fullerenes. Journal of Medicinal and Chemical Sciences, 1(2), 31-32. http://www.jmchemsci.com/article_65057.html

Muhtadi & Ariyati L.W., 2017, Aktivitas Antiinflamasi dari Kombinasi Ikan Gabus (Channa striata) dan Ekstrak Etanol Buah Pare (Momordica charantia L.) terhadap Tikus Wistar Jantan yang Diinduksi Karaginan, Dalam THE 5TH URECOL PROCEEDING, pp. 50–58.

Muhtadi M., Faroska A.A., Suhendi A. & Sutrisna E., 2018, Aktivitas Antidiabetes (Channa striata) dari Kombinasi Ekstrak Etanol Kulit Buah Rambutan (Nephelium lappaceum) pada Tikus Putih Jantan Galur Wistar, Jurnal Farmasi Sains dan Praktis, 4 (2), 9–14. https://doi.org/10.31603/pharmacy.v4i2.2314

Muhtadi, Suhendi A. & Sutrisna E.M., 2019, The Potential Antidiabetic and Anti-inflammatory Activity of Zingiber zerumbet Ethanolic Extracts and Channa striata Powder on Albino Wistar Mice, Drug Invention Today, 12 (1), 148–153.

Prastari C., Yasni S. & Nurilmala M., 2017, Karakteristik Protein Ikan Gabus yang Berpotensi sebagai Antihiperglikemik, Jurnal Pengolahan Hasil Perikanan Indonesia, 20 (2), 413–423. http://dx.doi.org/10.17844/jphpi.v20i2.18109

Pratama H.A., Efendi E. & Riyanti R., 2016, Pengaruh Ekstrak Albumin Ikan Gabus (Channa striata) terhadap Kadar IFN-γ Pasien Tuberkulosis Paru dengan Pengobatan Fase Intensif, e-Jurnal Pustaka Kesehatan, 4 (2), 222–228.

Rahayu P., Marcelline F., Sulistyaningrum E., Suhartono M.T. & Tjandrawinata R.R., 2016, Potential Effect of Striatin (DLBS0333), a Bioactive Protein Fraction Isolated From Channa striata for Wound Treatment, Asian Pacific Journal of Tropical Biomedicine, 6 (12), 1001–1007. https://doi.org/10.1016/j.apjtb.2016.10.008

Salmatia S., Isamu K.T. & Sartinah A., 2020, Pengaruh Proses Perebusan dan Pengukusan terhadap Kandungan Albumin dan Proksimat Ikan Gabus (Channa striata), J. Fish Protech, 3 (1), 67–73.

Suharjono, Annura S., Saputro D.I. & Rusiani D.R., 2016, Evaluasi Penggunaan Albumin pada Pasien Luka Bakar di RSUD dr. Soetomo, Dalam Prosiding Rakernas dan Pertemuan Ilmiah Tahunan Ikatan Apoteker Indonesia 2016, pp. 92–98. http://repository.unair.ac.id/id/eprint/52674

Suhendi A., Puspa F.E. & Pawarti H., 2020, Aktivitas Antioksidan Ekstrak Ikan Gabus (Channa striata) pada Tikus yang Diinduksi dengan Rifampisin-Isoniazid, Jurnal Kesehatan, 13 (1), 69–77. https://doi.org/10.23917/jk.v13i1.11103

Wahab S.Z.A., Kadir A.A., Hussain N.H.N., Omar J., Yunus R., Baie S., Noor N.M., Hassan I.I., Mahmood W.H.W., Razak A.A. & Yusoff W.Z.W., 2015, The Effect of Channa striatus (Haruan) Extract on Pain and Wound Healing of Post-Lower Segment Caesarean Section Women, Evidence-based Complementary and Alternative Medicine, 2015, 1–6. https://doi.org/10.1155/2015/849647