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REVIEW ARTICLE

Phytochemical Compounds in Sea Cucumber Have the Potential to Reduce Oxidative Stress and Inflammation Due to Exercise: Systematic Review

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Abstract

Study purpose. This study aims to analyze and highlight the potential of Sea Cucumber in reducing oxidative stress and inflammation caused by exercise.

Materials and methods. The study is a type of systematic review research using searches from various journal databases such as Science Direct, Pubmed and Web of Science. The inclusion criteria in this study were journals published in the last 5 years which discussed sea cucumber, oxidative stress, inflammation and exercise. Furthermore, the exclusion criteria in this research are journals that are not reputable or are not indexed by Scopus and Web of Science. A total of 1038 articles from the Science Direct, Pubmed and Web of Science databases were identified. A total of 8 articles that met the inclusion criteria were selected and analyzed for this systematic review. For standard operations, this study followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) assessment.

Results. The results of this systematic review research report that the strong phenolic content found in Sea Cucumber has anti-oxidant properties which may reduce oxidative stress. Furthermore, the anti-inflammatory properties of sea cucumbers have the potential to reduce uncontrolled inflammation caused by intense exercise.

Conclusions. The phenolic content in sea cucumbers has strong anti-oxidant properties in reducing oxidative stress. In addition, the anti-inflammatory properties of sea cucumbers may reduce uncontrolled inflammation caused by exercise. In this case, sea cucumbers have an anti-inflammatory effect by suppressing the secretion of pro-inflammatory cytokines. Through this systematic review, we recommend that future studies should perform clinical trials on the potential effects of sea cucumber on oxidative stress biomarkers and inflammatory biomarkers after exercise.

Keywords: sea cucumber, oxidative stress, inflammation, exercise.

Introduction

Regular physical exercise with light to moderate intensity is the main factor in preventing various diseases such as cardiovascular, diabetes, cancer, alzheimer's and dementia (Tian and Meng, 2019; Cannata et al., 2020). With physical activity, anaerobic and aerobic metabolism and energy requirements by active muscles increase (Taherkhani, Suzuki and Castell, 2020; Daniela et al., 2022). However, intense physical exercise can cause significant damage to skeletal muscle tissue leading to decreased muscle function performance (Ayubi, Kusnanik, Herawati, Muhammad, et al., 2023). To save muscle

performance through the immune system, an increase in the pro-anti/inflammatory balance is carried out which allows muscle regeneration (Volpe-Fix et al., 2023).

Another consequence, triggering changes in redox reactions in the immune system during muscle strength training can occur through neutrophil infiltration into damaged tissue, thereby causing increased oxidative stress and inflammation (Canals-Garzón et al., 2022). Oxidative stress occurs approximately one hour after exercise, characterized by an increase in reactive oxygen species (ROS) (McKeegan et al., 2021). In the next phase, exercise-induced muscle damage (EIMD) and increased ROS will trigger inflammation and reach its peak 24-48 hours after exercise (Chang et al., 2021; Hung et al., 2021). The inflammatory response due to exercise triggers a decrease in muscle strength, decreased range of motion (ROM), delayed onset muscle soreness (DOMS), local swelling, and an increase in muscle proteins in the blood (creatine kinase (CK), lactate dehydrogenase (LDH), and myoglobin (Mb) (Fernández-Lázaro et al., 2020; Tanabe, Fujii and Suzuki, 2021). In addition, EIMD triggers an inflammatory reaction that causes an increase in inflammatory markers such as C-reactive protein (CRP) and several inflammatory interleukins (IL-1 and IL-6) and tumor necrosis factor alpha (TNF-α) (Kyriakidou et al., 2021; Nejati et al., 2022). In the same way, this promotes the synthesis of ROS, which ultimately stimulates the development of transcription factors including nuclear factor kappa Beta (NF kB) which plays an active role in the secretion of TNF-α (Fern and Mielgo-ayuso, 2020). Use of nonsteroidal anti-inflammatory drugs (NSAIDs) is estimated at 30 million people worldwide, with a high prevalence among athletes and individuals performing high-intensity exercise (Kyriakidou et al., 2021). However, clinical data suggest that administration of nonsteroidal anti-inflammatory drugs after resistance training has a detrimental effect on recovery after EIMD (Ayubi et al., 2022; Ayubi, Kusnanik, Herawati, Komaini, et al., 2023).

Therefore, alternative solutions are needed to overcome this problem as a potential treatment. One natural product that can be used, with potential anti-inflammatory antioxidant effects is sea cucumber. Sea Cucumber is an invertebrate animal that belongs to the phylum Echinodermata. This species is rich in bioactive compounds that have various biological and pharmacological properties such as antioxidant, wound healing, anticoagulant, anti-cancer, anti-tumor, antibacterial, anti-inflammatory effects, improving hyperlipidemia, and regulating blood sugar (Zhao et al., 2018; Hossain et al., 2022; Rasyid, Putra and Yasman, 2023). The bioactive compounds contained in sea cucumbers include saponins, phenolics, proteins (peptides), carotenoids and lipids (Hossain, Dave and Shahidi, 2020). Based on research, it has been reported that the phenolic compounds in sea cucumbers act as antioxidants which can prevent or reduce oxidative stress in cells, prevent aging and play an important role in controlling various diseases, especially cardiovascular disease, inflammation and cancer (Hossain et al., 2022; Hossain, Dave and Shahidi, 2022; Senadheera et al., 2023). Phenolics can inhibit the synthesis of pro-inflammatory cytokines, especially inducible nitric oxide synthase (iNOS), nitric oxide (NO), TNF-α, interleukin-1β (IL-1β), and prostaglandin E2 (PGE2) (Hossain et al., 2022). The antioxidant activity in these phenolic compounds can help reduce oxidative damage due to exposure to high levels of UV radiation and reactive oxygen species (ROS) by donating electrons or hydrogen atoms to free radicals to inhibit free radical chain reactions (Hossain et al., 2022; Rasyid, Putra and Yasman, 2023). Therefore, we want to relate and discuss in depth the effect of using sea cucumbers in reducing oxidative stress and anti-inflammation after exercise through a systematic review.

This study aims to analyze and highlight the potential of sea cucumbers in reducing inflammation and inflammation due to exercise.

Materials and methods

Study Design

This type of systematic review research uses searches from journal databases such as Science Direct, Pubmed, and Web of Science. It is considered a premier platform worldwide as it brings together publications that have scientific impact and relevance.

Eligibility criteria

The inclusion criteria in this study were journals published in the last 5 years that discussed sea cucumber, oxidative stress, inflammation and exercise. Furthermore, the exclusion criteria in this research are journals that are not reputable or are not indexed by Scopus and Web of Science.

Procedure

Titles, abstracts and full texts of articles were filtered and then stored in Mendeley software. In the first stage, 1038 articles from the Science Direct, Pubmed and Web of Science databases were identified. Next, in the second stage, 186 articles were screened based on the suitability of the title and abstract. In the third stage, 36 articles were ordered for further processing. At this stage we filter based on the overall suitability of the article. Then in the final stage 8 articles were selected that met the inclusion criteria and analyzed for this systematic observation. For operational standards, this study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) assessment.

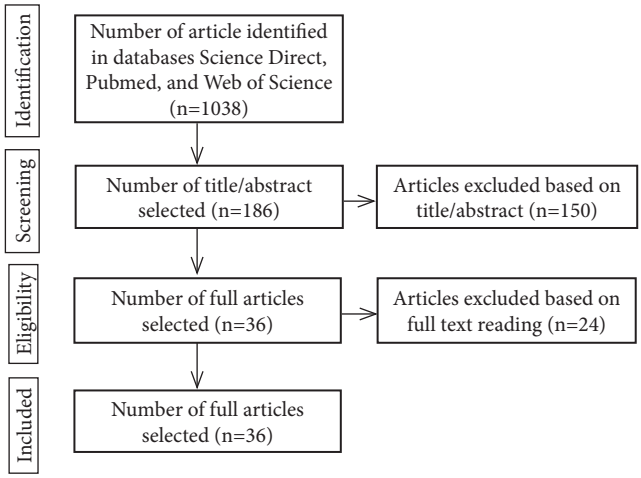

Fig. 1. PRISMA flowchart of the article selection process

Results

Table 1. Results of a review of the effects of sea cucumbers on oxidative stress and inflammation due to exercise

Author	Sample Characteristics	Study Design	Intervention	Results
Q. Wang et al. (2021)	Male ICR mice weighing 20 g were grouped into 6 groups, namely (1) negative control group, (2) whey peptide group, (3) low dose SCP-1 (peptide derivative) group, (4) high dose SCP-1 group, (5) low dose SCP-2 group, (6) high dose SCP-2 group.	Experimental	Peptides derived from sea cucumbers were characterized and then samples were given orally to mice for 30 days. After that, training and anti-fatigue performance of the two bioactive peptides (SCP-1 and SCP-2) were tested through a 30-minute swimming test combined with monitoring biochemical parameters (serum indicators BUN, LDH, NH3, and CK; liver indicator LG ; and muscle indicators SOD, MDA, MG, ATP).	Supplementation of bioactive peptides from sea cucumbers, namely SCP with low DH (SCP-1) and SCP with high DH (SCP-2) is reported to improve exercise performance and show anti-fatigue effects through inhibiting oxidative stress by regulating the NRF2 and AMPK signaling pathways that contribute to physical fatigue relief performance. In addition, the effect of SCP has the potential to protect muscles from muscle injury by significantly reducing LDH and CK levels. This SCP supplement effectively reduces MDA levels.
P. Wang et al. (2021)	Male Sprague Dawley (SD) rats weighing 180-220 g were grouped into 6 groups, namely: (1) normal control group, (2) model control (MC) group, (3) low dose SCP (peptide derivative) group, (4) medium dose SCP group, (5) high dose SCP group, and (6) positive control (PC) group.	Experimental	Peptide samples originating from sea cucumbers were characterized and then the samples were given orally to mice for 4 weeks. After that, sports performance and anti-fatigue testing were carried out through a 150minute swimming test combined with biochemical parameter monitoring (serum indicators BUN, LDH, NH3, and CK; liver indicator LG; muscle indicators SOD, MDA, MG, ATP), analysis of inflammatory cytokine levels (serum TNF-α, IL-1β, IL-6, and IL-10 levels).	Peptide supplementation from sea cucumbers in this study had high antioxidant activity due to the amino acid content in SCP. SCP can significantly increase liver glycogen, increase muscle glycogen, decrease BLA, decrease BUN, decrease CK, increase SOD, increase GSH-px, increase CAT, decrease MDA, decrease TNF-α, decrease IL-1β, decrease IL-6, and reduces NF-κB so that this supplement can reduce levels of oxidative stress, anti-inflammatory and anti-fatigue after physical exercise.
Yu et al. (2020)	Male mice weighing 33 g were grouped into 4 groups, namely a group of control mice, a group of mice fed a low dose of SCP (peptide derivative), a group of mice given a medium dose of SCP, and a group of mice given a high dose.	Experimental	Subjects were given bioactive peptide supplements from sea cucumbers (SCP) according to the dosage. Then, endurance and anti-fatigue performance were tested through a 1hour swimming test. And samples of these organs were taken to measure biochemical indicators related to fatigue and tissue damage after physical exercise.	Peptide supplementation in sea cucumbers (SCP) significantly increases antioxidant capacity. The results of physiological indicators related to fatigue showed that LD and BUN decreased significantly, followed by LDH and GOT which also decreased. Administration of SCP can increase anti-fatigue properties through improving mitochondrial quality which is useful for antioxidant capacity.

Table 1. Continued

Author	Sample Characteristics	Study Design	Intervention	Results
Wang et al. (2023)	40 male diabetic Sprague Dawley (SD) rats and 10 normal rats weighing 120-150 g were grouped into 5 groups and given the following treatment: (1) normal control group, (2) diabetic control group, (3) 250 mg metformin group /kg, (4) low dose SCH group 200 mg/kg, (5) high dose SCH group 400 mg/kg.	Experimental	Subjects were given Sea Cucumber Hydrosylate (SCH) and dissolved in normal saline orally for 8 consecutive weeks. Then biochemical testing of urine and plasma was carried out to test U-MA, SOD and MDA levels.	SCH supplements can reduce U-MA and reduce inflammatory disorders. Administration of SCH is reported to restore SOD, GSH, MDA levels which can effectively reduce oxidative damage. SCH also helps maintain increased antioxidant capacity through the Akt/Nrf2/NQO1 signaling pathway thereby reducing oxidative stress in the kidneys.
Carletti et al. (2022)	208 fresh sea cucumbers and tunicates were prepared then the samples were dried and ground into fine powder. Then it is extracted to become an extract and chemical testing is carried out.	Laboratory experiments	The prepared samples of sea cucumbers and tunicates were dried and processed until they became powder. Then extracted using an ethanol-water mixture. The extract was tested for its antioxidant and anti-inflammatory activity.	It was reported that sea cucumber and tunicate extracts as a source of bioactive compounds have high polyphenol content so they have potential for antioxidant and anti-inflammatory activity.
Aatab et al. (2023)	A 200 g sample of dried sea cucumber (H. tubulosa) was suspended in a phosphate buffer solution to form aqueous extracts (AEs). Then analyzed further for chemical and morphological characterization, total phenolic content, and antioxidant capacity.	Laboratory experiments	The sea cucumber specimens were dried first. Then the dry samples were ground and 200 g of dry samples were suspended in 400 mL of phosphate buffer solution for 3 and 4 hours to produce a supernatant and dried by spray and freeze drying to produce aqueous extracts (AEs) for further analysis. After that, chemical and morphological characterization tests were carried out, total phenolic content and antioxidant capacity were carried out on the sea cucumber extract.	All sea cucumber AE samples have similar characteristics which indicate a high content of phenolic compounds (gallic acid, pyrogallol, pyrogallic acid, vanillic acid) and flavonoids (quercetin, vanillin, routine, kaempferol) which have the potential to ward off free radicals so that they can contribute as antioxidants and anti-oxidants. -inflammation.
Wargasetia et al. (2023)	20 g of sea cucumbers were ground into powder and then extracted with methanol. Sea cucumber extracts were tested for antioxidant and anti-inflammatory activity.	Laboratory experiments	The sea cucumber sample powder was extracted using 500 mL methanol for 48 hours. The macerate is filtered and the filtrate is evaporated at a temperature of 50°-60°. Sea cucumber extract was mixed with DPPH and incubated for 30 minutes. Then antioxidant and anti-inflammatory activity tests were carried out.	The sea cucumber extract in this study showed the presence of active compounds that have strong activity against NO radicals so that they have potential as antioxidants and anti-inflammatory. Apart from that, the active compounds in sea cucumber extract also have the potential to inhibit the KEAP1 and iNOS proteins which cause oxidative stress and inflammation.

Table 1. Continued

Author	Sample Characteristics	Study Design	Intervention	Results
Ghaffari et al. (2019)	Samples of sea cucumbers that were in powder form were extracted to become extracts. Then, 30 Wistar-albino rats weighing 160-180 g were divided into 5 groups, namely: control group, treatment group with carrageenan, extract treatment group with a dose of 100 mg/kg MEHL and carrageenan, extract group with a dose of 200 mg/kg MEHL and carrageenan, the acetylsalicylic acid and carrageenan group. Then, the extract is given orally for 1 hour before carrageenan injection.	Experimental	The sea cucumbers were dried and extracted with a solution of hexane, ethyl acetate and methanol for 72 hours. Then, the sea cucumber extract was tested orally on 30 mice 1 hour before the carrageenan injection. For 5 days, inflammation was measured in the mice and the inflamed paw tissue was removed and tested for further analysis.	Sea cucumber extract shows a decrease in the inhibitory power of the lipoxygenase enzyme which causes inflammation. This is due to the presence of phytosterol compounds in it. So this extract is proven to have anti-inflammatory effects.

Discussion

The main research objective of this systematic review is to analyze and highlight the potential of sea cucumbers in reducing oxidative stress and inflammation due to exercise. Sea cucumbers are invertebrates belonging to Kingdom: Animalia; Phylum: Echinoderms; and Class: Holothuroidea. Sea cucumbers have a soft body, like a cucumber with an elongated tube-like body shape, and a single-branched gonad. The mouth is surrounded by tentacles/bulbs at one end of the body and the anus at the other end (Figure 2). The most commonly found species of marine biota include Holothuria tubulosa, Pearsonothuria graeffei, Isostichopus badionotus, Holothuria nobilis, Holothuria polii, Holothuria forskali, Cucumaria japonica, Cucumaria frondosa, Actinopyga mauritiana, Acaudina molpadioides, and Apostichopus japonicas (Kareh et al., 2018; Hossain, Dave and Shahidi, 2020; Aatab et al., 2023; Wargasetia et al., 2023).

Sea cucumbers can produce various useful natural ingredients, including for the food industry, cosmetics industry, and agricultural industry, and treat various diseases such as rheumatism, asthma, pain, hypertension, wounds, burns and kidney problems (Kustiariyah, 2007; Hossain, Dave and Shahidi, 2022). Sea cucumbers are known for their therapeutic potential which is rich in protein (40-60%), and low in fat (calcium, zinc, iron, and magnesium), vitamins and minerals. In addition, sea cucumbers are known to contain various bioactive compounds, such as polysaccharides, collagen and peptides, sphingoids, phenolics, triterpene glycosides (saponins), sterols, carotenoids, and chondroitin, which exhibit various biological and pharmacological functions such as antimicrobial, antioxidant , antihypertensive, immunoregulatory, anti-inflammatory, anticoagulant, anticancer, antidiabetic, antifatigue, antiaging, and antithrombotic which can be seen in Figure 3 (Suwanmala et al., 2016; Hossain, Dave and Shahidi, 2020, 2022; Yu et al., 2020; Q. Wang et al., 2021; Hossain et al., 2022; Senadheera et al., 2023).

It has been found that the content of phenolic compounds, proteins (collagen and peptides), carotenoids,

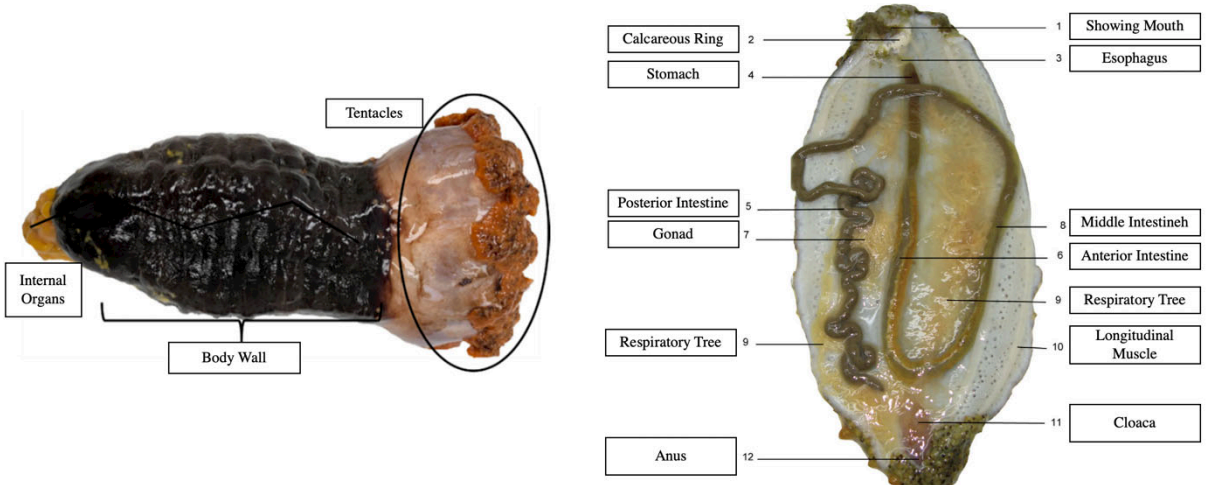

Fig. 2. Sea Cucumber Anatomy

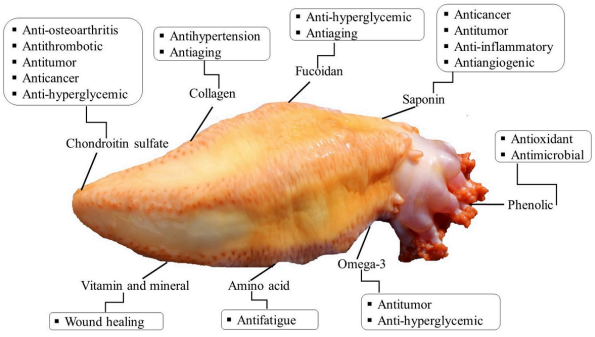

Fig. 3. Bioactive Compounds of Sea Cucumber and Their Potential Health Benefit (Hossain, Dave and Shahidi, 2020)

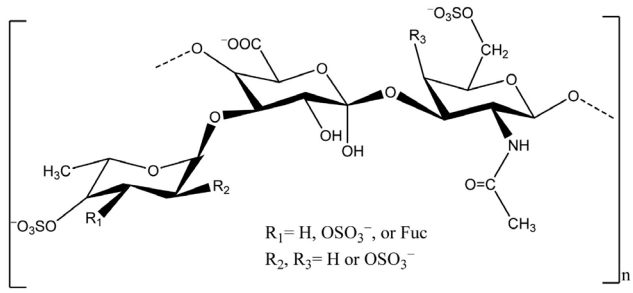

Fig. 5. Chemical structure of polysaccharides (fucosylated chondroitin sulphate, FCS) and fucan of sea cucumbers (Hossain, Dave and Shahidi, 2020)

and saponins have strong antioxidant properties, with their chemical structures which can be seen in Figure 4 and Figure 5. Antioxidants are responsible for scavenging free radicals thus preventing oxidation. Antioxidant activity can be attributed to the presence of phenolic content in sea cucumbers (Hossain, Dave and Shahidi, 2022). Phenolics act as scavengers of various oxidizing species namely superoxide anions, hydroxyl radicals, or peroxy radicals, they also act as singlet oxygen scavengers (Ajiboye, Shonibare and Oyinloye, 2020). The phenolic compounds commonly found in sea cucumbers are gallic acid, P-coumaric acid, ferulic acid, cinnamic acid, catechin, routine, quercetin, and pyrogallol. The research results report that phenolic compounds are able to inhibit oxidation, mediate anti-inflammatory actions by blocking the MAPK signaling pathway, inhibit the synthesis of pro-inflammatory cytokines, especially nitric oxide synthase (iNOS), nitric acid (NO), TNF- α, IL-1β, and PGE2 (Hossain, Dave and Shahidi, 2022).

According to previous research, peptide supplements increase the body's antioxidant capacity by providing hydrogen atoms or electrons, which help eliminate free radical reactions, chelate with metal ions to form inert complexes, prevent ROS and free radical formation, and increase the activity of antioxidant enzymes (Q. Wang et al., 2021). A study reported that peptides present in sea cucumbers act as reducing agents capable of protecting cells from oxidative stress by eliciting cell signal responses such as mitogen-activated protein kinase (MAPK), phosphoinositide 3-kinase (PI3K) or Akt signaling pathways, and nuclear factor signaling. NFκ-B (Lu et al., 2021).

Apart from that, phytochemical compounds such as carotenoids in sea cucumbers also have strong antioxidant properties (David et al., 2023). The main carotenoids contained in sea cucumbers are astaxanthin and canthaxanthin (Senadheera, Dave and Shahidi, 2020). The characteristic chemical structure of carotenoids (conjugated C=C) shows antioxidant properties that are related to the scavenging of ROS, especially singlet oxygen (O_2) and peroxyl radicals (Hossain, Dave and Shahidi, 2022).

The antioxidant potential of polysaccharides in sea cucumbers from previous studies revealed that polysaccharides show strong reducing power and the ability to capture hydroxyl radicals, DPPH, and superoxide (Wargasetia et al., 2023). The ability of free radicals to extract anomeric hydrogen from polysaccharides may be the cause. In addition, this is due to its association with its structural features such as its monosaccharide composition and the content of its carboxyl and sulfate groups (Hossain, Dave and Shahidi,

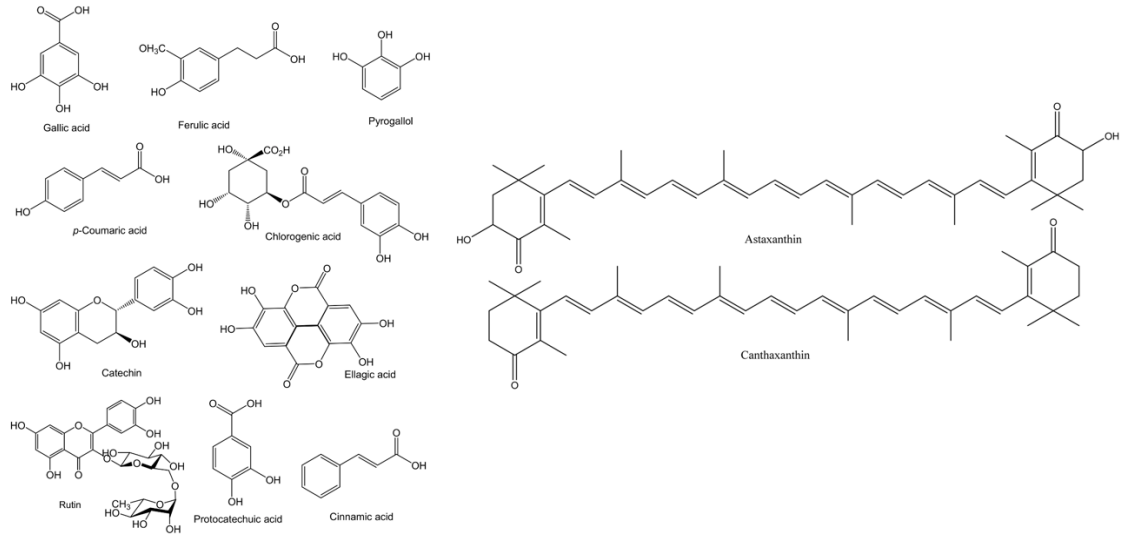

Fig. 4. Major phenolic compounds found in sea cucumbers (Hossain, Dave and Shahidi, 2020)

2022). This group is able to bind metal ions (Cu2+ and Fe2+) and is able to capture hydroxyl radicals (Hossain, Dave and Shahidi, 2022). In addition, because the sulfate group in sulfated polysaccharides is an electron-donating substituent in the polymerization process, the sulfate group can initiate superoxide radical scavenging activity (Hossain, Dave and Shahidi, 2022).

Oxidative stress is caused by an imbalance between the body's ability to capture free radicals and reactive oxygen species (ROS) and the formation of pro-oxidants (Darenskaya, Kolesnikova and Kolesnikov, 2021). In sports, oxidative stress occurs approximately one hour after exercise which is characterized by an increase in reactive oxygen species (ROS). (McKeegan et al., 2021). Nuclear factor E2 (NRF2)-mediated signaling pathway controls the inhibition of oxidative stress. NRF2 is an important transcription factor that controls the expression of several antioxidant enzymes, ultimately increasing the body's capacity to defend against free radicals (Q. Wang et al., 2021). Various diseases associated with oxidative stress, such as heart disease, neurological disease, cancer, diabetes mellitus, and uncontrolled inflammatory processes due to intense exercise can be prevented or treated with chemicals containing phenolic compounds (Senadheera, Dave and Shahidi, 2020). This compound is believed to have the capacity to scavenge free radicals and function as an antioxidant that can reduce oxidative stress, thus helping a person in the post-exercise recovery process (Mason et al., 2020; Rojano-Ortega, 2021). Phenolic compounds can inhibit enzymes that cause ROS to become highly oxidized and reduce the amount of ROS produced (Aatab et al., 2023).

The idea that sea cucumbers contain antioxidant properties and reduce oxidative stress is supported by a study conducted on male Sprague Dawley (SD) rats reporting that oral administration of sea cucumber extract intervention has the potential for high antioxidant activity (P. Wang et al., 2021). A study reported that sea cucumber hydroxylate extract (SCH), which mostly consists of peptides, was able to reduce oxidative stress and inflammation in mice (Wang et al., 2023). SCH supplements can increase GSH and SOD while reducing MDA. The results of this research also report that GSH and SOD act as antioxidants which can scavenge free radicals through activating the Akt/NRF2/NQO1 signaling pathway so that they are effective in reducing oxidative stress (Wang et al., 2023). Thus, the antioxidant effect of SCH is due to the presence of peptide compounds with large amounts of aromatic and hydrophobic amino acids through hydrogen bonds and hydrophobic interactions to disrupt the Keap1-Nrf2 interaction and modulate the Akt/NRF2 pathway, which plays an important role in its strong radical scavenging activity resulting in has the potential to fight oxidative stress.

This research is also strengthened by a laboratory study which reported that sea cucumber and tunicate extracts have potential antioxidant and anti-inflammatory activity (Carletti et al., 2022). This observation is supported by the high levels of polyphenols contained in sea cucumbers and tunicates. Polyphenolic compounds are able to provide a protective effect against reactive oxygen species in cells and reduce the detrimental effects of pro-inflammatory signals (Carletti et al., 2022). Furthermore, other studies reported that sea cucumber extract showed high antioxidant potential due to its phenolic content (Aatab et al., 2023). This extract functions as a hydrogen donor in stopping the oxidation process through free radical stabilization. Bioactive compounds such as phenolic acids (gallic acid, caffeic acid, pyrrolic acid, and vanillic acid) are able to ward off free radicals (Aatab et al., 2023). Therefore, these polyphenolic compounds contribute to antioxidant activity. The results of this research are strengthened by research which reports that sea cucumber extract is predicted to have anticancer activity from sea cucumber bioactive compounds as anti-inflammatory and antioxidant (Wargasetia et al., 2023). This active compound is able to ward off DPPH and NO radicals and has the potential to inhibit certain proteins that trigger oxidative stress (Wargasetia et al., 2023). Sea cucumber extract works by inhibiting the activity of the KEAP1 and iNOS proteins by blocking their interaction with the DLG NRF2 motif thereby inhibiting the occurrence of oxidative stress in cells. (Wargasetia et al., 2023).

Furthermore, EIMD and increased ROS will trigger inflammation and reach its peak 24-48 hours after exercise (Chang et al., 2021; Hung et al., 2021). The inflammatory response due to exercise triggers a decrease in muscle strength,

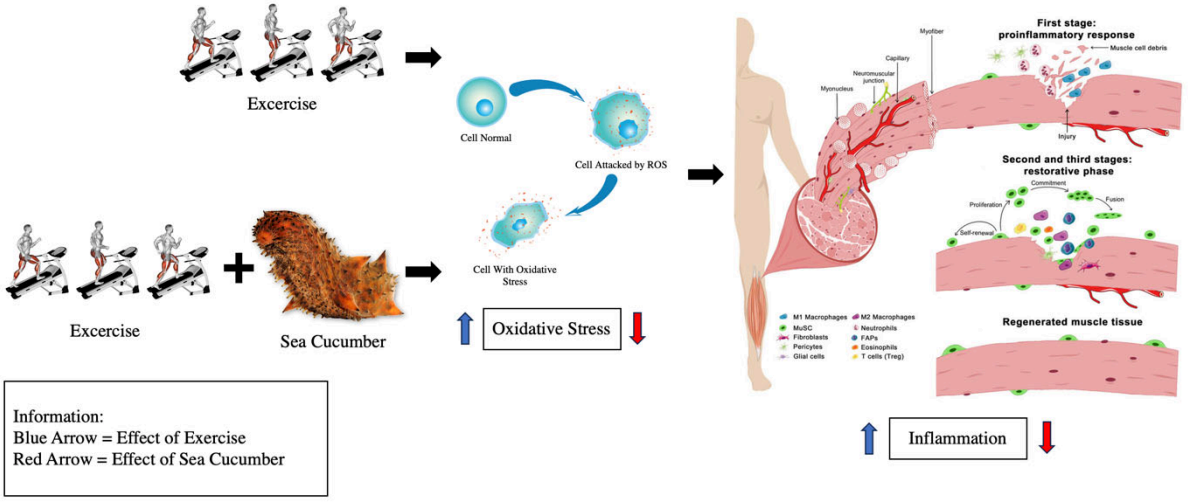

Fig. 6. Mechanism of Action of Sea Cucumbers to Reduce Oxidative Stress and Inflammation

decrease ROM, DOMS. (Ayubi, Kusnanik, Herawati, Muhammad, et al., 2023). In inflammatory situations, other myokines such as TNF-α and interleukin-10 IL-10 are also expressed (Porto et al., 2023; Volpe-Fix et al., 2023). TNF-α is one part of the pro-inflammatory cytokines that trigger muscle pain (Fernández-Lázaro et al., 2020; Ayubi et al., 2022; Nanavati et al., 2022). Related to this, sea cucumber SCP is also able to reduce pro-inflammatory cytokines such as TNF-α, IL-1β, IL-6 (P. Wang et al., 2021). SCP can inhibit TLR4 expression and NF-κB activation thereby reducing the release of pro-inflammatory cytokines (P. Wang et al., 2021). The results of this research were strengthened by research on mice which reported that sea cucumber extract was able to inhibit the lipoxygenase enzyme which causes inflammation (Ghaffari et al., 2019).

So, in short, the phenolic content contained in sea cucumbers has antioxidant properties that can reduce oxidative stress and anti-inflammatory properties that can reduce exercise pro-inflammatory cytokines. For more details regarding the benefits of sea cucumbers in reducing oxidative stress and inflammation, see Figure 6.

Conclusions

The phenolic content in sea cucumbers has strong antioxidant properties in reducing oxidative stress. Furthermore, the anti-inflammatory properties of sea cucumbers can reduce uncontrolled inflammation due to exercise. In this case, sea cucumbers work by reducing inflammation by suppressing the secretion of pro-inflammatory cytokines. Through this systematic review, we recommend that future research conduct clinical trials on the potential of sea cucumber on oxidative stress biomarkers and inflammatory biomarkers after exercise.

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Conflicts of Interest

The authors declare no conflict of interest

List of Abbreviations

ROS	Reactive Oxygen Species
EIMD	Exercise-Induced Muscle Damage
ROM	Range of Motion
DOMS	Delayed Onset Muscle Soreness
CK	Creatine Kinase
LDH	Lactate Dehydrogenase
Mb	Myoglobin
CRP	C-Reactive Protein
IL-1	Interleukin 1
IL-6	Interleukin 6
IL-10	Interleukin 10
IL-1β	Interleukin 1β
TNF-α	Tumor Necrosis Factor Alpha
NF kB	Nuclear Factor Kappa Beta
NSAIDs	Nonsteroidal Anti-Inflammatory Drugs
iNOS	Inducible Nitric Oxide Synthase
NO	Nitric Oxide
PGE2	Prostaglandin E2
SCP	Sea Cucumber Peptides
SCH	Sea Cucumber Hydrosylate
MDA	Malondialdehyde
SOD	Superoxide Dismutase
PC	Positive Control
MC	Model Control
ATP	Adenosine Triphosphate
SD	Sprague Dawley
BUN	Blood Urea Nitrogen
NH3	Hyperammonaemia
LG	Liver Glycogen
MG	muscle glycogen
NRF2	Nuclear Factor E2-Related Factor
AMPK	AMP-Activated Protein Kinase
GOT	Glutamic Oxalacetic Tansaminase
U-MA	Micro-albumin urine
AEs	Aqueous Extracts
DPPH	2,2-Diphenyl-1-Picrylhydrazyl
Cu2+	Copper(2+)
Fe2+	Ferro
O_2	Oxygen

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Потенціал впливу фітохімічних сполук морського огірка на зменшення оксидативного стресу та запалення, спричинених виконанням фізичних вправ: систематичний огляд

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 3 с., 1 табл., 6 рис., 43 джерела.

Мета дослідження. Метою цього дослідження є аналіз та висвітлення потенціалу впливу морського огірка на зменшення оксидативного стресу та запалення, спричинених фізичними вправами.

Матеріали та методи. Дослідження є різновидом систематичного огляду з використанням пошуку в різних наукометричних базах даних журналів, таких як Science Direct, Pubmed та Web of Science. Критеріями включення до даного дослідження були журнали, опубліковані за останні 5 років, в яких розглядалися такі питання, як морський огірок, оксидативний стрес, запалення та фізичні вправи. Крім того, критеріями виключення в цьому дослідженні були журнали, які не є авторитетними або не індексуються в Scopus і Web of Science. Загалом було виявлено 1038 статей з наукометричних баз даних Science Direct, Pubmed та Web of Science. Для даного систематичного огляду було відібрано та проаналізовано загалом 8 статей, які відповідали критеріям включення. Що стосується стандартних операцій, дане дослідження проводилося відповідно до оцінки «Переважні елементи звітності для систематичних оглядів і мета-аналізів» (PRISMA).

Результати. Результати даного систематичного оглядового дослідження свідчать, що високий вміст фенолів у морському огірку має антиоксидантні властивості, які можуть зменшити рівень оксидативного стресу. Крім того, протизапальні властивості морських огірків потенційно сприяють зниженню неконтрольованого запалення, спричиненого інтенсивними фізичними вправами.

Висновки. Вміст фенолів у морських огірках має сильні антиоксидантні властивості, зменшуючи рівень оксидативного стресу. Крім того, протизапальні властивості морських огірків можуть зменшити неконтрольоване запалення, викликане фізичними навантаженнями. В цьому випадку морські огірки володіють протизапальною дією, пригнічуючи секрецію прозапальних цитокінів. На основі цього систематичного огляду ми рекомендуємо в майбутніх дослідженнях провести клінічні випробування щодо потенціалу впливу морського огірка на біомаркери оксидативного стресу та запалення після виконання фізичних навантажень.

Ключові слова: морський огірок, оксидативний стрес, запалення, фізичні вправи.

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