

Herbal Supplements That Have the Potential to Accelerate Recovery of Exercise-Induced Muscle Damage: Systematic Review

Efecto de los suplementos a base de hierbas sobre el daño muscular inducido por el ejercicio: una revisión sistemática

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Abstract. This study aims to analyze herbal supplements that have the potential to accelerate recovery from exercise-induced muscle damage through a systematic review. Article searches were carried out using electronic databases originating from Pubmed and Scopus published from 2019 to 2022 using the keywords herbal, curcumin, garlic, ginger, tribulus, cinnamon, biomarkers, muscle pain, inflammatory markers, and antioxidant effects. The inclusion criteria in this literature review resulted in 14 selected articles resulting from a screening process of 90 articles. The results presented in this literature review reveal the fact that there are significant changes related to EIMD after consuming herbal supplements from 14 selected articles with doses varying between 500-2000 grams per day. In addition, other results showed that intervention with herbal products affected biomarkers and oxidative stress. Therefore, this systematic review provides evidence that supplemental intake strategies are essential for the average athlete or individual to minimize the negative effects of strenuous and excessive training. This systematic review concluded that herbal ingredients such as cinnamon, curcumin, garlic, ginger, and tribulus terrestris may help athletes or individuals recover from EIMD.

Keywords: Biomarkers, EIMD, Inflammation, Nutrition, Supplementation, Recovery

Resumen. El ejercicio físico intenso y excesivo puede causar lesión o daño muscular (EIMD) que Este estudio tiene como objetivo analizar los suplementos a base de hierbas que tienen el potencial de acelerar la recuperación del daño muscular inducido por el ejercicio a través de una revisión sistemática. Se realizaron búsquedas de artículos utilizando bases de datos electrónicas originadas en Pubmed y Scopus publicadas de 2019 a 2022 utilizando las palabras clave herbario, curcumina, ajo, jengibre, tribulus, canela, biomarcadores, dolor muscular, marcadores inflamatorios y efectos antioxidantes. Los criterios de inclusión en esta revisión de la literatura resultaron en 14 artículos seleccionados resultantes de un proceso de selección de 90 artículos. Los resultados presentados en esta revisión de la literatura revelan el hecho de que existen cambios significativos relacionados con la EIMD después de consumir suplementos a base de hierbas de 14 artículos seleccionados con dosis que varían entre 500 y 2000 gramos por día. Además, otros resultados mostraron que la intervención con productos herbarios afectaba los biomarcadores y el estrés oxidativo. Por lo tanto, esta revisión sistemática proporciona evidencia de que las estrategias de ingesta de suplementos son esenciales para que el atleta o individuo promedio minimice los efectos negativos del entrenamiento extenuante y excesivo. Esta revisión sistemática concluyó que los ingredientes a base de hierbas como la canela, la curcumina, el ajo, el jengibre y el tribulus terrestris pueden ayudar a los atletas o a las personas a recuperarse de la EIMD.

Palabras clave: Biomarcadores, EIMD, Inflamación, Nutrición, Suplementación, Recuperación

Fecha recepción: 28-06-23. Fecha de aceptación: 17-10-23

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Introduction

Exercising or doing physical exercise that is carried out systematically, programmed, and done in moderation has a positive impact on individuals. These positive impacts include increasing the health status and vital function of the lungs and heart. In addition, exercising or doing physical exercise has a function as an inducer of immune function (Bahri et al., 2021; Costache et al., 2021). However, there is an immunosuppressive effect when a series of sports activities or physical exercise is carried out excessively for 3 to 72 hours (Ayubi et al., 2022; Devi et al., 2023). In addition to the immunosuppressive effect, doing strenuous and excessive physical exercise can cause muscle injury or damage (EIMD) which is characterized by discomfort and pain in the muscles (Yoon et al., 2020). The response that occurs in the form of secondary inflammation during the exercise process is a sign of EIMD. In addition, mechanical stress also occurs as a primary response to EIMD symptoms (Markus et al., 2021; Nikkiah-Bodaghi et al., 2019;

Ștefănescu et al., 2020; Suzuki et al., 2020; Tanabe, Chino, Sagayama, et al., 2019).

The negative effects of strenuous and excessive training do not only occur in ordinary individuals but also in athletes. In general, athletes who experience injuries due to fatigue or muscle damage (EIMD) cannot participate in a series of training sessions to the fullest so this has a negative effect on athlete performance when training and even in matches (Harty et al., 2019). Therefore, fatigue recovery or muscle breakdown (EIMD) plays an important role in elite-level sports performance, given that elite sports results are usually determined by small margins (Gamonaes et al., 2022; Martínez-Guardado et al., 2020).

Strategies using nutritional intake and supplementation at this time are often carried out to at least maintain and further to improve sports performance both when training or competing. In addition, nutritional intake and supplementation are used as part of a strategy for a faster recovery process after carrying out a series of sports activities or doing physical exercise of various intensities

(Fernández-Lázaro et al., 2022; Tanabe, Chino, Sagayama, et al., 2019). Several types of food that are used as a source of food supplements for a faster recovery process after carrying out a series of activities and even improve performance such as magnesium, caffeine, sodium bicarbonate, and beta-alanine which have been tested and clinically proven to be able to help the recovery process and increase performance (Gamonales et al., 2022). In addition, supplement interventions based on herbal products such as pomegranate, green tea, cherries, turmeric, cinnamon and spinach are often used because supplements based on these herbal products have properties in reducing pain and severity of injuries, muscle pain and stiffness. Besides that, the efficacy of these herbal-based products is that they can modulate pro-inflammatory cytokines, and can help the digestive process in the intestine become smoother (Bahri et al., 2022; Gamonales et al., 2022).

Food supplements made from synthetic and non-synthetic ingredients as part of a strategy to at least maintain and further improve sports performance both during training or competition and for a faster recovery process have been widely used and clinically proven to be able to help the recovery process and improve performance. However, intervention using herbal products is still limited. The active phytochemicals in herbal supplements are the result of the extraction process from the roots, seeds, flowers of plants, or bark (Fernández-Lázaro et al., 2022). Herbal-based supplements are increasing in use mainly in the United States market, and an estimated annual growth rate of 8.9% over the following years (Fernández-Lázaro et al., 2022; Khan et al., 2022).

The popularity of using herbal-based supplements has increased, especially in the last 10 years, and has become increasingly popular after emerging as an additional therapy for treating COVID-19 patients (Khan et al., 2022). However, interventions using herbal products for individuals or athletes as part of a strategy to at least maintain and further improve sports performance both during training or competition and for a faster recovery process are still limited.

Therefore, the main objective of this systematic review is to identify, view and systematize the effects of consuming herbal-based supplements on muscle breakdown (EIMD), biomarkers, or those related to recovery processes related to physical activity or exercise. The results of this systematic review can provide information regarding the effectiveness and efficiency of nutritional intake as part of a strategy in the recovery process caused by muscle damage associated with physical activity using herbal-based supplements.

Materials and Methods

Eligibility Criteria

The main focus of this systematic review is the effect of taking herbal supplements on the activity of biomarkers,

muscle pain, inflammatory markers, and antioxidant effects based on the Preferred Reporting Elements for Systematic Review and Meta-analysis (PRISMA) guidelines (Page et al., 2021). In addition, we attempted in this systematic review to collect available scientific evidence in online databases according to inclusion and exclusion criteria based on PICOS (Page et al., 2021). The eligibility criteria are:

1. Population: ordinary individuals, active individuals, and athletes
2. Intervention: supplementation with herbal ingredients
3. Comparison: the same conditions as the placebo or control group
4. Outcomes: biomarkers, inflammatory markers, antioxidant effects, EIMD
5. Study Type: single or double-blind and randomized parallel or cross designs

The exclusion criteria are articles that are not available in English or articles that do not have full-text publications such as only titles and abstracts.

Data Source and Search

In this literature review, a comprehensive and systematic search was carried out for journals published between 2019 and 2022 through three high-quality online databases that guarantee good bibliographical support, namely Pubmed and Scopus. The following search terms were used in both databases: herbs, curcumin, garlic, ginger, Tribulus, cinnamon, biomarkers, muscle pain, inflammatory markers, and, antioxidant effects. Through the search process that has been carried out, some relevant articles were obtained from online databases. Cross-reference tests were performed on the title and abstract thereafter to avoid duplication.

The search process identified as many as ninety articles that met the requirements using search strategies from Pubmed, Scopus and Web of Science. Sixty-five articles remained after duplicates were removed, and twenty-five articles remained after title and abstract review. Therefore, a total of twenty-five articles containing the full text were reviewed for feasibility. After reviewing the articles in full and detail, fourteen articles were included in the inclusion criteria. The detailed process stages of the literature search are illustrated in Fig 1.

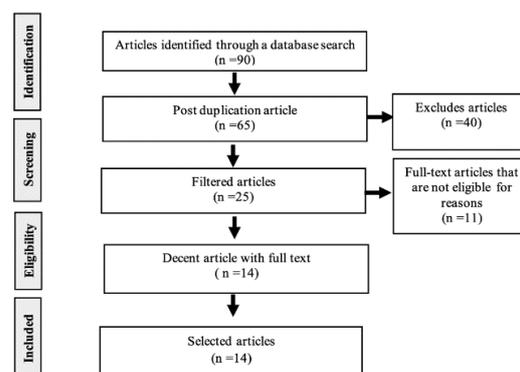


Figure 1. Article selection flowchart

Results

Table 1.

Article Summary About the Effects of Herbal Materials

Author(s) Year	Study Design	Samples	Intervention	Outcome
(Junaidi et al., 2020)	Randomized controlled double-blind trial	badminton athletes	<ul style="list-style-type: none"> 500 mg of cinnamon extract 6 weeks duration 	<ul style="list-style-type: none"> Significantly Reduced CK levels Improve performance
(Bahri et al., 2022)	double-blind, crossover trial	weightlifting athletes	<ul style="list-style-type: none"> 500 mg of cinnamon extract Duration 8 weeks duration 	<ul style="list-style-type: none"> Significantly Reduce CK, CRP, lactate, and glucose No effects on performances
(Faria et al., 2020)	A Randomized placebo-controlled, double-blind trial	amateur runners	<ul style="list-style-type: none"> 1500 mg of Curcumin extract 4 weeks duration 	<ul style="list-style-type: none"> Reduce biomarkers level
(Basham et al., 2020)	Randomized placebo-controlled, trial double-blind	healthy males	<ul style="list-style-type: none"> 150 mg curcumin extract 30 days duration 	<ul style="list-style-type: none"> Reduce DOMS and perceived muscle soreness No effects on performances
(Almaraj et al., 2019)	Randomized placebo-controlled, trial double-blind	healthy males and females	<ul style="list-style-type: none"> 500 mg of curcumin extract 7 days duration 	<ul style="list-style-type: none"> Reduce DOMS Reduce creatine kinase levels
(Mallard et al., 2020)	Randomized placebo-controlled, trial double-blind	trained healthy males	<ul style="list-style-type: none"> 500 mg of curcumin extract before test 	<ul style="list-style-type: none"> Reduce postexercise pain, Reduce blood lactate levels
(Khoobkhani et al., 2019)	quasi-experimental study	untrained males	<ul style="list-style-type: none"> 250 mg garlic extract 8 weeks duration 	<ul style="list-style-type: none"> Improved TAC Reduced malondialdehyde levels
(Moosavin et al., 2020)	Randomized placebo-controlled, trial double-blind	patients with Rheumatoid arthritis	<ul style="list-style-type: none"> 500 mg garlic extract 8 weeks duration 	<ul style="list-style-type: none"> Significant improvements in oxidative stress
(Zare et al., 2020)	Randomized placebo-controlled, trial double-blind	patients with peritoneal dialysis (PD)	<ul style="list-style-type: none"> 800 mg garlic extract 8 weeks duration 	<ul style="list-style-type: none"> Significantly Reduce Biomarkers (IL-6, CRP) levels
(Nikkhah-bodaghi et al., 2019)	Randomized placebo-controlled, trial double-blind	Unhealthy patients	<ul style="list-style-type: none"> 200 mg/day ginger extract 12 weeks duration 	<ul style="list-style-type: none"> Reduce inflammation
(Javid et al., 2019)	Randomized placebo-controlled, trial double-blind	Unhealthy patients	<ul style="list-style-type: none"> 200 mg/day ginger extract 8 weeks duration 	<ul style="list-style-type: none"> Reduce inflammation Improved oxidative, and periodontal status
(Rafie et al., 2019)	Randomized placebo-controlled, trial double-blind	Unhealthy patients	<ul style="list-style-type: none"> 150 mg/day ginger extract 12 weeks duration 	<ul style="list-style-type: none"> Reduced Malondialdehyde levels Increased patients quality of life
(Talemi et al., 2021)	Randomized placebo-controlled, trial double-blind	healthy males	<ul style="list-style-type: none"> 500 mg of Tribulus terrestris extract 2 weeks duration 	<ul style="list-style-type: none"> Significantly reduce Biomarkers (IL-6, CRP) levels Significantly Reduce muscle damage enzymes
(Lázaro et al., 2021)	Randomized placebo-controlled, trial double-blind	trained athletes	<ul style="list-style-type: none"> 770 mg of Tribulus terrestris extract 6 weeks duration 	<ul style="list-style-type: none"> Significantly Reduce muscle damage enzymes

Discussion

Article Summary About the Effects of Herbal Materials Heavy and excessive exercise can cause muscle damage (EIMD) which does not only occur in ordinary individuals but also occurs in athletes (Harty et al., 2019; Serinken et al., 2013). Muscle damage (EIMD) that occurs is characterized by disruption of the muscle ultrastructure which increases thereby releasing inflammatory cytokines from myofibers (Nanavati et al., 2022). Therefore, an intervention strategy using herbal-based supplements is an effort that must be made by ordinary individuals, trained individuals to athletes to achieve a faster recovery phase after carrying out a series of sports activities or doing physical exercise of various intensities. In addition, intervention strategies are intended to be able to improve

and maintain sports performance again (Fernández-Lázaro et al., 2022; Tanabe, Chino, Sagayama, et al., 2019).

Evidence suggests that interventions using herbal-based supplements have a better effect and are easily tolerated by the body when compared with synthetic-based supplements. However, information regarding its ineffectiveness and side effects on injury or disease is still lacking, so it becomes an important issues for the public, nutritionists, and even doctors. Therefore, this systematic review has the main objective of evaluating the effect of herbal-based supplementation, especially those based on Cinnamon, Curcumin, Garlic, Ginger, and Tribulus Terrestris on ordinary individuals, trained individuals, and elite athletes. Clinical results from several studies collected in this systematic review can provide scientific evidence and can be justified regarding the efficacy of herbal-based

supplements (Colalto, 2018; Izzo et al., 2016; Sheikhsossein et al., 2021). Our systematic review is a quantitative study that provides information on the effects of herbal supplementation based on Cinnamon, Curcumin, Garlic, Ginger, and Tribulus Terrestris on biomarkers, muscle pain, and antioxidant effects.

Cinnamon Supplements

Cinnamon is the most studied type of flowering family from Lauraceae because it consists of about 250 species (Shen et al., 2012). Besides its role as a food spice, cinnamon is used as a remedy for digestive ailments, respiratory problems, and women's health or reproductive or gynecological problems (Ranasinghe et al., 2013). In addition, the presence of phytochemicals in cinnamon such as phenolics and volatiles causes cinnamon to be known as an anti-diabetic, anti-cancer, anti-tumor, and anti-inflammatory agent. In addition, due to the presence of phytochemical compounds in cinnamon such as phenolic and volatile, cinnamon is known as an anti-cancer, anti-diabetic, anti-inflammatory, and anti-tumor (Goel & Mishra, 2020).

The effect of consumed cinnamon extract on biomarkers was analyzed in this systematic review. The conclusion of a previous study by (Junaidi et al., 2020) showed that adolescent badminton athletes who consumed cinnamon extract supplementation for 6 weeks with dose as 500 mg per day were able to significantly reduce biomarkers such as creatine kinase. Meanwhile, research (Bahri et al., 2022) stated consuming as much as 500 mg per day for 8 weeks helped weightlifting athletes reduce biomarkers such as creatine kinase, CRP, and blood sugar levels.

A supplement in the form of cinnamon extract which is consumed by athletes in the results of this literature review is because cinnamon can increase insulin activity, thereby preventing an increase in creatine kinase (Bahri et al., 2022; Junaidi et al., 2020). In addition, Cinnamaldehyde contained in cinnamon stimulates glucose uptake and glycogen synthesis (Goel & Mishra, 2020).

Curcumin Supplements

Curcumin, which is chemically known as diferuloylmethane (Cas & Ghidoni, 2019), which is produced from turmeric extract, is a natural polyphenolic substance (Tanabe, Chino, Ohnishi, et al., 2019). Curcumin has long been trusted by scientists as a medicine for certain diseases, especially metabolic problems, arthritis, and cancer because it has anti-inflammatory and anti-oxidant properties (Adamczak et al., 2020; Rocha et al., 2020; Rodrigues et al., 2021). However, the growing food technology has led scientists in recent years to test the use of curcumin extract as a supplement to treat exercise-induced muscle damage (EIMD).

The effects of curcumin supplementation on biomarkers and anti-inflammatory were analyzed in this systematic review. The results of several studies that have been

conducted state that supplementation of curcumin extract with various doses starting from 500 mg to 1500 mg can reduce several biomarkers, reduce DOMS, reduce inflammation, and can help recover faster after injury (Amalraj et al., 2020; Faria et al., 2020; Mallard et al., 2021; MS et al., 2020; Tanabe, Chino, Sagayama, et al., 2019). Previous study by (Faria et al., 2020) showed that consuming as much as 1500 mg per day for 4 weeks leads to decrease in myoglobin and IL-10 and in individuals after participating in marathon race. According to (MS et al., 2020), a study that examined the effects of curcumin on healthy individuals found that consuming 1.5 grams of curcumin extract for 30 days reduced muscle damage and perceived muscle pain without negatively impacting the natural inflammatory response after exercise. Similarly, (Mallard et al., 2021) conducted a study involving male and female participants who consumed 500 mg of curcumin for 7 days and found a significant reduction in DOMS and creatine kinase concentrations. Additionally, another study on trained individuals who consumed 500 mg of curcumin before exercise demonstrated that it improved the ability to perform high-intensity exercise after rest and reduced lactate accumulation and post-exercise pain.

The effect of consuming curcumin which indirectly reduces creatine kinase occurs in several ways. One way is that it provides a protective effect on blood vessel membranes by altering their structure and increasing their integrity, leading to a decrease in creatine kinase levels in the blood (Nanavati et al., 2022). The second way is regulation of the cyclooxygenase pathway (COX-1 and COX-2) suppressed by curcumin thereby reducing the release of prostaglandins which in this way can affect vascular permeability so that it can reduce the flow of creatine kinase (Nanavati et al., 2022). The final way is suppression of ROS (Reactive oxygen species) activity due to the antioxidant properties contained in curcumin during the muscle contraction process which contributes to the release of creatine kinase (Fernández-Lázaro et al., 2020; Rodrigues et al., 2021).

In addition to reducing biomarkers, curcumin also has anti-inflammatory effects. It does this by inhibiting the activation of nuclear factor-kappa B (NF- κ B), suppressing Janus kinase/signal transducers and activators of transcription (JAK/STAT) activation and phosphorylation, and inhibiting mitogen-activated protein kinase (MAPK) signaling. This reduces the release of inflammatory markers such as tumor necrosis factor-alpha (TNF- α), interleukin-8 (IL-8), and interleukin-6 (IL-6) at sites of inflammation or damage, particularly in muscles (Kahkhaie et al., 2019).

Garlic Supplements

Garlic supplements, made from *Allium sativum*, are known for their therapeutic effects due to the activity of bioactive compounds like organic sulfides, saponins, phenolic compounds, and polysaccharides (Khoobkhahi et al., 2019; Moosavian et al., 2020; Zare et al., 2019). Long before pharmaceutical products developed as they are

today, antibiotic products were not available in ancient times, so garlic was used as a medicine for influenza, dysentery, and cholera (Petrovska & Cekovska, 2010). Garlic has a therapeutic effect resulting from the activity of its bioactive compounds (Ansary et al., 2020), saponins (Diretto et al., 2017), phenolic compounds (Ansary et al., 2020), and polysaccharides (Wang et al., 2018).

Several studies have shown the effects of garlic supplement consumption on biomarkers and anti-inflammatory effects. These studies have found that garlic supplements in doses of 250-800 mg can reduce several biomarkers, lower oxidative stress levels, decrease malondialdehyde levels, and increase total antioxidant capacity (Khoobkhahi et al., 2019; Moosavian et al., 2020; Zare et al., 2019). For example, (Khoobkhahi et al., 2019) found that consuming 250 mg of garlic per day for 8 weeks, along with strength-endurance training, reduced oxidative stress, decreased malondialdehyde levels, and increased total antioxidant capacity in adolescent subjects (Khoobkhahi et al., 2019). Another study by (Moosavian et al., 2020) found that consuming 500 mg of garlic extract for 8 weeks reduced malondialdehyde levels and increased total antioxidant capacity in patients with rheumatoid arthritis. Meanwhile, a study by (Zare et al., 2019) involving patients on peritoneal dialysis found that consuming 800 mg of garlic extract per day for 8 weeks reduced inflammatory markers like IL-6 and biomarkers like CRP.

Garlic is known as an herbal plant that has benefits in inhibiting inflammation. This is due to the presence of organosulfur compounds in garlic such as ajoene, S-allylmercapto cysteine, diallyl disulfide, allicin, and S-allyl cysteine which can affect oxidative stress (Schäfer & Kaschula, 2014). In addition, thiacremonone, which is a sulfur compound found in garlic, can withstand the activation of NF- κ B by interacting with sulfhydryl groups (Ban et al., 2009). Furthermore, the presence of ajoene and its derivatives can inhibit inflammatory markers and biomarkers (Lee et al., 2012).

Ginger supplements

Ginger, a plant in the Zingiberaceae family, is commonly used as a food spice, but it is also known for its medicinal properties. It has been used to alleviate nausea, joint pain, muscle disorders, digestive issues, and respiratory problems such as the flu (Rasheed, 2020). Phenolic compounds (shogaol and terpene) contained in ginger makes ginger the main ingredient for anti-fungal, anti-inflammatory, anti-cancer, protective respiratory problems and has anti-obesity effects (Ballester et al., 2022; Mao et al., 2019; Rasheed, 2020).

Studies have shown that ginger supplements can reduce inflammation and decrease malondialdehyde (MDA) levels. For example, Nikkah et al. found that taking 200 mg of ginger extract per day for 12 weeks reduced inflammation in patients with non-alcoholic fatty liver disease aged 40-50 years (Nikkah-Bodaghi et al., 2019). Research (Javid et

al., 2019) found that consuming 1500 mg of ginger per day for 12 weeks decreased inflammation in type 2 diabetes mellitus patients. Research (Rafie et al., 2020) also found that consuming 150 mg of ginger extract per day for 12 weeks reduced MDA levels in patients with ulcerative colitis aged 40-50 years.

Ginger is rich in phenolic compounds like shogaol, gingerol, shogaol, paradol, and zingerone, which contribute to its anti-inflammatory properties (Ballester et al., 2022). It inhibits the synthesis of inflammatory cytokines by blocking the signaling pathway or activation of NF- κ B (Zhou et al., 2022). Ginger also suppresses the metabolism of arachidonic acid by inhibiting or blocking pro-inflammatory mediator pathways like cyclooxygenase (COX) and lipoxygenase (LOX), which reduces the production of prostaglandins, corticosterone, and subsequent inflammatory responses (Mao et al., 2019).

Tribulus Terrestris Supplements

Tribulus Terrestris (TT), also known as tribulus, caltrop, bullhead, and Mexican sandbur, is a herbal plant native to India and belonging to the Zygophyllaceae family. It grows in sub-tropical countries and in much of the Mediterranean region (Fernández-Lázaro et al., 2022). The popularity of TT as a traditional medicinal ingredient has been known since ancient times, especially as an antioxidant, anti-inflammatory, anti-tumor, and also as anti-diabetic (Nejati et al., 2022).

Several studies have shown the effects of TT supplement consumption on inflammatory markers and biomarkers. For example, (Talemi et al., 2021) found that consuming 500 mg of TT per day for 2 weeks reduced muscle breakdowns enzymes like CPK and lactate dehydrogenase (LDH) in healthy male subjects, but did not significantly reduce inflammatory markers like IL-6 or biomarkers like CRP. Another study by (Fernández-Lázaro et al., 2021) found that TT supplements at a dose of 770 mg per day for 6 weeks acted as a testosterone booster and helped with recovery and reduced feelings of fatigue in athletes aged 31-35 years.

Like other herbal supplements, TT can inhibit the synthesis of inflammatory cytokines by blocking the signaling pathway or activation of NF- κ B (Ranjithkumar et al., 2019). His suppresses leukocyte infiltration and the production of proinflammatory mediators like TNF- α and IL-4 (Fernández-Lázaro et al., 2021, 2022). However, the insignificant reduction in inflammatory markers and biomarkers seen in some studies may be due to the fact that several TT active ingredients and saponins are needed for their anti-inflammatory effect, and saponins alone are not sufficient (Fernández-Lázaro et al., 2021, 2022). Additionally, the increase in testosterone levels seen in some studies suggests that TT has pleiotropic effects that can affect testosterone levels. This may be due to the presence of steroidal saponins like Protodioscin, Tribulus Saponins, and Gideon, which stimulate the body to produce testosterone (Ștefănescu et al., 2020).

Although there are many studies reporting the benefits of herbal supplements. However, the limitations of our research do not discuss in depth the issue of improving performance in sports. We strongly recommend that future research examine the potential of herbal supplements to improve sports performance.

Conclusions

It can be concluded that herbal supplementation, especially those derived from cinnamon, curcumin, garlic, ginger, and Tribulus in particular have been proven to be successful, safe and have a positive effect on anti-inflammation, a marker of disease. muscle damage, or biomarkers, and also on performance. The field of sports nutrition and supplements is an active area of research, and there is still a lot we don't know about the most effective strategies for treating EIMD. Although this systematic review covers a wide range of topics, there are still many new nutritional and supplementation approaches that have not been fully explored. Future research in this area has the potential to uncover new and innovative ways to treat EIMD, and could result in significant advances in the treatment and management of this condition.

Acknowledgments

The authors would like to thank the support from Universitas Negeri Surabaya, Universitas Airlangga, Institut Teknologi Bandung, Universitas Sultan Ageng Tirtayasa, Kemendikbudristek and LPDP

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