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SELECTED TRADITIONAL INDIAN PLANTS AND SPORTS PERFORMANCE: A REVIEW

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Plants have been an intrinsic part of Indian culture and embedded in our daily lives in many vital forms. Many plants hold an important place in the religious sphere of the Indian way of life, medicinal value, and different cuisines. Ayurveda, the most ancient traditional medicine system in India, is widelypracticed, and the majority of people rely on plants and plant extracts for their primary health care needs. Among the multidimensional importance of plants in different fields, one of the emergent scientific interests is plants' role in enhancing physical performance, including sports and exercise performance in humans. In the current review, we have explored some selected traditionalIndian plants in promoting sports and exercise performance. Some of these plants are used as everyday ingredients in Indian food recipes. However, their role in physical performance enhancement is not scientifically studied in detail. Some studies have started bringing up their value as supplements for athletes, and much more still needs to be investigated in future research. The research initiated in establishing the importance of these plants as supplements for athletes is advancing rapidly. It is of great interest to athletes because there is a massivedemand for natural alternatives for enhancing sports performance and avoidingthe use of performance-enhancing drugs with harmful side effects. Therefore, this review aims to provide an overview of the growing body of literature for plant-based dietary supplements with the potential to promote physical performance. The plants discussed in this review are Ashwagandha (*Withania somnifera*), Arjuna (*Terminalia arjuna*), Ginger (*Zingiber officinale*), Turmeric (*Curcuma longa*), Tulsi (*Ocimum sanctum*), Cinnamon (*Cinnamomum verum*), and Saffron (*Crocus sativus*).The scientific studies on some of the traditional Indian plants compiled in this review illustrate their performance boosting positive attributes such as anti-inflammatory activity, antioxidant activity, muscle repair activity, decreasing muscle damage and soreness, increasing muscle growth and muscle mass, delaying fatigue, stabilizing blood sugar levels, reducing cholesterol, improving lipid profile, increasing endurance, improving gut health, relieving training stress, inducing cardioprotective effect, reducing muscle pain via analgesic effect, increased adaptation to training and many more benefits for a stronger and healthier physique and improved performance. Some of these plants are already used as supplements in sports nutrition for enhanced physical performance or sporting excellence regardless of adequate scientific evidence of large scale studies.

Keywords: Athletes, Endurance, Muscle recovery, Resistance training, Sports performance, Supplements, Traditional Indian plants.

Introduction

Athletes use many dietary supplements and ergogenic aids, and many more are being explored and developed for improving the overall performance of athletes[1-5].There is a need for new supplementation strategies considering the limitations and various adverse effects of currently used supplements, including performance-enhancing drugs in the sports and fitness industry[6].One of the evolving strategies is the development of natural alternatives for enhancing physical fitness. The use of plants in Indian traditional medicine "Ayurveda"and almost every aspect of daily life roots from the rich cultural heritage and Vedic culture of India[7,8]. Many herbs, spices, different parts of the plants such as bark, roots, flowers, leaves, etc. have their significance in treating various diseases, boosting energy, in food, in beverages such as tea, in pest control, and so on.Plants as supplements offer multiple benefits; for example, they are readily available, are safe, free from side effects, and are eco-friendly. For many decades, humans have relied on synthetics for medicine and supplements; however, now people are returning to plant-based alternatives to ensure safety of the human beings and the environment. The traditional Indian plants used in medicine or food or several other purposes also hold a strong potential to improve physical performance[7-9]. Such plants or plant extracts for boosting energy, stamina, or recovery are well known. Still, only a few plants have been scientifically investigated to understand the mechanism behind their performance enhancement properties. In the current review, we have discussed selected traditional Indian plants for whose physical performance improving properties some scientific evidence has already been established, and further research is continued. The literature in this review is compiled for the following plants: Ashwagandha (*Withania somnifera*), Arjuna (*Terminalia arjuna*), Ginger (*Zingiber officinale*), Turmeric (*Curcuma longa*), Tulsi (*Ocimum sanctum*), Cinnamon *Cinnamomum verum*) and Saffron (*Crocus sativus*)

Traditional Indian plants used in sports performance enhancement:

Ashwagandha (*Withania somnifera*)

Withania somnifera is commonly known as Ashwagandhaandholds an important place in Indian traditional medicine system-Ayurveda for more than 3000 years. It is also named as Indian ginseng or winter cherry. It is famously referred to as the "Queen of herbs" because of its numerous beneficial effects[10].It isuseful in treatment of several diseases such as diabetes, rheumatoid arthritis, epilepsy, gastrointestinal disorders, musculoskeletal conditions, and many more[11,12]. The added benefit of using this herb as a medicine is that it does not have any side effects. Here, we will discuss the role of Ashwagandha in boosting sports or athletic performance. In addition to being already known for its medicinal value, Ashwagandha has also been found to improve cardiorespiratory and cardiovascular endurance, muscular strength, neuro-muscular coordination, and physical performance of the elite athletes[10,13,14]. Its supplements help in increasing muscle mass if used in combination with resistance training. It is an adaptogen and therefore builds resistance against physical, chemical, or biological stress.It is known to delay exhaustion and is used as an adrenal fatigue supplement.Additionally, it helps stabilize blood sugar levels and increases total testosterone[15,16]. Also, it increases insulin secretion in muscle cells, leading to more glucose and amino acid storage in muscle cells[17]. It has the ability to increase red blood cell count, which results in an increase in maximum oxygen consumption. It increases muscle growth, muscle strength, and muscle size[17,18]. When taken as a supplement along with resistance training, it has been found to increase muscle mass[18]. It reduces exercise-induced muscle damage and helps

in body fat loss by increasing energy expenditure through stimulating mitochondrial function in adipose tissue and skeletal muscle [13,19]. It is used as an energy-boosting tonic with an overall improvement in health and longevity. It is useful in overcoming weakness, enhancing the speed, and improving lower limb muscular strength. It helps in increasing breathing power and lung oxygen capacity during exercise[13]. Ashwagandha supplementation has been shown to increase testosterone levels,an anabolic hormone and have multiple physiological effects such as increased muscular power, aerobic endurance, enhanced mental vigor and vitality, and increased regeneration of tissues, and rapid recovery from high exertion exercises[13,20]. In general, the recommended dosage of Ashwagandha is 1 gram per day and is safe for young athletes' consumption. The literature above indicates that Ashwagandha has the immense capability of boosting overall athletic performance and endurance of athletes[13].

Arjuna (*Terminalia arjuna*)

Terminalia arjuna, is known by the name of Arjuna in Indian traditional medicine and belongs to the family of Combretaceae. Its bark extract has been used in India for centuries to improve cardiovascular health [21,22]. It is used to treat various heart ailments such as coronary artery disease, hypercholesterolemia, hypertension, angina pain, and ischemic cardiomyopathy[22-24].Additionally, it has been found beneficial for performance enhancement in athletes[13]. It improves cardiovascular endurance and lowers systolic blood pressure.In a clinical trial with resistance training athletes, *Teminalia arjuna* extracts were found to induce a lower resting blood pressure effect. Besides, a reduction in cardiovascular risk and increased lung oxygen capacity was also observed during exercise[13]. It also causes anti-inflammatory and antioxidant effects, which helps prevent excessive injury or tissue damage and accelerate recovery, thus improving physical performance[20,23]. In a study by Girandola *et al.*, the *Terminalia arjuna* extract was found to enhance young male athletes' physical endurance by improving left ventricular ejection fraction, time to exhaustion, and rated perceived exertion score. It was also found to boost cardiovascular efficiency and enhanced athletic performance[25].Based on its cardioprotective effects, the supplements from bark extract of *Terminalia arjuna* can be used as cardiac endurance enhancer for exercise and optimal performance of athletes[20,26]. When taken in combination with Ashwagandha supplements,it induces multiple positive traits in the context of enhanced physical performance such as enhanced aerobic capacity, improved cardiovascular endurance, and increased muscular strength in legs[13].The benefits mentioned above indicate a better recovery after exercise and support this herb as a performance enhancement supplement.

Ginger (*Zingiber officinale*)

Ginger or *Zingiberofficinale*is generally used as a spice in food and to treat different ailments in traditional medicine systems in India and some other countries in Asia. Its role in enhancing sports performance is elucidated in multiple studies and is briefly discussed here. In a study by Mashhadi *et al.*, ginger supplements were given to women trained in competitive martial arts, and it was found that the muscle soreness decreased following exercise[27].The reduction in muscle soreness was due to the anti-inflammatory and anti-oxidative properties of ginger. Ginger stimulates increased athletic performance, and when used in combination with cinnamon, it decreases muscle soreness after intense exercise[27,28].According to some studies, Ginger can be used as an ergogenic aid in sports; it may accelerate maximal strength recovery after resistance exercise and suppress inflammation after cardiorespiratory exercise[29].Ginger also

possesses analgesic properties, which can be helpful during exercise training. To minimize existing or anticipated pain during exercise, athletes commonly consume Nonsteroidal anti-inflammatory drugs (NSAIDs). NSAID use is prevalent among athletes undergoing exercise or sports training and athletes in international athletic competitions. However, NSAIDs can cause multiple adverse effects and negatively affect an athlete's health and performance. Given its analgesic properties, Ginger can be a healthy alternative for popular pain medications among athletes with an added benefit of no side effects if taken in recommended amounts[29]. Ginger can also help relieve nausea or dizziness experienced by some swimmers during or after swimming. It can also keep the digestive tract healthy and help regain appetite in athletes, which is crucial for the body to recover and repair after exercise or sports[29,30]. Prolonged intense training in athletes can lead to elevated pro-inflammatory cytokines, which can negatively impact their immune system and induce fatigue like symptoms. In a study by Zehsaz*et al*., it was found that six weeks of ginger administration mitigated the rise of pro-inflammatory cytokines in circulation after exercise or heavy training. Therefore, it helped improve the immune system, avoid fatigue, and improve endurance, performance, and recovery of athletes[31].It also aids in maintaining the maximum muscle power and diminish the muscle sorenesspost-exercise or heavy training[32].It is also found to reduce the muscle damage markers via its anti-inflammatory and antioxidant properties[33].In multiple studies, it has been found to alleviate muscle pain caused by eccentric exercises[29,34].

Turmeric (*Curcuma longa*)

Turmeric or *Curcuma longa* is a versatile spice and is found effective in sports. It has anti-inflammatory and neuroprotective benefits. Turmeric contains several phytochemicals that can be helpful in the prevention and treatment of multiple ailments. The most intensely investigated phytocompound in turmeric is curcumin and is widely recognized for its multifunctional bioactivities. A study by Basham *et al.*, found that curcumin supplementation reduces exercise-induced oxidative stress, inflammation, muscle damage, and muscle soreness[35].This finding of curcumin supplementation is also supported in another study by Jager R. *et al.* confirming the dampening of muscle damage and a faster recovery in competitive athletes following muscle-damaging exercise. It also helps in increased adaptation rate during training and leads to consistently improved performance[36].Another study by McFarlin *et al.* supports the oral supplementation of curcumin for inflammation suppression associated with exercise-induced muscle damage[37]. The anti-inflammatory effect of curcumin takes place by modulating pro-inflammatory cytokines TNF-alpha, IL-6, and IL-8. It also helps in improving muscle performance by decreasing creatine kinase activity. The recommended daily dose for curcumin supplementation is between 150 and 1500 mg/day and should be administered pre and post-exercise for optimal performance improvement in athletes[38].For athletes, curcumin supplementation is an excellent alternative to NSAIDs for a reduction in muscle damage and muscle soreness[39]. A study by Huang W. *et al.* showed an increase in muscular glycogen content on curcumin supplementation[40]. Muscular glycogen is an important energy source for exercise and helps in improving exercise performance[40]. Turmeric is a powerful antioxidant, helps in faster muscle recovery, enhances grip strength and endurance, prevents exercise-induced fatigue, improves exercise performance, benefits body composition, lipid profile, liver, and rental parameters[41]. Though there are multiple studies throwing light on numerous benefits of turmeric supplementation for athletes, further

studies are required to investigate the mechanisms of action behind its supplementation effects on sports performance.

Tulsi (*Ocimum sanctum*)

Tulsi, *Ocimum sanctum*, or holy basil, is worshipped and has spiritual and religious significance in India for millions of years. This sacred plant has a significant place in Indian culture and also in traditional Indian medicine. It is popular for its medicinal value[42], it helps in reducing fasting blood glucose, total cholesterol and improves overall lipid profilein serum and tissue lipids[43,44].Besides its medicinal properties, it also can boost energy and enhance overall mental and physical health. It is named as "The queen of herbs," The incomparable one," and "The mother medicine of nature" because of its innumerable benefits. It is an adaptogen and helps athletes adapt to training stressors and maintain the homeostasis of the body[45]. Itreduces the stress hormone cortisol for endurance athletes, increases stamina, and increases immunity against respiratory infections. In several studies, Tulsi has been shown to enhance aerobic metabolism, improve swimming time via central nervous system stimulant or antistress activity[46], reduce oxidative tissue damage, and normalize physiological and biochemical parameters by physical stressors[47]. It also protects against physical stress from extended physical exertion[48].Tulsi is also named "Liquid yoga" because its regular consumption induces a calming and relaxing effect and nurtures a sense of overall well-being, just like the standard practice of yoga[48].It also possesses antioxidant properties, which can help reduce muscle damage after heavy training[49,50]. In a study by Kumar A. *et al*., the root extract of *Ocimum sanctum* was found to possess anti-inflammatory, analgesic, and antipyretic properties[51]. Therefore, it can also be used as an alternative to NSAIDs by athletes to avoid gastrointestinal problems caused by NSAIDs' long-term use. Tulsi consumption improves overall gut health and facilitates nutrient breakdown and absorption, crucial for coping with the exercise and training stress in athletes[48]. It is apparent that Tulsi supplementation holds substantial potential as a performance booster in athletes. However, many more studies are required to determine the role of Tulsi extract supplementation in sports nutrition and performance.

Cinnamon (*Cinnamomum verum*)

Cinnamon or *Cinnamomum verum* is native to India but is very popular andused in different cooking and baking recipesworldwide. Ceylon cinnamon and Cassia cinnamon are the two main kinds of cinnamon[52]. It is very high in the compound cinnamaldehyde[53] which is mostly credited for the most beneficial cinnamon effects on health and body metabolism. This compound also gives a distinct smell and flavor to cinnamon[53]. It has multiple health benefits and is in high demand as a supplement in the health and fitness industry. It is known to induce antidiabetic effect by slowing down the digestion of carbohydrates by inhibiting digestive enzymes, resulting in decreased uptake of glucose in the blood and stabilizing insulin levels within the bloodstream[54-58]. Also, it is found to decrease blood sugar levels, improve insulin sensitivity, and reduce insulin resistance[59-62]. It is highly enriched with antioxidants[63-67] and protects the body from damage by free radicals after strenuous exercises[63]. There is also evidence that cinnamon consumption can improve overall lipid profile by reducing bad cholesterol (LDL) and increasing good cholesterol (HDL). Some studies have also shown that cinnamon supplementation can also regulate blood pressure in combination with maintaining cholesterol levels, thus promoting good heart health. In addition to the anti-diabetic[68,69] and cardioprotective effects[58,63,70,71], Cinnamon also possesses sports performance-boosting effect. In a study by Belcher H. *et*

al. , it was found that cinnamon supplementation reduced muscle soreness, increased performance output in college athletes, and has the potential to optimize recovery during peak competition[72]. Cinnamon is rich in manganese and other minerals, important in building healthy bones and tissues. It has anti-inflammatory activity, which helps in reducing muscle pain and soreness[73-77]. It also possesses blood-thinning properties,which aid in improving blood circulation in the body. It has also been shown to boost brain activity and function.

Saffron (*Crocus sativus*)

Saffron or *Crocus sativus* is an expensive spice used in India and other Asian countries for ages. Looking at its potential as a supplement in sports nutrition, it has the capability to boost muscular strength in athletes undergoing strength training. In a study by Meamarbashi A. *et al.*, the ergogenic effect of saffron supplementation on muscular strength, pulmonary function, reaction time, and overall athletic performance was evaluated in university students. It was found that the ergogenic effect of saffron supplementation contributed to an increase in muscle mitochondrial biogenesis and faster audio and visual reaction times. A 10% increase in the force production on the leg press and improved muscle blood perfusion and oxygen transport were also observed[78]. These results indicate that saffron supplementation can help athletes perform better in competitive sports. Saffron can also help in quick recovery after strenuous exercises. Saffron also has anti-inflammatory activities and helps to relieve the lactic acid build-up during exercise. Besides, saffron also improves blood circulation in the body, allowing micronutrients and oxygen to reach all parts of the body during and after training, resulting in a healthier physique and better performance. In combination with a balanced diet, Saffron supplementation also helps in weight loss by creating a satiating effect and curbing the cravings for snacks between meals[79,80]. In another study by Meamarbashi A. *et al.*,it has been demonstrated that saffron supplementation prevents delayed onset muscle soreness (DOMS), which affects exercise performance after sustained exercise[81]. Besides, saffron supplementation also enhances VO2 max (maximal oxygen uptake) and improves cardiorespiratory fitness[82]. Saffron extract has also been shown to reduce physical fatigue in healthy humans on the supplement's daily oral administration. Many studies have established the efficacy of the saffron extract in reducing mental stress and improving relaxation state. Therefore, it helps avoid the harmful effects of anxiety in competitive athletes. In a study by Abassi W. *et al.*, an acute dose of saffron was found significant enough to improve anaerobic power in young athletic males[83]. Another study investigated the effect of saffron treatment on exercised Wistar rats and found that saffron supplementation enhanced mitochondrial biogenesis and endurance capacity, decreased inflammation, and oxidative stress during endurance training by modulating several metabolic and genomic factors[84]. However, its results on human endurance training still need to be established in future human trials on saffron supplementation.

Conclusion:

The above-discussed plants have compelling properties for enhancing sports performance, stamina, and recovery in athletes. Although there are limited scientific studies, expanding the use of plant-based supplements with reasonable evidence of their effectiveness, safety, and performance-enhancing benefits might be beneficial for athletes. Some of the studies cited in this review are based on observation in studies on animals. They are yet to be tested and verified for similar positive effects of supplementation in humans for different plants. A significant share of resources is required to establish evidence-based natural supplements for

consumption in the sports and fitness industry. Plant-based natural supplements will not only improve physical performance in athletes but will also protect against upper respiratory tract infections and diseases given their medicinal properties[85]. Strenuous exercise is known to affect the immune system of athletes, and the use of these supplements can overcome the negative impact via the immune-boosting properties[86]. Different formulations as combinations of other plant extracts can also be prepared and tested for their multiple benefits, including performance-enhancing abilities, just like the formulations in the Ayurvedic system for medicinal use against various ailments[7]. For example, the supplementation of Ashwagandha and Arjuna together in healthy young adultsto evaluate its effect on physical performance resulted in improved speed, lower limb muscular strength, neuro-muscular coordination, cardiovascular endurance, and muscular power[13].Future research in this area may shed new light on potential plant-based alternatives as supplements for athletes.

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