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Review Article / Derleme

Alternative protein sources in sustainable sports nutrition

Sürdürülebilir spor beslenmesinde alternatif protein kaynakları

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ABSTRACT

The rapid increase in the world's population leads to an increase in food demand. As a matter of fact, it is predicted that consumption of animal protein will double by 2050. However, increased consumption of animal protein raises climate crisis concerns as it may lead to an increased carbon and water footprint and more land use. Therefore, a sustainable sports nutrition concept is emerging for athletes with high animal protein consumption. As an alternative to animal protein sources, new protein sources are considered that can be used in athletes. In this review, the effects of plant, insect, fungal and algae-based protein sources on body composition, performance, and recovery by athletes were examined. Findings from the limited current literature reveal that: 1) vegetable protein sources are cost-effective and environmentally friendly, but they are low in sulfur containing essential amino acids, and must be consumed in large portions; 2) insect-based products have higher quality and higher protein content, but there is no consumption habit in many cultures; 3) although mycoproteins and microalgae have high protein content, they are not widely used yet due to their high production costs. In the future, it is expected that with the increase in awareness of the possible effects of animal protein production on the climate crisis, interest and research on alternative protein sources for sustainable sports nutrition will increase.

Keywords: *Plant-based protein, insect-based protein, mycoprotein, microalgae-based protein, sustainable sports nutrition*

ÖZ

Dünya nüfusundaki hızlı artış gıda talebini de arttırmaktadır. Nitekim hayvansal protein tüketiminin 2050 yılına kadar iki katına çıkacağı ön görülmektedir. Ancak hayvansal protein tüketimindeki artış, su ayak izi artışı ve daha çok arazi kullanımına bağlı olarak iklim krizi endişelerini beraberinde getirebilmektedir. Bu durum, yüksek hayvansal protein tüketen sporcular için de sürdürülebilir bir spor beslenmesi kavramının gelişmesine yol açmış olup hayvansal protein kaynaklarına alternatif olarak sporcularda kullanılabilecek yeni protein kaynakları ilgi çekmeye başlamıştır. Bu derlemede bitki, böcek, mantar ve alg bazlı alternatif protein kaynaklarının besin kalitesi ve sporcularda vücut kompozisyonu, performans ya da toparlanmaya yönelik kullanımları ele alınmaktadır. Sınırlı sayıdaki çalışmalar değerlendirildiğinde; 1) Bitkisel protein kaynaklarının uygun maliyetli ve çevre dostu olmakla beraber kükürtlü esansiyel amino asitlerden fakir olması ve büyük porsiyonlarda tüketilmesi gerekliliği dezavantaj oluşturmaktadır, 2) Böcek bazlı ürünler ise daha kaliteli ve yüksek protein içeriklidir ancak birçok toplumda tüketim alışkanlığı bulunmamaktadır, 3) Mikoproteinler ve mikroalgler ise yüksek protein içerikli olsalar da yüksek üretim maliyetleri nedeniyle henüz yaygın olarak kullanılmamaktadır. Önümüzdeki yıllarda hayvansal protein üretiminin iklim krizine olası etkilerine dair farkındalığın artmasıyla birlikte sürdürülebilir bir spor beslenmesi için alternatif protein kaynaklarına olan ilginin ve araştırmaların hız kazanacağı ön görülmektedir.

Anahtar Sözcükler: *Bitki bazlı protein, böcek bazlı protein, mikoprotein, mikroalg bazlı protein, sürdürülebilir spor beslenmesi*

INTRODUCTION

It is estimated that the world population will be 9.5 billion in 2050, and this will significantly increase the demand for food resources. Indeed, according to the report of the Food and Agriculture Organization (FAO), consumption of animal protein is expected to double in 2050, and this increase may trigger the climate crisis (1). Increase in animal protein production leads to an increased water footprint and more land use for breeding more animals and may be a major cause of deforestation, land degradation, water pollution, and desertification (2). In addition, animal protein production can cause more greenhouse gas production than vegetable protein production (2,3).

Increased consumption of animal protein may have a negative impact on individual health, as well as increased greenhouse gas emissions and biodiversity loss (4). Consumption of meat and processed meat products in excess of the recommended amounts can lead to high intakes of saturated fatty acids. This is associated with many diseases, especially cardiovascular disease and intestinal cancers (1). For this reason, interest in alternative protein sources is increasing due to their possible individual and global benefits, and it is expected that sustainable protein sources will be investigated more in future studies.

The concept of sustainable nutrition also emerges in athlete populations where animal protein consumption is the hig–

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hest. Reducing the consumption of animal protein sources and protein supplements, as well as sustainable nutrition recommendations such as reducing food waste and packaged foods, is the basis of sustainable sports nutrition (5). Within the scope of this review, plant, insect, fungus, and algae-based new protein sources that can be consumed as an alternative to animal protein sources for sustainable sports nutrition were examined with respect to their nutritional quality and their effects on body composition, performance, and recovery in athletes.

The Importance of Protein in Sports Nutrition

In 1816, French physiologist Francois Magendie pointed out to the need for nitrogen (N) food in the diet to sustain life. Later, in 1838, the term "protein" ("proteios" in Greek: primary) was used by Gerard J. Mulder to denote a radical containing complex nitrogen in both animal and plant materials. A variety of proteins are found in the musculoskeletal system (collagen, actin, and myosin), circulation (albumin and globulin), hormones, enzymes, and neurotransmitters (6). As a matter of fact, skeletal muscles, which constitute approximately 40% of the body mass of a healthy individual, contain 50-75% of all body proteins and account for 30-50% of the whole body protein turnover (7). All proteins within the body are made up of amino acids. Therefore, for a healthy protein synthesis and degradation cycle (protein turnover), the synthesis of non-essential amino acids that can be synthesized by the human body and the sufficient intake of essential amino acids that cannot be synthesized is extremely important.

Athletes have a higher daily protein requirement because their muscle protein turnover is faster than that of sedentary individuals and their muscular adaptations are at their peak (8). While 0.8 g/kg of protein intake is sufficient for a sedentary individual, the International Society of Sports Nutrition (ISSN) recommends 1.4-2.0 g/kg/day protein intake for athletes to increase and maintain muscle mass. Higher protein intake (2.3-3.1 g/kg/day) is recommended for resistance training athletes to maintain lean body mass (9).

When the recommended protein requirements cannot be met, the rate of protein synthesis decreases, and degradation increases due to the lack of amino acids required for the synthesis of new proteins. Among these amino acids, especially leucine, isoleucine and valine, which are in the branched-chain amino acids (BCAA) group of essential amino acids, increase the rate of protein synthesis by providing direct mTOR activation (10).

While animal protein sources such as meat, milk, and eggs are known as high quality protein sources due to their high BCAA content and bioavailability, legumes and cereal proteins are accepted as low-quality protein sources. However, in recent years, it has been shown that vegetable protein sources stimulate protein synthesis to the same extent as animal protein sources provided that they are consumed in an amount to provide the same amino acid content and supplemented with other foods rich in missing amino acids (11).

On the other hand, although animal protein sources rich in BCAAs are critical for the maintenance of muscle protein synthesis, the animal industry established to obtain animal protein is not sufficient to meet the increasing demand in the world. Moreover, as mentioned previously, this industry may be harmful to nature, especially with increased greenhouse gas production, and it has negative effects on health. For all these reasons, the search for alternative protein sources accelerates. In this regard, plant-based proteins, insect-based proteins, mycoproteins, and microalgae-based proteins are promising, although each has its advantages and disadvantages (Figure 1). These alternative protein sources and their use in sports nutrition are discussed in detail below.

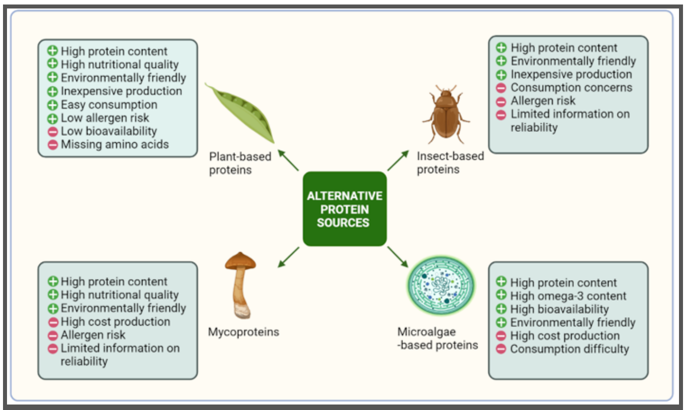

Figure 1. Advantages and disadvantages of alternative protein sources.

Plant-Based Proteins

Plant-based protein sources are good alternatives to animal protein sources due to their rich essential amino acid content and low cost (12). Soybeans and legumes are the most preferred foods among vegetable protein sources, while other foods such as beans and nuts can be used more rarely. Plant-based proteins are used, especially in vegan and vegetarian diets. On the other hand, they are increasingly preferred by omnivores due to their low cost, environmental friendliness, and positive effects on health. Plant-based diets reduce the risk of diabetes, hypertension, cardiovascular diseases, cholesterol and blood lipid levels, obesity, and many types of cancer and mortality (13,14). For example, consuming a cup of beans, chickpeas, or lentils for 90 days reduced the resting heart rate by nine beats and this value is equivalent to the effect of 250 hours of running (14). Preferring plant-based protein sources instead of animal protein sources in the diet for 12 weeks was found to be effective in decreasing blood cholesterol levels (13).

As for the nutritional quality of plant-based proteins, they are rich in flavonoids, fiber, and protein (12). For example, soybeans are a type of legume that is rich in both high-quality proteins and fats. It contains approximately 36% protein, 15% soluble and 15% insoluble carbohydrates, and %18 fat. It has the highest protein content among cereals and other legumes (15). Peas are vegetables containing various minerals, vitamins, fiber, carbohydrates, and protein. The main component of peas is starch, which makes up 50% of its dry form (16). Although peas are rich in protein content, about 24%, their methionine amino acid content is limited. Legumes are another plant-based food group rich in protein, which contains about twice as much protein as whole-grain cereals such as wheat, oats, barley and rice. Legumes are a good source of essential amino acids, especially leucine, threonine, and phenylalanine, but they are poor in methionine and cysteine (17). When the amino acid contents of plant and animal proteins are compared, most plant-based proteins contain less leucine and essential amino acids than animal proteins. However, it has been stated that if consumed sufficiently, plant-based proteins can be as effective as animal proteins in increasing protein synthesis (18).

The Effects of Plant-Based Proteins on Athletes

Studies comparing the effects of plant-based proteins and animal proteins reported similar changes in body composition (19-25), muscle protein synthesis (26,27), performance increase (19-21, 23-25) and reduction in muscle damage (28-30). For example, the consumption of 24 g of whey or pea protein before and after exercise, and between meals on non-training days during an 8-week high-intensity functional training program resulted in similar outcomes in body composition, muscle thickness, strength, and power (19). In vegan and omnivorous individuals, 1.6 g/kg protein intake from vegetable or animal sources during a 12-week resistance training program increased muscle strength and mass similarly (20).

Another study found that consumption of 50 g of pea protein or whey protein during a 12-week resistance training program led to similar increases in muscle thickness (22). Soybean and animal protein consumption during resistance exercise training similarly increased daily muscle protein synthesis (26). As a matter of fact, a meta-analysis revealed that the consumption of animal protein or soy, pea and rice proteins during resistance training affects lean mass and muscle strength similarly (23). In another meta-analysis (21), studies involving participants in different age groups (18-38 years and 61-67 years), consuming protein ranging from 18 to 85 g per day and training for 6 to 36 weeks were examined. This study (21) reported no differences in bench press power, squat/leg press power, or lean body mass between consumption of soy protein and animal protein.

Similar results are available for other vegetable protein sources. For example, consuming rice or whey protein combined with resistance training for eight weeks resulted in similar improvements in body composition, as an increase in lean mass and a decrease in fat mass (24,25), and similar outcomes in muscle strength (24,25) and anaerobic performance (25). Intake of 30 g of wheat, milk, or wheat + milk protein after exercise similarly increased the rate of myofibrillar protein synthesis (27).

Several studies examined the effects of different protein sources on muscle damage (28-30). No difference was observed in muscle damage, inflammation (CRP) or delayed muscle soreness markers between whey protein or pea protein consumption in athletes or non-obese (BMI<30) men after five days of 90-min whole body eccentric exercises (28). Shenoy et al. (29) also stated that consumption of isolated soy protein during a four week chronic exercise period, which may cause muscle damage, can help muscle recovery. Consuming 18 g of wheat protein after soccer exercise was also associated with decreased serum creatine kinase levels, suppressing the onset of delayed muscle injury (30).

In summary, current literature points that plant-based proteins increase muscle protein synthesis, and reduce muscle damage as much as animal sources. However, the size of the portions that must be consumed in order to get the necessary protein from plant sources poses a challenge for athletes. Nevertheless, it is predicted that, with the production of isolated pure proteins from plant sources, vegetable proteins may start to replace animal proteins (5). In addition to vegetable proteins, other protein sources based on insects, fungi and algae are attracting more and more attention with the development of technology.

Insect-Based Proteins

Although insects are animal species, they are sustainable foods because they cover less agricultural land compared to conventional livestock (31). Moreover, they are an alternative protein source thanks to their amino acid pattern and high protein content similar to animal proteins (31). Entomophagy, defined as the consumption of insects as food, has been common in many cultures for centuries. For instance, insects are consumed by an estimated two billion people in Africa, Asia, Central and South America, and Australia, as they are a nutritious and inexpensive food source, in addition to their taste (32). Edible insects constitute only a small part of the ~1,000,000 insect species (~2000 species) described in the world. Globally, the most commonly consumed insects are insect larvae (31%), caterpillars (18%), bees, wasps and ants (14%), grasshoppers, crickets (13%), plant bugs, scale insects (10%), termites (3%), dragonflies (3%), flies (2%) and other insects (5%) (33).

The history of entomophagy dates back to ancient times and has been included in the historical works of many societies, such as Roman, Greek, Native American, Chinese, and Australian, since 3000-9000 BC; entomophagy was present even in primates such as marmosets and tamarins. As a matter of fact, it is known that macronutrients were also obtained from insects before the development of skills for making hunting tools and hunting, but with the development of agriculture and the settlement of people, insect consumption disappeared in many societies (34).

However, nowadays, edible insect protein has become popular again, such that the annual patent applications on this subject have increased 20-fold in the last 10 years (35). Although EU legislation is cautious about insect consumption, the number of companies working on edible insects and their success in the food market is increasing. Among the reasons for this interest are many issues, ranging from the rapid increase in the world population and the inability of production to meet food demand, to the possible impact of meat production on the climate crisis. Insect farming is environmentally friendly, as insects emit significantly less greenhouse gases (GHG) and ammonia than most livestock and require less feed and water to produce than livestock. Furthermore, obtaining protein from insects is relatively cheap, and they contain the essential nutrients for humans. Insects can also be preferred due to their antifungal, antibacterial, anti-inflammatory, antioxidant, and antidiabetic properties (36). Insects are drawing attention in response to growing concerns about the future of food security around the world. It is thought that insect consumption will be acceptable in the near future, and its production as feed and food will become widespread (37).

In terms of nutritional quality, most insect-based protein sources are rich in protein, fatty acids, vitamins, fibers and minerals. Some insects, such as termites, grasshoppers, caterpillars, beetles and houseflies, are better sources of protein compared to beef, pork, chicken, and lamb (38). While 100 g of edible insects contain approximately 7-48% protein, the protein contents of the same amount of uncooked red meat, fish, and shrimp are 19-26%, 16-19% and 13-27%, respectively (39). Studies have shown that 100 g of insects contain between 400-500 kcal of energy (40), the protein content of insects ranges from 13% to 77% of dry weight, and the highest protein content is in the wasp (41). The essential amino acid content of insect-based protein sources varies between 10-30% (42).

On the other hand, since the protein content of insects is determined by multiplying the amount of nitrogen, known as the crude protein content, by 6.25, the actual protein content may be slightly overestimated due to the presence of other nitrogen-containing compounds such as chitin (36). Digestibility of insect proteins varies between 76% and 90%. Although this value is lower than that of egg protein (95%) or beef (98%), it is higher than that of most plant proteins (43). Regarding amino acid quality, many insect species meet the amino acid requirements recommended by WHO/FAO/ONU, high values being obtained for phenylalanine and tyrosine, and some insects are rich in tryptophan, lysine and threonine (44). In addition to their high protein content, insects also contain minerals such as copper, selenium, iron, zinc, calcium, magnesium, manganese and phosphorus. Insects are also rch in vitamins such as biotin, riboflavin, pantothenic acid and folic acid (45).

In summary, in addition to their high nutritional quality, they are also a good alternative protein source in terms of possible low greenhouse gas emissions due to the need for less water, energy, and land for production, as mentioned above (37). On the other hand, for the safe consumption of insects with high nutritional value, a regulatory legal framework is required to document that production practices, quality management, hazard analysis, and other aspects of nutrient content and quality meet acceptable standards. The preparation of a guideline to ensure food and nutrition safety in insect consumption according to the scientific guidelines announced by the European Food Safety Authority (EFSA) is of great importance (44).

The Effects of Insect-Based Proteins on Athletes

Insect powders can be used as a protein supplement for increasing and maintaining muscle mass due to their high protein content and potential to increase muscle protein synthesis. Studies comparing insect-based proteins to other protein sources reported that intake of insect-based proteins increases blood amino acid concentrations similarly to that intake of animal proteins (31), milk proteins (46), whey and soy protein (47). Vangsoe et al. (47) determined an increase in blood concentrations of all essential amino acids, leucine, and BCAAs 120 min after consuming 25 g of insect protein isolate. They concluded that insect protein can meet the essential amino acid requirements, and is absor–

bed slowly, as blood concentrations of amino acids were still high even 120 min after consumption (47).

It is thought that the intake of insect powder combined with carbohydrates following resistance exercise may have the potential to increase muscle protein synthesis and decrease muscle protein breakdown (31). It has been shown that 30 g of worm protein or milk protein supplementation after resistance exercise increases muscle protein synthesis at a similar rate, and no difference was observed between the two protein sources in terms of digestion, indicating that insect protein can be used as an alternative to milk protein (46). Another study (48) stated that although muscle strength and lean body mass increased in participants who consumed insect protein supplements or isocaloric carbohydrates during an 8-week resistance training program, there was no significant difference between the groups. However, the authors stated that the high protein consumption habits of the participants might also have been effective in not observing the benefit of insect supplementation (48).

Mycoprotein

Food scientists' search for new food sources began with single-cell proteins from bacteria and yeasts (49). However, many bacterial and yeast proteins have been found to cause side effects. The focus of research, therefore, turned to microfungi, and in 1967, a fungus (Fusarium venenatum) that could be converted to mycoprotein was described in Marlow, Buckinghamshire, UK. It was not until the 1980s that the mycoprotein obtained from these fungi could be produced to the extent that it would be a new protein food (50). After a decade-long safety assessment, mycoprotein was approved for human consumption in the UK in 1983 (51). Following this approval, a study (50) revealed that consumption of cookies containing 20 g of mycoprotein per day in addition to the daily diet did not have any side effects on blood values or gastrointestinal and dermatological parameters. In 2002, mycoprotein was recognized as "generally safe" by the US Food and Drug Administration (FDA), and seven mycoprotein products were introduced in the United States (52).

Mycoprotein production is obtained by fermentation from the fungus Fusarium venenatum (52). The cytoplasm of Fusarium venetatum contains high-quality proteins, while the cell membrane contains high amounts of unsaturated fatty acids and fiber (12). It is known that 100 g of dry Fusarium venenatum contains 45 g of protein, 13 g of fat, 10 g of carbohydrates, and 25 g of high fiber, and that its amino acid composition is similar to that of dairy products (15). However, its iron and vitamin B12 content is low compared to red meat. On the other hand, mycoprotein is a good source of zinc (9.0 mg/100 mg wet weight) and selenium (20 mg/100 mg wet weight) (52). It has also been demonstrated that mycoprotein may be effective in reducing cholesterol (50,53,54) and improving the glycemic profile (52,55,56).

The Effects of Insect-Based Proteins on Athletes

Since mycoprotein is a nutrient rich in terms of many amino acids, especially in leucine (6% of the total protein), and has a high bioavailability (57), it can be used in studies aimed at stimulating muscle protein synthesis and providing adaptation to training (58-60). Although consuming 40 g of mycoprotein (18 g of total protein) is sufficient to initiate the stimulation of muscle protein synthesis, ideally, 60 g of mycoprotein (27 g of total protein) is recommended for optimal stimulation. In addition, its bioavailability increases in a dose-dependent manner up to consumption of 60-80 g mycoprotein (i.e., 27-36 g protein; 2.1-2.9 g leucine) (58).

In resistance-trained healthy young males, mycoprotein intake (31.5 g of protein per 70 g) increased the rate of muscle protein synthesis at rest and after a bout of resistance exercise more compared to milk protein (26 g of protein per 31 g) (60). Therefore, the authors suggested mycoprotein as a source that can stimulate muscle protein synthesis due to its high protein content, and thus be included in the diets of individuals who regularly do resistance training (60).

In another study (59), consumption of 35 g of BCAA-enriched mycoprotein beverage (18.7 g protein, 2.5 g leucine, 1.5 g isoleucine, and 1.9 g valine) stimulated muscle protein synthesis at rest and after resistance exercise. Moreover, more muscle protein synthesis occurred as the amount of mycoprotein consumed increased. Since the increase in the amount of consumption affects the plasma BCAA concentrations to a small extent, it has been thought that mycoprotein is responsible for the increased muscle protein synthesis (59).

Microalgae Based Proteins

Single-celled algae, known as microalgae, have existed for over a billion years, play a vital role in the food chain of aquatic organisms, and are widely used as feed for aquatic animals such as mollusks, shrimps and fish (61). Besides animal feed, algae are also used for various biotechnological purposes including cosmetics, fatty acid production, wastewater treatment and biofuel. Various advanced technologies are used worldwide for the mass production and processing of microalgae, and the annual production of all microalgae species in the world is estimated to be around 10,000 tons (61).

In addition to their use in various fields, the interest in algae as a food source for humans increased in the early

20thcentury. For instance, Arthrospira platensis (Spirulina) and Chlorella vulgaris (Chlorella) are sold as functional foods due to their high vitamin and mineral content (62), and are recognized as safe by the European Food Safety Authority (EFSA). Microalgae also come to the fore with their positive effects on health. For example, they reduce blood glucose and cholesterol levels, regulate blood pressure, and increase hemoglobin concentration (63,64). Since it is an ideal and compact food, it has even been put on the agenda by the National Aeronautics and Space Administration (NASA) to add it to the diet of astronauts in space (65). Despite all these positive effects, it is not common enough because of its powder-like consistency, dark green color, and especially its light fishy smell. Due to these properties, its use as a protein enrichment in traditional foods is limited. On the other hand, production costs of microalgae are too high to compete with traditional protein sources, which prevents their mass production and availability in the market (66).

Microalgae have a very high nutritional quality comparing to conventional plants. The protein content of microalgae varies between species, and according to environmental conditions. Renaud et al. reported that more protein is available in diatoms compared to chlorophyte members (67). Spirulina, Scenedesmus and Chlorella have been accepted as unicellular protein sources due to their 40-70% protein content (68). Arthrospira platensis is a cyanobacteria with the highest protein content recorded among all foods. Algae protein is a source of all amino acids, especially glycine, alanine, arginine, proline, glutamic and aspartic acids. In microalgae, essential amino acids make up about half of the total amino acids, and their amino acid profiles are similar to those of eggs (69). In addition to their rich protein content, microalgae are also rich in many nutrients such as peptides, carbohydrates, lipids, vitamins, pigments, minerals and other valuable trace elements (67). They are also a source of vitamins A, B1, B2, B6, B12, C and E, and minerals such as potassium, iron, magnesium, calcium and iodine (70). Carbohydrates play an important role in the digestibility of algae. The carbohydrates of algae are in the forms of starch, cellulose, sugars, and other types of polysaccharides (67).

The Effects of Microalgae Proteins in Athletes

The use of microalgae in sports nutrition due to their rich protein content is being investigated (71-74). For instance, anthropometric measures and physical performances of 21 elite rugby players were investigated after consuming Spirulina platensis (5.7 g/day) for seven weeks. The study revealed that microalgae consumption did not affect body composition, jump performance, maximum leg strength, or aerobic capacity differently compared to placebo (71). In another study (72), consumption of 6 g/day of Spirulina for 21 days increased hemoglobin concentration, decreased lactate and heart rate during submaximal exercise, and increased power output in repeated sprint performance.

The effects of microalgae intake in combination with exercise in obese individuals have also been studied (73,74). Intake of 500 mg of spirulina twice a day combined with HIIT training for four weeks increased serum nesfatin-1 levels in women with obesity but did not affect blood lipid levels (73). On the other hand, intake of chlorella vulgaris (300 mg capsules three times a day) in addition to an 8-week HIIT program training in women with obesity decreased body fat mass, and increased markers of mitochondrial biogenesis in plasma (74).

CONCLUSION

It is well known that animal proteins are used by athletes in high amounts. However, high animal protein use triggers the climate crisis and negatively affects individual health. New protein sources based on plants, insects, fungi and algae, which can be used as an alternative to animal protein sources for sustainable sports nutrition, have attracted attention in recent years. Among the alternative protein sources, vegetable protein sources come forward due to their cost-effectiveness and environmental friendliness, but they possess disadvantages such as incomplete amino acid patterns and the need to be consumed in high amounts. Insect-based products, another alternative protein source, have high quality and high protein content, but there are cultural concerns about their consumption. Although mycoproteins and microalgae attract attention owing to their high protein content, they are not yet widespread due to high production costs and especially the consistency and odor of algae. It is predicted that the interest and research on alternative protein sources in sustainable sports nutrition will increase with the increased awareness of the possible effects of animal protein production on the climate crisis in the future.

Conflict of Interest / Çıkar Çatışması

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