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REVIEW ARTICLE

The effects of fresh foods on performance: A review

Nevruz CİN[1], Seda ÇİFTÇİ[2]

[1] Department of Nutrition and Dietetic, Faculty of Health Science, Izmir Democracy University, Izmir, Türkiye. [2] Department of Nutrition and Dietetic, Faculty of Health Science, Izmir Democracy University, Izmir, Türkiye.

Abstract. In recent years, it is gradually becoming important for athletes to show sufficient performance at competitions. To improve performance, athletes use ergogenic aids such as protein powders, creatine, and glutamine. However, recent research has also been conducted into the possible ergogenic effects of several fresh foods on exercise. Nutrients show the ergogenic effect by having macro and micronutrients, antioxidants, vitamins, minerals, and bioactive components. These potential ergogenic effects include muscle recovery, prevention of oxidative stress caused by exercise, improved performance, and inhibition of muscle damage. The purpose of this review was to examine the nutritional content and the effects of fresh foods such as beets, cherries, watermelon, tomatoes, grapes, and pomegranate.

Keywords. Ergogenic aid, fresh fruits, sport performance.

Introduction

Ergogenic means increasing the tendency to do work and increasing the tendency to produce work. In the field of sports, it includes techniques that improve energy production and performance, facilitate recovery after exercise, and facilitate adaptation to rigorous training (Bayram & Öztürkcan, 2020). Ergogenic aids are classified according to; muscle strength and recovery, improving exercise metabolism, reducing body fat, supporting the immune system, and meeting fluid and electrolyte needs (Porrini & del Bo, 2016). Ergogenic aids support athletes in competitions by demonstrating ergogenic effects such as muscle recovery, prevention of muscle damage, increased performance and capacity during training, and are preferred by athletes (Mut, 2018). However, if ergogenic supplements are not used in safe doses, they can negatively affect the athlete's health; for example, energy drinks may cause various side effects, including anxiety, headaches, nausea, organ failure, heart disease, etc. (Tatlibal et al., 2021). In recent years, studies have shown that fresh foods and their extracts have an ergogenic effect due to their macro and micronutrient content (Costa et al., 2022). These foods, which show ergogenic effects, are generally; curative effects against oxidative stress and inflammation come to the fore. In addition to these effects, these foods also show special effects that increase performance in sports, alleviate muscle damage, and stimulate protein synthesis (van der Avoort et al., 2018). Among foods with ergogenic effects, especially beet, watermelon, grape, tomato, blueberry, blackcurrant, and sour cherry are the main foods and are preferred (Costa et al., 2022). Beets are rich in dietary nitrate, and dietary nitrate consumption increases plasma nitrate levels (Woessner et al., 2018). Due to the nutritive content of beet juice, especially its nitrate content, it provides anti-inflammatory, antioxidant and vasodilator effects, making it one of the most consumed beverages among athletes (Smirnova et al., 2022). Watermelon is a source of L-citrulline, and short-term supplementation with L-citrulline has been shown to

✉ N. Cin, e-mail : diyetisyennevruzcin@gmail.com

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enhance skeletal muscle metabolism, force production, and resistance to exhaustion. Additionally, it has been suggested that taking supplements of L-citrulline can boost nitric oxide synthase activity and nitric oxide indicators (Bailey et al., 2016). Tomato's lycopene content helps to prevent the formation of lactate dehydrogenase in the muscles as a result of exercise and prevents exercise-induced oxidative stress through antioxidant vitamins (Samaras et al., 2014). Due to the high concentrations of phenolic compounds in grapes and their derivatives, including its juice, which has antioxidant, and anti-inflammatory activities, it can help prevent the formation of reactive oxygen species and exerts its ergogenic effects in this way (Martins et al., 2020). Thanks to the antioxidant effects of anthocyanins in cherries, they prevent the formation of ROS and prevent skeletal muscles, thus showing ergogenic effects (Santos et al., 2021). Finally, pomegranate can provide ergogenic benefits by increasing the passage of oxygen to muscles thanks to its nitrate and polyphenol content (D'Angelo & Rosa, 2020). The purpose of this review is to consider fresh foods that have the potential to have ergogenic effects and to evaluate their effects on the performance of athletes.

Beet and Beet Juice

Beetroot is a bright red vegetable that belongs to the *Chenopodiaceae* family. It is a significant vegetable in terms of its phytochemical content and minerals, vitamins, and nutritional content (Ceclu & Nistor, 2020). Beet; has carbohydrates such as starch, fructose, sucrose, glucose, dietary fiber, and a small amount of protein (Chhikara et al., 2019). In one hundred grams of the edible part of the beet contains; 88.17 g water, 8.02 g carbohydrates, 1.28 g dietary fiber, 2 µg vitamin A, trace amounts of B group vitamins niacin, riboflavin, thiamine, 3.6mg ascorbic acid, 80 µg folate and 77 mg Na, 16 mg Ca, 0.79 mg Fe and minerals such as 38 mg P, 305 mg K, 23 mg Mg and 0.35 mg Zn (Türkomp, 2022). Beetroot also has betalains, carotenoids, polyphenols, flavonoids, saponins, and high levels (Hadipour et al., 2020). Another significant feature of beetroot is that it meets 50-85% of dietary nitrate, thus increasing the content of nitrite and nitrate after consumption (Rg et al., 2018). With the highest nitrate and sugar content among natural foods, it has an increasing energy effect on athletes, and its importance is increasing daily (Lotfi et al., 2019). Studies have shown that beetroot has ergogenic effects. Beet juice contains high inorganic nitrate (NO_3^-) and is preferred as a supplement (Domínguez et al., 2017). When taken orally, NO_3^- is reduced to NO_2^- (nitrite) in the oral cavity by anaerobic bacteria and then to NO (nitric oxide) in the stomach via nitrate reductase enzymes. Nitrite, after passing through the acidic stomach, decomposes into NO and other nitrogen oxides, which perform certain physiological functions. Nitrate and nitrite pass from the intestines to the circulation and are then converted to bioactive NO in tissues and blood in case of physiological hypoxia (Ranchal-Sanchez et al., 2020). NO production accelerates in hypoxic conditions; therefore, it is produced in the parts of the muscles where oxygen is used or depleted more. NO supplies vasodilation of skeletal muscle, thus increasing blood flow to the muscles, creating potential effects in sports (Mosher et al., 2016). Supplementation of dietary NO3 prior to exercise has been shown to have significant effects on submaximal exercise efficiency, tolerance to high intensity exercise, and performance against time. These effects of nitric oxide: A decrease in the decomposition of phosphocreatine is associated with a reduced accumulation of oxidative stress metabolites (Kent et al., 2018). In the study of Muggeridge et al. (2014), nine cyclists were subjected to three beginner-level exercise trials. While beet juice was not supplemented in the first period, 70 ml of beet juice was added in the second and third periods. Maximum oxygen consumption levels, plasma nitrate, plasma nitrite levels, and trial performance against time were monitored before and after exercise. According to the results, plasma nitrate and nitrite levels were higher in the beetroot juice group compared to the placebo group, while the maximum oxygen consumption was lower than in the placebo group. Furthermore, it was concluded that the performance and speed of the beet juice group with time were higher than that of the placebo. In the study of Kozlowska et al. (2020), 20 athletes (10 men, 10 women) were subjected to 3 training sessions, each lasting 4 weeks. Parameters of maximum oxygen capacity, oxidative stress, inflammation, and skeletal muscle damage were monitored before and after each workout. After the first period of the study, the participants were given a diet and in the last period, beet juice supplement was given in addition to the diet. The maximum oxygen uptake capacity was significantly higher in the diet and beet juice group.

Watermelon and watermelon juice

Watermelon (*Citruluslanatus*) is an exotic fruit containing antioxidant and bioactive compounds that have been reported to have positive effects on health (Rawson et al., 2011). Water makes up 93% of the weight of a watermelon, the rest being its fleshy structure (Mohamad Salin et al., 2022). Watermelon is rich in antioxidant carotenoids and lycopene, the precursor of ß-carotenoids, as well as contains many amino acids, including L-citrulline (Ridwan et al., 2019). Hydroxycinnamic acid and its derivatives, phenolic compounds, and ascorbic acid are also found in watermelon and the watermelon juice (Ilahy et al., 2019). In one hundred grams of the edible part of the watermelon; It contains 91.4 g of water, 7.55 g of carbohydrates, 0.4 g dietary fiber, 7 mg Ca, 10 mg magnesium, 11 mg of P, 112 mg K, 8.1 mg vitamin C, 4530 µg lycopene and trace amounts of vitamins of the B group (USDA, 2019c). Athletes prefer watermelon and watermelon juice due to the positive effects of L-citrulline on sports performance (Cutrufello et al., 2015). L-citrulline shows positive effects on resistance and strength exercises, performance against time, and provides recovery after exercise. It shows these effects by increasing blood flow to muscles (Gonzalez & Trexler, 2020).

In the study of Blohm et al. (2019), 34 untrained men and women volunteered to assess heart rate response and muscle fatigue after submaximal exercise on a bicycle ergometer. Participants were divided into four groups to consume 355 ml of water, sugar water, watermelon juice, and Gatorade energy drink before exercise. The participants made four laboratory visits for two days of purification. It was observed that the change in heart rate and muscle fatigue after cycling exercise did not differ significantly between the groups, and diastolic blood pressure did not change in the women who consumed watermelon juice and increased in other groups. According to the study, the fact that L citrulline had a vasodilator effect was the reason why blood pressure did not increase in women in the watermelon juice group.

Cherry and cherry juice

Cherry belongs to the *Rosaceae* group, which is a stone fruit family. It has phytochemicals such as polyphenols, phenolic acids, and flavonoids, which have antioxidant and anti-inflammatory effects, and its phytochemical content is intensely composed of anthocyanins, hydroxycinnamic acid, and flavon-3-ols (Sabou et al., 2020). In one hundred grams of the edible part of the cherry; 82.2 g water, 16 g carbohydrates, 2.1 g dietary fiber, 13 mg Ca, 0.36 mg Fe, 11 mg Mg, 21 mg P, 222 mg K, 7 mg vitamin C, 4 µg folate, 38 µg It has ß carotene, 2.1 µg vitamin K (USDA, 2019a). Cherry has been shown to reduce muscle damage after intense exercise and has significant effects on physiological pathways that prevent diseases from developing in the skeletal musculature (Kelley et al., 2018). The antioxidant content of cherries and phytochemicals, such as anthocyanin, protects balance and promote strength recovery from exercise in strength and resistance exercises (Santos et al., 2021). In the study by Keane et al. (2018), ten trained male cyclists were divided into two groups. Participants were divided into two groups as those who consumed cherry juice and those who consumed a placebo drink. After hydration, the cyclists were subjected to a 6-minute moderate to vigorous marathon. Before and after fluid intake, participants' blood pressure, tissue oxygenation index, and plasma nitrite concentrations were measured. Compared to the placebo group, cyclists who consumed cherry juice had a lower systolic blood pressure and the time to exhaustion was 10% longer. In the study by Howatson et al. (2010), twenty marathon runners were divided into two groups those who consumed cherry juice and those who consumed a placebo. Creatine kinase, lactate dehydrogenase, muscle pain, isometric strength, and interleukin-6 (IL-6), C-reactive protein (CRP), and uric acid levels, which are markers of muscle damage, were examined. In addition to these markers, total antioxidant status and oxidative stress markers were monitored. The isometric strength showed a rapid improvement in the group that consumed cherry juice. While inflammation was lower in the cherry juice group, the total antioxidant level was higher. In addition to this study, it was discovered that cherry, cherry juice and cherry concentrate had significant effects on muscle recovery, exhaustion time, endurance, and sports performance in other studies. Table 1 supplies a summary of the studies.

Table 1
Studies on food with potential ergogenic effects on humans.

Author/Year	Study design	Population	Exercise Protocol	Intervention	Monitored parameters	Results
(Muggeridge et al., 2014)	Crossover Randomized Double Blind	9 male trained cyclists	5 min cycling at 50 followed by 5 min stretching, 1 w later 16.1 km time trial cycling at 60% $WR_{max.}$	70 ml of beetroot juice having 5 mmol of nitrate 3 h before the exercise	Plasma NO_3^- and NO_2, Diastolic Blood Pressure, Systolic Blood Pressure, VO_2, SpO_2, 16.1 km TT performance	↑Plasma NO_3^- and NO_2 ↓Diastolic Blood Pressure and Systolic Blood Pressure, ↓VO_2, ↑SpO_2, ↑Time trial performance
(Kozłowska et al., 2020)	Controlled Intervention Design	10M and 10F elite fencers	VO_{2max} test	Diet with 26 g of freeze-dried beetroot juice before the physical test for 4 w	VO_{2max}, LDH, MDA, CK, IL-6, GPx activities,	↑VO_{2max}; ↑LDH ; ↑MDA; ↑CK; ↓IL-6; ↑GP_x activities
(Blohm et al., 2019)	Crossover Randomised Design	13 M and 14 F untrained healthy participants	Stationary bike cycling test: 3 min of warm up at 20 watts followed by increased work rate at a rate of the 20 W/min until 80% of predicted HRmax is achieved.	355 mL watermelon juice prior to submaximal exercise	$HR_{max,}$ SBP, DBP, Muscle Soreness, Blood Lactate, Blood Glucose	Prevented an increase in SBP, DBP No effect of WJ on $HRmax_,$ Muscle Soreness, Blood Lactate, Blood Glucose
(Keane et al., 2018)	Crossover Randomized Placebo-Controlled Double-blind	10 M cyclists	Incremental test: 3 min baseline cycling at 0 W, increased work rate at a rate of 30 W/min until the tolerance limit, Followed by 2 moderate step exercise tests to severe intensity.	60 ml Montmorency Tart Cherry concentrate diluted with 100 mL water	Pulmonary VO_2 kinetics, Exercise Performance, SBP, Plasma NO_2^-, Plasma NO_3^-, Plasma Lactate	No significant effect on Pulmonary VO_2 kinetics, No significant effect on exercise performance; ↓SBP; No significant effect on Plasma NO_2^-, Plasma NO_3^-, No significant effect on Plasma Lactate
(Howatson et al., 2010)	Pseudo-randomized Placebo-Controlled	13 M and 7 F participants	Marathon Running	Two 8 fl oz bottles of a commercially available tart cherry juice blend the day before Marathon and 48 h after Marathon for 8 d	Muscle Damage Indices (CK, LDH), IL-6, CRP, Total Antioxidant Status,	↓CK; ↑LDH; ↓IL-6; ↑TAS ↓CRP

↑: statistically significant increase, ↓: statistically significant decrease, CK: creatine kinase , CO: Cardiac output, CPK: Creatinine phosphokinase ,CRP: C-reactive protein, DBP: diastolic blood pressure, F: female, FMD: Flow Mediated Dilatation, GJ: grape juice, GJG: grape juice group, GP_x :Glutathione peroxidase, GSH: glutathione, HDL-c: high density lipoprotein cholesterol, $HR_{max,}$: maximum heart rate, IL-6: : interleukin-6, LDH: lactate dehydrogenase , LDL-c: low density lipoprotein cholesterol, M: male, MAP: Mean Arterial Pressure, MDA: malondialdehyde, NO_3^- :nitrate, NO_2 :nitrite, RPP: Rate×Pressure Product, SBP: Systolic blood pressure ,SpO_2:oxygen saturation, SV: Stroke volume, TAS: Total Antioxidant Status, TBARS: Thio barbituric acid reactive substance , TJ: tomato juice, TT: Time trial, TVC: Total Vascular Conductance,VO_{2max} : maximal oxygen consumption, WJ: watermelon juice; w:weaks; d: days.

Table 1
Studies on food with potential ergogenic effects on humans (**continued**)

Author/Year	Study design	Population	Exercise Protocol	Intervention	Monitored parameters	Results
(Pour Khavari & Haghdoost, 2020)	Controlled Interventio n Design	11 M and 5 F healthy individuals.	Extensive physical exercise by cycling about 20 min until HRmax reached 80%, and repeated 3 times	100 mL/d tomato juice before and after the exercise for 3 w	8-Oxo-dG	Before and after exercise 8-Oxo-dG concentrations the same.
(Samaras et al., 2014)	Randomize d Placebo-Controlled	31 ultra-marathon runners	Years of training, Miles per w, Training sessions for w	Tomato juice before the marathon fot two months	Flow mediated dilatation, Oxidative status (TAC, TBARS), Common parameters (HDL-c, LDL-c, glucose, triglycerides, cholesterol)	↑FMD; ↑TAC; ↓TBARS GSH level unchanged. ↓Serum glucose; ↓LDL-c,↓Total cholesterol.
(Tsitsimpikou et al., 2013)	Randomize d Placebo-Controlled	11M and 5F trained athletes	Anaerobic training	Tomato juice during and after the exercise for 2 m.	LDH, CRP, CPK, homocysteine.	TJ reduced LDH and CPK, attenuated the CRP and homocysteine.
(Toscano et al., 2015)	Randomize d Placebo-Controlled	28 runners	Cardiopulmonary exercise test followed by time to exhaustion running exercise.	10 mL/kg/day purple grape juice supplementa tion prior and at once after the training for 28 d.	TAC, MDA, CRP, Time to exhaustion, CK, LDH	GJG showed an increase in running time to exhaustion exercise.↑TAC: CRP levels did not change.LDH and CK N/C; ↑MDA levels indicated that GJ supplementation did not prevent lipid peroxidation.
(Kim et al., 2018)	Crossover Randomize d Double Blind	9 prehypertens ive men.	2 min of unloaded cycling followed by in by increases of 30 W/min until the tolerance limit, Subjects then completed the pre-arranged submaximal cycling exercise (5 min at a peak of 40% VO2 followed by 5 min at 60% VO_2 peak.)	300 mg grape seed extract capsule form before and after the exercise.	Mean Arterial Pressure (MAP), Cardiac Output (CO), Stroke Volume (SV), Total Vascular Conductance (TVC), Rate×Pressure Product (RPP), Flow Mediated Dilatation (FMD).	↓MAP; ↓RPP; ↑SV; ↑CO ↑TVC; ↑FMD; GSE lower the blood pressure in prehypertensive men.

↑: statistically significant increase, ↓: statistically significant decrease, CK: creatine kinase , CO: Cardiac output, CPK: Creatinine phosphokinase ,CRP: C-reactive protein, DBP: diastolic blood pressure, F: female, FMD: Flow Mediated Dilatation, GJ: grape juice, GJG: grape juice group, GP_x :Glutathione peroxidase, GSH: glutathione, HDL-c: high density lipoprotein cholesterol, $HR_{max,:}$ maximum heart rate, IL-6: : interleukin-6, LDH: lactate dehydrogenase , LDL-c: low density lipoprotein cholesterol, M: male, MAP: Mean Arterial Pressure, MDA: malondialdehyde, NO_3^- :nitrate, NO_2 :nitrite, RPP: Rate×Pressure Product, SBP: Systolic blood pressure ,SpO_2:oxygen saturation, SV: Stroke volume, TAS: Total Antioxidant Status, TBARS: Thio barbituric acid reactive substance , TJ: tomato juice, TT: Time trial, TVC: Total Vascular Conductance,VO_{2max} : maximal oxygen consumption, WJ: watermelon juice; m: months; w:weaks; d: days; N/C: Not cha.

Tomato and tomato juice

Tomato (*Solanum Lycopersicum L.*), which is often included in the Mediterranean diet and widely consumed, plays a significant role in nutrition due to its health benefits (Salehi et al., 2019). Tomato contains minerals, vitamins, proteins, essential amino acids leucine, threonine, valine, histidine, lysine, arginine, monounsaturated fatty acids linoleic and linolenic acids and carotenoids, phytosterols. Lycopene is the essential dietary carotenoid of tomatoes and has high antioxidant activity (P. A. Silva et al., 2019). In 100 grams of the edible part of the tomato; 94.7 g of water, 3.84 g of of carbohydrates, 1 g dietary fiber, 10 mg Ca, 0.1 mg Fe, 8.1 mg Mg, 19 mg P, 193 mg of K, 2.5 mg Na, 17.8 mg vitamin C, 10 µg folate, 276 µg ß carotene and 2860 µg of lycopene (USDA, 2019b). Exercise leads to the formation of ROS (reactive oxygen species), and the production of moderate reactive oxygen products is necessary to achieve physiological adaptation to exercise. However, excessive ROS production causes an antioxidant imbalance and, as a result, oxidative stress develops (Kawamura & Muraoka, 2018). As a result of oxidative stress, lipid peroxidation develops and as a result, biological markers such as MDA (malondialdehyde) and 8-isoprostane are formed. Thanks to its lycopene content, tomatoes prevent ROS formation of ROS and prevent oxidative stress in athletes (Gholami et al., 2021). There are studies supporting that tomatoes have ergogenic effects. In the study of Ali et al. (Pour Khavari & Haghdoost, 2020), 16 participants demonstrated cycling performance by maintaining a maximum heart rate of 80% for 20 minutes. Cycling exercise was repeated for three weeks before tomato juice supplementation and three weeks after tomato juice supplementation. 8 oxo-dG, a marker of oxidative stress, was examined before and after activity. According to the results, 20 minutes of intense physical activity caused an increase in 8 oxo-dG levels, while 100 ml of tomato juice consumption prevented an excessive increase in 8 oxo-dG levels during 20 minutes of physical activity. In one research, tomato juice was reported to prevent vascular endothelial damage, as well as oxidative stress. Antonios et al. (Samaras et al., 2014) In this study, ultramarathon runners were given a bar and tomato juice supplement containing a certain amount of carbohydrates and whey protein. At the beginning and end of the study, endothelial function markers and oxidative stress markers were monitored. According to the results, while endothelial function markers increased in both groups, the increase rate in the tomato juice group was found to be significantly higher. According to the results obtained from the study, tomato juice prevents oxidative stress and positively affects endothelial function. Lycopene in tomatoes also reduces the levels of creatine phosphokinase and lactate dehydrogenase, which are biological markers of muscle damage. Tsitsimpikou et al. (Tsitsimpikou et al., 2013) evaluated the response of tomato juice consumption before anaerobic training to lactate dehydrogenase and creatine phosphokinase responses. Fifteen athletes were included in the study, and 9 of the participants were asked to drink tomato juice instead of the carbohydrate-containing sports drink they frequently consume, and the remaining 6 participants were asked to continue to consume carbohydrate-containing sports drinks. At the end of the two months, the blood parameters of the athletes were examined, and it was concluded that the levels of lactate dehydrogenase and creatine phosphokinase returned to almost the baseline level and the level of decrease in the lactate dehydrogenase was 63% in the tomato juice group.

Grape and grape juice

Grape (*Vitis vinifera L. Vitaceae*) has been used for centuries in the production of beverages such as wine and fruit juice as well as in human nutrition due to its structure and antioxidant content (Kandylis, 2021). According to studies conducted in recent years, grape seed, skin, and pulp contain significant levels of phytochemicals and phenolic compounds. Grape contains triterpenoid oleanolic acid and betulinic acid as well as E-resveratrol, gallic acid, catechin and gallocatechin (Dutra et al., 2021). In 100 grams of the edible part of grapes, there are 78.2 g water, 20.2 g carbohydrates, 10 mg Ca, 0.16 mg Fe, 8.6 mg Mg, 25 mg P, 229 mg K, 7 mg Na, and 3.3 mg vitamin C (USDA, 2022). Studies on the ergogenic effects of grapes have concluded that grapes increase antioxidant capacity, prevent oxidative stress that develops after sports, positively affect athlete performance, significantly increase the time to exhaustion, and prevent cell damage (Elejalde et al., 2021). In the study conducted by Toscano et al. (Toscano et al., 2015) on 28 volunteer runners, the participants were divided into two groups. While the first group was supplemented with grape juice, the second group was supplemented with isolarolic beverages. Oxidative stress, immune response, markers of inflammation, muscle damage, time to exhaustion, aerobic capacity test, and anaerobic threshold test were monitored within 48 hours after onset and supplementation. According to the results, grape juice supplementation increased the time to exhaustion during exercise, without affecting aerobic capacity or the anaerobic threshold. Grape juice supplementation was also found to increase antioxidant capacity and did not significantly change the level of C-reactive protein, which is an inflammation marker. In a study conducted by Kim et al. (Kim et al., 2018) on male students at Kyung Hee University, participants were divided into two groups to receive a single dose of placebo (300 mg starch) or grape seed extract (300 mg). Two hours after the placebo and grape seed extract supplementation, in the groups; systolic blood pressure, diastolic blood pressure, mean arterial pressure, cardiac output, and total vascular conductivity values were compared 2 hours after the cycling marathon. According to the results, the placebo did not affect the parameters. Single-dose grape seed extract supplementation reduced blood pressure and peripheral vasoconstriction while increasing oxygen transfer to tissues. It has been suggested that these effects of grape seed extract on exercise are achieved by providing endothelium-dependent vasodilation.

Pomegranate and pomegranate juice

Pomegranate (*Punica granatum L.*) is a fruit belonging to the *Lythraceae* family. The high anthocyanin content gives the pomegranate a red color. In the food content, there are gallic acid, caffeic acid from phenolic acids, citric acid, and malic acid (Khomich et al., 2019), the flavonoid content consists of anthocyanins such as pelargonidin, delphinidin, cyanidin, and its derivatives, and anthoxanthins such as catechin, and epicatechin (Singh et al., 2018). In one hundred grams of the edible part of the pomegranate, 77.9 g of of water, 18.7 g of carbohydrates, 4 g dietary fiber, 10 mg Ca, 0.3 mg Fe, 12 mg Mg, 36 mg P, 236 mg of K, 3 mg Na, 10.2 mg vitamin C, 38 µg folate and 16.4 µg vitamin K (USDA, 2019d). Pomegranate shows its ergogenic effect thanks to the anthocyanins it contains. Anthocyanins and antioxidants prevent oxidative stress, the formation of oxidative stress markers, lipid oxidation, and cell inflammation (Afaq et al., 2005). Although the mechanisms of the effect on noncommunicable diseases have been explained, the mechanisms of its potential effects on physical performance have not (Ammar et al., 2017). However, according to some sources, the ergogenic mechanism of action of pomegranate is associated with the high bioavailability of the polyphenols in its content (Seeram et al., 2008). Although physical activity causes an increase in inflammation markers associated with muscle damage and oxidative stress, it is a versatile and powerful physiological factor that also causes muscle weakness and muscle pain during the recovery period after exercise (Trombold et al., 2010). Through antioxidant vitamins and phenolic compounds in pomegranate, oxidative stress can be prevented. The effects of pomegranate on exercise are summarized as follows; It has been found to increase blood flow, delay exercise-induced fatigue, provide muscle recovery after exercise, increase exercise performance and muscle strength, and positively affect cardiovascular responses such as blood pressure and heart rate (d'Unienville et al., 2021). In the study by Trombold et al. (Trombold et al., 2011), which examined the effect of pomegranate on strength recovery and fatigue after eccentric exercise, seventeen male trained male participants were divided into two groups to consume 250 ml of pomegranate juice or the same amount of placebo drink. The supplements were consumed 2 times a day, 12 hours apart, for 15 days. Excentric exercise was performed on the eighth day of the intervention, and post-exercise supplements were continued. Muscle pain, maximum isometric elbow flexion, and knee extension strength measurements were measured at the beginning and second, 24th, 48th, 72nd and 96th hours after exercise. Elbow flexion strength was found to be higher in the group with pomegranate juice supplementation over a 2–168-hour period, and elbow flexor muscle pain was decreased in the pomegranate juice group compared to placebo. According to the study's results, pomegranate juice reduces pain during exercise and enhances strength recovery afterward. In another study, the effects of pomegranate juice on blood flow, blood pressure, oxygen saturation, and heart rate were examined. The study included nineteen participants who received recreational resistance training and were divided into two groups, consuming 100 ml of pomegranate extract or the same amount of placebo 30 minutes before the repeated sprint test and leg press exercise. Blood flow and vessel diameter increased in the group supplemented with pomegranate extract, but there was no significant difference in leg press exercise performance between the two groups. According to the results, athletes can benefit from the consumption of pomegranate in capsule form due to its ergogenic effects (Roelofs et al., 2017).

Conclusion and Recommendation

According to this review, fresh foods such as beets, pomegranates, grapes, tomatoes, and watermelon have potential ergogenic effects on exercise and can be replaced with sport drinks. Beets show ergogenic effects through nitric oxide, which increases blood flow to the blood vessels in the muscles; tomato exerts ergogenic effects through lycopene, which has an antioxidant effect on exercise-induced oxidative stress; watermelon exerts ergogenic effects through L-citrulline, which can be converted to nitric oxide; Grapes, cherries and pomegranates show ergogenic effects thanks to their phenolic content. Based on the results of the studies in this review, these fresh foods commonly increase the performance of the time to exhaustion, increasing the time trial, lower blood pressure during the exercise, increasing the antioxidant capacity, increasing blood flow to muscles, preventing muscle damage, and accelerating muscle recovery. The current data support that these fresh foods are able to enhance athletic performance however, studies did not determine definitive conclusions regarding the dosage of these fresh foods, extracts, and juices, and how long before exercise should be consumed. Furthermore, beet is one of these fresh foods that has been the subject of more studies than others, and since research on other foods is also debatable, additional studies will be required in the future.

Authors' Contribution

Study Design: NC, SÇ; Manuscript Preparation: NC, SÇ.

Conflict of interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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