Journal of Pioneering Medical Sciences
Received: September 21, 2025 | Accepted: February 05, 2026 | Published: March 05, 2026
Volume 14, Issue 02, Pages 38-55

DOI https://doi.org/10.47310/jpms2026150206

Tart Cherry as a Potent Antioxidant and Anti-Inflammatory Natural Supplement in Managing Post-Exercise Fatigue, Gout, Osteoarthritis and Potentially Fibromyalgia: A Review Article

Fatimah M. Yousef[1*]
[1]Department of Food and Nutrition, Faculty of Human Sciences and Design, King Abdulaziz University, Jeddah, Saudi Arabia

Author Designation: [1]Associate Professor

*Corresponding author: Fatimah M.A. Yousef (e-mail: Fyousef@kau.edu.sa).

Abstract Gout, osteoarthritis, fibromyalgia and muscle damage following exercise have all been linked to increased inflammation and oxidative stress in the body. Tart cherries (*Prunus cerasus* L.) may be useful as a healing aid due to their high levels of bioactive constituents, including anthocyanins, flavonoids and other phenolic compounds, all of which have demonstrated antioxidant and anti-inflammatory properties. Tart cherries may help provide a protective effect against muscle damage. The purpose of this review, in particular, is to consolidate and evaluate various clinical and experimental studies about the potential benefits of tart cherry on the management of exercise-induced muscle damage, osteoarthritis, gout and fibromyalgia. To identify pertinent information, a thorough literature review was conducted across the databases PubMed, Google Scholar, Web of Science and Scopus, with the last update on September 30, 2025. Research has shown that tart cherry supplementation (specifically the Montmorency variety) has been proven to improve post-exercise recovery by decreasing muscle soreness, fatigue indices and oxidative stress. Additionally, tart cherry products have been shown to relieve symptoms of osteoarthritis, gout and fibromyalgia due to their antioxidant, uric acid-lowering and anti-inflammatory properties. These studies show promising results; however, more studies are needed to determine the specifics of how tart cherry remedies work and how effective they are in the long term.

Key Words Tart Cherry, Antioxidant, Anti-Inflammatory, Exercise, Fatigue, Gout, Osteoarthritis, Fibromyalgia

INTRODUCTION

Tart cherries are a bioactive phytochemical-rich food with documented health benefits [1,2]. Montmorency tart cherries (*Prunus cerasus* L.) are cited as a recovery aid owing to their phytochemicals content, including anthocyanins, flavonoids and other phenolic compounds. Such compounds are known to have anti-inflammatory and antioxidant properties by selectively modulating Reactive Oxygen Species (ROS), bolstering the antioxidant defense mechanisms and inhibiting the COX-2 anti-inflammatory pathway [3-6]. Many investigations have highlighted antidiabetic [7], anticancer [8], neuroprotective [9] and cardioprotective [10] properties of these potent antioxidants.

Research has shown that foods, especially tart cherry and Tart Cherry Juice (TCJ), may help combat Exercise-Induced Muscle Damage (EIMD). Empirical studies suggest that TCJ may help most because it reduces inflammation and exercise-induced lipid peroxidation, likely due to its bioactive compound, anthocyanins. Thus, TCJ may aid recovery and decrease muscle soreness and strain after exercise [11-15]. While studies have demonstrated benefits from consuming TCJ after resistance exercise and running, the benefits of consuming TCJ after cycling may be reduced due to the comparatively small muscle damage induced by cycling [11].

A meta-analysis and systematic review showed that Tart Cherry Juice (TCJ) results in a small improvement in muscle function after exercise-induced muscle damage. It increased maximal voluntary isometric contraction by 9.13% and lowered the levels of the pro-inflammatory cytokines such as interleukin-6 (IL-6) and interleukin-8 (IL-8). However, it did not cause a significant change in CK, C-reactive protein, TNF-α, IL-1β or pain scores (VAS). A dose-response analysis indicated that as the dose of TCJ increased, contraction improved non-linearly, suggesting that TCJ may improve performance and lower the mild inflammation associated with EIMD [16]. Tart cherries can support post-exercise recovery by reducing soreness and oxidative stress,

lowering inflammation, improving sleep and enhancing muscle power retention. Greater recovery was associated with reductions in CRP and IL-6, with the most notable performance improvements in jump height and modest improvements in strength [17].

High-intensity exercise that exceeds an individual's limits-especially unfamiliar tasks and eccentric movements-can trigger primary EIMD, which reduces performance across maximal power output, jumping, agility, speed and both isokinetic and isometric strength [18]. A common manifestation is Delayed-Onset Muscle Soreness (DOMS), marked by soreness, stiffness, swelling, weakness, reduced joint range of motion and impaired proprioception and it often accompanies EIMD [19,20]. EIMD typically involves an initial mechanical insult followed by an inflammatory response [21,22]. Although DOMS can coincide with muscle damage, it is frequently viewed as the most performance-disruptive symptom and its mechanisms remain debated (e.g., inflammation, connective tissue micro-damage, enzyme leakage and neural factors), with soreness felt during exercise representing a distinct phenomenon [23-26]. Strenuous or prolonged activity can also cause fatigue via mechanical stress and cytokine/ROS production; while these processes aid repair and adaptation, excessive inflammation and oxidative stress can worsen damage, elevate markers such as myoglobin and CK, temporarily impair muscle function and hinder training outcomes [27]. Nutritional strategies with anti-inflammatory and antioxidant effects may help mitigate these consequences and support recovery [28].

Objectives

This review summarizes and evaluates clinical and experimental studies on the health benefits of cherries, particularly their effects on EIMD, osteoarthritis, gout and fibromyalgia. The review also aimed to synthesize findings on cherry-based interventions (e.g., tart cherry/ Montmorency cherry/TCJ) for post-exercise recovery and EIMD-related outcomes. Additionally, it assesses the evidence for cherries' role in symptom relief and in modulating biomarkers in osteoarthritis, gout and fibromyalgia.

METHODS

Literature Search Strategy

A detailed manual literature search was conducted across various online databases to identify relevant clinical and experimental studies on the health effects of cherries. Terms searched included "exercise-induced muscle damage and recovery," "cherry juice," "tart cherry," "Montmorency cherry," "osteoarthritis," "gout," "fibromyalgia," and "procyanidins." Boolean operators were used to set 'OR' for an inclusive search and 'AND' for an exclusive search related to recovery and cherry-based interventions.

Inclusion Criteria

Original English published clinical or experimental research articles that investigated cherry-based products (e.g., tart cherry, Montmorency cherry or TCJ) on exercise-induced muscle damage, recovery, inflammation, pain or clinical symptoms of osteoarthritis, gout or fibromyalgia were included in this review.

Exclusion Criteria

Studies were excluded if they were systematic reviews, reviews, editorials or conference abstracts; did not contain relevant outcomes; and did not include any cherry-derived interventions.

Study Screening and Selection

Initially, the titles and abstracts were screened for relevance. The full texts of the studies that appeared to meet our eligibility criteria were reviewed. The searches were conducted independently for each database to reduce the possibility of selection bias.

Reporting Guidelines

This review was conducted as a narrative review. Whilst it has followed a structured and systematic approach to identifying and selecting literature, it has not been strictly aligned with the PRISMA guidelines for systematic reviews.

Overview and Active Constituents of Tart Cherry

Prunus cerasus L., also known as *Cerasus vulgaris* and/or *Prunus vulgaris*, is a fruit from the family Rosaceae that goes by the name "tart cherry." Tart cherry, often called sour cherry, is a little tree that usually doesn't grow taller than eight meters. Its dark-colored berries have a unique sour taste. The Montmorency tart cherry is the most widespread variety farmed in the United States [29] (Figure 1). People utilize tart cherries to make juices, canned fruit, brandy, liqueurs, preserves and other things at home or in factories. The fruit has a tart taste, luscious flesh, a pleasant aroma and a hue ranging from pale crimson to dark red.

Tart cherries among the many fruits now called "super foods." The idea of "super foods" is primarily based on guesswork, yet there is substantial evidence that sour cherries can be good for your health [30,31]. Tart cherries are rich in polyphenols, particularly flavonoids, flavonols and anthocyanins, with studies identifying at least 12 phenolic acids, 24 anthocyanins, 18 flavones and 17 flavanols [32]. Chlorogenic acid, neochlorogenic acid, cyanidins, 3-coumaroylquinic acid, kaempferol, melatonin and quercetin are the primary polyphenols in tart cherry [33].

Figure 1(a-c): (a) Montmorency cherries (*Prunus cerasus*) fruit, (b) Tart cherry juice and () Tart cherry capsules

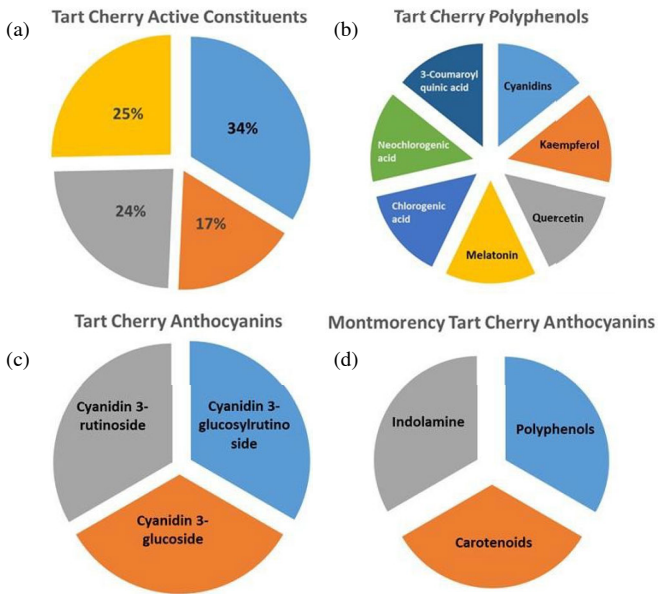

Figure 2(a-d): (a) Tart Cherry Active Constituents, (b) Tart Cherry Polyphenols, (c) Tart Cherry Anthocyanins and (d) Montmorency Tart Cherry Anthocyanins

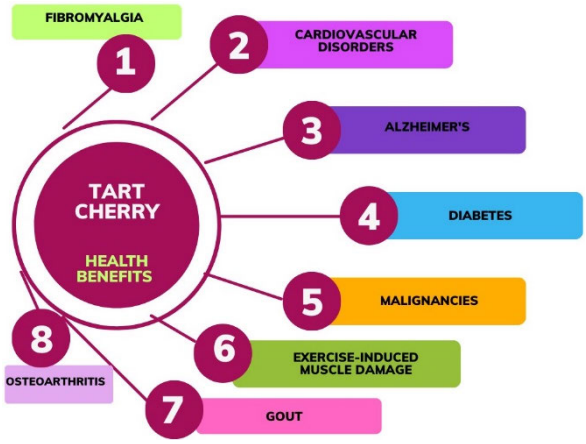

Figure 3: Tart Cherry Health Benefits

The bioactive anthocyanins found in tart cherries, including cyanidin 3-glucoside, cyanidin 3-glucosylrutinoside and cyanidin 3-rutinoside [34]. Anthocyanins give the fruits their deep red color [35]. Montmorency tart cherries are rich in anthocyanins and other plant compounds, such as polyphenols, carotenoids and indolamines [36] (Figure 2).

The cultivar, climate and soil conditions all affect the chemical makeup of sour cherry fruit [37]. The literature indicates that tart cherry fruits contain 8.0-21.5 g/100 g Fresh Weight (FW) of sugars, predominantly sucrose, glucose and fructose and 295-1742 mg/100 g FW of organic acids, chiefly malic acid. Cherries contain 254-407 mg of total polyphenols per 100 g of FW [38]. The primary phenolic acids are p-coumaric acid, 3-caffeoylquinic and 5-caffeoylquinic. Flavanols (catechin/epicatechin derivatives) and flavonols (kaempferol and quercetin glycosides) are commonly present. Sour cherries have an antioxidant capacity of 200-2000 µmol TE/100 g FW [39,40].

Biological Activities and Health Advantages of Tart Cherry

Studies have focused on cherry anthocyanins, especially cyanidin-3-sophorside, cyanidin-3-rhamnoglucoside, cyanidin-3-glucosylrutinoside, cyanidin-3-glucoside, peonidin-3-rutinoside and peonidin-3-glucoside. However, evidence suggests that the entire phytocomplex and the various cherry polyphenols likely act synergistically, influencing several molecular pathways through synergistic effects [14]. In addition to polyphenols, cherries contain carotenoids (like beta-carotene), vitamins (such as vitamin C), essential fatty acids, bioactives (like ellagic and chlorogenic acids) and organic acids (citric and malic), as well as some minerals that may beneficially interact to improve health effects [41,42].

There is growing research linking tart cherries to various health benefits. Traditionally, tart cherries have been used for vascular and heart protection, neurodegeneration (i.e., Alzheimer's), inflammation and chronic diseases related to oxidative stress (i.e., diabetes and cancer). Reported benefits include reduced appetite, lower blood pressure, improved antioxidant defenses, reduced muscle damage and soreness after exercise, improved glycemic control, reduced inflammation, lower uric acid and lower markers of oxidative stress and inflammation. Tart cherry supplementation may also lessen knee osteoarthritis pain and symptoms [30,39,43-47] (Figure 3).

Molecular Pathways and Mechanisms of Tart Cherry Antioxidant and Anti-Inflammatory Potentials

Based on earlier research, anthocyanins remove free radicals in several ways. The initial one is an attack on the hydroxyl group (s) in the B-ring of anthocyanin, whereas the other one is an attack on the oxonium ion in the C-ring [48]. Increasing research suggests that, instead of directly acting as radical scavengers, polyphenols enhance the body's own antioxidant capabilities through the induction of the nuclear-related factor 2 (Nrf2)/antioxidant response element pathway [49-51]. *In vitro*, polyphenols have demonstrated the capacity to safeguard the Keap1-Nrf2 complex against breakdown while also facilitating Nrf2 phosphorylation. Phosphorylated Nrf2 translocates to the nucleus, leading to downstream expression of proteins and genes, which eventually ends in enhanced production of antioxidant enzymes [52]. Polyphenols may also inhibit the formation and function of enzymes that produce superoxide anions, such as nicotinamide adenine dinucleotide phosphate (NADPH) oxidase, thereby reducing the amount of Reactive Oxygen Species (ROS) released [53-55] (Figure 4).

Systemic inflammation may be eased by tart cherry. *In vitro* studies have examined how polyphenols reduce inflammation at the molecular level. The available research demonstrates that polyphenols inhibit the function and gene expression of both cyclooxygenase (COX) isoforms, COX1 and COX2, thereby blocking the synthesis of prostaglandins, a class of lipid compounds that facilitate the inflammatory response by inducing pain, inflammation and edema [56-58]. TLRs, in particular the TLR4/CD14 pathway, are important for detection/or innate immune response, especially for LPS endotoxin. TLR4 signalling via LPS induces the nuclear factor-kB (NF-kB) pathway, which promotes the synthesis of inflammation indicators like tumor necrosis factor-alpha (TNF-α), interleukin 1 beta (IL-1β), IL-6 and COX-2 [59]. Additionally, polyphenols may suppress the activation of NF-kB, a transcription factor that regulates the expression of more than 200 genes associated with the body's pro-inflammatory response [60-62] (Figure 4).

Exercise-Induced Muscle Damage (EIMD)

Making up to 40% of body mass, skeletal muscles use oxygen mainly during maximal effort, movement, posture, endurance, rapid actions and heat production, all of which are essential and vital [63-66]. During an isometric exercise, the muscle generates force while maintaining its length. In a concentric exercise, the muscle produces force while shortening. In an eccentric exercise, the muscle is under tension while lengthening [67]. Posture is maintained and loads are supported by isometric contractions. Movement is generated by concentric contractions. Motion is controlled and/or slowed down by eccentric contractions [68]. Unfamiliar, unusually intense or prolonged exercise can lead to muscle damage and soreness; but EIMD mainly results from high-intensity eccentric efforts [69]. EIMD occurs when muscle fibers become overstressed or injured by new exercises, a new exercise technique or greater exercise volume or intensity. This is due to the change in the muscle's biochemical composition, such as increased muscle composition, less mechanical energy output, decreased muscle power output and greater muscle soreness. In most cases, soreness peaks about 24 to 48 hours after exercise [70].

Pathogenesis of Exercise-Induced Muscle Damage (EIMD)

Exercise-related muscle injury is associated with inflammation during recovery [71-74]. Within 24 hours, there is a transient increase in neutrophils often with leukocytosis [75], along with an influx of inflammatory fluids and proteins, natural killer and lymphocytes [76]. These elevations in neutrophils can last several days [77]. However, within 24 hours macrophages become the dominant cell type and can persist for about 2 weeks [78]. Meanwhile, myocytes that are injured secrete the cytokines TNF-α and IL-1β for several days following exercise [79], process involved in the early polarization of M1 macrophages (CD68+/macrosialin/ED1+) [76]. Neutrophils alongside M1 macrophages produce ROS/RNS during the respiratory burst [76,80]. Excess ROS can negatively impact insulin-stimulated glucose uptake, which reducing it due to impaired GLUT4 translocation [81] and diminish muscle force production [82]. Obstructing post-exercise remodeling is the TNF-α, which acts on the ubiquitin-proteasome pathway via the E3 ligases (MuRF1, MAFbx/Atrogin-1). In this regard, muscle proteolysis and remodeling after EIMD are the results of the pro-inflammatory cytokines 'stimuli [83].

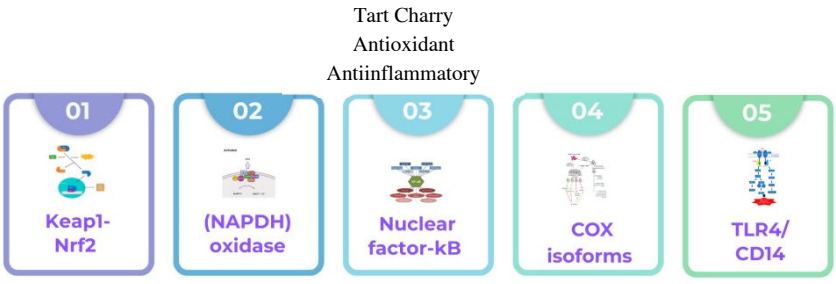

Figure 4: Molecular Pathways and Mechanisms of Tart Cherry Antioxidant and Anti-Inflammatory Potentials [68-72]

Clinical Trials

- A specific research study focused on recovery from lower-body strength rugby sled training using TCJ in 24 male collegiate soccer players. Participants completed sled-based resistance training after drinking either TCJ or a placebo (PL) (70 mL, twice daily) for 3 weeks in a double blind design. Baseline evaluations included counter-movement jumps and knee flexion tests, with three follow-up evaluations at 24, 48 and 72 hours post-training to assess performance. Consistent with the findings outlined in Table 1, TCJ supplementation was accompanied by enhanced after-exercise recovery following high-intensity sprint training, with little inter-limb difference [84]
- Thirteen participants consumed tart cherry for five days (200 mg anthocyanin/day for four days, 100 mg on day 5) or PL, then completed an incremental cycle test to exhaustion in hypoxia (13% O_2). Time to exhaustion was significantly longer with tart cherry (940±84 s) compared to PL (912±63 s; $p<0.05$) [85]
- Researchers studied the impact of Montmorency cherry concentrate (MCC) on exercise recovery, attributing potential benefits to its antioxidant and anti-inflammatory properties. In the study, 10 participants received either MCC or a PL for 7 days to support muscle recovery before undergoing knee extension trials. The study measured anthocyanin content at 7.2 mg/ml and phenolic content at 20.2 mg/ml, providing 216 mg anthocyanins and 605 mg phenolics per 30 ml serving. MCC improved strength recovery (76.5% vs. 59.5% for PL), increased plasma phenolic acids and upregulated gene and protein expressions tied to antioxidant activity [86]
- An investigation focused on the impact of drinking TCJ on the recovery of female university field hockey players. Sixteen players were randomly assigned to either a control group (8 players, no TCJ) or a TCJ group (8 players, received TCJ). The TCJ group was monitored for 48 hours after the Yo-Yo Intermittent Recovery Test. Compared to controls, players in the TCJ group showed improved agility and jumping take-off performance and experienced a smaller increase in IL-6, LDH and other inflammatory markers over time [87]
- A study examined how powdered Tart Cherry Extract (TCE) affects recovery and oxidative stress after heavy resistance training. Thirteen men took either a 500 mg powdered TCE capsule or a PL for 7 days, then completed a strenuous exercise regimen. Powdered TCE significantly decreased oxidative stress markers-creatine kinase myocardial band content, protein carbonyl content and creatine kinase activity-compared to PL. According to Table 1, powdered TCE also reduced declines in handgrip strength and lowered oxidative stress markers, suggesting it may help reduce central fatigue after heavy resistance exercise [88]
- A PL-controlled, single-blind, randomized clinical trial studied the effects of TCJ supplementation for 8 days on recovery after intermittent exercise in 20 team-sport players. Subjects received either TCJ or PL for 8 days and on the 6th day, performed the Loughborough Intermittent Shuttle Test. As shown in Table 1, short-term TCJ supplementation was associated with accelerated functional recovery and reduced muscle soreness following intermittent team-sport exercise, though no significant differences emerged in markers of muscle damage or inflammation [89]
- Typically active adult females (n = 20) participated in a double-blinded, randomized PL trial in which they performed a repeated-sprint protocol and recovered for up to 72 hours. During this period, participants were given either a PL or MCC (30 ml twice daily for 8 days). Recovery metrics included countermovement jump height, muscle soreness and pain threshold. As summarized in Table 1, MCC supplementation improved restoration of countermovement jump height and accelerated recovery from muscle soreness and pain threshold but had no effects on limb girth or lowered high-sensitivity C-reactive protein (hsCRP) [90]
- The effects of MCC on exercise performance, vascular function and nitric oxide biomarkers were examined in trained cyclists using a PL-controlled, double-blind, randomized crossover design. Participants consumed either 60 ml of PL or MCC before performing bouts of moderate- and severe-intensity cycling. As summarized in Table 1, MCC supplementation substantially decreased systolic blood pressure and enhanced end-sprint performance, resulting in 10% greater peak 20-second power and total 60-second work outputs compared to the PL leg. performance during these tests [91]
- The impact of TCJ supplementation on airway oxidative stress and inflammation was evaluated in 19 recreational runners aged 18-50 years who completed a 42.2 km trail run. Participants ingested a PL or TCJ for 4 days before the run and for 48 hours afterwards. Inflammation was measured using FeNO and induced sputum were analyzed for inflammation (IL-6, CD163, CD44, CD62E, CD66E) and oxidative stress (SOD and PC). Compared to the PL, TCJ lowered most inflammation markers but FeNO and protein carbonyls were slightly higher [92]
- One study assessed the effect of TCJ with whey protein (TCW) on recovery post plyometric exercise in 16 participants. They consumed 2,240 mL of TCW or PL beverage twice daily for 10 days. Participants performed 5×20 drop jumps on the 6th day. As summarized in Table 1, compared with PL, TCW resulted in greater improvements in antioxidant capacity and reported soreness. However, CK and LDH levels were elevated post-exercise in all participants, with no significant differences observed between the TCW and PL groups [93]

Table 1: Clinical Studies Concerned with the Effect of Tart Cherry on Exercise-Induced Muscle Damage

Serial	Study	Participants Number	Tart cherry dose/duration	Outcome
1	Yu *et al.* [84]	24	TCJ, 70 mL, twice daily for 3 weeks	Reduced strength loss
				Accelerated recovery time
2	Horiuchi *et al.* [85]	13	TCE (200 mg of anthocyanins on days 1-4, 100 mg on day 5)	Prolonged exhaustion time
3	Wangdi *et al.* [86]	10	MCC for 7 days (the total phenolic and anthocyanin content of 605 mg and 216 mg/30 ml serving)	Improved strength recovery
				Reduced oxidative stress markers
4	Choi *et al.* [87]	16	TCJ, 5 times over 48 hours	Quick recovery
				Reduced muscle damage
				Reduced inflammatory markers
5	Hooper *et al.* [88]	13	TCE capsule (500 mg) for 7 days	Attenuated decline in handgrip strength
				Reduced central fatigue
				Reduced oxidative stress markers
6	Quinlan and Hill [89]	20	TCJ, 2 servings /day (one serving contains 30ml juice and 70ml water) for 8 days	Accelerated recovery
				Reduced muscle soreness
7	Brown *et al.* [90]	20	MCC (30 ml twice a day) for 8 days	Reduced muscle recovery symptoms
				Improved recovery
8	Keane *et al.* [91]	10	MCC, 60 ml before exercise	Enhanced end-sprint performance
9	Dimitriou *et al.* [92]	19	TCJ 4 days before the run and for 48 hours afterwards	Reduced exercise-induced airway inflammatory markers
10	Hillman *et al.* [93]	16	TCJ + whey protein (2 x 240 ml/day) for 10 days	Improved recovery
				Reduced muscle soreness
				Increased antioxidant capacity
11	Beals *et al.* [94]	29	TCE (2 capsules of 1000 mg) for 8 days	Reduced muscle soreness
12	Bell *et al.* [95]	16	MCC (30 ml, 2 times/day) for 8 days	Improved recovery
				Reduced inflammatory markers
13	O'Connor *et al.* [96]	27	TCE (480 mg/day) for 10 days	Improved race performance
				Improved post-exercise recovery
				Reduced inflammatory markers
14	Levers *et al.* [97]	23	TCE (480 mg/day) for 10 days	Improved recovery
				Reduced muscle soreness
15	Bell *et al.* [98]	16	MCC (30 ml, twice/day) for 8 days	Improved recovery
				Reduced inflammatory markers
16	Bell *et al.* [99]	16	MCC (30 ml, twice/day) for 7 days	Reduced inflammatory markers
				Reduced oxidative stress markers
17	Galvan *et al.* [100]	27	TCE (480 mg/day) for 10 days	Improved recovery
				Reduced muscle soreness
18	Bowtell *et al.* [101]	10	MCC (273 mg/30 ml) for 9 days	Improved recovery
				Reduced oxidative stress markers
19	Howatson *et al.* [102]	20	TCJ (600 mg phenolic compounds twice/day) for 7 days	Improved recovery
				Reduced inflammatory markers
				Reduced oxidative stress markers
20	Kuehl *et al.* [103]	54	TCJ (355 ml twice daily) for 7 days	Reduced muscle soreness

- A study evaluating TCJ effects on DOMS post-eccentric exercise compared a consumption group (TCJ: n = 15, placebo: n = 14) and evaluated them for strength, flexibility, thigh girth, muscle tenderness, pain and exercise muscle damage markers at baseline, immediately following and 24 h, 48 h, 96 h and one week post-eccentric fatigue protocol. As summarized in Table 1, TCJ consumption was associated with significant time effects for strength, flexibility, thigh girth and tenderness [94]
- Among semi-professional soccer players, supplementation with MCC (30 ml, twice daily for 8 days) improved recovery after intermittent sprint exercise. Compared with PL, MCC accelerated recovery of maximal voluntary isometric contraction and counter-movement jump performance. In addition, it improved agility, muscle soreness and IL-6 rise, without affecting other inflammatory markers, CK or oxidative stress [95]
- Tart cherry supplements improved race performance and helped control inflammation during and after a half-marathon in trained athletes. Athletes who took the supplement also recovered better than those who took a PL. After recovery, lower levels of immune and inflammation-related molecules (IL-2, IL-5, IL-6, IL-12p70, IL-13) were found. Early after the race, the levels of IL-12p70 and IL-6, which signal quick inflammation, were higher [96]
- A clinical trial using a double-blind method with 23 resistance-trained men found that tart cherry powder supplementation (480 mg daily for 10 days, pre- and post-exercise) significantly reduced post-exercise muscle soreness-the primary outcome-and lessened muscle catabolism (creatinine, AST, ALT, bilirubin, total protein) compared to PL. Although changes in inflammatory cytokines or oxidative stress were insignificant, recovery strength improved and post-exercise soreness decreased, indicating a positive effect on recovery [97]
- In a randomized trial, trained cyclists (n = 16)/to examine the effect of 30 ml MCC or an isoenergetic PL taken twice daily for 8 days. On the fifth day of the trial, participants performed a 109-minute stochastic cycling trial designed to simulate the demands of a road cycling competition. Compared with the PL, participants who consumed the MCC maintained isometric maximum contraction for 72 hours, improved cycling economy at 24 hours and reported lower muscle soreness than the PL group. The indicators of the inflammatory response (hsCRP, IL-6) were substantially lower than those of the PL group. The markers of muscle damage (CK) and oxidative stress (lipid hydroperoxides) were the same in both groups. These results illustrate the ability of MCC to aid recovery of muscle function and inflammation control during exercise [98]
- A study examined the effects of MCC on muscle damage, oxidative stress and inflammation over 3 days of simulated high-intensity road cycling (n = 16) in trained cyclists. Participants ingested 30 ml of either PL or MCC twice daily for 7 days, with cycling trials on days 5-7. Blood analyses showed that, compared with PL, MCC reduced lipid hydroperoxide (LOOH) levels and IL-6 levels, while hsCRP and other markers remained unchanged. These results suggest that MCC can reduce oxidative and inflammatory responses to exercise, supporting its use in cycling and other sports that require multiple performances in a single day [99]
- The current study examines how powdered TCE affects muscle soreness and stress following intense endurance exercise. In the study, 27 trained endurance athletes (18 men and 9 women) took either a PL or 480 mg of TCE daily for 10 days. The results showed that, compared to PL, TCE clearly reduced thigh muscle soreness, as well as cortisol levels and the Blood Urea Nitrogen (BUN) to creatinine ratio. This suggests less muscle damage and stress [100]
- A crossover study involved 10 trained male athletes aged 40-70 years. Participants used MCC (anthocyanin content of 9.1 mg/ml; 273 mg per 30 ml serving) and an isoenergetic fruit control. Supplements were taken for 7 days prior to and 48 h after a unilateral leg exercise. The exercise consisted of 10 sets of 10 repetitions of knee extensor exercises at 80% 1RM. With MCC supplementation, muscle strength recovery was higher at 24 and 48 hours post-exercise (recovery conditioned at 91% vs. 85% and 93% vs. 89%, respectively). Prolonged exercise spanning 24 hours also showed a reduction in protein carbonyls (24% vs. 83% increase). Values on markers of nitrotyrosine, hsCRP and total nitrotyrosine were unresponsive, as were other collateral markers that may indicate total antioxidant capacity. These data suggest MCC may help muscles recover after exercise by reducing oxidative protein damage [101]
- In a PL-controlled randomized clinical trial, recreational marathon runners ingested PL or TCJ for 5 days prior to, on the day of and for 2 days following a marathon. TCJ but not PL, mitigated the post-race decline in isometric strength and markers of post-race inflammation (IL-6, CRP and uric acid). Total antioxidant capacity was approximately 10% higher during the post-supplementation period and TBARS decreased markedly, indicating reduced lipid peroxidation at 48 hours post-race. No between-group differences were observed for protein carbonyls or other indicators of muscle damage in this population [102]
- This PL-controlled, double-blind, randomized study examined the effect of TCJ on pain in long-distance runners (ages 18-61) who averaged 26.3 km over 24 hours. Fifty-four participants drank 355 ml of either PL or TCJ twice daily for 7 days before and during the race. Both groups reported increased pain but the PL group had a 37±20 mm increase, compared with 12±18 mm in the TCJ group. TCJ drinkers reported greater overall satisfaction and a higher likelihood of consuming the juice again. These findings suggest that TCJ intake before and during a run may significantly reduce muscle pain and improve satisfaction among high-volume runners compared to PL [103]

Experimental Studies

- The study specifically examined how TCJ and kernel extract influence muscle regeneration and antioxidant status in aging male BALB/c mice. Researchers administered kernel extract (30 mg/kg/day) and/or TCJ (1 mg anthocyanins/day) daily for three weeks. They measured antioxidant and muscle stem cell (satellite cell) levels in muscle and blood tissues to assess regenerative and antioxidant potential. The results revealed a marked increase in muscle stem cells, particularly in mice treated with kernel extract, while antioxidant markers remained largely unchanged. These findings highlight the potential for TCE supplements to preserve muscle mass and combat sarcopenia-related degeneration in aging populations [104]
- A study explored whether tart cherry concentrate powder can prevent glucocorticoid-induced muscle atrophy in mice. Mice treated with TCE (250 or 500 mg/kg) showed significant protection against muscle wastage, as shown by preserved calf muscle strength, thickness and weight, along with improved histology. The treatment also modulated inflammation and oxidative stress, as well as the expression of genes related to both muscle atrophy (SIRT1, myostatin, atrogin-1, MuRF1) and muscle synthesis (PI3K, Akt1, A1R, TRPV4). Overall, these results suggest that tart cherry concentrate powder appears effective in lessening glucocorticoid-induced muscular atrophy [105]
- TCE enhances skeletal muscle recovery after exercise-induced damage. In a mouse muscle and immune cell system, TCE increased muscle regeneration markers (MHC, MCP-1, HGF) and neutrophil-derived ROS. TCE moderately decreased myoblast proliferation but did not affect cell viability, myeloid differentiation or cell type. These findings show that TCE enhances muscle repair by boosting regenerative signaling and ROS production, while reducing myoblast proliferation and the inflammatory response. The effects may occur directly in muscle tissue or through changed cross-talk between immune and muscle cells [106]

Fibromyalgia

Fibromyalgia is a long-term musculoskeletal disease that causes problems with pain. It is now the second most prevalent rheumatologic diagnosis [107]. A known symptom of fibromyalgia is increased discomfort after activity (fibroflares) and faster DOMS might be a cause of this sort of pain. DOMS is a well-known result of hard exercise, especially when it involves eccentric contractions in muscles that aren't used to it [108]. The temporal progression of DOMS mirrors its pathophysiology [109]. Fibromyalgia is one of the most common musculoskeletal disorders. It causes pain, soreness and stiffness in the joints, tendons and muscles [110]. Fibromyalgia frequently presents in young to middle-aged females with chronic generalized pain, exhaustion, stiffness, sleep disturbances and cognitive impairments. Fibromyalgia frequently occurs alongside various unexplained symptoms, sadness and/or anxiety and a decline in daily life tasks. Fibromyalgia usually produces widespread bilateral pain that has many "tender points." Even though fibromyalgia brings about severe physical pain, it does not cause tissue deformity, damage or inflammation [111].

Research indicates that the stimulus strength required to provoke a pain response in individuals with fibromyalgia is over 50% less than that of normal subjects [111,112]. Researchers have looked into the pathophysiology of this increased sensitivity (allodynia and hyperalgesia) and think it has to do with problems in the central cortical processing and problems with the central nervous system at the spinal cord level [113]. Cumulative evidence shows altered neurotransmitter systems in fibromyalgia, affecting sleep, fatigue, pain and mood. Patients exhibit elevated plasma norepinephrine [114] but reduced dopamine and serotonin [115], contributing to widespread pain and discomfort. Increased glutamate heightens pain sensitization [116].

Because a lot of people with fibromyalgia have trouble sleeping, the melatonin concentration was also thought to be a factor in the disease's development. It was demonstrated that diminished melatonin levels at evening may exacerbate night time pain perception [117]. In fibromyalgia, hypothalamic-pituitary-adrenal axis disruption causes adrenal insufficiency, hindering the release of endorphins, ACTH and cortisol. This makes people tired all the time, makes it harder for them to exercise and makes their muscles operate improperly [118].

Recent data indicated that oxidative stress may significantly contribute to fibromyalgia. Recent results indicate a link between prooxidative processes and pain sensitization in individuals with fibromyalgia [119]. In fibromyalgia, the level of coenzyme Q10 (CoQ10) is decreased, which causes problems with mitochondria. Consequently, there is a diminished mitochondrial membrane potential, heightened superoxide anion action and an elevated production of lipid peroxidation byproduct [120]. The quantity of lipid peroxidation products has been shown to possess a positive relationship with the degree of severity of fibromyalgia as measured by the Fibromyalgia Impact Questionnaire-Revised (FIQR) [121]. Numerous lines demonstrate that fibromyalgia patients have too many oxidants and not enough antioxidants. Prooxidative processes in fibromyalgia patients are linked to particular gene variations that have a role in oxidative equilibrium. For example, diminished Activity of Catalase (CAT), Superoxide Dismutase (SOD) and NADPH oxidase is associated with the degree of fatigue and pain severity, as measured by the FIQR [122]. People with fibromyalgia have lower levels of antioxidant enzymes (SOD, CAT, GPx and GR) and higher levels of NO and malondialdehyde (MDA). Antioxidant enzyme levels are negatively correlated with symptom severity but lipid peroxidation is positively correlated with elevated FIQR scores [121]. In fibromyalgia, there are higher amounts of NO in the blood, which is a key pain sensitizer [121].

Effective supplementation involves 250-350 ml of juice (or 30 ml concentrate) taken twice daily for several days before, after or around the time of exercise, with the total phenolic content being the primary determinant >1000 mg/day of phenolic compounds is often a threshold required to see benefits. Studies show that chronic intake (60-65 ml concentrate or 500 ml of regular juice/day for 7-9 days) can enhance muscle function and diminish fatigue biomarkers and soreness during recovery from resistance or intermittent exercise [27].

Consequently, antioxidant treatments may help lessen the bad effects of fibromyalgia. The use of antioxidative methods for therapy has reduced the majority of symptoms associated with fibromyalgia. Numerous investigations have validated the notion of advantageous antioxidant treatment for this condition through clinical interventions, including hyperbaric oxygen therapy [123], aerobic activities (yoga and Tai Chi) [124] and antioxidant adjuncts (CoQ10 and vitamins D and E) [125-126].

Fibromyalgia is characterized by persistent low-grade inflammation, increased pro-inflammatory cytokines, immunological dysregulation and neuroinflammation, all of which contribute to pain pathway stimulation and symptom worsening [127]. Recent data highlights the crucial association of peripheral inflammation with fibromyalgia pathophysiology, suggesting that inflammation is not merely a consequence but a basic factor propelling fibromyalgia onset and continued existence [127,128]. Several investigations have shown that fibromyalgia patients commonly have greater levels of inflammatory indicators, such as C-reactive protein (CRP), which is an excellent indicator of low-level systemic inflammation [129-130]. Chemokine (C-C motif) ligand 2 (CCL2), a strong chemoattractant molecule that has a role in inflammation, was found in the plasma of those suffering from fibromyalgia [131,132]. A catalytic response may be initiated by this inflammatory state, intensifying the excruciating symptoms that define fibromyalgia and possibly increasing the disease's entire impact [133]. Furthermore, the severity of fibromyalgia symptoms has been linked to high levels of inflammatory serum cytokines, like IL-8 and IL-37 [127]. Certain immune cells are attracted to inflammatory sites by IL-8 and IL-37. Therefore, in fibromyalgia sufferers, its spikes indicate an extremely stimulated inflammatory reaction [134]. With the emergence of neuroinflammation as a crucial element of its pathophysiology, fibromyalgia has come to be understood as a condition closely associated with central inflammation [135]. Central inflammation in fibromyalgia is caused by the induction of glial cells, especially astrocytes and microglia, which release pro-inflammatory cytokines (IL-10, IL-8, IL-6, IL-1β, TNF-α, GDNF and BDNF) [136,137]. This ongoing neuroinflammatory state is further supported by raised cytokine concentrations in CSF [138].

Modern fibromyalgia anti-inflammatory treatments include a wide range of pharmaceutical and alternative medications. Because of their good safety records and potential for long-term advantages, alternatives to pharmaceutical therapies-such as dietary changes-are often considered the first option for fibromyalgia [139]. Although a lot of research has been done on the possible advantages of taking antioxidants, magnesium, CoQ10 and vitamins C and D as supplements, managing symptoms is still a challenging area [139-145].

Clinical Trials

- Fibromyalgia is a chronic pain condition that might respond to intake of tart cherry [169]. The study conducted by Elliot et al. consisted of a randomized, PL-controlled, dual-blind, cross-over study of the therapeutic impact of MCC, concerning 14 women with fibromyalgia and an eccentric exercise protocol. Subjects ingested 10.5 ounces of the juice daily (≈ 600 mg phenolics, 40 mg anthocyanins) for 10 days. No change to the local muscle soreness was noted, though MCC did have some PL-controlled advantages, noting preservation of muscle strength and a reduction of pain in some of the patients. This study indicates that MCC supplements, particularly when used as a pre-loading strategy in the face of anticipated physical stress, may assist fibromyalgia patients with muscle recovery and pain management [109] (Table 2)

Though many tests were done on patients without fibromyalgia, the results could still apply to the management of fibromyalgia since both have concerns about muscle pain and muscle preservation and the decrease of inflammation and oxidative stress. While the trial “Efficacy of a tart cherry juice blend in preventing the symptoms of muscle damage” focused on healthy male college students, the outcomes might be useful in managing muscle-related pain central to fibromyalgia. Participants in this study completed a placebo-controlled, randomized, crossover trial where they consumed a tart cherry-apple juice blend (equal to around 100-120 cherries daily) for eight days with an eccentric exercise session. Participants on the placebo cherry juice reported a substantial decrease in pain ($p = 0.017$), experienced strength loss averaging 22% over 4 days and experienced muscle tenderness, with a 22% loss of strength exercise. Participants on the placebo cherry juice reported a substantial decrease in pain ($p = 0.017$), while the loss of strength averaged 22% over 4 days and muscle tenderness with a loss of strength was 22% exercise [147].

While initial results from one clinical trial indicate possible advantages of supplementation with tart cherries for fibromyalgia, fibromyalgia and cherries does not have enough clinical backing to prove anything substantial Currently, there are no studies to suggest that, fibromyalgia and cherries are directly correlated. A sufficient number of good-quality, randomized controlled trials have yet to be conducted to confirm these results.

Gout

Almost 3% of adults suffer from the most common inflammatory arthritis condition: gout. Most of these cases

are in developing countries. Gout can cause kidney issues, coronary artery disease, diabetes, stroke or metabolic syndrome [148]. Its origin is monoclonal in hyperuricemia, as urate crystals form and trigger inflammation in the joints and tendons. During an attack, anti-inflammatory medicines usually provide relief [149].

Clinical Trials

- A randomized, double-blind crossover trial with a PL investigated 25 adults with mild uric acid elevation. Intake of 960 mg of TCE (20.7 mg proanthocyanins bis-equivalent) over one week did not significantly change postprandial uric acid levels after a purine-rich, tart cherry apple meal. However, tart cherry consumption appeared to diminish postprandial Blood Glucose Level (BGL). It also tended to reduce IL-1β and IL-10 levels and increase interferon gamma (IFN-γ), while uric acid remained unchanged during the acute period. These findings may indicate unexplored metabolic and immunomodulatory functions of tart cherries [150] (Table 3)
- In a randomized trial of 282 men with gout starting urate-lowering therapy, a tart cherry citrate (TaCCi) mixture was compared with a citrate mixture plus sodium bicarbonate over 12 weeks. All groups had comparable improvements in urine pH and serum urate. Still, TaCCi achieved greater reductions in CRP and urine albumin-to-creatinine ratio, which were associated with fewer gout flare episodes. These findings indicate that tart cherry supplementation has added anti-inflammatory and renal protective impacts in the management of gout [151]
- In a randomized study comprising 48 subjects, tart cherry was consumed as a capsule (480 mg) or as a juice (240 ml), once or twice daily for 48 hrs. All participants were over 18 years old. The study found supplementing with tart cherry lowered uric acid levels, albeit temporarily. The most pronounced and sustained effect was observed after the consumption of a single capsule. No measurable changes were observed in hsCRP levels, an inflammatory marker in blood plasma or in defenses, however. The study concluded that TCJ and capsules were equally effective for short-term uric acid lowering, without any demonstrated anti-inflammatory or antioxidant effects [152]
- A cohort of 26 overweight or obese participants participated in a randomized, placebo-controlled, crossover study in which each participant received, for 4 weeks, either a PL or 240 ml/day of TCJ, followed by a 4 week washout period. Participants who consumed TCJ substantially decreased their serum uric acid levels, on average by 19.2% and showed a tendency towards moderation in a number of inflammatory markers, including hsCRP and MCP-1. These results support the suggestion that the daily intake of TCJ could help in managing hyperuricemia and inflammation due to gout [153]

  MCC intake has been demonstrated to reduce blood uric acid levels, which may alleviate gout-related pain. Administration of 30 or 60 ml of MCC twice daily resulted in decreased blood uric acid and increased urinary uric acid excretion, with both dosages producing comparable outcomes. Furthermore, MCC consumption elevated plasma antioxidant anthocyanin concentrations, as corroborated by additional studies indicating that blood antioxidant levels remained elevated for up to 12 hours post-consumption [154]
- In a single-blind, randomized, two-phase crossover study, 12 healthy adults (average age 26) drank either 30 or 60 ml of MCC mixed with water, with at least 10 days between tests. Both amounts lowered blood uric acid and increased the amount of uric acid excreted in urine, yielding similar results and suggesting that MCC

Table 2: Clinical Studies Concerned with the Effect of tart Cherry on Fibromyalgia

Serial	Study	Participants Number	Tart cherry dose/duration	Outcome
1	Elliot *et al.* [109]	14	TCJ (10.5 daily (≈ 600 mg phenolics, 40 mg anthocyanins) for 10 days	-Preserved muscle strength
				-Reduced muscle pain

Table 3: Clinical Studies Concerned with the Effect of Tart Cherry on Gout

Serial	Study	Participants Number	Tart cherry dose/duration	Outcome
1	Gonzalez *et al.* [150]	25	TCE 960 mg (20.7 mg proanthocyanins) for 1 week	Reduced BGL
				Reduced serum IL-1β and IL-10
				Increased serum INF-γ
2	Wang *et al.* [151]	282	TaCCi for 12 weeks	Improved urine pH
				Reduced serum urate
				Decreased serum CRP
				Decreased urine albumin/creatinine ratio
				Decreased gout flare episodes
3	Hillman *et al.* [152]	48	TCJ (240 ml) or capsule (480 mg) for 48 hours	Reduced serum urate
4	Martin and Coles [153]	26	TCJ (240 ml/day) for 4 weeks	Reduced serum urate
				Reduced serum hsCRP and MCP-1
5	Cock [154]	-	TCC (30 or 60 ml /day)	Reduced serum urate
				Increased urine urate
6	Bell *et al.* [155]	12	MCC (30 or 60 ml) for 2 days	Reduced serum urate
				Increased urine urate
7	Martin *et al.* [156]	10	TCJ (240 ml/day) for 4 weeks	Reduced serum urate
				Reduced serum TNF-α and MCP-1

may help with gout-related pain. MCC also increased blood levels of anthocyanins and antioxidants for up to 12 hours after drinking [155]

- In a small randomized, PL-controlled crossover study, 10 overweight or obese adults (average age 38.1 years, BMI 32.2) drank 8 ounces of 100% TCJ or a PL daily for four weeks, with a two-week break in between. Most participants had normal uric acid levels but 70% had lower serum uric acid levels after drinking TCJ. The juice also lowered ESR and was associated with decreases in TNF-α and MCP-1. For those who began with TCJ, triglycerides fell from 168-139 mg/dl, along with decreases in VLDL and the TG/HDL ratio. These early results suggest TCJ might help with uric acid levels and inflammation [156]

Experimental Studies

- Xanthine Oxidase (XO) metabolizes purines to uric acid and, in doing so, produces reactive oxygen species, which, in turn, contribute to conditions such as gout. XO was extracted from bovine milk and the inhibitory effects of allopurinol, TCJ and its active compound (kaempferol) were compared using UV-Vis assays and Michaelis-Menten kinetics. Allopurinol, TCJ and kaempferol inhibit XO at molybdenum, with relative inhibition quantified as an IC_{50} value [157]
- A study sought to ascertain the therapeutic effects of active compounds extracted from tart cherries harvested from ultrasound-assisted ethanol extraction (TCU), as well as those from thermal reflux extraction (TCH), on acute gouty arthritis induced by monosodium urate (MSU) in an animal model. In particular, TCH treatment demonstrated a pronounced efficacy by attenuating joint swelling and eliciting a concomitant increase in pain thresholds, in addition to exhibiting a dose-dependent decrease in neutrophil infiltration, TNF-α and IL-1β, blockade of the NF-κB/TRIF pathway, silencing of the NLRP3 inflammasome and promoting the enzymatic activity of superoxide dismutase (SOD), thereby suggesting a possible anti-gout therapeutic rationale [158]
- In one study, researchers gave TCE to rats with hyperuricemia caused by oteracil potassium and adenine. The group that received a low dose (0.17 g/kg) had lower serum uric acid levels and less kidney injury, likely due to reduced adenosine deaminase activity [159]
- Researchers used LC-MS to analyze anthocyanins in TCJ concentrate and found that cyanidin 3-glucosylrutinoside was the main compound, followed by cyanidin 3-rutinoside. In a mouse model of acute gout, daily oral TCJ concentrate for 14 days reduced inflammation caused by monosodium urate (MSU). This treatment led to about a twofold decrease in NF-κB activation and reduced inflammatory cell accumulation in the ankle joint compared with the controls. These results show that TCJ concentrate, at doses relevant to clinical use, can suppress MSU-triggered NF-κB-mediated inflammation [160]

Osteoarthritis

- A study was conducted to examine the effect of daily consumption of TCJ on symptoms of knee osteoarthritis (OA) in 66 participants aged 45-79 years over 120 days, in a double-masked, randomized controlled trial. Each participant was administered 16 ounces of either PL or TCJ daily. In contrast, the participants' pain, stiffness, joint flexibility, quality of life and plasma cartilage biomarkers were assessed at baseline, 2 and 4 months intervals during the study. Of the 57 participants who completed the study, the TCJ knee extension group achieved considerable improvements absent in the PL group, including pain, quality of life, knee range of motion and a reduction in YKL-40, a cartilage degradation marker. There were no other changes that were statistically relevant in the PL group (Table 4) [161]
- A PL-controlled, double-blinded, randomized, crossover trial with 58 individuals with mild to moderate knee OA examined the effects of TCJ. For six weeks, participants drank two 8-ounce bottles of TCJ every day. Each bottle had about 30 mg of anthocyanins and 450 mg of phenolic compounds. After that, they took a PL. Results showed that WOMAC scores, which measure pain, stiffness and function, improved more during the TCJ phase than during the PL phase. Even though the variations in treatment results were not statistically significant, TCJ caused a significant drop of 23% in the inflammatory marker, hsCRP levels, whereas the other therapy caused a 51% rise [47]
- A PL-controlled trial spanning 21 days studied 20 participants aged 40-70 years with inflammatory OA who consumed 10.5 ounces of TCJ twice daily. Supplementation with TCJ significantly reduced serum CRP and inflammatory markers (TNF-α, IL-10, IL-6) but showed no significant changes. It may be that TCJ reduces systemic inflammation and provides symptomatic relief in OA, thus serving as an adjunct or an alternative to NSAIDs [162]

Table 4: Clinical Studies Concerned with the Effect of Tart Cherry on Osteoarthritis

Serial	Study	Participants Number	Tart cherry dose/duration	Outcome
1	Du *et al.* [161]	66	TCJ (16 oz/day) for 4 weeks	Reduced pain and stiffness
				Improved knee ROM
				Reduced serum YKL-40
2	Schumacher *et al.* [47]	58	TCJ (16 oz/day) for 6 weeks	Reduced pain and stiffness
				Reduced serum hsCRP
3	Kuehl *et al.* [162]	20	TCJ (21 oz/day) for 3 weeks	Reduced serum CRP

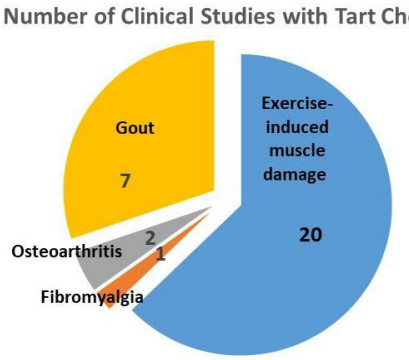

Figure 5: Number of Clinical Trials with Tart Cherry Presented in the Study

CONCLUSIONS

This review involved 31 clinical trials with tart cherry (juice, extract or concentrate) administration in subjects to prevent exercise-induced muscle damage (20 clinical trials), gout-induced pain (7 clinical trials), osteoarthritis (3 clinical trials) and fibromyalgia (1 clinical trial). All trials showed a positive influence of tart cherry administration on muscle pain and recovery (Figure 5). Overall, exercise recovery was the area with the most consistent clinical findings, with multiple studies showing positive impact on soreness and recovery outcomes. Gout studies showed promise with respect to uric acid and inflammation, yet sample sizes and study designs varied greatly. There are only 3 studies on osteoarthritis, which showed limited and mostly short-term symptom and biomarker improvements. Evidence on fibromyalgia is also very limited (1 study) and as with the other studies, findings should be interpreted with caution. Though tart cherry has potential as a nutritional intervention, chronic conditions especially need more definitive longer randomized control trials to assess the efficacy and durability of the intervention. The review also included three studies exploring the effects of tart cherry on damage to muscles induced by exercise and four studies examining its possible advantages in gout.

REFERENCES

[1] Han, B. *et al.* "The Effect of Sour Cherry Consumption on Blood Pressure, IL-6, CRP and TNF-α Levels: A Systematic Review and Meta-Analysis of Randomized Controlled Trials." *Journal of King Saud University - Science*, vol. 32, no. 2, January 2020, pp. 1687-1693. https://doi.org/10.1016/j.jksus.2020.01.002.

[2] Gao, R. and P. Chilibeck. "Effect of Tart Cherry Concentrate on Endurance Exercise Performance: A Meta-Analysis." *Journal of the American College of Nutrition*, vol. 39, no. 7, September 2020, pp. 657-664. https://doi.org/10.1080/07315724.2020.1713246.

[3] Carvalho, F. *et al.* "Effects of Cherry Consumption on Metabolic Health: A Pilot Clinical Study on Healthy Adults." *International Journal of Molecular Sciences*, vol. 26, no. 18, September 2025. https://doi.org/10.3390/ijms26188891.

[4] Williamson, G. "The Role of Polyphenols in Modern Nutrition." *Nutrition Bulletin*, vol. 42, no. 3, August 2017, pp. 226-235. https://doi.org/10.1111/nbu.12278.

[5] Meccariello, R. and S. D'Angelo. "Impact of Polyphenolic Food on Longevity: An Elixir of Life. An Overview." *Antioxidants*, vol. 10, no. 4, March 2021. https://doi.org/10.3390/antiox10040507.

[6] Amini, A.M. *et al.* "Effects of Pelargonidin-3-O-Glucoside and Its Metabolites on Lipopolysaccharide-Stimulated Cytokine Production by THP-1 Monocytes and Macrophages." *Cytokine*, vol. 103, March 2018, pp. 29-33. https://doi.org/10.1016/j.cyto.2017.12.031.

[7] Ren, L. *et al.* "Hypoglycaemic Activity of the Anthocyanin Enriched Fraction of *Lycium ruthenicum* Murr. Fruits and Its Ingredient Identification via UPLC-Triple-TOF-MS/MS." *Food Chemistry*, vol. 461, December 2024. https://doi.org/10.1016/j.foodchem.2024.140837.

[8] Li, W. *et al.* "Chemopreventive and Therapeutic Properties of Anthocyanins in Breast Cancer: A Comprehensive Review." *Nutrition Research*, vol. 107, November 2022, pp. 48-64. https://doi.org/10.1016/j.nutres.2022.08.005.

[9] Khan, M. *et al.* "Anthocyanins Protect against LPS-Induced Oxidative Stress-Mediated Neuroinflammation and Neurodegeneration in the Adult Mouse Cortex." *Neurochemistry International*, vol. 100, November 2016, pp. 1-10. https://doi.org/10.1016/j.neuint.2016.08.005.

[10] Zhao, Y. *et al.* "Anthocyanins in Vascular Health and Disease: Mechanisms of Action and Therapeutic Potential." *Journal of Cardiovascular Pharmacology*, vol. 84, no. 3, September 2024, pp. 289-302. https://doi.org/10.1097/FJC.0000000000001602.

[11] Gao, R. *et al.* "The Effect of Tart Cherry Juice Compared to a Sports Drink on Cycling Exercise Performance, Substrate Metabolism and Recovery." *PLoS One*, vol. 19, no. 8, August 2024. https://doi.org/10.1371/journal.pone.0307263.

[12] Vitale, K.C. *et al.* "Tart Cherry Juice in Athletes: A Literature Review and Commentary." *Current Sports Medicine Reports*, vol. 16, no. 4, August 2017, pp. 230-239. https://doi.org/10.1249/JSR.0000000000000385.

[13] McHugh, M.P. "'Precovery' versus Recovery: Understanding the Role of Cherry Juice in Exercise Recovery." *Scandinavian Journal of Medicine & Science in Sports*, vol. 32, no. 6, February 2022, pp. 940-950. https://doi.org/10.1111/sms.14141.

[14] Colletti, A. *et al.* "Health Benefits of (Poly)phenols from Cherries: A Review of Clinical Trials." *Nutraceuticals*, vol. 5, no. 2, April 2025. https://doi.org/10.3390/nutraceuticals5020012.

[15] Morgans, R. *et al.* "A Comprehensive Review of the Effects of Cherry Juice and Chocolate Milk Supplementation on Football Performance and Recovery." *Journal of Physical Education and Sport*, vol. 24, no. 5, 2024, pp. 1249-1265. https://doi.org/10.7752/jpes.2024.05143.

[16] Dehghani, E. *et al.* "The Effect of Tart Cherry Juice (TCJ) Supplementation on Exercise-Induced Muscle Damage (EIMD) in an Athletic Population." *Annals of Medicine & Surgery*, vol. 87, no. 2, 2025, pp. 880-890. https://doi.org/10.1097/MS9.0000000000002914.

[17] Marbut, L. "The Impact of Tart Cherry on Strength, Soreness and Inflammation Following Strenuous Exercise." *JSU Student Symposium*, 2025.

[18] Boyd, L. *et al.* "The Effects of Pre-Conditioning on Exercise-Induced Muscle Damage: A Systematic Review and Meta-Analysis." *Sports Medicine*, vol. 53, no. 8, August 2023, pp. 1537-1557. https://doi.org/10.1007/s40279-023-01839-8.

[19] Sonkodi, B. "Delayed Onset Muscle Soreness and Critical Neural Microdamage-Derived Neuroinflammation." *Biomolecules*, vol. 12, no. 9, August 2022. https://doi.org/10.3390/biom12091207.

[20] Hill, J. *et al.* "Compression Garments and Recovery from Exercise-Induced Muscle Damage: A Meta-Analysis." *British Journal of Sports Medicine*, vol. 48, no. 18, September 2014, pp. 1340-1346. https://doi.org/10.1136/bjsports-2013-092456.

[21] Tiidus, P.M. "Radical Species in Inflammation and Overtraining." *Canadian Journal of Physiology and Pharmacology*, vol. 76, no. 5, May 1998, pp. 533-538. https://doi.org/10.1139/cjpp-76-5-533.

[22] Clarkson, P.M. *et al.* "Muscle Function after Exercise-Induced Muscle Damage and Rapid Adaptation." *Medicine and Science in Sports and Exercise*, vol. 24, no. 5, May 1992, pp. 512-520.

[23] Heiss, R. *et al.* "Advances in Delayed-Onset Muscle Soreness (DOMS) - Part II: Treatment and Prevention." *Sportverletzung· Sportschaden*, vol. 33, no. 1, March 2019, pp. 21-29. https://doi.org/10.1055/a-0810-3516.

[24] Sonkodi, B. *et al.* "Post Orgasmic Illness Syndrome (POIS) and Delayed Onset Muscle Soreness (DOMS): Do They Have Anything in Common?" *Cells*, vol. 10, no. 8, July 2021. https://doi.org/10.3390/cells10081867.

[25] Sonkodi, B. *et al.* "Have We Looked in the Wrong Direction for More than 100 Years? Delayed Onset Muscle Soreness Is, in Fact, Neural Microdamage Rather than Muscle Damage." *Antioxidants*, vol. 9, no. 3, March 2020. https://doi.org/10.3390/antiox9030212.

[26] Hayashi, K. *et al.* "Muscular Mechanical Hyperalgesia after Lengthening Contractions in Rats Depends on Stretch Velocity and Range of Motion." *European Journal of Pain*, vol. 21, no. 1, January 2017, pp. 125-139. https://doi.org/10.1002/ejp.909.

[27] Ferrara, L. and S. D'Angelo. "Post-Exercise Fatigue, Lactate and Natural Nutritional Strategy." *Journal of Physical Education and Sport*, vol. 23, no. 9, September 2023, pp. 2274-2283. https://doi.org/10.7752/jpes.2023.09261.

[28] Tanabe, Y. *et al.* "Dietary Supplementation for Attenuating Exercise-Induced Muscle Damage and Delayed-Onset Muscle Soreness in Humans." *Nutrients*, vol. 14, no. 1, December 2022. https://doi.org/10.3390/nu14010070.

[29] Brinckmann, J. and T. Brendler. "Tart Cherry - *Prunus cerasus* (syn. *Cerasus vulgaris*) - Family: Rosaceae." *Herb Pro File*, vol. 128, no. 6-16, 2020.

[30] Alba, M. *et al.* "Tart Cherries and Health: Current Knowledge and Need for a Better Understanding of the Fate of Phytochemicals in the Human Gastrointestinal Tract." *Critical Reviews in Food Science and Nutrition*, vol. 59, no. 4, 2019, pp. 626-638. https://doi.org/10.1080/10408398.2017.1384918.

[31] Levers, K. *et al.* "Effects of Powdered Montmorency Tart Cherry Supplementation on Acute Endurance Exercise Performance in Aerobically Trained Individuals." *Journal of the International Society of Sports Nutrition*, vol. 13, no. 1, May 2016. https://doi.org/10.1186/s12970-016-0133-z.

[32] Poonam, V. *et al.* "Chemical Constituents of the Genus Prunus and Their Medicinal Properties." *Current Medicinal Chemistry*, vol. 18, no. 25, 2011, pp. 3758-3824. https://doi.org/10.2174/092986711803414386.

[33] Mansoori, S. *et al.* "Effects of Tart Cherry and Its Metabolites on Aging and Inflammatory Conditions: Efficacy and Possible Mechanisms." *Ageing Research Reviews*, vol. 66, March 2021. https://doi.org/10.1016/j.arr.2021.101254.

[34] Seeram, N.P. *et al.* "Degradation Products of Cyanidin Glycosides from Tart Cherries and Their Bioactivities." *Journal of Agricultural and Food Chemistry*, vol. 49, no. 10, 2001, pp. 4924-4929. https://doi.org/10.1021/jf0107508.

[35] Alrgei, H. *et al.* "Chemical Profile of Major Taste- and Health-Related Compounds of Oblačinska Sour Cherry." *Journal of the Science of Food and Agriculture*, vol. 96, no. 4, April 2016, pp. 1241-1251. https://doi.org/10.1002/jsfa.7212.

[36] Quero-Garcia, J. *et al. Cherries: Botany, Production and Uses*. CABI, 2017.

[37] Vuletić, M. *et al.* "Season, Location and Cultivar Influence on Bioactive Compounds of Sour Cherry Fruits." *Plant, Soil and Environment*, vol. 63, no. 9, September 2017, pp. 389-395. https://doi.org/10.17221/472/2017-PSE.

[38] Neveu, V. *et al.* "Phenol-Explorer: An Online Comprehensive Database on Polyphenol Contents in Foods." *Database (Oxford)*, 2010, bap024. https://doi.org/10.1093/database/bap024.

[39] Blando, F. and B.D. Oomah. "Sweet and Sour Cherries: Origin, Distribution, Nutritional Composition and Health Benefits." *Trends in Food Science and Technology*, vol. 86, April 2019, pp. 517-529. https://doi.org/10.1016/j.tifs.2019.02.052.

[40] Sokół-Łętowska, A. *et al.* "Chemical Composition of 21 Cultivars of Sour Cherry (*Prunus cerasus*) Fruit Cultivated in Poland." *Molecules*, vol. 25, no. 19, 2020. https://doi.org/10.3390/molecules25194587.

[41] Norouzzadeh, M. *et al.* "Dose-Dependent Effect of Tart Cherry on Blood Pressure and Selected Inflammation Biomarkers: A GRADE-Assessed Systematic Review and Meta-Analysis of Randomized Controlled Trials." *Heliyon*, vol. 9, no. 9, September 2023. https://doi.org/10.1016/j.heliyon.2023.e19987.

[42] Gonçalves, B. *et al.* "From Orchard to Wellness: Unveiling the Health Effects of Sweet Cherry Nutrients." *Nutrients*, vol. 16, no. 21, October 2024. https://doi.org/10.3390/nu16213660.

[43] Kelley, D.S. *et al.* "A Review of the Health Benefits of Cherries." *Nutrients*, vol. 10, no. 3, March 2018. https://doi.org/10.3390/nu10030368.

[44] Stretton, B. *et al.* "Too Sour to Be True? Tart Cherries (*Prunus cerasus*) and Sleep: A Systematic Review and Meta-Analysis." vol. 9, no. 3, July 2023, pp. 225-233. https://doi.org/10.1007/s40675-023-00261-w.

[45] Desai, T. *et al.* "Effects of Montmorency Tart Cherry Supplementation on Cardio-Metabolic Markers in Metabolic Syndrome Participants: A Pilot Study." *Journal of Functional Foods*, vol. 57, June 2019, pp. 286-298. https://doi.org/10.1016/j.jff.2019.04.005.

[46] Chai, S.C. *et al.* "Impact of Tart Cherry Juice on Systolic Blood Pressure and Low-Density Lipoprotein Cholesterol in Older Adults: A Randomized Controlled Trial." *Food & Function*, vol. 9, no. 6, June 2018, pp. 3185-3194. https://doi.org/10.1039/c8fo00468d.

[47] Schumacher, H.R. *et al.* "Randomized Double-Blind Crossover Study of the Efficacy of a Tart Cherry Juice Blend in Treatment of Osteoarthritis (OA) of the Knee." *Osteoarthritis and Cartilage*, vol. 21, no. 8, August 2013, pp. 1035-1041. https://doi.org/10.1016/j.joca.2013.05.009.

[48] Khoo, H. *et al.* "Anthocyanidins and Anthocyanins: Colored Pigments as Food, Pharmaceutical Ingredients and the Potential Health Benefits." *Food and Nutrition Research*, vol. 61, no. 1, August 2017. https://doi.org/10.1016/j.joca.2013.05.009.

[49] Scapagnini, G. *et al.* "Modulation of Nrf2/ARE Pathway by Food Polyphenols: A Nutritional Neuroprotective Strategy for Cognitive and Neurodegenerative Disorders." *Molecular Neurobiology*, vol. 44, no. 2, October 2011, pp. 192-201. https://doi.org/10.1007/s12035-011-8181-5.

[50] Zhang, Q. *et al.* "A Systems Biology Perspective on Nrf2-Mediated Antioxidant Response." *Toxicology and Applied Pharmacology*, vol. 244, no. 1, April 2010, pp. 84-97. https://doi.org/10.1016/j.taap.2009.08.018.

[51] Sabou, V.R. *et al.* "Review of Analytical Methods and Reporting of the Polyphenol Content of Tart Cherry Supplements in Human Supplementation Studies Investigating Health and Exercise Performance Effects: Recommendations for Good Practice." *Frontiers in Nutrition*, vol. 8, March 2021. https://doi.org/10.3389/fnut.2021.652094.

[52] Huang, Y. *et al.* "The Complexity of the Nrf2 Pathway: Beyond the Antioxidant Response." *The Journal of Nutritional Biochemistry*, vol. 26, no. 12, December 2015, pp. 1401-1413. https://doi.org/10.1016/j.jnutbio.2015.08.001.

[53] Dávalos, A. *et al.* "Effects of Red Grape Juice Polyphenols in NADPH Oxidase Subunit Expression in Human Neutrophils and Mononuclear Blood Cells." *British Journal of Nutrition*, vol. 102, no. 8, October 2009, pp. 1125-1135. https://doi.org/10.1017/S0007114509382148.

[54] Calabriso, N. *et al.* "Extra Virgin Olive Oil Rich in Polyphenols Modulates VEGF-Induced Angiogenic Responses by Preventing NADPH Oxidase Activity and Expression." *Journal of Nutritional Biochemistry*, vol. 28, February 2016, pp. 19-29. https://doi.org/10.1016/j.jnutbio.2015.09.026.

[55] Rodriguez-Mateos, A. *et al.* "Intake and Time Dependence of Blueberry Flavonoid-Induced Improvements in Vascular Function: A Randomized, Controlled, Double-Blind, Crossover Intervention Study with Mechanistic Insights into Biological Activity." *American Journal of Clinical Nutrition*, vol. 98, no. 5, November 2013, pp. 1179-1191. https://doi.org/10.3945/ajcn.113.066639.

[56] Corona, G. *et al.* "Inhibition of p38/CREB Phosphorylation and COX-2 Expression by Olive Oil Polyphenols Underlies Their Anti-Proliferative Effects." *Biochemical and Biophysical Research Communications*, vol. 362, no. 3, October 2007, pp. 606-611. https://doi.org/10.1016/j.bbrc.2007.08.049.

[57] Scoditti, E. *et al.* "Mediterranean Diet Polyphenols Reduce Inflammatory Angiogenesis through MMP-9 and COX-2 Inhibition in Human Vascular Endothelial Cells: A Potentially Protective Mechanism in Atherosclerotic Vascular Disease and Cancer." *Archives of Biochemistry and Biophysics*, vol. 527, no. 2, 2012, pp. 81-89. https://doi.org/10.1016/j.abb.2012.05.003.

[58] Burgos-Edwards, A. *et al.* "Anti-Inflammatory Effect of Polyphenols from Chilean Currants (*Ribes magellanicum* and *R. punctatum*) after in Vitro Gastrointestinal Digestion on Caco-2 Cells." *Journal of Functional Foods*, vol. 59, August 2019, pp. 329-336. https://doi.org/10.1016/j.jff.2019.06.007.

[59] Ma, Z. *et al.* "An Insight into Anti-Inflammatory Activities and Inflammation Related Diseases of Anthocyanins: A Review of Both in Vivo and in Vitro Investigations." *International Journal of Molecular Sciences*, vol. 22, no. 20, October 2021. https://doi.org/10.3390/ijms222011076.

[60] Karlsen, A. *et al.* "Anthocyanins Inhibit Nuclear Factor-κB Activation in Monocytes and Reduce Plasma Concentrations of Pro-Inflammatory Mediators in Healthy Adults." *Journal of Nutrition*, vol. 137, no. 8, August 2007, pp. 1951-1954. https://doi.org/10.1093/jn/137.8.1951.

[61] Chen, C.Y. *et al.* "The Cancer Prevention, Anti-Inflammatory and Anti-Oxidation of Bioactive Phytochemicals Targeting the TLR4 Signaling Pathway." *International Journal of Molecular Sciences*, vol. 19, no. 9, September 2018. https://doi.org/10.3390/ijms19092729.

[62] Gandhi, J. *et al.* "Role of Modulator of Inflammation Cyclooxygenase-2 in Gammaherpesvirus Mediated Tumorigenesis." *Frontiers in Microbiology*, vol. 8, March 2017. https://doi.org/10.3389/fmicb.2017.00538.

[63] Mortimer, P.M. *et al.* "Beyond the Extra Respiration of Phagocytosis: NADPH Oxidase 2 in Adaptive Immunity and Inflammation." *Frontiers in Immunology*, vol. 12, September 2021. https://doi.org/10.3389/fimmu.2021.733918.

[64] Swentek, L. *et al.* "Antioxidant Therapy in Pancreatitis." *Antioxidants*, vol. 10, no. 5, April 2021. https://doi.org/10.3390/antiox10050657.

[65] Purita, J. "NF-κB: The Pathway of Inflammation. Good Cop, Bad Cop: The Different Faces of NF-κB." *PUR-FORM*, vol. 561, January 2021, pp. 368-1880.

[66] Lindstedt, S.L. "Skeletal Muscle Tissue in Movement and Health: Positives and Negatives." *Journal of Experimental Biology*, vol. 219, no. 2, January 2016, pp. 185-188. https://doi.org/10.1242/jeb.124297.

[67] Faulkner, J.A. "Terminology for Contractions of Muscles during Shortening, while Isometric and during Lengthening." *Journal of Applied Physiology*, vol. 95, no. 2, August 2003, pp. 455-459. https://doi.org/10.1152/japplphysiol.00280.2003.

[68] Hoppeler, H. "Moderate Load Eccentric Exercise: A Distinct Novel Training Modality." *Frontiers in Physiology*, vol. 7, November 2016. https://doi.org/10.3389/fphys.2016.00483.

[69] Proske, U. and D.L. Morgan. "Muscle Damage from Eccentric Exercise: Mechanism, Mechanical Signs, Adaptation and Clinical Applications." *Journal of Physiology*, vol. 537, no. Pt 2, December 2001, pp. 333-345. https://doi.org/10.1111/j.1469-7793.2001.00333.x.

[70] Stožer, A. *et al.* "Pathophysiology of Exercise-Induced Muscle Damage and Its Structural, Functional, Metabolic and Clinical Consequences." *Physiological Research*, vol. 69, no. 4, July 2020, pp. 565-598. https://doi.org/10.33549/physiolres.934371.

[71] Tu, H. and Y. Li. "Inflammation Balance in Skeletal Muscle Damage and Repair." *Frontiers in Immunology*, vol. 14, January 2023. https://doi.org/10.3389/fimmu.2023.1133355.

[72] Chazaud, B. "Inflammation during Skeletal Muscle Regeneration and Tissue Remodeling: Application to Exercise-Induced Muscle Damage Management." *Immunology and Cell Biology*, vol. 94, no. 2, February 2016, pp. 140-145. https://doi.org/10.1038/icb.2015.97.

[73] Fatouros, I.G. and A.Z. Jamurtas. "Insights into the Molecular Etiology of Exercise-Induced Inflammation: Opportunities for Optimizing Performance." *Journal of Inflammation Research*, vol. 9, October 2016, pp. 175-186. https://doi.org/10.2147/JIR.S114635.

[74] Hayashi, T. *et al.* "Exercise Regulation of Glucose Transport in Skeletal Muscle." *American Journal of Physiology*, vol. 273, no. 6, December 1997, pp. E1039-E1051. https://doi.org/10.1152/ajpendo.1997.273.6.E1039.

[75] Close, G.L. *et al.* "Eccentric Exercise, Isokinetic Muscle Torque and Delayed Onset Muscle Soreness: The Role of Reactive Oxygen Species." *European Journal of Applied Physiology*, vol. 91, no. 5-6, May 2004, pp. 615-621. https://doi.org/10.1007/s00421-003-1012-2.

[76] Tidball, J.G. and S.A. Villalta. "Regulatory Interactions between Muscle and the Immune System during Muscle Regeneration." *American Journal of Physiology - Regulatory Integrative and Comparative Physiology*, vol. 298, no. 5, May 2010, pp. R1173-R1187. https://doi.org/10.1152/ajpregu.00735.2009.

[77] McKune, A.J. *et al.* "Acute Exercise-Induced Muscle Injury." *Biology of Sport*, vol. 29, no. 1, March 2012, pp. 3-10. https://doi.org/10.5604/20831862.978976.

[78] Peake, J.M. *et al.* "Muscle Damage and Inflammation during Recovery from Exercise." *Journal of Applied Physiology*, vol. 122, no. 3, March 2017, pp. 559-570. https://doi.org/10.1152/japplphysiol.00971.2016.

[79] Peake, J.M. *et al.* "Cytokine Expression and Secretion by Skeletal Muscle Cells: Regulatory Mechanisms and Exercise Effects." *Exercise Immunology Review*, vol. 21, 2015, pp. 8-25.

[80] Tidball, J.G. "Inflammatory Processes in Muscle Injury and Repair." *American Journal of Physiology-Regulatory Integrative and Comparative Physiology*, vol. 288, no. 2, February 2005, pp. R345-R353. https://doi.org/10.1152/ajpregu.00454.2004.

[81] Aoi, W. *et al.* "Exercise-Induced Muscle Damage Impairs Insulin Signaling Pathway Associated with IRS-1 Oxidative Modification." *Physiological Research*, vol. 61, no. 1, December 2012, pp. 81-88. https://doi.org/10.33549/physiolres.932239.

[82] Powers, S.K. *et al.* "Exercise-Induced Oxidative Stress: Friend or Foe?" *Journal of Sport and Health Science*, vol. 9, no. 5, September 2020, pp. 415-425. https://doi.org/10.1016/j.jshs.2020.04.001.

[83] Patel, H.P. *et al.* "Lean Mass, Muscle Strength and Gene Expression in Community Dwelling Older Men: Findings from the Hertfordshire Sarcopenia Study (HSS)." *Calcified Tissue International*, vol. 95, no. 4, October 2014, pp. 308-316. https://doi.org/10.1007/s00223-014-9894-z.

[84] Yu, T. *et al.* "Effect of Tart Cherry Juice Supplement on Lower Extremity Strength Recovery Performance after Periodization Resisted Sled-Based Training." *Journal of Men's Health*, vol. 20, no. 1, January 2024, pp. 90-98. https://doi.org/10.22514/jomh.2024.012.

[85] Horiuchi, M. *et al.* "Five Days of Tart Cherry Supplementation Improves Exercise Performance in Normobaric Hypoxia." *Nutrients*, vol. 15, no. 2, January 2023. https://doi.org/10.3390/nu15020388.

[86] Wangdi, J.T. *et al.* "Tart Cherry Supplement Enhances Skeletal Muscle Glutathione Peroxidase Expression and Functional Recovery after Muscle Damage." *Medicine & Science in Sports & Exercise*, vol. 54, no. 4, November 2021, pp. 609-621. https://doi.org/10.1249/MSS.0000000000002827.

[87] Choi, M. *et al.* "Effects of Acute Tart Cherry Juice Intake on Recovery after Intermittent Exercise in Elite Female Field Hockey Players." *Korean Journal of Sport Science*, vol. 33, no. 1, March 2020, pp. 1-9. https://doi.org/10.24985/kjss.2022.33.1.1.

[88] Hooper, D.R. *et al.* "Broad Spectrum Polyphenol Supplementation from Tart Cherry Extract on Markers of Recovery from Intense Resistance Exercise." *Journal of the International Society of Sports Nutrition*, vol. 18, no. 1, June 2021, Article 47. https://doi.org/10.1186/s12970-021-00449-x.

[89] Quinlan, R. and J.A. Hill. "The Efficacy of Tart Cherry Juice in Aiding Recovery after Intermittent Exercise." *International Journal of Sports Physiology and Performance*, vol. 15, no. 3, March 2020, pp. 368-374. https://doi.org/10.1123/ijspp.2019-0101.

[90] Brown, M.A. *et al.* "Montmorency Tart Cherry (*Prunus cerasus* L.) Supplementation Accelerates Recovery from Exercise-Induced Muscle Damage in Females." *European Journal of Sport Science*, vol. 19, no. 1, January 2019, pp. 95-102. https://doi.org/10.1080/17461391.2018.1502360.

[91] Keane, K.M. *et al.* "Effects of Montmorency Tart Cherry (*L. Prunus cerasus*) Consumption on Nitric Oxide Biomarkers and Exercise Performance." *Scandinavian Journal of Medicine & Science in Sports*, vol. 28, no. 7, March 2018, pp. 1746-1756. https://doi.org/10.1111/sms.13088.

[92] Dimitriou, L. *et al.* "Influence of Tart Cherry Juice on Airway Biomarkers of Inflammation and Oxidative Stress Following a 42.2 km Trail Run." *Environmental Science and Medicine*, July 2018.

[93] Hillman, A.R. *et al.* "The Effects of Tart Cherry Juice with Whey Protein on the Signs and Symptoms of Exercise-Induced Muscle Damage Following Plyometric Exercise." *Journal of Functional Foods*, vol. 29, February 2017, pp. 185-192. https://doi.org/10.1016/j.jff.2016.12.026.

[94] Beals, K. *et al.* "The Effects of a Tart Cherry Beverage on Reducing Exercise-Induced Muscle Soreness." *Isokinetics and Exercise Science*, vol. 25, no. 1, February 2017, pp. 53-63. https://doi.org/10.3233/IES-16064.

[95] Bell, P.G. *et al.* "The Effects of Montmorency Tart Cherry Concentrate Supplementation on Recovery Following Prolonged, Intermittent Exercise." *Nutrients*, vol. 8, no. 7, July 2016. https://doi.org/10.3390/nu8070441.

[96] O'Connor, A. *et al.* "Short-Term Powdered Tart Cherry Supplementation Encircling an Acute Endurance Challenge Potentially Increases Running Performance and Attenuates Post-Race Markers of Inflammation." *Journal of the International Society of Sports Nutrition*, vol. 12, no. Suppl 1, September 2015. https://doi.org/10.1186/1550-2783-12-S1-P7.

[97] Levers, K. *et al.* "Effects of Powdered Montmorency Tart Cherry Supplementation on an Acute Bout of Intense Lower Body Strength Exercise in Resistance-Trained Males." *Journal of the International Society of Sports Nutrition*, vol. 12, no. 1, November 2015. https://doi.org/10.1186/s12970-015-0102-y.

[98] Bell, P.G. *et al.* "Recovery Facilitation with Montmorency Cherries Following High-Intensity, Metabolically Challenging Exercise." *Applied Physiology, Nutrition and Metabolism*, vol. 40, no. 4, April 2015, pp. 414-423. https://doi.org/10.1139/apnm-2014-0244.

[99] Bell, P.G. *et al.* "Montmorency Cherries Reduce the Oxidative Stress and Inflammatory Responses to Repeated Days High-Intensity Stochastic Cycling." *Nutrients*, vol. 6, no. 2, February 2014, pp. 829-843. https://doi.org/10.3390/nu6020829.

[100] Galvan, E. *et al.* "Powdered Tart Cherry Supplementation Effectively Reduces Markers of Catabolism and Perceptions of Muscle Soreness Following an Acute Bout of Intense Endurance Exercise." *Journal of the International Society of Sports Nutrition*, vol. 11, no. Suppl 1, December 2014. https://doi.org/10.1186/1550-2783-11-S1-P33.

[101] Bowtell, J.L. *et al.* "Montmorency Cherry Juice Reduces Muscle Damage Caused by Intensive Strength Exercise." *Medicine and Science in Sports and Exercise*, vol. 43, no. 8, August 2011, pp. 1544-1551. https://doi.org/10.1249/MSS.0b013e31820e5adc.

[102] Howatson, G. *et al.* "Influence of Tart Cherry Juice on Indices of Recovery Following Marathon Running." *Scandinavian Journal of Medicine & Science in Sports*, vol. 20, no. 6, December 2010, pp. 843-852. https://doi.org/10.1111/j.1600-0838.2009.01005.x.

[103] Kuehl, K.S. *et al.* "Efficacy of Tart Cherry Juice in Reducing Muscle Pain during Running: A Randomized Controlled Trial." *Journal of the International Society of Sports Nutrition*, vol. 7, no. 1, May 2010, pp. 1-6. https://doi.org/10.1186/1550-2783-7-17.

[104] Beghelli, D. *et al.* "Effects of a Supplementation with Tart Cherry (*Prunus cerasus* L.) Juice and Its Kernel Extract on Antioxidant Status and Muscle Health." *First International Conference on Antioxidants: Sources, Methods, Health Benefits and Industrial Applications*, vol. 1, 2023.

[105] Ku, S. *et al.* "Tart Cherry (Fruit of *Prunus cerasus*) Concentrated Powder (TCCP) Ameliorates Glucocorticoid-Induced Muscular Atrophy in Mice." *Medicina*, vol. 57, no. 5, May 2021. https://doi.org/10.3390/medicina57050485.

[106] Pelletier, M. *et al.* "Tart Cherry Extract Improves Skeletal Muscle Recovery by Increasing Type II MHC Expression, MCP-1 and HGF Secretion and Attenuating ROS Production by Neutrophils." *The Journal of Immunology*, vol. 200, no. 1 Suppl, May 2018. https://doi.org/10.4049/jimmunol.200.Supp.46.20.

[107] Mease, P. *et al.* "Fibromyalgia Syndrome." *Australian Doctor*, vol. 34, no. 6, June 2007, pp. 1415-1425.

[108] McHugh, M.P. *et al.* "Exercise-Induced Muscle Damage and Potential Mechanisms for the Repeated Bout Effect." *Sports Medicine*, vol. 27, no. 3, March 1999, pp. 157-170. https://doi.org/10.2165/00007256-199927030-00002.

[109] Elliot, D.L. *et al.* "Using an Eccentric Exercise-Testing Protocol to Assess the Beneficial Effects of Tart Cherry Juice in Fibromyalgia Patients." *Integrative Medicine: A Clinician's Journal*, vol. 9, no. 6, June 2010, pp. 24-29.

[110] Gyorfi, M. *et al.* "Fibromyalgia Pathophysiology." *Biomedicines*, vol. 10, no. 12, November 2022. https://doi.org/10.3390/biomedicines10123070.

[111] Chinn, S. *et al.* "Fibromyalgia Pathogenesis and Treatment Options Update." *Current Pain and Headache Reports*, vol. 20, no. 4, April 2016, pp. 1-10. https://doi.org/10.1007/s11916-016-0556-x.

[112] Sarzi-Puttini, P. *et al.* "Fibromyalgia: An Update on Clinical Characteristics, Aetiopathogenesis and Treatment." *Nature Reviews Rheumatology*, vol. 16, no. 11, November 2020, pp. 645-660. https://doi.org/10.1038/s41584-020-00506-w.

[113] Cagnie, B. *et al.* "Central Sensitization in Fibromyalgia? A Systematic Review on Structural and Functional Brain MRI." *Seminars in Arthritis and Rheumatism*, vol. 44, no. 1, August 2014, pp. 68-75. https://doi.org/10.1016/j.semarthrit.2014.01.001.

[114] Rus, A. *et al.* "Catecholamine and Indolamine Pathway: A Case-Control Study in Fibromyalgia." *Biological Research for Nursing*, vol. 20, no. 5, October 2018, pp. 577-586. https://doi.org/10.1177/1099800418787672.

[115] Wood, P. *et al.* "Fibromyalgia Patients Show an Abnormal Dopamine Response to Pain." *European Journal of Neuroscience*, vol. 25, no. 12, June 2007, pp. 3576-3582. https://doi.org/10.1111/j.1460-9568.2007.05623.x.

[116] Sarchielli, P. *et al.* "Sensitization, Glutamate and the Link between Migraine and Fibromyalgia." *Current Pain and Headache Reports*, vol. 11, no. 5, October 2007, pp. 343-351. https://doi.org/10.1007/s11916-007-0216-2.

[117] Wikner, J. *et al.* "Fibromyalgia - A Syndrome Associated with Decreased Nocturnal Melatonin Secretion." *Clinical Endocrinology*, vol. 49, no. 2, August 1998, pp. 179-183. https://doi.org/10.1046/j.1365-2265.1998.00503.x.

[118] Griep, E. *et al.* "Altered Reactivity of the Hypothalamic-Pituitary-Adrenal Axis in the Primary Fibromyalgia Syndrome." *Journal of Rheumatology*, vol. 20, no. 3, March 1993, pp. 469-474.

[119] Assavarittirong, C. *et al.* "Oxidative Stress in Fibromyalgia: From Pathology to Treatment." *Oxidative Medicine and Cellular Longevity*, vol. 2022, October 2022. https://doi.org/10.1155/2022/1582432.

[120] Cordero, M. *et al.* "Oxidative Stress and Mitochondrial Dysfunction in Fibromyalgia." *Neuro Endocrinology Letters*, vol. 31, no. 2, 2010, pp. 169-173.

[121] Shukla, V. *et al.* "Nitric Oxide, Lipid Peroxidation Products and Antioxidants in Primary Fibromyalgia and Correlation with Disease Severity." *Journal of Medical Biochemistry*, vol. 39, no. 2, January 2020, pp. 165-170. https://doi.org/10.2478/jomb-2019-0033.

[122] Rus, A. *et al.* "Influence of Oxidative Stress-Related Genes on Susceptibility to Fibromyalgia." *Nursing Research*, vol. 70, no. 1, January 2021, pp. 44-50. https://doi.org/10.1097/NNR.0000000000000480.

[123] El-Shewy, K. *et al.* "Hyperbaric Oxygen and Aerobic Exercise in the Long-Term Treatment of Fibromyalgia." *Biomedicine and Pharmacotherapy*, vol. 109, January 2019, pp. 629-638. https://doi.org/10.1016/j.biopha.2018.10.157

[124] Wang, C. *et al.* "Effect of Tai Chi versus Aerobic Exercise for Fibromyalgia: Comparative Effectiveness Randomized Controlled Trial." *BMJ*, vol. 360, March 2018, pp. k851. https://doi.org/10.1136/bmj.k851.

[125] Cordero, M. *et al.* "Oral Coenzyme Q10 Supplementation Improves Clinical Symptoms and Recovers Pathologic Alterations in Blood Mononuclear Cells in a Fibromyalgia Patient." *Nutrition*, vol. 28, no. 11-12, November 2012, pp. 1200-1203. https://doi.org/10.1016/j.nut.2012.03.018.

[126] Wepner, F. *et al.* "Effects of Vitamin D on Patients with Fibromyalgia Syndrome: A Randomized Placebo-Controlled Trial." *Pain*, vol. 155, no. 2, February 2014, pp. 261-268. https://doi.org/10.1016/j.pain.2013.10.002.

[127] García-Domínguez, M. "Fibromyalgia and Inflammation: Unrevealing the Connection." *Cells*, vol. 14, no. 4, February 2025, pp. 271. https://doi.org/10.3390/cells14040271.

[128] Bains, A. *et al.* "A Link between Inflammatory Mechanisms and Fibromyalgia." *Advances in Experimental Medicine and Biology*, vol. 1411, March 2023, pp. 357-378. https://doi.org/10.1007/978-981-19-7376-5_16.

[129] Beiner, E. *et al.* "Elevated High Sensitive C-Reactive Protein in Fibromyalgia." *Frontiers in Psychiatry*, vol. 14, November 2023. https://doi.org/10.3389/fpsyt.2023.1237518.

[130] Groven, N. *et al.* "Patients with Fibromyalgia and Chronic Fatigue Syndrome Show Increased hsCRP Compared to Healthy Controls." *Brain, Behavior and Immunity*, vol. 81, October 2019, pp. 172-177. https://doi.org/10.1016/j.bbi.2019.06.010.

[131] Lin, Z. *et al.* "CCL2: An Important Cytokine in Normal and Pathological Pregnancies: A Review." *Frontiers in Immunology*, vol. 13, January 2023. https://doi.org/10.3389/fimmu.2022.1053457.

[132] Ang, D.C. *et al.* "MCP-1 and IL-8 as Pain Biomarkers in Fibromyalgia: A Pilot Study." *Pain Medicine*, vol. 12, no. 8, August 2011, pp. 1154-1161. https://doi.org/10.1111/j.1526-4637.2011.01179.x.

[133] Benlidayi, I. "Role of Inflammation in the Pathogenesis and Treatment of Fibromyalgia." *Rheumatology International*, vol. 39, no. 5, February 2019, pp. 781-791. https://doi.org/10.1007/s00296-019-04251-6.

[134] Surendran, S. *et al.* "Serum Interleukin-6, Interleukin-8 and Interleukin-1 Receptor Antagonist Levels in South Indian Fibromyalgia Patients and Its Correlation with Disease Severity." *Indian Journal of Rheumatology*, vol. 16, no. 4, December 2021, pp. 381-387. https://doi.org/10.4103/injr.injr_275_20.

[135] Dumolard, A. *et al.* "Central Sensitization and Small-Fiber Neuropathy Are Associated in Patients with Fibromyalgia." *Clinical Journal of Pain*, vol. 39, no. 1, January 2023, pp. 8-14. https://doi.org/10.1097/AJP.0000000000001085.

[136] Yang, J. *et al.* "Potential Neuroimmune Interaction in Chronic Pain: A Review on Immune Cells in Peripheral and Central Sensitization." *Frontiers in Pain Research*, vol. 3, July 2022. https://doi.org/10.3389/fpain.2022.946846.

[137] Puja, G. *et al.* "Mechanisms of Peripheral and Central Pain Sensitization: Focus on Ocular Pain." *Frontiers in Pharmacology*, vol. 12, November 2021. https://doi.org/10.3389/fphar.2021.764396.

[138] Rosenström, A.H.C. *et al.* "Cytokines in Cerebrospinal Fluid and Chronic Pain in Humans: Past, Present and Future." *NeuroImmunoModulation*, vol. 31, no. 1, January 2024, pp. 157-172. https://doi.org/10.1159/000540324.

[139] Häuser, W. *et al.* "Non-Pharmacological Interventions for Fibromyalgia (Fibromyalgia Syndrome) in Adults: An Overview of Cochrane Reviews." *Cochrane Database of Systematic Reviews*, vol. 2022, no. 1, January 2022. https://doi.org/10.1002/14651858.CD015074.

[140] Fernández-Araque, A. *et al.* "Effects of Antioxidants on Pain Perception in Patients with Fibromyalgia-A Systematic Review." *Journal of Clinical Medicine*, vol. 11, no. 9, April 2022. https://doi.org/10.3390/jcm11092462.

[141] Assavarittirong, C. *et al.* "Oxidative Stress in Fibromyalgia: From Pathology to Treatment." *Oxidative Medicine and Cellular Longevity*, vol. 2022, October 2022. https://doi.org/10.1155/2022/1582432.

[142] Boulis, M. *et al.* "Magnesium and Fibromyalgia: A Literature Review." *Journal of Primary Care and Community Health*, vol. 12, January 2021. https://doi.org/10.1177/21501327211038433.

[143] Sawaddiruk, P. *et al.* "Coenzyme Q10 Supplementation Alleviates Pain in Pregabalin-Treated Fibromyalgia Patients via Reducing Brain Activity and Mitochondrial Dysfunction." *Free Radical Research*, vol. 53, no. 8, August 2019, pp. 901-909. https://doi.org/10.1080/10715762.2019.1645955.

[144] Carr, A.C. *et al.* "The Role of Vitamin C in the Treatment of Pain: New Insights." *Journal of Translational Medicine*, vol. 15, no. 1, April 2017. https://doi.org/10.1186/s12967-017-1179-7.

[145] Lombardo, M. *et al.* "The Efficacy of Vitamin D Supplementation in the Treatment of Fibromyalgia Syndrome and Chronic Musculoskeletal Pain." *Nutrients*, vol. 14, no. 15, July 2022. https://doi.org/10.3390/nu14153010.

[146] Tiernan, C. *et al.* "Tart Cherry in Amelioration of Pain in the Elderly." *Nutrition and Aging*, vol. 3, no. 2-4, February 2016, pp. 203-217. https://doi.org/10.3233/NUA-150060.

[147] Connolly, D.A.J. *et al.* "Efficacy of a Tart Cherry Juice Blend in Preventing the Symptoms of Muscle Damage." *British Journal of Sports Medicine*, vol. 40, no. 8, June 2006, pp. 679-683. https://doi.org/10.1136/bjsm.2005.025429.

[148] Singh, J.A. and A. Gaffo. "Gout Epidemiology and Comorbidities." *Seminars in Arthritis and Rheumatism*, vol. 50, no. 3S, June 2020, pp. S11-S16. https://doi.org/10.1016/j.semarthrit.2020.04.008

[149] Pillinger, M.H. and B.F. Mandell. "Therapeutic Approaches in the Treatment of Gout." *Seminars in Arthritis and Rheumatism*, vol. 50, no. 3S, June 2020, pp. S24-S30. https://doi.org/10.1016/j.semarthrit.2020.04.010.

[150] Gonzalez, D.E. *et al.* "Effects of Acute and One-Week Supplementation with Montmorency Tart Cherry Powder on Food-Induced Uremic Response and Markers of Health: A Proof-of-Concept Study." *Nutrients*, vol. 16, no. 19, October 2024, pp. 3391. https://doi.org/10.3390/nu16193391.

[151] Wang, C. *et al.* "Efficacy and Safety of Tart Cherry Supplementary Citrate Mixture on Gout Patients: A Prospective, Randomized, Controlled Study." *Arthritis Research & Therapy*, vol. 25, no. 1, September 2023, pp. 164. https://doi.org/10.1186/s13075-023-03152-1.

[152] Hillman, A.R. and K. Uhranowsky. "Acute Ingestion of Montmorency Tart Cherry Reduces Serum Uric Acid but Has No Impact on High Sensitivity C-Reactive Protein or Oxidative Capacity." *Plant Foods for Human Nutrition*, vol. 76, no. 1, January 2021, pp. 83-89. https://doi.org/10.1007/s11130-021-00879-7.

[153] Martin, K.R. and K.M. Coles. "Consumption of 100% Tart Cherry Juice Reduces Serum Urate in Overweight and Obese Adults." *Current Developments in Nutrition*, vol. 3, no. 5, February 2019, pp. nzz011. https://doi.org/10.1093/cdn/nzz011.

[154] Cock, I. "Montmorency Tart Cherries Alleviate Gout Associated Pain via a Reduction in Uric Acid Levels." *Pharmacognosy Communications*, vol. 5, no. 4, October 2015, pp. 270. https://doi.org/10.5530/pc.2015.4.10.

[155] Bell, P.G. *et al.* "Montmorency Tart Cherry (*Prunus cerasus* L.) Concentrate Lowers Uric Acid, Independent of Plasma Cyanidin-3-O-Glucosiderutinoside." *Journal of Functional Foods*, vol. 11, November 2014, pp. 82-90. https://doi.org/10.1016/j.jff.2014.09.004.

[156] Martin, K.R. *et al.* "The Effect of 100% Tart Cherry Juice on Serum Uric Acid Levels, Biomarkers of Inflammation and Cardiovascular Disease Risk Factors." *The FASEB Journal*, vol. 25, no. 1 Supplement, April 2011, pp. 339.2-339.2. https://doi.org/10.1096/fasebj.2.

[157] McInnis, S. and A. Piefer. "Abstract 2265 Green Tea and Tart Cherry Juice Inhibition of Xanthine Oxidase." *Journal of Biological Chemistry*, vol. 301, no. 5, May 2025.

[158] Shi, E. *et al.* "Tart Cherry Extract Allevites Gouty Inflammatory Response by Downregulating NF-κB Signaling Pathway." *Food Bioscience*, vol. 71, July 2025. https://doi.org/10.1016/j.fbio.2025.107253.

[159] Li, R. *et al.* "Effects of Tart Cherry Powder on Serum Uric Acid in Hyperuricemia Rat Model." *Evidence-Based Complementary and Alternative Medicine*, vol. 2020, no. 1, July 2020. https://doi.org/10.1155/2020/1454305.

[160] Schlesinger, N. *et al.* "Components of Tart Cherry Juice Inhibit NFκB Activation and Inflammation in Acute Gout." *Clinical and Experimental Rheumatology*, vol. 40, no. 7, July 2021, pp. 1293-1298. https://doi.org/10.55563/clinexprheumatol/xnb7hp

[161] Du, C. *et al.* "Impact of Tart Cherry Juice on Joint Flexibility and Pain in Individuals with Self-Reported Knee Osteoarthritis (P01-030-19)." *Current Developments in Nutrition*, vol. 3, no. Supplement 1, June 2019. https://doi.org/10.1093/cdn/nzz028.P01-030-19

[162] Kuehl, K. *et al.* "Efficacy of Tart Cherry Juice to Reduce Inflammation Biomarkers among Women with Inflammatory Osteoarthritis (OA)." *Journal of Food Studies*, vol. 1, no. 1, July 2012, pp. 1-12. https://doi.org/10.5296/jfs.v1i1.192.