REVIEW OF FRUITS' ANTI-INFLAMMATORY POLYPHENOLS AS A HEALTHY MEANS OF LOWERING INFLAMMATION IN COMPETITIVE SWIMMERS

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https://doi.org/10.52846/jskm/44.2024.1.2

Abstract: Polyphenols in fruits can be useful supplements to conventional therapy. Polyphenols are the predominant contributor to the total antioxidant activities of fruits. The antioxidant activity is intended to aid swimmers' capacity to recuperate as they experience high levels of oxidative stress and inflammation. In order to reduce swelling in competitive swimmers, this review evaluates scientific literature that offers recommendations for fruits' anti-inflammatory properties. The anti-inflammatory impact of polyphenols on overworked systems seems promising: most of the studies analyzed seem to reveal fruit consumption as the natural way to reduce inflammation. The chemical composition of the fruit undoubtedly has a preventive or therapeutic effect in young people, the anti-inflammatory effects are not attributed only to polyphenols, but to all the active components in the fruit, but the mechanism of operation is still a subject of study to determine the exact potential in prevention and treatment inflammations, for the creation of treatment strategies in performance athletes.

Keywords: *polyphenols; fruits; swimmers; inflammation.*

Introduction

We began with the idea that high-performance swimmers have a variety of inflammatory variables in their bodies, so we thought it was important to research the nutritional intake required in an anti-inflammatory diet. As a result, we examined all the data we could find in publications from open access journals concerning the anti-inflammatory capabilities of polyphenols in fruits as well as data about inflammations that affect competitive swimmers. We developed our own ideas and suggestions about fruit eating based on this information.

More and more researchers, in recent years, are focusing on the study of fruits regarding their composition and pharmacological activities, although the culture of using medicinal plants and natural products to treat or prevent various diseases has ancient roots and continues today in many parts of the world. (Kiki et al., 2022; Bojarczuk et al., 2023)

If some antioxidant mechanisms do not remove the free radicals from the cell, oxidative stress will result. Cellular DNA, proteins, and lipids are negatively impacted by reactive oxygen species. As a result, the cell's structure and essential processes are both impacted (Cutler, 2005). These subcellular organs will be impacted by the oxidative damage that has built up in the mitochondria, which will result in a reduction in the amount of adenosine triphosphate produced as energy (ATP). As DNA integrity-preserving molecular processes become less effective, mutations build up over time (Afanes'ev, I 2005). Through a variety of non-enzymatic processes including glycation or oxidation, proteins go through post-translational modifications. Specific systems will no longer be able to get rid of these changed proteins, which then form aggregates that build up inside cells and lead to malfunction or inflammation (Afanes'ev, 2005).

Ignoring inflammation contributes to the body's excessive production of free radicals. Athletes who consume enough nutrients can avoid hazardous conditions, physiological tension, and malfunction brought on by damaging external forces. As long-term anti-inflammatory medications can have an impact on kidney and liver functioning, which are already under extreme stress from athletes' continual exertion, the nutritional assistance is required to sustain regular biological processes is the all-natural solution to the problem of chronic inflammation.

We ponder if strictly regulating each swimmer's daily diet might be able to stop numerous inflammatory processes.

Literature review

Inflammation is a complex biological process that is part of the body's defense mechanisms to aggression that must be neutralized or eliminated. (Ortet et al., 2022) It is a reaction of the body to an infection, irritation, or injury and it can affect most organs and tissues. It is manifested by redness, fever, swelling and pain, and restriction

of movement in addition to other factors such as heat, physical trauma, exposure to radiation, and irritating chemicals. (Ortet et al., 2022) Inflammation can be acute (body response to wounds or infections) and chronic (it is manifested by the occurrence of side effects that can underpin many diseases). The most common inflammation occurs in the joints and is manifested most often through pain and slow movements. (Chen et al., 2021)

The majority of swimming athletes' injuries and complaints are caused by repeated microtrauma or overuse, with many of these problems stemming from improper technique and poor swimming biomechanics (Pollard et al., 2004; Kammer, et al., 1999). The negative regulatory system seems to be faulty when persistent inflammation develops (Iwu, 2017). Although inflammation is usually a protective reaction (in response to toxins, allergens, or microorganisms), prolonged and uncontrolled inflammation can be harmful to the tissues involved. This can happen when repetitive motions cause inflammation.

Respiratory issues are also linked to the swimming pool environment (WHO, 2006; Fernandez-Luna et al. 2013). Competitive swimmers spend a lot of time in an unhealthy environment, and studies have shown that they can develop asthma, bronchial hyperresponsiveness, eye, throat, and nose irritation, coughing, wheezing, and chest tightness. (Swinarew et al., 2020)

A significant incidence of bronchial reactivity on exercise challenge tests, as well as persistent nasal symptoms, have been found in investigations of competitive swimmers (Bougault et al., 2010; Clearie et al, 2010). There has been evidence of neutrophilic airway inflammation in studies on elite swimmers (Pedersen et al., 2008), and more recently, it has been proposed that airway dysfunction in competitive swimmers may be caused by a noncellular (perhaps neurogenic) inflammation (Clearie, et al., 2010). Although other inflammatory patterns may be elicited, the lack of any increase in exhaled nitric oxide in swimmers as reported in studies (Clearie et al., 2010; Pedersen et al., 2008; Carraro et al., 2006) suggests that the combination of disinfectant chemicals such as chlorine and physical activity of swimming is related with any eosinophilic "asthma-like" inflammation, chronic nasal symptoms (Bougault et al., 2010), and a high preponderence of bronchial response to high-exertion tests (Clearie et al., 2010). There has been evidence of neutrophilic airway inflammation in studies on elite swimmers (Pedersen et al., 2008).

Furthermore, although it has been well shown in adults (Pedersen et al., 2008), the issue of airway injury in competitive swimmers is currently being discussed in teenagers (Clearie et al., 2010; Pedersen et al., 2008). To better address the temporal aspect of possible harmful effects of chlorine on swimmers, a fuller understanding of the effects of chlorine exposure on youngsters through time is therefore unquestionably necessary (Piacentini, 2011).

Competitive swimmers can burn up to 5,000 calories in a four-hour practice session and use between 1.5 to 3 times more energy than active, untrained people. (Peterson, 2019) The remaining energy requirements must then be satisfied by consuming necessary fatty acids, particularly from sources like fish and plants that are naturally anti-inflammatory. To help swimmers adapt resiliently to the strain and demands of rigorous training, it is recommended that they consume an adequate amount of nutrient-dense meals each day (whole grains, fresh produce, and lean protein). (Khodaee**,** et al., 2016)

Every meal need to have about 20–25 percent lipids, ideally unsaturated, 25–30 percent protein, a combination of meat and vegetables, and 45–50 percent carbs, preferably of the low glycemic index (Marinof et al., 2016). Through interactions between vitamins and minerals, a diversified diet enhances nutritional intake and absorption.

Each athlete is different. It is crucial that athletes are not compared to one another since no two athletes will have the same nutritional needs or the same food and hydration regimen.

Due to the phytochemical richness of fruits, vegetables, and whole grain cereals, eating is presently advocated by health authorities. (Hassimotto et al., 2005; Larsson et al., 2012) Nutraceuticals such as polyphenols, flavonoids, folates, minerals, and vitamins C and B are all found in vegetables and fruits, as well as carotenoids like lycopene and -carotene.

More and more scientific research has been conducted recently to prove that there are certain components in fresh and dry fruits and vegetables that have real benefits for human health. (Garcia Mier et al., 2013) Researchers have proven the action of polyphenols as antiproliferative, antioxidant, antimicrobial, anti-inflammatory, cardioprotective, anti-itch, and antidiabetic activity. (Manach et al, 2004; Sur et al, 2008; González-Molina et al., 2010; Hanhineva et al, 2010; Feregrino-Pérez et al, 2011; Cardador et al, 2022; Silva, et al., 2012; Fresco, 2006; Jiao et al, 2010)

Selecting a natural-coloured diet guarantees both a diversified and balanced diet. High-performance athletes who utilize nutritional supplements had

reduced levels of dietary insufficiency. (Sousa et al., 2016) In human bodies, flavonoids and other polyphenolic chemicals have a stronger preventative function by helping to halt or reduce the progression of illnesses and so maintaining good health. Based on the information now available, flavonoids ingested from plant foods cannot be absorbed by the body in a quantity that results in negative consequences, as no pathological process has been identified in vegetarians that may be connected to excessive flavonoid consumption. Anthocyanins have a number of positive health effects, including increased ocular blood flow and protection against degradation of photoreceptor cell function during retinal inflammation. (Elez, 2012)

The effects of a flavonoid chemical that has been taken out of food, cleaned, and taken long-term in large levels as a dietary supplement have not been studied in any detail. The outcomes of research involving various pharmaceutical product types in relation to the secondary effects noted, ie the periods of use that must be complied with and the medical surveillance.

Anthocyanins provide a variety of health advantages, including increased ocular blood flow (Ohguro et al., 2012) and protection against degradation of photoreceptor cell function during retinal inflammation. (Miyake et al., 2012) Each fruit has its own unique blend of polyphenols and in Table 3 we find all of this. Fruits, both fresh and dried, are an essential part of our daily diet and are abundant in antioxidants. It has been demonstrated that eating fruits full of antioxidants can prevent numerous degenerative illnesses. The fruit must be ingested every day, even though there may be variations in concentration between each slice of fruit on the plant and even between the different pieces of a single slice of fruit, depending on the length of sunshine exposure. The flavanols are present in the outer and other tissues (skin and leaves) because their biosynthesis is stimulated by light. (Price et al., 1995) The genotype/cultivar, growing condition, ripening stage, postharvest management, and cooking circumstances all affect the nutraceuticals' content. (Luthria et al., 2010; Shahidi, 2009; Heredia et al., 2009; Yahia et al., 2010; Menichini et al., 2009; Matsufuji et al., 2007)

Other research has demonstrated the significance of elements including ripeness, UV exposure, postharvest storage, and processing techniques on phytochemical composition. (Par et al., 2000) The quantities of phytochemical antioxidants were also shown to be influenced by heredity and whether or not the fruit's skins were consumed, according to recent research on various apple and strawberry fruits. (Tasao et al., 2003; Rekika et al., 2005)

Secondary metabolite levels in plants are also known to be influenced by environmental variables such as location, growth season, soil type, and mineral status. (Tasao, et al., 2006; Manach et al., 2004) Polyphenols don't work by themselves. (Tsao, 2010) It has been shown that polyphenols have a role in vitamin regeneration and can act as a co-antioxidant. (Zhou et al., 2005)

A complex phytochemical cocktail is present in each plant containing anthocyanins (Lila, 2004), and not all polyphenols are as well absorbed. This implies that the eating of any food may impede the absorption of polyphenols and that the only way to get high plasma concentrations would be to take supplements apart from meals. (Manach et al., 2004)

More frequently, cells react to polyphenols by direct interactions with signal transduction receptors or enzymes, which may change the redox status of the cell and cause several redox-dependent events. (Halliwell et al., 2005; Moskaug et al., 2005; Forman et al., 2005)

Purified phytochemical antioxidants in high quantities can have undesirable consequences. (Lowe et al., 2006) Numerous polyphenols and carotenoids' bioavailability hasn't been well studied, and there aren't any suggested daily amounts for any particular substances. Consuming a tioxidant-rich dietary supplements should be done with caution until further toxicological research proves otherwise. (Tasao et al., 2006)

The whole composition of all fruits and vegetables is yet unknown to science, thus it is impossible to determine the ideal daily calorie intake, especially in terms of health benefits. Little information is available regarding possible synergistic or antagonistic biochemical interactions among polyphenols contained in fruits and vegetables. (Tasao et al., 2006)

Materials and methods

A systematic literature review has a surprisingly positivistic aspect that comes from well-defined processes that aim to objectify the process by minimizing biases and mistakes while looking for high-quality instances and evidence of the researched phenomena in the topic literature. (Weed, 2005) The purpose of a systematic literature review is typically to: a) outline and evaluate the existing scientific achievements of the phenomenon under study; b) outline the challenging areas and develop research questions that could add to the body of knowledge already known; c) evaluate the research methods employed by other authors; d) evaluate the research findings of other authors; and e) develop one's own literature base.

A systematic review of the literature is conducted using highly well-defined, repeatable techniques, which include numerous steps and are discussed at length in the methodological assumptions section of the review.

Steps taken in planning this review:

- choosing the theme,
- outlining the treated aspects:
  - the inflammatory process in swimming athletes
  - polyphenols from fruits eaten raw
- going through the specialized literature,
- the choice of databases,
- choosing the composition of the fruits,
- the choice of inflammations in swimming athletes,
- selection of articles.

Database search

This Article has complied with the criteria for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) in the screening process of the existing bibliographic sources (Moher et al., 2009).

Inclusion and exclusion Criteria for Studies.

From online databases, including Taylor and Francis Online, ResearchGate, ScienceDirect and PubMed Central 860 bibliographic were extract from these databases, and 232 sources were included in this review. The eligible sources were included based on the following criteria: 1) studies focusing on research (swimming as a competitive sport); 2) aliments related topics (fruits); 3) medical studies focusing on anti-inflammatory research (polyphenols); 4) human studies. Conversely, sources were excluded based on the following criteria: 1) they were non-human studies (animal studies); 2) contacted sport non-related data; 3) they are not reported to the specific investigated theme or not enough information was available.

Tabel 1 Number of records identified in electronic Databases (n = 860) for all bibliographic search

Detabases	**Eligible sources criteria**		
	Swimming as a competitive sport	**Fruits**	**Polyphenols**
Taylor and Francis Online	125	98	56
ResearchGate	70	86	27
ScienceDirect	97	82	30
PubMed	43	76	70
Number of records	335	342	183

Table 2 Number of eligible criteria included in article in rapport with the selected databases

Criteria	**Articles excluded**		
	Non-human studies	**Duplication**	**Non relevant information**
Swimming as a competitive sport	-	48	109
Fruits	78	104	158
Polyphenols	43	29	59
Number of records	121	181	326

A number of 335 of articles about swimming, 342 articles of fruits and 183 of polyphenols were systematically reviewed in the specialized literature as eligible sources. Over the course of 6 months we went through a number of databases such as:

- National Library of Medicine National Center for Biotechnology Information - https://www.ncbi.nlm.nih.gov
- Taylor and Francis Online - https://www.tandfonline.com
- MDPI Journals - https://www.mdpi.com
- Oxford Academic - https://academic.oup.com
- Science Direct Journals and Books - https://www.sciencedirect.com
- Academia - https://www.academia.edu
- Elsevier - https://www.elsevier.com
- ResearchGate - https://www.researchgate.net.

The development of AGEPs (advanced glycation end products) is thought to be the beginning of a series of events that might lead to tissue damage as a result of oxidative stress and the buildup of free radicals. (Ramasamy et al., 2007) The AGEPs bind to the particular RAGE receptor, increase oxidative stress, and cause inflammation by forming conjugates with proteins. The heart, lung, and skeletal muscle all have this RAGE receptor, which is a multiligand member of the immunoglobulin superfamily. (Basta, 2008)

It has been established beyond a doubt that AGEPs contribute to the vicious cycle of inflammation. A number of processes, including the reduction of superoxide dismutase (SOD) and catalase activity, the depletion of glutathione stores, and the activation of protein kinase C, have

been proposed to relate AGEPs to an excess generation of free radicals. Studies that demonstrate how N-carboxymethyl-lysine, one of the AGEPs molecules, is directly produced when the myeloperoxidase pathway is activated have revealed a direct connection between the synthesis of AGEPs and inflammation. (Sell et al., 2012)

Through repetitive movements, tendons that are used the most in a swimmer's life might receive less blood flow. Poor blood supply and difficulty in getting nutrients to tendons can contribute to tissue damage and inflammation, which is why it's important to do all that it can to improve circulation, nutrient intake, blood pressure levels, and body wide inflammation.

Chlorine-organic matter reactions can produce chemicals that irritate the respiratory system and cause upper and lower respiratory symptoms. Hypochlorite ions and hypochlorous acid, which are present in the water for disinfection, along with chemical compounds created by reactions with nitrogen-containing substances brought into the water by swimmers in the form of, for example, skin, urine, sweat, and cosmetics, cause mucosal problems in the environment of indoor swimming pools. (Fornander, 2015) Elite swimmers have higher rates of atopy, rhinitis, asthma, and airway hyperresponsiveness than the overall population.

Significant airway inflammation and hyperresponsiveness were identified in competitive athletes by Bougault V. et al. However, the majority of top athletes had bronchial epithelial injury that could have accelerated the onset of airway hyperresponsiveness. (Bougault et al., 2009)

Swimmers' airways are irritated by the chemicals used in swimming pools, making them more susceptible to external stressors like allergens or infection agents. Biomarker studies demonstrating that chlorination products can affect the lung epithelial barriers acutely or chronically corroborate this hypothesis. (Bernard, 2007; Bernard et al., 2003; Bernard et al., 2007)

Otitis externa, sometimes known as swimmer's ear, is a painful ear canal infection and inflammation. The ear canal appears red and enlarged as a result of the removal of the lipid layer, which serves as a protective coating across the ear canal.

Health professionals advise fruit eating every day because of the phytochemicals found in fruits. Nutraceuticals found in vegetables and fruits include vitamins C and B, carotenoids like lycopene and -carotene, polyphenols, flavonoids, folates, isothiocyanates, glycosylates, and minerals. (Pace et al., 2017) The major objective of scientific investigation in recent years has been the connection between fruit intake and health advantages. Polyphenols' antiproliferative, antioxidant, estrogenic, antimicrobial, anti-inflammatory, cardioprotective, and antidiabetic effects have been demonstrated by researchers. (Bakhiya et al., 2017)

Phytonutrients in fresh fruits.

Antioxidants, also known as phytonutrients, are substances that exist naturally in plants, such as those that produce fruits, vegetables, grains, legumes, seeds, flowers, leaves, and bark. (Macready et al., 2014). In recent years, mounting data has suggested that carotenoids and polyphenols, two main classes of phytochemicals, may significantly contribute to the prevention of many chronic illnesses, either alone or in conjunction with other vital nutrients. (Miyake et al., 2012) Most of the components that make up the overall antioxidant activity of fruits are polyphenols from phytochemicals. Flavonoids, vitamin C and E, and other nutrients found in fruits and vegetables are thought to have a role in the body's main defensive mechanism. Studies have revealed that some foods have anti-inflammatory effects, even if there isn't a miraculous cure-all at the grocery store. (Sadowska-Krepe, 2015)

The amount of anti-inflammatory food consumed each day should be based on how much energy swimmers use. Each vitamin must be consumed in a minimal quantity for it to have any effect on the body. What dosage is necessary for swimmers, without going beyond certain limits for particular meals that also cause adverse reactions?

Flavonoids: anthocyanidins (cyanidin – in cherry, raspberry, strawberry; delphinidin and pelargonidin – in red, blue, purple fruits, apigenin – in stored fruits; petunidin, malvidin), known as bioflavonoids, are linked to a wide range of health benefits (in red, blue, purple color, in berries, purple sweet potato, apples). Anthocyanins are found especially in the skin but, for some of red fruit, they also are in the flesh, like in cherries and strawberries (Cassidy et al., 2015); flavones (chrysin – in fruit skin; apigenin, rutin – in citrus); flavanones (are present in high concentrations thus: naringin – in citrus, grapefruit; naringenin, sakuranetin and taxifolin – in citrus; hesperidin – in oranges); flavonols (kaempferol – in grapefruit; quercetin – in berries, apples; myricetin – in berries, wine; isorhamnetin); flavanonols (engeletin and astilbin – in white grape skin; taxifolin – in citrus fruits); isoflavones (genistein, daidzein); neoflavonoids and chalcones – in apple; flavanols or flavan-3-oils are very strong antioxidants, with many potential health benefits; they are found in many types of fruit: catechin (epicatechin, epigallocatechin, Clausen-3-

epicatechin), the richest source is apricots, which contain 250 mg/kg of fresh wt., and procyanidin - condensed tannins that are responsible for the astringent character of the fruit; are found in grapes, peaches, khakis, apples, pears, berries.

Phenolic Acids: hydroxycinnamic acids include p-coumaric acid and caffeic acid, which are found in the highest concentrations in the outer parts of ripe fruit (found in apple, pear, plum, and grape), chlorogenic acid, ferulic acid, and synaptic acids; and hydroxybenzoic acids, which include ellagic acid and gallic acid, which are both found in red fruits and berries such as raspberries, strawberries, blackberries, cranberries.

Other polyphenols include resveratrol, which is only present in trace amounts in wine and is usually found in pears and prunes, as well as those found in plants, grapes, and red wine. These other polyphenols are only found in very small amounts and have a variety of health benefits.

Long-term fruit and vegetable intake recommendations in diets are extremely alluring and effective for producing positive health effects. (Fatemeh, 2012)

Results

The information in this material supports the efficacy and safety of eating fruits with anti-inflammatory qualities; nevertheless, further research is required to examine the diets of highly trained endurance swimmers. This has to be optimized, modified, and individually tailored for each swimmer's age, swimming experience, and health status.

Apples are abundant in phytochemicals that have an antioxidant role (Ferretti et al., 2014), and their high polyphenol content provides an anti-inflammatory effect. (Boyer et al., 2004) They can help improve eyesight because vitamin C, antioxidants, and phytonutrients fight free radicals in the retina, protect the lens, and speed up the healing of corneal wounds (Semba, 2007), and the peel contains vitamin A, which strengthens the ocular muscles. They also play a role in improving bone density, are helpful in renewing skin cells, and are helpful in treating skin disorders.

According to Chinese medicine, **apricot** fruit can help with cough relief, respiratory system tuning, body fluid regeneration, and detoxification (Kan et al., 2010). The bioactive components in apricots have anti-inflammatory properties, making them beneficial for people with asthma, osteoporosis prevention, calcium intake, and potassium intake. Carotene, the precursor to vitamin A, is essential for the health of the epithelial tissue that surrounds the organs, eye health, bone and tooth development, and endocrine glands. (Selamoglu et al., 2017)

Given its numerous health benefits, **avocados** are regarded as superfoods (Dabas, et al., 2013), are extremely nutrient-rich and contain a wide range of nutrients, bioactive compounds (Lopez et al., 2020), including 20 different vitamins and minerals. In vitro studies have shown that avocado soy treatments can induce therapeutic activities to counteract pathological processes associated with osteoarthritis, such as collagen production and inflammation. (Skkiner et al., 2013; Khayyal et al., 1998)

Berries. Small berries constitute an important source of potential health-promoting phytochemicals. (Shahidi et al., 2006)

The most common berries are bilberry, blackberry, raspberry, cranberry, black, white, or red currant, blueberry and strawberry.

Berries are consumed as fresh products as well as processed foods (juices, jams, freeze, dried) and are very rich sources of flavonoids and other phenolics that display potential health-promoting effects. (Shahidi et al., 2006)

All berries contain the highest levels of polyphenols including flavonoids (anthocyanins, flavonols, and flavonols), hydrolyzable tannins (ellagitannins), condensed tannins (proanthocyanidins), stilbenoids, and lignans and phenolic acids (hydroxybenzoic and hydroxycinnamic acids, chlorogenic acid). (Nile et al., 2014; Szajdek, et al., 2008) Their concentration is depending of type, genotype, by the level of growth, and post-harvesting conditions. (Manganaris et al., 2014)

In berries there is a lot of myricetin, a compound of flavonols, that displayed activity against rheumatoid arthritis by inducing differentiation in human MG-63 osteoblast-like cells at various concentrations, i.e., 1, 5, 10, and 20 μM, in the absence of cytotoxicity against the MG-63 cell viability and inhibited xylene-induced ear edema. (Semwal et al, 2016)

Also, myricetin intake has been scientifically proven to have a strong effect on the health of the eyes and the lungs. (Yadav et al, 2013)

Ellagic acid is a phenolic compound found in blackberries, raspberries, strawberries, cranberries, grapes, pomegranate, and walnuts. (Abe et al., 2012) Ellagic acid is considered a potent antioxidant and exhibits antibacterial, antiviral, anti-inflammatory, anti-fibrotic, anti-atherogenic, anti-mutagenic, and immunoregulatory properties (Kannan et al., 2012)

The anthocyanins provide the pigments in flowers and fruits (red, violet, blue), it possess protective roles against some biotic and abiotic stresses, and also provide all kinds of benefits for health. (Falcone et al., 2012) Anthocyanins are

predominantly found in the vacuoles of skin in the fruits, but can also be found in the pulp of the berries. (Riihinen et al., 2008; He et al., 2010)

Cranberries. Cranberries were identified with plenty of antioxidant phytonutrients. Cranberry is rarely consumed fresh, due to its very sharp and sour taste.

Concentrated in the peel, ursolic acid is a triterpene found in high amounts in cranberries. It is an ingredient in many traditional herbal medicines and has strong anti-inflammatory effects. (Kondo et al., 2011; Ikeda et al., 2008)

Cherries. According to research, cherries' anthocyanins and other antioxidants may be helpful for a variety of inflammation-related diseases, such as joint discomfort. According to recent studies, cherries' anti-inflammatory properties may help muscles that have been harmed by exercise to heal. Specific anthocyanins have been linked to this action, helping to reduce inflammation-related muscle and joint discomfort. (Alleaume, 2010)

Papaya. Papain is frequently utilized to assist in effective inflammation control. It is also used to treat certain skin problems and certain forms of pain. It is used to treat sore throats and, when combined with other enzymes, can lessen muscular soreness prior to aerobic activity. Bromelain and papazian are also regarded as phytochemicals.

Pineapple In addition to bromelain (Pavan et al., 2012; Kwatra, 2019; Saptarini et al., 2020), which has well-known properties like anti-inflammatory and analgesic, antithrombotic and fibrinolytic effects, anticancer activity, and immunomodulatory effects (Chakraborty et al, 2021), in addition to being a wound healing and circulatory improvement agent, pineapple contains phenols. (630.7 mg/1 kg FW (Rasheed, 2012)) The majority of inflammatory mediators are reduced by bromelain, which also has a strong anti-inflammatory impact in a number of illnesses. (Barth et al., 2005)

These are sufficient reasons for swimmers to consume this fruit. Currently, bromelain is used for acute inflammation and sports injuries. It is not a licensed medical product and is freely available to the general public in health food stores and pharmacies in the USA and Europe. (Cooreman et al., 1976; Mauer, 2001; Italiano et al., 2020)

Pomegranate Components of pomegranates decrease joint degeneration and stop collagen breakdown. (Dharmananda, 2017) Pomegranate contains anti-inflammatory qualities that point to its potential use as a therapy or adjuvant for the prevention and treatment of several forms of cancer and cardiovascular disease. It is a powerful antioxidant that is superior to red wine and equal to or better than green tea. (Jurenka, 2008)

Sea buckthorn is one of the most potent natural antioxidants that aid in tissue regeneration is white, which contains a lot of flavonoids. (Dharmananda, 2017) The amount of vitamin C in sea buckthorn is ten times more than that in citrus fruit and rosehips.

According to a review in the Journal of Ethnopharmacology, sea buckthorn has undergone scientific analysis and has been linked to a number of pharmacological effects, including those that are anti-stress, immunomodulatory, hepatoprotective, radioprotective, anti-atherogenic, anti-microbial, and tissue regeneration. (Suryakumar et al., 2011) It has also been linked to effects on pain and inflammation, arthritis, mental acuity and memory, endurance, healthy skin and hair.

Sea buckthorn oil supplements for atopic dermatitis significantly alleviate symptoms (Carolanne, 2013); the oil has emollient and UV-blocking qualities and aids in encouraging tissue regeneration. (Ianev et al., 1995)

Discussions

Many supplements are utilized in athletics as an alternative to enhancing a natural diet. Unfortunately, the supplement industry as a whole lacks credibility. The content and, ultimately, the efficacy, of supplements and herbal medicines are still unknown because the Food and Drug Administration does not regulate them (Lampen, et al., 2017). These supplements are frequently used without a thorough knowledge of their possible advantages and hazards, or without seeking the advice of a sports nutrition expert. (Maughan, 2009)

The amount of anti-inflammatory food consumed each day should be based on how much energy swimmers use. Each vitamin must be consumed in a minimal quantity for it to have any effect on the body. What dosage is necessary for swimmers, without going beyond certain limits for particular meals that also cause adverse reactions?

Depending on how hard they work out, the average individual will burn between 400 and 600 calories per hour when swimming. Olympic swimmers may work off between 3,000 and 10,000 calories per day (Maughan, 2009; Carroll, 2018).

Anti-inflammatory medications speed up the recovery process and return to training much more quickly than the specialized medical care the doctor has prescribed.

Numerous clinical studies show that feeding foods that are effective at lowering inflammation can alleviate the inflammation linked to certain traumas or injuries.

Cyclooxygenase-2, which causes joint inflammation, is inhibited by foods rich in antioxidants and phytochemicals.

Additionally, there is mounting evidence that oxidative stress may impair athletic performance, cause tiredness, and prolong recovery (Davison et al., 2007; Lawrence et al., 2002; Atalay et al, 2013). Since there is presently little data to demonstrate the positive effects of antioxidant supplementation on performance and exercise recovery, many athletes utilize antioxidant supplements (Powers et al., 2013).

Intestinal ulcers (with the possibility of internal bleeding) develop in 10–30% of chronic users of non-steroidal anti-inflammatory medicines (NSAIDs), while stomach mucosa and intestinal tract erosion occur in 30–50% of cases. Additionally, long-term use of these medicines might harm the liver and kidneys, among other organs.

Studies that have shown a negative connection between apple consumption and the prevalence and incidence of asthma and a favorable association with lung function provide epidemiological evidence that polyphenols may protect against obstructive lung disease. (Tabak et al, 2009) Consuming isoflavones is said to be helpful in halting the decrease of trabecular volume and bone mineral density. (Nakajima et al, 2009) Polyphenols also defend against sun-induced skin damage. (Manach et al., 2004)

Studies on animals show that the polyphenols in tea, when consumed orally or topically, reduce the negative effects of UV radiation on the skin, such as skin damage, erythema, and lipid peroxidation. (Kim et al., 2009)

Table 3. Composition of unique blend of polyphenols in fruits

No	*Fruit*	*Phenolics*	*Flavonoids*				
			Anthocyanidins	**Flavan-3-ols**	**Flavonols**	**Flavanones**	**Flavones**
1	***Acai berries***	1.98 mg GAE ml of juice	53.63	-	-	-	-
2	***Apples***	1000-6000	0-4.91	6.92-23.13	0.42-4.15	-	0-0.12
3	***Apricots***	340	-	8.41	2.26		
4	***Avocados***	716-44,062 DW	0.33	0.52	-	-	-
5	***Bananas***	750-6855.7	0-7.39	6.12	0.18	-	-
6	***Bilberries***	33,000-38,200 DW	285.21	-	4.13	-	-
7	***Blackberries***	4865.3	100.61	42.5	4.79	-	-
8	***Blueberries***	430-3760	163.3-148.61	6.69-124.13	7.31-19.7	-	0.2
9	***Cherries***	2740	27.82-33.44	4.13-9.75	2.43-2.63	-	-
10	***Chokeberries***	1756	349.79	-	18.87	-	-
11	***Cranberries***	1000	5.11-104.02	6.47-31.73	10.73-21.59		-
12	***Currants (black)***	6940 -38,200	1-157.78	0.30-2.78	1.69-11.46	-	-
13	***Elderberries***	9632.43	485.28	-	32.77		
14	***Grapefruits***	0.747 mg GA/ml of juice	-	-	0-0.90	21.98-54.50	0.60
15	***Grapes***	114.9-361.2	48.04-120.01	2.14-1.63	1.05-2.39	-	0.13
16	***Lemons***	0.322 mg GA/ml of juice	-	-	1.67	49.81	1.90
17	***Limes***	249.17 - 422.51mg/100ml	-	-	0.40	46.80	-
18	***Nectarines***	250	0.74-2.13	5.52-0.64	0.12-0.69	-	-
19	***Oranges***	0.437 mg GA/ml of juice	-	-	0.22-0.73	28.97-42.77	0.19-0.70
20	***Papayas***	112-604	-	-	0.03	-	0.03
21	***Peaches***	213-1800	0.97-1.92	8.50-6.34	0.88	-	-
22	***Pears***	3700	2.06	1.88-4.81	3.26	-	-
23	***Plums***	3777	6.98-558.19	7.58-3.53	0-12.47	-	0.02-0.60
24	***Pomegranate***	1808-2566 mg/L	-	0.81	-	-	-
25	***Raspberries***	1137-29,900	48.63-686.79	5.83	1.11	-	-
26	***Sea buckthorn berries***	8.82-14.42	0.08	-	45.87	-	-
27	***Strawberries***	1840-2320	27.01	4.6	1.65	0.26	-

Conclusions

The studied fruits provide a major source of polyphenols whose health-enhancing benefits have been accepted in the studied scientific literature. In the specific case of the fruits studied, the general scientific data on their biological effects show an impactful role on the inflammations of swimmers through their regular consumption, allowing not only an absolute prevention but also a faster recovery by reducing the inflammatory process in case of certain traumas or accidents.

The anti-inflammatory impact of polyphenols on overworked systems seems promising: most of the studies analyzed seem to reveal fruit consumption as the natural way to reduce inflammation.

References

Abe, L. T., Lajolo, F. M., & Genovese, M. I. (2012). Potential dietary sources of ellagic acid and other antioxidants among fruits consumed in Brazil: jabuticaba (Myrciaria jaboticaba (Vell.) Berg). *Journal of the science of food and agriculture*, *92*(8), 1679–1687. https://doi.org/10.1002/jsfa.5531

Afanas'ev I. B. (2005). Free radical mechanisms of aging processes under physiological conditions. *Biogerontology*, *6*(4), 283–290. https://doi.org/10.1007/s10522-005-2626-z

Bojarczuk A., Dzitkowska-Zabielska, M., (2023). Polyphenol Supplementation and Antioxidant Status in Athletes: A Narrative Review, Nutrients, 15(1), 158; https://doi.org/10.3390/nu15010158

Alleaume, K. (2010). The Australian Cherry Report http://australiancherries.com.au/wpcontent/uploads/2011/10/AustralianCherries-Report.pdf

Atalay, M., Lappalainen, J., & Sen, C. K. (2006). Dietary antioxidants for the athlete. *Current sports medicine reports*, *5*(4), 182–186. https://doi.org/10.1097/01.csmr.0000306504.71105.6e

Kiki, G. A. À., Pop, R. M., Sabin, O., Bocsan, I. C., Chedea, V. S., Socaci, S. A., Pârvu, A. E., Finsia, E., Francis, T., Mathieu, Z., & Buzoianu, A. D. (2022). Polyphenols from *Dichrostachys cinerea* Fruits Anti-Inflammatory, Analgesic, and Antioxidant Capacity in Freund's Adjuvant-Induced Arthritic Rat Model. *Molecules (Basel, Switzerland)*, *27*(17), 5445. https://doi.org/10.3390/molecules27175445

Bakhiya, N., Ziegenhagen, R., Hirsch-Ernst, K. I., Dusemund, B., Richter, K., Schultrich, K., Pevny, S., Schäfer, B., & Lampen, A. (2017). Phytochemical compounds in sport nutrition: Synephrine and hydroxycitric acid (HCA) as examples for evaluation of possible health risks. *Molecular nutrition & food research*, *61*(6), 10.1002/mnfr.201601020. https://doi.org/10.1002/mnfr.201601020

Barth, H., Guseo, A., & Klein, R. (2005). In vitro study on the immunological effect of bromelain and trypsin on mononuclear cells from humans. *European journal of medical research*, *10*(8), 325–331.

Basta G. (2008). Receptor for advanced glycation endproducts and atherosclerosis: From basic mechanisms to clinical implications. *Atherosclerosis*, *196*(1), 9–21. https://doi.org/10.1016/j.atherosclerosis.2007.07.025

Bernard A. (2007). Chlorination products: emerging links with allergic diseases. *Current medicinal chemistry*, *14*(16), 1771–1782. https://doi.org/10.2174/092986707781058940

Bernard, A., Carbonnelle, S., Michel, O., Higuet, S., De Burbure, C., Buchet, J. P., Hermans, C., Dumont, X., & Doyle, I. (2003). Lung hyperpermeability and asthma prevalence in schoolchildren: unexpected associations with the attendance at indoor chlorinated swimming pools. *Occupational and environmental medicine*, *60*(6), 385–394. https://doi.org/10.1136/oem.60.6.385

Bougault, V., Turmel, J., Levesque, B., & Boulet, L. P. (2009). The respiratory health of swimmers. *Sports medicine (Auckland, N.Z.)*, *39*(4), 295–312. https://doi.org/10.2165/00007256-200939040-00003

Bougault, V., Turmel, J., St-Laurent, J., Bertrand, M., & Boulet, L. P. (2009). Asthma, airway inflammation and epithelial damage in swimmers and cold-air athletes. *The European respiratory journal*, *33*(4), 740–746. https://doi.org/10.1183/09031936.00117708

Boyer, J., & Liu, R. H. (2004). Apple phytochemicals and their health benefits. *Nutrition journal*, *3*, 5. https://doi.org/10.1186/1475-2891-3-5

Cardador-Martínez, A., Castaño-Tostado, E., & Loarca-Piña, G. (2002). Antimutagenic activity of natural phenolic compounds present in the common bean (Phaseolus vulgaris) against aflatoxin B1. *Food additives and contaminants*, *19*(1), 62–69. https://doi.org/10.1080/02652030110062110

Carolanne, W. (2013) Concerned about cancer, inflammation, memory loss or diabetes? 'Holy Fruit of the Himalayas' can help. Originally published on Saturday,. http://www.seabuckthorninsider.com/health-benefits/concerned-about-cancer-inflammation-memory-loss-or-diabetes-holy-fruit-of-the-himalayas-can-help/

Carraro, S., Pasquale, M. F., Da Frè, M., Rusconi, F., Bonetto, G., Zanconato, S., & Baraldi, E. (2006). Swimming pool attendance and exhaled nitric oxide in children. *The Journal of allergy and clinical immunology*, *118*(4),

958–960. https://doi.org/10.1016/j.jaci.2006.07.016

Carroll, T. How much food do swimmers really need to eat? https://swimswam.com/how-much-food-do-swimmers-really-need-to-eat/ 2015

Cassidy, A., Rogers, G., Peterson, J. J., Dwyer, J. T., Lin, H., & Jacques, P. F. (2015). Higher dietary anthocyanin and flavonol intakes are associated with anti-inflammatory effects in a population of US adults. *The American journal of clinical nutrition*, *102*(1), 172–181. https://doi.org/10.3945/ajcn.115.108555

Chen, J., Abbod, M., & Shieh, J. S. (2021). Pain and Stress Detection Using Wearable Sensors and Devices-A Review. *Sensors (Basel, Switzerland)*, *21*(4), 1030. https://doi.org/10.3390/s21041030

Clearie, K. L., Vaidyanathan, S., Williamson, P. A., Goudie, A., Short, P., Schembri, S., & Lipworth, B. J. (2010). Effects of chlorine and exercise on the unified airway in adolescent elite Scottish swimmers. *Allergy*, *65*(2), 269–273. https://doi.org/10.1111/j.1398-9995.2009.02173.x

Chakraborty, A. J., Mitra, S., Tallei, T. E., Tareq, A. M., Nainu, F., Cicia, D., Dhama, K., Emran, T. B., Simal-Gandara, J., & Capasso, R. (2024). Correction: Chakraborty et al. Bromelain a Potential Bioactive Compound: A Comprehensive Overview from a Pharmacological Perspective. *Life* 2021, *11*, 317. *Life (Basel, Switzerland)*, *14*(4), 483. https://doi.org/10.3390/life14040483

Cooreman, W. M., Scharpé, S., Demeester, J., & Lauwers, A. (1976). Bromelain, biochemical and pharmacological properties. *Pharmaceutica acta Helvetiae*, *51*(4), 73–97.

Cutler R. G. (2005). Oxidative stress profiling: part I. Its potential importance in the optimization of human health. *Annals of the New York Academy of Sciences*, *1055*, 93–135. https://doi.org/10.1196/annals.1323.027

Dabas, D., Shegog, R. M., Ziegler, G. R., & Lambert, J. D. (2013). Avocado (Persea americana) seed as a source of bioactive phytochemicals. *Current pharmaceutical design*, *19*(34), 6133–6140. https://doi.org/10.2174/13816128113193400007

Davison, G., Gleeson, M., & Phillips, S. (2007). Antioxidant supplementation and immunoendocrine responses to prolonged exercise. *Medicine and science in sports and exercise*, *39*(4), 645–652. https://doi.org/10.1249/mss.0b013e318031303d

DHARMANANDA, S. Sea buckthorn. http://www.itmonline.org/arts/seabuckthorn.htm

Fatemeh, S., Saifullah, R., Abbas, F.M., & Azhar, M.E. (2012). Total phenolics, flavonoids and antioxidant activity of banana pulp and peel flours: influence of variety and stage of ripeness. *international food research journal*, *19*, 1041-1046.

Feregrino-Pérez, A. A., Torres-Pacheco, I., Vargas-Hernández, M., Munguía-Fragozo, P. V., Loarca-Piña, G. F., Mendoza-Díaz, S. O., ... & Guevara-Gónzalez, R. G. (2011). Antioxidant and antimutagenic activities of Acacia pennatula pods, J. Sci. Ind. Res. India, 70:859–864

Fernández-Luna, Á., Gallardo, L., Plaza-Carmona, M., García-Unanue, J., Sánchez-Sánchez, J., Felipe, J. L., Burillo, P., & Ara, I. (2013). Respiratory function and changes in lung epithelium biomarkers after a short-training intervention in chlorinated vs. ozone indoor pools. *PloS one*, *8*(7), e68447. https://doi.org/10.1371/journal.pone.0068447

Ferretti, G., Turco, I. and Bacchetti, T. (2014) Apple as a Source of Dietary Phytonutrients: Bioavailability and Evidence of Protective Effects against Human Cardiovascular Disease. *Food and Nutrition Sciences*, 5, 1234-1246. doi: 10.4236/fns.2014.513134.

Falcone Ferreyra, M. L., Rius, S. P., & Casati, P. (2012). Flavonoids: biosynthesis, biological functions, and biotechnological applications. *Frontiers in plant science*, *3*, 222. https://doi.org/10.3389/fpls.2012.00222

Forman, H. J., Torres, M., & Fukuto, J. (2002). Redox signaling. *Molecular and cellular biochemistry*, *234-235*(1-2), 49–62

Fornander, L. (2015). *Upper Airway Mucosal Inflammation: Proteomic Studies After Exposure to Irritants and Microbial Agents* (Vol. 1453). Linköping University Electronic Press.

Fresco, P., Borges, F., Diniz, C., & Marques, M. P. (2006). New insights on the anticancer properties of dietary polyphenols. *Medicinal research reviews*, *26*(6), 747–766. https://doi.org/10.1002/med.20060

Elez Garofulić, I., Kovačević Ganić, K., Galić, I., Dragović-Uzelac, V., & Savić, Z. (2012). The influence of processing on physico-chemical parameters, phenolics, antioxidant activity and sensory attributes of elderberry (Sambucus nigra L.) fruit wine. Hrvatski časopis za prehrambenu tehnologiju, biotehnologiju i nutricionizam, 7(SPECIAL ISSUE-7th), 9-13.

González-Molina, E., Domínguez-Perles, R., Moreno, D. A., & García-Viguera, C. (2010). Natural bioactive compounds of Citrus limon for food and health. *Journal of pharmaceutical and biomedical analysis*, *51*(2), 327-345.

Halliwell, B., Rafter, J., & Jenner, A. (2005). Health promotion by flavonoids, tocopherols, tocotrienols, and other phenols: direct or indirect effects? Antioxidant or not?. *The American journal of clinical nutrition*, *81*(1 Suppl), 268S–276S. https://doi.org/10.1093/ajcn/81.1.268S

Hanhineva, K., Törrönen, R., Bondia-Pons, I., Pekkinen, J., Kolehmainen, M., Mykkänen, H., & Poutanen, K. (2010). Impact of dietary polyphenols on carbohydrate metabolism. *International journal of molecular sciences*, *11*(4), 1365–1402. https://doi.org/10.3390/ijms11041365

Hassimotto, N. M., Genovese, M. I., & Lajolo, F. M. (2005). Antioxidant activity of dietary fruits, vegetables, and commercial frozen fruit pulps. *Journal of agricultural and food chemistry*, *53*(8), 2928–2935. https://doi.org/10.1021/jf047894h

He, J. J., Liu, Y. X., Pan, Q. H., Cui, X. Y., & Duan, C. Q. (2010). Different anthocyanin profiles of the skin and the pulp of Yan73 (Muscat Hamburg× Alicante Bouschet) grape berries. *Molecules*, *15*(3), 1141-1153. DOI: 10.3390/molecules15031141

Heredia, J. B., & Cisneros-Zevallos, L. (2009). The effects of exogenous ethylene and methyl jasmonate on the accumulation of phenolic antioxidants in selected whole and wounded fresh produce. Food Chemistry, 115(4), 1500-1508.

Ianev, E., Radev, S., Balutsov, M., Klouchek, E., & Popov, A. (1995). The effect of an extract of sea buckthorn (Hippophae rhamnoides L.) on the healing of experimental skin wounds in rats. *Khirurgiia*, *48*(3), 30-33.

Ikeda, Y., Murakami, A., & Ohigashi, H. (2008). Ursolic acid: an anti- and pro-inflammatory triterpenoid. *Molecular nutrition & food research*, *52*(1), 26–42. https://doi.org/10.1002/mnfr.200700389.

Jiao, R., Zhang, Z., Yu, H., Huang, Y., & Chen, Z. Y. (2010). Hypocholesterolemic activity of grape seed proanthocyanidin is mediated by enhancement of bile acid excretion and up-regulation of CYP7A1. *The Journal of nutritional biochemistry*, *21*(11), 1134–1139. https://doi.org/10.1016/j.jnutbio.2009.10.007

Jurenka J. S. (2008). Therapeutic applications of pomegranate (Punica granatum L.): a review. *Alternative medicine review : a journal of clinical therapeutic*, *13*(2), 128–144.

Kammer, C. S., Young, C. C., & Niedfeldt, M. W. (1999). Swimming injuries and illnesses. *The Physician and sportsmedicine*, *27*(4), 51–60. https://doi.org/10.3810/psm.1999.04.783

Kan, T., & Bostan, S. Z. (2010). Changes of contents of polyphenols and vitamin a of organic and conventional fresh and dried apricot cultivars (Prunus armeniaca L.). *World Journal of Agricultural Sciences*, *6*(2), 120-126.

Kannan, M. M., Quine, S. D., & Sangeetha, T. (2012). Protective efficacy of ellagic acid on glycoproteins, hematological parameters, biochemical changes, and electrolytes in myocardial infarcted rats. *Journal of biochemical and molecular toxicology*, *26*(7), 270–275. https://doi.org/10.1002/jbt.21418

Khayyal, M. T., & el-Ghazaly, M. A. (1998). The possible "chondroprotective" effect of the unsaponifiable constituents of avocado and soya in vivo. *Drugs under experimental and clinical research*, *24*(1), 41–50.

Kim, J., Hwang, J. S., Cho, Y. K., Han, Y., Jeon, Y. J., & Yang, K. H. (2001). Protective effects of (-)-epigallocatechin-3-gallate on UVA- and UVB-induced skin damage. *Skin pharmacology and applied skin physiology*, *14*(1), 11–19. https://doi.org/10.1159/000056329

Kondo, M., MacKinnon, S. L., Craft, C. C., Matchett, M. D., Hurta, R. A., & Neto, C. C. (2011). Ursolic acid and its esters: occurrence in cranberries and other Vaccinium fruit and effects on matrix metalloproteinase activity in DU145 prostate tumor cells. *Journal of the science of food and agriculture*, *91*(5), 789–796. https://doi.org/10.1002/jsfa.4330.

Kwatra, B. (2019). A review on potential properties and therapeutic applications of bromelain. *World J. Pharm. Pharm. Sci*, *8*(11), 488-500. doi: 10.20959/wjpps201911-149

LAMPEN, C. (2017 December 27) This Shocking News Might Make You Question The Supplements You've Been Taking A new study calls calcium and vitamin D pills into question.. https://www.womenshealthmag.com/health/calcium-vitamin-d-bone-fractures

Larsson, S. C., Virtamo, J., & Wolk, A. (2013). Total and specific fruit and vegetable consumption and risk of stroke: a prospective study. *Atherosclerosis*, *227*(1), 147–152. https://doi.org/10.1016/j.atherosclerosis.2012.12.022

Lawrence, M. E., & Kirby, D. F. (2002). Nutrition and sports supplements: fact or fiction. *Journal of clinical gastroenterology*, *35*(4), 299–306. https://doi.org/10.1097/00004836-200210000-00005

Lila M. A. (2004). Anthocyanins and Human Health: An In Vitro Investigative Approach. *Journal of biomedicine & biotechnology*, *2004*(5), 306–313. https://doi.org/10.1155/S111072430440401X

Luthria, D., Singh, A. P., Wilson, T., Vorsa, N., Banuelos, G. S., & Vinyard, B. T. (2010). Influence of conventional and organic agricultural practices on the phenolic content in eggplant pulp: Plant-to-plant variation. *Food Chemistry*, *121*(2), 406-411.

Macready, A. L., George, T. W., Chong, M. F., Alimbetov, D. S., Jin, Y., Vidal, A., Spencer, J. P., Kennedy, O. B., Tuohy, K. M., Minihane, A. M., Gordon, M. H., Lovegrove, J. A., & FLAVURS Study Group (2014). Flavonoid-rich fruit and vegetables improve microvascular reactivity and inflammatory status in men at risk of cardiovascular disease--FLAVURS: a randomized controlled trial.

The American journal of clinical nutrition, *99*(3), 479–489. https://doi.org/10.3945/ajcn.113.074237

Manach, C., Scalbert, A., Morand, C., Rémésy, C., & Jiménez, L. (2004). Polyphenols: food sources and bioavailability. *The American journal of clinical nutrition*, *79*(5), 727–747. https://doi.org/10.1093/ajcn/79.5.727

Manganaris, G. A., Goulas, V., Vicente, A. R., & Terry, L. A. (2014). Berry antioxidants: small fruits providing large benefits. *Journal of the science of food and agriculture*, *94*(5), 825–833. https://doi.org/10.1002/jsfa.6432

Marinof, A., & Coumbe-Lilley, J. (2017). *Science of Sport: Swimming*. The Crowood Press.

Matsufuji, H., Ishikawa, K., Nunomura, O., Chino, M., & Takeda, M. (2007). Anti-oxidant content of different coloured sweet peppers, white, green, yellow, orange and red (Capsicum annuum L.). *International Journal of Food Science & Technology*, *42*(12), 1482-1488. https://academic.oup.com/ajcn/article/79/5/727/4690182

Maurer H. R. (2001). Bromelain: biochemistry, pharmacology and medical use. *Cellular and molecular life sciences : CMLS*, *58*(9), 1234–1245. https://doi.org/10.1007/PL00000936

Maughan, R. J., Depiesse, F., Geyer, H., & International Association of Athletics Federations (2007). The use of dietary supplements by athletes. *Journal of sports sciences*, *25 Suppl 1*, S103–S113. https://doi.org/10.1080/02640410701607395

Iwu, M. M. (2016). Food as Medicine Functional Food Plants of Africa, CRC Press

Menichini, F., Tundis, R., Bonesi, M., Loizzo, M.R., Conforti, F., Statti, G., Cindio, B.D., & Houghton, P.J. (2009). The influence of fruit ripening on the phytochemical content and biological activity of Capsicum chinense Jacq. cv Habanero. *Food Chemistry, 114*, 553-560.

García-Mier, L., Guevara-González, R. G., Mondragón-Olguín, V. M., Del Rocío Verduzco-Cuellar, B., & Torres-Pacheco, I. (2013). Agriculture and bioactives: achieving both crop yield and phytochemicals. *International journal of molecular sciences*, *14*(2), 4203–4222. https://doi.org/10.3390/ijms14024203

Miyake, S., Takahashi, N., Sasaki, M., Kobayashi, S., Tsubota, K., & Ozawa, Y. (2012). Vision preservation during retinal inflammation by anthocyanin-rich bilberry extract: cellular and molecular mechanism. *Laboratory investigation; a journal of technical methods and pathology*, *92*(1), 102–109. https://doi.org/10.1038/labinvest.2011.132

Khodaee, M., Edelman, G. T., Spittler, J., Wilber, R., Krabak, B. J., Solomon, D., Riewald, S., Kendig, A., Borgelt, L. M., Riederer, M., Puzovic, V., & Rodeo, S. (2016). Medical Care for Swimmers. *Sports medicine - open*, *2*, 27. https://doi.org/10.1186/s40798-016-0051-2

Moskaug, J. Ø., Carlsen, H., Myhrstad, M. C., & Blomhoff, R. (2005). Polyphenols and glutathione synthesis regulation. *The American journal of clinical nutrition*, *81*(1 Suppl), 277S–283S. https://doi.org/10.1093/ajcn/81.1.277S

Nakajima, D., Kim, C. S., Oh, T. W., Yang, C. Y., Naka, T., Igawa, S., & Ohta, F. (2001). Suppressive effects of genistein dosage and resistance exercise on bone loss in ovariectomized rats. *Journal of physiological anthropology and applied human science*, *20*(5), 285–291. https://doi.org/10.2114/jpa.20.285

Nile, S. H., & Park, S. W. (2014). Edible berries: bioactive components and their effect on human health. *Nutrition (Burbank, Los Angeles County, Calif.)*, *30*(2), 134–144. https://doi.org/10.1016/j.nut.2013.04.007

Saptarini, N. M., Rahayu, D., & Kartikawati, E. (2020). Immunomodulatory Activity of Crude Bromelain of Pineapple (Ananas comosus (L.) Merr.) Crown from Subang District, Indonesia. *Research Journal of Pharmacy and Technology*, *13*(11), 5177-5182.

Ohguro, H., Ohguro, I., Katai, M., & Tanaka, S. (2012). Two-year randomized, placebo-controlled study of black currant anthocyanins on visual field in glaucoma. *Ophthalmologica. Journal international d'ophtalmologie. International journal of ophthalmology. Zeitschrift fur Augenheilkunde*, *228*(1), 26–35. https://doi.org/10.1159/000335961

Ortet, C., & Vale Costa, L. (2022). "Listen to Your Immune System When It's Calling for You": Monitoring Autoimmune Diseases Using the iShU App. *Sensors (Basel, Switzerland)*, *22*(10), 3834. https://doi.org/10.3390/s22103834

Pace, C., Dagda, R., & Angermann, J. (2017). Antioxidants Protect against Arsenic Induced Mitochondrial Cardio-Toxicity. *Toxics*, *5*(4), 38. https://doi.org/10.3390/toxics5040038

Parr, A. J., & Bolwell, G. P. (2000). Phenols in the plant and in man. The potential for possible nutritional enhancement of the diet by modifying the phenols content or profile. *Journal of the Science of Food and Agriculture*, *80*(7), 985-1012.

Pavan, R., Jain, S., Shraddha, & Kumar, A. (2012). Properties and therapeutic application of bromelain: a review. *Biotechnology research international*, *2012*(1), 976203. **https://doi.org/10.1155/2012/976203**

Pedersen, L., Lund, T. K., Barnes, P. J., Kharitonov, S. A., & Backer, V. (2008). Airway responsiveness and inflammation in

adolescent elite swimmers. *The Journal of allergy and clinical immunology*, *122*(2), 322–327.e1. https://doi.org/10.1016/j.jaci.2008.04.041

Peterson, B. (2019) *Nutritional Needs for Competitive Swimmers*.. https://cehsp.d.umn.edu/sites/cehsp.d.umn.edu/files/nutritionalneedsofcompetitiveswimmers.pdf

Piacentini, G. L., & Baraldi, E. (2011). Pro: swimming in chlorinated pools and risk of asthma: we can now carry on sending our children to swimming pools!. *American journal of respiratory and critical care medicine*, *183*(5), 569–570. https://doi.org/10.1164/rccm.201008-1277ED

Pollard, H., & Fernandez, M. (2004). Spinal musculoskeletal injuries associated with swimming: a discussion of technique. *Australasian chiropractic & osteopathy: journal of the Chiropractic & Osteopathic College of Australasia*, *12*(2), 72–80.

Powers, S., Nelson, W. B., & Larson-Meyer, E. (2011). Antioxidant and Vitamin D supplements for athletes: sense or nonsense?. *Journal of sports sciences*, *29 Suppl 1*, S47–S55. https://doi.org/10.1080/02640414.2011.602098

Price, S. F., Breen, P. J., Valladao, M., & Watson, B. T. (1995). Cluster sun exposure and quercetin in Pinot noir grapes and wine. *American Journal of Enology and Viticulture*, *46*(2), 187-194. DOI: 10.5344/ajev.1995.46.2 ttps://www.ajevonline.org/content/46/2/187.short

Ramasamy, R., Yan, S. F., & Schmidt, A. M. (2007). Arguing for the motion: yes, RAGE is a receptor for advanced glycation endproducts. *Molecular nutrition & food research*, *51*(9), 1111–1115. https://doi.org/10.1002/mnfr.200700008

Rasheed, A., Cobham, E. I., Zeighmami, M., & Ong, S. (2012, June). Extraction of phenolic compounds from pineapple fruit. In *Proceedings of the 2nd International Symposium on Processing & Drying of Foods, Fruits & Vegetables, Kuala Lumpur, Malaysia* (pp. 18-19).

Rekika, D., Khanizadeh, S., Deschênes, M., Levasseur, A., Charles, M. T., Tsao, R., & Yang, R. (2005). Antioxidant capacity and phenolic content of selected strawberry genotypes. *HortScience*, *40*(6), 1777-1781.

Riihinen, K., Jaakola, L., Kärenlampi, S., & Hohtola, A. (2008). Organ-specific distribution of phenolic compounds in bilberry (Vaccinium myrtillus) and 'northblue' blueberry (Vaccinium corymbosum x V. angustifolium). *Food chemistry*, *110*(1), 156–160. https://doi.org/10.1016/j.foodchem.2008.01.057

Sadowska-Krępa, E., Kłapcińska, B., Podgórski, T., Szade, B., Tyl, K., & Hadzik, A. (2015). Effects of supplementation with acai (Euterpe oleracea Mart.) berry-based juice blend on the blood antioxidant defence capacity and lipid profile in junior hurdlers. A pilot study. *Biology of sport*, *32*(2), 161–168. https://doi.org/10.5604/20831862.1144419

Selamoglu, Z., & Erdemli, M. E. (2017). The significance of apricot in human health and nutrition. 9th International Conference and Exhibition on Metabolomics and Systems Biology *Biochemistry & Molecular Biology Journal*, *3*(2). DOI: 10.21767/2471-8084-C1-003

Sell, D. R., & Monnier, V. M. (2012). Molecular basis of arterial stiffening: role of glycation - a mini-review. *Gerontology*, *58*(3), 227–237. https://doi.org/10.1159/000334668

Semba, R. D. (2007). Vitamin C and Eye Health. *Handbook of Nutrition and Ophthalmology*, 371-390.

Semwal, D. K., Semwal, R. B., Combrinck, S., & Viljoen, A. (2016). Myricetin: A Dietary Molecule with Diverse Biological Activities. *Nutrients*, *8*(2), 90. https://doi.org/10.3390/nu8020090

Shahidi, F. (2009). Nutraceuticals and functional foods: Whole versus processed foods. *Trends in Food Science and Technology, 20*, 376-387.

Shahidi, F., & Naczk, M. (2003). Phenolics in Food and Nutraceuticals (2nd ed.). CRC Press. https://doi.org/10.1201/9780203508732

Silva, J. C., Rodrigues, S., Feás, X., & Estevinho, L. M. (2012). Antimicrobial activity, phenolic profile and role in the inflammation of propolis. *Food and chemical toxicology : an international journal published for the British Industrial Biological Research Association*, *50*(5), 1790–1795. https://doi.org/10.1016/j.fct.2012.02.097'

Skinner, M., & Hunter, D. (Eds.). (2013). *Bioactives in fruit: health benefits and functional foods*. Wiley-Blackwell

Sousa, M., Fernandes, M. J., Carvalho, P., Soares, J., Moreira, P., & Teixeira, V. H. (2016). Nutritional supplements use in high-performance athletes is related with lower nutritional inadequacy from food. *Journal of sport and health science*, *5*(3), 368–374. https://doi.org/10.1016/j.jshs.2015.01.006

Szajdek, A., & Borowska, E. J. (2008). Bioactive compounds and health-promoting properties of berry fruits: a review. *Plant foods for human nutrition (Dordrecht, Netherlands)*, *63*(4), 147–156. https://doi.org/10.1007/s11130-008-0097-5.

Sur, R., Nigam, A., Grote, D., Liebel, F., & Southall, M. D. (2008). Avenanthramides, polyphenols from oats, exhibit anti-inflammatory and anti-itch activity. *Archives of dermatological*

research, *300*(10), 569–574. https://doi.org/10.1007/s00403-008-0858-x

Suryakumar, G., & Gupta, A. (2011). Medicinal and therapeutic potential of Sea buckthorn (Hippophae rhamnoides L.). *Journal of ethnopharmacology*, *138*(2), 268-278. DOI: 10.1016/j.jep.2011.09.024.

Swinarew, A. S., Stanula, A. J., Gabor, J., Raif, P., Paluch, J., Karpiński, J., Kubik, K., Okła, H., Ostrowski, A., Tkacz, E., Skoczyński, S., Waśkiewicz, Z., Rosemann, T., Nikolaidis, P. T., & Knechtle, B. (2020). The influence of chlorine in indoor swimming pools on the composition of breathing phase of professional swimmers. *Respiratory research*, *21*(1), 88. https://doi.org/10.1186/s12931-020-01350-y

Tabak, C., Arts, I. C., Smit, H. A., Heederik, D., & Kromhout, D. (2001). Chronic obstructive pulmonary disease and intake of catechins, flavonols, and flavones: the MORGEN Study. *American journal of respiratory and critical care medicine*, *164*(1), 61–64. https://doi.org/10.1164/ajrccm.164.1.2010025

Tsao, R., YANG, R., SOCKOVIE, E., ZHOU, T., DALE, A. (2003). Antioxidant phytochemicals in antioxidant phytochemicals in cultivated and wild Canadian strawberries. Acta Hortic. (ISHS), 2003, 626: 25–35

Tsao R. (2010). Chemistry and biochemistry of dietary polyphenols. *Nutrients*, *2*(12), 1231–1246. https://doi.org/10.3390/nu2121231

Veloz-García, R., Marín-Martínez, R., Veloz-Rodríguez, R., Rodríguez-Guerra, R., Torres-Pacheco, I., González-Chavira, M. M., ... & Guevara-González, R. G. (2010). Antimicrobial activities of cascalote (Caesalpinia cacalaco) phenolics-containing extract against fungus Colletotrichum lindemuthianum. *Industrial crops and products*, *31*(1), 134-138.

WHO. (2006) Guidelines for safe recreational water environments. Volume 2: Swimming pools and similar environments. https://www.who.int/publications/i/item/9241546808

Yadav, A. K., Thakur, J., Prakash, O. M., Khan, F., Saikia, D., & Gupta, M. M. (2013). Screening of flavonoids for antitubercular activity and their structure–activity relationships. *Medicinal Chemistry Research*, *22*, 2706-2716. DOI: 10.1007/s00044-012-0268-7

YAHIA, E.M., ORNELAS-PAZ, J.J. (2010) Chemistry, Stability and Biological Actions of Carotenoids. In: de la Rosa L.A., Álvarez-Parrilla E., González-Aguilar G.A., editors. Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability. Wiley-Blackwell, Oxford, UK, pp. 177–222

Zhou, B., Wu, L. M., Yang, L., & Liu, Z. L. (2005). Evidence for alpha-tocopherol regeneration reaction of green tea polyphenols in SDS micelles. *Free radical biology & medicine*, *38*(1), 78–84. https://doi.org/10.1016/j.freeradbiomed.2004.09.023