Beetroot-Watermelon Juice as an Ergogenic Aid for Increasing the Source of Nitric Oxide within the Human Body

Brian Hemenway and Conner Jackson

Background

Use of nutritional supplementation in exercise has been widely popular for many years. Whether they are elite athletes or recreational gym goers, people seek out unique ways to give themselves a special edge. Though supplements come in many forms, such as bars, drinks, and boosters, sport drinks seem to have really taken over the market with companies like GNC, MaxMuscle, and BodyBuilder.com emphasizing their simplicity. As the go-to, quick and easy way of replenishing one’s body with important nutrients for vigorous exercise, millions of sport supplements are sold each year.

As reported by da Silva et al. (2014), supplement users most commonly exercise to improve aesthetics, health, and hypertrophy—in that order of prevalence. However, there is often a lot of concern as to whether or not a given supplement is safe to use, and with so many out there it is not an easy task to test them all. Loopholes in U.S. Food and Drug Administration (FDA) regulations allow certain companies to produce and sell products that have never been tested and/or reviewed, by simply claiming: “These statements have not been approved by the Food and Drug Administration.”
Therefore, instead of having an ingredient label with more words that are a struggle to pronounce than there are letters in the alphabet, we set out to create a more natural and energy-efficient sports nutrition supplement. Keeping in mind that one of the most desired qualities of an exercise supplement is to increase the individual’s blood flow, along with providing an energetic sensation for the workout ahead, we put a heavy emphasis on nitric oxide (NO), a very common vasodilator. Emphasizing the importance of NO during anaerobic stages of exercise, Bescós et al. (2012) describes how this gas is not only an important modulator of blood flow, but also that it helps regulate mitochondrial respiration. Through much analysis of systematic reviews and write-ups on exercise testing, we were able to come to strong conclusions regarding the most efficacious ingredients (Sureda et al., 2010; Cermak et al., 2012; Ormbsee et al., 2013).

As recent trends suggest, beetroot juice is potentially the perfect ingredient. Gaining tons of publicity, beets are known to be one of the strongest, most natural sources of nitrate, a crucial ion required for the synthesis of nitric oxide. We also researched the possible benefits of adding watermelon juice. As a strong source of two amino acids, L-arginine (an essential amino acid) and L-citrulline (a non-essential amino acid), both of which attain a crucial role in the nitric oxide synthase (NOS)–dependent pathway, watermelon will conceivably make the perfect combination with beetroot juice. With this knowledge, we designed a recipe for a sport drink that could potentially increase one’s bioavailability of NO’s main sources of production: nitrate, L-arginine, and L-citrulline. In order to improve flavor and add other beneficial micronutrients, we also added orange and pineapple juice, which will be further discussed throughout the article.
Beetroot

Before delving right into the physiological aspects of beetroot juice, we first must discuss the basics: What is a beet? A beet is the bulbous taproot portion of a root vegetable, or a vegetable that grows underground similar to potatoes. Though there are different kinds of beets—golden, candy-cane, garden beets, etc.—the most commonly known is the red beet. It has a deep red, almost purple hue, and when eaten raw tastes of a natural, somewhat sweet, woody flavor. According to the United States Department of Agriculture (2014), a 2-inch beet is roughly 88 percent water and contains fair amounts of carbohydrates, protein, natural sugars, and potassium. Though you can boil, roast, steam, or pickle beets, we decided to keep ours raw in order to preserve the majority of nutrients while avoiding the transformation of nitrates into the very undesirable form of nitrosamines (further discussed in Practical Applications).

The standard beet contains 0.25 mg of nitrate (NO₃⁻) per 100 g of fresh weight (Ormsbee, 2013). Because there is no way of taking NO directly into the body, people rely on nutrients such as nitrates and nitrites found in their natural form. Once digested, the body stores away these nutrients so they are readily available to be converted into the desired form of NO further down the road. Researchers long believed that nitrates and nitrites were only by-products of NO metabolism. Fortunately, current research has revealed that they are also recycled back into the system and used as a primary source of NO (Figure 1). Supporting this notion, Lundberg et al. (2008) discuss how nitrates and nitrites actually act
as what they refer to as “storage-pools” for NO, providing high levels of bioavailability and supporting the NOS-independent pathway with a readily available source.

**Figure 1:** The nitric oxide cycle, including both NOS-dependent and -independent pathways.

**Watermelon**

Watermelon, the second main ingredient of our drink, is a fruit with which everyone is a little more familiar. Growing from a vine-like plant, watermelons grow above ground similar to the way pumpkins grow in a pumpkin patch. According to the United States Department of Agriculture (2014), a 15-inch x 7.5-inch watermelon weighing roughly 4,520 g contains approximately 4,130 g of water (91%), giving it its ever-so-creative name.

As many are aware, it is extremely important to stay hydrated, and even more crucial when taking part in regular vigorous exercise. Therefore, watermelon juice containing a large portion of water is very practical for our primary goal—to create an all-natural, yet nutrient-efficient, sports nutrition drink.
Watermelon is also packed with carbohydrates, natural sugars, potassium, vitamin C, and vitamin A. Although as mentioned earlier, our main focus is drawn toward the two amino acids, L-citrulline and L-arginine. Bescós et al. (2012) recounts how L-citrulline can be classified as an “alternative donor” of NO by simply increasing levels of L-arginine. L-citrulline is converted into L-arginine with the aid of specific catalysts such as argininosuccinate. Similar to nitrates, L-arginine is easily converted to NO. However, it goes through a specific NOS-dependent pathway where both L-citrulline and NO are by-products.

Figure 1 shows that L-citrulline is recycled out of L-arginine while the NO conversion process takes place, demonstrating how efficient this cycle really is. The true benefit of L-citrulline is not derived from a quick source of NO to be used during exercise, but rather, according to Tarazona-Díaz et al. (2013), as a prolonged effect, which can lead to increased recovery. Due to a more complex transformation of one amino acid to another prior to the final transformation into NO, L-citrulline subsequently takes longer to provide the body with the desired product. It is for this exact reason that L-citrulline speeds up recovery. By lengthening the supply of NO, even after one’s exercise is complete, the body’s blood vessels continue to stay vasodilated. This prolonged vasodilation allows for not only the continuing transportation of essential nutrients, but also the removal of waste and other by-products of exercise. For example, the increased blood flow provides a steady supply of oxygen and other essential nutrients to the fatigued muscles post-exercise, while also
removing excess hydrogen ions (commonly recognized as the cause of acidic blood) at a more efficient rate.

**Orange and Pineapple**

Though we went into this research expecting to make our drink solely from beetroot and watermelon, we immediately knew it would need something more upon drinking our first batch. It was not so much that the flavor was bad, but rather bland. Wanting to keep our drink as natural as possible, we headed back to the local market to pick up some citrus for additional flavor, and ended up with the final four ingredients: beetroot, watermelon, orange, and pineapple. By taking the juice from one whole orange and a portion of the pineapple, we not only added flavor, but also a fair amount of calcium (Ca\(^{2+}\)), vitamin A, vitamin C, and potassium (K\(^+\)).

While all of these nutrients contain their own unique health benefits (vitamin A with immune function and vitamin C with increasing iron absorption), we were rather excited about the addition of even more potassium and calcium than what the beets and watermelon provided. Calcium helps with nerve impulse transmission, muscle contraction, pH regulation, and blood coagulation (Wildman & Medeiros, 2000). Potassium is known to play a huge role in maintaining homeostasis within the cell membrane. Along with sodium (Na\(^+\)), potassium constantly flows in and out of a cell membrane via sodium-potassium pumps. As an action potential is transported to one’s muscle fibers during the contraction phase, sodium floods into the cell membrane, throwing off the balance and causing depolarization to occur. Depolarizing the membrane is crucial in beginning the contraction
phase, and while this is occurring, the action potential continues to travel to the sarcoplasmic reticulum, triggering the release of stored calcium ions into the adjoining sarcoplasm. Within the muscle fibers, the calcium binds to troponin that lies along the actin molecules, causing the troponin to shift the tropomyosin away from the myosin-binding sites. This allows the myosin heads to cock back, bind to the troponin, and complete the muscle contraction. Therefore, with what started out as a search for additional flavor in our sports drink, we were able to introduce two great sources of extremely important nutrients utilized during exercise.

**Practical Applications**

After extensive preliminary research, we were able to infer what amount of ingredients would provide adequate proportions of aforementioned desired substrates (nitrate, L-arginine, and L-citrulline). For example, in a study by Lansley et al. (2011), subjects were provided 0.5 L of organic beetroot juice, which contained approximately 6.2 mmol of nitrate, two hours prior to exercise. There was a demonstrated increase of plasma nitrite levels by 138 percent. Using this type of research, we were able to piece together what we believed to be a foundational recipe. With a detailed understanding of which ingredients we were using and why we chose each one, we derived the final recipe:

½ cup diced beets
1 cup diced watermelon
The juice from 1 whole orange
½ cup diced pineapple
Other similar studies from Ormbsee et al., (2013), Cermak et al., (2012), and Bescós et. al., (2012) led us to believe that 6 fluid ounces of our own mixture, roughly two hours prior to exercise, for at least seven consecutive days would provide a desired increase in performance. By thoroughly blending all ingredients together and straining out just the juice, on average we were able to obtain approximately 12 fluid ounces (two servings). However, due to limited resources, we were unable to determine the specific amount of nitrates, L-arginine, and L-citrulline contained within the final drink.

It is important to note that not every person will not have the same response to this supplement, or any supplement for that matter. With the increased dosage of certain nutrients, there can be altered effects within the body. For example, beets containing the pigment betanin can potentially cause one’s stool and/or urine to exhibit a red tint if the consumer does not regularly eat these vegetables, or has not exposed them to their body for a period of time. Fortunately, this side effect is only temporary and not harmful.

Another consideration with regards to beets is that nitrates have a bad reputation for being potentially carcinogenic. Typically, it is when nitrates are added to a product, such as deli meat, and especially when heated, that their molecular structure is altered, transforming them into the carcinogenic form known as nitrosamine. Fortunately, when consuming nitrates in their natural form, such as in beets, they are being consumed with other extremely beneficial complementary nutrients that help prevent the transformation into nitrosamines and they therefore provide a positive health benefit. Thus, this drink is a great
option for endurance athletes, where the exercise very quickly becomes anaerobic and the body struggles to transport oxygen. Whether riding technical single track, running a marathon, climbing a multi-pitch route, or just performing a long training session in the gym, this drink can potentially provide that extra push to keep you going strong.

Figure 2: Brian Hemenway mountain biking and Conner Jackson running his first marathon.

Conclusion

In an effort to design a health-oriented ergogenic aid, avoiding the addition of chemically derived ingredients, we successfully created our own pre-workout sports drink. Putting a heavy emphasis on increasing one’s go-to sources of nitric oxide–producing nutrients, beetroot and watermelon juice played a huge role in this supplement. Upon adding in orange and pineapple juice for flavor, we also saw other possible benefits from micronutrients contained within those fruits. Developed around the notion of prolonged endurance exercise, this drink is not the stereotypical mixture that can be purchased from a large supplement manufacturer where intentions are geared toward helping the consumer put on pounds and pounds of muscle mass. Instead, with the intended use prior to prolonged
anaerobic exercise, this supplement not only increases blood flow and oxygen transportation, but also decreases blood pressure and helps speed recovery.

**Figure 3: Nutrition Label for Beetroot, Watermelon, Orange, and Pineapple ergogenic aid.**
References


