To beet or not to beet?

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SPORTS NUTRITION HAS BEEN EAGERLY AWAITING THE “NEXT CREATINE”; a supplement that would capture the attention and resources of exercise scientists, athletes, and the medical world. Like creatine, it would quickly amass a literature showing clear evidence of benefits to exercise capacity and sports performance. The strength of this support would be underpinned not only by the quantity of publications but also the quality of the researchers, experimental techniques, and mechanistic enquiries involved. Finally, the application of the product would encompass popular interests (e.g., sports performance), community health issues (e.g., addressing suboptimal physiological function or aging), and even therapeutic uses.

I admit to being taken by surprise when the first studies of beetroot juice supplementation appeared in the peer-reviewed literature (1, 4) and news cycle. In fact, if I hadn’t already recognized the considerable expertise of Andy Jones from the University of Exeter, I might not have paid much attention. However, as the plot thickened, it quickly developed some intriguing elements. First, we learned that the spotlight on beetroot juice occurred rather serendipitously, resulting from a search for a natural food source of nitrate supplementation to substitute for the nitrate salts that are not permitted for such use in many countries. Although other laboratories have used self-prepared beetroot relish or spinach as alternative nitrate sources in subsequent studies, the practical application of this work requires a product that is commonly available with known and reliable nitrate content. Here, the food industry has responded with commercial production and marketing of high-nitrate beetroot juice concentrates (3). Somewhat ironically, and in contrast to many of the boutique fruit/vegetable juices coming to market, beetroot juice products with the highest nitrate concentrations are deliberately produced from nonorganic farming methods to allow the use of fertilizers to contribute to the final nitrate concentration.

A second interesting element involved the challenge of finding a suitable placebo for an unusual and highly distinguishable treatment (beetroot juice is both an acquired taste and a cause of pink urine!). This problem was solved by collaboration between Jones’ group and a juice manufacturer to produce a nitrate-depleted form of beetroot juice concentrate, indistinguishable from their commercial product. Then there was the intriguing plotline in which mouth bacteria play an essential role in the efficacy of beetroot juice use by converting salivary nitrate to nitrite; antibacterial mouthwash and chewing gums need to be avoided in association with supplementation protocols. Finally, the concept of an improvement in the economy (oxygen cost) of exercise seemed magical, representing a holy grail to athletes as well as important therapeutic opportunities.

Nevertheless, the science underpinning the beetroot juice story is where the most compelling story is accumulating. The varied roles of nitric oxide (NO) in health and physiological function are well known, with the generation of this signaling molecule being largely attributed to the oxidation of the amino acid L-arginine. However, awareness of an alternative pathway of NO generation involving the reduction of nitrite has created renewed interest, particularly because it appears to be enhanced by dietary nitrate supplementation and important in acidic or hypoxic tissues or scenarios. Early studies of beetroot juice supplementation from Professor Jones’ laboratory established that acute (a single dose prior to exercise) or chronic (daily intake) protocols were associated with reductions in blood pressure and the oxygen cost of submaximal exercise (1, 4). The proposed mechanisms for such outcomes include hemodynamic effects as well as direct effects on mitochondrial or muscle contractile efficiency.

These findings suggest that beetroot juice supplementation might provide substantial benefits to health and daily function of populations with impaired exercise tolerance attributable to cardiovascular or pulmonary disease or simply aging. In sports nutrition, the possibilities of enhanced performance from a simple and wholesome supplementation strategy are also exciting. This explains the number of studies that have examined beetroot juice supplementation on measures of exercise capacity or performance in healthy adults (3). Overall, the results confirm a moderate significant benefit on protocols involving time to exhaustion and a small but potentially meaningful enhancement of more sports-specific protocols (3). These benefits seem more apparent in recreational to trained subjects rather than highly trained and elite athletes (3). Many questions must be answered before definitive guidelines can be given for beetroot juice use by athletes. The newest investigation from Professor Jones’ group (5) helps to address an obvious issue: the optimal dose of beetroot juice concentrate in an acute supplementation protocol. Here, they found a dose-dependent response of beetroot juice on plasma nitrite and enhancement of exercise capacity (time to failure at severe intensity cycling) with an apparent threshold at an intake of ~8 mmol of nitrate, equivalent to two 70-ml bottles of juice concentrate. There was no apparent ceiling for the reduction in exercise economy (oxygen cost of moderate intensity cycling) associated with the nitrate doses that were studied. Increasing the dose of beetroot juice not only increased the mean values of the exercise responses, but reduced the number of apparent nonresponders among the group. The mechanism of “responsiveness” remains elusive, however, because the study failed to find evidence of characteristics suggested or reported in previous studies, such as a relationship between the change in plasma nitrite concentrations from baseline to pre-exercise and enhancement of the exercise test. Further systematic study of this issue is required, involving large sample sizes of subjects of different training history and sporting caliber, different doses of nitrate/beetroot juice, and manipulation of the timing of juice intake to allow the indi-
individual variable peaks in nitrate concentrations to be achieved at the onset of exercise. Few laboratories are likely to have the capacity to monitor oxygen kinetics during exercise as exactingly as the current group, but other investigators may add to the practical application of this knowledge by testing exercise protocols that better mimic real-life sport. Whether beetroot juice will rival the study and marketing of creatine supplements is a developing story. In the meantime, many mothers and nutritionists are simply grateful that Professor Jones has accomplished a task that has eluded their own endeavors: getting boys to increase their intake of vegetables!

DISCLOSURES

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