SuperStarch

A Technological Breakthrough in Sports Nutrition Innovation

By Jeff S. Volek, PhD, RD

Sports Nutrition Evolution

The importance of carbohydrate for athletes was recognized as far back as the 1924 Boston marathon where it was discovered that blood glucose levels decreased in the top runners during the 1924 Boston marathon. The following year carbohydrate feeding was shown to prevent the decline in blood glucose and improve performance. However the notion that carbohydrate feeding was important for athletes was not fully appreciated until the late 1960s shortly after the advent of the biopsy needle which allowed histological and biochemical studies of human muscle before, during and after exercise. This early research led to the understanding of the importance of muscle glycogen, the storage form of carbohydrate in muscles, as a fuel for active muscle during prolonged exercise and made the connection between glycogen depletion and fatigue(1, 2). Researchers discovered that manipulating an athlete's training combined with a high carbohydrate diet several days prior to exercise (carbohydrate loading) significantly increased muscle glycogen levels and delayed fatigue(3). Subsequent work throughout the 1970s and 80s continued to investigate the impact of carbohydrate feeding and fluid intake on exercise performance. During this time the carbohydrate and electrolyte beverage Gatorade, originally created by medical researchers at the University of Florida for players during hot summer football practices, was being formulated and commercialized on a massive scale. The momentum created by the early science and consumer marketing of carbohydrate based beverages to athletes continues strong today.

The Need for Innovation

Despite decades of research and creation of a billion dollar sports drink industry; there has been little innovation with respect to formulation. First generation sports drinks, including many formulas that are still current, consisted of sugars (e.g., glucose, dextrose, sucrose) with an emphasis on providing quick energy. To be effective, the rapid but short-lived energy provided by these products requires repeated use during prolonged exercise. Moreover, because simple sugar-based formulas consist of many individual sugar molecules in solution they exert a high osmolality in the gastrointestinal tract. The osmotic force in the stomach negatively impacts gastric emptying and increases gastric distress. Maltodextrin, a complex carbohydrate or "glucose polymer" consisting of anywhere from about 3 to 20 glucose units loosely bound together to form one molecule, was introduced into many formulations. Maltodextrin allowed for provision of more carbohydrate with less osmolality (osmolality is the number of particles in solution, regardless of size). Although theoretically drinking maltodextrin should allow for increased delivery of carbohydrate and water because of better gastric emptying, experimental results have proved disappointing. Because maltodextrin is rapidly assimilated like sugars in existing formulas, this was not a paradigm shifting innovation in the sports drink industry and it shares many of the same concerns as sugar-based products.

The Problem with Sugar and Maltodextrin-Based Formulas

Sugar-based sports drinks are based on a simple concept - they rescue blood sugar during a crash. If used repeatedly during exercise that may aid in maintenance of blood sugar and provide fluids and minerals to support hydration and electrolyte balance. Notably, sugar based sports nutrition products encourage the body to rely on carbohydrates for energy while suppressing use of fat. A more optimal carbohydrate would provide a slower release and use of carbohydrate as fuel while simultaneously permitting increased breakdown and utilization of fat. There are other substantial drawbacks of short- and long-term ingestion of sugar and maltodextrin products. The bottom line is that existing sports drinks are not the most effective way to enhance performance and promote health.

The downside of sugar-based sports drinks:

Characteristic	Outcome
High osmolality	Slows gastric emptying Increases gastric distress Limits amount of carbohydrate that can be provided
Rapidly increases blood glucose	Requires repeated dosing Potential for rebound hypoglycemia
Rapidly increases blood insulin	Blocks fat breakdown Blocks fat oxidation Increased reliance on carbohydrate for fuel Chronic negative implications on body composition & health

SuperStarch - A Distinctive Advantage

A more optimal carbohydrate source for athletes would have a low osmolality with a slow “time-released” glucose profile and low insulin impact to avoid the spike and crash phenomena and extend maintenance of blood glucose. SuperStarch represents an innovative solution that overcomes the negative qualities of existing carbohydrate sport drinks.

Therapeutic Origins of SuperStarch

SuperStarch was originally designed by Scottish researchers in the treatment of a rare genetic disorder called glycogen storage disease, which is characterized by an impaired ability to convert glycogen to glucose in the liver. Newborns with glycogen storage disease need to be fed a frequent source of carbohydrate to maintain blood glucose levels or else they risk experiencing severe hypoglycemia and ultimately death. The development of SuperStarch evolved from an innovative product discovery for a food that could provide up to ten hours release of energy (as glucose) for children with Glycogen Storage Disease, and for Diabetics who frequently experience episodes of low blood sugar during the night. Two peer-reviewed scientific studies have confirmed that ingestion of a novel heat-moisture processed cornstarch is superior to conventional treatments in preventing hypoglycemia over extended periods of time in subjects with Glycogen Storage Disease(4, 5). The patent pending proprietary method for making the starch involves a hydrothermal (heat-moisture) treatment process to the native starch which significantly alters the metabolism of the carbohydrate in the body. The UCAN Company holds the worldwide rights to create a product derived from starch for consumer nutritional purposes.

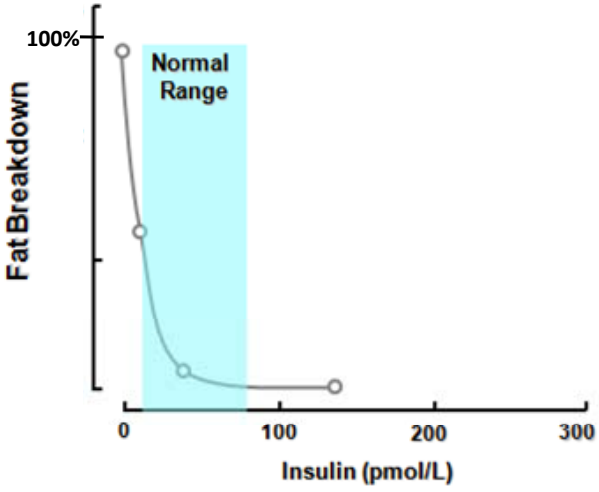
SuperStarch - A Unique Carbohydrate

SuperStarch is not a sugar or fiber. Chemically it is a complex carbohydrate or starch that is completely absorbed. SuperStarch is an extremely large glucose polymer with a molecular weight between 500,000 and 700,000 g/mol. Since molecular weight and osmolality are inversely related, SuperStarch exerts a very low osmotic pressure in the gastrointestinal tract and is rapidly emptied from the stomach into the intestines. Therefore SuperStarch is gentle on the stomach and highly palatable. In the intestines, SuperStarch is semi-resistant to digestion, but is eventually completely absorbed into the bloodstream, thereby giving it a slow time-released absorption profile. Because of the low glycemic impact, there is also little stimulation of the hormone insulin following ingestion.

Importance of Controlling Insulin

The diverse functions of insulin can be summarized as anabolic. Insulin inhibits breakdown and promotes storage of nutrients. In this way, dietary carbohydrate-induced increases in circulating glucose and insulin levels serves as an important control element on metabolism, especially the regulation of fuel selection between carbohydrate and fat. A low insulin level is associated with a metabolic state characterized by increased fat oxidation and decreased fat synthesis. In fact, adipose tissue lipolysis is exquisitely sensitive to changes in insulin within the physiological range of concentrations(6) (Figure 1). Small-to-moderate decreases in insulin can increase lipolysis several-fold, the response being virtually immediate. Small reductions in insulin levels, such as that easily achieved with a slow absorbing carbohydrate like SuperStarch, removes the normal inhibition on fat breakdown. SuperStarch would therefore be predicted to accelerate breakdown and oxidation of fat during exercise and recovery.

A rapidly absorbed carbohydrate that induces a spike in insulin is often encouraged to speed the rate of glycogen synthesis after exercise. However, the rate of glycogen synthesis is primarily independent of insulin after exercise. Further, lower insulin during exercise would promote increase use of fat and glycogen sparing, thereby alleviating the need to synthesize large amount of glycogen during recovery. Finally it is important to consider the potent effects of carbohydrate ingestion on inhibition of fat breakdown and fat oxidation which could be counter-productive for maintaining extended energy needs during prolonged exercise, and negatively impact body composition over time which is an obvious concern for most Americans including athletes.



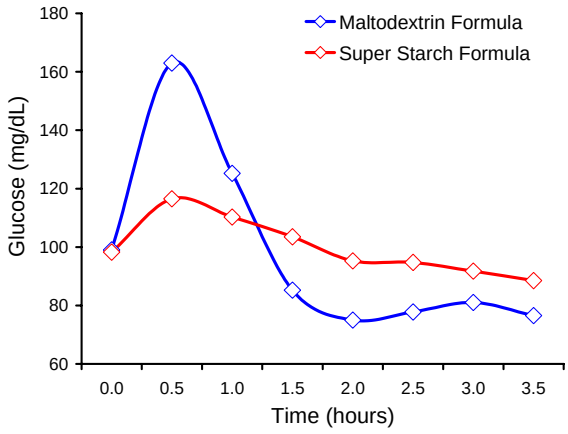
Internal Validation of SuperStarch

Study #1:
In order to determine the glycemic impact of SuperStarch, 16 subjects completed 3 trials in a random order. The trials involved consuming 75 g of carbohydrate in the form of SuperStarch, Argo starch, or glucose followed by serial blood glucose measurements for 7 hours. All testing occurred after an overnight fast and a standardized diet the day before.

Salient Findings:
- SuperStarch had the lowest glycemic impact and maintained glucose levels for 7 hours after intake.
- Compared to consumption of glucose, SuperStarch decreased the acute glycemic impact by 57%.
- Compared to consumption of Argo, SuperStarch decreased the acute glycemic impact by 13%.
- Glucose levels were maintained closer to baseline 7 hours after ingestion of SuperStarch (-4% from fasting) compared to Argo (-13%).

Study #2:
In order to compare SuperStarch to a popular sport nutrition beverage, 4 subjects completed two trials in random order similar to Study #1. One trial involved consuming a carbohydrate-based sports nutrition beverage consisting of maltodextrin (28 g) and fructose (5 g) with additional additives. A SuperStarch formula was created that matched this beverage except that the maltodextrin was replaced with Super Starch (25 g). Serial blood glucose measures were made at 30 min intervals for 3.5 hours after intake of the two beverages.

Salient Findings:
- Compared to consumption of the maltodextrin formula, peak glucose levels were 28% lower after SuperStarch.
- Two hours after consumption of the maltodextrin formula glucose levels had crashed 24% below baseline, whereas concentrations were maintained after SuperStarch (-3%).



Synopsis
These experiments clearly show SuperStarch has a unique time-released absorption profile characterized by a substantially lower early peak and prolonged maintenance of blood glucose. This smooth release of glucose prevents episodes of hyper- and hypo-glycemia which is highly desirable for fitness enthusiasts and recreational athletes with goals of weight maintenance and general health, as well as elite athletes looking for an edge.

External Validation of SuperStarch – The Oklahoma Study

The findings from our internal experiments in healthy individuals and scientific papers published in people with Glycogen Storage Disease clearly showed that SuperStarch impacted glucose kinetics in a positive manner. Since glucose is the major stimulator of insulin and insulin in turn is the principle hormone inhibiting fat metabolism, we predicted that SuperStarch would have a significant impact on metabolic and hormonal responses to prolonged cycling. In order to test these hypotheses, The UCAN Company sponsored a randomized double blind placebo controlled study conducted by independent exercise science researchers at the University of Oklahoma. In a rigorously controlled and implemented study, they enrolled ten highly trained male cyclists with an average age of 30 years. After determining their peak oxygen consumption (VO_2peak) while cycling, the athletes returned to the laboratory on two occasions one week apart and cycled for 150 min at 70% VO_2peak. Before and after exercise, participants ingested 1g/kg (average 79 g) of either SuperStarch or Maltodextrin while providing blood and expired gas samples every 15 and 30 min, respectively, before, during, and following exercise. The major outcome variables were glucose, insulin, fatty acids, glycerol, and fat oxidation during and after exercise. There was a rapid increase in blood glucose immediately after the ingestion of Maltodextrin pre- and post-exercise, which was significantly attenuated by SuperStarch. In a similar manner, serum insulin levels were markedly higher after Maltodextrin compared to SuperStarch. Peak insulin levels were more than 8-fold higher after ingestion of Maltodextrin compared to SuperStarch. SuperStarch was associated with greater fat breakdown during exercise and recovery as indicated by significantly increased serum non-esterified fatty acids and glycerol levels. There was also a trend for lower respiratory exchange ratios during in the SuperStarch trial compared to Maltodextrin indicating increased oxidation of fat. In summary, the findings from this carefully controlled experiment confirmed our belief that SuperStarch would significantly alter metabolic responses to exercise and promote a more efficient utilization of fat while maintaining blood glucose levels. The study findings will be presented at the annual Experimental Biology meetings in New Orleans in April 2009.

<u>Salient Findings:</u>

- Ingested before exercise, SuperStarch:
  - Blunted initial spike in blood glucose and insulin
  - Enhanced breakdown of fat during exercise
  - Enhanced fat oxidation (carbohydrate sparing) during exercise
- Ingested after exercise, SuperStarch:
  - Blunted glucose and insulin spike
  - Enhanced breakdown and use of fat during recovery

Sports Nutrition Applications

As far as sports nutrition applications, we see the main use of SuperStarch as a pre-exercise and a post-exercise recovery drink.

Pre-Exercise

The value of a slow release glucose profile in a pre-exercise beverage is avoidance of the spike and crash, better balance of glucose supply with demand, and less of a need to re-dose during exercise which is the case with sugar based drinks. Because of the low osmolality,

it is possible to use higher amounts of carbohydrate and less risk for stomach distress. Activities and sports that could potentially benefit from this include endurance athletes, strength athletes, team sports like football, soccer, hockey, basketball, etc. SuperStarch could also be beneficial of individuals in physically demanding occupations such as construction workers, and military personnel who need prolonged energy during sustained missions or even pilots on long flights who require sharp focus.

Post-Exercise

The advantage of consuming SuperStarch post-exercise is to enhance recovery by supporting maintenance of blood glucose and glycogen synthesis while still encouraging fat burning. SuperStarch avoids the potential spike and crash cycling that can lead to hunger and fatigue and a host of other metabolic problems. The over use of existing sugar-based sports drinks that chronically elevate insulin are likely to have a negative impact on body composition. SuperStarch represents a healthier carbohydrate with reduced risk for obesity, metabolic syndrome, diabetes, and a host of other chronic diseases.

Nutraceutical Applications

Maintenance of normal blood glucose (blood sugar) levels is absolutely critical for both exercise performance and optimal health. In health, the body normally defends against large fluctuations in blood glucose. Importantly, obesity and related disorders are often associated with dysregulation of blood glucose. An estimated one-third of adults in the U.S. have elevated fasting glucose levels, dramatically increasing their likelihood of developing Type 2 diabetes. An overwhelming body of scientific work has connected meal-induced elevations in blood sugar with adverse consequences (e.g., insulin resistance, impaired antioxidant status, inflammation, oxidative damage, vascular dysfunction) ultimately increasing risk of many diseases including diabetes, cardiovascular disease, and cancer.

Work Cited

1. Bergstrom J, Hultman E. Muscle glycogen synthesis after exercise: an enhancing factor localized to the muscle cells in man. Nature 1966;210:309-10.
2. Bergstrom J, Hultman E. A study of the glycogen metabolism during exercise in man. Scand J Clin Lab Invest 1967;19:218-28.
3. Bergstrom J, Hermansen L, Hultman E, Saltin B. Diet, muscle glycogen and physical performance. Acta Physiol Scand 1967;71:140-50.
4. Bhattacharya K, Orton RC, Qi X, et al. A novel starch for the treatment of glycogen storage diseases. J Inherit Metab Dis 2007;30:350-7.
5. Correia CE, Bhattacharya K, Lee PJ, et al. Use of modified cornstarch therapy to extend fasting in glycogen storage disease types Ia and Ib. Am J Clin Nutr 2008;88:1272-6.
6. Jensen MD, Caruso M, Heiling V, Miles JM. Insulin regulation of lipolysis in nondiabetic and IDDM subjects. Diabetes 1989;38:1595-601.