Dextrose & Maltodextrin an in-depth analysis

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Abstract

It is the intention of the writer to do a comprehensive analysis on the application of dextrose, maltodextrin, water, and sodium for post workout nutrition.

Below is an outline that will allow you to instantaneously access whatever aspect of the article you seek to examine:

For a complete review on this important meal, click the following link, The Window of Opportunity.

Introduction to Gastric emptying and Osmolarity

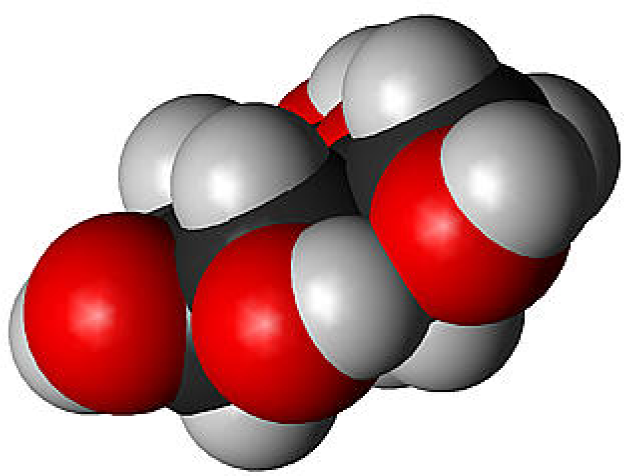
In the near future, we will do a complete breakdown on both these important physiological occurrences. But for now, here is a general overview, as it pertains to the article:

- Gastric emptying - the process of digesting and emptying food out of the stomach.
- Osmolarity - the concentration of particles in a solution.

How to speed gastric emptying, and what levels of osmolarity are optimal in a given solution will be discussed. But first, two carbohydrates, dextrose and maltodextrin, will be analyzed.

Dextrose

Dextrose, commonly called glucose, d-glucose, or blood sugar, occurs naturally in food, and is moderately sweet. It is a monosaccharide (basic unit of carbohydrates, $C_6H_{12}0_6$) and has a high glycemic index (digested carbohydrates ability to raise blood glucose levels, also called GI) ranking at 100.



Maltodextrin

Maltodextrin is a sweat, easily digested carbohydrate made from cornstarch. The starch is cooked, and then acid and/or enzymes (a process similar to that used by the body to digest carbohydrates) are used to break the starch into smaller chains (3-20 chains in maltodextrin). These chains are composed of several dextrose molecules held together by very weak hydrogen bonds.

To clarify, carbohydrates are molecules of carbon, hydrogen, and oxygen produced by plants through photosynthesis. The term saccharide is a synonym for carbohydrate; a monosaccharide (mono=1) is the fundamental unit of carbohydrates. Disaccharides (Di=2) are molecules containing 2 monosaccharide units. Di and monosaccharides are also known as sugars, simple sugars, or simple carbohydrates. Next are oligosaccharides, and polysaccharides. Oligosaccharides are made of 3-9 monosaccharide links. Polysaccharides consist of 10 to thousands of monosaccharide links. A complex carbohydrate refers to many monosaccharide units linked together. In addition, you will often hear the terms “long”, and “short” carbohydrate chains. Short carbohydrate chains are those under 10 sugar molecules. And long chains are those over 10 sugar molecules. Which fits in conjunction with the above terms, Oligosaccharides and Polysaccharides.

Dextrose is labeled a simple carbohydrate and Maltodextrin complex. And now this should make perfect sense. But don’t be fooled by the word, “complex.” The bonds that compose maltodextrin are very weak, and readily broken apart in your stomach; moreover, the chain is extremely minimal in composition. The weak bonds, and fragile composition of maltodextrin cause it to be digested a fraction slower than dextrose. Why this is so and what exactly hydrogen bonds are will be assessed subsequently.

Hydrogen Bonds/Digestion process

A covalent bond is defined as atoms, which are held together by their mutual attraction for sharing electrons. Co is for sharing, and valent refers to valance electrons that are shared. Covalent bonds tend to form from atoms in the upper right of the periodic table, know as *nonmetallic elements* (with the exception of noble gases, which are the last group of the periodic table to the right. These elements are very stable and tend not to form bonds.) Now, electro negativity is an atom’s ability to pull electrons toward itself when bonded. Electro negativity is greatest for elements at the upper right of the periodic table, and lowest for elements at the lower left. Noble gases again are not included, because primarily they do not participate in chemical bonding. To represent this, scientists use what is called a dipole (pronounced die-pole) to say a side is slightly negative, or slightly positive, because it has more or less electrons around itself. A bond with a dipole (remember, di=2, 2 poles) is classified as a polar bond. The higher amount of difference in electro negativity in the bonds, the more polar the atom is (greater charge difference).

Electrical attractions are based on polarity between particles; they tend to be very weak. The kind discussed today is called a dipole-dipole attraction, which is defined as an attraction between two polar molecules. In particular, one of the strongest dipole-dipole attractions, known as the hydrogen bond will be analyzed. This attraction occurs between molecules that have a hydrogen atom covalently bonded to a highly electronegative atom--typically nitrogen, oxygen or fluorine. In the case of maltodextrin, this is an H-O bond. The strength of a hydrogen bond is based on two factors:

1. The strength of the dipoles involved (which depends on the difference in electro negativity for the two atoms in either polar molecule)

2. How strongly nonbonding electrons on one molecule can attract a hydrogen atom on a nearby molecule.

Recent research has revealed that a small amount of electron sharing occurs between the hydrogen and the nonbonding pair. Because electron sharing is the definition of covalent bonds, the hydrogen bond is correctly named a covalent bond. However, any hydrogen bond is many times weaker than the typical covalent bond; therefore, it is also appropriate to think of the hydrogen bond not as a bond, but as a very strong dipole-dipole attraction between separate molecules. When confronted with the proper enzymes, this bond has no chance, and is easily separated from the above attractions. Which leads to the next subject, digestion.

Editors Note: I am extremely glad that Venom is covering this subject. Hydrogen bonds are one of the key subjects that one must understand if they are intent on understanding nutrition, and how sizable biological molecules are constructed.

Maltodextrin digestion starts right when it enters the mouth. The salivary glands, located along the base of the jaw (there are actually three specific glands here - parotid, submandibular and sublingual), continually secrete lubricating mucus substances that mingle with food particles during chewing. The enzyme salivary amylase (ptyalin) breaks the hydrogen bonds between the repeating glucose units, beginning the reduction of maltodextrin into smaller linked glucose molecules. When the food-saliva mixture enters the more acidic stomach, breakdowns in the chains from enzymatic action quickly cease because salivary amylase deactivates under conditions of low pH (lower pH means more acidity). After this, food enters the small intestine, and encounters pancreatic amylase, a powerful enzyme released from the pancreas. This enzyme, in conjunction with other enzymes, completes hydrolysis (catabolism of larger molecules into smaller ones the body can absorb. Done by enzymes and water) of maltodextrin into smaller chains of glucose molecules. Finally, enzyme action on the surfaces of the cells of the intestinal lumen's brush border completes the final stage of carbohydrate digestion to monosaccharides. Due to the weak nature of these hydrogen bonds, this is a swift process. In addition, the shorter the chains, the quicker these molecules are separated. Therefore, maltodextrin at 3-20 monosaccharide links, is very easily digested. Once absorbed from the small intestines into the bloodstream, the body uses glucose for 3 potential tasks:

1. Given directly to muscle cells for energy.

2. Stored as glycogen in the muscles and liver.

3. Converted to fat for energy storage. (Again see Window of Opportunity for how to eliminate option three)

As stated earlier, scientists simply try and mimic this process when breaking down starches to maltodextrin. Actually, as one ventures further in the studies of chemistry, biology, endocrinology, and such like, they will see this is commonly the case.

Importance of consuming a combination of Maltodextrin & Dextrose

After reading Old School's excellent article on post workout nutrition, the reader is now aware of the importance of consuming easily digested, high GI carbohydrates at this time. But the question is, why a combination of dextrose and maltodextrin? Both are high in GI rating, and easily digested right? True, but there is more logic than GI rating to stacking these two powerhouses. Read on for the answer.

Beginning with the first concept discussed called, "gastric emptying." Our goal post workout is to maintain a prompt digestion rate so nutrients can transport swiftly and efficiently to our muscles. With that said, it has been shown that this process slows when the ingested fluid contains a high osmolarity concentration (the second concept studied). Osmolarity is dependent on the number of particles in a solution. That is, a100-milliliter solution with 20 glucose molecules will have a higher osmolarity then a100-millileter solution that only contains 10 molecules. The shorter chain length a carbohydrate has, the higher it raises the solution's osmolarity. Therefore, it is no surprise that a pure glucose solution (or dextrose, a monosaccharide) induces very high concentrations of solute (1,3,10).

Fortunately these negative effects become greatly reduced when the drink contains a glucose polymer stacked with dextrose. However, a carbohydrate that is easily digested, and has a high GI is still desired. Hence, a combination of dextrose and maltodextrin is advised. Osmolarity will be decreased, and glucose will still enter the blood stream at a proficient rate, thus maintaining its anabolic nature (1,3).

A second factor concerning osmolarity must now be examined. From a clinical standpoint, it is vital to take into consideration the fact that plasma (the liquid portion of blood) has an Osmolarity of 300 mOsm. This means that if one were to inject a solution with a greater concentration of solute into their blood, it would cause water from inside their red blood cells to leave by Osmosis (water always travels down its concentration gradient) and move into the plasma, in turn shrinking the erythrocytes (red blood cells). This is because the cells are iso-osmotic to the plasma (both have the same concentration of solute) (11).

A similar concept can be applied to your post workout meal. If a competitor were to consume a solution that was hypertonic or had a higher concentration of solute then 300 mOsm, it could dehydrate them (showing why digestion is rightfully slowed in a high concentrated solution). The addition of maltodextrin once again solves this problem (2,13).

The next question is, why not just use maltodextrin, and eliminate dextrose since it is so proficient? Ah, once again it is not that simple. Shi. X et al. in an outstanding study, tested the digestive effects of two substrates (any substance acted upon by an enzyme) as opposed to only one substrate in the small intestine. What they found was quite fascinating. The solution containing two substrates stimulated the activation of more transport mechanisms in the intestinal lumen, than did its singular counterpart. Therefore, more carbohydrates were transported out of the small intestine (absorbed into the blood), which additionally aided a greater absorption rate of water into the blood stream (by osmosis). Thus, the higher activation rate of transport mechanisms, even with higher osmolarity facilitated faster energy uptake and hydration (12)!

Editors note: Truly Fascinating!

One of these mechanisms is the glucose/Sodium co transport system (discussed in further detail shortly). When a proper amount of sodium and glucose are combined, an even greater amount of glucose is absorbed, and in turn, a higher rate of H20 is absorbed. Thus, dextrose increases fluid uptake, and contributes to blood glucose maintenance. Which in turn helps spare liver and muscle glycogen from being depleted (4,5,6).

As discussed in the Window of Opportunity, these factors make dextrose and maltodextrin the perfect post workout combo. One can purchase both of these in pure form from a local grocery store, or the Internet.

Importance of water

Gastric emptying is greatly influenced by its volume. Emptying rate decreases exponentially as fluid volume is depleted. Therefore, an effective way to speed gastric emptying is by maintaining high fluid volumes in the stomach. This will also optimize nutrient passage into the intestines. About 500 mL of water immediately before training (spread through a 30 minute time span), and 200 mL every 15-20 minutes (about the rate at which fluids are drained during intense training sessions) of the workout has been recommended to maintain high water levels in your stomach. For optimal hydration, consume a 92% water solution in your post-workout shake. To calculate this, divide the carbohydrate content (in grams) by the fluid volume (in millimeters), and multiply by 100. Thus if you consumed 80 grams of carbohydrates in 1 L of water (1000 mL) you would be having 8% carbohydrates, and 92% H_2O (1,3,4,10).

Another reason to frequently drink water is avoidance of dehydration. To name a few reasons why, dehydration reduces circulatory and temperature-regulating capacities, which meet metabolic needs and thermal demands of exercise, and recovery (8,9). The effects of this can further reduce blood flow to the skin for more effective cooling. For much more, read, Effect of Plasma Volume on Myofibril Hydration, Nutrient Delivery, and Athletic Performance and Thermoregulation: Physiological Responses and Adaptations to Exercise in Hot and Cold Environments.

What Hyponatremia is and how to avoid it

Hyponatremia occurs when plasma sodium concentrations fall below normal levels in the body, and severe symptoms are triggered. Lighter symptoms are headaches, nausea, cramping, and confusion. Ultimately, this may lead to seizures, coma, pulmonary edema, and even death! These fatal conditions usually pertain to long distance runners, consuming large amounts of water with little or no sodium contained, and training in stifling heat. Non-the-less, bodybuilders are still at risk, especially during cutting season when cardio and posing hours are at a high point. As such, I would highly recommend using sodium post workout, not only to avoid any minor (much likelier to occur) or major side symptoms, but also for its anabolic effects (5,7,8).

Editors Note: From Venom's description you can see why sodium depletion pre-contest can be dangerous if not done correctly. Quite frankly it usually is done incorrectly. Such a concept is worthy of a future hyperplasia magazine article.

Sodium is the most abundant ion in the extra cellular space (outside of cells). Adding a small amount has several benefits, such as:

1. Reduces urine output by maintaining osmotic drive (prevents water from leaving, going out, or coming into cell to rapidly, maintaining even flow). Moreover, this will promote thirst, and fluid retention during recovery, further amplifying hydration.

2. Helps prevent hyponatremia by keeping sodium levels stable.

3. Helps maintain proper osmolarity levels.

4. Enhanced co transport efficiency.

In general, it is recommend to have 500-600 mg of sodium per liter of solution after a workout, the solution being the recommended amount of water and carbohydrates to consume at this time (6,7). For more read, Sodium - A comprehensive Analysis

Glucose/Sodium transport system

Earlier in the article, the sodium/glucose co transport mechanism was discussed. This concept falls under the heading of secondary active transport. Primary active transport takes place via a pumping system. Each cell contains proteins which break down ATP into ADP + P + Energy, and uses the products to power the pump. The Sodium/Potassium Atpase, pumps three sodium's out of the cell, and only two potassium's into it. This makes sodium’s concentration higher on the outside of the cell. Additionally, the inside of the cell is more negatively charged than the outside. Sodium is a positively charged ion, and attracted to the negative area. It has been pumped against its electrochemical gradient (concentration is greater outside of the cell and more negative). Thus, Na+ (sodium) will now move back into the cell.

There are proteins within a cell membrane, which act to transport glucose. However, the binding site for glucose has a low affinity for it, unless sodium is bound to it. Due to the electrochemical gradient, sodium enters a binding site specific for it on the protein, and when it does so, the protein changes its shape (allosteric reaction), so that sodium can now bind, and be transported into the cell. This is called co transport because two substances are transported into the cell together; and secondary active transport because it takes advantage of the concentration gradient set up by the primary mechanism. Therefore, by taking in the proper amount of sodium, one increases the concentration gradient outside of the cell, and therefore, increases sodium's ability to bind to transport proteins. In doing so, one not only increase glucose absorption, but as pointed out, you also further increase water uptake across the luminal membrane of the intestine.

Measurements

For complete comprehension of the recommended serving sizes in this article, I included a conversion sheet (with additional information as well). Enjoy!:

CONVERSION CHART

Measures of Length	
1 inch (in)= 2.54 centimeter (cm)	1 kilometer = 1000 meters
1 yard (yd)= 0.9144 meter (m)	1 centimeter = 10 millimeters
1 mile (mi)= 1.609 kilometers (km)	1 meter = 100 centimeters
1 kilometer= .621 miles	1 meter = 39.37 inches
Measures of Mass	
1 pound (lb)= 453.59 grams (g)	1 milligram = 1000 micrograms (mcg)
1 ounce (oz)= 28.35 grams	1 kilogram (kg)= 2.2046 pounds
1 gram = 1000 milligrams (mg)	1 tablespoon (Tbsp) = 3 teaspoons (tsp.)
1 kg= 1000g=2.2 lb	1 oz.= 30g
16 oz= 1 lb	32 oz =1,000 g=1kg
Measures of Volume	
1 cubic centimeter (cm^3)= 1 milliliter (mL)	1 liter = 1.0567 quarts
1 quart (qt)= 0.9463 liter (L)	1 liter = 1000 milliliters
1 tsp. =1/6 fl. oz.= 5 ml.	1 Tbsp = 1/2 fl. oz.= 15 ml.
1 cup = 8 fl. oz.= 240 ml	1 pint = 16 fluid ounces (fl oz.)= 480ml.
1 qt. = 32 fl. oz.= 960ml.	1 mL = .0339 fl oz
16 cups=1 gallon	1 cup= 16 table spoons
2 cups=1 pint	16 fl. oz. = 2 cups = 480 ml

Conclusion

Post workout is not any easy meal to get in. But with your new found understanding on the physiological aspects, and undeniable benefits of this anabolic monster, I hope you have been motivated to equip yourself with the dedication to get the job done.

Keep it Hardcore

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