



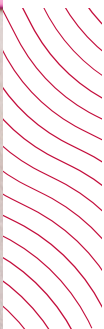
enduracarb®

A science-backed trehalose
ingredient for athletic endurance



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Introducing

In collaboration with the world-renowned Japanese company Hayashibara*, Prinova is proud to have developed enduracarb® for sporting and athletic consumers. This branded trehalose has functional benefits for endurance exercise.

Produced using a high-purity production process and certified as an Informed Ingredient, **enduracarb® is now considered to be one of the world's leading trehalose brands.**

enduracarb® allows manufacturers to incorporate an easy-to-understand, science-backed fuel that consumers can trust to power their athletic performance when they need it most.

Trehalose is a carbohydrate that is commonly found in the natural world, helping to preserve the life of plants and animals. Insects, for example, use trehalose as a principal body sugar, providing energy for flight.

Though historically extracted from yeast, trehalose's potential was transformed in the mid-1990s when Hayashibara pioneered a new technology to produce it from starch. As a result, the ingredient can be produced on an industrial scale, enabling it to be widely used for various applications in the food industry and beyond.

Approved in the EU as a novel food and reviewed by most major regulatory agencies in the world, trehalose is widely considered to be safe for use in foods.

Already well known for its ability to keep food products' colour, texture, and taste fresh for longer, scientific studies are now spotlighting the benefits trehalose can bring to sports nutrition products. Clinical research shows trehalose can **boost endurance, reduce insulin spikes, combat dehydration, and even enhance products' taste.** With demand for science-based sports nutrition products reaching even higher levels since 2020, trehalose is now attracting widespread interest as a highly effective fuel for endurance exercise.

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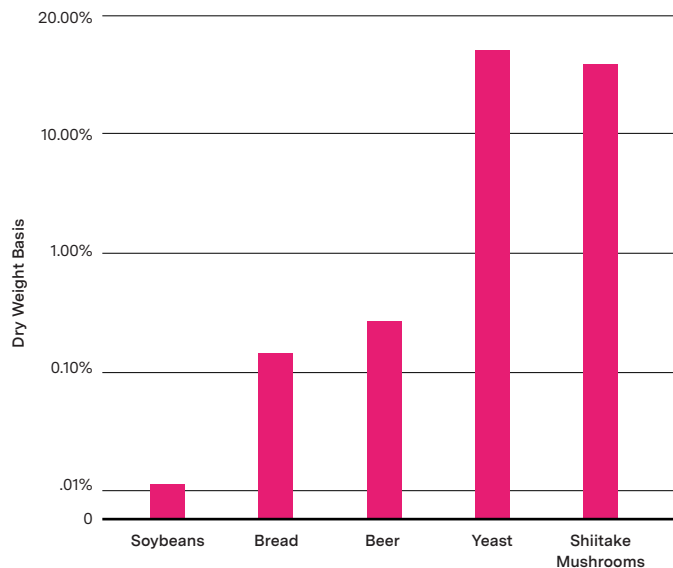
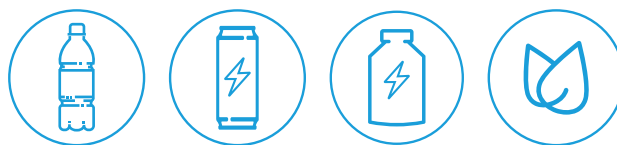


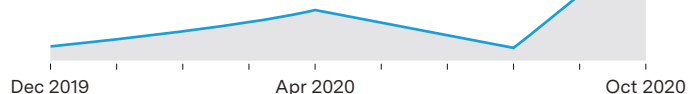
Figure 1:

Naturally occurring Trehalose

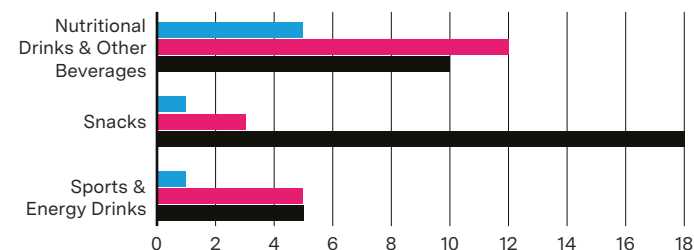
Trehalose is suitable for applications including **protein RTDs, energy drinks, gels** and **vegetarian beverages.**



Global Google searches for **"endurance exercise"** reached **unprecedented heights** in late 2020⁵.



Global sports nutrition product launches featuring trehalose more than **doubled** from 2018 to 2020⁵.



* Hayashibara's trehalose is sold as TREHA®. TREHA® is plant-based, GRAS-designated, and Kosher- and Halal-certified. TREHA® distributed in the US and Canada is a Non-GMO Project verified product.

Getting to grips with trehalose

Trehalose is a disaccharide. Also known as a 'double sugar', it is formed of two glucose molecules joined together with what is known as α, α -1,1 glycosidic bond.

Crucially, the bonded glucose molecules are indigestible without the enzyme trehalase, which is present in the human intestine in limited activity. As a result, trehalose does not stimulate rapid increases in blood glucose and excessive secretion of insulin, digesting slower than other sugars².

Trehalose therefore provides **significant advantages** over the rapidly digested carbohydrate sources commonly used in sports nutrition products, such as glucose and maltose.

Isomaltulose, meanwhile, is a popular disaccharide that breaks down into a single glucose molecule and a fructose molecule. Fructose can be perceived as undesirable among consumers due to its association with fatty build-ups in the liver³.

As a result, trehalose is emerging as **the fuel of choice for endurance exercise**, helping to maintain performance through steady blood sugar and insulin levels.



Fitness trends hitting new heights

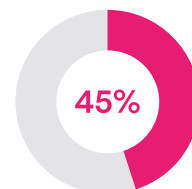
Health and fitness trends are more popular than ever. The 2020 IHRSA Global Report shows the global health club industry finishing the previous decade with a record performance⁴.

Since the pandemic, evidence shows consumers are taking even greater interest in improving their fitness levels, with endurance exercise proving particularly popular, especially from home.

- In April 2020, population-level interest in exercise across **Australia**, the **UK**, and the **US** was at its highest level since Google Trends records began in January 2004⁵



- New Hope Network consumer research found that **45% of consumers** were biking, running or walking/hiking since the start of the pandemic⁶



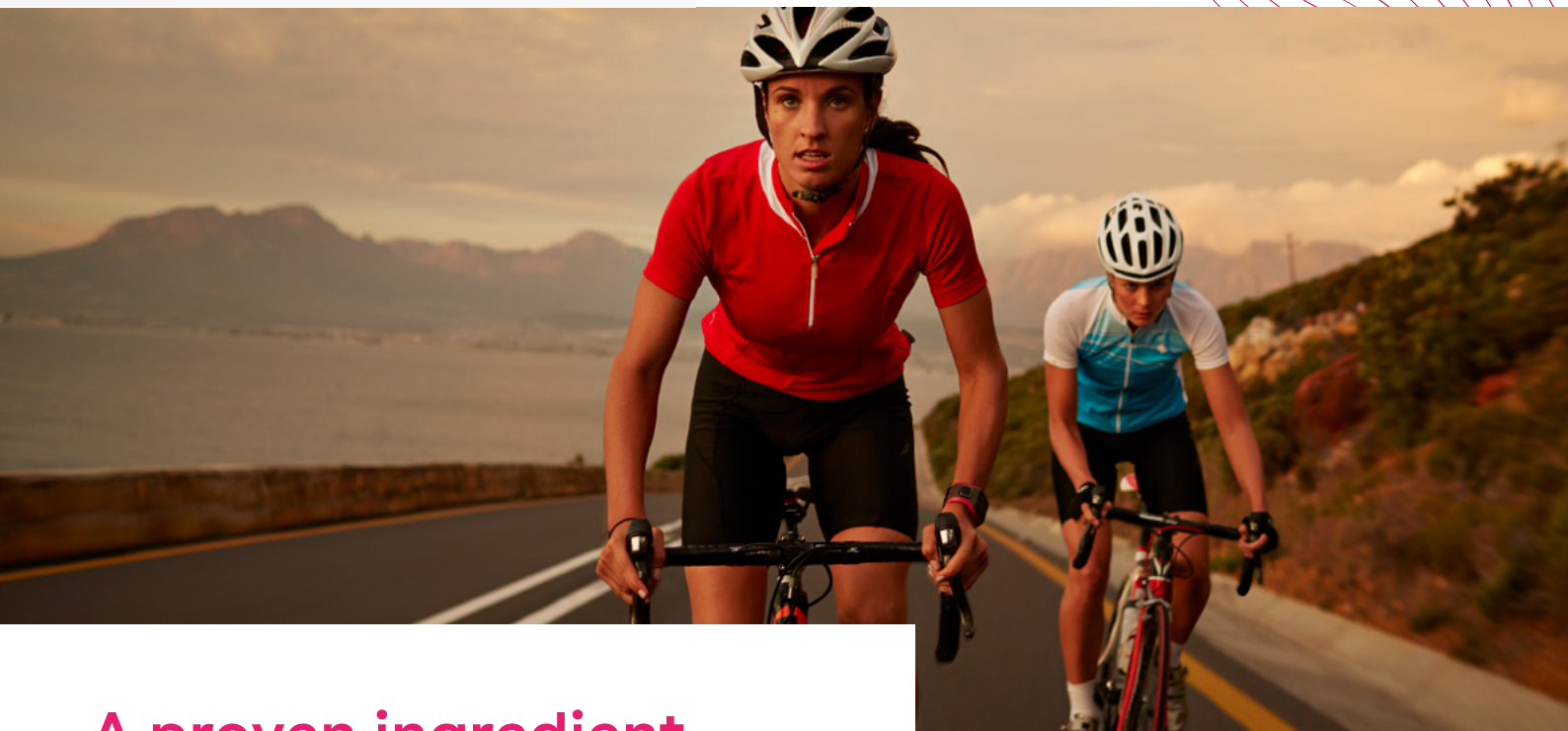
- GPS fitness tracking data from Garmin showed Americans' virtual **cycling activity was up 64%** in the second half of March 2020, while overall **indoor cardio showed an 18% week-over-week increase** during the same period⁷



This growing dedication to physical fitness is helping to fuel demand for science-backed sports nutrition products, which have been enjoying healthy growth despite the challenges of COVID-19.

- Sports nutrition supplements** were projected to see an **8.7% boost** in growth for 2020 – up from 6.3% in 2019⁸
- Growth for **sports hydration** and **energy beverages** was projected to increase from 8% in 2019 to **8.4% in 2020**⁸





A proven ingredient for athletic endurance

During exercise, the body uses a form of glucose called glycogen for fuel. When taking part in endurance sports, the glycogen in the muscles can deplete to a level that impairs performance⁹.

To compensate for the loss of glycogen, carbohydrates can be consumed to delay the onset of fatigue and allow athletes to exercise for longer periods¹⁰. However, carbohydrates' benefits vary as the result of differences in their absorption properties and availability to the skeletal muscles.

Research is now showing trehalose could have particular advantages for endurance athletes. Because it is digested more slowly than glucose and maltose, it appears ideally suited to providing fuel to the body during the later stages of prolonged exercise.

Research carried out in 2019 found that **trehalose was more effective than glucose for prolonged exercise** comprised of ultra-high-intensity intermittent exercise⁹. The study indicated that the low insulin secretion of trehalose led the body to reduce glucose consumption, therefore allowing

the preservation of skeletal muscle glycogen until the later stages of exercise. In the case of low intensity exercise for 60 minutes, more lipids are used as an energy source by taking trehalose.

A 2020 study looking at the impact of trehalose consumption in male collegiate distance runners also demonstrated that it can **enhance running performance**¹¹. Male collegiate distance runners were asked to complete a warm-up before consuming water, glucose, or trehalose. They were then asked to perform exercise tests on a bicycle ergometer, consisting of two sets of pedalling for 10 minutes and sprinting for 30 seconds, keeping their effort equivalent to their pace in a 10,000-meter track race. During the tests, trehalose was shown to have the highest mean power outputs, offering statistically significant advantages over water and glucose, particularly during the first bout of pedalling and then the final sprint.

Suppressing insulin spikes

Fast-acting carbohydrates such as glucose can cause a rapid rise in blood sugar, which then prompts the body to produce more insulin to control the rise.

This can have negative impacts for athletes. An excess of insulin can not only impair the body's ability to burn fat for fuel¹², but can also reduce blood sugar and cause hypoglycaemia, which leads to fatigue and diminished performance¹³.

Unlike glucose, trehalose is **slowly digested and absorbed** in the small intestine. As a result, experiments in healthy human subjects have shown that both blood glucose and insulin levels were significantly lower and more stable among those given trehalose compared to those given glucose².

One study explored the impact of trehalose on cyclists' performances. It found that pre-exercise consumption of trehalose leads to **more stable blood sugar** and **reduced insulin spikes** prior to exercise compared to glucose, as well as reducing the prevalence of rebound hypoglycaemia¹⁴.

Healthy participants ingest 25 g of glucose or trehalose in 100 ml of water

Trehalose can result in lower blood glucose peaks and lower spikes in insulin concentrations

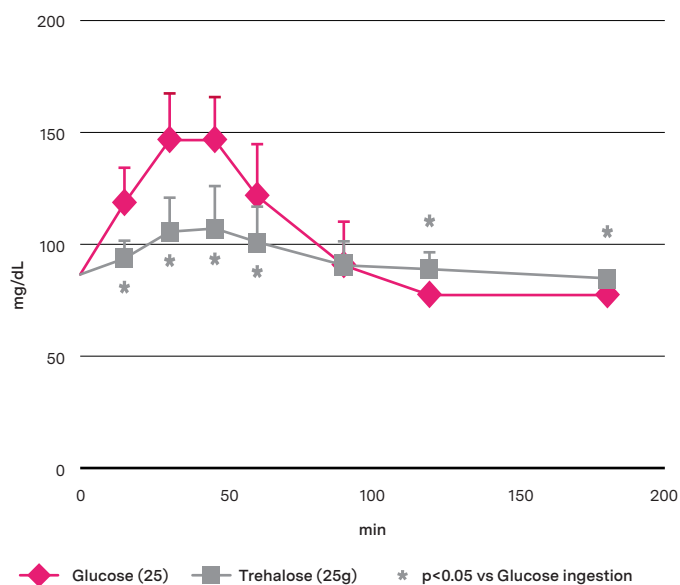


Figure 2:

Blood glucose concentration, n=20
C. Yoshizane et al., Nutr J., 16:9 (2017)

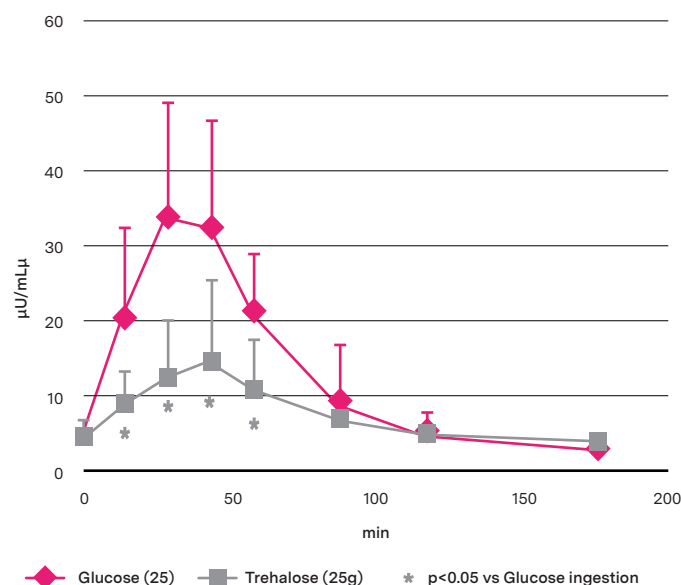


Figure 3:

Insulin concentration in serum, n=20
C. Yoshizane et al., Nutr J., 16:9 (2017)

Dealing with dehydration



For endurance athletes, dehydration can have a variety of negative impacts on performance. Cardiovascular drift, for example, occurs during prolonged exercise at moderate intensity, causing a progressive rise in heart rate and a decline in the volume of blood pumped from the heart with each beat.

This is often followed by a drop in cardiac output and mean arterial pressure and can impair athletic performance¹⁵. Research has indicated that well-hydrated athletes are less prone to cardiovascular drift¹⁶.

Clinical research on trehalose has shown it is transported from the stomach more rapidly than both glucose and maltose, demonstrating its ability to help athletes

maintain water absorption. In the case of hydration, trehalose also **serves as an energy supply** that drives quickly from stomach to the small intestine¹⁷.

Additional benefits also include:

Helping to take taste to the next level

Beyond its functional benefits for athletes, trehalose can also help manufacturers unleash their products' potential by enhancing taste. Trehalose has been shown to mask the bitterness of ingredients including proteins, vitamins, minerals, and sweeteners¹⁸. In protein products, for example, adding low levels of trehalose has been shown to reduce the bitterness of the branched-chain amino acids L-valine, L-leucine, and L-isoleucine, as well as L-phenylalanine, L-tryptophan, L-arginine, and L-lysine.



AMINO ACIDS (AA)	CONCENTRATION (WT.%)	TREHALOSE (WT.%)				
		0	0.5	1.0	2.0	5.0
L-Val	1.0	-	-	+	++	++
L-Leu	1.0	-	-	+	++	++
L-Ile	1.0	-	-	+	++	++
L-Phe	0.2	-	±	+	+	++
L-Trp	0.2	-	±	+	+	++
L-Arg	0.2	-	±	+	+	++
L-Lys	0.2	-	±	+	+	++

How 10 of 11 panellists felt about the reduction of bitterness:

- = No effect; ± = Weak effect; + = Clear effect; ++ = Strong effect (little or no bitter taste)

Formulation made easier

Trehalose offers excellent stabilisation properties.

Laboratory tests carried out by Hayashibara compared trehalose to a variety of sugar ingredients. The graph below shows the percentage of humidity created versus the weight gained after 10 days of leaving the substance in 25 degrees Celsius, with trehalose demonstrating exceptional results.

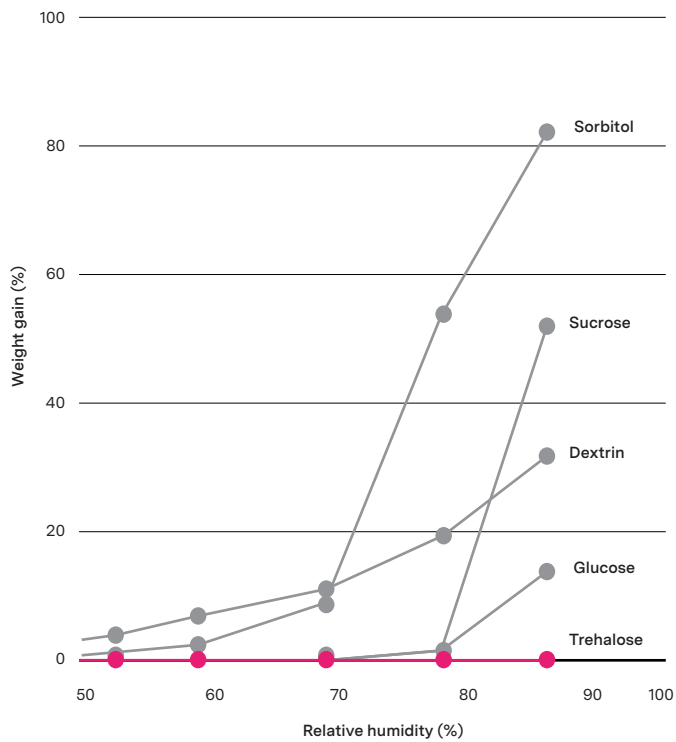


Figure 4:

25°C, 10 days later





The Prinova advantage

Since 1978, Prinova has been a leader in providing high-quality ingredients, flavours, and value-added nutrient fortification products to the global food, feed, and wellness industries.

Prinova operates six plants and holds strategic stocks in more than 35 distribution centres around the world to ensure continuity of supply and is the leading global supplier of ascorbates and food-grade B vitamins and amino acids.

In many ways, nutrient premixes and blends represent the full power of Prinova because they integrate the company's many ingredients, specialties, and capabilities.

Prinova's solutions include liquid vitamin premixes, dry vitamin and mineral premixes, drum-to-hopper premixes, and more complex formulations that include botanicals, amino acids, sweeteners, flavours, and functional ingredients.

Prinova also has a team of application and technical specialists to help customers develop, improve, and enhance the taste and function of their products. Its facilities are BRC certified.

The company's corporate office is in Carol Stream, Illinois, with the EMEA head office in the United Kingdom. Additional regional offices are located throughout the United States, Mexico, Spain, Germany, Belgium, France, Australia, Turkey, Canada, and China.



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- ¹⁸ Japan patent JP2003-274896A 'Bitter taste reduction agent for amino acids tasting bitter and use thereof'