



Key references related to the physiological benefits of Palatinose™

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Palatinose™ - a carbohydrate with unique physiological properties

Palatinose™ (generic name: isomaltulose) is a disaccharide carbohydrate that occurs naturally in honey and sugar cane juice. It is derived from sucrose by enzymatic conversion. And it is a “slow release carbohydrate” with a unique combination of physiological properties: As result of its slow yet complete digestion and absorption, Palatinose™ has a low effect on blood glucose levels (GI: 32) and insulin release. It provides carbohydrate energy in a more balanced way over a longer period of time. And thus it contributes to modern energy management with characteristics like steadier energy supply and a higher proportion of fat oxidation. Apart from that, Palatinose™ is kind to teeth. The slow release properties, the higher fat oxidation and tooth-friendliness are all unique to Palatinose™ and make it different from sugars like fructose or sucrose.

BENEO has undertaken comprehensive research to study the unique nutritional and physiological properties of this functional carbohydrate. This document provides a list of the most relevant publications per physiological aspect, while it – by far – does not represent a complete list of references. More detailed information can be provided upon request.

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1. Palatinose™ - a fully available carbohydrate for slow and sustained energy release

a) *Palatinose™ is a fully available carbohydrate*

The essentially complete digestion and absorption of Palatinose™ within the small intestine has been confirmed in human and animal studies. Palatinose™ is a fully digestible carbohydrate and as such provides the full carbohydrate energy (4 kcal/g).

Key reference:

- Study in healthy subjects with an end ileostomy showing the full digestibility of Palatinose™

Holub I, Gostner A, Theis S, Nosek L, Kudlich T, Melcher R, Scheppach W (2010) Novel findings on the metabolic effects of the low glycaemic carbohydrate isomaltulose (Palatinose™). Br J Nutr 103(12):1730–1737. (see trial 1 for ileostomy study)
<http://www.ncbi.nlm.nih.gov/pubmed/20211041>

b) *Palatinose™ is a slow and sustained release carbohydrate*

The “slow release” aspect is evidenced by **enzyme kinetic studies** (animal and human enzymes) which show that the enzymatic hydrolysis of Palatinose™ in the small intestine occurs much slower than that of e.g. sucrose (i.e. difference in $V_{\max}$ by a factor of 4 to 5). Observations on **incretin hormones** illustrate that the digestion of Palatinose™ and subsequent absorption is a slow process that is extended to more distal parts of the small intestine. Relevant for the enzymatic hydrolysis in the small intestine is the 2-center-enzyme complex “Sucrase-Isomaltase”, responsible for the breakdown of starch-type (respective their break down product isomaltose with an α -1-6 linkage) and disaccharide-type carbohydrates with α -1,2 linkages. Isomaltulose is hydrolysed at the starch-centre of the enzyme complex with a slower rate of hydrolysis.

Enzyme kinetic references:

- *In vitro* study with enzymes isolated from pig small intestinal mucosa showing the slow hydrolysis of Palatinose™ compared to maltose
Dahlqvist A (1961) Hydrolysis of palatinose (Isomaltulose) by pig intestinal glycosidases. Acta Chem Scand 15(4):808–816. <https://cir.nii.ac.jp/crid/1573668925784119168>

- *In vitro* studies with enzymes isolated from small intestinal mucosa of rat, pig and human confirming the slow hydrolysis of Palatinose™ compared to maltose

Heinz F (1987) The enzymatic splitting of sugar substitutes by isolated enzymes and enzyme complexes from the small intestinal mucosa. Hanover University Medical School, Biochemistry Centre, Research Project No. 6539. See also: Heymann, H., Heinz, F. (1987) Kinetic studies on glucoamylase/maltase and sucrase/isomaltase complex of human, pig and rat intestinal mucosa. 4th European Carbohydrate Symposium, Darmstadt, (12.-17.07.87).

- *In vitro* study with enzymes isolated from human small intestinal mucosa confirming the slow hydrolysis of Palatinose™ compared to maltose

Ziesenitz SC (1986a) Zur Verwertung des Zuckeraustauschstoffes Palatinit im Stoffwechsel. [Utilization of the sugar substitute Palatinit® in metabolism]. In: Bässler K, Grünert A, Kleinberger G, Reissigl H (eds) Beiträge zu Infusionstherapie und klinische Ernährung 16. Karger, Basel, pp 120–132.

Incretin response references:

- Study in patients with diabetes mellitus type 2 showing a significant increase in GLP-1 release and a significant decrease in GIP release with Palatinose™ compared to sucrose

Ang M, Linn T (2014) Comparison of the effects of slowly and rapidly absorbed carbohydrates on postprandial glucose metabolism in type 2 diabetes mellitus patients: a randomized trial. Am J Clin Nutr 100(4):1059–1068.

<https://pubmed.ncbi.nlm.nih.gov/25030779/>

- Study confirming a significant increase in GLP-1 release and a significant decrease in GIP release with Palatinose™ compared to sucrose in healthy adults

Maeda A, Miyagawa J, Miuchi M, Nagai E, Konishi K, Matsuo T, Tokuda M, Kusunoki Y, Ochi H, Murai K, Katsuno T, Hamaguchi T, Harano Y, Namba M (2013) Effects of the naturally-occurring disaccharides, palatinose and sucrose, on incretin secretion in healthy non-obese subjects. J Diabetes Investig. 4(3):281–286.

<http://www.ncbi.nlm.nih.gov/pubmed/24843667>

- Review article including an otherwise unpublished study in healthy adults that confirmed the different incretin response with Palatinose™ compared to sucrose

Pfeiffer AFH, Keyhani-Nejad F (2018) High glycemic index metabolic damage - a pivotal role of GIP and GLP-1. Trends Endocrinol Metab 29(5):289-299.

[https://www.cell.com/trends/endocrinology-metabolism/fulltext/S1043-2760\(18\)30046-8](https://www.cell.com/trends/endocrinology-metabolism/fulltext/S1043-2760(18)30046-8)

c) **Palatinose™ - the carbohydrate for sustained energy supply**

The sustained energy supply of Palatinose™ is additionally reflected in subsequent metabolic processes: In comparison with readily available carbohydrates, Palatinose™ shows a **slower, overall lower and sustained rise in blood glucose levels**. Since blood glucose means fuel for the body and its energy metabolism, the sustained glucose supply from Palatinose™ is associated with a more steady and sustained energy gain from carbohydrate oxidation: Palatinose™ provides sustained energy. Numerous blood glucose response studies have been conducted on behalf of BENEIO and specifically *analysed* to test whether the characteristics of sustained glucose supply from Palatinose™ can be shown in this methodology with its high variance. The sustained glucose supply of Palatinose™ has been concomitantly shown in all of these studies. Moreover, individual studies confirm the link between sustained glucose supply and sustained carbohydrate oxidation.

Key reference:

- Study showing a low and sustained blood glucose response in healthy adults at various doses of Palatinose™

Macdonald, I.; Daniel, J. W. (1983): The bio-availability of isomaltulose in man and rat. In Nutr Rep Int 28, pp. 1083–1090. cabidigitallibrary.org/doi/full/10.5555/19841455170
- Study confirming a low and sustained blood glucose response with Palatinose™ in healthy and diabetic adults

Kawai, K.; Yoshikawa, H.; Murayama, Y.; Okuda, Y.; Yamashita, K. (1989): Usefulness of palatinose as a caloric sweetener for diabetic patients. Horm Metab Res 21 (6), pp. 338-340. <https://pubmed.ncbi.nlm.nih.gov/2673967/>
- Study in overweight adults linking a low and sustained blood glucose response with Palatinose™ to a higher fat oxidation

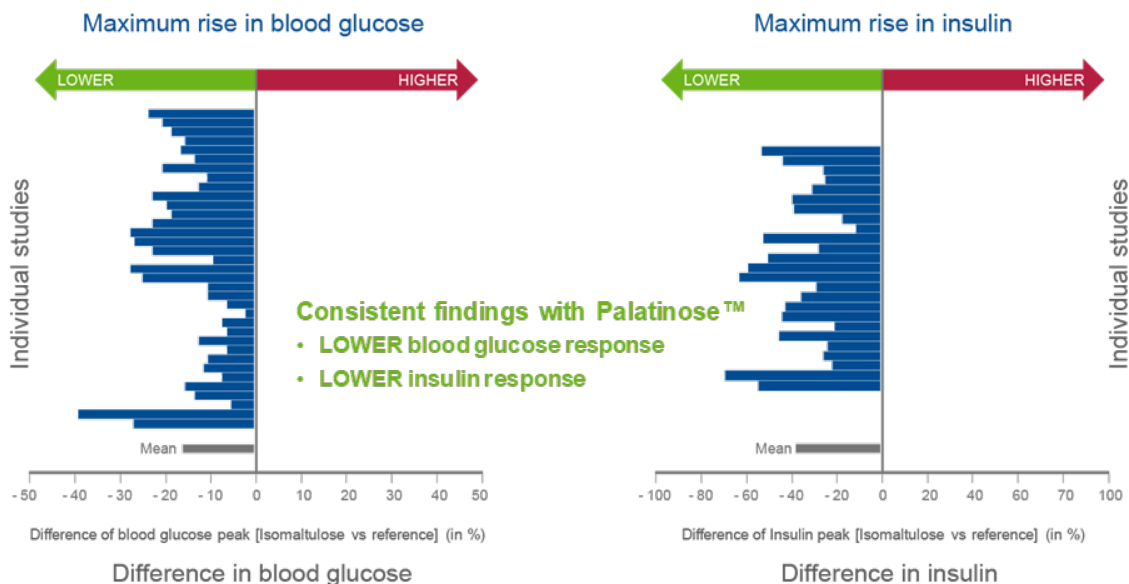
van Can, J. G.P.; Ijzerman, T. H.; van Loon, L. J.C.; Brouns, F.; Blaak, E. E. (2009): Reduced glycaemic and insulinaemic responses following isomaltulose ingestion: implications for postprandial substrate use. In The British journal of nutrition 102 (10), pp. 1408–1413. DOI: 10.1017/S0007114509990687.
<http://www.ncbi.nlm.nih.gov/pubmed/19671200>

2. Palatinose™ - a low glycaemic carbohydrate

As result of its slow (yet complete) intestinal release, Palatinose™ has a low effect on blood glucose levels and insulin release. A Glycaemic Index (GI) of 32 has been determined for Palatinose™ by Sydney University.

The “low glycaemic” properties of Palatinose™ have been experimentally verified in extensive research initiated by BENEEO - including more than 30 human trials from the past 10 to 15 years conducted according to internationally recognised standard methodology in leading test centres worldwide (see Figure below) - and are well described in literature. A corresponding claim has been laid down in EU legislation following the publication of a positive EFSA opinion.

Low glycaemic properties confirmed in over 30 human trials with Palatinose™



Confirmation in a study population of in total >250 adults, and also children, covering healthy people with normal body weight or overweight/obese, with normal or impaired glucose tolerance (including type 1 and type 2 diabetes mellitus).

Key references of published blood glucose response studies in (pre-) diabetic and healthy populations:

Healthy adults:

Studies in healthy adults showing a lower blood glucose and insulin response with Palatinose™

- Kawai K, Okuda Y, Yamashita K (1985) Changes in blood glucose and insulin after an oral palatinose administration in normal subjects. Endocrinol Jpn 32:933–936.
<http://www.ncbi.nlm.nih.gov/pubmed/3914416>
- Sydney University's Glycemic Index Research Service GI of Isomaltulose, Palatinose™ (Südzucker AG, Mannheim, Germany): https://glycemicindex.com/gi-search/?food_name=Isomaltulose&product_category=&country=&gi=&gi_filter=&serving

[size \(g\)=&serving size \(g\) filter=&carbs per serve \(g\)=&carbs per serve \(g\) filter=&gl=&gl filter=](#)

- Henry CJ, Kaur B, Quek RYC, Camps SG (2017) A Low Glycaemic Index Diet Incorporating Isomaltulose Is Associated with Lower Glycaemic Response and Variability, and Promotes Fat Oxidation in Asians. *Nutrients* 9(5).
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5452203/pdf>

“Citizen science” study confirming the positive effect on blood glucose in people in everyday surroundings, following their normal dietary lifestyle

- Kordowski A, Künstner A, Schweitzer L, Theis S, Schröder T, Busch H, Sina C, Smollich M (2022) Palatinose™ (Isomaltulose) and Prebiotic Inulin-Type Fructans Have Beneficial Effects on Glycemic Response and Gut Microbiota Composition in Healthy Volunteers-A Real-Life, Retrospective Study of a Cohort That Participated in a Digital Nutrition Program. *Front. Nutr.* 9:829933.
<https://www.frontiersin.org/articles/10.3389/fnut.2022.829933/full>

Healthy children:

Studies confirming a lower blood glucose and insulin response with Palatinose™ in healthy children

- Sünram-Lea, SI; Gentile-Rapinett, G; Macé, K; Rytz, A (2021): Assessment of Glycemic Response to Model Breakfasts Varying in Glycemic Index (GI) in 5-7-Year-Old School Children. In *Nutrients* 13 (12).
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8707352/pdf/>
- Schweitzer L, Theis S (2024) Replacing sugar with Isomaltulose reduces postprandial blood glucose response in school children: results from a double-blind, randomised, controlled cross-over study. *Diabetologia* (67 Suppl 1):S1-593.
<https://link.springer.com/article/10.1007/s00125-024-06226-0#Sec102>

Impaired glucose tolerance (prediabetes):

Studies showing a lower blood glucose and insulin response with Palatinose™ in overweight adults with impaired glucose tolerance

- König D, Theis S, Kozianowski G, Berg A (2012) Postprandial substrate use in overweight subjects with the metabolic syndrome after isomaltulose (Palatinose™) ingestion. *Nutrition* 28(6):651–656. <http://www.ncbi.nlm.nih.gov/pubmed/22264450>
- van Can JG, van Loon LJ, Brouns F, Blaak EE (2012) Reduced glycaemic and insulinaemic responses following trehalose and isomaltulose ingestion: implications for postprandial substrate use in impaired glucose-tolerant subjects. *Br J Nutr* 108(7):1210–1217. <http://www.ncbi.nlm.nih.gov/pubmed/22172468>

Diabetes mellitus type 2:

Studies showing an improved blood glucose management with Palatinose™ in adults with diabetes mellitus type 2

- Ang M, Linn T (2014) Comparison of the effects of slowly and rapidly absorbed carbohydrates on postprandial glucose metabolism in type 2 diabetes mellitus patients: a randomized trial. Am J Clin Nutr 100(4):1059–1068.
<https://pubmed.ncbi.nlm.nih.gov/25030779/>
- Kawai K, Yoshikawa H, Murayama Y, Okuda Y, Yamashita K (1989) Usefulness of palatinose as a caloric sweetener for diabetic patients. Horm Metab Res 21(6):338–340.
<http://www.ncbi.nlm.nih.gov/pubmed/2673967>
- Keyhani-Nejad F, Kemper M, Schueler R, Pivovarov O, Rudovich N, Pfeiffer AF (2016) Effects of Palatinose and Sucrose Intake on Glucose Metabolism and Incretin Secretion in Subjects With Type 2 Diabetes. Dia Care 39(3):e38–e39.
<http://www.ncbi.nlm.nih.gov/pubmed/26721819>

Diabetes mellitus type 1:

Studies showing that Palatinose™ improves the blood glucose response during and after exercise in adults with diabetes mellitus type 1

- West DJ, Morton RD, Stephens JW, Bain SC, Kilduff LP, Luzio S, Still R, Bracken RM (2011) Isomaltulose improves postexercise glycemia by reducing CHO oxidation in T1DM. Med Sci Sports Exerc 43(2):204–210. <https://pubmed.ncbi.nlm.nih.gov/20543751/>
- Bracken RM, Page R, Gray B, Kilduff LP, West DJ, Stephens JW, Bain SC (2012) Isomaltulose improves glycemia and maintains run performance in type 1 diabetes. Med Sci Sports Exerc 44(5):800–808. <https://pubmed.ncbi.nlm.nih.gov/22051571/>

Studies with diabetes-specific clinical nutrition products:

- Study showing a lower and balanced blood glucose response with Palatinose™ provided as part of enteral nutrition tube feeding in patients with diabetes mellitus type 2
Alish CJ, Garvey WT, Maki KC, Sacks GS, Hustead DS, Hegazi RA, Mustad VA (2010) A diabetes-specific enteral formula improves glycemic variability in patients with type 2 diabetes. Diabetes Technol Ther 12(6):419–25.
<https://pubmed.ncbi.nlm.nih.gov/20470226/>
- Study confirming a lower blood glucose and insulin response with Palatinose™ provided as part of an oral nutrition supplement in patients with diabetes mellitus type 2
Vanschoonbeek, K.; Lansink, M.; van Laere, K.; Senden, J. M. G.; Verdijk, L. B.; van Loon, L. J. (2009): Slowly digestible carbohydrate sources can be used to attenuate the postprandial glycemic response to the ingestion of diabetes-specific enteral formulas. The Diabetes Educator 35, pp. 631–640. <https://www.ncbi.nlm.nih.gov/pubmed/19448045>

Review articles:

- Review of studies with Palatinose™ in different populations linking the low glycaemic properties of Palatinose™ to various health benefits

Maresch CC, Petry SF, Theis S, Bosy-Westphal A, Linn T (2017) Low Glycemic Index Prototype Isomaltulose-Update of Clinical Trials. *Nutrients* 9(4).
<https://pubmed.ncbi.nlm.nih.gov/28406437/>

- Positive opinion of the EFSA Panel on Palatinose™ and its ability to reduce the glycaemic properties of foods when replacing other sugars

EFSA Panel on Dietetic Products, Nutrition and Allergies (2011) Scientific Opinion on the substantiation of health claims related to the sugar replacers xylitol, sorbitol, mannitol, lactitol, isomalt, erythritol, D-tagatose, isomaltulose, sucralose and polydextrose and maintenance of tooth mineralisation by decreasing tooth demineralisation (...), and reduction of post-prandial glycaemic responses (...) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. *EFSA Journal* 9(4):2076.
<http://www.efsa.europa.eu/de/efsajournal/doc/2076.pdf>

3. Palatinose™ and long-term blood glucose control and insulin sensitivity

Sugar replacement with the slow release carbohydrate Palatinose™ exerts positive effects on longer-term blood glucose control and insulin sensitivity as studies looking into markers such as glycated haemoglobin HbA1c and oral glucose tolerance or insulin resistance (HOMA-IR) have demonstrated.

Key references:

- Study showing a better glycaemic control (lower glycated haemoglobin levels) with Palatinose™ in adults with impaired glucose tolerance and diabetes mellitus type 2

Sakuma, M.; Arai, H.; Mizuno, A.; Fukaya, M.; Matsuura, M.; Sasaki, H. et al. (2009): Improvement of glucose metabolism in patients with impaired glucose tolerance or diabetes by long-term administration of a palatinose-based liquid formula as a part of breakfast. *J Clin Biochem Nutr* 45 (2), pp. 155–162.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2735627/>

- Study showing a reduced fasting blood glucose and improved insulin sensitivity (HOMA-IR) with Palatinose™ in overweight adults with hyperlipidaemia

Holub I, Gostner A, Theis S, Nosek L, Kudlich T, Melcher R, Scheppach W (2010) Novel findings on the metabolic effects of the low glycaemic carbohydrate isomaltulose (Palatinose™). *Br J Nutr* 103(12):1730–1737. (see trial 3 for effects of regular consumption of isomaltulose) <http://www.ncbi.nlm.nih.gov/pubmed/20211041>

- Study confirming an improved insulin sensitivity (HOMA-IR) with Palatinose™ in healthy, normal weight adults

Okuno, M.; Kim, M. K.; Mizu, M.; Mori, M.; Mori, H.; Yamori, Y. (2010): Palatinose-blended sugar compared with sucrose: different effects on insulin sensitivity after 12 weeks supplementation in sedentary adults. *Int J Food Sci Nutr* 61 (6), pp. 643–651.
<http://www.ncbi.nlm.nih.gov/pubmed/20367218>

4. Palatinose™ and its role in weight management

As result of its slow release properties and resulting lower and sustained blood glucose response, Palatinose™ triggers less insulin release and therefore enables higher fat oxidation in energy metabolism. Higher levels of fat burning with Palatinose™ in comparison with conventional carbohydrates such as e.g. sucrose or maltodextrin (but also in comparison with fructose) have been observed in human intervention studies with healthy and overweight individuals in mostly sedentary circumstances (see below) as well as with physically active trained persons (see chapter 5.).

In addition to its effects on fat metabolism, Palatinose™, through its slower digestion and extended absorption in the distal small intestine, leads to a more sustained and overall higher secretion of the gut hormone GLP-1 compared to sucrose and other high-glycaemic carbohydrates. GLP-1 plays a key role in metabolic regulation, contributing to appetite control and weight management. Notably, Palatinose™ has been shown to promote higher GLP-1 levels even when consumed before a meal, further supporting its role in metabolic health.

Related long-term benefits of Palatinose™ refer to body weight and body composition: Longer-term feeding studies in animals reported beneficial effects of Palatinose™ on body fat accumulation and body weight. Some publications provide first human data on the effect of Palatinose™ on body composition, i.e. visceral fat accumulation.

a) Palatinose™ promotes the release of GLP-1

Key references:

- Study showing an increase in GLP-1 secretion with a Palatinose™ compared to sucrose in healthy adults, adults with impaired glucose tolerance and type 2 diabetes
Keyhani-Nejad F, Barbosa Yanez RL, Kemper M, Schueler R, Pivovarova-Ramich O, Rudovich N, Pfeiffer AF (2020) Endogenously released GIP reduces and GLP-1 increases hepatic insulin extraction. *Peptides* 125:170231.
<https://pubmed.ncbi.nlm.nih.gov/31870938/>
- Study showing in healthy adults and adults with type 2 diabetes an increase in GLP-1 secretion with a Palatinose™ compared to sucrose 1 hour before the intake of a mixed meal

Zhang J, Sonnenburg D, Tricò D, Kabisch S, Mari A, Theis S, Kemper M, Pivovarova-Ramich O, Rohn S, Pfeiffer AFH (2024) Isomaltulose Enhances GLP-1 and PYY Secretion to a Mixed Meal in People With or Without Type 2 Diabetes as Compared to Saccharose. Mol Nutr Food Res:e2300086. <https://pubmed.ncbi.nlm.nih.gov/38332571/>

b) Palatinose™ and its influence on fat oxidation in energy metabolism

Key references:

- Study in healthy adults showing an increase in fat oxidation after consumption of a Palatinose™ based formula
Arai H, Mizuno A, Sakuma M, Fukaya M, Matsuo K, Muto K, Sasaki H, Matsuura M, Okumura H, Yamamoto H, Taketani Y, Doi T, Takeda E (2007) Effects of a palatinose-based liquid diet (Inslow) on glycemic control and the second-meal effect in healthy men. Metabolism 56(1):115–121. (see experiment 1 formula loading and substrate oxidation experiment). <http://www.ncbi.nlm.nih.gov/pubmed/17161233>
- Study in healthy adults confirming an increase in fat oxidation with a diet containing Palatinose™
Henry CJ, Kaur B, Quek RYC, Camps SG (2017) A Low Glycaemic Index Diet Incorporating Isomaltulose Is Associated with Lower Glycaemic Response and Variability, and Promotes Fat Oxidation in Asians. Nutrients 9(5). <https://pubmed.ncbi.nlm.nih.gov/28486426/>
- Study linking the lower blood glucose and insulin response with Palatinose™ to a higher fat oxidation in overweight adults with metabolic syndrome
König D, Theis S, Kozianowski G, Berg A (2012) Postprandial substrate use in overweight subjects with the metabolic syndrome after isomaltulose (Palatinose™) ingestion. Nutrition 28(6):651–656. <https://pubmed.ncbi.nlm.nih.gov/22264450/>

Review article:

- Review of studies with Palatinose™ in different populations linking the low glycaemic properties of Palatinose™ to various health benefits
Maresch CC, Petry SF, Theis S, Bosy-Westphal A, Linn T (2017) Low Glycemic Index Prototype Isomaltulose-Update of Clinical Trials. Nutrients 9(4). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5409720/>

c) Long-term benefits of Palatinose™ on body weight and body composition

Key references:

- 12-week weight loss study in overweight to obese adults showing a higher reduction in energy intake and higher losses in body weight and fat mass, especially visceral fat mass after consumption of Palatinose™ compared to sucrose as part of a calorie restricted diet
Lightowler H, Schweitzer L, Theis S, Henry CJ (2019) Changes in Weight and Substrate Oxidation in Overweight Adults Following Isomaltulose Intake During a 12-Week Weight Loss Intervention: A Randomized, Double-Blind, Controlled Trial. *Nutrients* 11(10).
<https://pubmed.ncbi.nlm.nih.gov/32764258/>
- Study showing a reduction in visceral fat mass after consumption of Palatinose™ for 12 weeks in prediabetic, obese adults with visceral fat accumulation
Oizumi T, Daimon M, Jimbu Y, Kameda W, Arawaka N, Yamaguchi H, Ohnuma H, Sasaki H, Kato T (2007) A palatinose-based balanced formula improves glucose tolerance, serum free fatty acid levels and body fat composition. *Tohoku J Exp Med* 212(2):91–99. <http://www.ncbi.nlm.nih.gov/pubmed/17548953>
- Study confirming a reduction in visceral fat mass after consumption of Palatinose™ for 16 weeks in overweight adults
Yamori Y, Mori H, Mori M, Kashimura J, Sakamua T, Ishikawa PM, Moriguchi E, Moriguchi Y (2007) Japanese perspective on reduction in lifestyle disease risk in immigrant japanese brazilians: a double-blind, placebo-controlled intervention study on palatinose. *Clin Exp Pharmacol Physiol* 34(S5-S7).
<http://onlinelibrary.wiley.com/doi/10.1111/j.1440-1681.2007.04759.x/abstract>

5. Palatinose™ in sports nutrition

Palatinose™ delivers the carbohydrate energy essential for physical activity in a more sustained and balanced manner compared to conventional, rapidly available carbohydrates. Its unique, low-glycaemic profile supports a greater reliance on fat oxidation within energy metabolism, which is particularly beneficial during endurance activities by helping to conserve glycogen stores and potentially enhancing stamina. The role of Palatinose™ in modulating substrate utilization and promoting fat oxidation has been substantiated through a number of well-designed intervention studies. Furthermore, some studies suggest that these metabolic benefits may translate into improved athletic performance.

Beyond healthy athletes, research at Swansea University has specifically investigated the benefits of Palatinose™ in adults with diabetes mellitus type 1. The studies highlighted its positive impact on fat oxidation, improved metabolic control, and reduced incidences of exercise-induced hypoglycaemia.

a) Palatinose™ promotes fat oxidation in endurance performance

Key references:

- Study in endurance trained adults showing a higher fat oxidation during exercise with Palatinose™ compared to sucrose
Achten J, Jentjens RL, Brouns F, Jeukendrup AE (2007) Exogenous oxidation of isomaltulose is lower than that of sucrose during exercise in men. J Nutr 137(5):1143–1148. <http://www.ncbi.nlm.nih.gov/pubmed/17449572>
- Study showing a more favourable metabolism for endurance and enhanced performance (trend) during prolonged endurance sports with Palatinose™ vs. maltodextrin in endurance trained athletes
König D, Zdzieblik D, Holz A, Theis S, Gollhofer A (2016) Substrate Utilization and Cycling Performance Following Palatinose™ Ingestion: A Randomized, Double-Blind, Controlled Trial. Nutrients 8(7):390. <https://pubmed.ncbi.nlm.nih.gov/27347996/>
- Study confirming an enhanced endurance performance during soccer-type endurance sports with Palatinose™ compared to maltodextrin in soccer players
Stevenson EJ, Watson A, Theis S, Holz A, Harper LD, Russell M (2017): A comparison of isomaltulose versus maltodextrin ingestion during soccer-specific exercise. European journal of applied physiology 117 (11), pp. 2321–2333. <https://pubmed.ncbi.nlm.nih.gov/28929343/>
- Study confirming an improved performance in the final exercise phase (Wingate test after treadmill running) with Palatinose™ compared to sucrose in athletes
Onuma N, Shindo D, Matsuo E, Sakazaki M, NAGAI Y, Yamanaka K (2023) Pre-exercise isomaltulose intake affects carbohydrate oxidation reduction during endurance

exercise and maximal power output in the subsequent Wingate test. BMC Sports Sci Med Rehabil 15(1):89. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10364385/>

Review article:

- Review of studies with Palatinose™ for sports nutrition describing a higher fat oxidation during exercise, an improvement in physical performance and protection against hypoglycaemia during exercise

Maresch CC, Petry SF, Theis S, Bosy-Westphal A, Linn T (2017) Low Glycemic Index Prototype Isomaltulose-Update of Clinical Trials. Nutrients 9(4).
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5409720/>

b) Palatinose™ benefits in type 1 diabetes and exercise

- Study showing a good glycaemic control after exercise and an enhanced fat oxidation during exercise with Palatinose™ in endurance-trained adults with diabetes mellitus type 1

West, D. J.; Stephens, J. W.; Bain, S. C.; Kilduff, L. P.; Luzio, S.; Still, R.; Bracken, R. M. (2011): A combined insulin reduction and carbohydrate feeding strategy 30 min before running best preserves blood glucose concentration after exercise through improved fuel oxidation in type 1 diabetes mellitus. J Sports Sci 29 (3), pp. 279–289.
<https://www.ncbi.nlm.nih.gov/pubmed/21154013>

- Study confirming a better glycaemic control after exercise and an increase in oxidation during exercise with Palatinose™ compared to dextrose in endurance-trained adults with diabetes mellitus type 1

West, D. J.; Morton, R. D.; Stephens, J. W.; Bain, S. C.; Kilduff, L. P.; Luzio, S. et al. (2011): Isomaltulose improves postexercise glycemia by reducing CHO oxidation in T1DM. In Med Sci Sports Exerc 43 (2), pp. 204–210.
<https://pubmed.ncbi.nlm.nih.gov/20543751/>

6. Palatinose™ and its potential in cognitive performance and mood

Carbohydrates and their supply of glucose to the brain play a central role in cognitive performance and mood. Palatinose™ with its steady and sustained glucose supply is of particular interest with respect to beneficial effects in the later phase after a meal. The potential of Palatinose™ in cognitive performance and mood has been addressed in the following key studies:

Key references:

- Study showing that the lower glycaemic response to Palatinose™ provided as a breakfast concept is linked to benefits for cognitive performance in children
Young H, Benton D (2015) The effect of using isomaltulose (Palatinose™) to modulate the glycaemic properties of breakfast on the cognitive performance of children. Eur J Nutr 54(6):1013–1020. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4540784/pdf/>
- Study confirming a better cognitive performance with Palatinose™ as part of a breakfast concept in adults
Young H, Benton D (2014) The glycemic load of meals, cognition and mood in middle and older aged adults with differences in glucose tolerance: A randomized trial. e-SPEN.Journal 9(4):e147-e154. [http://www.clinicalnutritionespen.com/article/S2212-8263\(14\)00020-7/pdf](http://www.clinicalnutritionespen.com/article/S2212-8263(14)00020-7/pdf)

7. Palatinose™ enhances hydration

Conventional carbohydrate-electrolyte drinks typically use rapidly digestible carbohydrates like glucose, fructose, maltodextrin, or sucrose to support fluid absorption by facilitating sodium-glucose co-transport in the small intestine. This mechanism improves water uptake compared to plain water. The slower release of glucose and fructose from Palatinose™ has been shown to support hydration by promoting more gradual water absorption and reducing urine output.

A series of studies demonstrated that incorporating Palatinose™ into electrolyte drinks helps enhance fluid retention, whether consumed during or after physical activity or at rest.

Key references:

- Study confirming the maintenance temperature regulation with Palatinose™ compared to sucrose in carbohydrate-electrolyte drinks during exercise
Otsuka J, Okamoto Y, Fujii N, Enoki Y, Maejima D, Nishiyasu T, Amano T (2021) Effects of Isomaltulose Ingestion on Thermoregulatory Responses during Exercise in a Hot Environment. Int J Environ Res Public Health 18(11). <https://pubmed.ncbi.nlm.nih.gov/34072006/>

- Study in physically active men showing an enhanced rehydration after exercise with Palatinose™ compared to sucrose in carbohydrate-electrolyte

Amano T, Katayama S, Okamoto Y, Otsuka J, Fujii N, Kenny GP, Nishiyasu T, Enoki Y, Maejima D, Murray R, Eddy DE, Bartoli WP, Paul GL (2021) Comparisons of isomaltulose, sucrose, and mixture of glucose and fructose ingestions on postexercise hydration state in young men. Eur J Nutr 60(8):4519.
<https://pubmed.ncbi.nlm.nih.gov/34129073/>

- Study showing a higher fluid retention due to reduced urine reduction Palatinose™ with Palatinose™ compared to sucrose in carbohydrate-electrolyte drinks at rest

Amano T, Watanabe D, Otsuka J, Okamoto Y, Takada S, Fujii N, Kenny GP, Enoki Y, Maejima D (2022) Comparison of hydration efficacy of carbohydrate-electrolytes beverages consisting of isomaltulose and sucrose in healthy young adults: A randomized crossover trial. Physiol Behav 249:113770. <https://pubmed.ncbi.nlm.nih.gov/35247444/>

8. Palatinose™ supports cardiovascular health

Growing evidence highlights the role of Palatinose™ in supporting cardiovascular health. Its unique slow-release carbohydrate profile leads to lower postprandial blood glucose and insulin levels, while stimulating GLP-1 release. Together, these effects help maintain insulin sensitivity and contribute to improved vascular function, reduced arterial stiffness, and long-term blood pressure stability.

Key references:

- Study demonstrating that Palatinose™ preserved insulin sensitivity, prevented arterial stiffening, and promoted favorable cardiovascular parameters compared to high-GI sugar-sweetened beverages in young, healthy individuals during a short period of physical inactivity

Keller J, Kahlhöfer J, Peter A, Bosy-Westphal A (2016) Effects of Low versus High Glycemic Index Sugar-Sweetened Beverages on Postprandial Vasodilatation and Inactivity-Induced Impairment of Glucose Metabolism in Healthy Men. Nutrients 8(12):802. <https://pubmed.ncbi.nlm.nih.gov/27973411/>

- Study in overweight to obese adults with mild hypertension confirming that Palatinose™ attenuates the impairment in arterial relaxation which was seen with sucrose

De Groot E, Schweitzer L, Theis S (2020) Efficacy of Isomaltulose Compared to Sucrose in Modulating Endothelial Function in Overweight Adults. Nutrients 12(1):141.
<https://pubmed.ncbi.nlm.nih.gov/31947853/>

- Study showing that Palatinose™ replacing sucrose prevents the increase in arterial stiffness and systolic blood pressure following postprandial hyperglycemia in healthy middle-aged and older adults

Kobayashi R, Sakazaki M, NAGAI Y, Okamoto T, Hashimoto Y, Sato K, Seki S, Hata U, Esaki K, Tanigawa R, Mitsuoka A, Funaki A, Niki Y, Hashiguchi T, Negoro H (2023) Habitual isomaltulose intake reduces arterial stiffness associated with postprandial hyperglycemia in middle-aged and elderly people: a randomized controlled trial. Heart Vessels 39(2):123–134. <https://link.springer.com/article/10.1007/s00380-023-02316-y>

9. Palatinose™ is kind to teeth

Palatinose™ is not a substrate for oral bacteria and therefore the first sugar that is kind to teeth. Its tooth-friendliness has been confirmed in pH telemetry studies. A corresponding claim was accepted a) in the USA by FDA and implemented in the Code of Federal Regulations as well as b) in the EU following the publication of a positive EFSA opinion.

Key references:

- FDA statement on the amendment of the health claim on non-cariogenic carbohydrate sweeteners and dental caries to include isomaltulose

Department of Health and Human Services - Food and Drug Administration (2007) 21 CFR Part 101 [Docket No 2006P-0487] Food labeling, health claims, dietary non-cariogenic carbohydrate sweeteners and dental caries. Federal Register Vol 72 No 179, September 17:p. 52783. <http://www.fda.gov/OHRMS/DOCKETS/98fr/cf086.pdf>

- Positive opinion of the EFSA Panel on Palatinose™ and its ability to maintain tooth mineralisation

EFSA Panel on Dietetic Products, Nutrition and Allergies (2011) Scientific Opinion on the substantiation of health claims related to the sugar replacers xylitol, sorbitol, mannitol, lactitol, isomalt, erythritol, D-tagatose, isomaltulose, sucralose and polydextrose and maintenance of tooth mineralisation by decreasing tooth demineralisation (...), and reduction of post-prandial glycaemic responses (...) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal 9(4):2076. <http://www.efsa.europa.eu/de/efsajournal/doc/2076.pdf>

10. Palatinose™ in infant and small children nutrition

Palatinose™ is suitable for infants from the age of about 4-6 months, when complementary feeding starts. It provides benefits to milk formula applications when used in place of maltodextrin, glucose or other high glycaemic carbohydrates, as it is slowly and fully available and therefore delivers the necessary energy for infants and small children in a more balanced way. Hence, Palatinose™ brings the metabolic profile closer to that of mother milk.

Reference:

- Study confirming the suitability and good tolerance of Palatinose™ in infants
Fleddermann M, Rauh-Pfeiffer A, Demmelmair H, Holdt L, Teupser D, Koletzko B (2016) Effects of a Follow-On Formula Containing Isomaltulose (Palatinose™) on Metabolic Response, Acceptance, Tolerance and Safety in Infants: A Randomized-Controlled Trial. PloS ONE 11(3):e0151614. <http://www.ncbi.nlm.nih.gov/pubmed/26987056>

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