MALTITOL

Is Maltitol suitable for the Keto Certified Program?

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Karen E. E. Pendergrass [1] | **Zad R. Chow** [2]

[1] Department of Standards, Paleo Foundation, Encinitas, CA
[2] Department of Standards, Paleo Foundation, New York, NY

Correspondence
Karen E. E. Pendergrass
Department of Standards, Paleo Foundation, Encinitas, CA

Contact
[1]Email: karen@paleofoundation.com
[1]Twitter: @5WordsorlessKP
[2]Email: zad@lesslikely.com
[2]Twitter: @DailyZad

Community Arguments

1) Maltitol is not keto because it has a high glycemic index.
2) Maltitol is not keto because it has a high insulin index.
3) Maltitol is not keto the because the oxidation of alcohol compounds within the body suppresses fatty acid oxidation.
4) Maltitol is not keto because its consumption leads to gastrointestinal side effects such as bloating, cramping, and diarrhea.
5) Maltitol is not keto because it is calorically dense and has no nutritional value.

KEYWORDS
Glycemic Index (GI), Insulin Index, fatty acid oxidation.

1 | BACKGROUND

Sugar alcohols are bulk sweeteners that have increasingly displaced sugar (sucrose) in commercial food products because of their desirable properties such as containing fewer calories than sugar, being much sweeter, and not contributing to tooth decay [1,2].

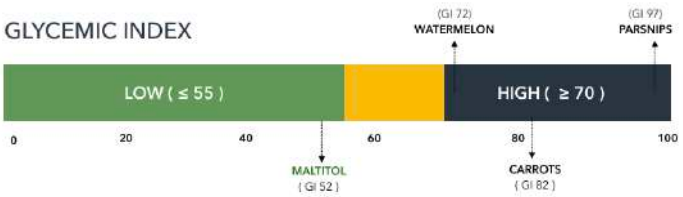
In fact, one of the most popular sugar alcohols, xylitol, is promoted as an ingredient that prevents tooth decay, and a large body of evidence supports a small beneficial effect [3,4]. Such sweeteners have shown much promise as sugar substitutes for decades [5], yet they have often been controversial due to a wide range of concerns. These concerns have led several keto community leaders to completely discourage the consumption of certain sugar alcohols such as maltitol.

As a Keto certification organization, we are trusted and tasked with making decisions about the place of such food ingredients within the ketogenic diet. We do not make these decisions without careful consideration of available data, benefits, and uncertainties.

In a random sample of websites articles from the top 100 results on Google for the search phrase "Maltitol Keto," sites were classified as "positive interpretations" or "negative interpretations" based on whether or not they thought maltitol was "Keto Friendly" or not, respectively.

Extrapolated from the data of the random sample, it is estimated that 80% of the information regarding Maltitol involves negative interpretations, and only 20% of information available involves positive interpretations.

In this Consensus Report, we critically examine arguments about maltitol from the keto community, the logical stature of these arguments, as well as arguments from leading Keto experts. Finally, we will make a decision that takes all these perspectives into account to determine whether maltitol has a place within the ketogenic diet and Keto Certified Standards.



[Figure 1]. Glycemic index scoring scale showing the placement of Maltitol within the low range.

2 | ARGUMENTS

- **Maltitol is not keto because it has a high glycemic index.**

GLYCEMIC INDEX

The glycemic index (GI) is a quantitative scale ranging from 0 to 100 that assesses how quickly a portion of food with a specific amount of carbohydrates (usually 50 grams) relatively raises blood glucose levels within the average person [6]. It uses pure glucose, which has a GI of 100, as a reference to compare to other foods.

A range of 0 - 55 is considered to be low, a range of 56 - 69 is considered to be medium, and a range from 70 - 100 is considered to be high. [**Figure 1**]

Maltitol is often estimated to have a glycemic index around 52, which is on the upper end of what is considered to be "low." Thus, the claim that maltitol has a high glycemic index and is therefore not a keto-friendly ingredient is not a good argument because maltitol is actually within the low range of the glycemic index scale.

However, there are other reasons to avoid relying on the glycemic index of an ingredient or food as a way to predict whether the ingredient or food will have a meaningful impact on an individual's state of ketosis.

While the glycemic index may seem useful — since high blood glucose levels can suppress ketone production — the glycemic index has severe limitations because it is a poor predictor of whether an actual food or ingredient will have a clinically meaningful impact on someone's blood sugar levels or affect their state of ketosis.

For example, the scale does not factor into account the amount of carbohydrates consumed in a serving, which is an important predictor of how large the rise in blood glucose levels will be [7]. Eating twenty oranges will clearly raise most individuals' blood glucose levels far more than eating one orange, yet the glycemic index will give both of these amounts scores around 40, which is not predictive of the rise in blood glucose levels from eating varying amounts of the fruit in the real world.

Furthermore, the scale's utility is limited by the fact that it estimates how quickly blood glucose levels rise in the average person as a result of consuming the food in isolation. Yet, most individuals do not consume their foods in isolation, instead they often consume them with other foods, as part of a meal, which will certainly impact the speed at which blood glucose levels rise.

This is noteworthy given that certain properties of a food, such as the protein [8,9] and fiber content, will affect the rate of digestion and absorption, and

therefore, the rise in blood glucose levels [10 – 12]. So, it's not very useful to know that a boiled pumpkin has a glycemic index around 64 (a quantity estimated from isolated consumption), when the pumpkin is being served as a part of a complex dish that includes lean animal products full of protein and other vegetables rich in fiber.

Adding to these limitations is the fact that the glycemic index is derived from relative increases in blood glucose levels within the average person. This property of the scale may be useful for researchers who are studying populations and dietary patterns, but it has little bearing for an individual consuming that food, who will have a unique response to consuming the food, that is influenced by several factors [13]. This is further supported by within-person variability of glycemic responses to the same food, which can change depending on factors such as blood glucose levels and insulin resistance [14].

In short, not only is the argument that "maltitol has a high glycemic index" false, the glycemic index has little merit for determining whether or not the sweetener has a place in the ketogenic diet, given that the glycemic index is not useful for determining an individual's blood glucose response to eating a particular food product that has been sweetened with varying amounts of maltitol.

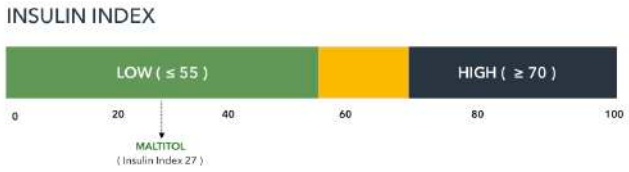
- **Maltitol is not keto because it has a high insulin index.**

Insulin is a hormone created by the pancreas that transports glucose molecules into the cells, so that the cells can utilize the molecules for energy [15]. The hormone is also known to suppress ketone production [16,17]. Therefore, it seems logical to avoid food products that largely raise insulin levels.

The insulin index is used by many for this purpose, and similar to the glycemic index in principle, it measures the insulin rise in the body, in response to a specific density of food (240 kcal) and compares this response to the one produced by the reference food, which is usually white bread.

The insulin index ranges from 0 - 100, which represents relative increases in blood insulin levels in a two hour period, in comparison to the reference food (white bread), which has a score of 100.

Just like the glycemic index, foods with insulin index scores of 0 to 55 are considered to have a low insulin index, foods with scores of 56 to 70 are considered to have a medium insulin index, and foods with scores of 70 and above are considered to have a high insulin index. **[Figure 2]**



[Figure 2]. Insulin index scoring scale showing the placement of Maltitol within the low range.

Some studies have estimated that maltitol has an insulin index of 27, which would put it in the middle of the low range of the index [18]. Thus, the claim that maltitol has a high insulin index is false because it has a low insulin index score. Despite this, many continue to label maltitol as a high insulin index ingredient. Some of these claims even cite higher insulin index numbers. These claims are misleading because they often do not cite the insulin index of pure maltitol, but instead, reference different formulations of maltitol.

These formulations are produced by combining pure maltitol with hydrogenated polymers, often in a 1:1 ratio [18]. Such modified forms of maltitol are known as "high polymer maltitol syrups" or simply, "maltitol syrups", and they have significantly larger insulin index scores than pure maltitol. For example, one study estimated that pure maltitol has an insulin index of 27, while maltitol syrup has an insulin index that could range from 31 all the way up to 44, depending on the formulation of the maltitol syrup. Claims about maltitol having a high insulin index have often cited these forms of maltitol rather than pure maltitol itself.

However, even if pure maltitol had scores that were in this range, they would still be considered "low" insulin index scores. Yet, pure maltitol has a much lower score (estimated to be around 27), making claims about it having a "high" insulin index false.

Furthermore, the insulin index suffers from several of the same limitations that plague the glycemic index. It is calculated by administering isolated foods/ ingredients; therefore, it is not a very good predictor of individual rises in insulin levels, but rather, increases in insulin levels in the average person, derived from administering a portion of the food product (240 kcal) in isolation [15]. Therefore, the claim that "maltitol has a high insulin index" is not only false, it is also misleading, and the insulin index is not useful to determine the insulin response to a food that simply contains an ingredient. Thus, it is a poor argument to discount pure maltitol as a sweetener in a ketogenic diet or as a Keto Certified ingredient.

- **Maltitol is not keto the because the oxidation of alcohol compounds within the body suppresses fatty acid oxidation.**

The evidence often used to back up this statement is a series of experiments done in the early 1900s, in which aldehyde compounds such as glycol aldehyde or glycerin aldehyde were administered to diabetic patients or healthy patients and the researchers observed that ketone production was lowered [16]. However, none of these administered alcohols were sugar alcohols, and therefore, one cannot logically infer that the same exact reactions would occur with the administration of sugar alcohols in healthy or diabetic patients on a ketogenic diet.

Other evidence to back up these claims are a series of animal experiments in which sugar alcohols were administered to diabetic rats and fatty acid oxidation was found to be lowered in these animal models [17 – 20]. However, the results of such animal studies are rarely applicable to humans, and these studies have been repeatedly criticized for their low reproducibility rates making their findings dubious [21, 22].

Therefore, claims about sugar alcohols such as maltitol being antiketogenic are misleading, potentially untrue, and the evidence being used to make these inferences relies on making giant leaps in assumptions. Thus, the argument that maltitol is not keto because the oxidation of alcohol compounds within the body suppresses fatty acid oxidation is not substantiated, and is therefore not useful in determining the official 'keto' status of maltitol.

- **Maltitol is not keto because its consumption leads to gastrointestinal side effects such as bloating, cramping, and diarrhea.**

Maltitol, like other sugar alcohols, is not fully absorbed within the small intestine, which means that some of it will be fermented by bacteria in the large intestine [23].

This can cause gastrointestinal side effects in some individuals, but these experiences are highly variable, and depend on the amount consumed, the composition of an individual's gut flora, and the frequency of consumption, with reports that tolerance improves over time and experiments showing that symptoms are rarely severe [24 – 27].

However, the determining factor that makes a food or ingredient "keto friendly" has to do with its interaction with ketotic and glycemic pathways. And although it is true that gastrointestinal side effects can definitely affect these individuals, and it is definitely something worth considering when consuming products that contain maltitol, it does not inherently alter the keto status of maltitol.

Further, there are several other foods, especially those rich in prebiotics and fibers, that are known to cause gastrointestinal side effects. However, prebiotics are almost universally accepted within the keto community as a keto-friendly and often imperative addition to the Ketogenic Diet.

Thus, the argument that maltitol has the potential to cause gastrointestinal side effects is not sufficient to determine whether the sweetener should be universally prohibited in a ketogenic diet, an eating framework that emphasizes being in a state of ketosis by reducing carbohydrate consumption, not avoiding foods in order to reduce gastrointestinal side effects.

- **Maltitol is not keto because it is calorically dense with no nutritional value.**

Maltitol is a disaccharide (composed of two monosaccharides) that is produced by hydrogenating maltose. In order to assess the calorie density of this sweetener, we must compare maltitol to other commonly used sweeteners. Maltitol contains 2.1 kilocalories per gram, less than sucrose (table sugar), which contains about 4 kilocalories per gram, and less than honey, which contains about 3 kilocalories per gram [28, 29].

A notable portion of maltitol (15%) is also resistant to digestion, and will end up being excreted. Therefore, less of it will be absorbed when compared to the sweeteners mentioned. So even if maltitol has 2.1 kilocalories per gram, not all of it will be absorbed. Furthermore, its properties make it incredibly sweet, meaning much less of it is needed to attain a certain level of sweetness, a level which may require higher amounts of other sweeteners.

Thus, when realistically taking into account its energy density relative to other sweeteners such as honey, and its properties which make it resistant to digestion/absorption, and which make it incredibly sweet, the claim that maltitol is calorically dense is misleading.

While the argument that maltitol does not have any nutritional value is true, the argument would only hold merit if individuals on a ketogenic diet depended on and acquired all their micronutrients from sweeteners, but of course, this is far from what actually occurs. Sweeteners like maltitol are simply used to enhance the palatability of foods, and most individuals on the ketogenic diet obtain their micronutrients from whole foods, often rich in fat, not added sweeteners.

Thus, the argument that maltitol is not keto because it is calorically dense and has no nutritional value bears no relevance to its effect on ketotic pathways, or its value for improving palatability of foods and thus improving tolerability of the ketogenic diet, which is widely recognized as the single-most important factor limiting individual acceptance for initiation in patients. [30-33].

3 | EXPERT INPUT

Andreas Eenfeldt, MD, a Swedish physician who specializes in family medicine, is the founder and CEO of Diet Doctor, a website that has written several articles on the ketogenic diet. Dr. Eenfeldt is often referred to by community members for his opinions on the ketogenic diet and low-carbohydrate diets.

In a recent article titled "Keto sweeteners – the best and the worst" Dr. Eenfeldt argues that maltitol is one of the worst sugar substitutes, and nearly as bad as sugar itself. In the article, Dr. Eenfeldt writes,

"Do not consume maltitol on a keto diet. It has been shown to raise blood sugar and increase insulin response. It is not good for anyone with diabetes or pre-diabetes. It also has three-quarters of the calories as sugar.

It is also a powerful laxative. While 50% of it is absorbed in the small intestine, the remaining 50% ferments in the colon. Studies have shown that maltitol may cause significant gastrointestinal symptoms (gas, bloating, diarrhea etc.) even when consumed in moderate amounts." [34]

Jocelyn Tan, MD is a medical oncologist who conducts research on the ketogenic diet and cancer, and regularly discusses the research and the utility of the diet on her website KetoOncologist.com.

In an article titled "Can I use sugar substitutes?-Sugar alcohols, aspartame etc." Dr. Tan writes the following,

"Sugar alcohols technically are natural compounds and are a form of digestible carbohydrate. Sugar alcohols come in a variety of "ol" names- erythritol, maltitol, sorbitol, isomalt, lactitol, mannitol, xylitol. They are also present naturally in fruits, some vegetables and in mushrooms. Commonly present in food additives to give sweetness, they don't bring up blood glucose as much and don't stimulate the secretion of insulin.

Generally regarded as safe to consume, why then, are they discouraged in a ketogenic diet?

Table sugar obviously is anti-ketogenic. Fructose, is also antiketogenic. Aside from the obvious side effects, diarrhea and bloating, sugar alcohols are apparently also "anti-ketogenic". They are also considered carbohydrates though to a lesser degree than common table sugar.

Woodyatt in 1910 suggested that when ketoacids are mixed with alcohol, they undergo combustion in the presence of light. Reactions ensue where alcohols, glycerin or sugars become oxidized and ketones are reduced. When starvation occurs, carbohydrates are absent and fats turn into butyric acid which in turn become acetoacetate, acetone and beta-oxybutyric acid. Sugar oxidation/sugar combustion then decreases and acidosis develops. When fed sugar alcohols, laboratory induced diabetic rats not given sugar alcohols were found to have 52% less fatty acid oxidation. The proposed explanation for this is that it prevents fatty acid oxidation and therefore decreases ketone production." [35]

4 | DISCUSSION

As we can see, the main concerns (from both the community and the experts) about maltitol's place within a ketogenic diet have been about the glycemic response to its consumption, but many of these claims are outright false, misleading, or simply not reliable for determining whether a food is keto friendly or not, as they do not threaten one's state of being in ketosis.

5 | CONCLUSION

Maltitol and other sugar alcohols are controversial within the Keto community (as shown by the community and expert arguments) due to myths that are perpetuated by misleading interpretations of research or misleading data. Nonetheless, a thorough examination of these arguments show them to be logically and evidently bankrupt.

Based on our critical appraisal of the existing arguments and the evidence, we will support the inclusion of maltitol in the Keto Certified standards. We anticipate some opposition from those in the community who believe maltitol to be antiketogenic, and we believe that addressing these myths via education efforts is vital in promoting a diet that is based on evidence-based principles, rather than distorted beliefs.

6 | CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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