

YOGURT

White
book

A convenient food for all,
including **lactose maldigesters**
and intolerants

PREFACE

Lactose intolerance has become an obsessive preoccupation of a growing population worldwide, along with exclusion diet new trends. These new trends could be seen as a **better overall consideration of the role of food in human health** or as **misinformation related to some type of foods**.

For instance, lactose intolerance is often confused with cow's milk allergy and avoidance of dairy is often considered the only alternative for the lactose intolerant.

Dairy products contain lactose, a necessary substrate for our bodies. The total exclusion of dairy products is not recommended. Often people with lactose intolerance **can tolerate dairy products** by having them with meals, and better tolerate hard cheese and **yogurts** than milk.

This white book is a review of scientific publications that offers you a better understanding of lactose intolerance and the risks of a restrictive diet. **Yogurt can be a good alternative, even for some lactose intolerant people.**

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LACTOSE AS A NUTRIENT

Lactose is the principal sugar (or carbohydrate) naturally found, in various amount, in milk and dairy.



Figure 1. Average amount of lactose in common dairy products. Adapted from Misselwitz *et al.*¹

Lactase, an enzyme present in the small intestine, is necessary to split lactose into **glucose** and **galactose**, two simple sugars.

In the small intestine...

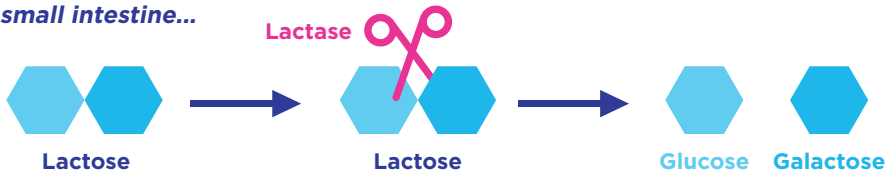


Figure 2. Lactose digestion in the intestine.

Glucose is the body's main source of energy, and can be found in several types of foods.

Conversely, lactose is the only source of galactose among life. It is a component of several macromolecules (cerebrosides, gangliosides and mucoproteins). Galactose has various biological functions and serves in neural and immunological processes. It is also a component of the molecules present in blood cells that determine the ABO blood types.²

LACTOSE, AN ESSENTIAL NUTRIENT DURING CHILDHOOD

Lactose is a necessary substrate, as evidenced by human milk content, which **contains 7.2% of lactose** and provides **up to 50% of an infant's energy needs**, while cow's milk contains only 4.7% of lactose and only provides up to 30% of an infant's energy needs.^{3, 4}



LACTOSE, A USEFUL NUTRIENT

When lactose is not digested in the small intestine, **it may be used as a nutrient by the intestinal microbiota** (the microorganism population that lives in the digestive tract).⁵ Bacteria produce their own lactase, digesting lactose and resulting in the production of **short chain fatty acids** (acetate, propionate, butyrate) and gases (hydrogen, carbon dioxide, methane). Short chain fatty acids serve as energy locally for the gut microbiota and systemically after their absorption and their transport to the liver. Undigested lactose and other milk sugars contribute also to promote the growth of bifidobacteria, a health-positive genus of bacteria.⁶

A **reduction in bifidobacteria** and of markers of the immune function is observed with **aging**. Lactose, which can then be considered as a **prebiotic**, may play a life-long role in countering the aging-associated decline of some immune functions.^{9, 10} Moreover, regular consumption of food containing lactose could lead to a tolerance by the microbiome.



According to more recent studies, **lactose may also play a role in the absorption of calcium** and other minerals such as copper and zinc, especially during infancy.^{9, 10} Further studies are needed in order to confirm this hypothesis.

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LACTASE ACTIVITY

In the intestine during digestion, lactose is usually split into **glucose** and **galactose** by the **lactase**. This enzyme is located in the brush border membrane of enterocytes, the absorptive cells of the small intestine. Lactase, encoded by the LCT gene, becomes normally less active with age.¹¹ In congenital lactase deficiency, a very rare genetic disorder (affecting fewer than 50 patients in the world, mainly in Finland), **lactase activity** is drastically reduced or non-existent.¹ Infants with this disease can experience symptoms such as nausea, abdominal cramps and bloating, vomiting, flatulence, diarrhea, dehydration, loose stool, metabolic acidosis, the presence of lactose in urine and a distended abdomen. These infants must completely avoid lactose.^{6, 12}

In the normal population, lactase activity reaches a maximum at birth and starts declining after weaning to reach less than 10% of the pre-weaning level. This **normal decline is called lactase non-persistence**. It is more common in people of Asian, African, South American, Southern European and Australian Aboriginal heritage. However, in some populations of Northern European descent (Scandinavia, the British Isles and Germany) who continue to consume dairy products during adulthood, lactase activity remains in most people.

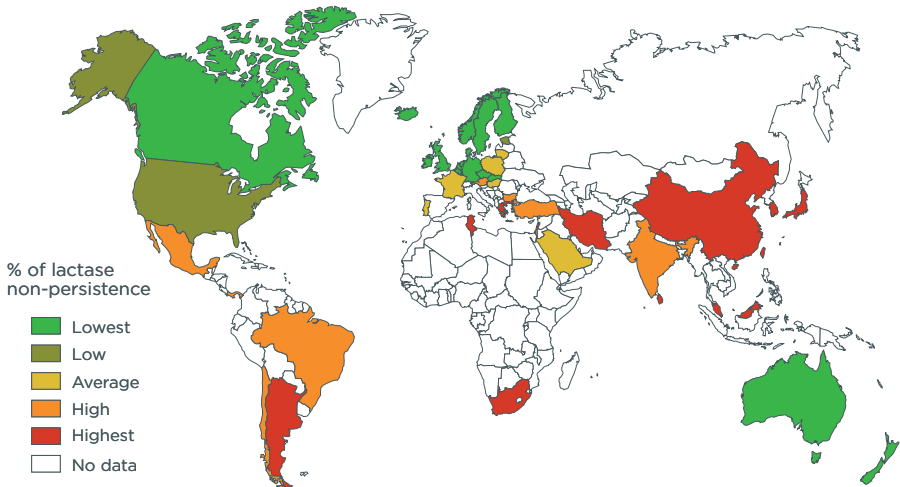


Figure 3. World map of lactase non-persistence.^{11, 13}

LACTOSE MALDIGESTION AND LACTOSE INTOLERANCE, TWO DIFFERENT CONDITIONS

In case of reduced lactase activity, some lactose is not digested. **This is called lactose maldigestion.** Non-digested lactose enters the colon where it is digested by the resident microbiota. For most individuals, this **lactose maldigestion produces few or no symptoms.**

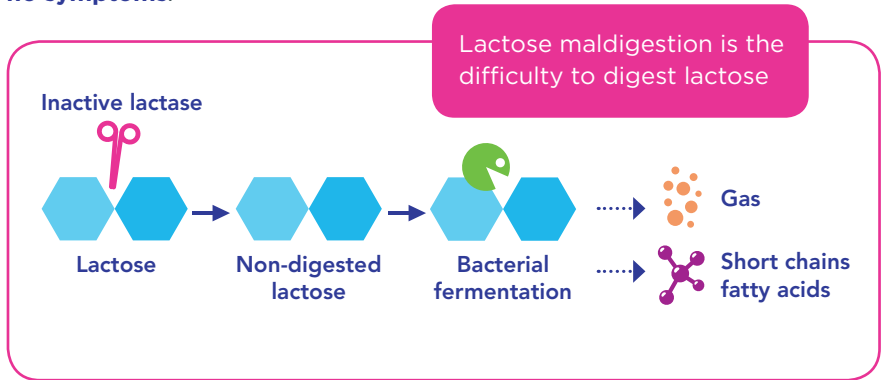


Figure 4. Lactose maldigestion.

However, for other individuals, the bacterial fermentation of lactose **produces gas and increases** gut transit time and intracolonic pressure, resulting in one or many symptoms such as **bloating, diarrhea, and flatulence.** This is called **lactose intolerance.** Thus, lactose intolerance is lactose maldigestion that results in one or many of these symptoms.¹⁴



Yet these symptoms can also occur for other reasons and are **not specific to lactose intolerance.** They can be observed in some **gastro-intestinal dysfunctions** such as irritable bowel syndrome, inflammatory bowel diseases (Crohn's disease and ulcerative colitis) and intolerance to FODMAP (Fermentable, Oligo-, Di-, Mono-saccharides And Polyols, which are short chain carbohydrates poorly absorbed in the small intestine). **Psychological factors** such as somatic anxiety, stress and depression can also cause the occurrence of these symptoms.¹⁵⁻¹⁸

Lactose malabsorption can also occur temporarily in case of infectious diarrhea, malnutrition, radiotherapy, mucosal damage due to coeliac disease or some medicine use, and give rise to similar symptoms.¹⁹

Thus the presence of the aforementioned intestinal symptoms **cannot systematically lead to the correct diagnosis of lactose intolerance.**

LACTOSE INTOLERANCE DIAGNOSTIC

It's not possible to self-diagnose lactose intolerance. Such self-diagnosis is an example of a widespread tendency for consumers to exercise control over their health by eliminating dietary factors considered suspect without medical evidence or oversight. The incorrect attribution of symptoms and the relative severity of symptoms could explain it.

The proper way to diagnose lactose intolerance, called the Breath test, is to measure, in the exhaled air, the hydrogen produced by the intestinal microbiota after consumption of a standard dose of lactose (usually 20 to 50 g). This diagnosis should be performed under medical control.²⁰

The diagnosis is only complete when one or many of the following symptoms occur:

bloating, diarrhea, and flatulence. For some patients, this test can be improved by simultaneous measurement of methane.²¹

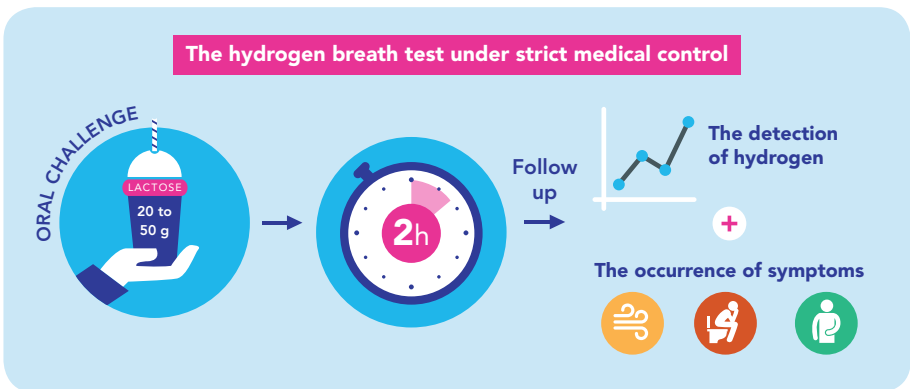


Figure 5. The diagnosis of lactose intolerance.

A real medical diagnosis is especially important as, when it is performed, only 50% of self-diagnoses of lactose intolerance are confirmed.^{20, 22, 23} Furthermore, perceived or even diagnosed lactose intolerance is one of the reasons for limiting or avoiding dairy food, which could lead to **possible nutrient shortcomings** and health consequences.²⁴

Intolerance ≠ allergy

Lactose intolerance is not to be confused with cow's milk protein allergy. In cow's milk allergy, the immune system overreacts to one or more proteins contained in cow's milk such as caseins and whey proteins. Symptoms include hives, swelling, nausea and wheezing and can arise within an hour and even up to 72 hours after drinking cow's milk.^{25, 26}

Interesting fact: the subjective perception of lactose intolerance influences the decision to avoid dairy consumption even more than objective malabsorption does. Furthermore, according to a recent study, a self-reported opinion of intolerance to lactose is also clearly associated with more symptoms and worse quality of life.²⁷



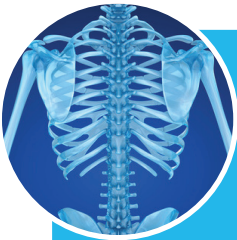
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LACTOSE INTOLERANCE, WHAT RISKS? WHAT IMPACTS? WHAT SOLUTION?

ELIMINATING DAIRY FOODS MAY LEAD TO NUTRIENT SHORTCOMINGS

Per se, **lactose maldigestion has no direct consequence on health.** It concerns most people in the world; **it's a normal process, usually not noticeable.** Lactose intolerance, which results in one or many symptoms such as bloating, diarrhea, and flatulence, can on the contrary impair quality of life but has, likewise, **no direct consequence on health.**

However, because self-diagnosed or even diagnosed lactose intolerance can lead to an unfounded limitation or avoidance of dairy products, lactose intolerance could result in nutrient shortcomings, such as low calcium intake, which may result in adverse health effects.^{23, 24, 28-30}



Calcium is an essential micronutrient. It is involved in various physiological and cellular processes and low calcium intake could harm these processes. European Food Safety Authority states that calcium is needed for maintenance of normal **bones and teeth**.^{28, 31}

NUTRITIONAL RECOMMENDATIONS FOR LACTOSE INTOLERANTS

In order to consume the recommended daily intake of calcium among others, lactose intolerants can consume other forms of dairy products such as cheeses that contain low or no lactose, and more specifically yogurts that **contain live bacteria, which improve the digestion of the lactose contained in yogurt.**^{24, 32}

The two specific yogurt bacteria



Lactobacillus delbrueckii subsp. bulgaricus



Streptococcus thermophilus

Nutritional guidelines for lactose intolerants

Several medical organizations (NMA, NIH, EFSA, FAO* among others)^{24, 33, 34, 37} recommend that lactose intolerants **should not avoid dairy foods** in order to **prevent nutrients shortcomings**. Instead, these medical organizations advise lactose intolerants to adapt their diet, and particularly recommend the consumption of yogurt. WGO has put forth a similar statement, to consume fermented dairy products containing probiotics, with proven benefits on digestive health, which is a tip from their 10 global diet and lifestyle tips on how to improve digestive health.³⁶

Lactose intolerants can also consume food containing lactose in modest amounts, up to 12 g in one intake or up to 24 g (the equivalent of one or two bowls of milk, respectively), preferably in **fractioned amounts across the day, during meals**, without triggering any symptoms.^{22, 33, 34}

The regular consumption of lactose-containing food by lactose maldigesters could even lead to colonic adaptation by the gut microbiota and may allow them to tolerate more lactose.¹⁴

Lactose-free food or total avoidance of dairy food is only needed for rare infants with congenital lactase deficiency.⁶

Nevertheless, the **elimination of a particular type of food could lead to nutritional imbalances and may have significant health consequences.**

*NMA (National Medical Association), NIH (the National Institutes of Health, a part of the U.S. Department of Health and Human Services), EFSA (the European Food Safety Agency), WGO (the World Gastroenterology Organization) and FAO (the Food and Agriculture Organization of the United Nations).

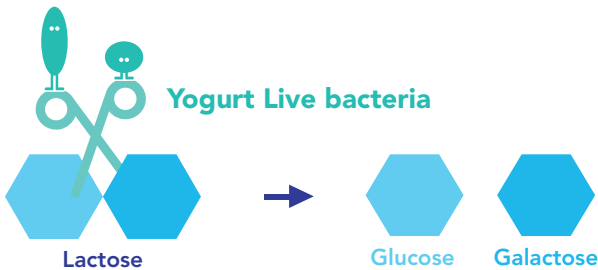
BENEFIT OF YOGURT FOR LACTOSE DIGESTION

Yogurt is a **source of lactose**; but it also contains **live bacteria that produce lactase, which improve the digestion of the lactose contained**.

This is why yogurt can be consumed by lactose maldigesters and lactose intolerants. The European Food Safety Authority²⁴ (EFSA) has issued a scientific opinion that claims that the consumption of live yogurt cultures in yogurt, *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus*, improves digestion of lactose in yogurt in individuals with lactose maldigestion. In order to bear the claim, the yogurt should contain at least 10^8 live microorganisms per gram of yogurt.

The scientific substantiation is based on the information provided by 14 publications. The EFSA considers that improved lactose digestion is a beneficial physiological effect for individuals with lactose maldigestion. It's one of the rare claims about a food.³²

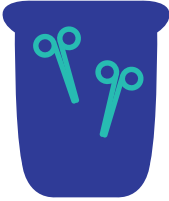
In the small intestine...



Yogurt improves lactose digestion

Figure 6. Yogurt improves lactose digestion in lactose maldigesters or intolerants.

Lactase of live bacteria in the yogurt stored in a refrigerator (4°C and $\text{pH} \approx 4$) is inactive.



pH ACID
($\text{pH} \approx 4$)

4°C



When live bacteria arrive in the small intestine (37°C and $\text{pH} \approx 7$), lactase becomes active.



pH NEUTRAL
($\text{pH} \approx 7$)

37°C



Figure 7. Lactase functioning through digestion.



EFSA SCIENTIFIC OPINION

14 studies showed enhanced digestion of lactose in yogurt in lactose maldigesters, when live yogurt starter cultures were ingested in yogurt.

222 Lactose maldigesters.

PRODUCTS TESTED

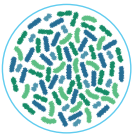


Milk

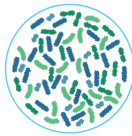
Milk with
bacteriaLactose-
hydrolysed
milkLactase
tabletsFresh
yogurt
(with live cultures)Heated
yogurt
(with reduced
or no live cultures
10^2 CFU/g)

BACTERIA CONCENTRATION TESTED

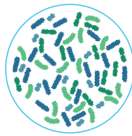
(CFU* per g of yogurt of both cultures)



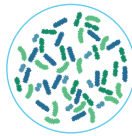
3×10^8



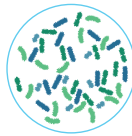
1.6×10^8



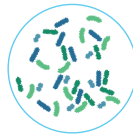
10^8



10^7



10^6



10^5

In order to bear the claim, the yogurt should contain **at least 10^8 CFU live starter microorganisms** (*Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus*) per gram.

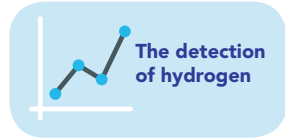
*CFU: Colony forming unit

References

Kolars JC *et al.*, 1984. Savaiano *et al.*, 1984. Dewit *et al.*, 1988. Lerebours *et al.*, 1989. Marteau *et al.*, 1990. Onwulata *et al.*, 1989. Martini *et al.*, 1991. Rosado *et al.*, 1992. Varela-Moreiras *et al.*, 1992. Shermak *et al.*, 1995. Rizkalla *et al.*, 2000. Labayen *et al.* 2001. Pelletier *et al.*, 2001. Pochart P *et al.*, 1989.

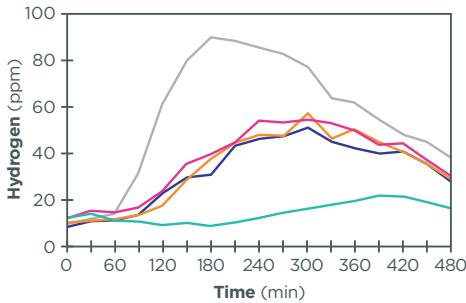
THE TEST

The breath hydrogen concentration method has been applied to measure lactose digestion.



THE ANALYSIS

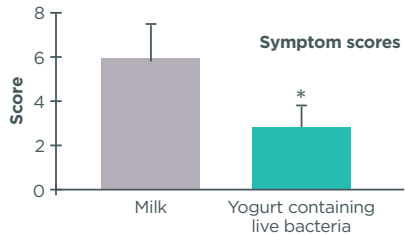
The evolution of hydrogen excretion is lower upon ingestion of yogurt than upon ingestion of any other product (see summary table). A cause and effect relationship has been established between the consumption of live yogurt cultures in yogurt and improved digestion of lactose in yogurt in individuals with lactose maldigestion.



From Pelletier *et al.*, 2001. Evolution of hydrogen concentration in Breath of lactose malabsorbers upon ingestion of yogurt, milk or fermented-then-pasteurised dairy products

- Yogurt: 10⁸ bacteria/mL
- Fermented dairy products: 10⁶ bacteria/mL
- Fermented dairy products: 10⁵ bacteria/mL
- Heat-treated yogurt: 15 bacteria/mL
- Milk

From Shermak *et al.*, 1995. The symptom record indicates a significant difference between milk and yogurt ($p < 0,005$)



SCIENTIFIC OPINION

« Live yogurt cultures in yogurt improve digestion of lactose in yogurt in individuals with lactose maldigestion ».*



*In order to bear the claim, the yogurt should contain at least 10⁸ live microorganisms per gram of yogurt.

References	Products tested	Numbers	The breath hydrogen concentration (BHC) method*
Kolars JC <i>et al.</i> , 1984	Milk, yogurt, lactose in water	10 maldigesters	BHC is 3 times lower ($p < 0.01$) with yogurt compared to the other products
Savaiano <i>et al.</i> , 1984	Yogurt, fermented milk with different bacteria, heat-treated yogurt	9 maldigesters	BHC is 3 to 5 times lower with yogurt compared to milk ($p < 0.05$)
Dewit <i>et al.</i> , 1988	Water, milk, fresh or heated yogurt, lactose solution	26 maldigesters	BHC is 6-8 times lower with yogurt compared to milk or lactose solution ($p < 0.001$) BHC is 8 times lower with yogurt compared to heated yogurt ($p < 0.01$)
Lerebours <i>et al.</i> , 1989	Milk, heat-treated fermented milk, yogurt	16 maldigesters	BHC is 3 times lower ($p < 0.05$) with yogurt compared to milk. There is no difference between milk and heat-treated fermented milk
Onwulata <i>et al.</i> , 1989	Milk, yogurt, fermented milk, Lactosehydrolysed milk, milk with lactase tablets	13 people with 10 maldigesters	BHC is 3 times lower ($p < 0.001$) with yogurt compared to milk, milk with lactase and fermented milk
Pochart P <i>et al.</i> , 1989	Fresh and heated yogurt	12 maldigesters	BHC is lower with yogurt ($p < 0.05$). There is no significant difference with heated yogurt
Marteau <i>et al.</i> , 1990	Milk, heat-treated fermented milk, yogurt	8 maldigesters	BHC is 4 times lower ($p < 0.001$) with yogurt compared to milk
Martini <i>et al.</i> , 1991	Milk, different types of yogurt, different types of fermented milk	19 maldigesters	BHC has decreased with yogurt compared to milk ($p < 0.001$). The different brands of yogurt have decreased the BHC in the same way. Fermentation by isolated bacteria results in a decrease in BHC compared to milk, but yogurt bacteria remain the most effective
Rosado <i>et al.</i> , 1992	Milk, different types of yogurt, yogurt without lactose,	14 maldigesters	BHC is 3 to 8 times lower with yogurts compared to milk ($p < 0.05$)
Varela-Moreiras <i>et al.</i> , 1992	Milk, yogurt, heat-treated fermented milk	53 people with 19 maldigesters	BHC is 3 times lower with yogurt compared to milk ($p < 0.05$)
Shermak <i>et al.</i> , 1995	Milk, yogurt, heat-treated fermented milk	14 maldigesters	Non-significant but the excretion peak is more acute and more precise with milk compared to yogurt
Rizkalla <i>et al.</i> , 2000	Yogurt, heat-treated fermented milk	24 people with 12 maldigesters	BHC is 2 times lower with yogurt compared to heat-treated fermented milk ($p < 0.01$)
Labayen <i>et al.</i> , 2001	Yogurt, heat-treated fermented milk	22 maldigesters	BHC has decreased with yogurt compared to heat-treated fermented milk ($p < 0.01$)
Pelletier <i>et al.</i> , 2001	Yogurt, heat-treated fermented milk, jellified water, diluted yogurt	24 maldigesters	BHC has decreased with yogurt compared to the other products ($p < 0.001$)

*When the BHC decreases, the digestion of the lactose is improved

4

THE BENEFITS OF YOGURT

More and more positive scientific data are published on yogurt and its effects on health.

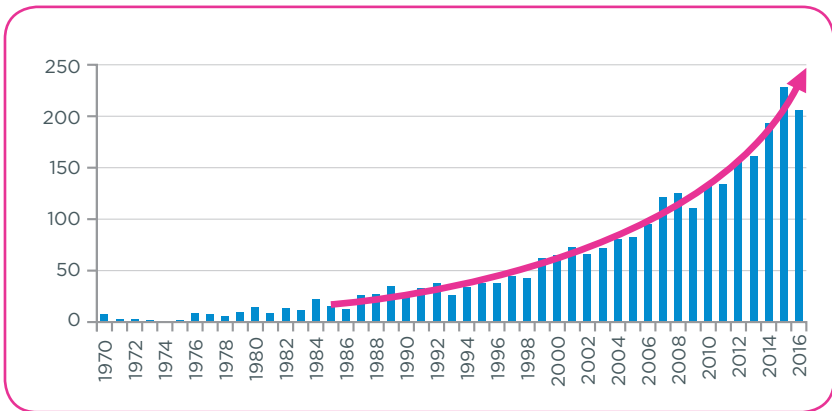


Figure 8. Number of publications about yogurt (Pubmed data).

As a nutrient-dense food and fermented milk product, yogurt contributes to meeting daily macronutrient and micronutrient recommendations and to reducing possible health risks in vulnerable groups.

NUTRITIONAL ADVANTAGES OF YOGURT

Yogurt is a predigested food, which contains a lot of nutrients, such as carbohydrates, proteins, lipids, minerals and vitamins.³⁸

Six reasons to eat yogurt:

1. Yogurt has a similar micronutrient composition to milk, generally with a good **bioavailability** and **affordability**.³⁹
2. Yogurt has a **low energy density** (Figure 9).
3. Yogurt is a **good source of calcium and other minerals** such as magnesium, potassium and zinc. It is also low in sodium. Yogurt consumers have overall a better calcium intake than non-yogurt consumers.⁴⁰⁻⁴²
4. Yogurt contains B (B1, B2, B3, B6, B9 and B12), A and E vitamins.⁴⁰
5. Yogurt is an **excellent source of high-quality proteins**, whey and casein proteins, which can lead to a reduction in appetite and aid muscle and bone growth.^{43, 44}
6. Yogurt has a **higher concentration of conjugated linoleic acids** than milk.¹³ Conjugated linoleic acids are reported to have immunostimulatory and anticarcinogenic properties.⁴⁵

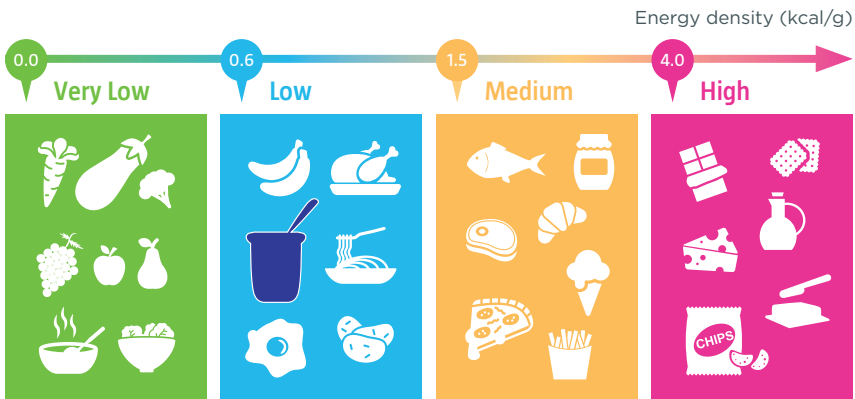


Figure 9. Energy density of food. Adapted from British Nutrition Foundation Feed Yourself Fuller Chart 2009.

Yogurt consumption helps to improve the overall diet quality.

YOGURT HEALTH BENEFITS

Beyond the nutritional benefits of yogurt, several studies have investigated the health effects of yogurt consumption.

Five extra reasons to eat yogurt:

1. Recent scientific studies have reported that yogurt consumers have a **better overall diet quality** than non-consumers: indeed, regular yogurt consumers have a more **diverse** and **balanced** diet that **respects the dietary guidelines** regarding nutrient intakes and food choices (more fruit, more whole grains, less processed meat, less refined grains...) than non-consumers.⁴⁶⁻⁴⁹
2. Adult yogurt consumers tend to have **healthier lifestyles**, are more likely to be physically active and are less likely to smoke than non-yogurt consumers are.⁴⁹
3. Yogurt consumption could also be involved in the **control of body weight** and energy homeostasis, since analysis of cohorts has shown that regular consumers of yogurt gain less weight over time than non-consumers.⁵⁰⁻⁵²
4. Yogurt consumption is also associated with lower risk of type 2 diabetes.^{51, 52}
5. Yogurt consumption is associated with a better metabolic profile in adults and children: lower levels of circulating triglycerides and glucose, lower systolic blood pressure and healthier insulin profile.^{40, 53}

And about microbiota?

The long-term consumption of live bacteria of yogurt does not result in significant changes in the overall gut microbiota constitution of healthy people, but it can modify the presence of certain microbiota bacterial strains; for example, the level of *Enterobacteriaceae* (which include pathogenic bacteria) was significantly lower in yogurt consumers.^{54, 55}



Yogurt is an easy way to digest lactose and a nutrient-dense food

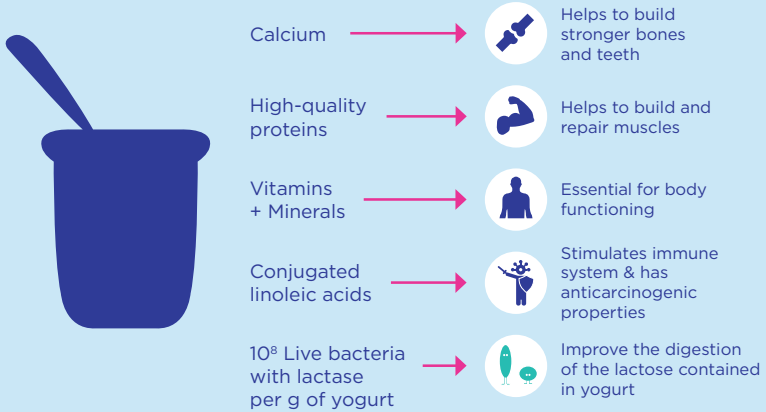


Figure 10. Nutritional advantages of yogurt.



5 CONCLUSION

Lactose intolerance is not a life-threatening condition but it can impair the quality of life. A **total avoidance of dairy products** is not only unnecessary for lactose intolerants, it also **represents a risk of an unbalanced diet** and the occurrence of nutrient deficiency such as insufficient calcium intake, which **could lead to adverse health effects**.

In order to prevent any nutrient deficiency, persons who experience lactose intolerance, can still **enjoy dairy and maintain a healthy and balanced diet** by adapting their eating habits:

- 1. Consume yogurts that contain live bacteria, which improve the digestion of the lactose contained in yogurt.**
- 2. Consume cheeses** that contain low or no lactose.
- 3. Consume lactose-containing foods in modest amounts throughout the day, during meals, not more than the equivalent of 2 bowls of milk.**

Thus, yogurt is a **convenient food for all**, and it represents a **good alternative to keep a balanced diet**, particularly for lactose intolerants.

6

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