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

Prof Naïma AMRANI, MD. Ph.D.
Secretary General of the World Gastroenterology Organisation and professor at the Faculty of Medicine and Pharmacy, Mohammed V University, Rabat-Morocco

Prof Lorenzo MORELLI, Ph.D.
Direttore Istituto di Microbiologia e Centro Ricerche Biotecnologiche, Università Cattolica del Sacro Cuore, Cremona, Italy

Dr Widjaja LUKITO, MD. Ph.D.
Human Nutrition Research Cluster, Indonesian Medical Education and Research Institute (IMERI), Faculty of Medicine, Universitas Indonesia
Lactose is the principal sugar (or carbohydrate) naturally found, in various amount, in milk and dairy.

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

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.
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.
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. 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. 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.

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.
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. 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. 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.
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.

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.

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.

---

**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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{27}
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

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 Authority (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 Live bacteria

Lactose → Glucose, Galactose

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 pH ≈ 4) is inactive.

When live bacteria arrive in the small intestine (37°C and pH ≈ 7), lactase becomes active.

Figure 7. Lactase functioning through digestion.
14 studies showed enhanced digestion of lactose in yogurt in lactose maldigesters, when live yogurt starter cultures were ingested in yogurt.

222 Lactose maldigesters.

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
In order to bear the claim, the yogurt should contain at least $10^8$ live microorganisms per gram of yogurt.

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

*When the BHC decreases, the digestion of the lactose is improved*
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.\textsuperscript{38}

**Six reasons to eat yogurt:**

1. Yogurt has a similar micronutrient composition to milk, generally with a good bioavailability and affordability.\textsuperscript{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.\textsuperscript{40-42}

4. Yogurt contains B (B1, B2, B3, B6, B9 and B12), A and E vitamins.\textsuperscript{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.\textsuperscript{43, 44}

6. Yogurt has a higher concentration of conjugated linoleic acids than milk.\textsuperscript{13} Conjugated linoleic acids are reported to have immunostimulatory and anticarcinogenic properties.\textsuperscript{45}

![Figure 9. Energy density of food. Adapted from British Nutrition Foundation Feed Yourself Fuller Chart 2009.](image)

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...) than non-consumers.  

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.

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.

4. Yogurt consumption is also associated with lower risk of type 2 diabetes.

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.

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

- **Calcium**: Helps to build stronger bones and teeth
- **High-quality proteins**: Helps to build and repair muscles
- **Vitamins + Minerals**: Essential for body functioning
- **Conjugated linoleic acids**: Stimulates immune system & has anticarcinogenic properties
- **10^8 Live bacteria with lactase per g of yogurt**: Improve the digestion of the lactose contained in yogurt

Figure 10. Nutritional advantages of yogurt.
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.
31. EfSA Panel on Dietetic Products N, Allergies. Scientific Opinion on the substantiation of health claims related to calcium and maintenance of normal bone and teeth (ID 2731, 3155, 4311, 4312, 4703), maintenance of normal hair and nails (ID 399, 3155), maintenance of normal blood LDL-cholesterol concentrations (ID 349, 1893), maintenance of normal blood HDL-cholesterol concentrations (ID 349, 1893), reduction in the severity of symptoms related to the premenstrual syndrome (ID 348, 1892), “cell membrane permeability” (ID 363), reduction of tiredness and fatigue (ID 232), contribution to normal psychological functions (ID 233), contribution to the maintenance or achievement of a normal body weight (ID 228, 229) and regulation of normal cell division and differentiation (ID 237) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal 2010;8:n/a-n/a.
32. EfSA Panel on Dietetic Products N, Allergies. Scientific Opinion on lactose thresholds in lactose intolerance and galactosaemia. EFSA Journal 2010;8:n/a-n/a.
34. EfSA Panel on Dietetic Products N, Allergies. Scientific Opinion on lactose thresholds in lactose intolerance and galactosaemia. EFSA Journal 2010;8:n/a-n/a.