Explore enzymes and the science of lactose intolerance using lactase tablets

Worksheet 2

Investigating lactase activity on different sugars, whole milk, and oat milk

Introduction: Lactose intolerance is a common phenomenon in many populations around the world. In lactose-intolerant individuals, the digestive enzyme β-galactosidase (= lactase) is absent or present in insufficient quantities in the small intestine. Lactase typically breaks down the disaccharide lactose into the monosaccharides glucose (Glc) and galactose (Gal) (figure 1, top). However, if lactose-containing foods have been consumed in the absence of lactase, the chyme is transported to the large intestine with undigested lactose. Due to the water-binding property of lactose, the digested food pulp cannot be thickened properly, which may result in diarrhoea. In addition, bacteria populating the large intestine can break down lactose differently, thus producing various gases through fermentation, which can lead to flatulence.

In reaction to their lactose intolerance, affected individuals might resort to avoiding foods containing lactose. In response, a growing market for lactose-free foods, such as plant-based milk alternatives (rice milk, oat milk, etc.), has emerged. Alternatively, affected individuals may choose to ingest lactase in tablet form to help them digest lactose-containing foods (e.g., cow's milk or dairy products). In milk alternatives such as oat milk, the sugar maltose (figure 1, bottom) can be found. Maltose consists of two chemically linked glucose units; the minor structural differences between lactose and maltose are the spatial position of a single hydroxy group and the type of glycosidic bond between monosaccharide units (figure 1, red highlights).

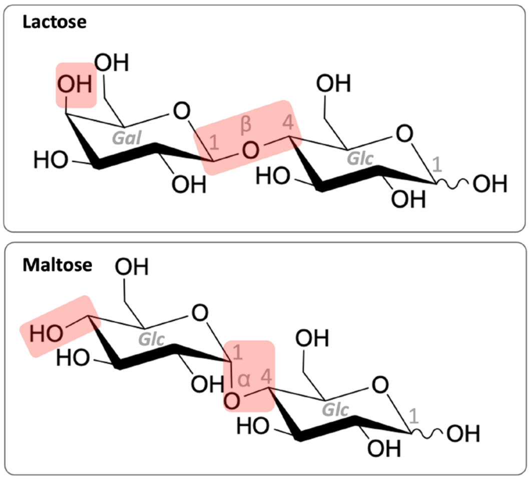

Figure 1: Molecular structures of the disaccharides lactose (top) and maltose (bottom), shown here as chair conformations. Respective monosaccharide units (galactose, Gal; glucose, Glc), carbon-atom numbers, and types of glycosidic bond are indicated in grey; structural differences are highlighted in red; wavy bonds indicate reductive or ring-opening capabilities.
Image courtesy of the author

Tasks:

1) Perform the experiment 'Investigating lactase activity on different sugars, whole milk, and oat milk'.
2) Record your observation by completing Table 1, column 2.
3) Complete Table 1, column 3. (Tip: remember what colours the Fearon test gives with monosaccharides and disaccharides.)
4) Summarize your results in a short text by answering the following questions:
    a) Why is there a colour change for lactose and whole milk but not for maltose and oat milk?
    b) What does this result tell you about the substrate specificity of an enzyme?
    c) Make a guess as to which sugar might be in oat milk.

Table 1: results

Sugar/milk	**Colour detected by using Fearon's reagent and lactase**	**Are monosaccharides or 1,4-linked disaccharides contained in the sample?**
Lactose		
Maltose		
Whole milk		
Oat milk		