DAIRY INNOVATION HUB

UNIVERSITY OF WISCONSIN RIVER FALLS

WISCONSIN UNIVERSITY OF WISCONSIN–MADISON

FDC FROZEN DESSERT CENTER

Lactose-free ice cream

10/21/2025

Dr. Grace Lewis | Animal and Food Science Department

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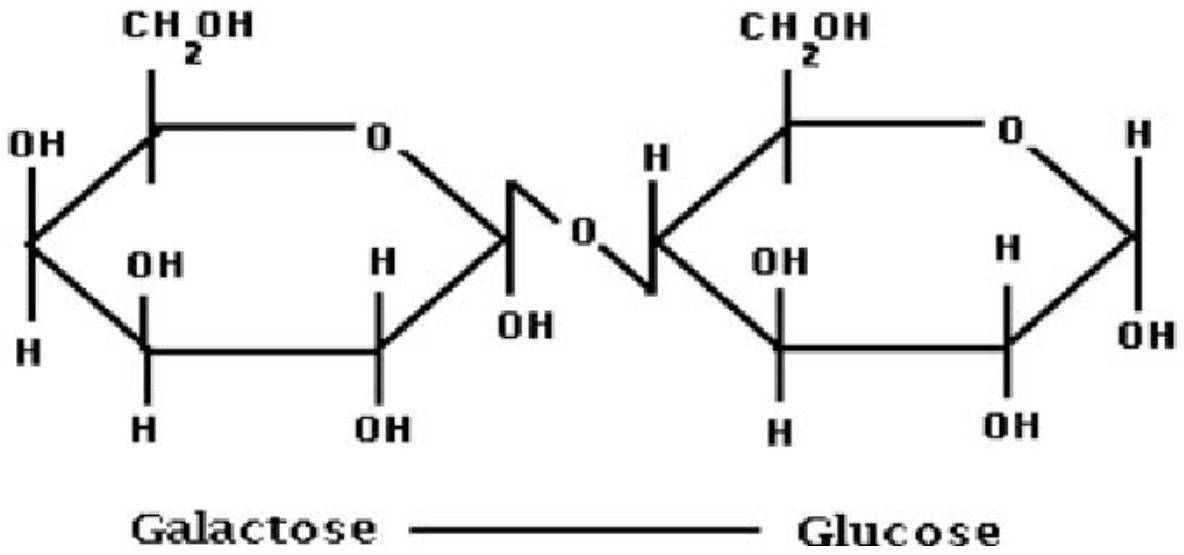
Lactose overview

- Major **carbohydrate** in milk
- Disaccharide of **glucose** and **galactose**

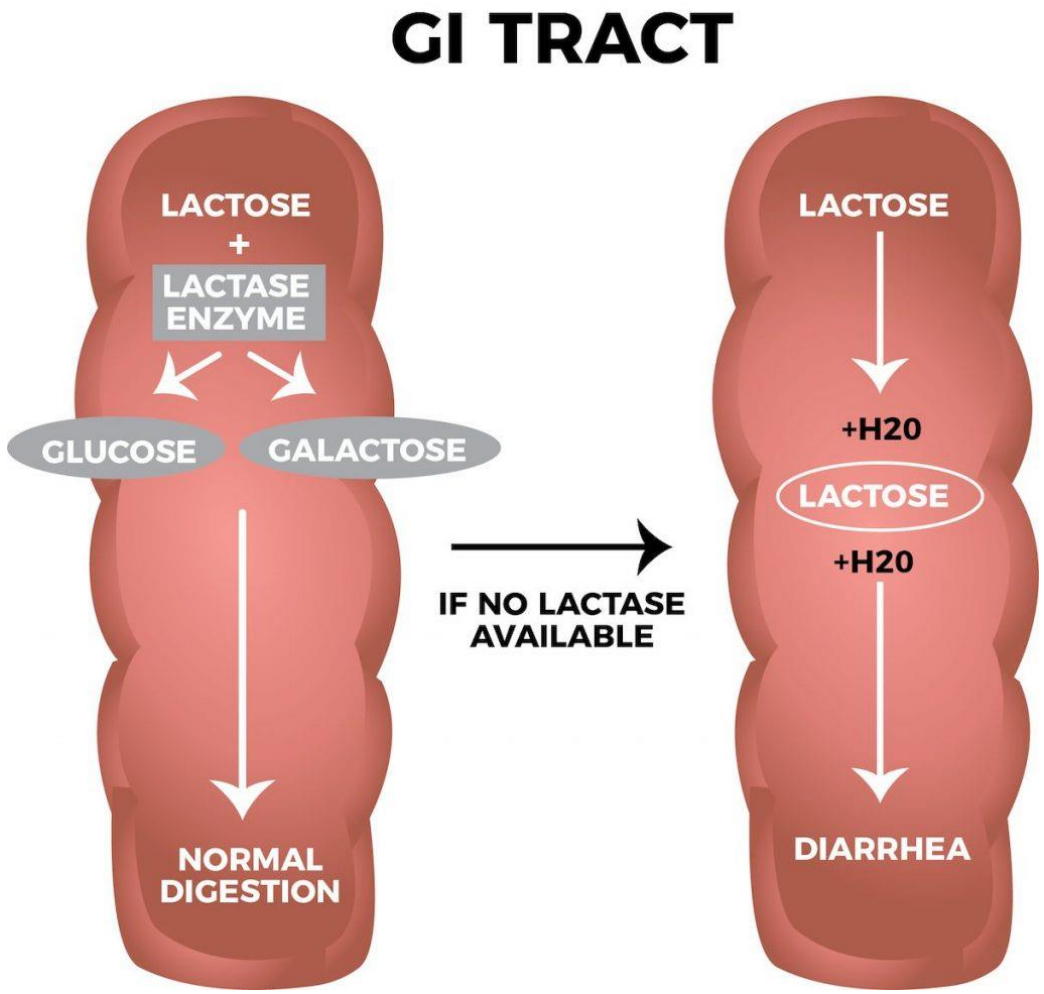
Component	Approximate Percentage
Water	86.6
Lactose (milk sugar)	4.9
Fat	4.6
Protein	3.4
Vitamins and Minerals	0.5



Roos (2018)

Lactose intolerance

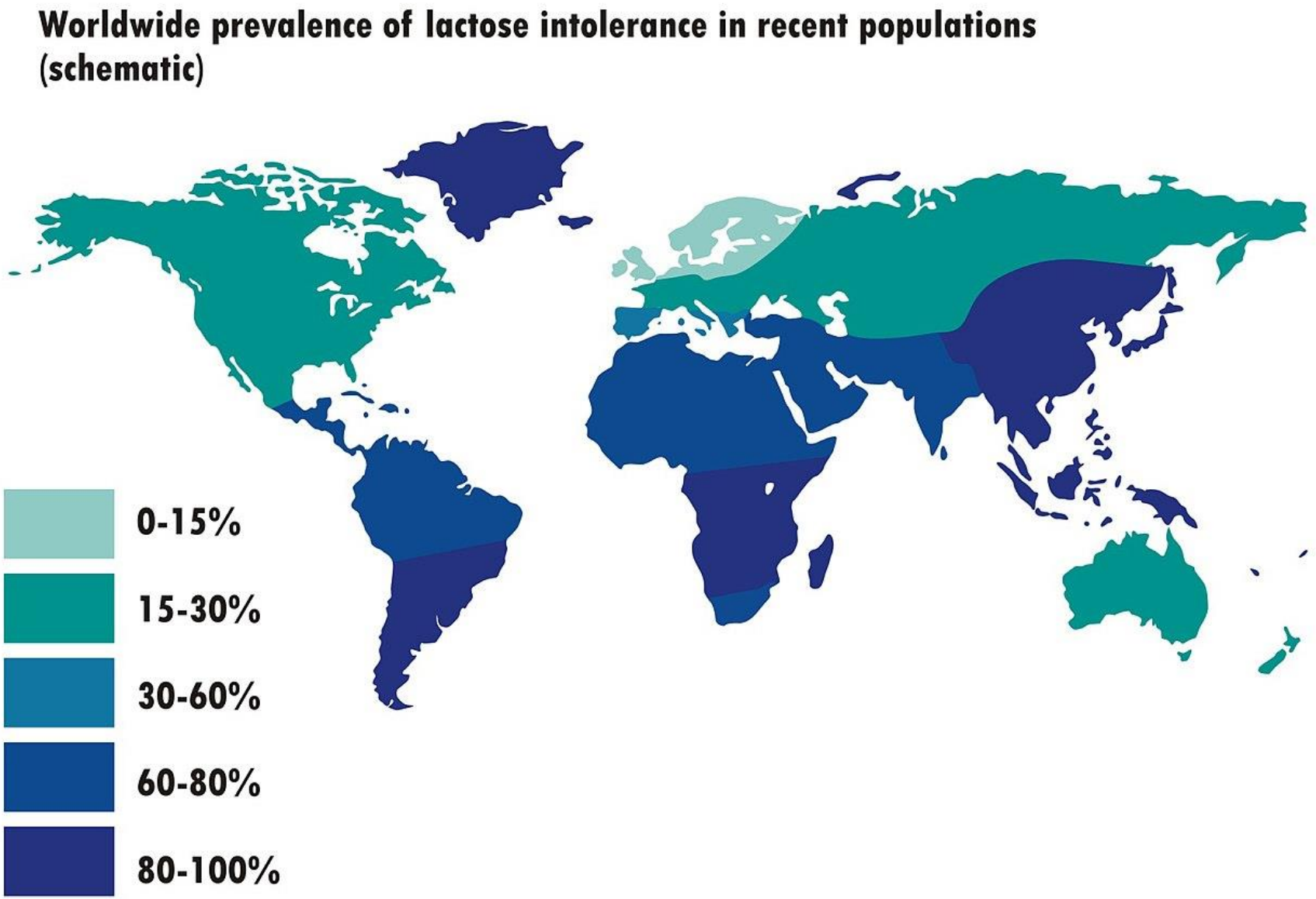
- Some people lack β-D-galactosidase (**lactase**) enzyme in their gastrointestinal tract
  - Lactose is not hydrolyzed
  - Gut microbiota form gases
  - Causes bloating, etc.



What percent of the **world** is **lactose intolerant**?

~65%

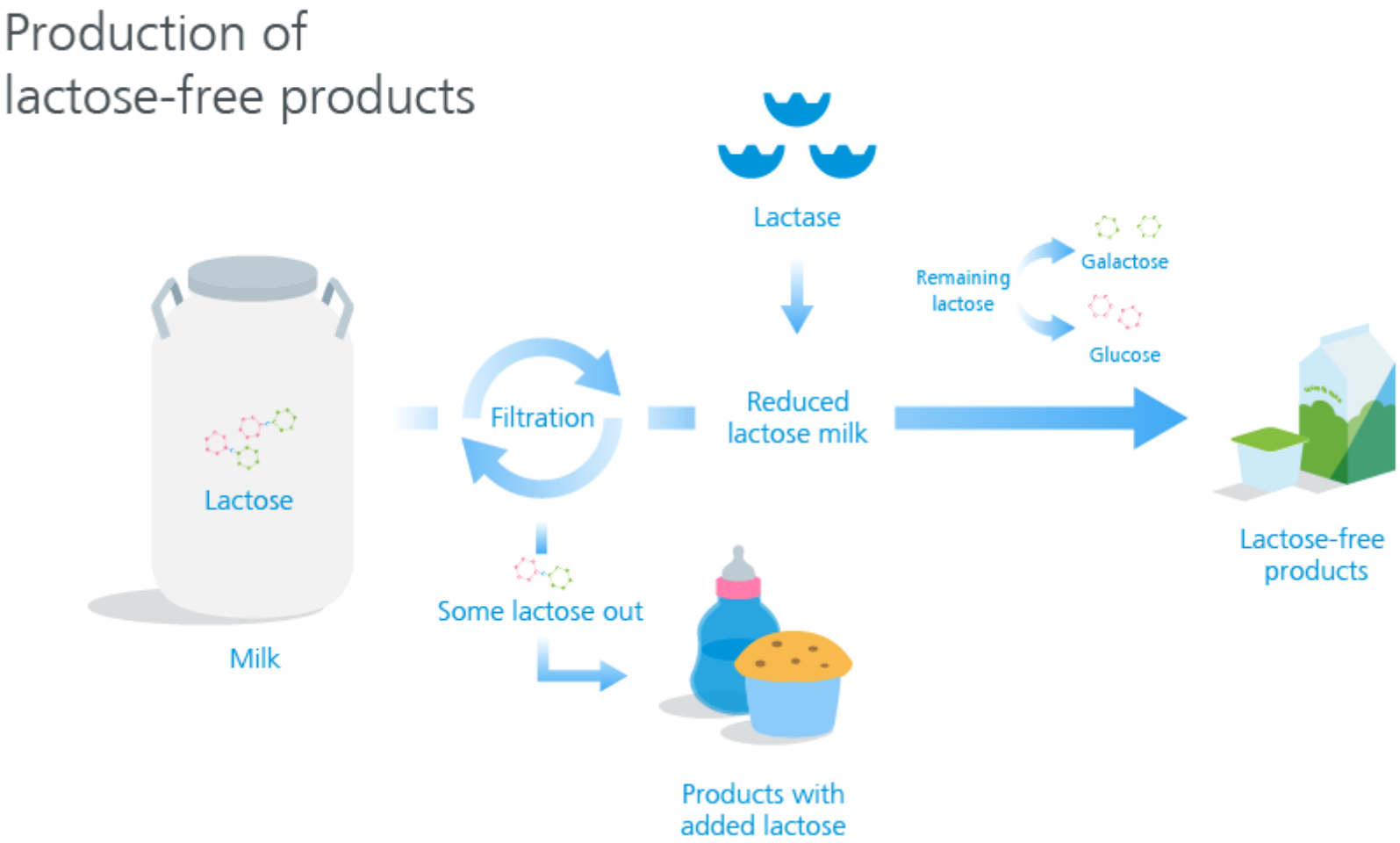
Lactose Intolerance



Lactose intolerance – cont.

- Some dairy foods are **naturally low in lactose** (ex. **aged cheeses**, **butter**)
- **Specialized products** modified to contain low levels of lactose
  - **Filtration** or **enzymes** used

Lactose intolerance – cont.



Consumer comment #1

★★★★★ **Verified Purchase** ⓘ

perfect for my little one and i who cant have dairy!

Helpful? (0) (0) | Report

Regulations related to “lactose-free”

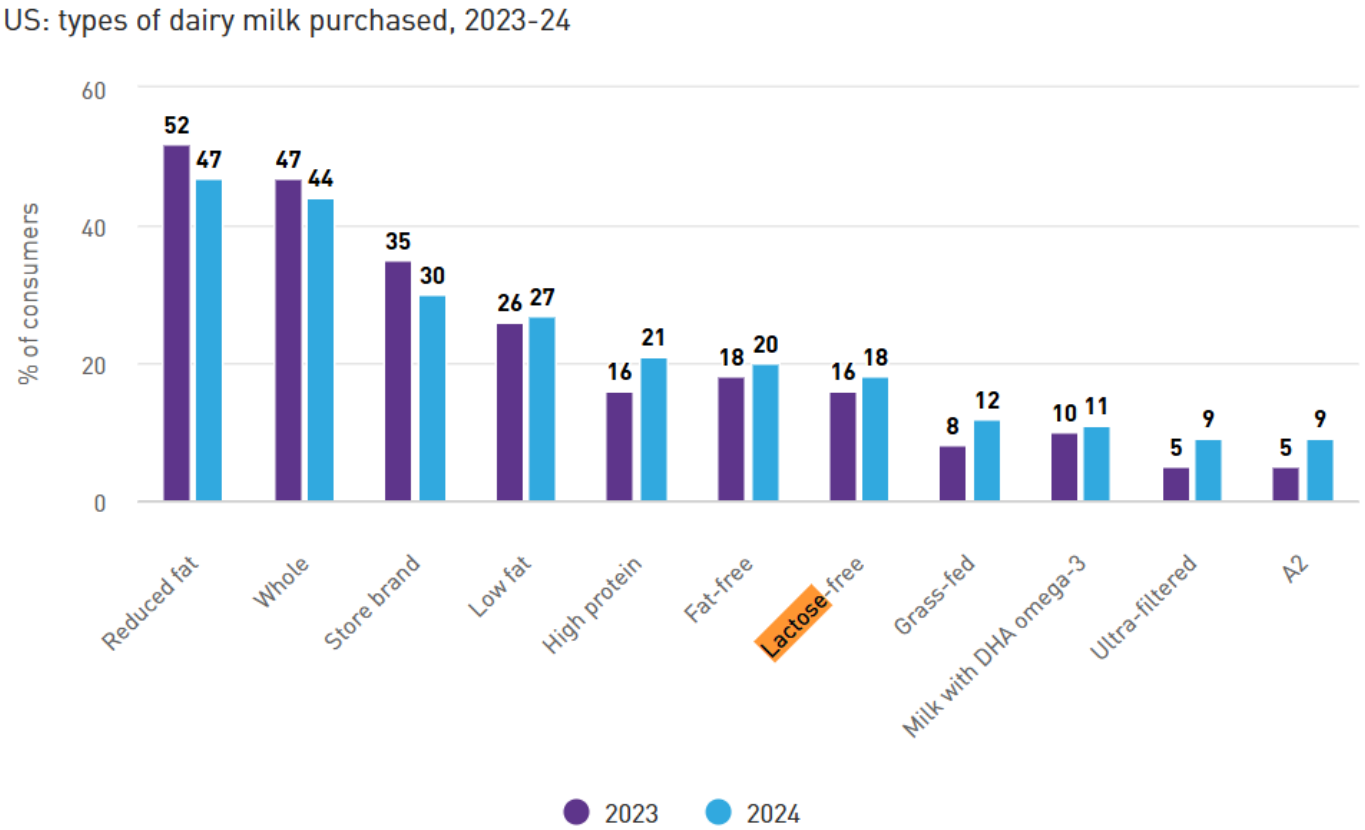
In the United States, there are **no FDA-mandated definitions or regulations** specifically for "lactose-free" products

*However, the FDA requires that all food labels be **truthful***

Country	“Lactose-free” Threshold
European countries	< 1000 mg/L (0.1% w/v)
China	< 5000 mg/L (0.5% w/v)
India	< 100 mg/L (0.01% w/v)
Italy	0.1% (w/w)

Li 2023

Lactose-free market: Overview

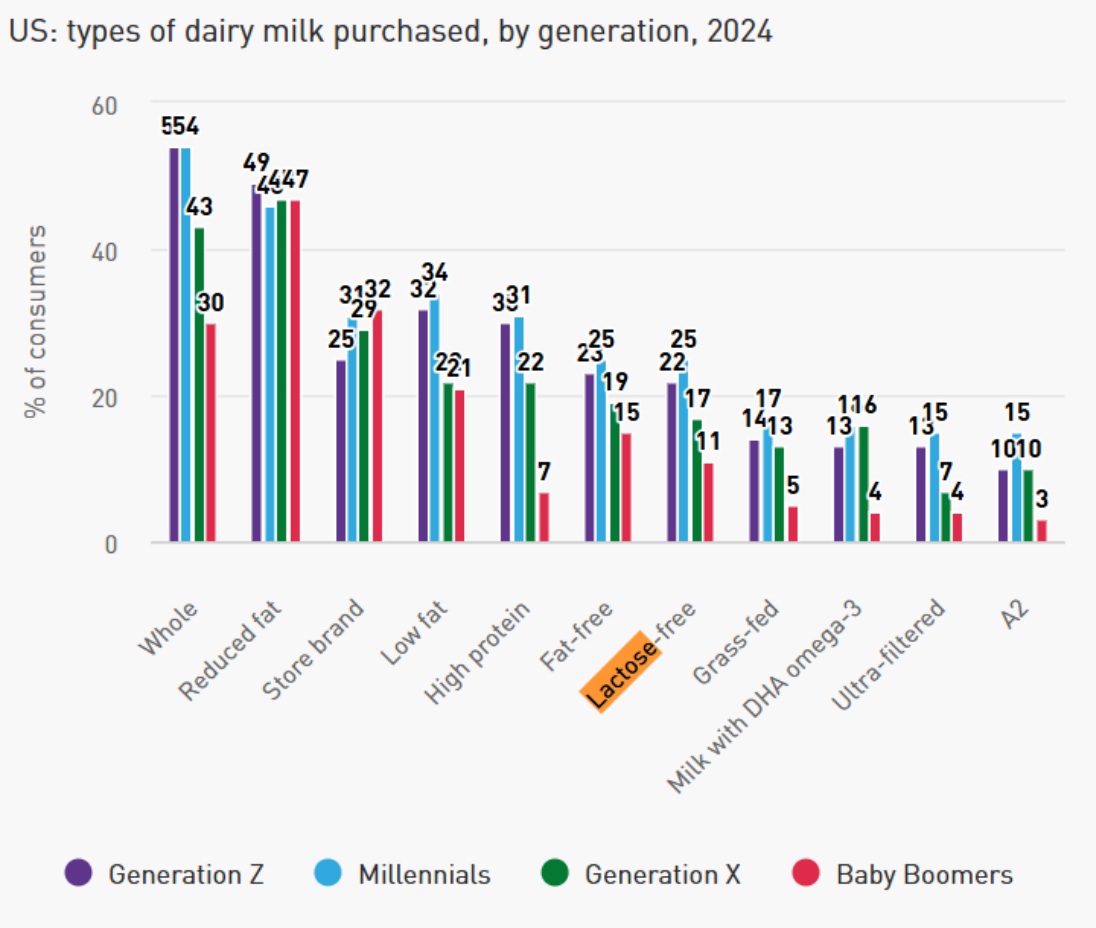


Base: *1,354 internet users aged 18+ who purchase dairy milk*
Source: *Kantar Profiles/Mintel, May 2023, July 2024*

$12-14 billion in 2024 and is projected to reach about **$19 billion by 2029**, growing at a CAGR of 8.4%

Lactose-free market: Consumers

"Milk launches with **lactose-free** formulations increased by 56% from 2022 to 2023." – Mintel, July 2024



Base: 1,354 internet users aged 18+ who purchase dairy milk
Source: Kantar Profiles/Mintel, July 2024

Lactose-free market potential

“Lactose-free dairy products only represent **4.6% of total dairy sales**, dairy processors can capitalize on the positive growth trajectory of lactose free.”

https://www.dairyfoods.com/articles/98524-there-is-nothing-but-upside-for-lactose-free-dairy

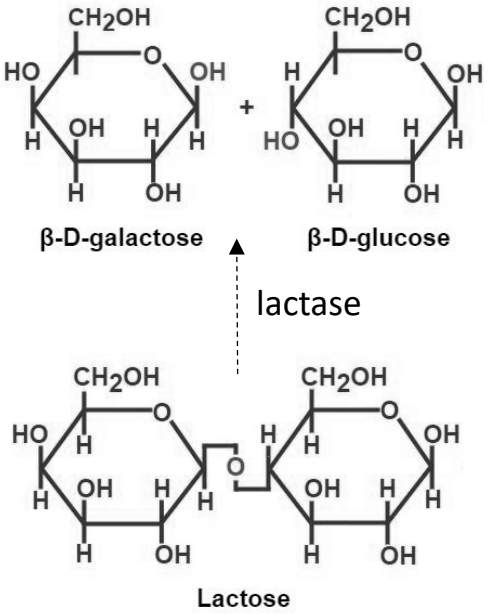
A lot of potential for lactose-free products, but can we also **add value to lactose**?

Try lactose-free sample. What do you notice?

Relative sweetness

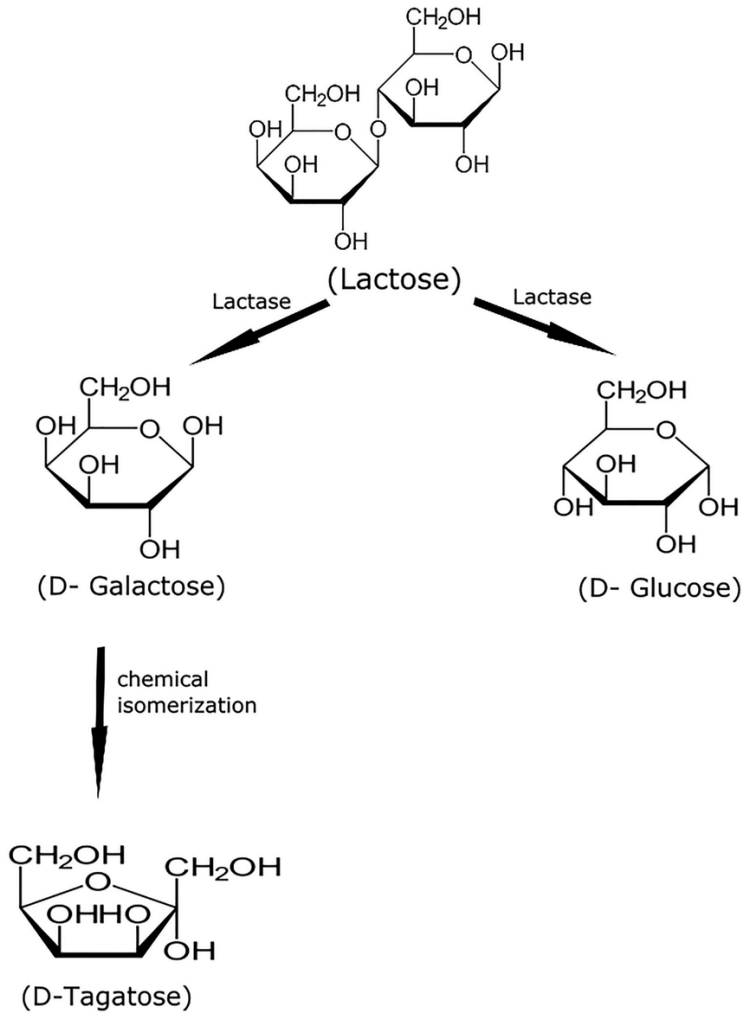
Baseline →

Sweetener	Relative sweetness
Fructose	1.20-1.80
Sucrose	1.00
Glucose	0.60
Maltose	0.50
Galactose	0.32
Lactose	0.15-0.30



Opportunity: Reduced added sugar content

Other sweeteners from lactose



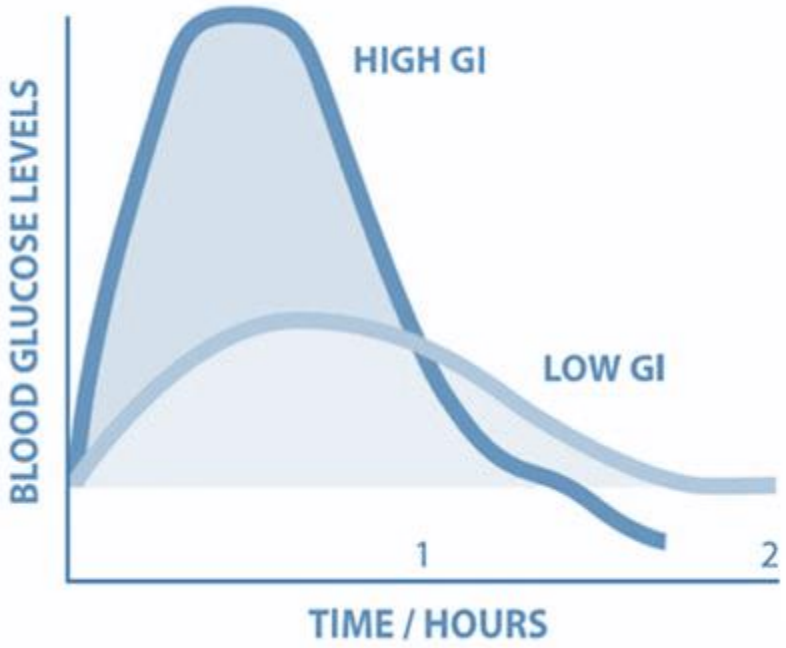
Opportunity: Novel sweeteners

Tagatose – cont.

"The manufacturing technology developed by **Galasys**, which has been patented through WARF, involves converting a dairy food processing byproduct into **tagatose**, a natural, low-calorie sweetener."

Glycemic Index

Sugar	Glycemic Index (GI)	GI Ranking
Tagatose	3	Low
Galactose	20	Low
Lactose	46	Medium
Sucrose	65	Medium
Glucose	100	Baseline



Other opportunities for lactose

- **Infant formula** – galacto-oligosaccharide production
- **Pharmaceuticals** – tablet making
- **Animal feed**
- **Fermentations**
  - Alcoholic beverages
  - Value-added chemicals – lactic acid, bioethanol, hydrogels, bioplastics

"It's time to rethink whey permeate" – John Lucey

Consumer comment #2

★★★★★ **Verified Purchase** ⓘ

Best non-dairy vanilla ice cream!

Best non-dairy vanilla ice cream! Taste great, holds up well, good size!

Helpful? (0) (0) | Report

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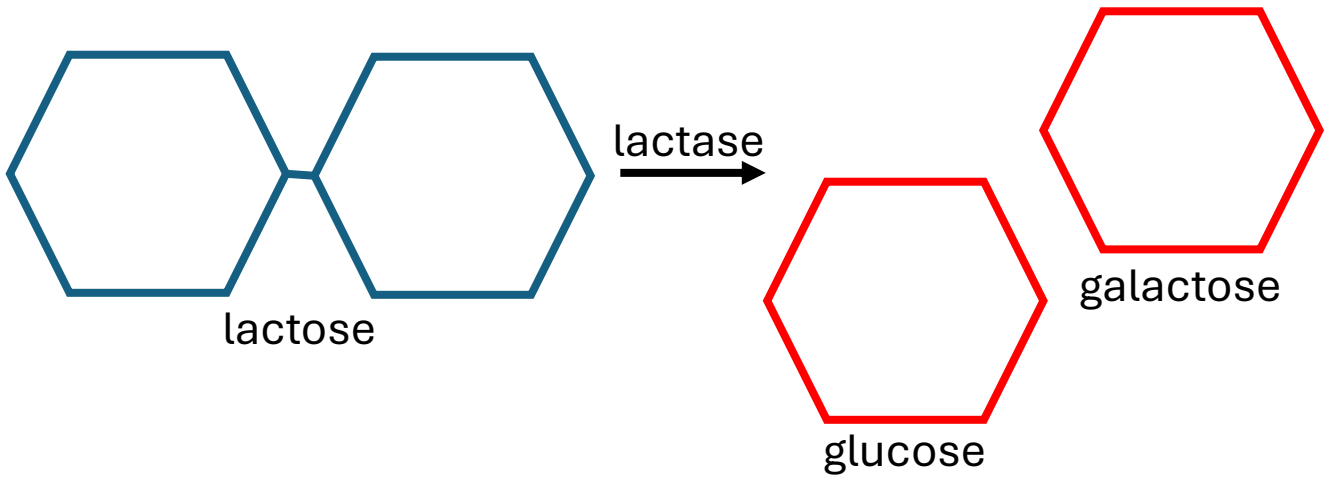
Function of lactose in ice cream

- Freezing point depression
- (Cheap) Solids
- Some sweetness

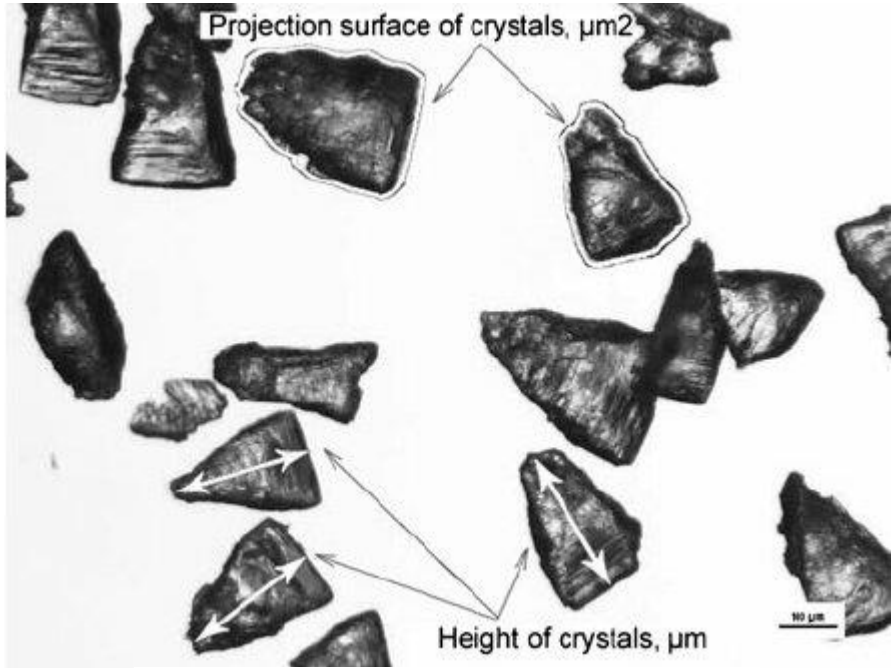
Sweetener	Relative Effect on Freezing Point Depression
Sucrose	1.0
Lactose	1.0
Monosaccharides	1.82
55% HFCS	1.85
Sorbitol	1.90
Glycerol	3.70
Alcohol	7.40

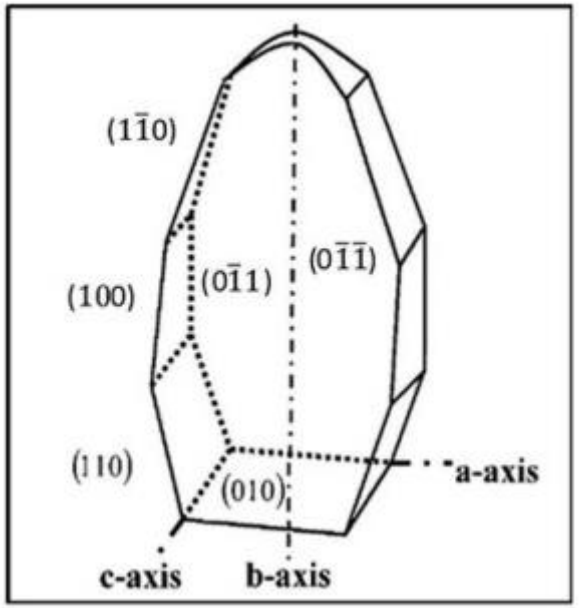


Sandiness in ice cream

- Lactose has a relatively **low solubility**
- **Sandy defect** = lactose crystals in ice cream

Sugar	Solubility (g/L)
Lactose	195 (25°C)
Glucose	909 (25°C)
Galactose	650 (20°C)





Pisponen 2013; Wijayasinghe 2020

LF Ice cream manufacture

Dairy ingredients
Sucrose
Other ingredients

*could use lactose-free ingredients here

Standardize → Blending → Homogenize → Pasteurize → + lactase → Aging → Dynamic Freezer → Packaging → Hardening → Storage and Distribution

Incubation (Time/Temperature?) → + lactase

Dynamic Freezer → [lactose] verification?

Properties:
Sweetness
Hardness
Melting rate
Etc.

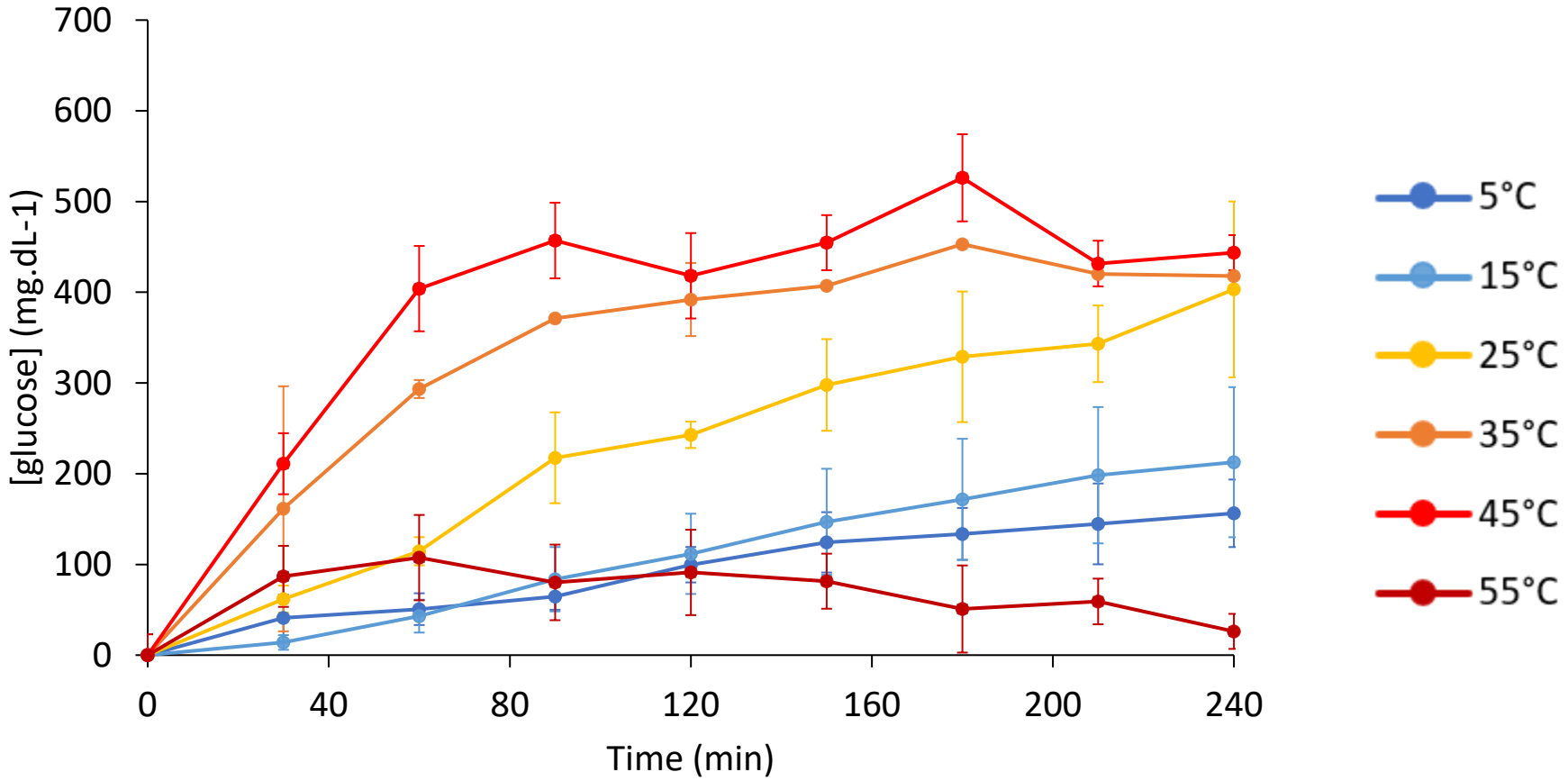
Lactose-free ice cream

Ice cream production + enzyme + time + storage and hydrolyzation tanks for batches + verification = more expensive product

Opportunities

Reduced added sugar, less sandiness in high-solids formulations… but will consumers pay more?

Rapid method – Blood Glucose Meter



Consumer comment #3

a

artistgurl211

5 ★★★★★ 10 months ago

Milk Allergy Approved

So, let me start out by saying that I have a milk allergy. It's not an intolerance, it's an actual allergy that's been confirmed through lab tests. I have been able to eat this without any issues whatsoever, and I am not restricting myself in any way in terms of portion sizes (sorry, I love myself too much). It tastes great!

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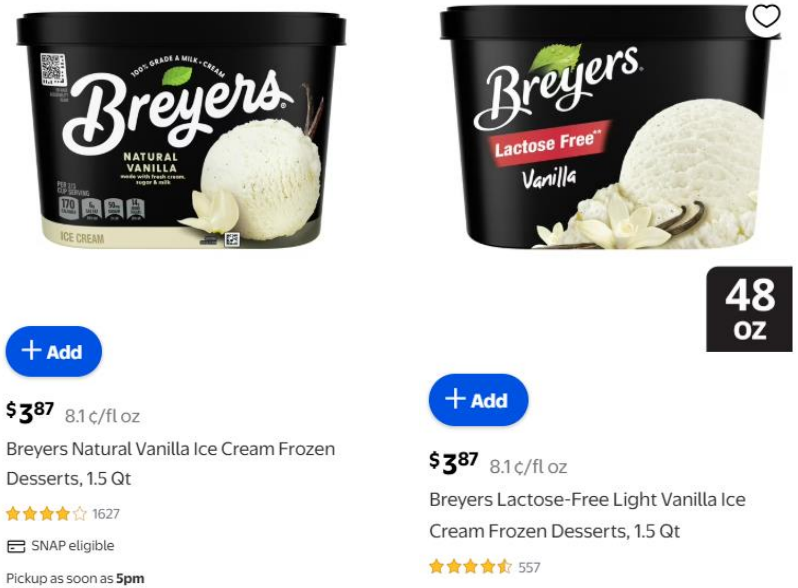
Price of lactose-free products

- Typically sold for same price as regular products *unless* a specialty brand

.... But **additional** production **costs** exist



Objectives

Objective 1. To evaluate the **kinetics of lactase** in ice cream mix at varying temperatures as a means of establishing suitable conditions for lactose hydrolysis.

Objective 2. To produce **lactose-free ice cream** at Babcock Dairy and the UWRF Wuethrich Family/Grassland Dairy Center of Excellence and evaluate the freezing characteristics, textural properties, and melting behavior of this lactose-free product compared to a lactose-containing control.

Objective 3. To evaluate the **economic feasibility** of producing lactose-free ice cream at plant scale, assess consumer willingness to pay and project potential market-wide impacts from scaled-up production.

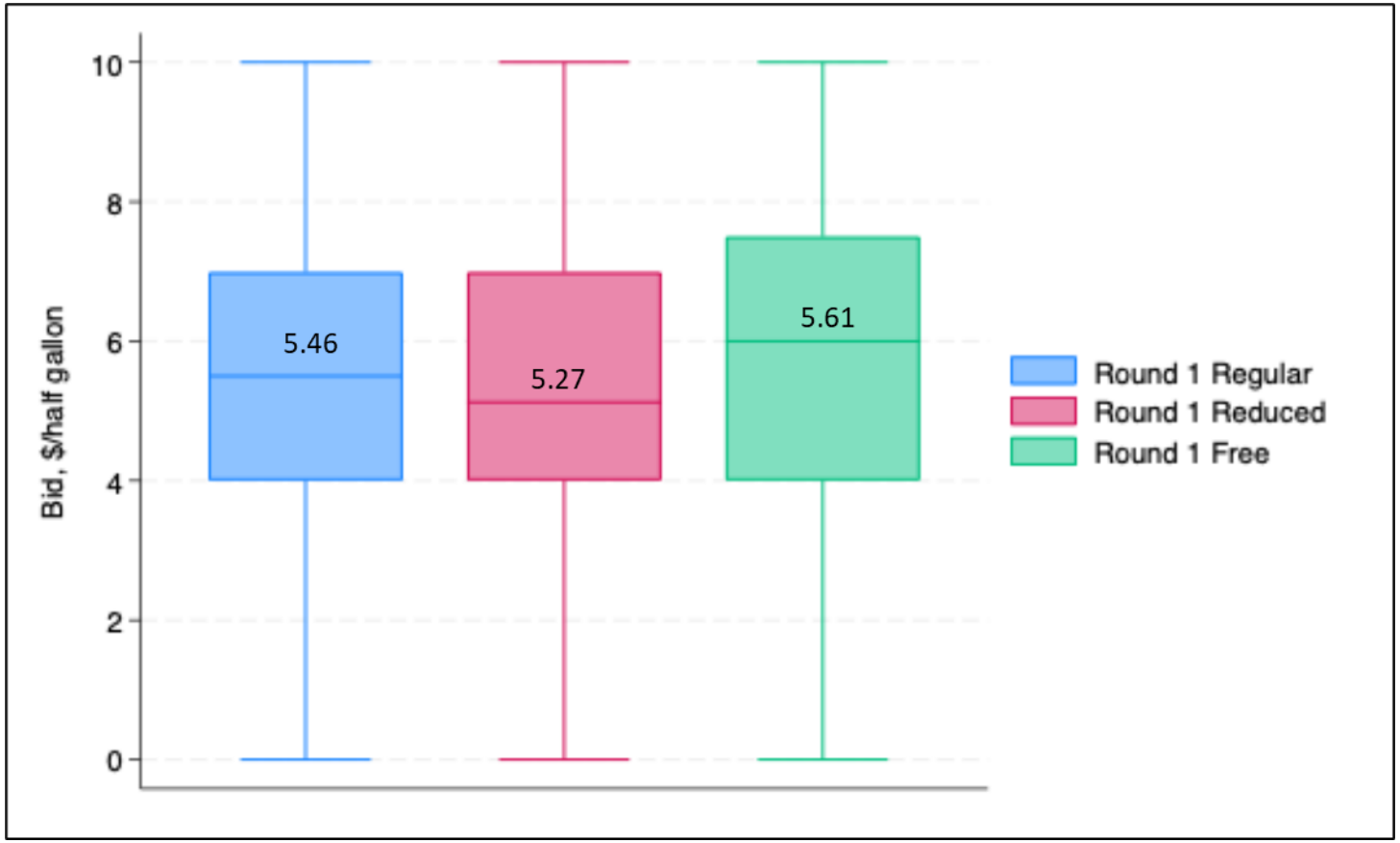
Lactose-free economics – experimental design

- Experimental **auction** in a laboratory setting
- Guided to respond in person to Qualtrics survey questions
- Elicited "**Willingness to Pay**" (WTP) for three ice cream products
  - Regular, Reduced-Lactose, Lactose-Free
- Relevant demographics, **lactose tolerance status**, and shopping behavior information collected at the end

WTP for ice cream products

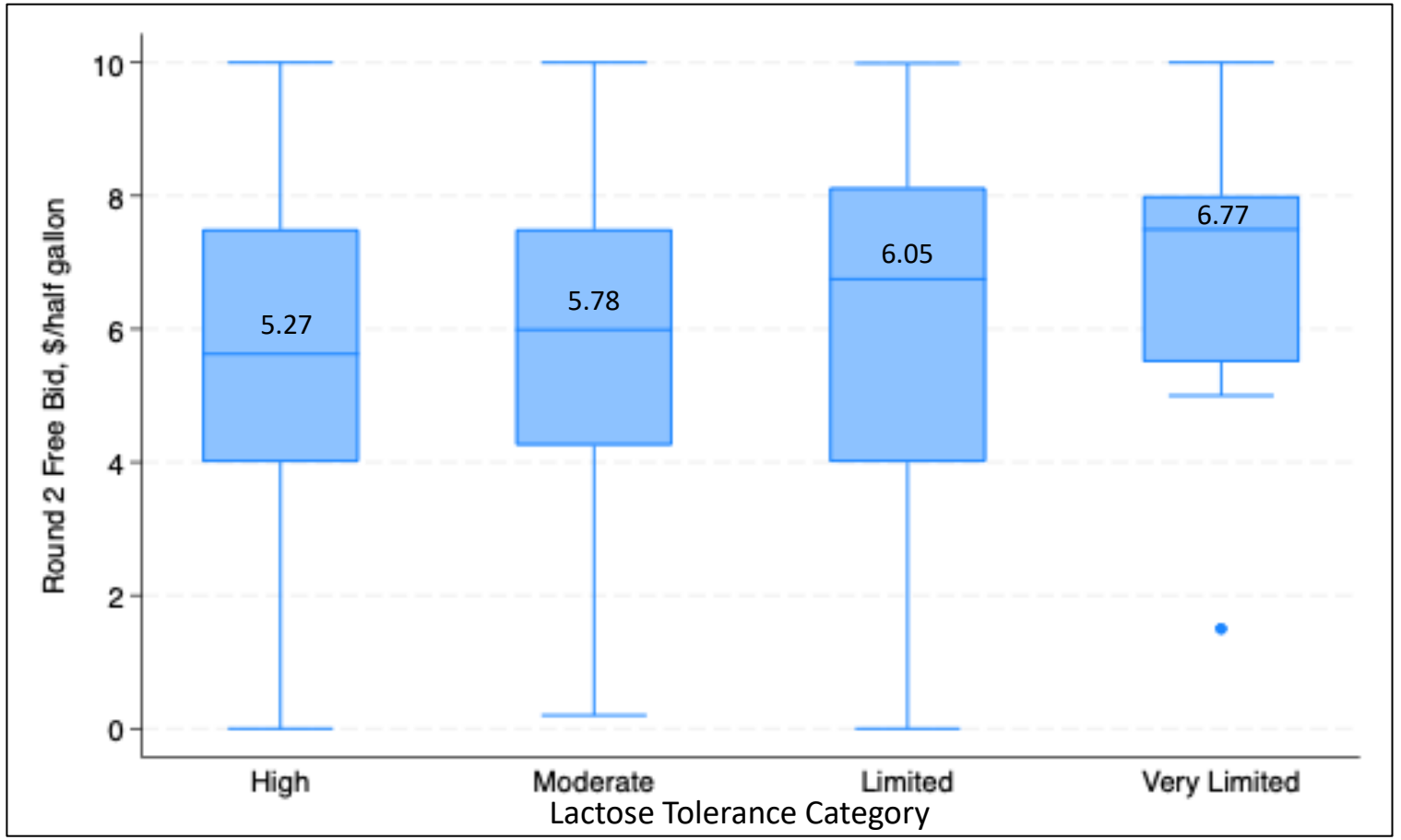
Bid values from $0 to $10/half gallon

Higher mean bid value for Lactose-Free, but lower for Reduced lactose



Bid values for **lactose-free ice cream** by lactose tolerance status

Bids for Lactose-Free <u>increased</u> with increasing lactose intolerance



Empirical model

Panel structure of our data and censored auction bids dictate a use of **random effects tobit model:**

$$WTP_{ij}^{*} = \beta_0 + \beta attribute_j + \gamma info_j + \theta X_i + \nu_i + \varepsilon_{ij}$$

$$WTP_{ij} = WTP_{ij}^{*} \; if \; 0 \leq WTP_{ij}^{*} \leq 10$$

$$WTP_{ij} = 0 \; if \; WTP_{ij}^{*} < 0$$

$$WTP_{ij} = 10 \; if \; WTP_{ij}^{*} > 10$$

Data allows to estimate model by attribute and by product

Empirical model

Panel structure of our data and censored auction bids dictate a use of **random effects tobit model:**

$$WTP_{ij}^{*} = \beta_0 + \beta attribute_j + \gamma info_j + \theta X_i + \nu_i + \varepsilon_{ij}$$

Constant = Mean bid value

Coefficient value = Change in WTP above mean value

Empirical Results

For participants reporting <u>no lactose intolerance</u>:

- Impact of products labeled lactose-reduced and lactose-free on bid values was **negative**
  - They want the lactose

Variable	Coefficient Value	P-value
Lactose-reduced Product	**-0.59**	**0.00**
Lactose-free Product	**-0.61**	**0.00**
Constant	5.46	0.00

Empirical Results

For participants with <u>any degree of lactose intolerance</u>:

- Lactose-reduced and lactose-free products increased bid values by **$0.68** and **$1.27** per half gallon , respectively
  - 12% to 23% increase over the mean bid value of $5.46

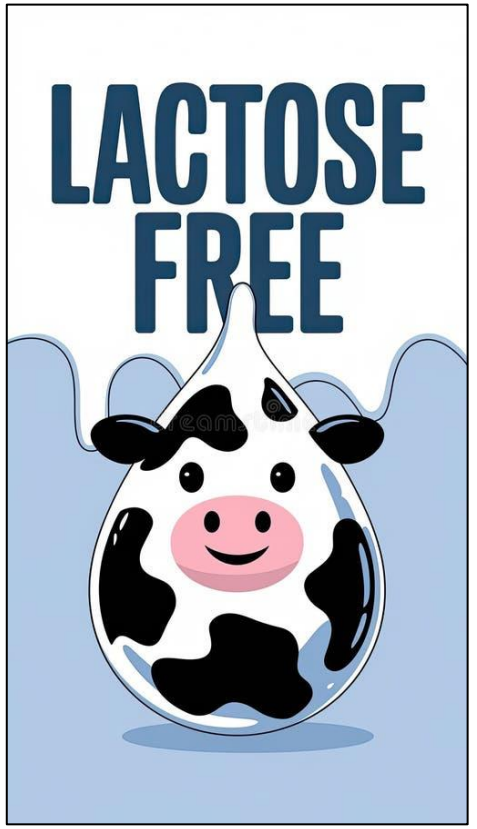
Variable	Coefficient Value	P-value
Lactose-reduced Product x Any Degree of Lactose Intolerance	**0.68**	**0.00**
Lactose Free Product x Any Degree of Lactose Intolerance	**1.27**	**0.00**
Constant	5.46	0.00

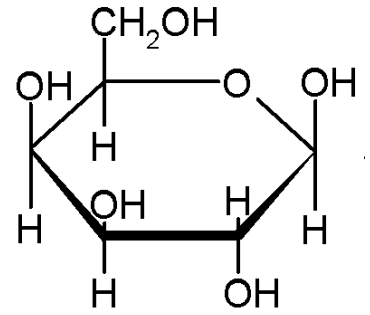
Summarizing Comments and Next Steps

- Lactose intolerant consumers are willing to pay more for lactose-free products
- Every dairy product is different
- Need for easily **accessible literature** regarding the production of lactose-free dairy products
  - Formulation and manufacturing considerations
  - Enzyme kinetics
  - Pricing
  - New avenues

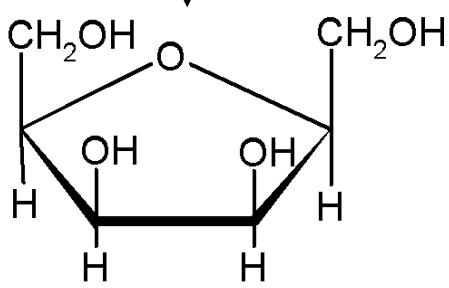
Next Steps:

- Additional statistical analysis of auction data
- Assess the costs of introducing lactose-free products in a smaller-scale ice cream operation
  - Ingredients and testing costs
  - Operational costs





Galactose



Tagatose

Education needed...

There is demand...

★★★★★ Verified Purchase

lact free ice cream

so great to have lactose free ice-cream!! NEED MORE OPTIONS!!! MORE FLAVORS!!

Helpful? (0) (0) | Report

★★★☆☆

Too much sugar

This great and all just wish that they make some (lactose free) with no sugar added or at least low sugar

Helpful? (0) (0) | Report

There is confusion...

★★★★★ Verified Purchase

Made with love

I only dislike that it was a little sweet for a dairy free .

Helpful? (0) (0) | Report

★★★★★ Verified Purchase

perfect for my little one and i who cant have dairy!

Helpful? (0) (0) | Report

★★★★★ Verified Purchase

Best non-dairy vanilla ice cream!

Best non-dairy vanilla ice cream! Taste great, holds up well, good size!

Helpful? (0) (0) | Report

There is... this

★★★★★ Verified Purchase

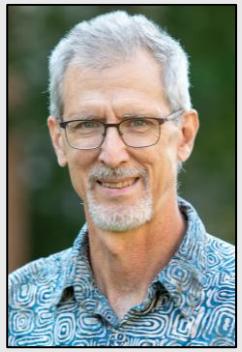
Yummy

My dogs are lactose intolerant and they love this ice cream. I also enjoy it!

Helpful? (0) (0) | Report

Acknowledgments

Dr. Scott Rankin



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Extension

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References

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Additional Slides

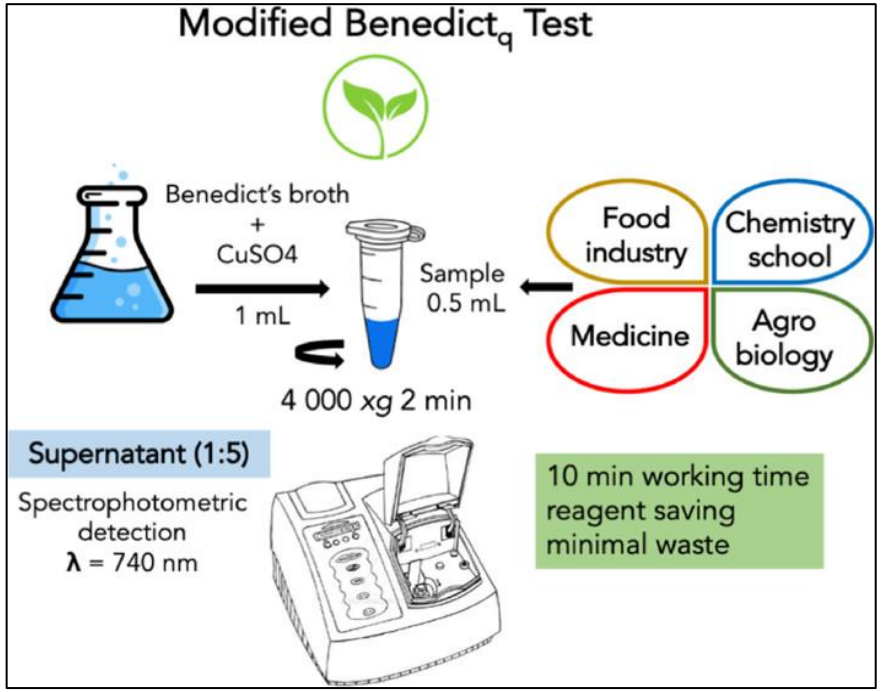
Other methods – not ideal for low [lactose]

- **Near- and mid-infrared spectroscopy**
  - **Advantages**: rapid, online monitoring, little sample preparation
  - **Disadvantages**: calibration, **does not work in low-lactose products** (without additional sample preparation)

Other methods

- Enzymatic
- Reducing sugar

typically require sample purification, calibration curve

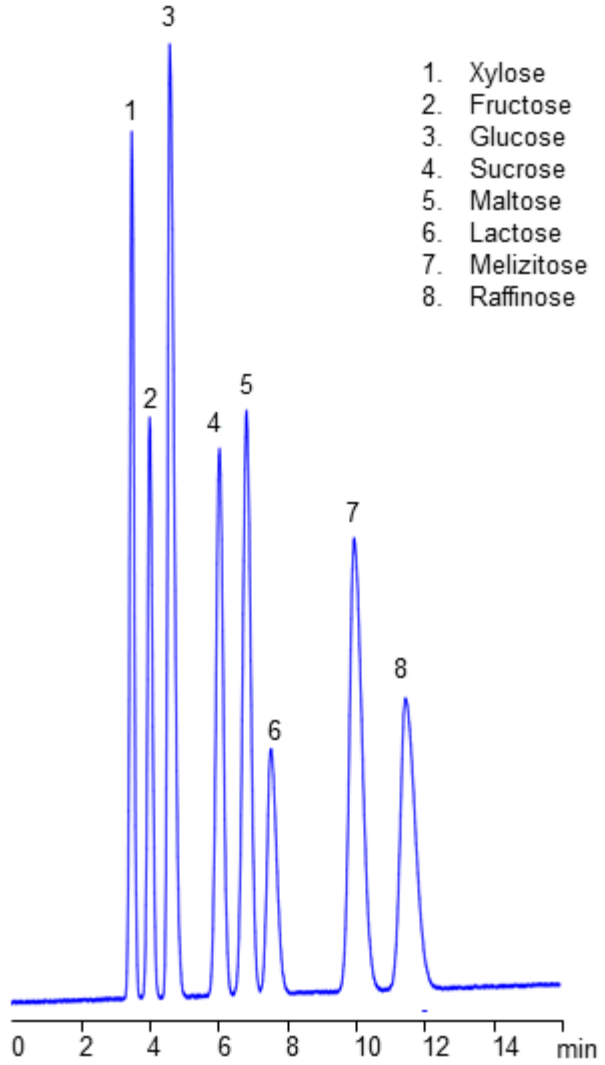


ACS Omega 2020, 5, 50, 32403-32410

Gold standard: High-Performance Liquid Chromatography (HPLC)

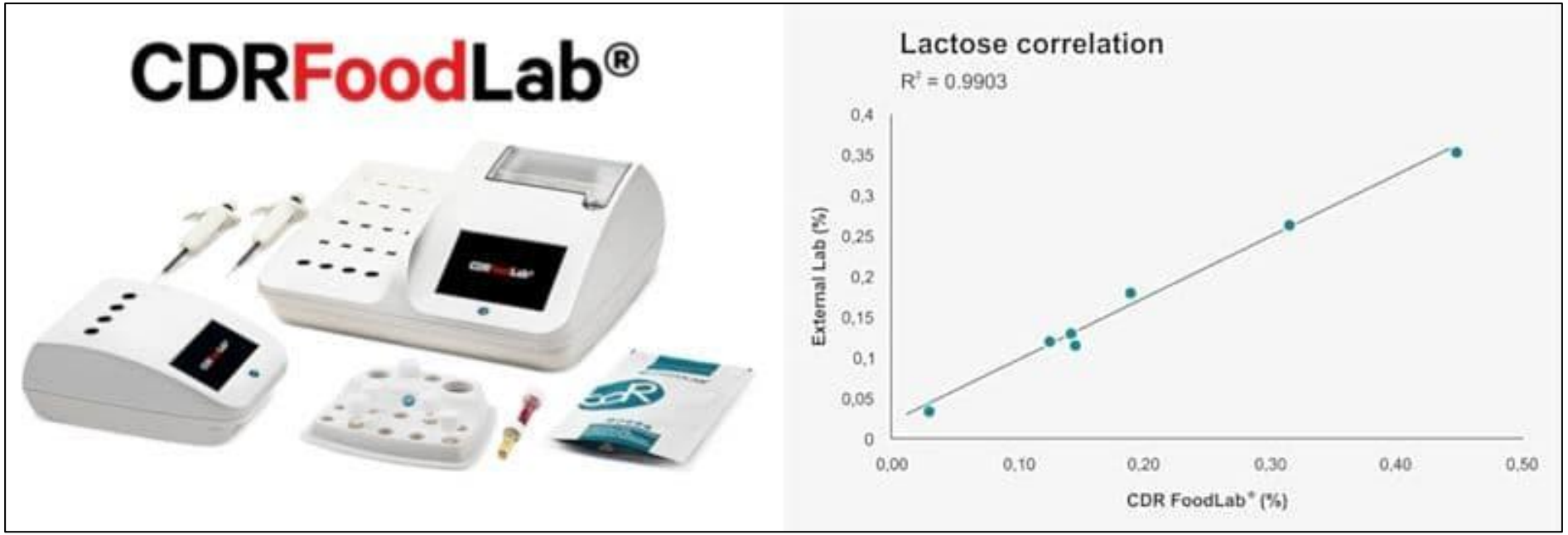
- **Advantages**: High precision and accuracy even in complex media (dairy), specificity for lactose

- **Disadvantages**: cost, expensive, skilled operation, not as rapid as some other methods



https://helixchrom.com/compounds/lactose/

“Rapid” method - CDRFoodLab



*Not an AOAC method