

Dairy Opportunities, Challenges and Innovation: the KEYS to the kingdom



MaryAnne Drake



NC STATE UNIVERSITY

01

MARKET TRENDS

02

WINDS OF CHANGE

03

CHALLENGES

04

OPPORTUNITIES

05

RESEARCH PLATFORMS



Dairy Beverage Trends

Conscious consumption



New processing technologies



High-protein products





Green consumerism continues to grow...

Sustainability includes more than just carbon footprint for consumers

Differences in how industry and consumers define sustainability, and lack of transparent information leaves consumers guessing on how to factor sustainability into their purchases

Schiano and Drake, JDS 2021





PLANT-BASED proteins
have increased in popularity

**MANY
PROTEIN
SOURCE
OPTIONS**

ANIMAL-FREE

(cell-based) dairy proteins are a
new emerging category



WINDS OF CHANGE



**Consumers have a lot
of choices today...**



DAIRY is still leading,
but....



Increasing pressure for **SUSTAINABILITY**

there is competition from **PLANT** protein
& **ANIMAL-FREE** dairy protein and a **shift** in
PROTEIN TYPE IMPORTANCE

and gaps in consumer **KNOWLEDGE**



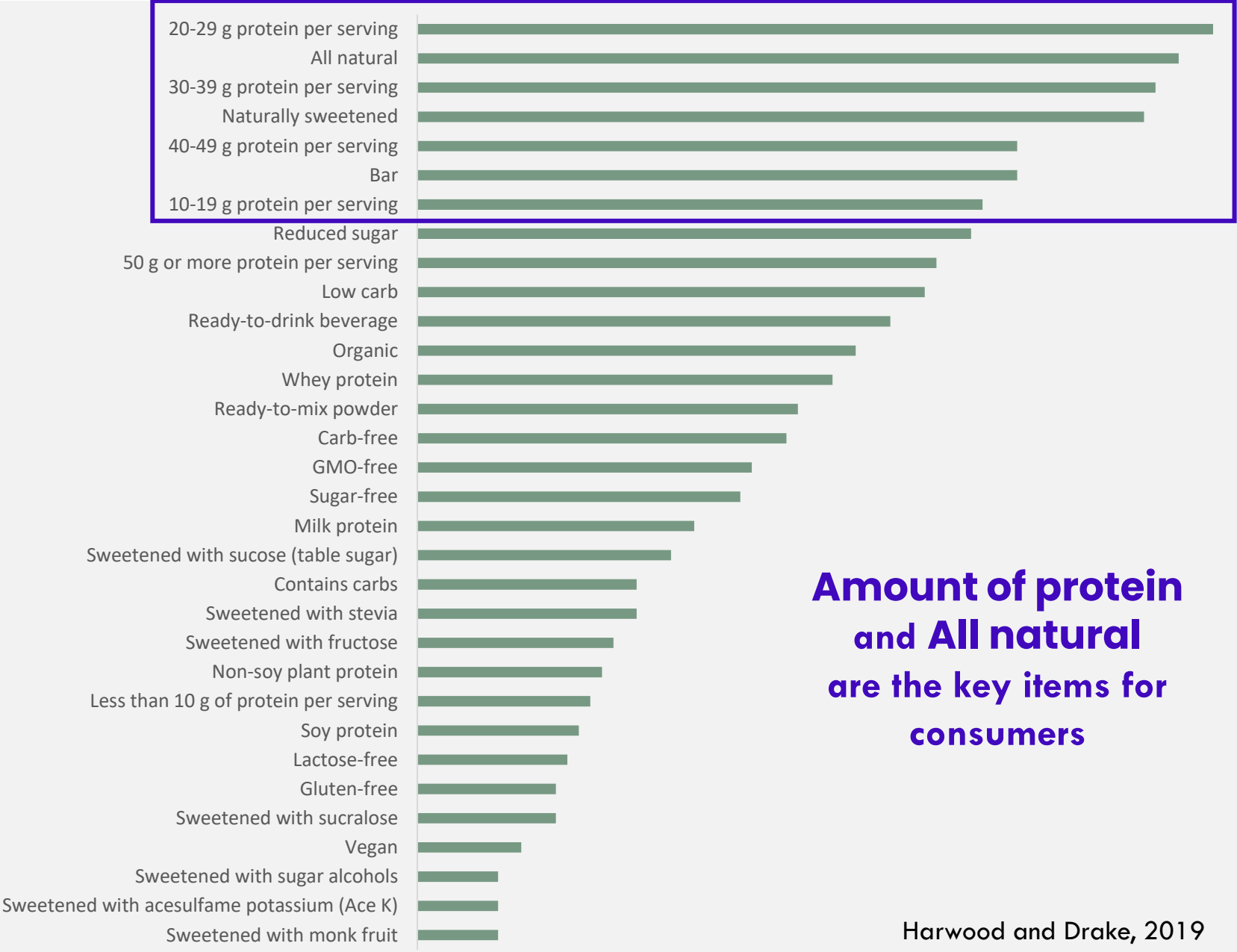
In this changing market... what are the Challenges and Opportunities for DAIRY?



Changes in Consumer Attitudes

MaxDiff scaling exercise
for protein product
characteristics

2018
N=1012 consumers



**Amount of protein
and All natural
are the key items for
consumers**

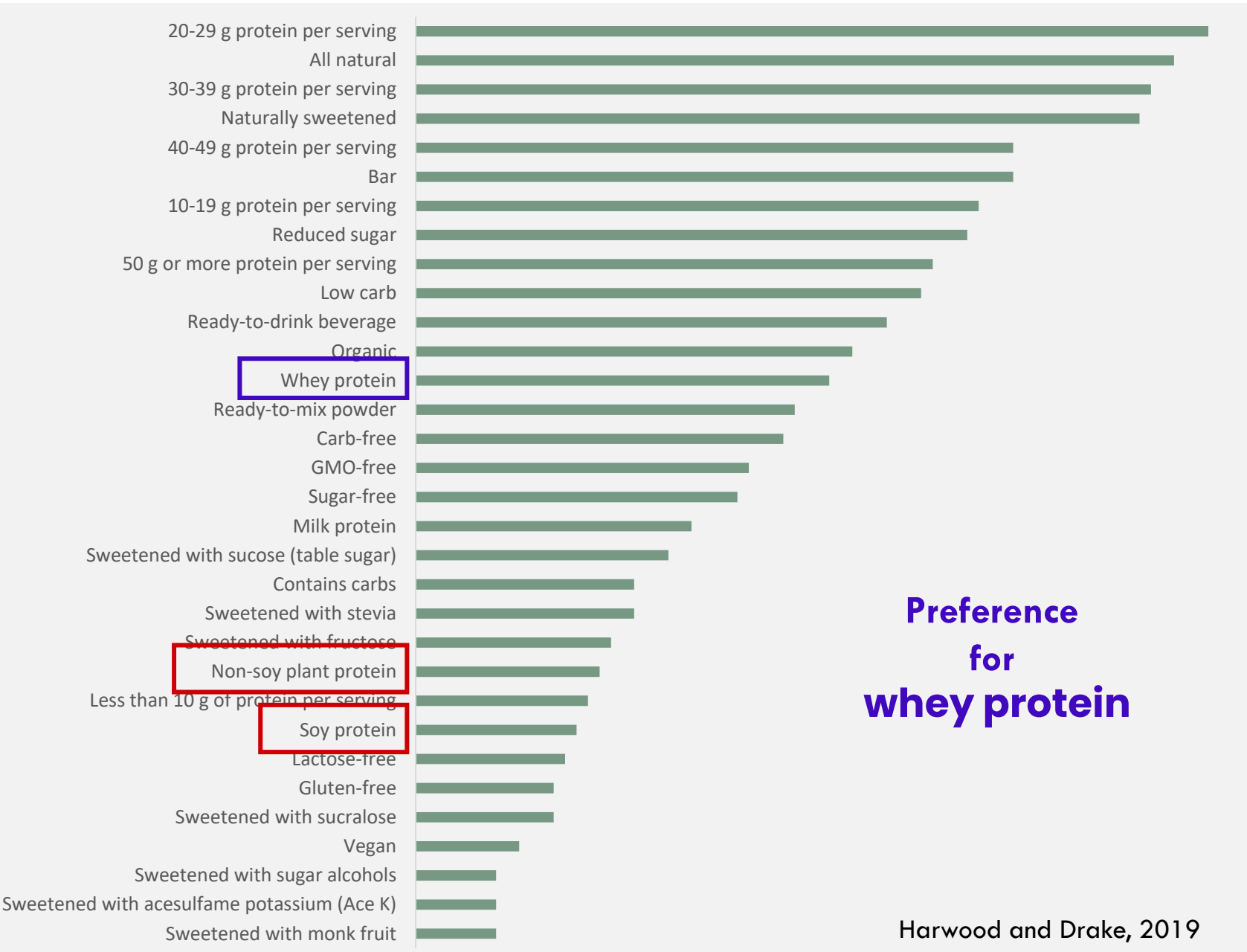
Harwood and Drake, 2019

Changes in Consumer Attitudes

MaxDiff scaling exercise
for protein product
characteristics

2018
N=1012 consumers

Protein type was a
differentiating attribute for
consumers



Preference
for
whey protein

Harwood and Drake, 2019

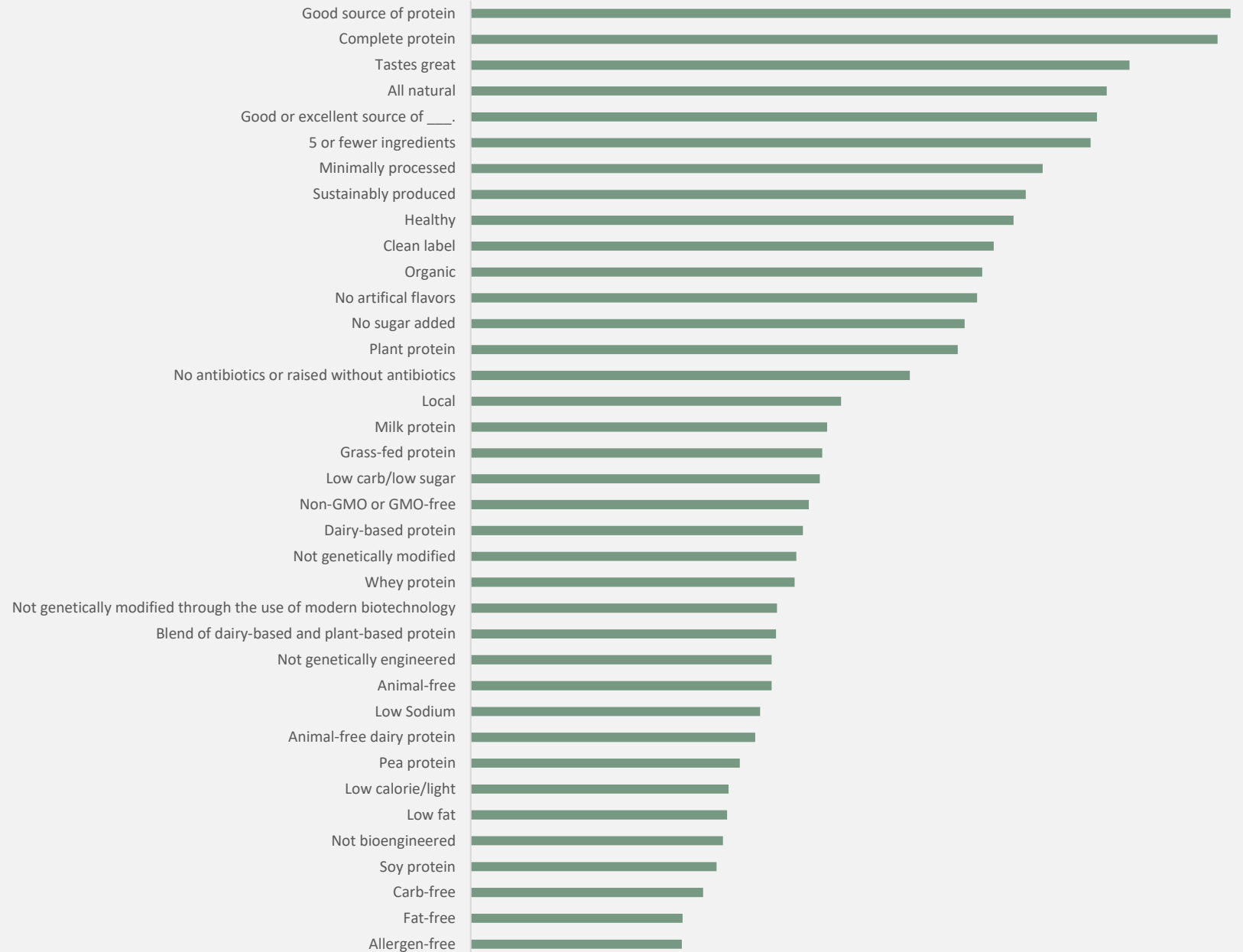
Changes in Consumer Attitudes

MaxDiff scaling exercise
for appealing food product
attributes

2021

N=536 consumers

Health and Flavor were
top of mind in 2021,
sustainability emerges



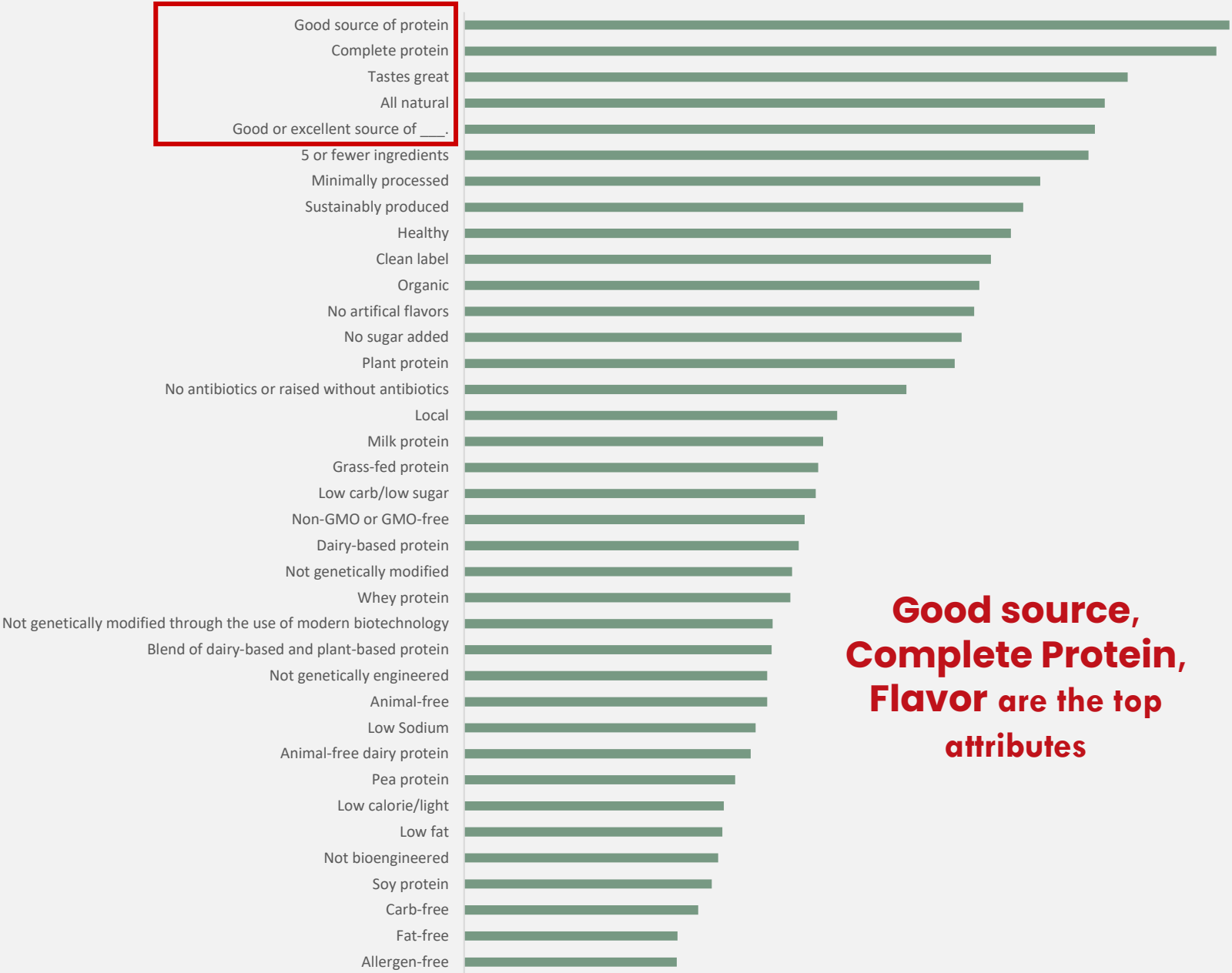
Changes in Consumer Attitudes

MaxDiff scaling exercise
for appealing food product
attributes

2021

N=536 consumers

Health and Flavor were
top of mind in 2021,
sustainability emerges



**Good source,
Complete Protein,
Flavor are the top
attributes**

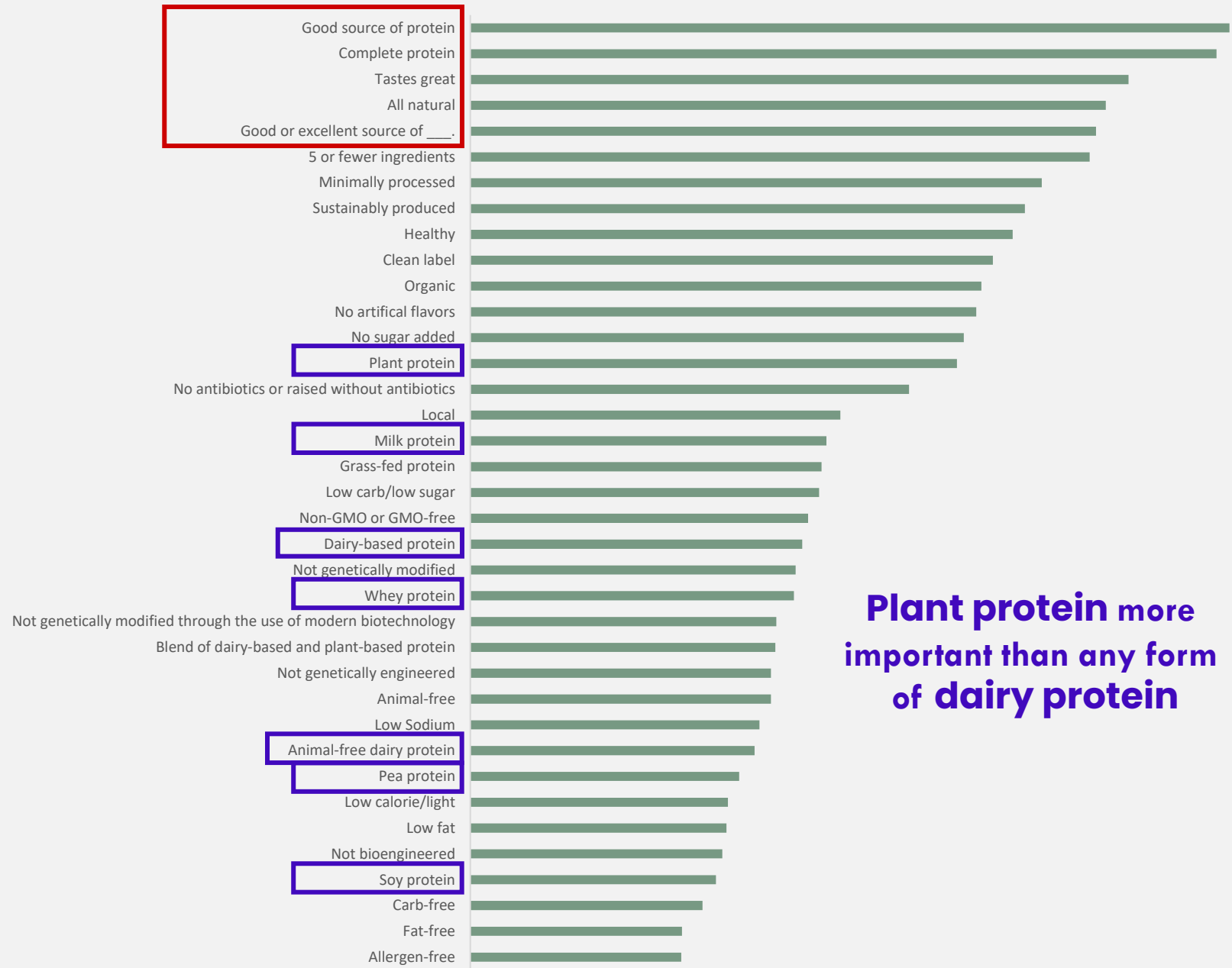
Changes in Consumer Attitudes

MaxDiff scaling exercise
for appealing food product
attributes

2021

N=536 consumers

Health and Flavor were
top of mind in 2021,
sustainability emerges



**Plant protein more
important than any form
of dairy protein**

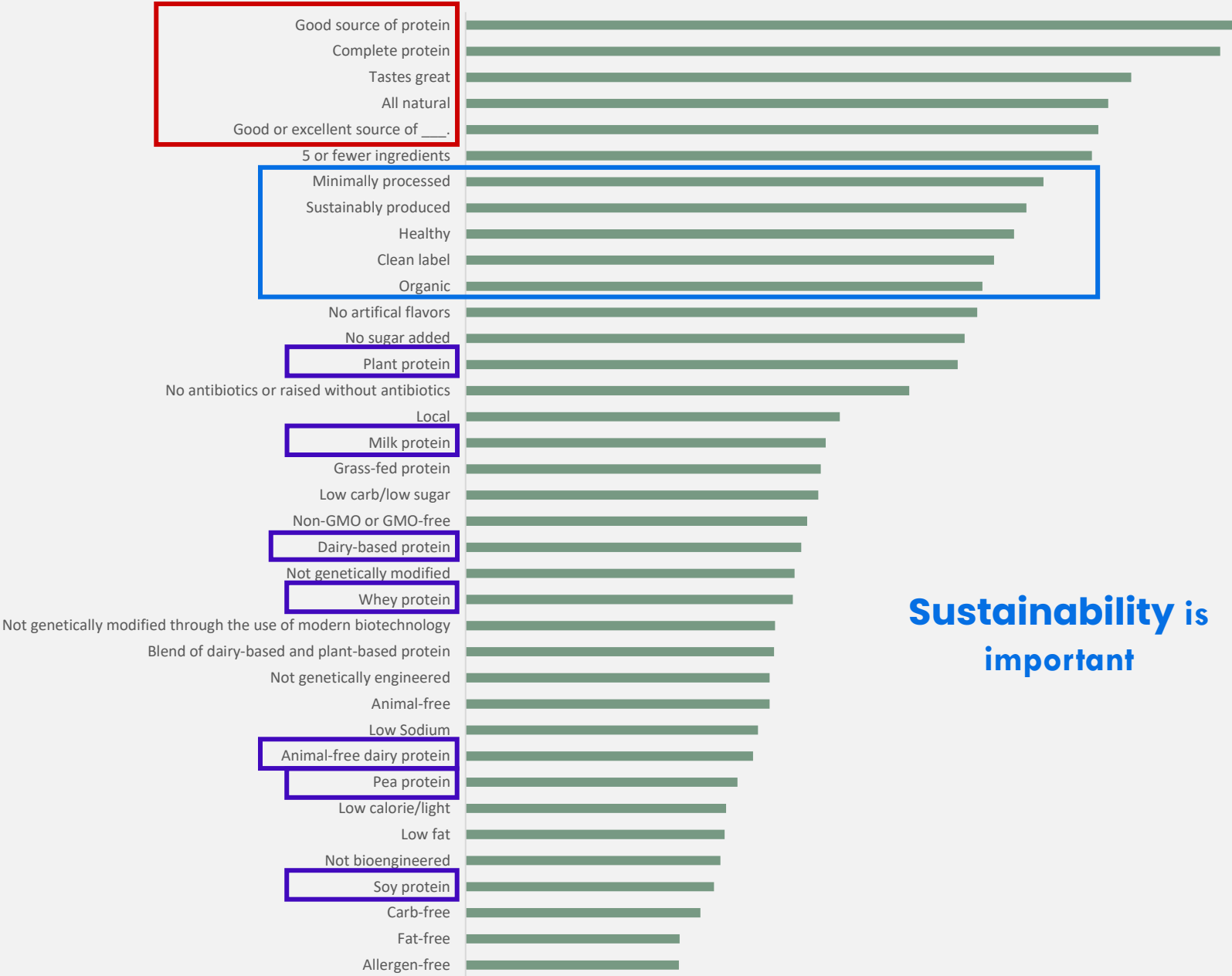
Changes in Consumer Attitudes

MaxDiff scaling exercise
for appealing food product
attributes

2021

N=536 consumers

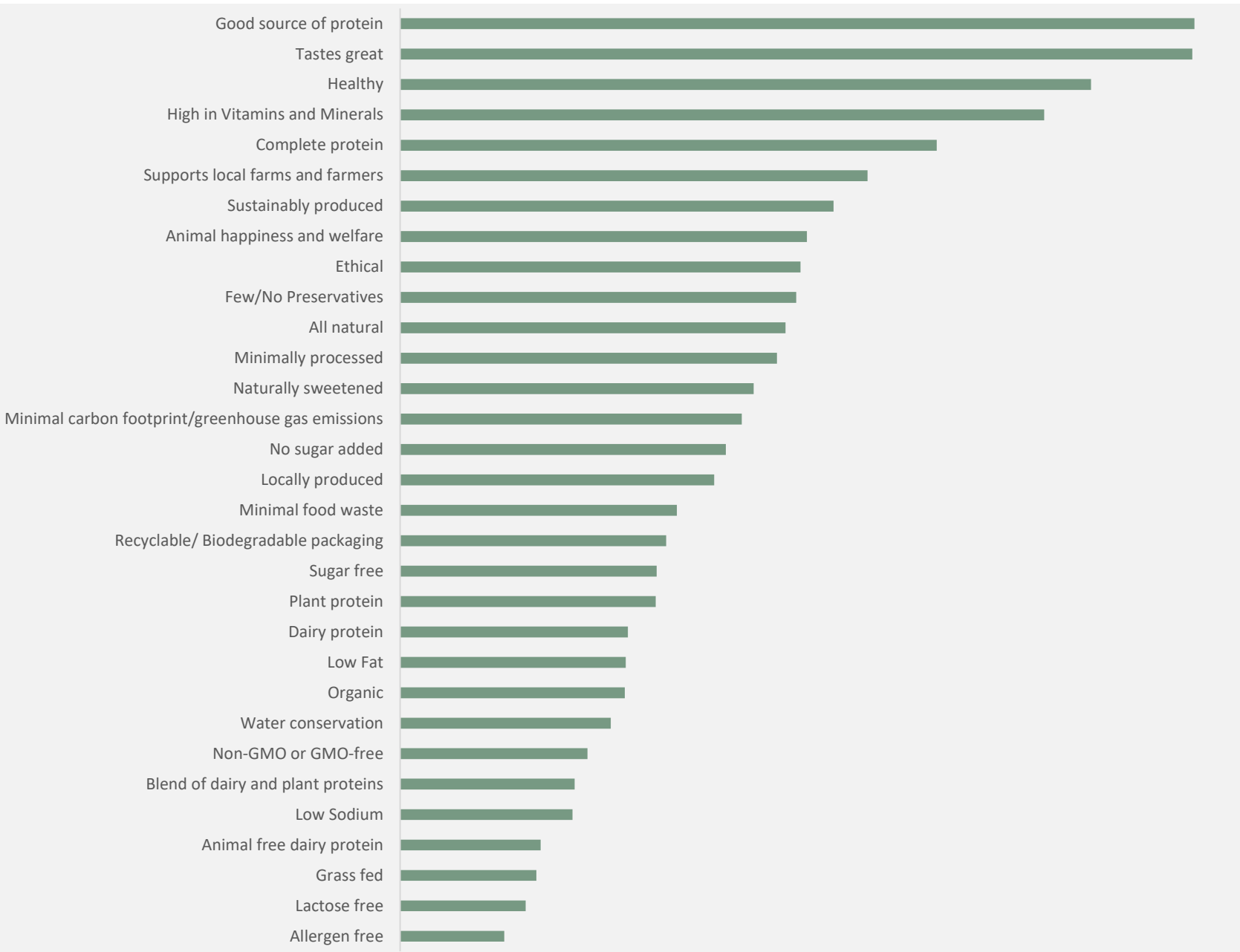
Health and Flavor were
top of mind in 2021,
sustainability emerges



Changes in Consumer Attitudes

MaxDiff scaling exercise
for protein product
characteristics

2022
N=541 consumers

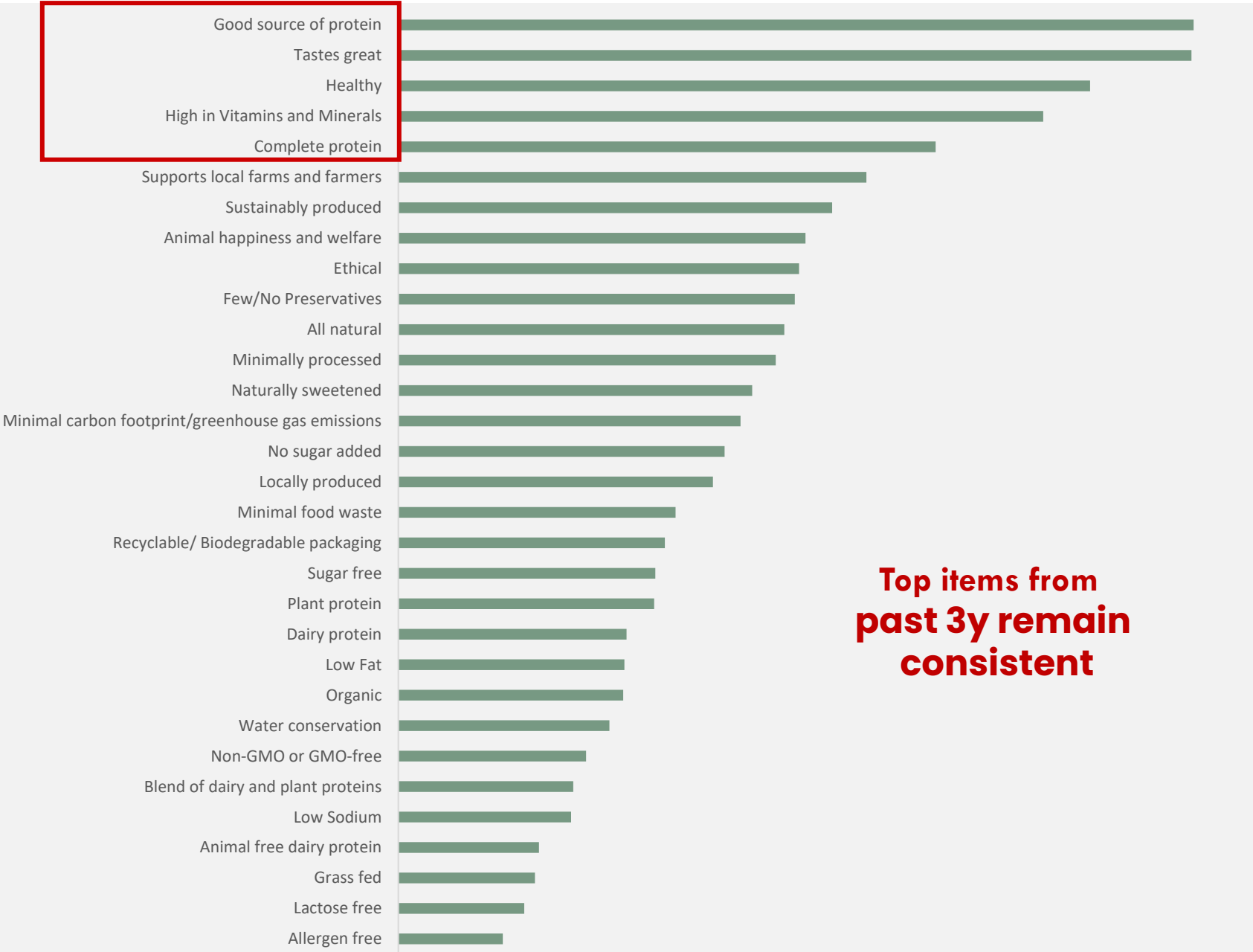


Changes in Consumer Attitudes

MaxDiff scaling exercise
for protein product
characteristics

2022
N=541 consumers

Nutrition, Health and
Flavor are still important



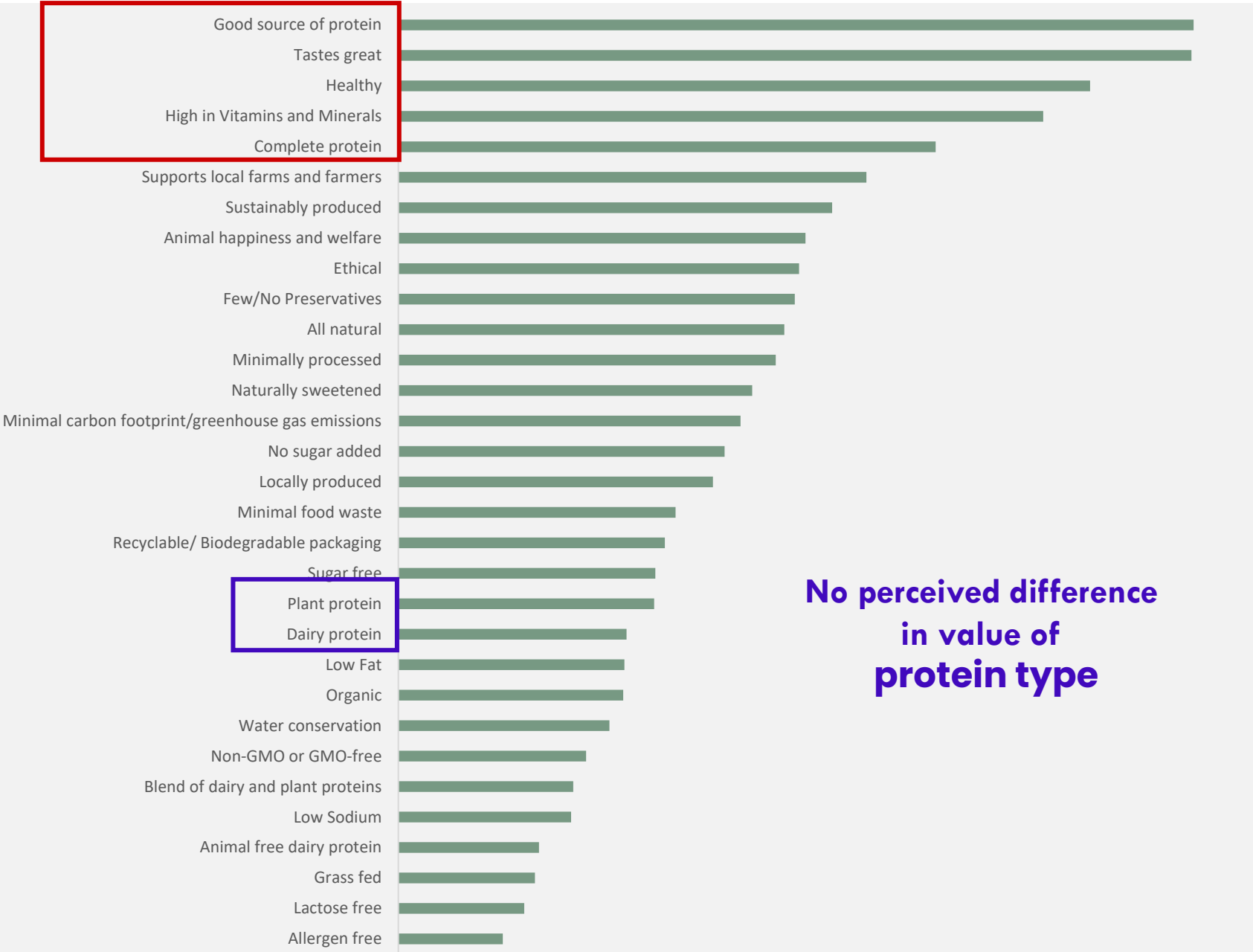
Top items from
past 3y remain
consistent

Changes in Consumer Key Protein Product Attributes

MaxDiff scaling exercise
for protein product
characteristics

2022
N=541 consumers

Nutrition, Health and
Flavor are still important,
but plant vs dairy protein are equal

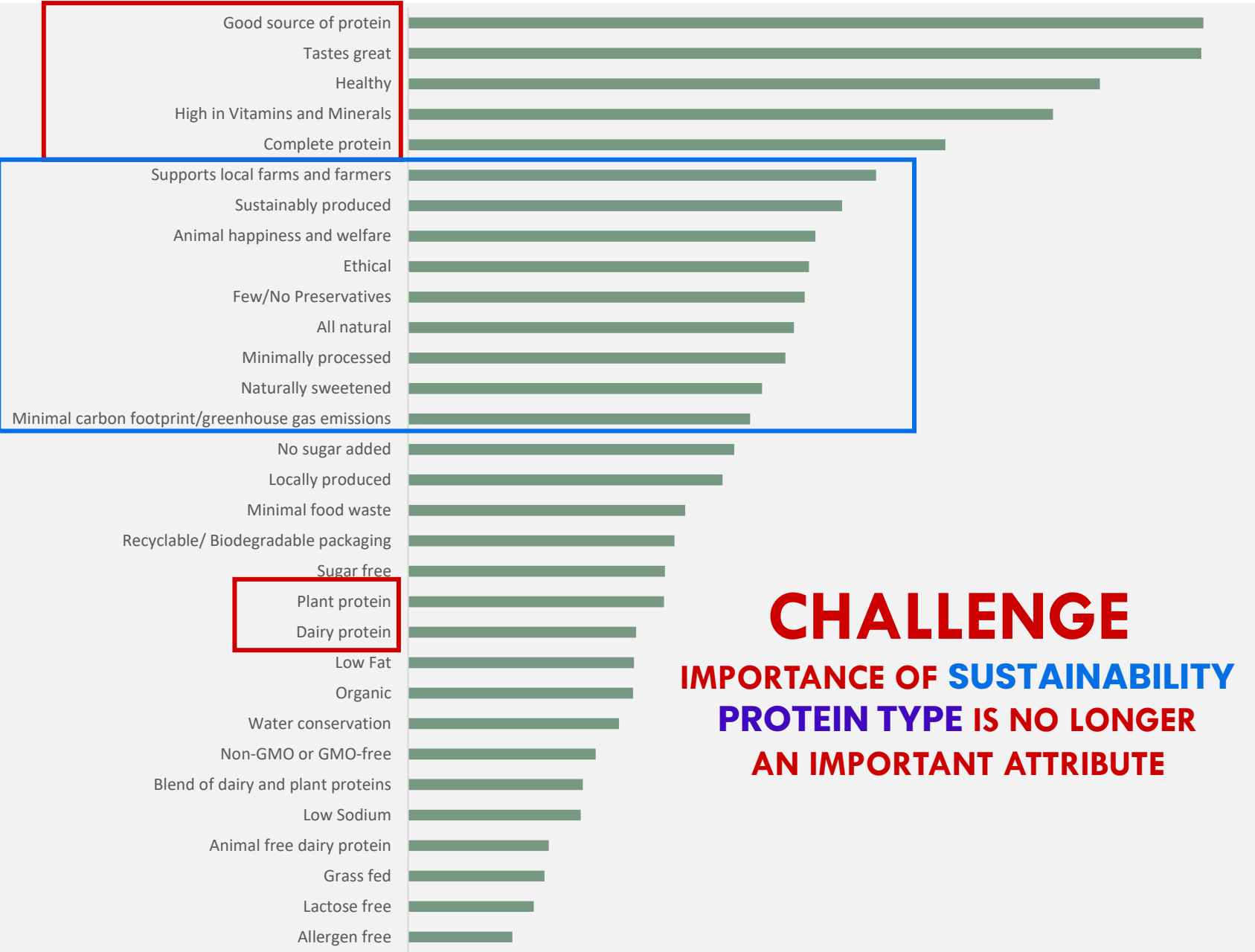


Changes in Consumer Key Protein Product Attributes

MaxDiff scaling exercise
for protein product
characteristics

2022
N=541 consumers

Increased interest in sustainability



CHALLENGE
IMPORTANCE OF SUSTAINABILITY
PROTEIN TYPE IS NO LONGER
AN IMPORTANT ATTRIBUTE

CHALLENGES



Challenge: Rising interest in sustainability plays to plants

What is sustainability to the consumer?



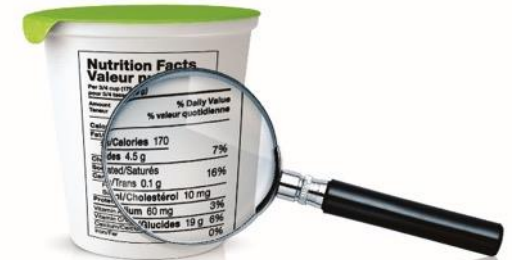
Packaging



Animal Welfare



**Environmental
Impacts**



**Simple/Minimal
Ingredients**

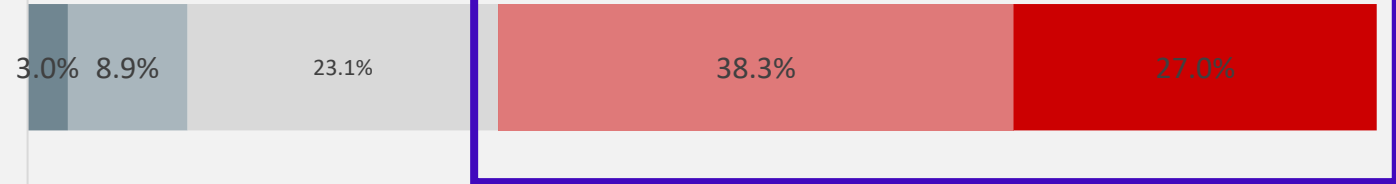
Organic more sustainable than conventional
Plant source universally perceived as more sustainable
No effect for GMO/non-GMO

Schiano et al. 2020 JDS

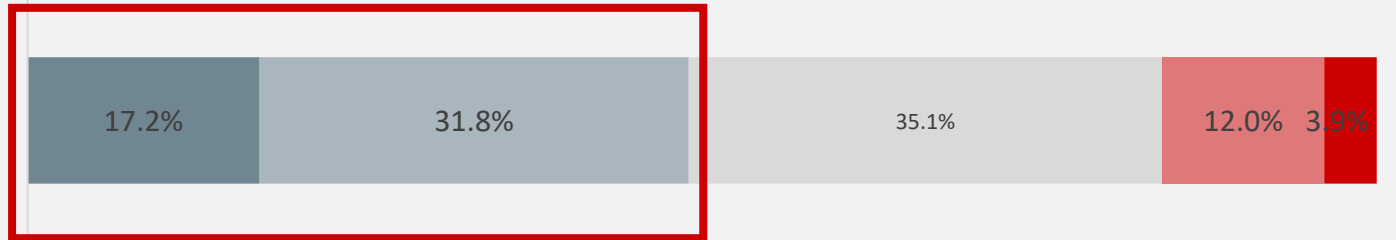


Challenge: What consumers believe...

US agriculture is a significant contributor to greenhouse gas emissions



The US dairy industry is ethical and transparent



■ strongly disagree ■ disagree ■ unsure ■ agree ■ strongly agree

N=541 consumers, 2022



Challenge: What Consumers don't know

2%

of consumers
know
**fluid milk
composition**

36%

of consumers think
**Whey protein is
Plant Protein**

22.7g

consumer belief
of
**'Good Source' of
Protein'**
(5-9.5g)

29.6g

consumer belief
of
**'High Source
of Protein'**
(10g)

?

consumers cannot
define **Complete
Protein**

N=1210 consumers, 2020

N=536 consumers, 2021





Age demographics correlate with dairy knowledge

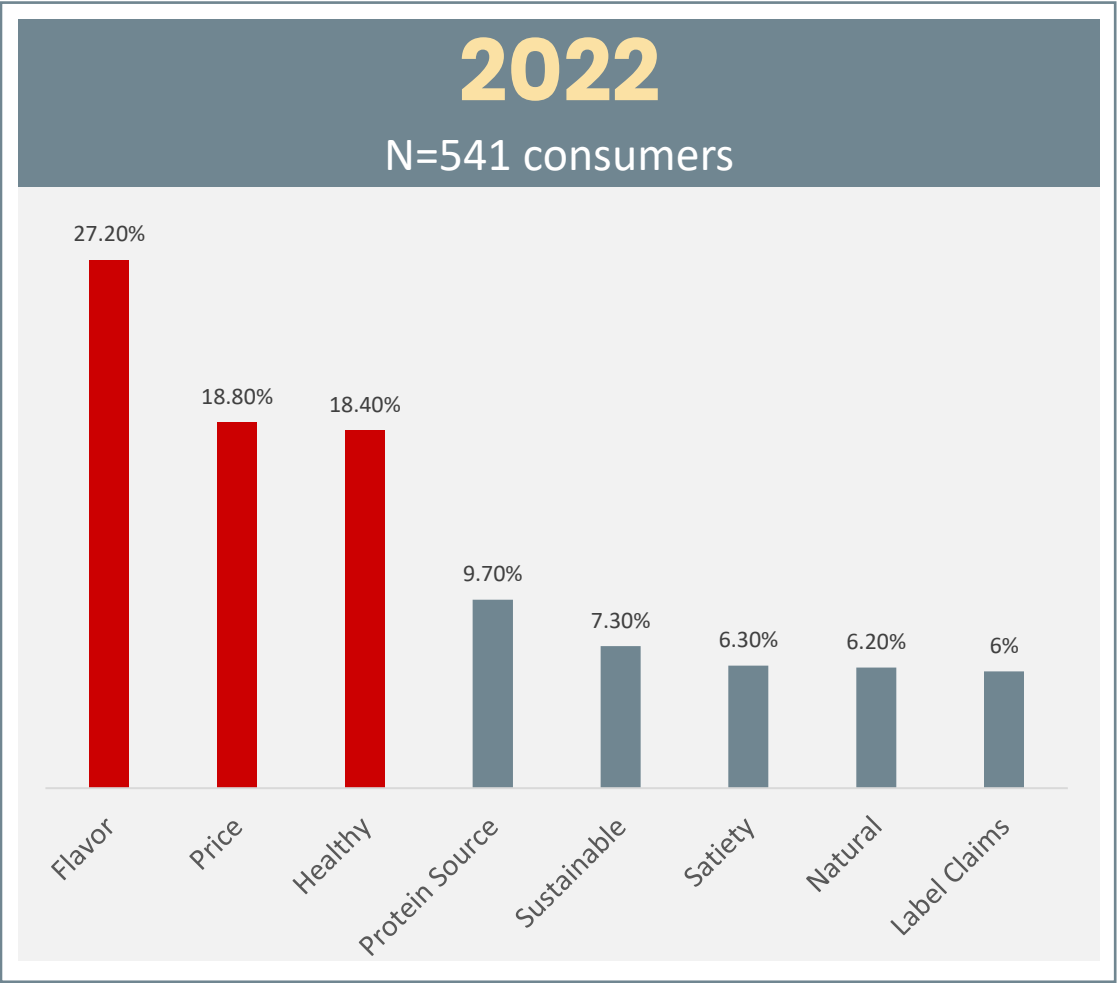
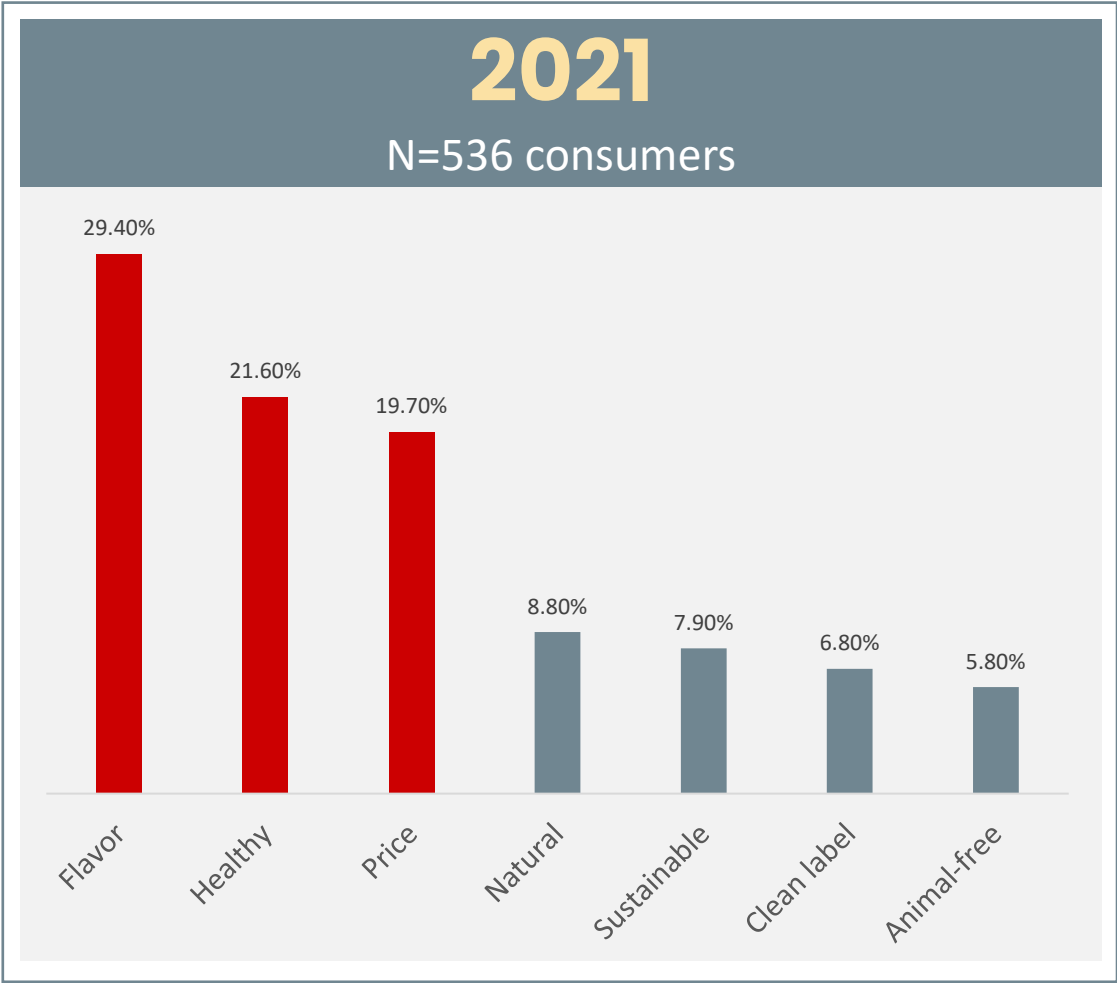
Older consumers (Boomers/Silent Generation members) and **consumers with advanced or professional degrees** have a better understanding of dairy products and dairy proteins

CHALLENGE

Call to action for younger consumers



Flavor, price and healthy still rule at the end of the day For now



Chip allocation questions: averages are based off a total sum of 100% for the combined attributes.

OPPORTUNITIES



L-leucine (Leu, L)



L-lysine (Lys, K)



L-valine (Val, V)



L-isoleucine (Ile, I)



L-threonine (Thr, T)



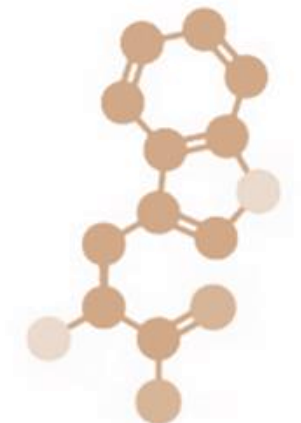
L-phenylalanine (Phe, F)



L-methionine (Met, M)



L-histidine (His, H)



L-tryptophan (Trp, W)

A large iceberg floats in a blue ocean under a sky with scattered white clouds. The visible tip of the iceberg is jagged and white, while the submerged portion is much larger, showing a textured, blue-tinged surface. A white bracket on the right side of the submerged part of the iceberg points towards the text below.

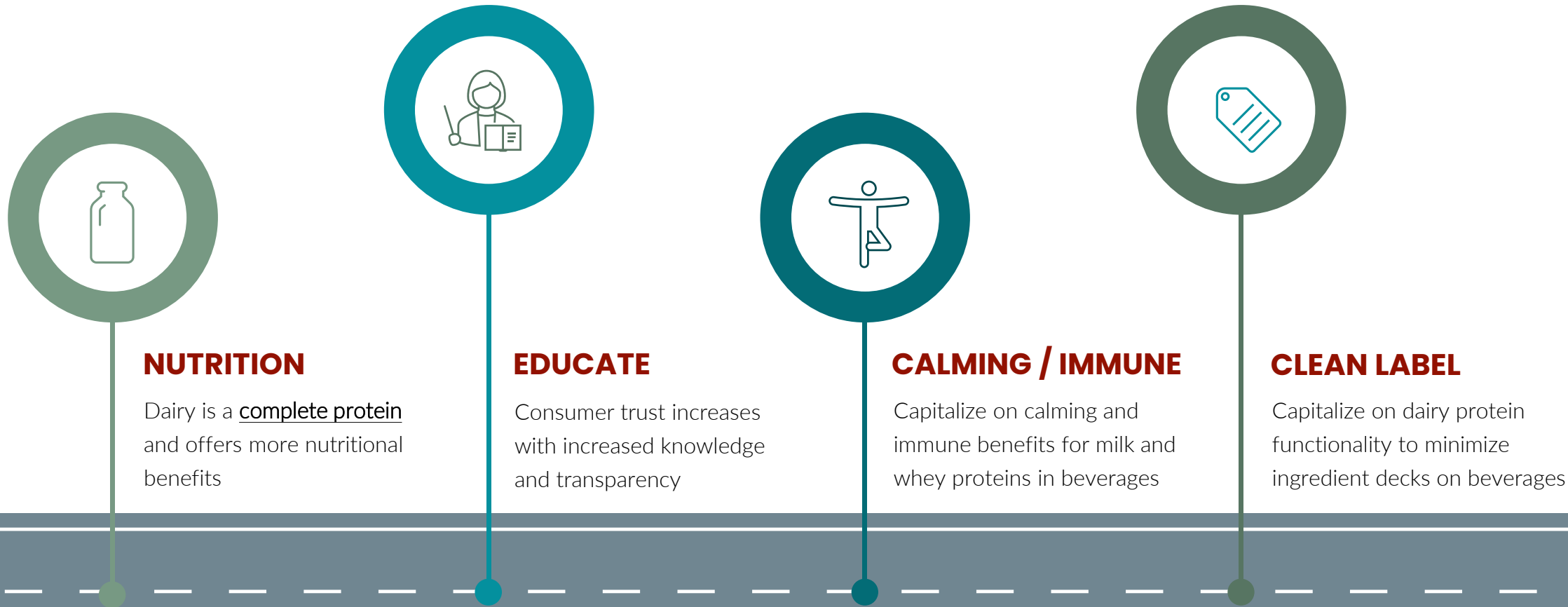
'Got Milk' is only getting us so far...

... there are many positive
benefits **INHERENT** to **Dairy** we
need to focus on and actively
educate and promote



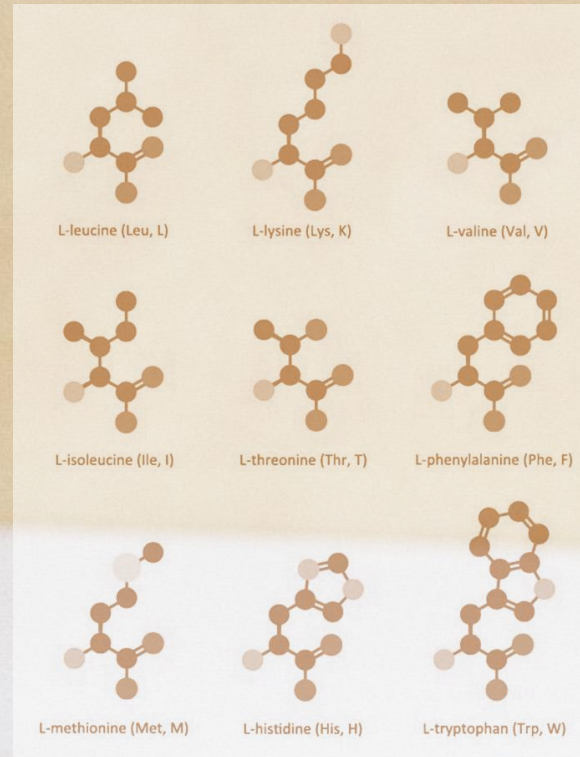
Roadmap for DAIRY Opportunities

‘play to strengths’



OPPORTUNITY:

Complete Protein



- *'All the proteins on the market are complete. I don't think there are any incomplete proteins floating around.'*
- *'I kind of know, but I don't know how it's healthier. Does it really matter if this is complete?'*
- *'Maybe not processed. No additives make it complete. I don't know.'*
- *'I was an athlete. I don't remember. For some plants, they are not complete.'*
- *'I look for protein supplements. Don't think it matters on my choices.'*
- *'That's the amino acids. 7 or 9 amino acids. To be complete, you have to have all of them to be labeled as complete.'*

focus groups 2022



Complete Protein is a valuable indicator for dairy protein once consumers are educated of the definition

Opinion prior to Research

- *'I don't think there is technical definition. I think it's a marketing term'*
- *'If it comes from an animal (dairy) then it probably is more complete than a plant'*
- *'Because milk is [initially] for a calf and they need a lot to grow, I am assuming it is complete unless some of that is removed then making it into whey protein'*
- *'My friends who are really into protein always look at the back of labels and tell me that a mix of different proteins are healthier'*

Opinion post Research

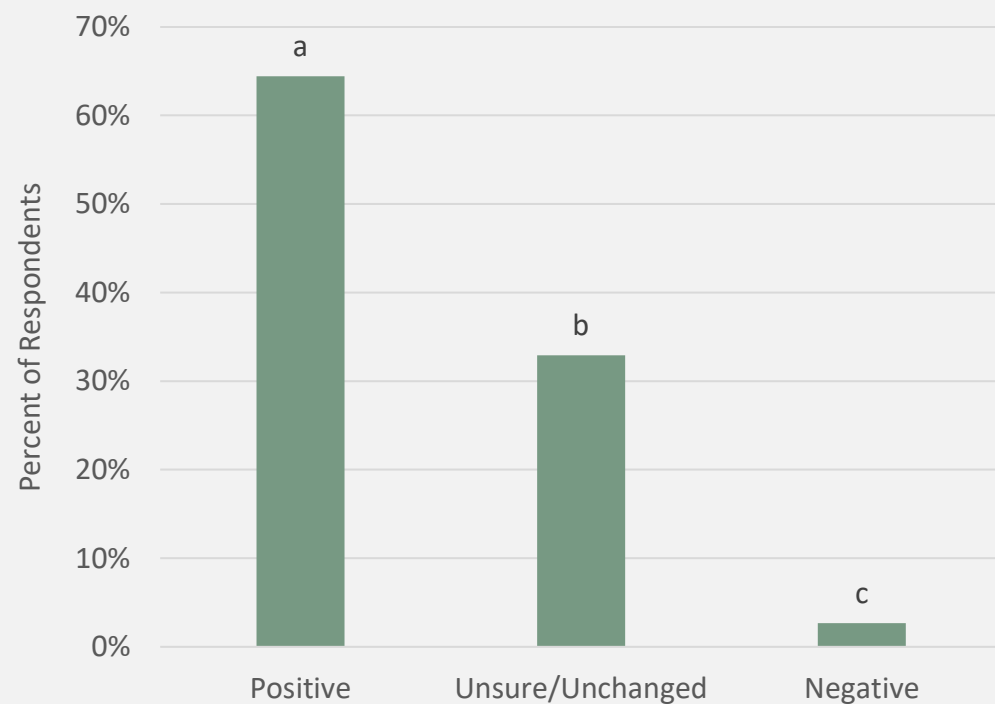
- *"Complete and incomplete it is pretty clear. There is a clear definition of it."*
- *Learning that dairy is a complete protein is a positive for consumers.*

focus groups 2022

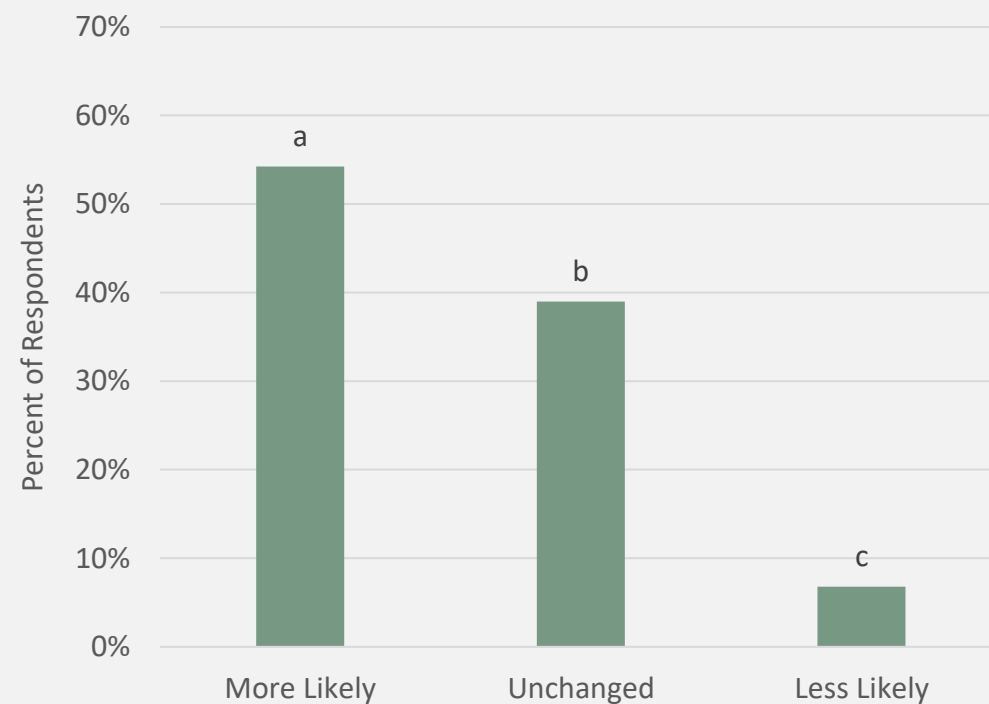


OPPORTUNITY: Education impacts beliefs

Post-Definition beliefs about ultrafiltered and microfiltered milk



Purchase intent for milk, cheese, or cultured dairy products assuming they would be made with ultrafiltered/microfiltered/filtered milk



N=1003 respondents unfamiliar with ultrafiltered/microfiltered milk before a definition was provided.



OPPORTUNITY:

Dairy beverages and dairy proteins can seize an opportunity in the current immune/calming need-state landscape

80% of Americans seeking immune boosting foods and supplements

(New York Post – SWNS, 2021)

1/3 of Americans have displayed clinical signs of anxiety, depression since pandemic began. (US Census Bureau, 2020)





A **third** of consumers currently use dairy products for immune health.

Yes, I use dairy products to improve my immune health	30.9%
No, I use other products to improve my immune health	31.0%
Not currently using dairy products to improve immune health, but I would like to use dairy products for this benefit	23.6%
I am not trying to improve my immune health	14.5%





A third of consumers currently use dairy products for immune health.

Major opportunity lies with the 50%+ of dairy consumers who don't seek dairy for this purpose.

Yes, I use dairy products to improve my immune health	30.9%
No, I use other products to improve my immune health	31.0%
Not currently using dairy products to improve immune health, but I would like to use dairy products for this benefit	23.6%
I am not trying to improve my immune health	14.5%





When it comes to dairy, a product that consumers feel is nutritional, **consumers want to learn more about the nutritional components that are inherently present** rather than ingredients added for Immune benefits.

Specifically for immune health, consumers need assurance that the **messages are coming from a credible source.**

Most motivating feature to encourage dairy consumption for immunity (n=410)

Recommended by My Doctor	9.6a
Contains Immune-Boosting Protein (lactoferrin, immunoglobulins (IgG), etc.)	7.4b
Scientific Article	7.3b
Contains Antioxidants	7.2b
Contains Live and Active Cultures	6.4c
Contains Prebiotics	5.3d
Fortified with Vitamin C	5.1de
Fortified with Calcium	4.7ef
Recommended by a Friend	4.6f
"Immune-Boosting" Label	4.5f
Contains Extra Protein	4.4f
Contains Herbal Ingredients (Turmeric, Ginger, Ginseng, Chamomile, Lavender, etc.)	3.7g
Contains Folate/Folic Acid	3.4gh
"Anti-Inflammatory" Label	3.1hi
Fortified with Zinc	2.9i
Contains Tea Ingredients (Green Tea, Oolong Tea, Black Tea, Assam Tea, etc.)	2.7i
Contains Honey as an Ingredient	1.9j
Contains DHA	1.6jk
Newspaper/Magazine Article	1.5jk
Online Article	1.5kl
Contains Melatonin	1.1lm
TV News Show Segment	0.9mn
Contains Capsaicin	0.7no
YouTube Video	0.3op
Recommended by a Social Media Personality	0.2p





When it comes to dairy, a product that consumers feel is nutritional, **consumers want to learn more about the nutritional components that are inherently present** rather than ingredients added for Immune benefits.

Specifically for immune health, consumers need assurance that the **messages are coming from a credible source.**

Most motivating feature to encourage dairy consumption for immunity (n=410)

Recommended by My Doctor	9.6a
Contains Immune-Boosting Protein (lactoferrin, immunoglobulins (IgG), etc.)	7.4b
Scientific Article	7.3b
Contains Antioxidants	7.2b
Contains Live and Active Cultures	6.4c
Contains Prebiotics	5.3d
Fortified with Vitamin C	5.1de
Fortified with Calcium	4.7ef
Recommended by a Friend	4.6f
"Immune-Boosting" Label	4.5f
Contains Extra Protein	4.4f
Contains Herbal Ingredients (Turmeric, Ginger, Ginseng, Chamomile, Lavender, etc.)	3.7g
Contains Folate/Folic Acid	3.4gh
"Anti-Inflammatory" Label	3.1hi
Fortified with Zinc	2.9i
Contains Tea Ingredients (Green Tea, Oolong Tea, Black Tea, Assam Tea, etc.)	2.7i
Contains Honey as an Ingredient	1.9j
Contains DHA	1.6jk
Newspaper/Magazine Article	1.5jk
Online Article	1.5kl
Contains Melatonin	1.1lm
TV News Show Segment	0.9mn
Contains Capsaicin	0.7no
YouTube Video	0.3op
Recommended by a Social Media Personality	0.2p





When it comes to dairy, a product that consumers feel is nutritional, **consumers want to learn more about the nutritional components that are inherently present** rather than ingredients added for Immune benefits.

Specifically for immune health, consumers need assurance that the **messages are coming from a credible source.**

Most motivating feature to encourage dairy consumption for immunity (n=410)

Recommended by My Doctor	9.6a
Contains Immune-Boosting Protein (lactoferrin, immunoglobulins (IgG), etc.)	7.4b
Scientific Article	7.3b
Contains Antioxidants	7.2b
Contains Live and Active Cultures	6.4c
Contains Prebiotics	5.3d
Fortified with Vitamin C	5.1de
Fortified with Calcium	4.7ef
Recommended by a Friend	4.6f
"Immune-Boosting" Label	4.5f
Contains Extra Protein	4.4f
Contains Herbal Ingredients (Turmeric, Ginger, Ginseng, Chamomile, Lavender, etc.)	3.7g
Contains Folate/Folic Acid	3.4gh
"Anti-Inflammatory" Label	3.1hi
Fortified with Zinc	2.9i
Contains Tea Ingredients (Green Tea, Oolong Tea, Black Tea, Assam Tea, etc.)	2.7i
Contains Honey as an Ingredient	1.9j
Contains DHA	1.6jk
Newspaper/Magazine Article	1.5jk
Online Article	1.5kl
Contains Melatonin	1.1lm
TV News Show Segment	0.9mn
Contains Capsaicin	0.7no
YouTube Video	0.3op
Recommended by a Social Media Personality	0.2p





Calming is personal, so the **anticipated enjoyment and stress relief comes from sensory cues rather than messaging.**

But messages around ingredients consumers know to be calming like herbs, tea, and melatonin can be positive, as long as the **messages are coming from a credible source.**

Most motivating feature to encourage consumption of dairy foods for calming (N=458)

Recommended by My Doctor	10.5a
Recommended by a Mental Health Professional	9.6b
Scientific Article	7.8c
Tastes Great	7.8c
Contains Herbal Ingredients (Turmeric, Ginger, Ginseng, Chamomile, Lavender, etc.)	6.8d
Recommended by a Friend	6.1e
Tastes Indulgent	5.8e
Contains Melatonin	5.7ef
Contains Tea Ingredients (Green Tea, Oolong Tea, Black Tea, Assam Tea, etc.)	5.3f
Contains CBD (Cannabidiol)	4.3g
Contains Live and Active Cultures	4.3g
Contains Spice Ingredients (cinnamon, nutmeg, etc.)	4g
Contains Prebiotics	3.5h
Contains Honey as an Ingredient	3.3h
Creamy Mouthfeel	3.2h
Contains Alcohol	1.8i
Newspaper/Magazine Article	1.7i
Online Article	1.7i
TV News Show Segment	1.1j
YouTube Video	0.5k
Recommended by a Social Media Personality	0.2k





Calming is personal, so the **anticipated enjoyment and stress relief comes from sensory cues** rather than messaging.

But messages around ingredients consumers know to be calming like herbs, tea, and melatonin can be positive, as long as the **messages are coming from a credible source.**

Most motivating feature to encourage consumption of dairy foods for calming (N=458)

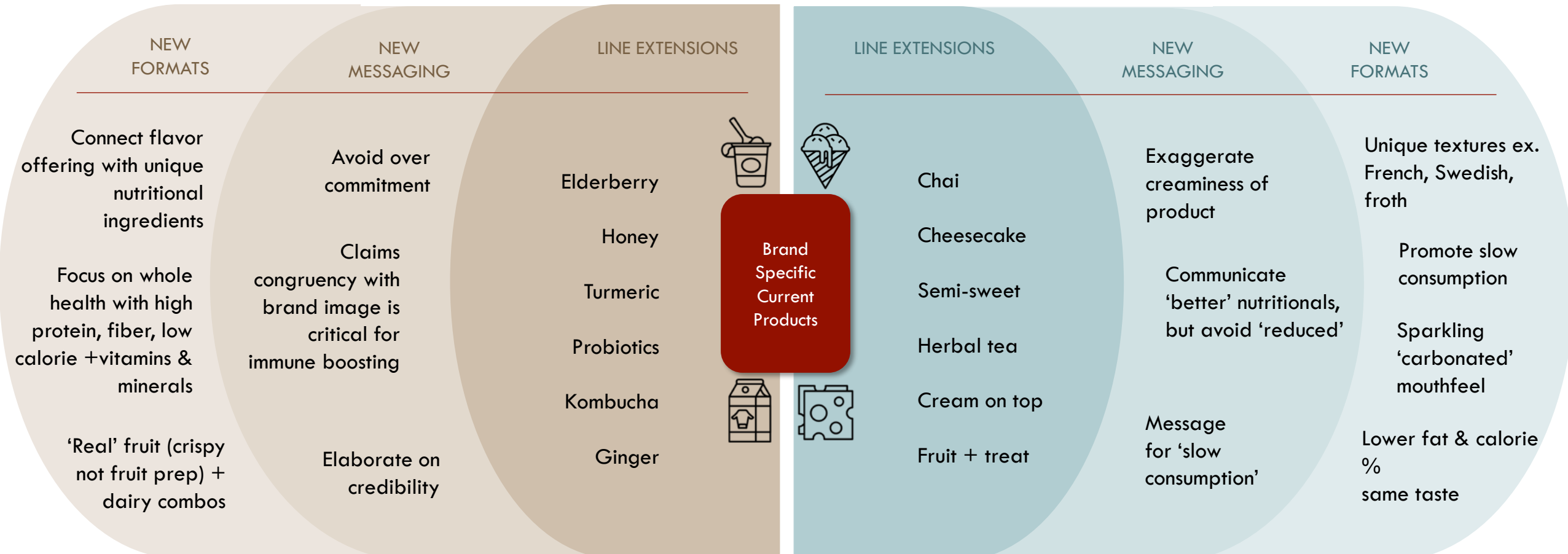
Recommended by My Doctor	10.5a
Recommended by a Mental Health Professional	9.6b
Scientific Article	7.8c
Tastes Great	7.8c
Contains Herbal Ingredients (Turmeric, Ginger, Ginseng, Chamomile, Lavender, etc.)	6.8d
Recommended by a Friend	6.1e
Tastes Indulgent	5.8e
Contains Melatonin	5.7ef
Contains Tea Ingredients (Green Tea, Oolong Tea, Black Tea, Assam Tea, etc.)	5.3f
Contains CBD (Cannabidiol)	4.3g
Contains Live and Active Cultures	4.3g
Contains Spice Ingredients (cinnamon, nutmeg, etc.)	4g
Contains Prebiotics	3.5h
Contains Honey as an Ingredient	3.3h
Creamy Mouthfeel	3.2h
Contains Alcohol	1.8i
Newspaper/Magazine Article	1.7i
Online Article	1.7i
TV News Show Segment	1.1j
YouTube Video	0.5k
Recommended by a Social Media Personality	0.2k



OPPORTUNITY: Capitalize on the inherent properties of dairy foods

IMMUNE BOOSTING

CALMING



Calming & Immune are here to stay & there is opportunity to better satisfy need states with new dairy innovations.



OPPORTUNITY: High Demand on High Protein Products

- Global protein market valued at 38.5 million in 2020 and projected to grow
- Nutritional drinks market continue to grow steadily and have strong consumer penetration (Mintel, 2022)
- 42% of consumers are making eating healthy a higher priority as a result of COVID-19 (Mintel, 2020)
- 8.6 million conversations about protein (95% positive) across Instagram, Pinterest and Twitter from Oct 2019 to Sep 2020 (Infegy, 2020)



**But what
ingredients do
consumers want in
their high protein
beverages?**



Consumer Attitude to Protein Beverage Ingredients

MaxDiff Scaling &
Projective Mapping exercise
for appealing protein
beverage ingredients

2023

N=400 consumers

I would **LIKE** to
see this on the
ingredient list

I would **NOT**
LIKE to see this
on the
ingredient list

LIKING

FAMILIARITY

I have **NEVER**
HEARD OF
this ingredient

I am **VERY**
FAMILIAR with
this ingredient



Consumer Attitude to Protein Beverage Ingredients

PROTEINS

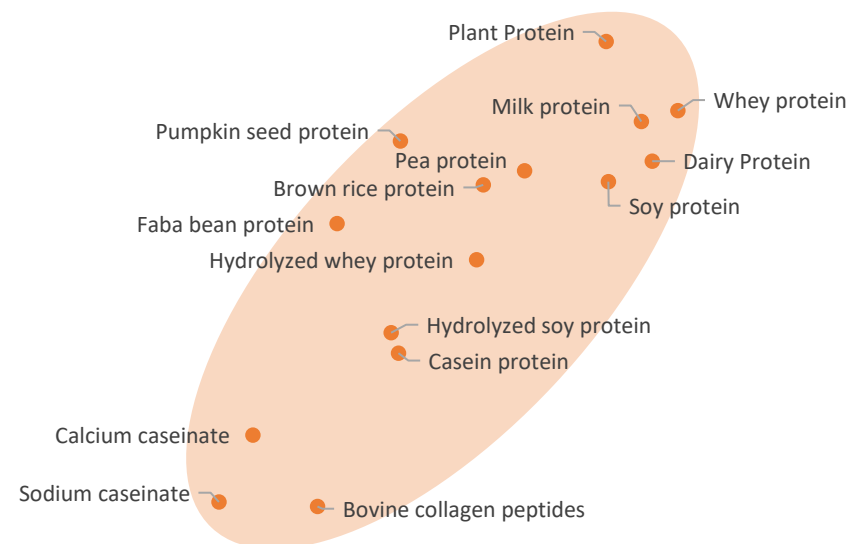
Plant protein	53.6a
Whey protein	48.9b
Milk protein	43.5c
Pumpkin seed protein	42.7cd
Dairy protein	41.8cd
Pea protein	39.3de
Brown rice protein	35.8ef
Soy protein	33.6f
Faba bean protein	28.1g
Hydrolyzed whey protein	26.0g
Casein protein	20.0h
Calcium caseinate	17.3h
Hydrolyzed soy protein	16.5h
Bovine collagen peptides	8.4i
Sodium caseinate	6.5i

**DAIRY &
PLANT**

I would **LIKE** to see this on the ingredient list

I would **NOT LIKE** to see this on the ingredient list

PROTEINS



As familiarity increases, liking also increases

I have **NEVER HEARD OF** this ingredient

I am **VERY FAMILIAR** with this ingredient



Consumer Attitude to Protein Beverage Ingredients

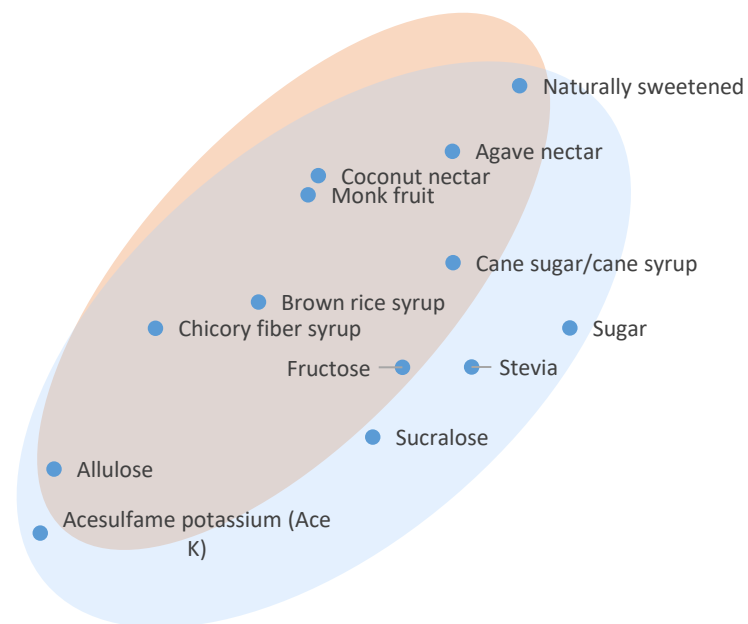
SWEETENERS

Naturally sweetened	56.8a
Agave nectar	49.5b
Monk fruit	41.6c
Cane sugar/cane syrup	39.7c
Coconut nectar	39.4c
Sugar	33.0d
Brown rice syrup	27.0e
Stevia	23.7ef
Chicory fiber syrup	20.0fg
Fructose	17.1g
Sucralose	12.4h
Allulose	12.0h
Acesulfame potassium (Ace K)	-0.2i

I would **LIKE** to see this on the ingredient list

I would **NOT LIKE** to see this on the ingredient list

SWEETENERS



Again, as familiarity increases, liking also increases

I have **NEVER HEARD OF** this ingredient

I am **VERY FAMILIAR** with this ingredient



Consumer Attitude to Protein Beverage Ingredients

THICKENERS

Vegetable fiber	57.4a
Tapioca fiber	49.6b
Rice flour	49.5b
Pea starch	46.5bc
Tapioca starch	46.3bc
Rice starch	43.7cd
Soy fiber	40.9de
Chicory root fiber	40.4de
Chicory fiber	39.8de
Soy flour	37.7ef
Agar	35.2fg
Corn fiber	35.2fg
Enriched flour	32.4gh
Soluble corn fiber	32.0gh
Acacia gum	29.4h
Locust bean gum	20.8i
Cellulose gum	19.8ij
Cellulose gel	19.1ijk
Inulin	17.2ijk
Carrageenan	15.9jk
Gellan gum	15.3k

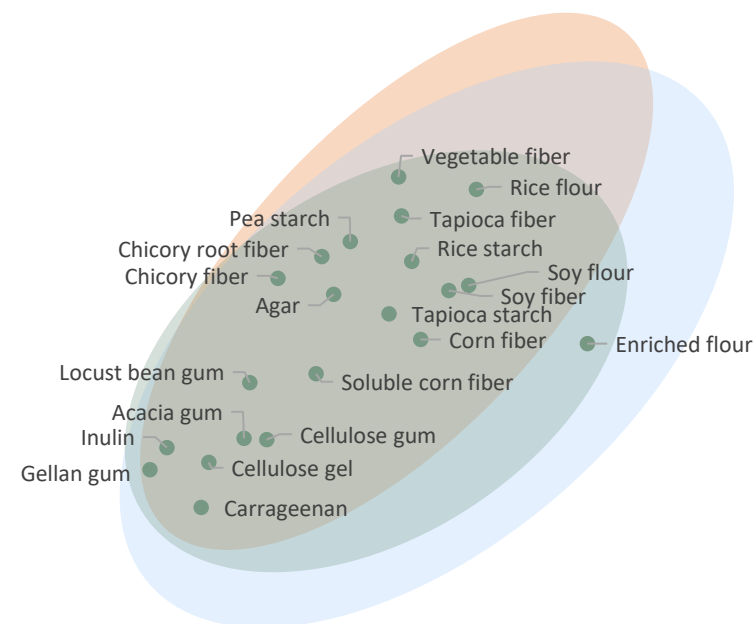
FIBERS & STARCHES

GUM & GELS

I would **LIKE** to see this on the ingredient list

I would **NOT LIKE** to see this on the ingredient list

THICKENERS



Less familiarity = less differentiation in liking

I have **NEVER HEARD OF** this ingredient

I am **VERY FAMILIAR** with this ingredient



Consumer Attitude to Protein Beverage Ingredients

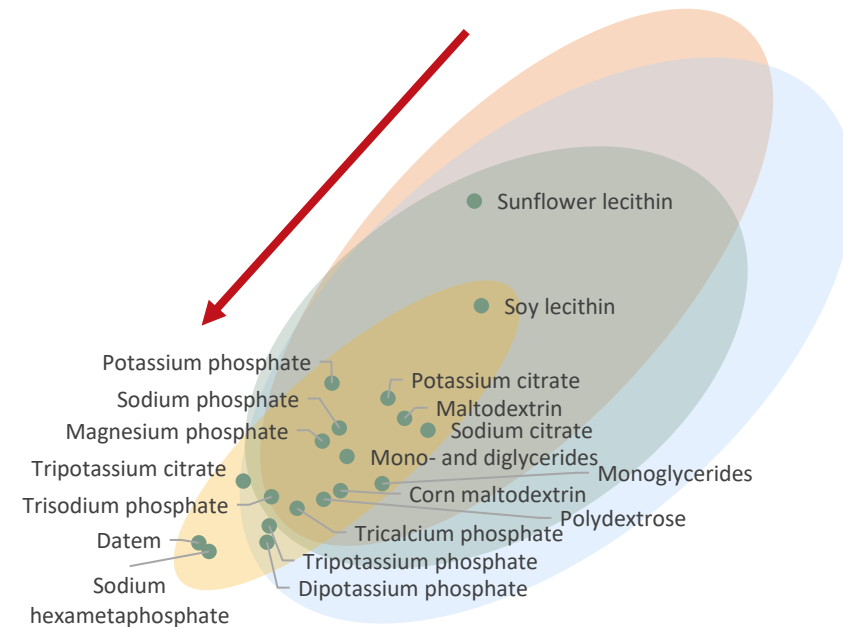
STABILIZERS

Sunflower lecithin	68.5a
Soy lecithin	49.6b
Potassium citrate	48.2bc
Potassium phosphate	45.6bc
Magnesium phosphate	43.9c
Sodium citrate	38.9d
Monoglycerides	35.3de
Corn maltodextrin	34.5de
Tripotassium citrate	34.4def
Maltodextrin	34.2defg
Tricalcium phosphate	34.0efg
Sodium phosphate	33.6efg
Dipotassium phosphate	31.5efg
Mono- and diglycerides	31.1efg
Tripotassium phosphate	29.6fg
Polydextrose	29.4g
Trisodium phosphate	23.8h
Datam	22.5h
Sodium hexametaphosphate	12.6i
Anchor	0.0j

I would **LIKE** to see this on the ingredient list

I would **NOT LIKE** to see this on the ingredient list

STABILIZERS



**But even less familiarity
= less liking**

Consumers don't want these ingredients

I have **NEVER HEARD OF** this ingredient

I am **VERY FAMILIAR** with this ingredient



Protein beverages and consumer desires

- Desirable flavor, texture, appearance, and clean label/simple ingredients are key consumer attributes that dairy proteins can deliver
 - Understand how processing parameters impact **flavor** of beverages
 - Understand how processing parameters impact **functionality** of beverages
 - Understand how added ingredients affect beverage functionality and build functionality of milk components to eliminate the need for other added ingredients



**Fluid Milk
Beverages**



**Protein
Beverages**



Milk research continuum

**A PLATFORM
APPROACH**

MILK BEVERAGE PLATFORM



Milk Beverage Platform

LOOKING BACK

The influence of UP by indirect versus direct steam injection on skim and 2% milk (Lee et al. 2017)

Flavor chemistry difference among milk processes by HTST or UP. (Jo et al. 2018)

Identification of source of volatile sulfur compounds produced during thermal processing of milk (Jo et al. 2019)

Hunter vs CIE color measurement systems for analysis of milk based beverages. (Cheng et al. 2019)

Effects of milk fat, casein, and serum protein concentrations on sensory properties of milk-based beverages (Cheng et al. 2019)

MILK BEVERAGES

LOOKING FORWARD

Reducing sugar in school lunch chocolate milk (Nakamura et al.)

Milkfat preference in unflavored and chocolate milk (Keefer et al.)

Role of packaging on unflavored and chocolate milk flavor. (Cadwallader et al.)

Role of complete lactose removal, fat and protein on physical and sensory properties of milk beverages (Hernandez et al.)

Role of cooling and storage on the flavor of aseptic milk (Cadwallader et al.)

REPRESENTING THE DAIRY BEST



Milk Beverage Platform

LOOKING BACK

The influence of UP by indirect versus direct steam injection on skim and 2% milk (Lee et al. 2017)

Flavor chemistry difference among milk processes by HTST or UP. (Jo et al. 2018)

Identification of source of volatile sulfur compounds produced during thermal processing of milk (Jo et al. 2019)

Hunter vs CIE color measurement systems for analysis of milk based beverages. (Cheng et al. 2019)

Effects of milk fat, casein, and serum protein concentrations on sensory properties of milk-based beverages (Cheng et al. 2019)

MILK BEVERAGES

LOOKING FORWARD

Reducing sugar in school lunch chocolate milk (Nakamura et al.)

Milkfat preference in unflavored and chocolate milk (Keefer et al.)

Role of packaging on unflavored and chocolate milk flavor. (Cadwallader et al.)

Role of complete lactose removal, fat and protein on physical and sensory properties of milk beverages (Hernandez et al.)

Role of cooling and storage on the flavor of aseptic milk (Cadwallader et al.)

REPRESENTING THE DAIRY BEST





Delivering desirable milk beverages

1

Understand how reducing
sugar
impacts acceptance

- The role of sugar reduction on flavor and acceptance of school lunch milk

School lunch chocolate milk that tastes great and has low or no added sugar!

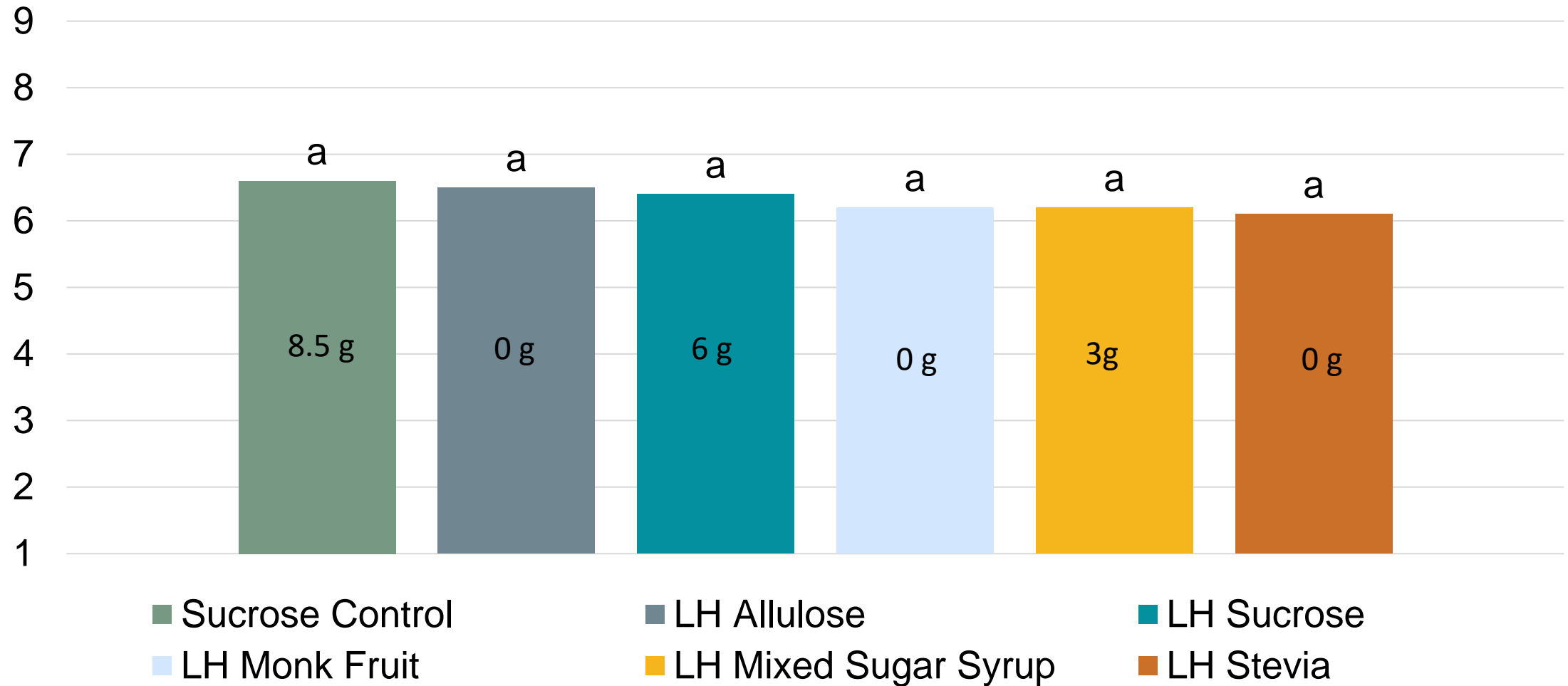
OBJECTIVE

Reduce sugar in school lunch chocolate milk

240 mL serving = 8.5 g added sugar

Consumer Acceptance of lactose *hydrolyzed* chocolate milks

School
Chocolate
Milk



N=160

LH = Lactose Hydrolyzed

Practical Application



Great tasting school lunch milk that is lactose free and has no added sugar

Delivering desirable milk beverages

1

**Understand how reducing
sugar
impacts acceptance**

- The role of sugar reduction on flavor and acceptance of school lunch milk

2

**Understand how package
and storage impact
aseptic milk flavor**

- The role of package and storage temperature on flavor of aseptic milk



Improving the flavor of aseptic milk

OBJECTIVE

Determine the impact of storage temperature of 1% aseptic milk on physical and sensory properties

Aseptic milk receives a similar DSI time/temp to ultrapasteurized milk but tastes quite distinct

- Are the differences due to storage time or storage temperature?
- Aseptic milk is filled warm and not cooled; UP milk is filled and chilled

Accomplishing this experiment, was no small effort

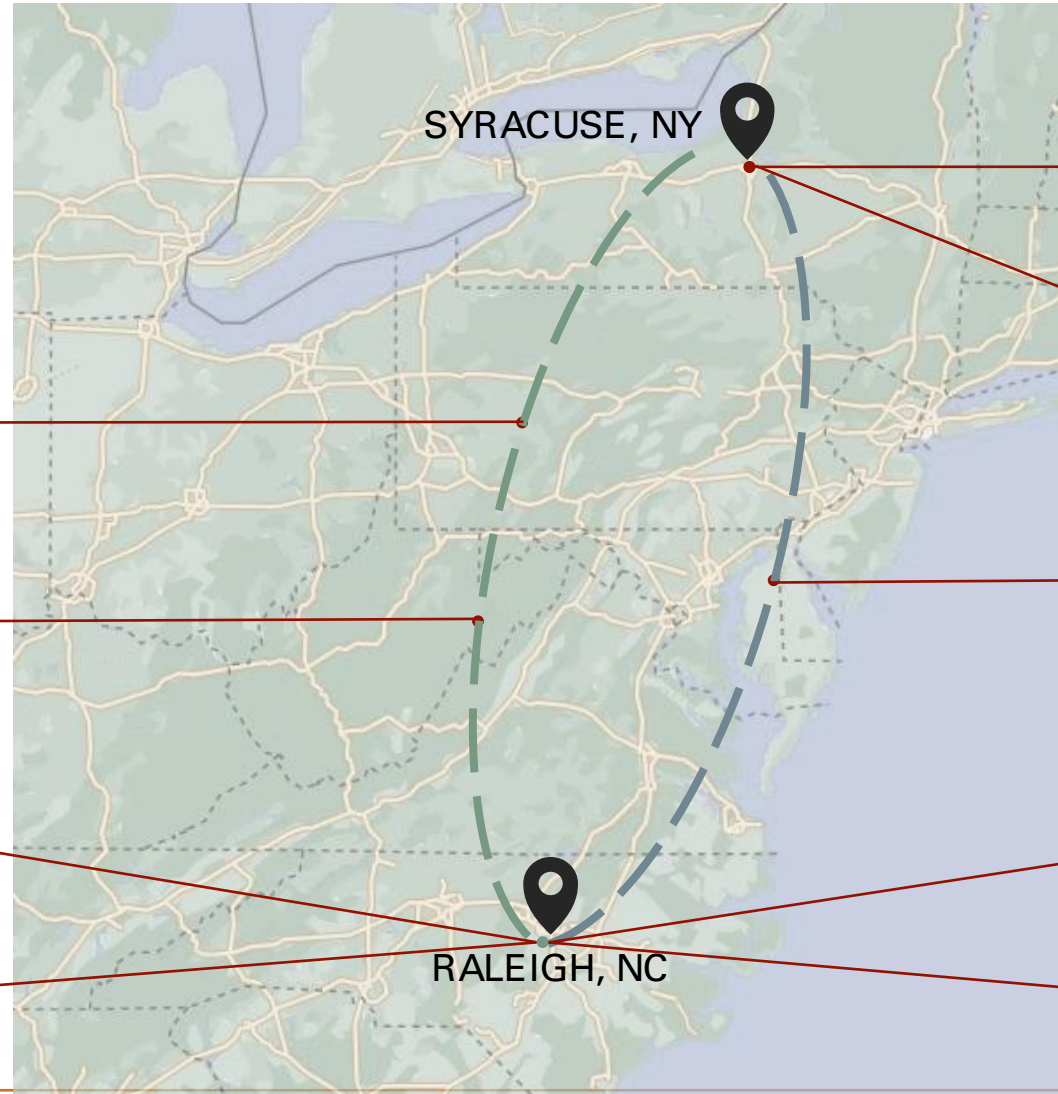
To ensure variables
(time & temp post aseptic fill) were
protected, special care with many
dedicated man hours was required

11hr drive
to Syracuse

Repeat for
REPLICATION 2!

Configure Logistics:
15 coolers, 1 rental van,
2 drivers, lots of snacks!

Wait for 'GO' call...



1

Identify a Supplier: Aseptic
milk right from filler (Byrne
Dairy)

5

Load 200 tetra bricks
for 4C and RT transport

6

11hr drive to Raleigh
maintaining temp & product
safety

7

Unload and store 200
tetra bricks at NCSU

9

Analytical, DA & CLT for timepoints
across
18m storage

4

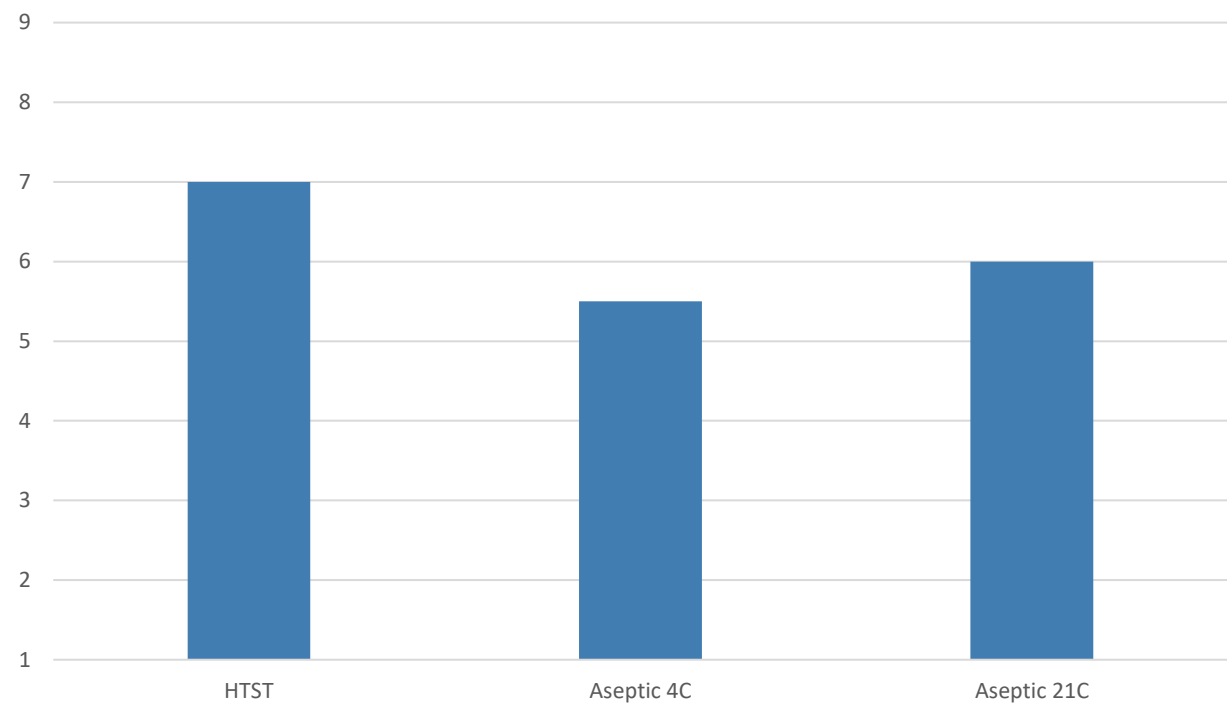
8

2

3

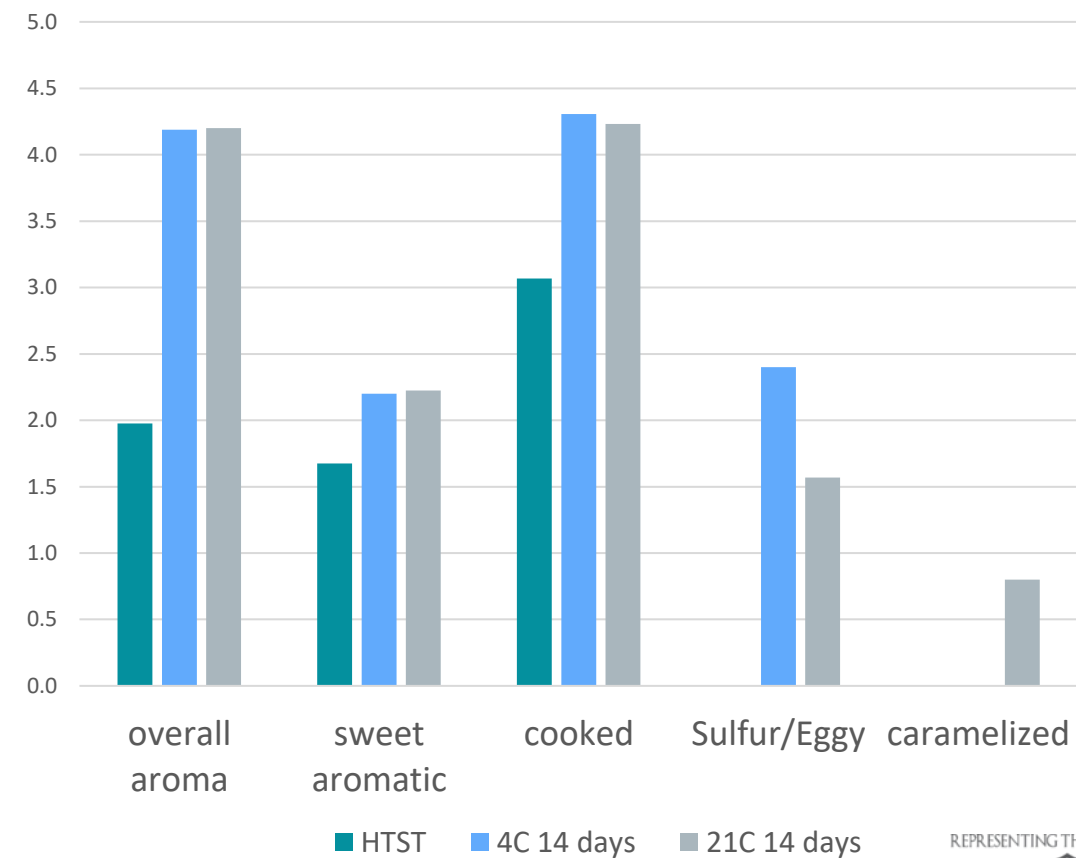
Aseptic milk flavor at 14 days

overall liking



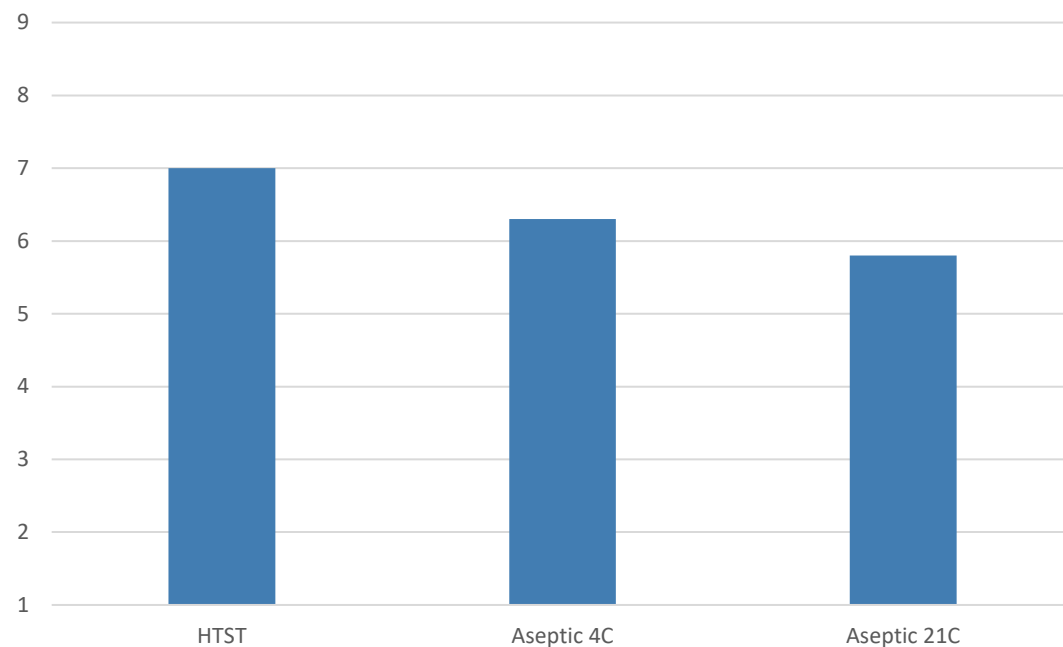
N=200 milk consumers

Trained Panel 14 days



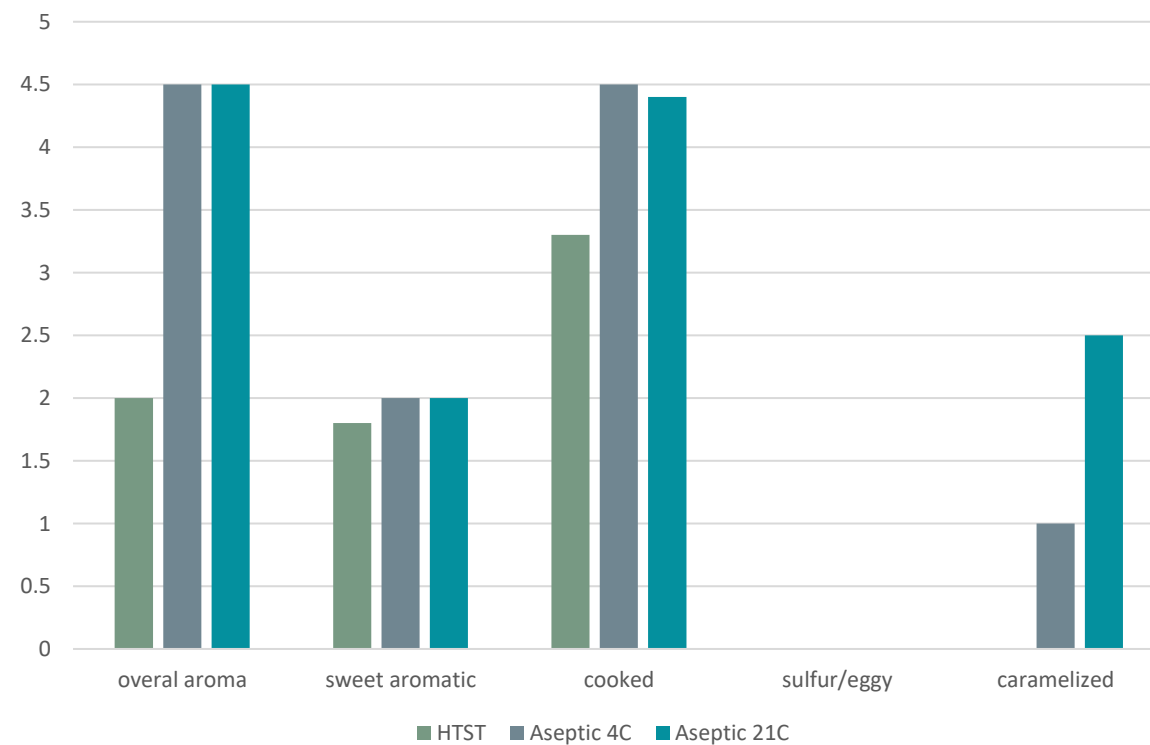
Aseptic milk flavor at 6 mo

overall liking 6 mo

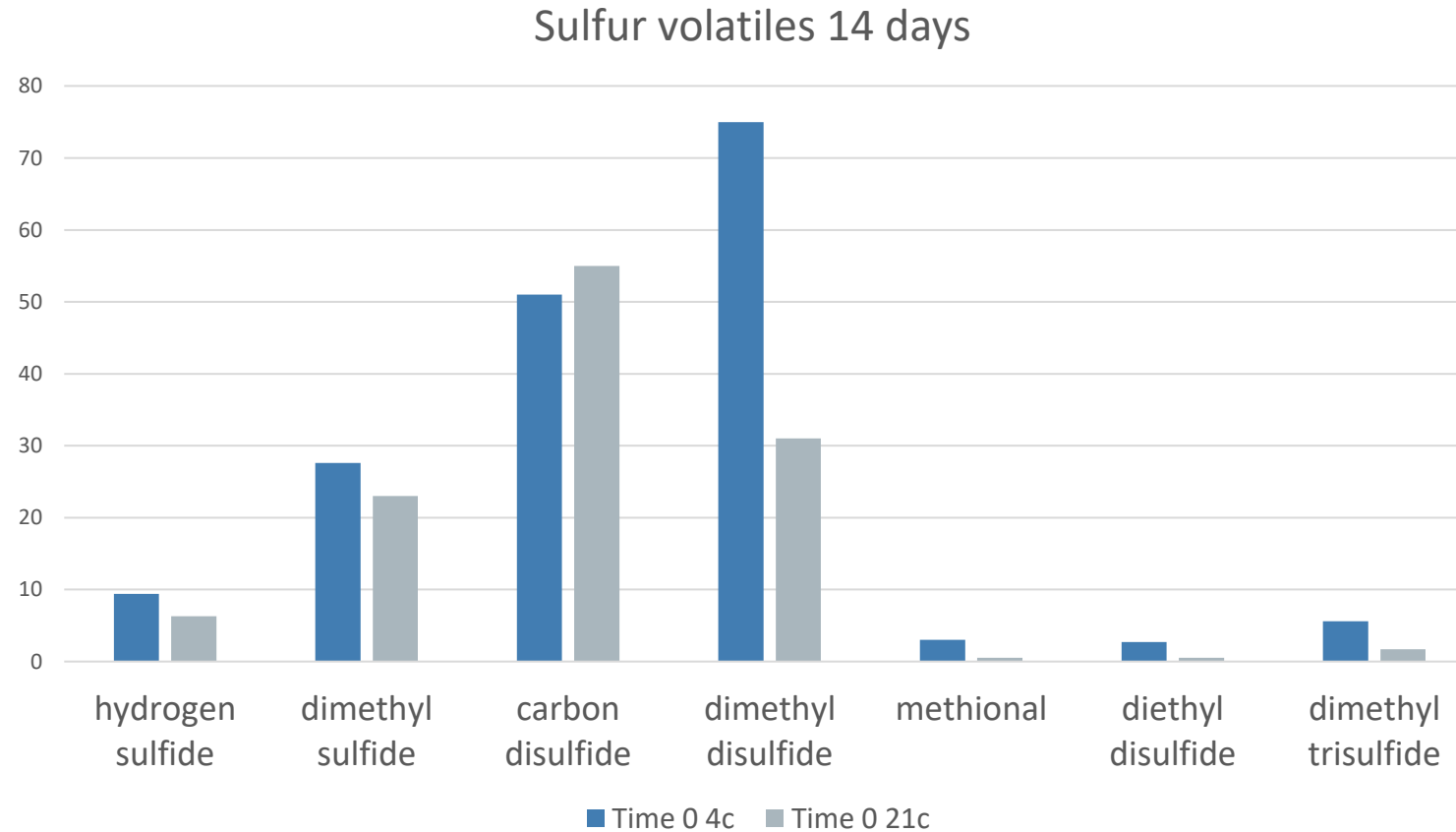


N=200 milk consumers

Trained Panel 6 mo



Sulfur volatiles impacted by storage temperature



Practical Application



Shelf stable milk that tastes great and meets consumer needs for convenience and sustainability

Delivering desirable milk beverages



1

Understand how reducing
sugar
impacts acceptance

- The role of **sugar reduction** on flavor and acceptance of school lunch milk

2

Understand how package
and storage impact
aseptic milk flavor

- The role of package and storage temperature on flavor of **aseptic milk**

3

Understand how
processing and
composition
impact flavor

- The role of **complete lactose removal, fat and protein** on physical and sensory properties of milk beverages

REPRESENTING THE DAIRY BEST

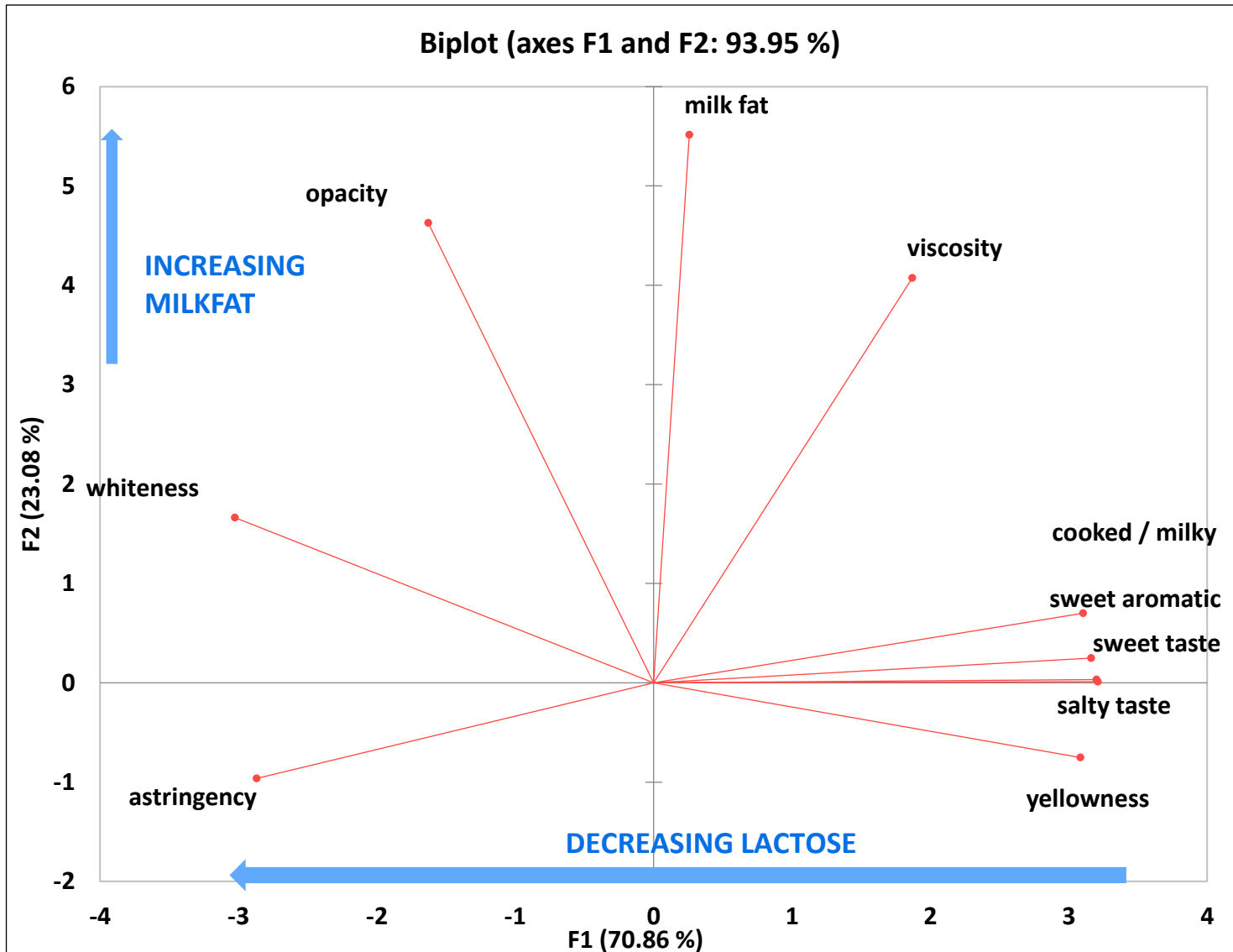


Milk beverages that are lactose free

OBJECTIVE

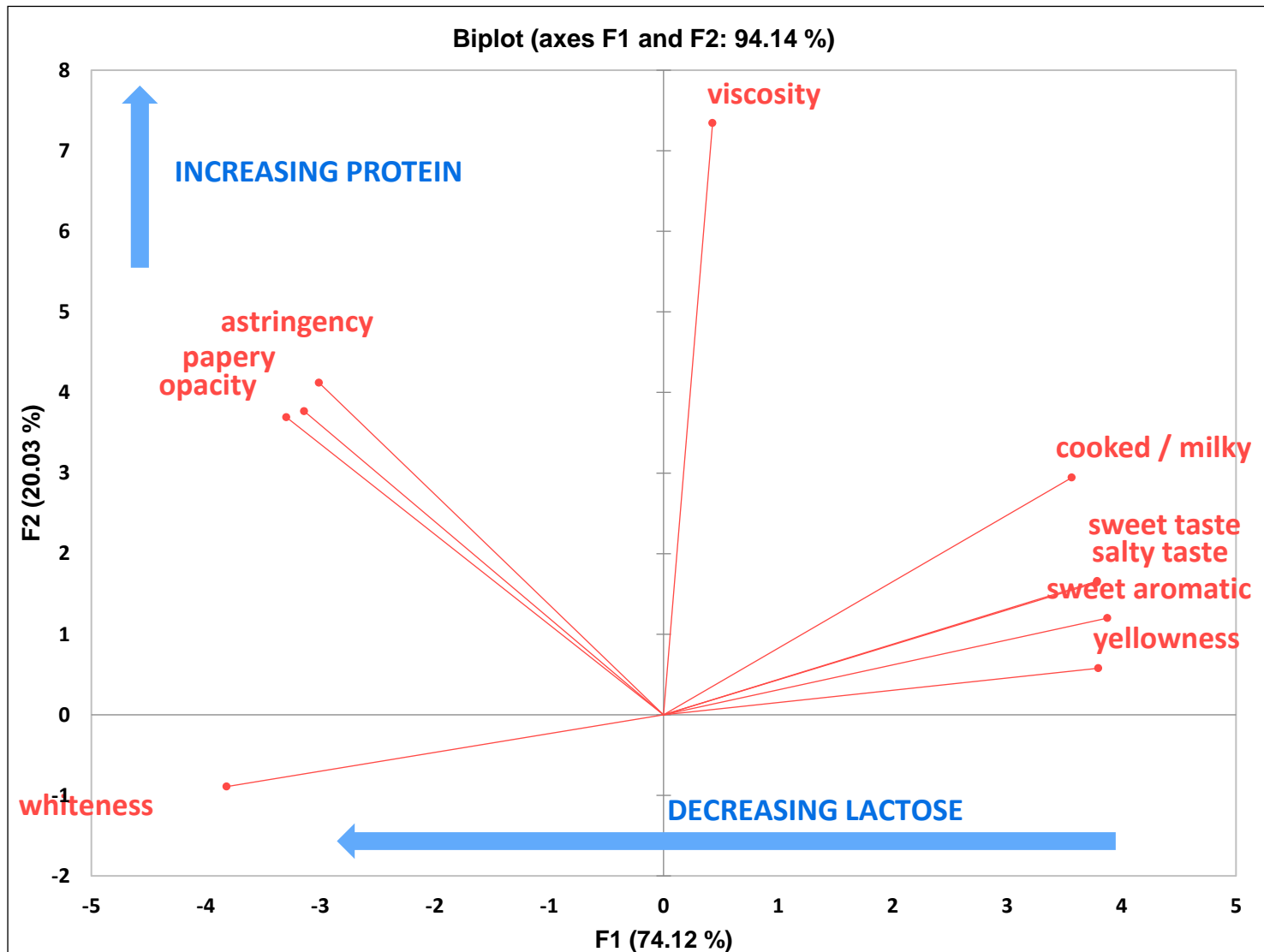
Determine the impact of full lactose **removal by UF**, fat and protein on sensory and physical properties of milk

Exp. 1 – Fat impacts flavor & appearance



- Lactose removal increased appearance/whiteness and astringent mouthfeel
- Lactose removal decreased cooked/milky, sweet aromatic, sweet and salty tastes
- As milkfat percentage increased so did milkfat, cooked/milky and viscosity

Exp. 2 – Protein impacts flavor & appearance



- Lactose removal increased whiteness and astringency
- Lactose removal decreased cooked/milky, sweet aromatic, sweet and salty tastes
- As protein percentage increased so did opacity, papery, viscosity, and astringency

Practical Application



Lactose free milk beverages can be manufactured by removal of lactose using ultrafiltration (UF)

- Produce a wide range of sensory properties and nutrients to consume as-is or as a lactose free (and sugar free) base for manufacture of flavored milks.

DAIRY PROTEIN BEVERAGE PLATFORM



Dairy Protein Beverage Platform

LOOKING BACK

Effect of dairy protein type (MPC and MCC) on beverage flavor and physiochemical properties (Vogel et al. 2021)

Viscosity and gel formation of MCC (Dunn et al. 2021)

Effect of MCC purity on sulfur eggy flavor in protein beverages (Whitt, Pranata et al. 2022)

DAIRY PROTEIN BEVERAGES

LOOKING FORWARD

Role of mineral composition, pH and added minerals on heat stability of milk protein

Dipotassium phosphate impact on milk beverage viscosity and color (Hoyt and Pranata et al.)

The impact of hot and cold UF on mineral balance and heat stability on MPC (Truong et al.)

Physical properties heat stability of lactose free micellar casein concentrated model beverages

The role of retort vs. DSI UP on physical and sensory qualities of protein beverages (Liu et al.)

Delivering desirable protein beverages

1

Understand how
processing impacts flavor

- Dipotassium phosphate
impact on beverage
physical properties



Protein Beverage Additives

Often added to improve mouthfeel and heat stability

Consumers do not want these ingredients!

Common additives

Calcium Chelators

Bind calcium and prevent protein aggregation (de Kort et al., 2012)

Hydrocolloids

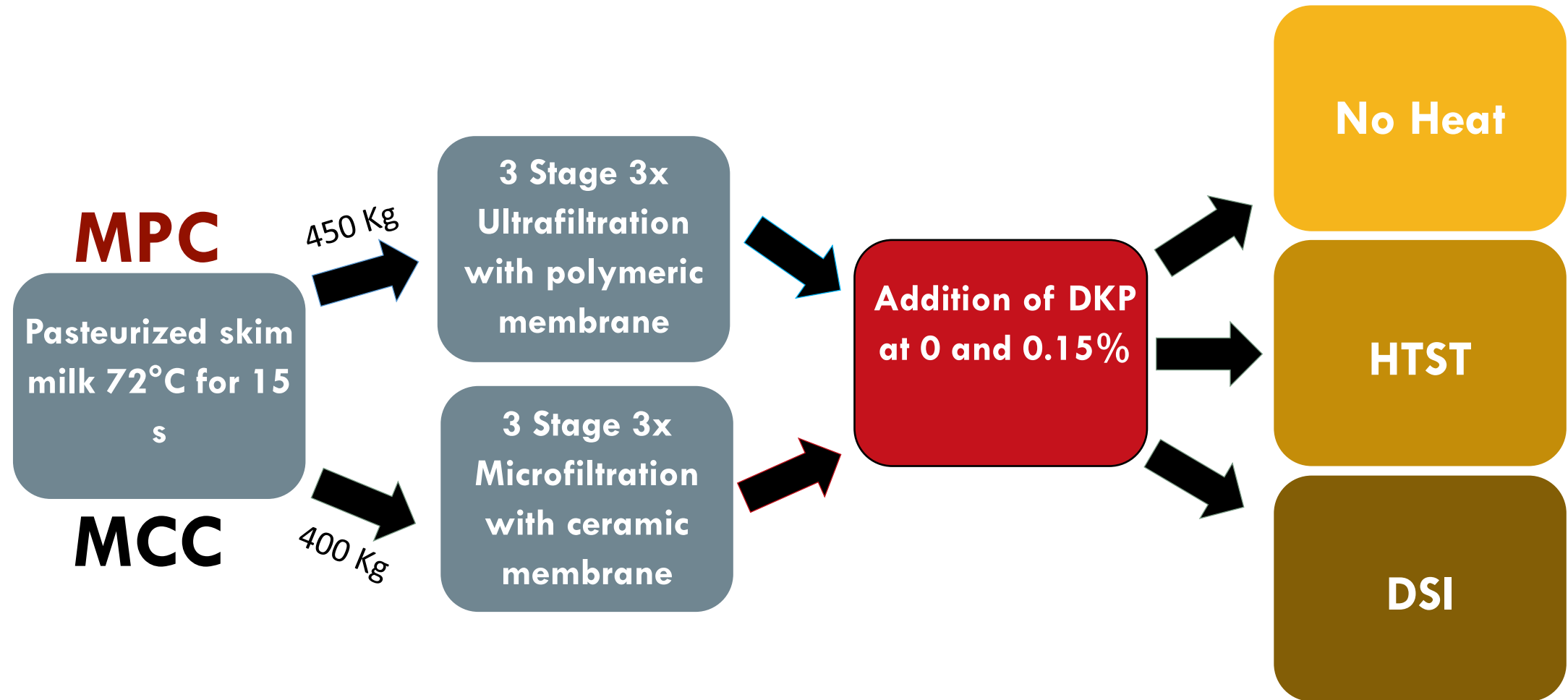
Group of polysaccharides and proteins that either provide texture (thickening agent) or produce a gel network (gelling agent) that can suspend small particles and can increase viscosity of a food system (Fallourd and Viscione, 2009; Williams and Phillips, 2009)

Dipotassium phosphate

(**DKP**: K_2HPO_4) is a common ingredient used in dairy creamers processed under UHT conditions to prevent changes in coagulation (National Center for Biotechnology Information, 2022)



Experimental Design



These experiments were done in duplicate

Beverage Processing

No Heat

- Beverages received no heat treatment after filtration and addition of DKP

HTST Processing

- 72°C for 15 seconds

DSI Processing

- 140°C for 2.3 seconds



Practical application and future work

The findings from the study may be useful for beverage manufacturers in the formulation of clean label dairy protein beverages. **DKP is not needed at 7.5% protein.**



Future work

- The role of phosphates and other salts in high protein beverages
- Clean label approaches to control viscosity and protein aggregate particle size in shelf-stable high protein milk based beverages.

A photograph of a cow grazing in a field, partially obscured by a diagonal white line that separates it from the red background.

OPPORTUNITIES: Moving Forward

Tremendous opportunities exist for positioning of dairy foods to deliver what consumers **STILL** want

- **Flavor and functionality**
- **Minimal ingredients/clean label**
- Nutrition
- Education, messaging, positioning



A photograph of a black and white cow grazing in a green field under a blue sky. The image is partially obscured by a red diagonal graphic element that serves as a background for the text.

Dairy Beverage Platform: Moving Forward

Ongoing work:

- Clean label milk and milk protein beverages
 - Processing parameters to optimize flavor and functionality
- Consumer messaging:
 - Clean label
 - Local
 - Dairy Education (virtual vs on farm)

Acknowledgements

Collaborator:
Dave Barbano, Cornell
University



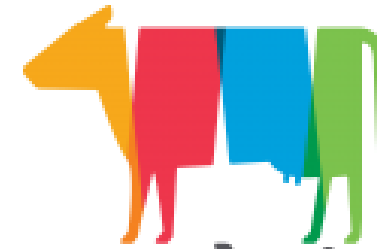
MAD Lab 2022

Acknowledgements



**Sensory
Service
Center**

DMi
DAIRY MANAGEMENT INC.™



PIONEERS BY NATURE
dairy west



**THE DAIRY
ALLIANCE**

