The Surprisingly Practical New Nutrition Effort Linking Agriculture and Health

PRESENTED BY
P. Stephen Baenziger, PhD
Rod Wallace, PhD

Oklahoma Academy of Nutrition and Dietetics

P. Stephen Baenziger

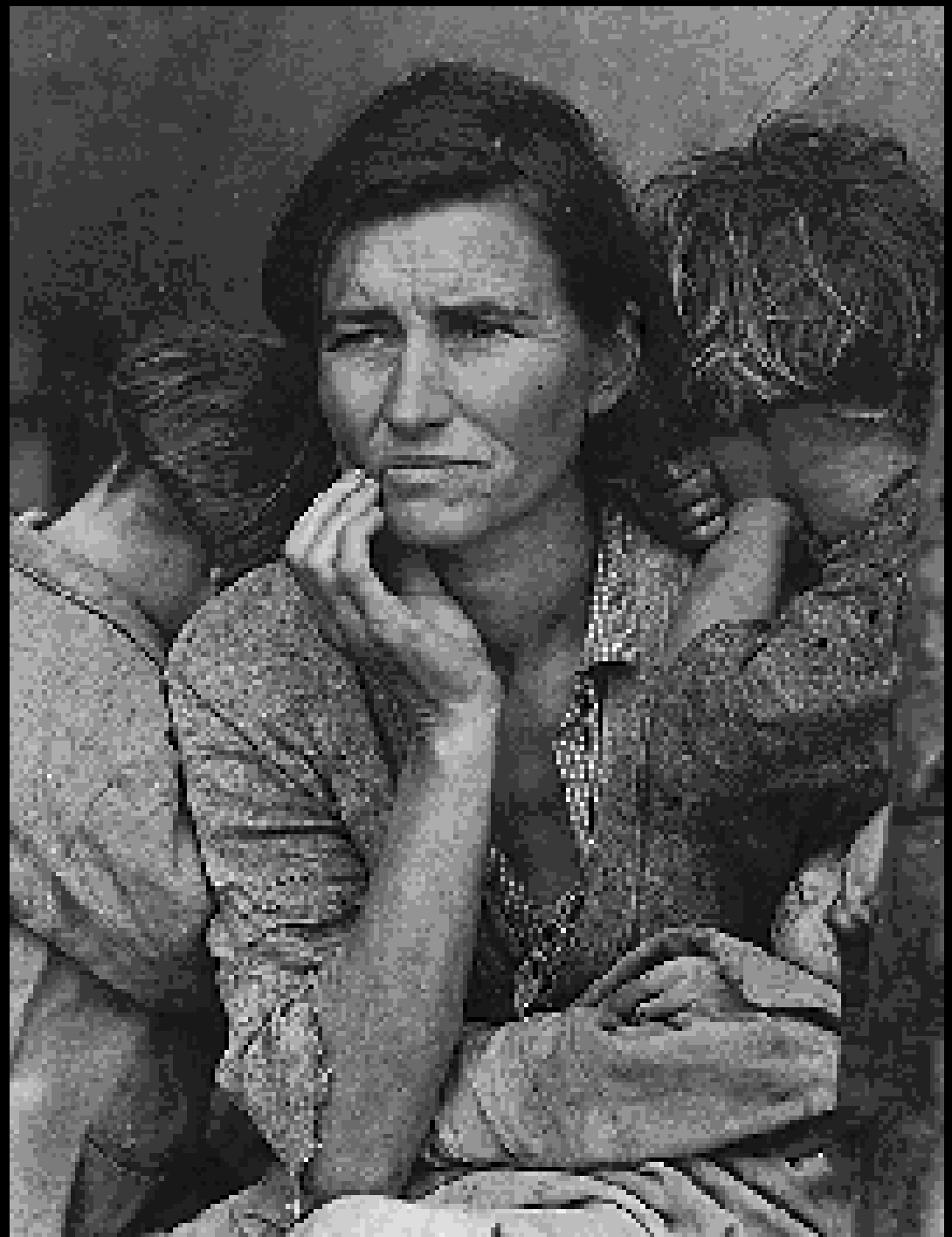
- Started my breeding career in 1976 working on small grains. Common thread is wheat. Sometimes and currently barley and triticale.
- Worked at the USDA-ARS, Monsanto, and the University of Nebraska.
- Released 46 winter wheat, 8 winter barley, and 14 winter triticale cultivars.
- Have 325 peer reviewed publications, 32 symposia and proceedings, 16 book chapters, and one CAST Issue paper.
- Retired in 2021, Joined FIHF in 2022.

P. Stephen Baenziger

My why:

Freedom from want

Conflicts: None to Declare



Rod Wallace

- Experience across companies in food and agriculture, including key roles in strategy development and front-line leadership for flour milling, grain elevation, oil refining, cocoa and chocolate, and corn processing.
- Worked at the Japanese Ministry of Trade, Economy, and Industry as Fulbright Fellow, at Cargill, and bought a small power plant in France.
- The only PhD economist to have sold over a $billion in vegetable oil
- President of FIHF since 2021.

Rod Wallace

My why:

Leave the world a better place for my kids.

Conflicts: None to Declare

Who We Are…

Oklahoma Academy of Nutrition and Dietetics

FOUNDATION FOR INNOVATION IN HEALTHY FOOD

COALITION FOR GRAIN FIBER

We are a broad-based grassroots 501(c)3 nonprofit seeking to save lives and reduce healthcare costs at global scale, by increasing nutrition in everyday foods

Topics

An Emerging Paradigm

- The Challenge—A Brief Review
- The Approach—This is Doable
- Request for Insights and Help from OKAND

Baenziger et al., 2023. Nature Food 4: 5-6

Chronic Disease Kills Millions and Costs Billions

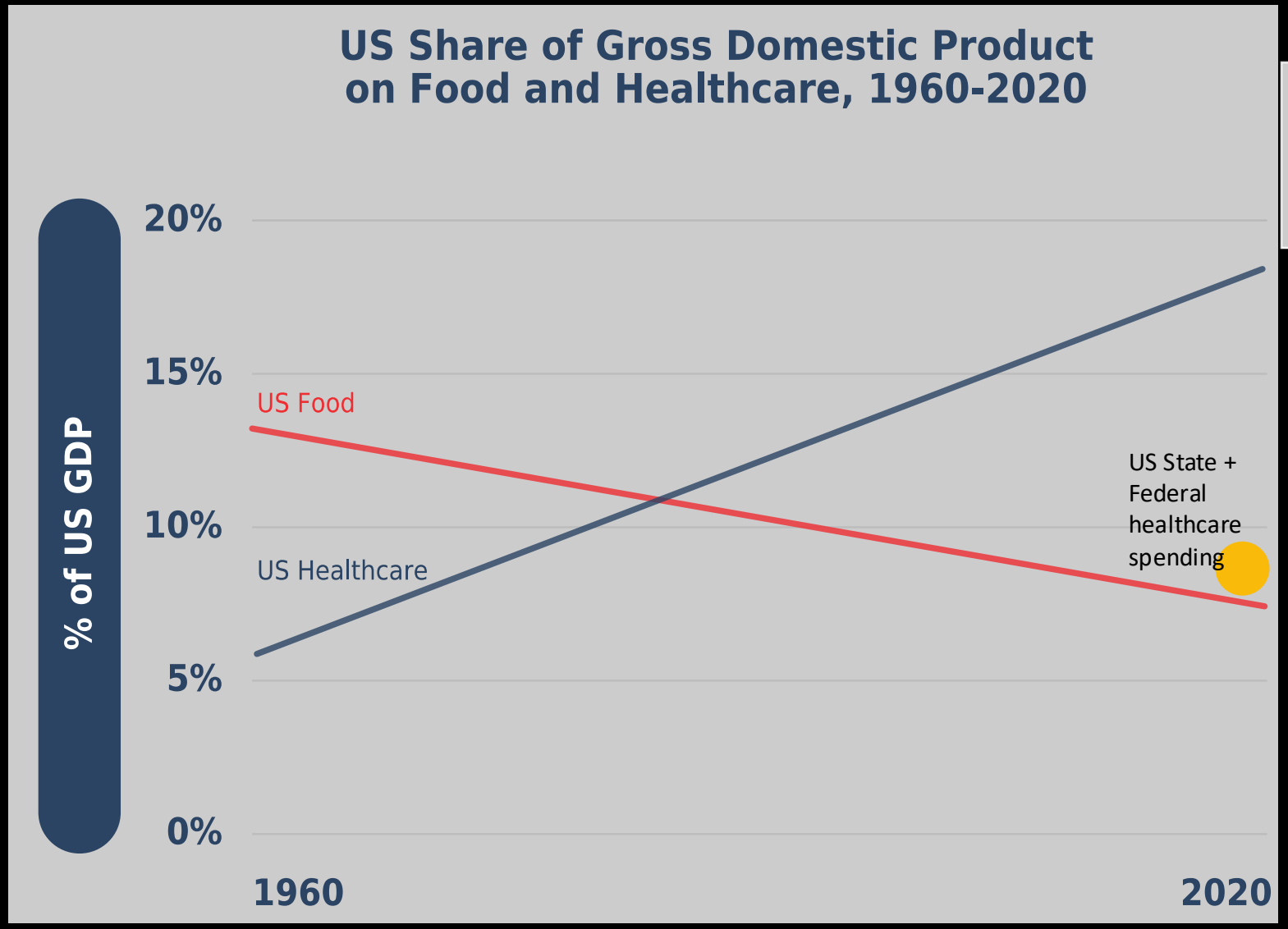
Nutrition can Make a Difference

Diabetes kills every 5 seconds.

Cardiovascular disease, every 2 seconds.

Nutrition Can Help

Now Is the Time
Shifting National Trajectory of Chronic Disease



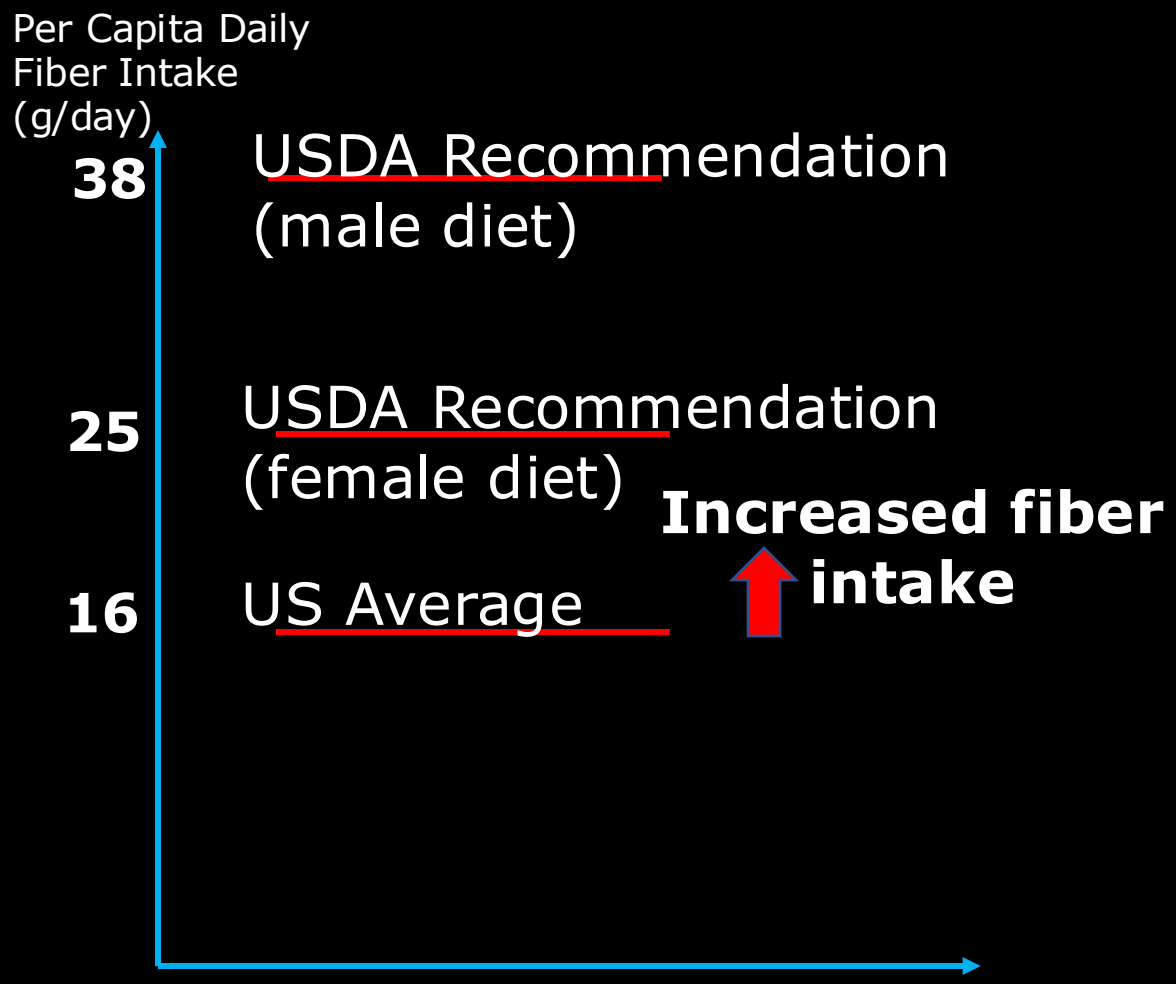
"We will make our tax dollars support healthy foods." Robert F Kennedy

"Instead of focusing on who covers our exorbitant health care costs, we need to reduce these costs by directing our attention to prevention and keeping people healthy." Lisa Murkowski (R) Alaska

Dietary Fiber

Under-consumed Nutrient of Concern

A Step in the Right Direction



Authoritative Scientific Bodies (including USDA)

- Fill gap in dietary fiber intake linked with improving health outcomes.
- Support food-based approach with fiber component in complex system
- Cereal fiber is prominent in National Academy of Sciences discussion of CVD
- Dietary fiber is one of four under-consumed nutrients of concern for entire population (calcium, potassium, vitamin D, dietary fiber)

Immense Cost of Chronic Disease

Impacted by Dietary Fiber

Oklahoma Academy of Nutrition and Dietetics

2% reduction = $200/ year

US Healthcare Cost of Cardiovascular Disease (CVD) + Diabetes

National
$700 Billion
Each year

50 times larger than annual US Wheat Crop ($10-20B)

Family of 5
Over $10,000
Each year

+ Others

Evidence Suggests Dietary Fiber CUTS

Including: obesity, chronic kidney disease, periodontal disease, cognition, depression, anxiety, ADHD, diabetic retinopathy, head and neck cancer, gut cancers, tinnitus, female fertility, pulmonary disease, arthritis, and depression.

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Enrolling America's Favorite Foods

Wheat and the Fight vs Chronic Disease

- 20% of global calories and protein
- White flour fortification cuts birth defects 25-50%
- Largest source of fiber in American diets (33%)
- Non-GMO US crop

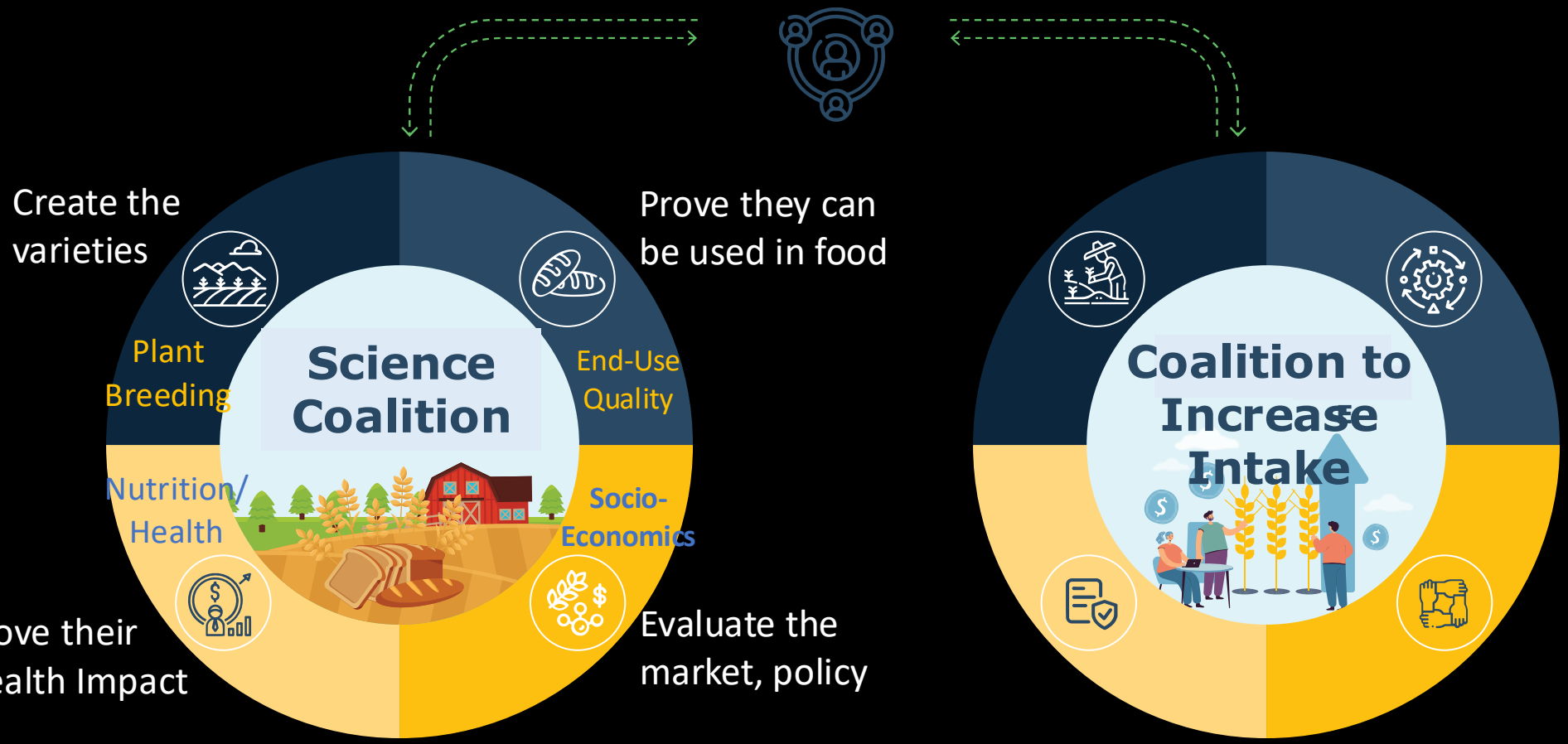
Langridge et al. 2022, Agronomy12: 2767

How do we increase wheat dietary fiber ?

Coordinated, Low-Cost, Transformation

"Little Hinge"

Coordinator & Connector



If you want to go fast, go alone.
If you want to far, go together. African Proverb

World-Class Science Team
Dedicated to Transforming Food

Over $3,000,000 in volunteered time

Over 50 Laboratory Leaders

25 States and 5 Nations

27 Full Professors

6 Distinguished Professors

1 Winner of the Wolf World Award for Agricultural Science

Research endorsed by Nobel Peace Laureate

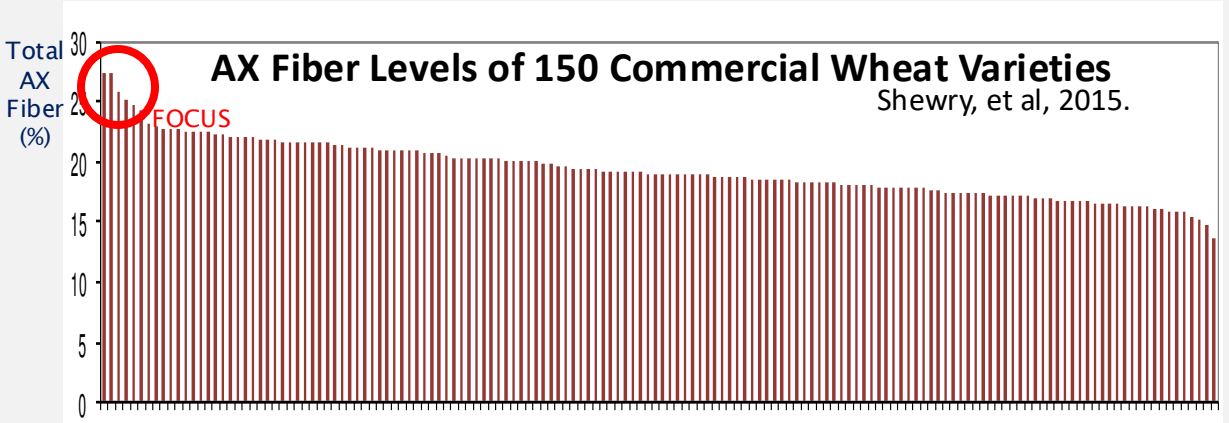
Experience from across the wheat supply chain, food industry, and beyond.

What are the key questions?

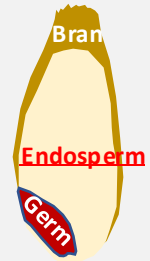
- Will the new varieties be grown—are they competitive?
- Can higher fiber wheat be milled commercially?
- Will the higher fiber wheat still be good in commercial scale wheat-based products?
- How will higher fiber wheat-based products taste and what is their mouth feel?
- Are there barriers to adoption?
- Do you want adoption to go fast or do you want adoption to go slow?

Enrolling the World's Favorite Foods in the Fight Against Disease
Search for Existing Variation

Situation: Wheat (a non-GMO crop) is the #1 source of fiber* in the American diet (33% of total) – although wheat plants *naturally vary* in amount.



Action: Grow wheat varieties with more fiber in white flour and whole wheat* to benefit all socioeconomic groups, with no change in consumer behavior.



* Fiber in endosperm cell walls

We aim for NO consumer price impact on staple foods.

* Wheat is the #1 source for dietary fiber-- an under-consumed nutrient of concern for the entire US population– according to US Dietary Guidelines and other esteemed scientific bodies globally. Fewer than 5% of individuals incorporate recommended intake in their diets.

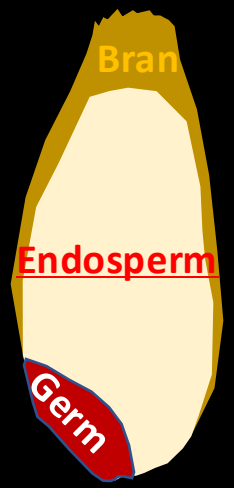
Arabinoxylan in Wheat

Wheat Biology

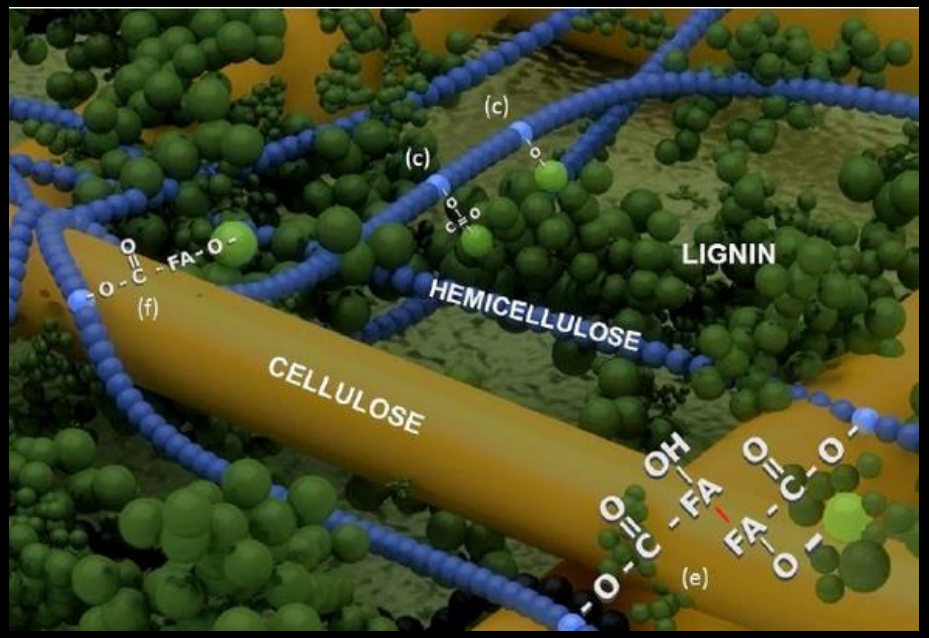
Endosperm cell walls

(In white flour *and* whole grain)

'Stackable' fiber trait



Izydorczyk, 2023.
Handbook of Hydrocolloids (pp. 399–461).



Fiber in wheat
- Cell Wall
  - Cellulose
  - Arabinoxylan
  - Beta-glucan
  - Lignin
  - Glucomannan

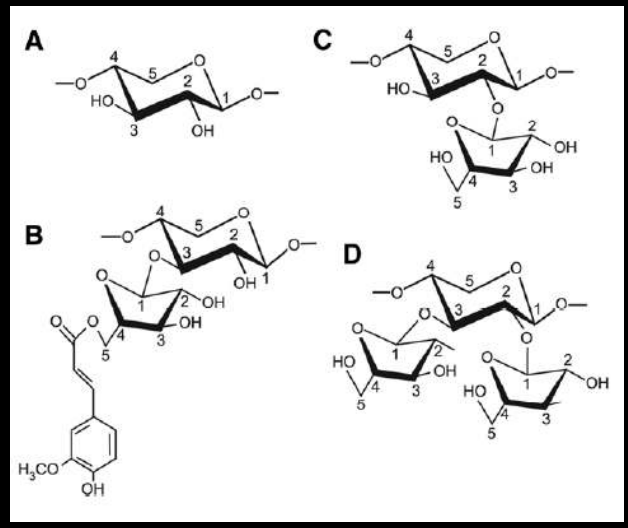
Fructans (FODMAPS)
Resistant Starch

Arabinoxylan: A Class of Dietary Fiber

β 1-4 linked D-xylose units as the backbone (A)

Monomeric α-L-arabinose units linked at the 2 and/or 3 carbon position. (C & D)

Ferulic acid can be bound to arabinose at the 5 carbon position (B)

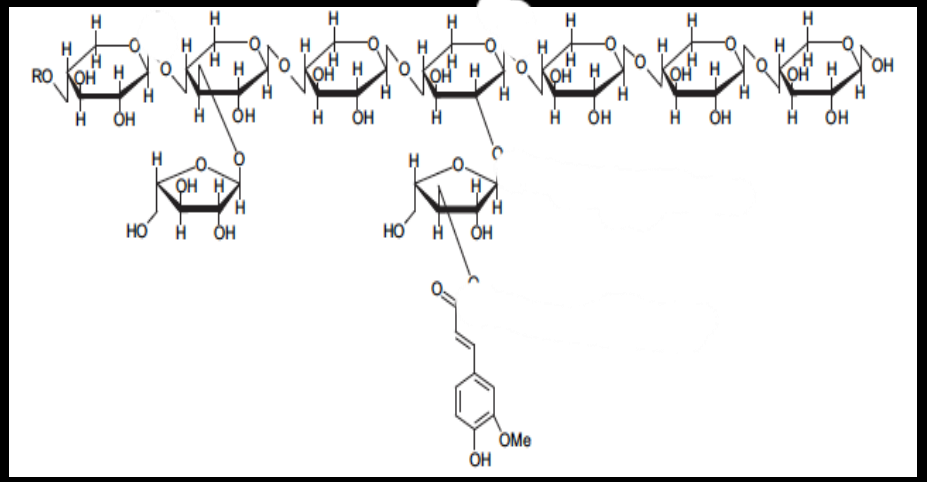


Degree and patter of substitution determines water solubility

Wheat has both:

Water Unextractable AX (WUAX)

Water Extractable AX(WEAX)



Kiszonas et. al. 2013. Cereal Chemistry, 90(4), 387–395.

Arabinoxylan

Very high Likelihood of Technical Success, based on 19+ years UK BBSRC research, Other research foundation

BREEDING

- Non-GMO natural variation
- 5 + year development
- No long-term yield loss or other agronomic impact
- 2 QTLs in UK, France, China bread wheat varieties
- High heritability (60-70%)
- Can be integrated in any region's wheat
- Available royalty free, to any interested party

Second Wave: 5-7 years

Improving Wheat Lines with Traditional Plant Breeding

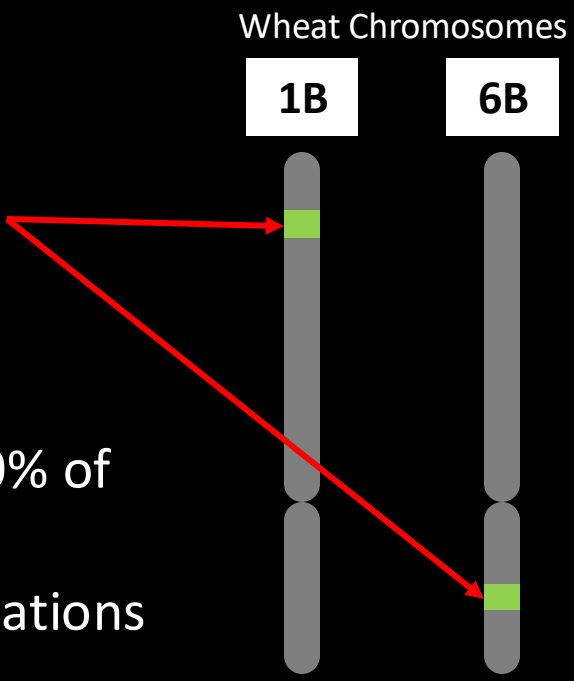
Oklahoma Academy of Nutrition and Dietetics

Lincoln, NE High Fiber Wheat Test Plot

Science: High Fiber Parent Wheats → High Fiber Next Generation (non-GMO)

- Positive alleles w/ available markers

- Genetics explain 70% of variation
- Gene (QTL) combinations multiply impact



Lovegrove et al., 2020. PLoS ONE, 15(2). https://doi.org/10.1371/journal.pone.0227826

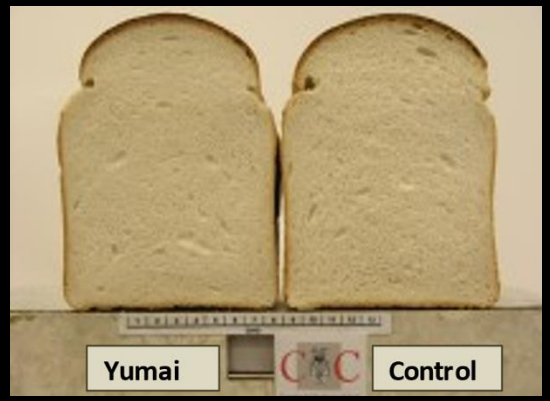
Arabinoxylan (AX) in Baking

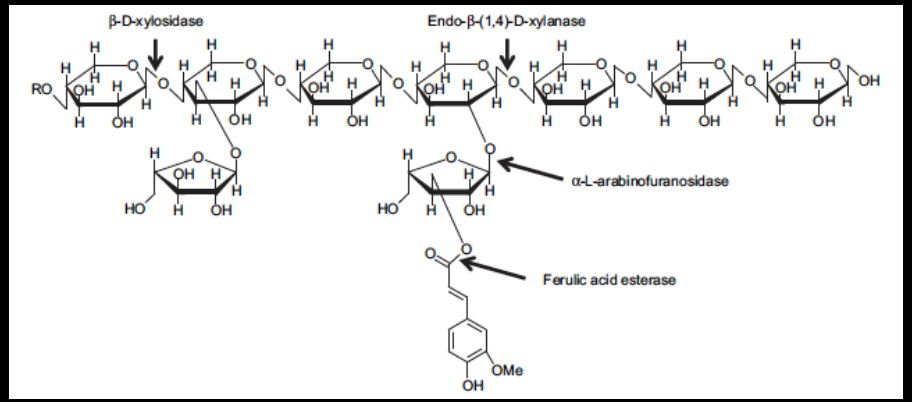
END-USE-QUALITY

- Measurements of arabinoxylan in flour reflect arabinoxylan in the finished product.
- Arabinoxylan is stable in fermentation and in baking.
- Enzymes can correct negative or enhance the positive effects of arabinoxylan

- HARD WHEAT: Acceptable bread for US, UK baking:
  - ✓ Less impact than shift old to new crop
  - ✓ Aim for NOT identity preserved
  - ✓ High fiber wheats were commercially sold.
- SOFT WHEAT: Potentially for doughy applications only

UK Bread Test



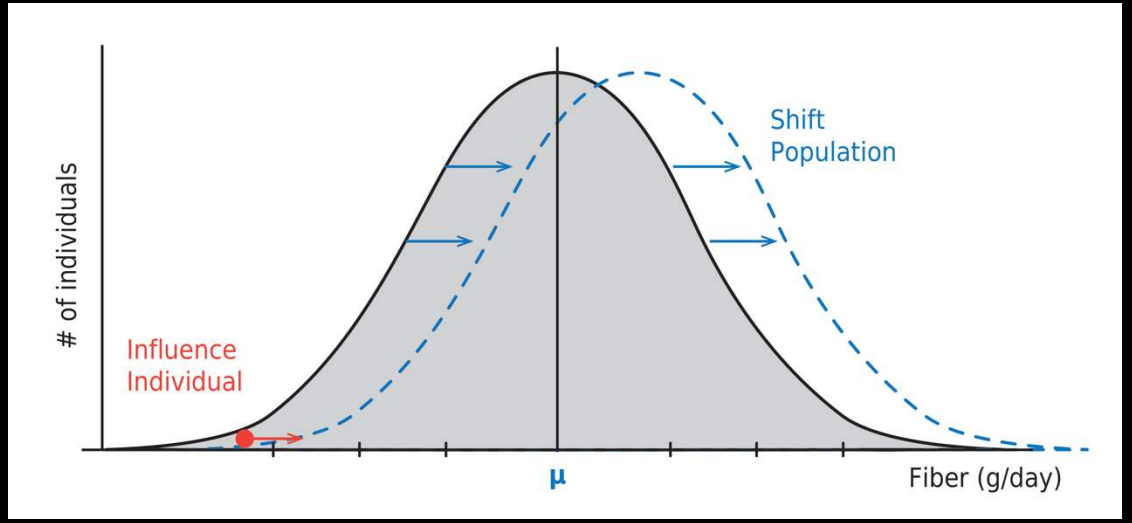


Kiszonas et al., 2015. Int. Journal Food Sci. Tech. 50: 1911-1921.

Arabinoxylan

PUBLIC HEALTH

- Dietary fiber under-consumed nutrient of concern (US Dietary Guidelines, NASEM guidance), Global need
- Modest increase, several times a day, billions of people



- No major side effects from increased arabinoxylan.
- Remember not all arabinoxylans are the same, so we need to prove the known fiber benefits extend to arabinoxylan.

The market For Higher Fiber Wheat

- Does not have to be identity preserved but could be.
- Do you want to fast or slow? An ounce of prevention is worth a pound of cure.
- Do you need incentives and yes where should they go? Paid from healthcare savings.
  - Farmer/producer
  - Elevator
  - Miller
  - Baker
  - Consumer

Our goal is not to change the existing commodity market.

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With healthier food innovations and introductions:

- What have we learned that worked well.
- What have we seen that did not work well.
- How do we use past successes, learn from past failures, to build a communication and implementation strategy that promotes the creation of healthier foods that we love and already eat.

How Will This Approach Affect Dietitians and Nutritionists.

- If we are successful, the food labels will reflect higher fiber in wheat-based products (assumes a commodity change).
- There may be higher fiber specialty products (identity preserved marketing)
- There may be markets for low fiber cereals needed for some medical conditions.

Questions:

- How do we prepare the consumer for these changes (those that are health conscious and those that are not).

Integrated Diet Perspective

Dietary Fiber Background for Food Service Implementation

- Food Options (Dietary Guideline Focus)
  - Dietary fiber is under-consumed nutrient of concern globally
  - Eat more fruits, vegetables, and legumes
  - At least half of all grains consumed are whole grains; other half fortified
  - E.g., 'Chia yogurt' (chia seeds + milk)
- Community Culture and Economic Environment

Our Focus

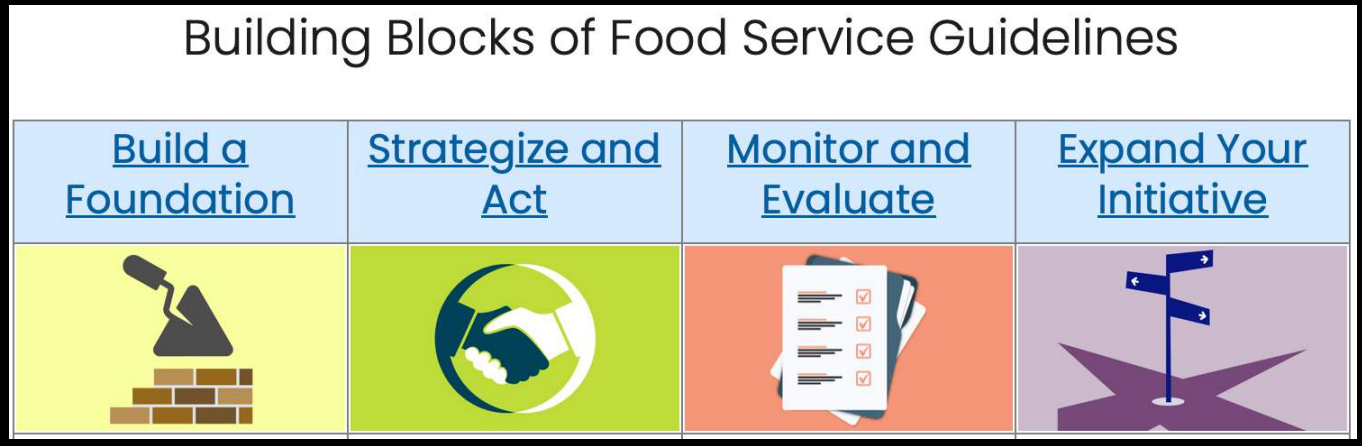
- Food Production and Processing
  - Increased-fiber wheat options exist for most most white flour and whole grain foods
  - Several fruit, vegetable varieties vary in fiber; peels tend to be high in fiber
  - Banana fiber:
    Green 15 g; ripe 4-5 g; over-ripe 2 g
  - Twice-cooked, refrigerated carbohydrates (rice, wheat, corn, potatoes) materially increase resistant starch levels, which acts as a dietary fiber.
- Health Impact

Food Service Implementation

Supporting Healthier Diets, without Relying on Behavior Change

We plan to explore and develop standards that align diets more closely to guidelines by improving foods people already choose to eat:

- Focus is on commodity production, processing, and formulation choices.
- We look forward to collaboration, including with health insurers.



This approach builds on Center for Disease Control (CDC) standards for healthier food service operations focused on food options, food safety, less waste, 'buy local'

Current Center for Disease Control (CDC) standards for healthier food service focus on food options, safety, waste, and local E.g., offer at least 3 fruit options daily; offer half of total grains as whole grains. We suggest highlighting more nutrient rich food production and processing options.

We Need You

Request for Insights and Help from OKAND

- How do you suggest we modify or materially shift the approach and message?
- From your perspective, what are the biggest risks and hurdles to overcome?
- What opportunities may there be to leverage this new paradigm with your clients?
- Where should we focus to have the greatest impact?
- Can you help us share our message with your people, in the way they need to hear it?

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How to Contact Us

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Foundation for Innovation in Healthy Food: https:/fihf.org

Coalition for Grain Fiber: https://fihf.org/coalition-for-grain-fiber/


Better food for better lives.

Topics

An Emerging Paradigm

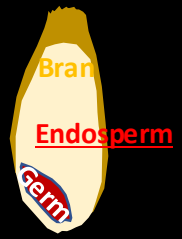
- The Challenge
- The Approach
- The Impact
- How We Can Work Together

Arabinoxylan

85%+ Likelihood of Technical Success, based on 19+ years UK BBSRC research, Other research foundation

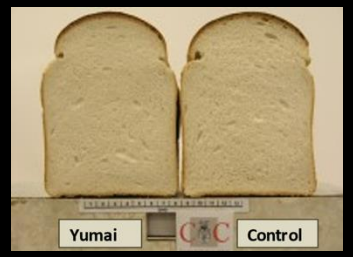
BREEDING

- Non-GMO natural variation
- 5 + year development
- No long-term yield loss or other agronomic impact
- 2 QTLs in UK, France, China bread wheat varieties
- High heritability (60-70%)
- Can be integrated in any region's wheat
- Available royalty free, to any interested party



BIOLOGY

Endosperm cell walls
(In white flour *and* whole grain)
'Stackable' fiber trait



END-USE-QUALITY

- HARD WHEAT: Acceptable bread for US, UK baking:
  - ✓ Less impact than shift old to new crop
  - ✓ Aim for NOT identity preserved
- SOFT WHEAT: Potentially for doughy applications only

PUBLIC HEALTH

- Dietary fiber under-consumed nutrient of concern (US Dietary Guidelines, NASEM guidance), Global need
- Modest increase, several times a day, billions of people
- No major side effects

MARKETING

- Government financial incentive paid by health saving; consumers' price for staple foods remains unchanged

How do You Accomplish this effort?

- You have to build a team to coordinate the science and policy.

Plant Breeding	End-Use Quality	Nutrition/ Health	**Socio-Economics**
Create the varieties	Prove they can be used in food	Prove their Health Impact	Develop the market

If you want to go fast, go alone.
If you want to far, go together.

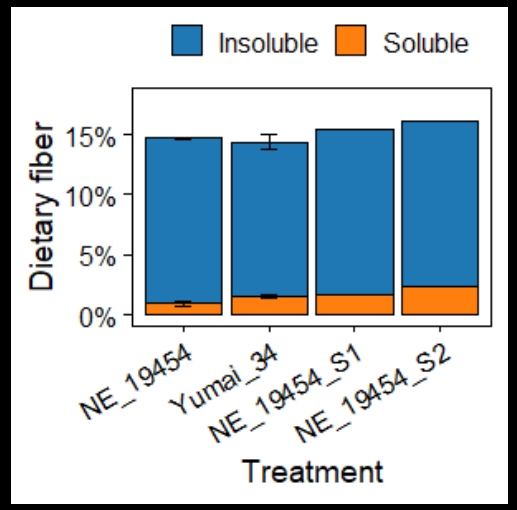
African Proverb

Arabinoxylan Fiber Impact

Testing Small Dose Increases in Wheat Arabinoxylan

Description under review

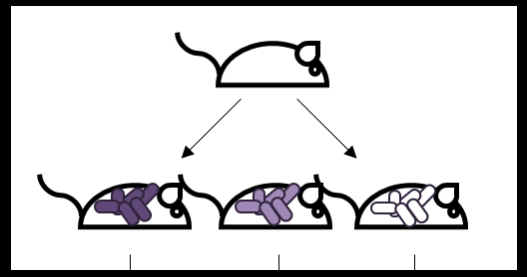
Positive In Vitro Gut Microbiome Test



Results consistent with hypothesis:

- Low-dose fiber increase, Propionate ↑
- Slightly reduced ASVs (Amplicon Sequence Variants)

Human Microbiota-Associated Mouse Study



Feed control low-fat (LF) diet or Western diet containing 30% wheat with varying fiber levels:

↓ 12 Weeks ↓

Human Studies to Follow

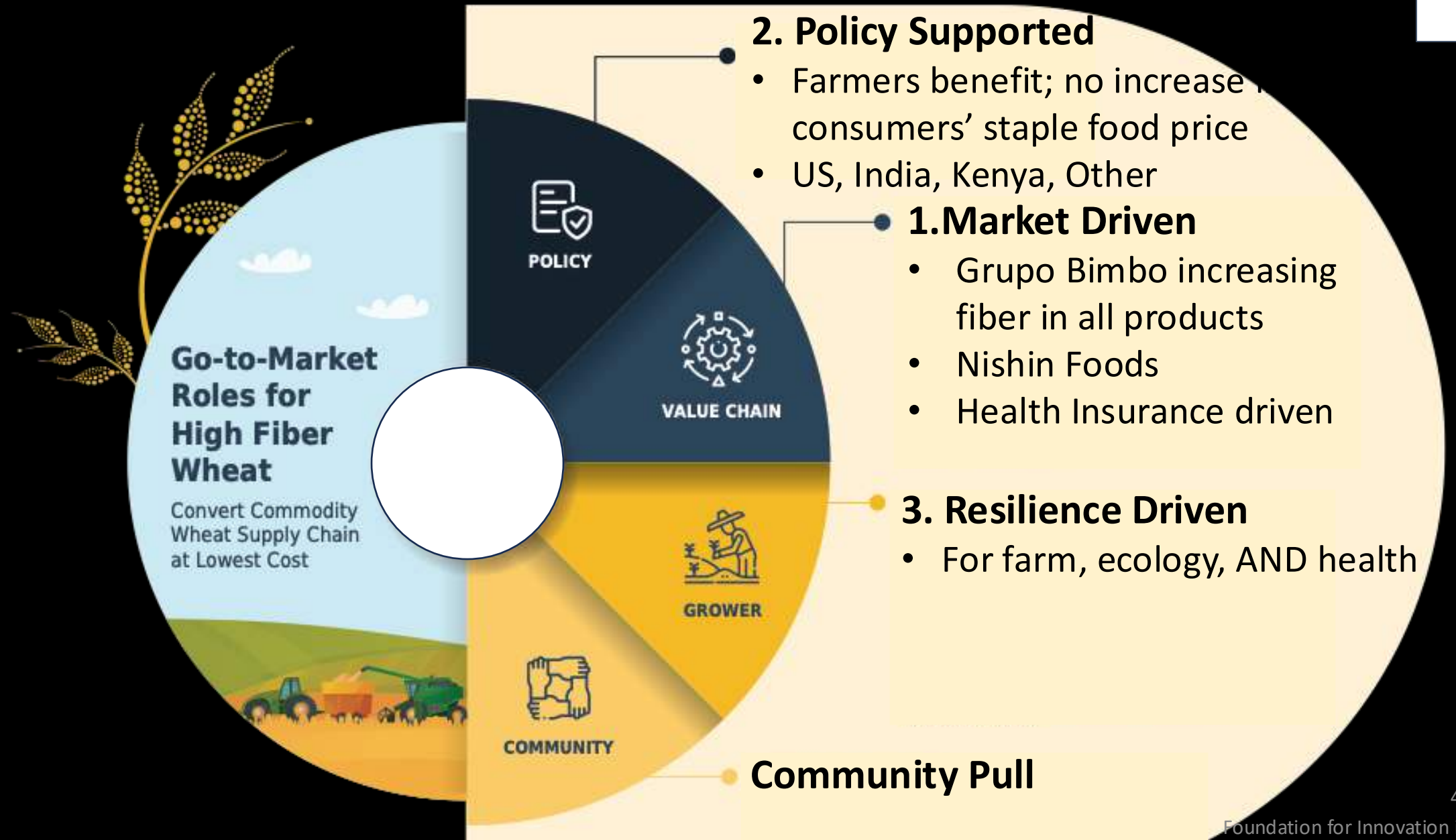
Developing Methods to Enhance Rigor for Evaluation of Low-Dose Nutrient Increases

Here We can add some of the nutrition or economics plans/questions

- We need slides to explain some of our questions.
  - Is arabinoxylan the right fiber?
  - Arabinoxylan in the flour stays in the bread
  - Will it taste as expected
  - Will it require processing changes.
- The economic argument: Health savings pay for ag
  - How do we incentivize the value chain.
  - How do you make these changes sustainable
  - Does the product have to be identity preserved

Bringing High-Fiber Wheat to-Market

Three Approaches Attractive Today



2. Policy Supported

- Farmers benefit; no increase in consumers' staple food price
- US, India, Kenya, Other

1.Market Driven

- Grupo Bimbo increasing fiber in all products
- Nishin Foods
- Health Insurance driven

3. Resilience Driven

- For farm, ecology, AND health

Community Pull

Increased Fiber Value and Supply Chain

Three Approaches Attractive Today

1. Package 'Helping fight chronic disease with every purchase' (mass balance)
   - Increased-fiber wheat is blended into commodity supply chain
   - Low-cost approach focused on increasing general fiber intake

2. Step-by-step increase in targeted (blended) wheat fiber specifications
   - Supply chain minimizes cost to meet specs

3. Four options available today for increased-fiber white flour and whole grain
   - Price points vary

Integrated Diet Perspective

Dietary Fiber

- Food Options (Dietary Guideline Focus)
  - Dietary fiber is under-consumed nutrient of concern globally
  - Eat more fruits, vegetables, and legumes
  - At least half of all grains consumed are whole grains; other half fortified
  - E.g., 'Chia yogurt' (chia seeds + milk)

Data under review

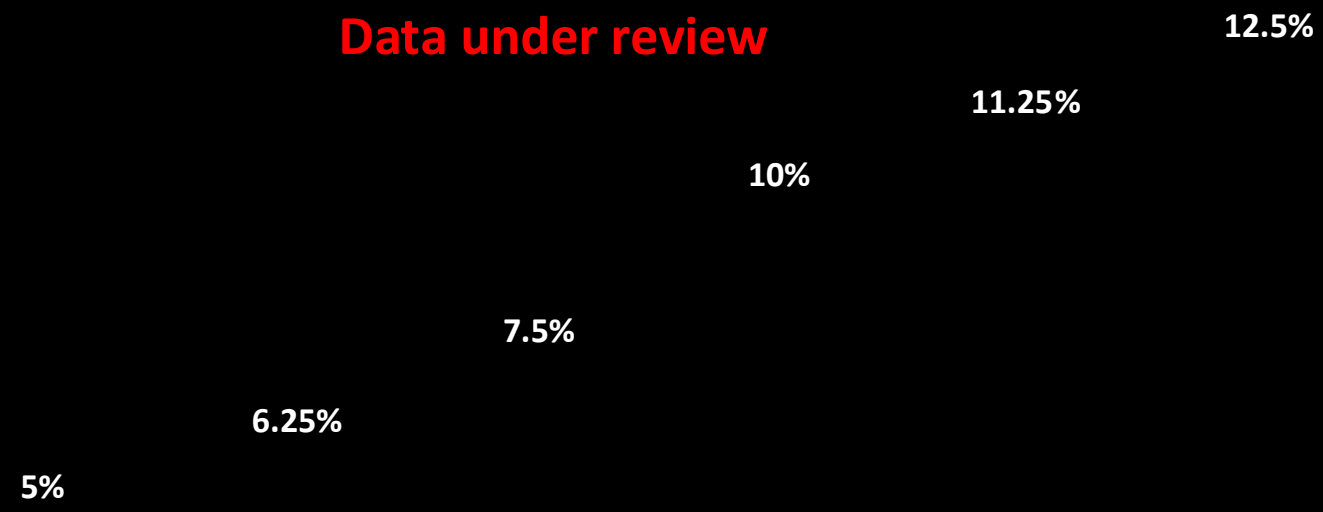
- Food Production and Processing
  - Consider frozen fruits and vegetables (less expensive– AND generally higher vitamins and fiber than fresh)
  - Increased-fiber wheat / grains in fortified and whole grain foods (arabinoxylan, amylose, white wheat class w/ targeted milling)
  - Twice-cooked, stored grains (e.g., fried rice, leftover pasta)*

*** can increase fiber content *more* than switching fortified-to-whole grain**

- Community Culture and Economic Environment
- Health Impact

Population Impact

Fiber Impact Across Chronic Diseases



Clinical Significance

An Economic Question

- Low-dose increase, several times a day, for billions of people
- No major side effects

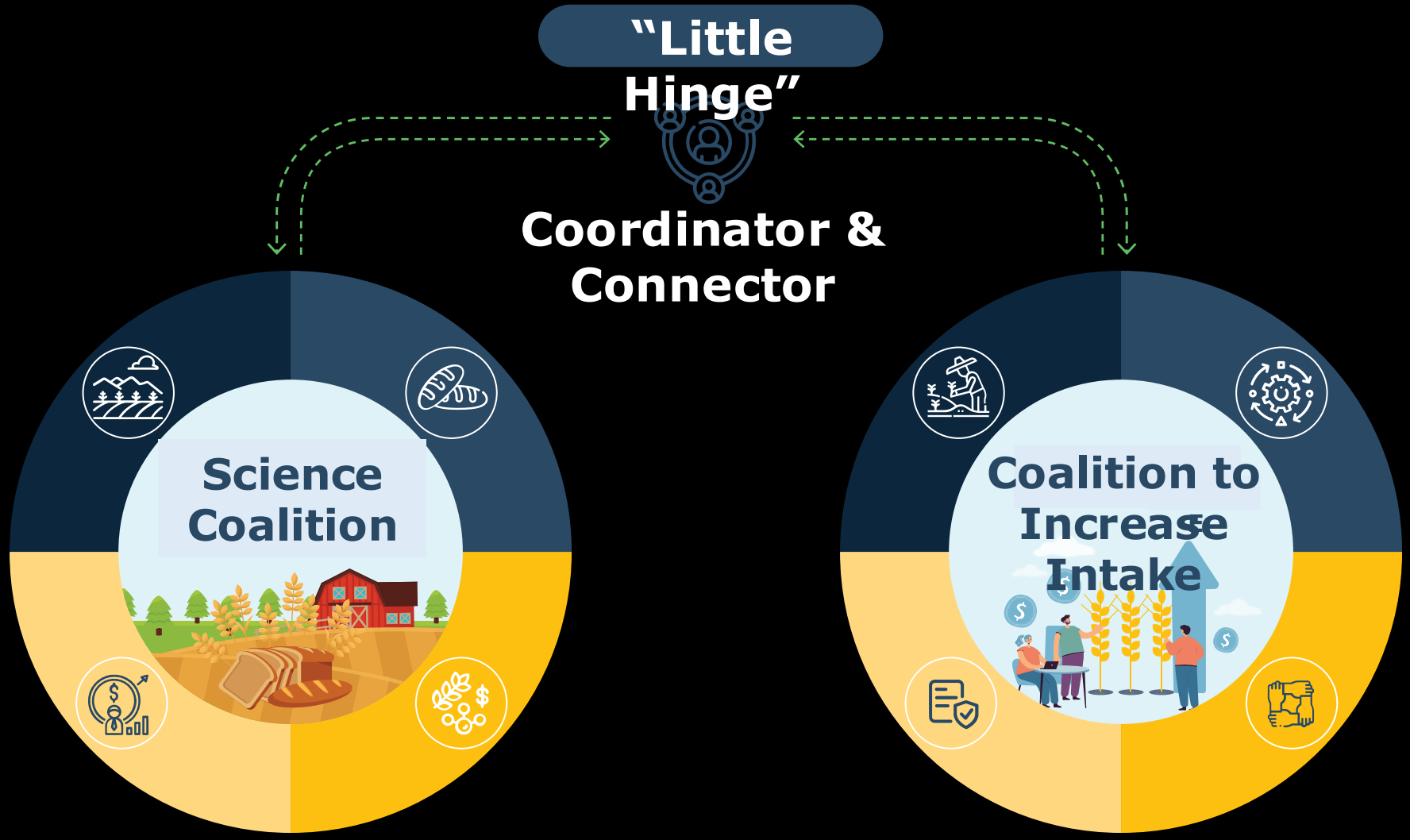
- $250+ billion net present value of public health benefits*
  (under $30 million in science costs over next three years)

- Millions expected spared due to chronic diseases prevention
- Project $ billions in healthcare costs saved annually, with reduced risks of chronic diseases:
  - 1-3% less cardiovascular disease
  - 3-4.5% less Type 2 diabetes
  - 1.75% less gut cancer

- $120 in public health benefits per $1 cost in US*

* Only includes cardiovascular disease, diabetes type 2, and colorectal cancer impact

Coordinated, Low-Cost, Transformation



Beyond Wheat: Foods with Global Impact

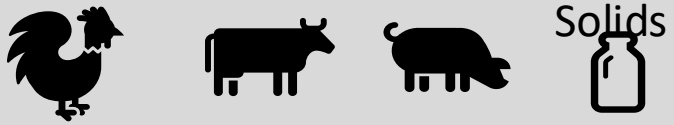
Homogeneous Diet and High Health Costs

Oklahoma Academy of Nutrition and Dietetics

US

13 Most-Consumed Ingredients

(% by mass)

		% of total
Wheat, Maize, Rice, Potatoes		31%
Chicken, Beef, Pork, Milk Solids		27%
Sugar, Corn Sweetener, Oils		18%
Tomatoes, Lettuce		7%

83% of total

9 Highest- Cost Chronic Diseases

	Cost ($BB)	% US GDP
Mental Illness	418	1.8%
Cardiovascular Disease	363	1.6%
Diabetes	327	1.4%
Alzheimer	305	1.3%
Arthritis	304	1.3%
Cancer	240	1.0%
Obesity	173	0.7%
Pulmonary	50	0.2%
Dental	45	0.2%
Top 9	2,225	10%

World

7 Most-Consumed Foods

(% total by energy)

Wheat, Maize, Rice

51% of total

Chicken, Beef, Pork, Cow Milk

19% of total

70% of total

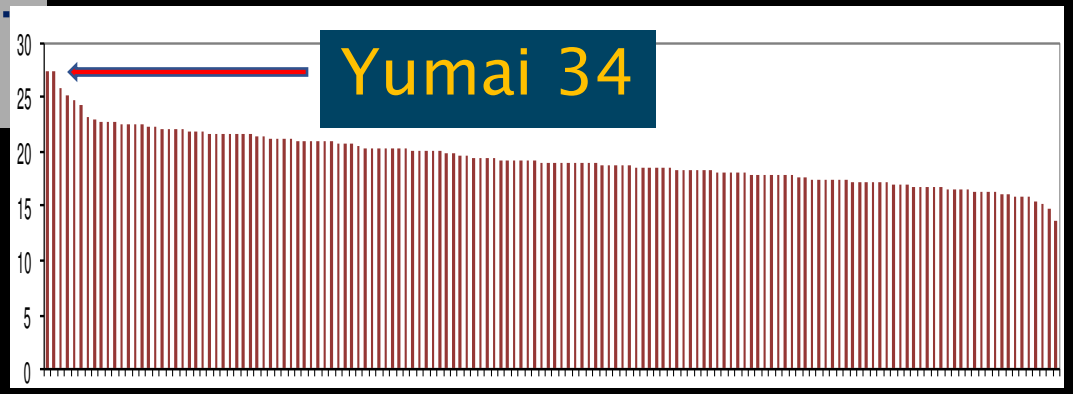
2-Fold Arabinoxylan Variation with ID'ed QTLs

Work of UK BBSRC ISP, *Designing Future Wheat*

Oklahoma Academy of Nutrition and Dietetics

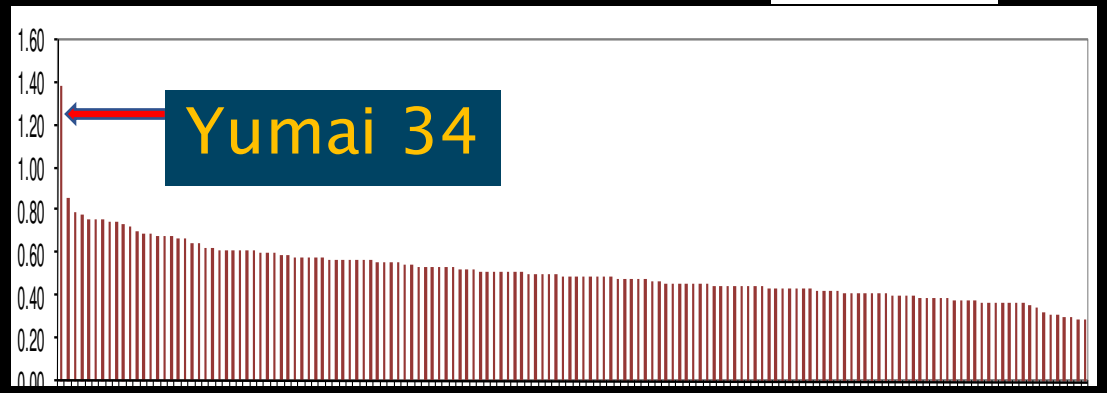
White flour: 150 lines

Total AX: 1.4–2.8%

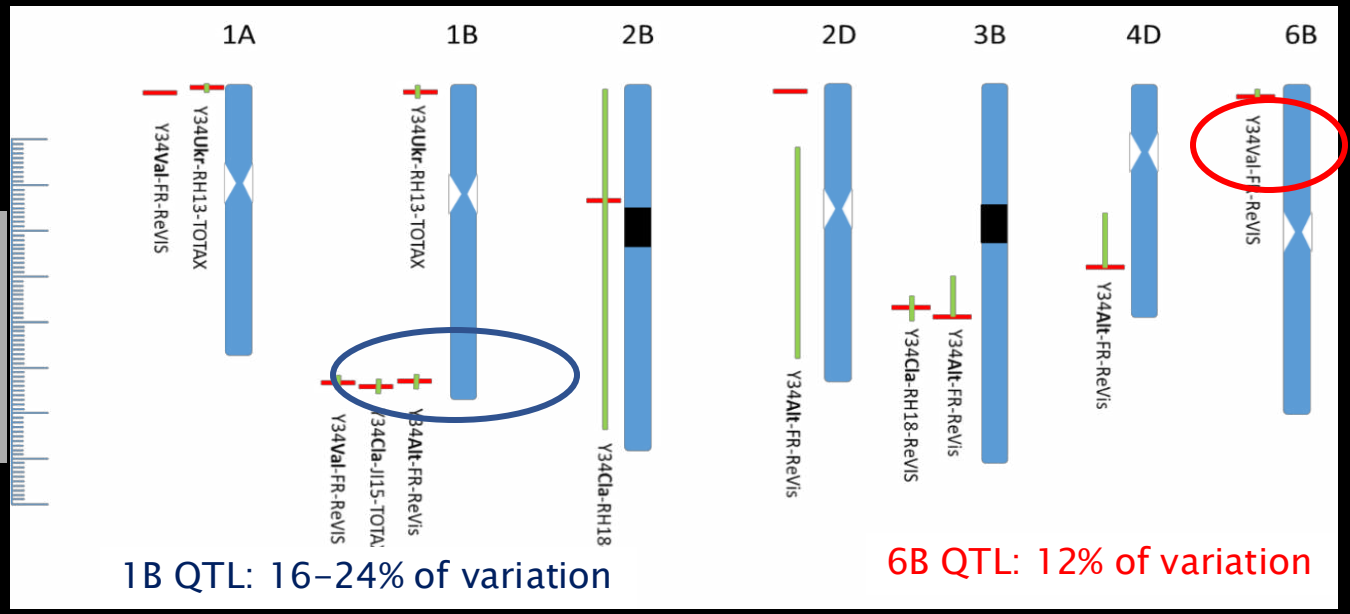


Soluble AX: 0.3–1.4%

Up to 50% soluble



Four crosses with Yumai 34 ID chromosomal regions (QTLs) for high total and soluble AX fibre



1B QTL: 16–24% of variation

6B QTL: 12% of variation

High heritability: 60–70%

Amenable to selection

A Paradigm Shift Learned from History

Modest Improvement in Foods Eaten By Everyone Several Times a Day

Oklahoma Academy of Nutrition and Dietetics

Most Impactful Health Strategies

- Fortified white flour birth defects ↓
- Vitamin D dairy rickets ↓
- Others

Food safety*

Other Examples?

Our Attractive Choices

Top 3 Foods' Diet Share

Global 51% **US 33%**

7 Foods 70% 13 Foods 84%

Financial incentives building on existing policy and strategies

Without relying on consumers to change behavior

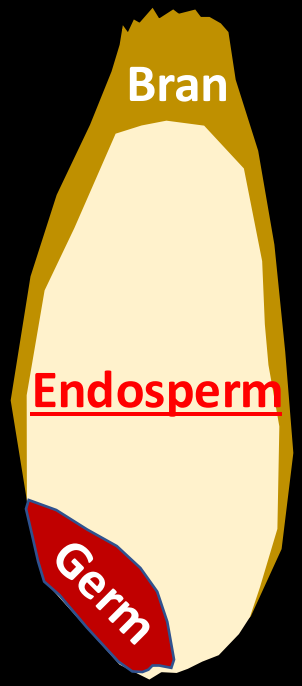
* 20th Century Greatest Public Health Strategies

Appendix

Arabinoxylan Fiber Increase

Suited for Broad Application

- Clean label
- In intact food
- No yield loss
- Royalty free, to all
- Minimal baking adjustment and supply chain disruption



Target fiber in endosperm cell walls

Doable
For Farms and Bakeries

COALITION FOR GRAIN FIBER

DEVELOPMENT

- **Fiber content naturally varies in current commercial wheat varieties (a non-GMO crop)**
- We can rapidly identify existing varieties that– by chance– have higher-fiber
- 19 years of research on commercial wheat illustrates potential to follow with wave(s) of increased fiber

PLANT BREEDING IMPACT

- No yield loss
- Any region, wheat class
- Royalty free

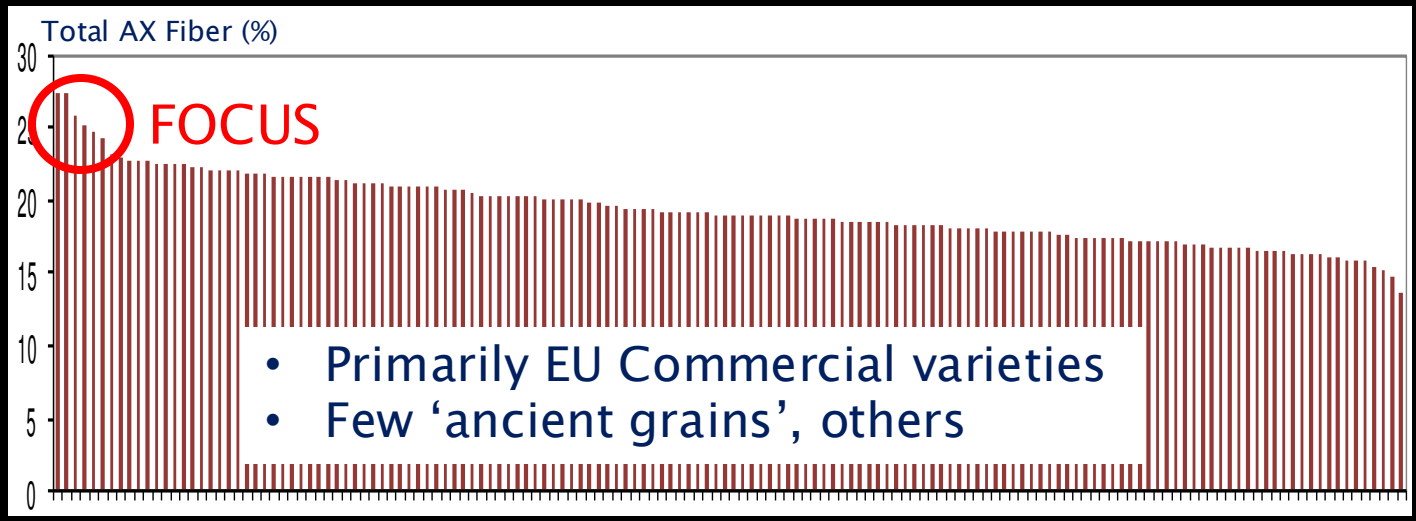
END USE QUALITY IMPACT

- HARD WHEAT: Commercial baking within commercial variation
- SOFT WHEAT: Best for doughy applications

First Wave: Increase Achievable 'Tomorrow'

Comparatively High-Fiber, Quality Wheat Exists NOW

AX Fiber Levels of 150 Commercial Varieties



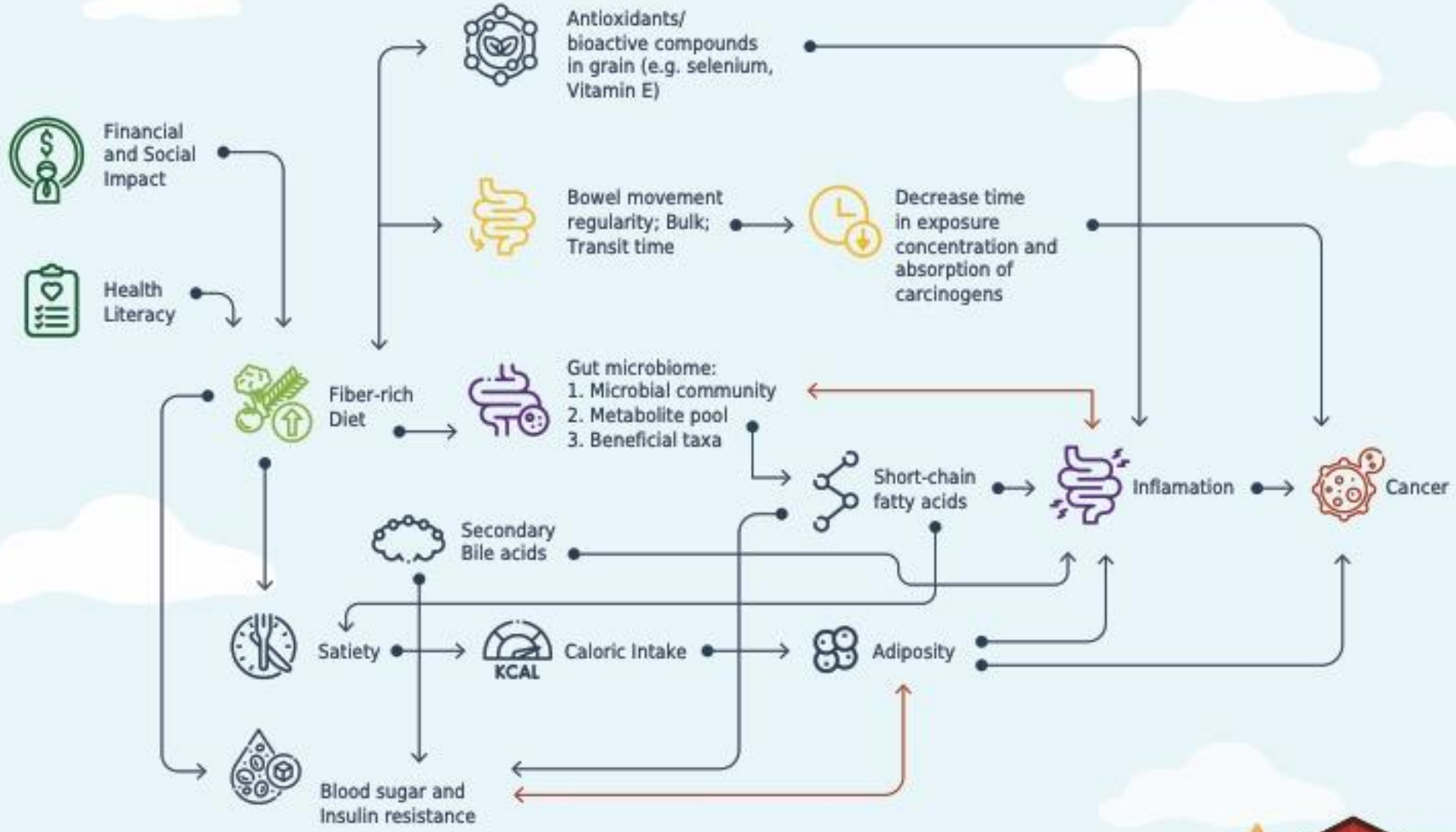
Shewry, et al, 2015.

Variation in US wheat is consistent with European experience

COALITION FOR GRAIN FIBER

How Dietary Fiber Reduces Cancer Risks

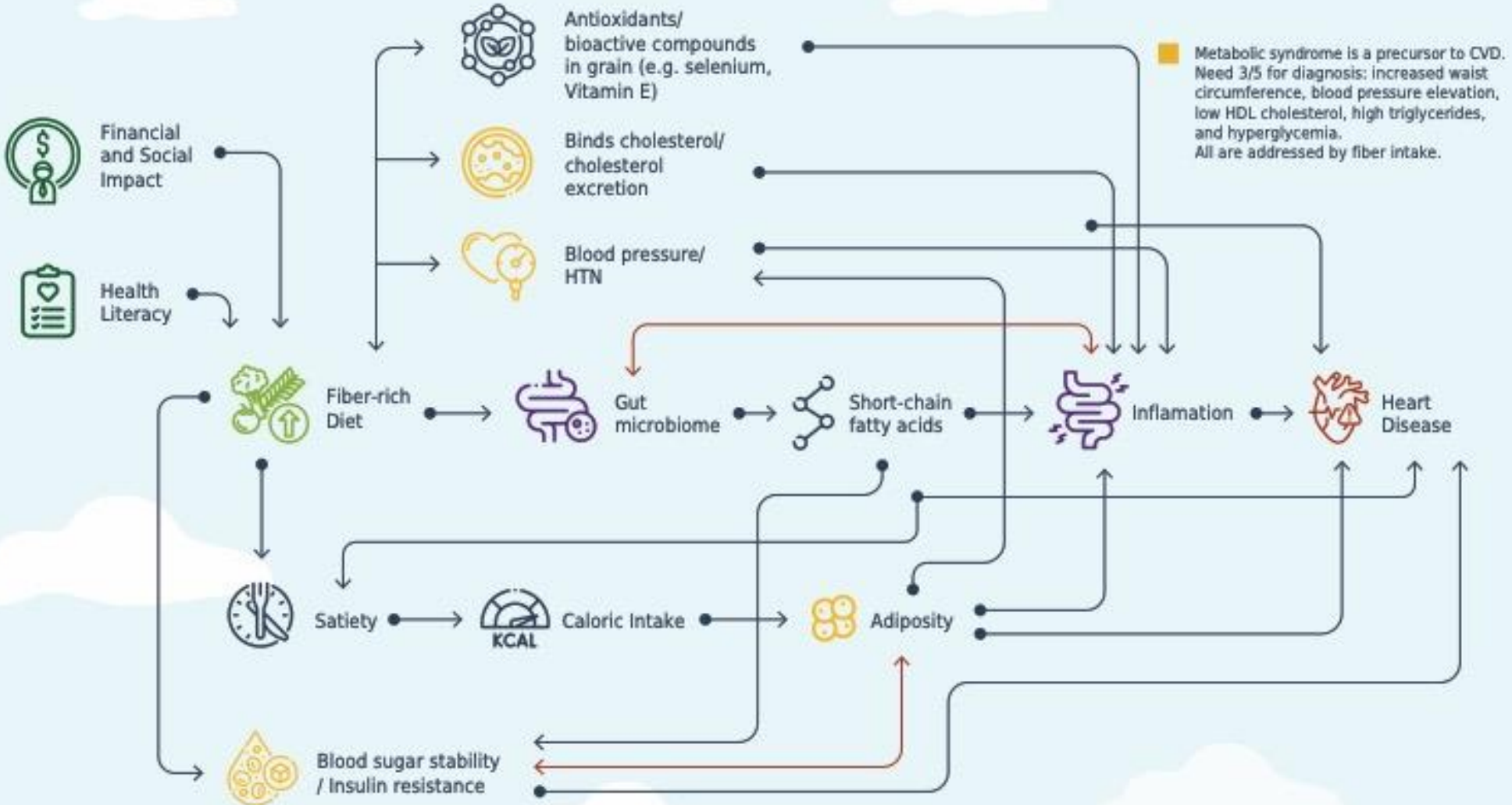
FOUNDATION FOR INNOVATION IN HEALTHY FOOD



COALITION FOR GRAIN FIBER

How Dietary Fiber Reduces Heart Disease Risks

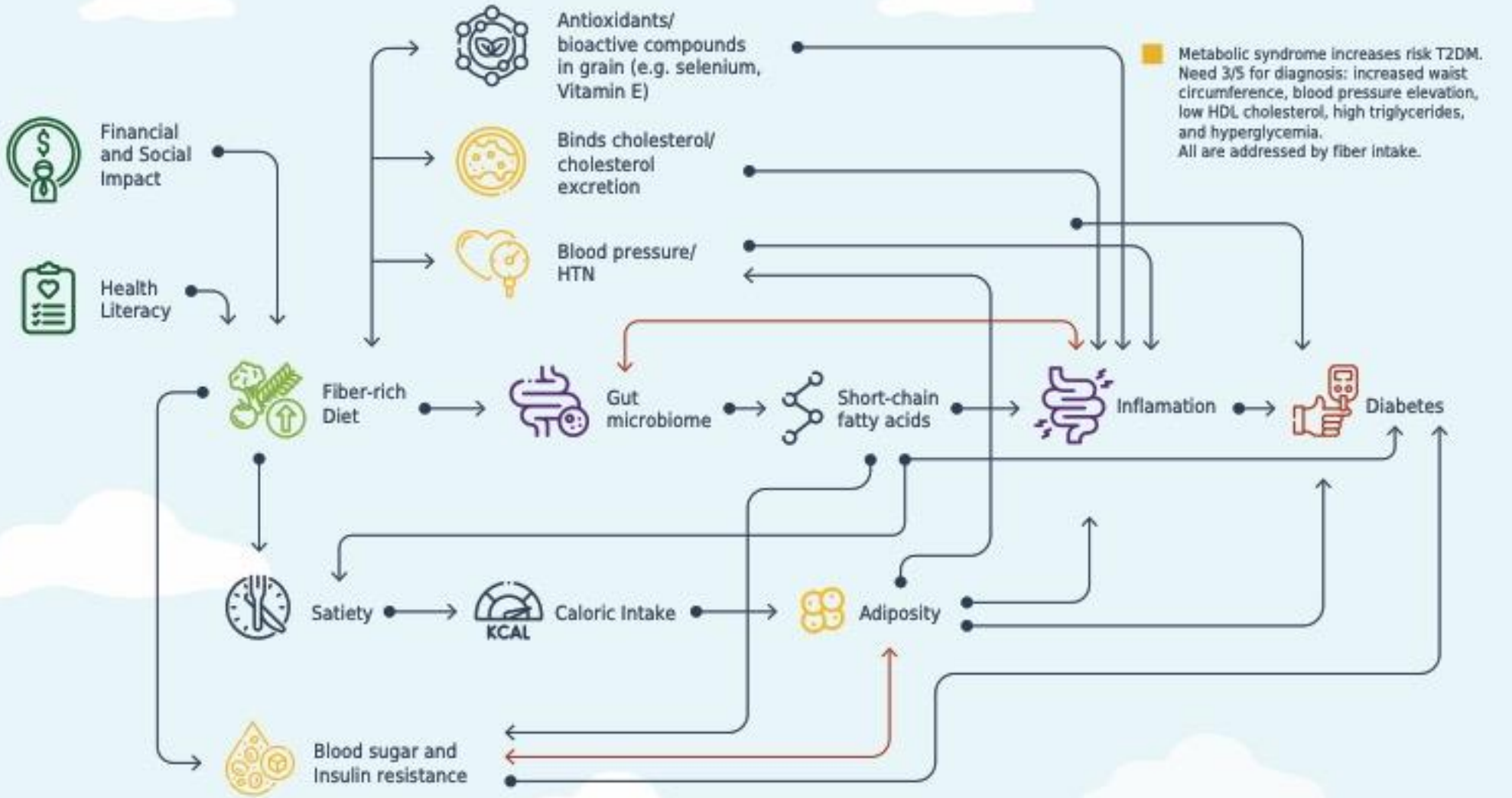
FOUNDATION FOR INNOVATION IN HEALTHY FOOD



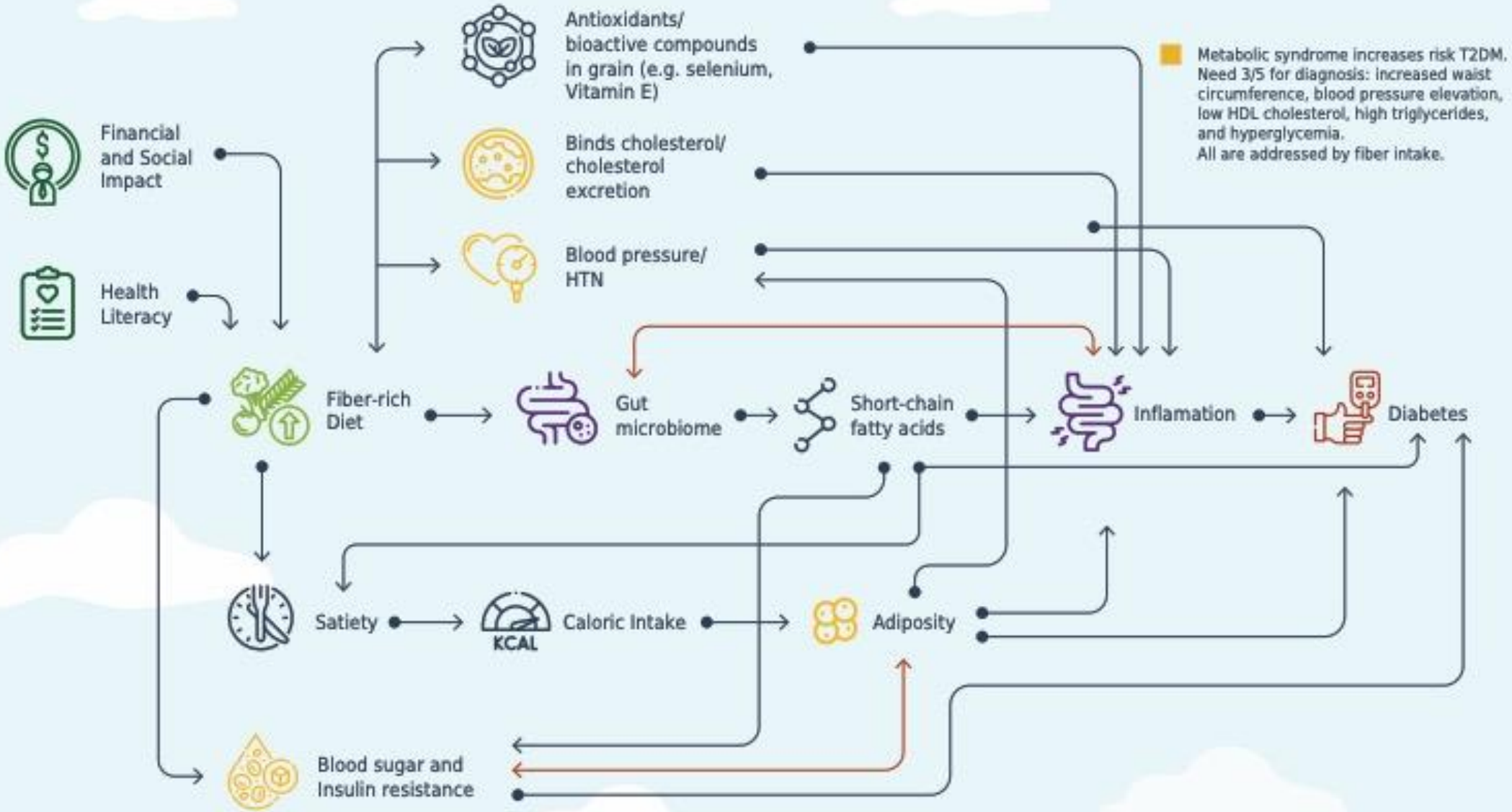
COALITION FOR GRAIN FIBER

How Dietary Fiber Reduces Diabetes Risks

FOUNDATION FOR INNOVATION IN HEALTHY FOOD



How Dietary Fiber Reduces Diabetes Risks
Addressing All Diagnostic Criteria



What You Need to Know

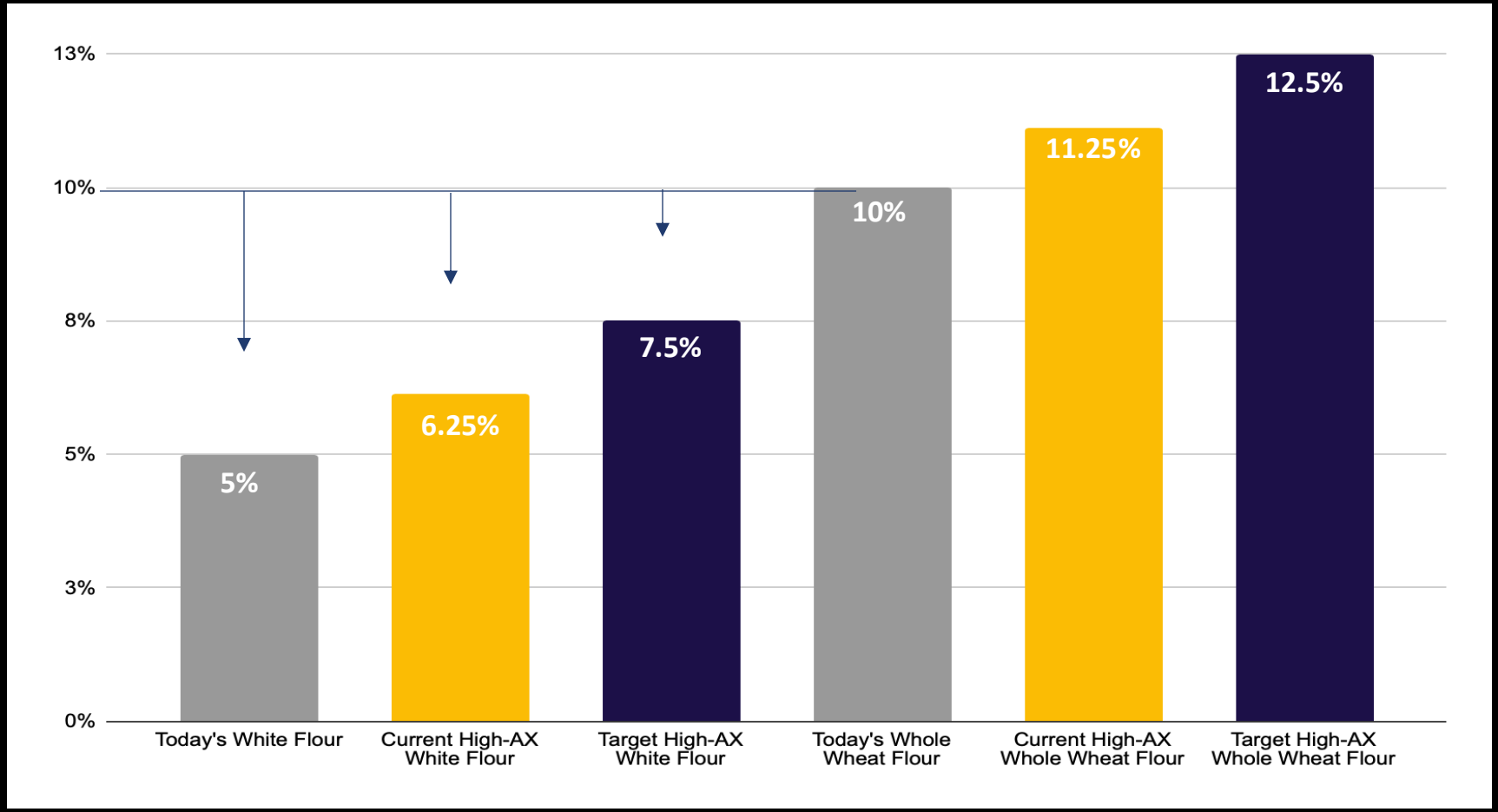
An Emerging Paradigm

- The Challenge
- Our Approach
- The Impact
- We Need You

Nature's Opportunity
To Increase Wheat Fiber

Oklahoma Academy of Nutrition and Dietetics

Wheat Flour Fiber, High Arabinoxylan Project (Indicative)

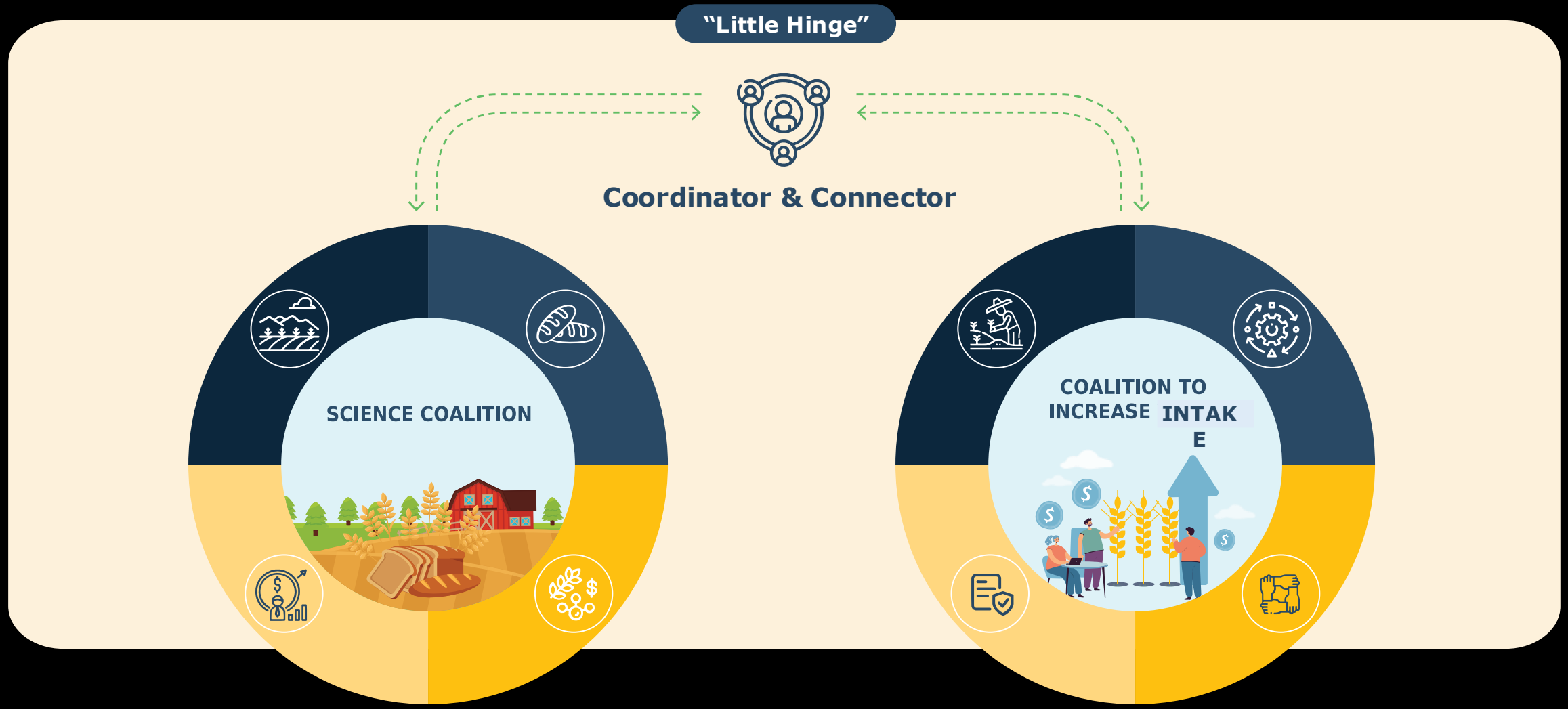


Based on Shewry, P. and Hey (2015). The contribution of wheat to human diet and health.

Coalition for Grain Fiber

Coordinated, Low-Cost, Transformation

FOUNDATION FOR INNOVATION IN HEALTHY FOOD



Coalition to Increase Fiber Intake
Coalition for Grain Fiber (CGF)

- **Farmers: field days grain fiber topic**
  - 4-minute intro to CGF's farmer business value
  - Take-home covering business value + 'actions to keep your family healthy with grain fiber'

To Be Revised

laware State University, Southern University, others) Feb '26

  - Plan social entrepreneurship student competition, 'Healthy baked goods for our communities supply chain / business'
  - CGF 'case study' to engage students in science education
  - Plan community grain fiber community outreach

Public Health Strategy
A Paradigm Shift Learned from History

FOUNDATION FOR INNOVATION IN HEALTHY FOOD

Food-for-Healthier Lives

- Fluoridated water: cut cavities
- Fortified white flour: reduced birth defects
- Vitamin D dairy: nearly eradicated rickets

Our Attractive Choices

Top Foods' Share of Diet

51% **33%**

- Celebrate culture and individual tastes without relying on consumer behavior change.
- Enhance nutrients in intact foods
- Non-GMO wheat
- Embrace environmental values

Beyond Wheat: Foods with Global Impact

Homogeneous Diet and High Health Costs

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US

13 Most-Consumed Ingredients

(% total by mass)

Wheat 17%

Maize 5%

Rice 3%

Potatoes 6%

Chicken 8%

Beef 7%

Pork 7%

Milk Solids 5%

Sugar 9%

Corn Sweetener 7%

Oils 2%

Tomatoes 4%

Lettuce 3%

84% of total

9 Highest- Cost Chronic Diseases

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COALITION FOR
GRAIN FIBER