Understanding Whole Grain Processing and Impacts on Nutrition

November 19, 2020

bell institute
OF HEALTH & NUTRITION
General Mills

BIG G

OLDWAYS
WHOLE
GRAINS
COUNCIL

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Health Benefits of Whole Grains

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- Nutrition Epidemiology

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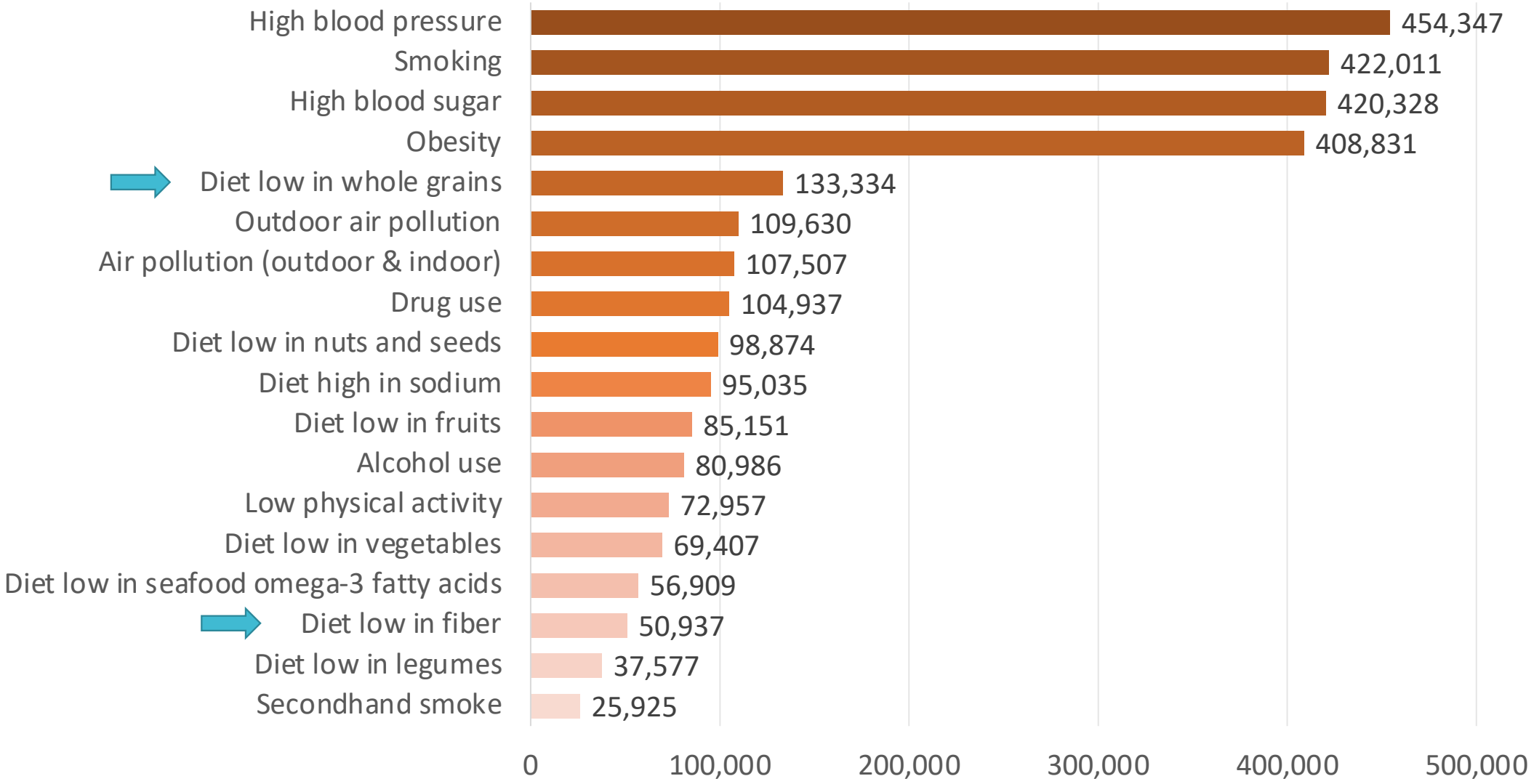
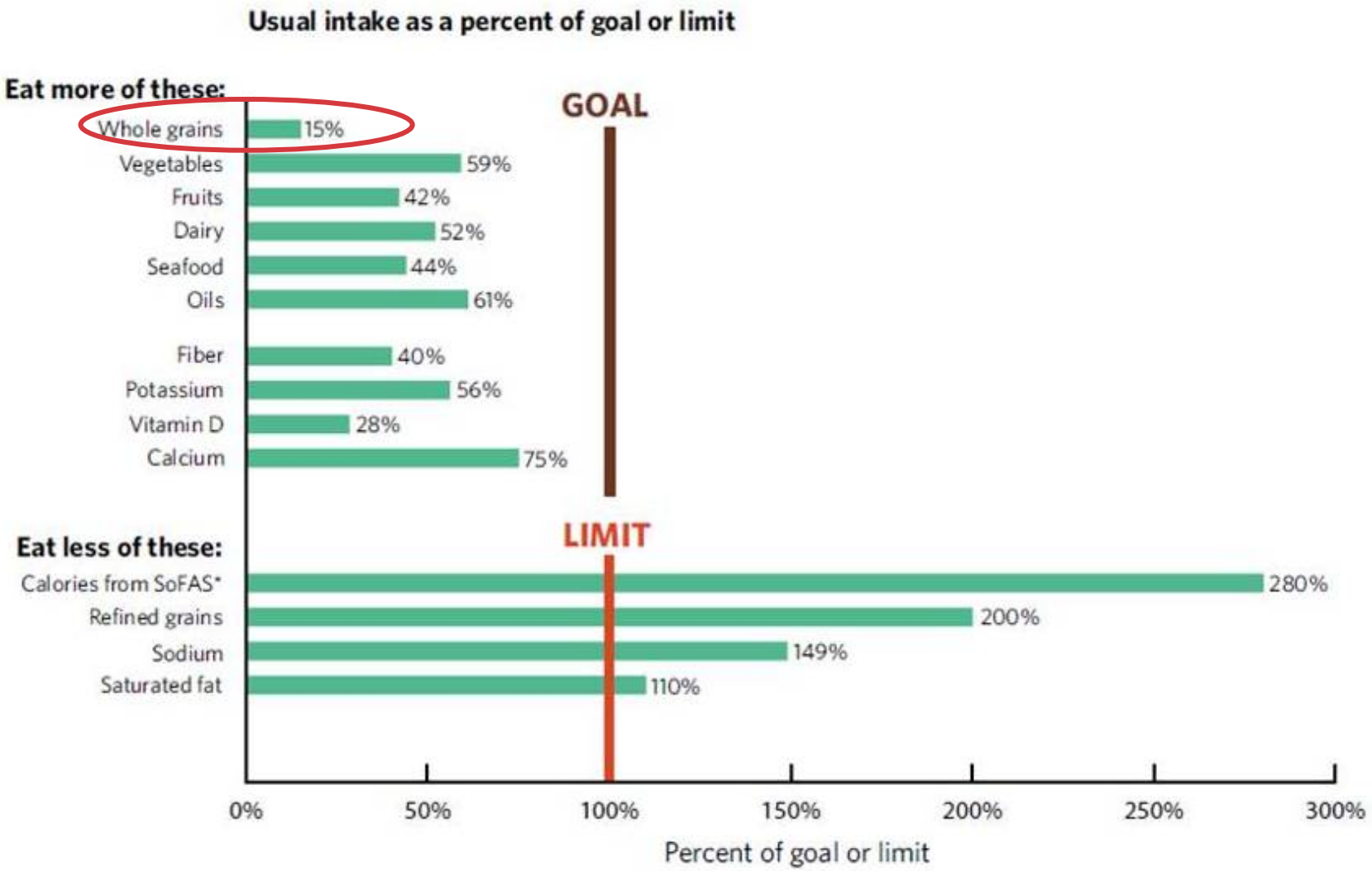
Number of deaths by risk factor, United States, 2017



Our World in Data

Source: IHME, Global Burden of Disease (GBD)

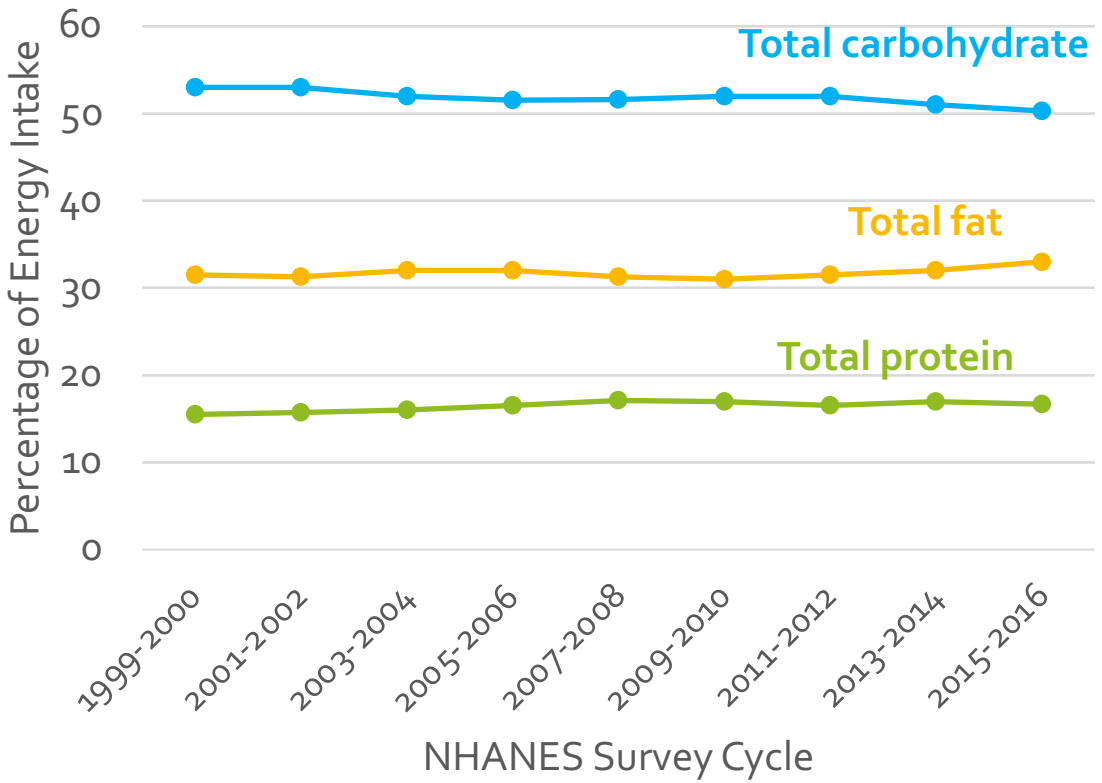
Dietary Guidelines for Americans

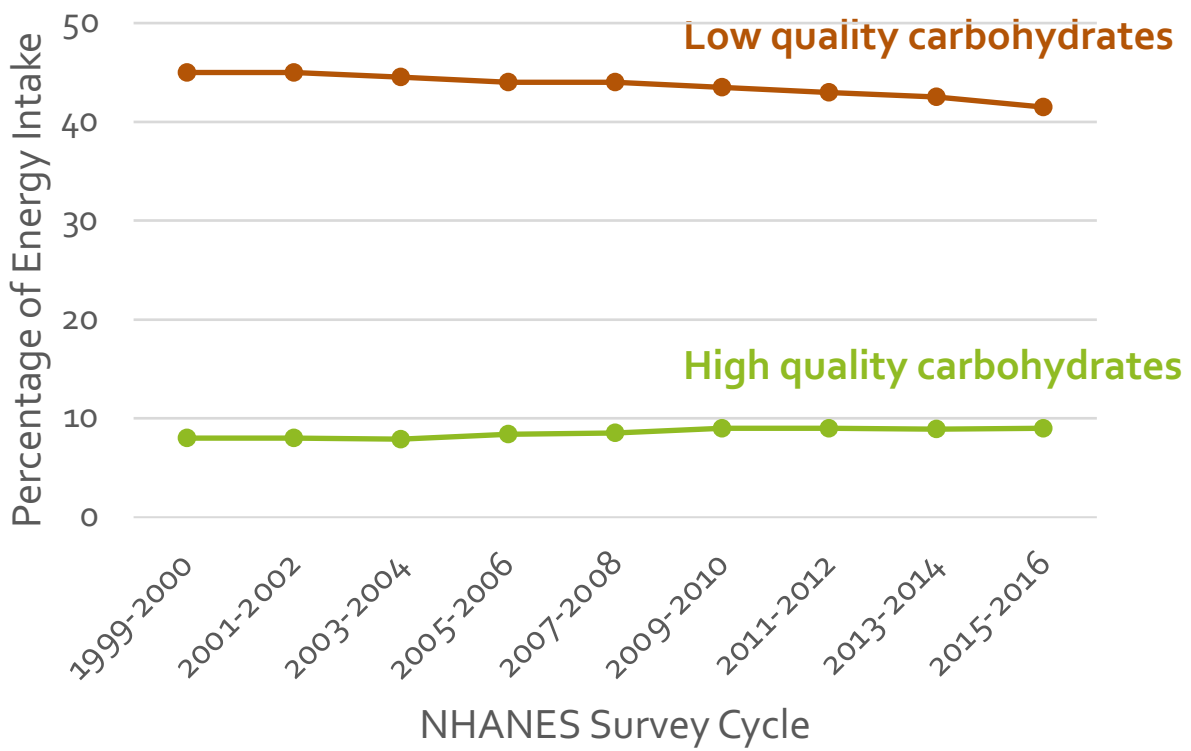


Whole Grains
3 or more servings/d

DGA 2015

Carbohydrates make up 50% of energy intake





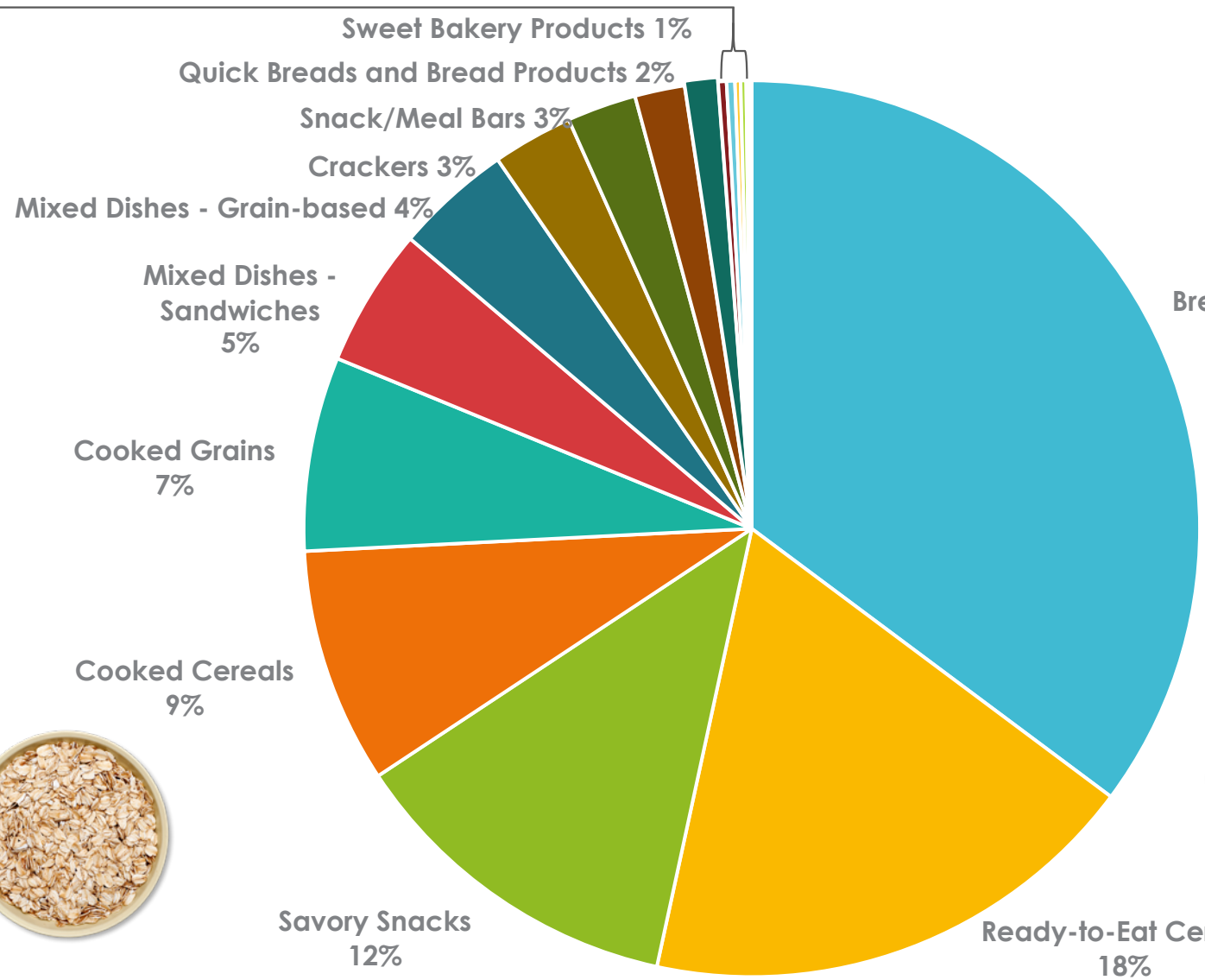
NHANES indicates National Health and Nutrition Examination Survey. Data were adjusted for NHANES survey weights to be nationally representative. Error bars indicate 95% CIs. $P < .001$ for trend for all (decrease for total carbohydrates; increase for total protein and total fat).

Shan et al. 2019, JAMA

Whole Grain Food Sources

Less than 1%:

- Mixed Dishes – Asian Seafood
- Mixed Dishes – Pizza
- Not included in a food category
- Plant-based Protein Foods
- Mixed Dishes – Meat, Poultry, Seafood



- *NHANES 15-16*

Whole grain kernel is nutrient dense

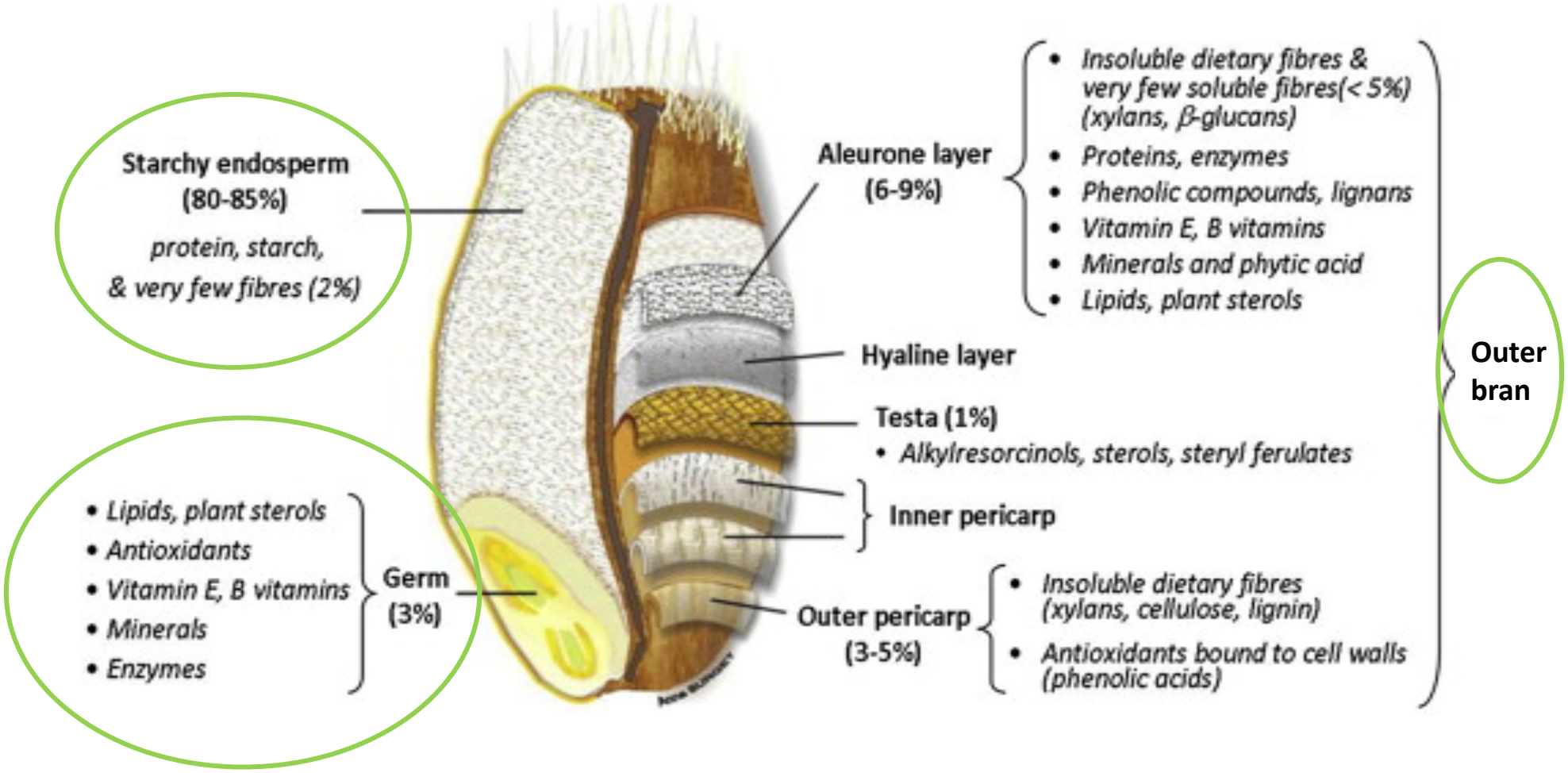
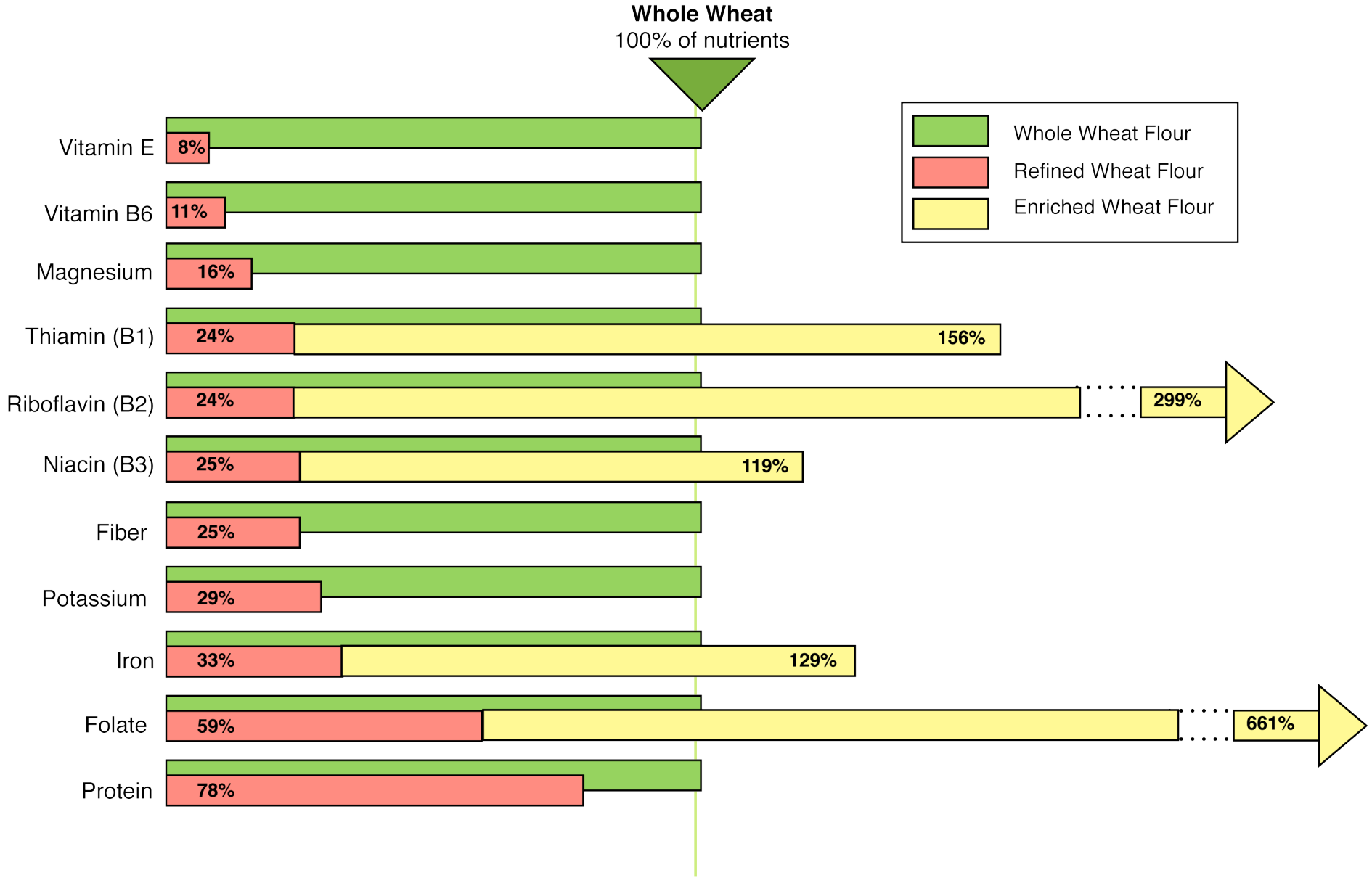


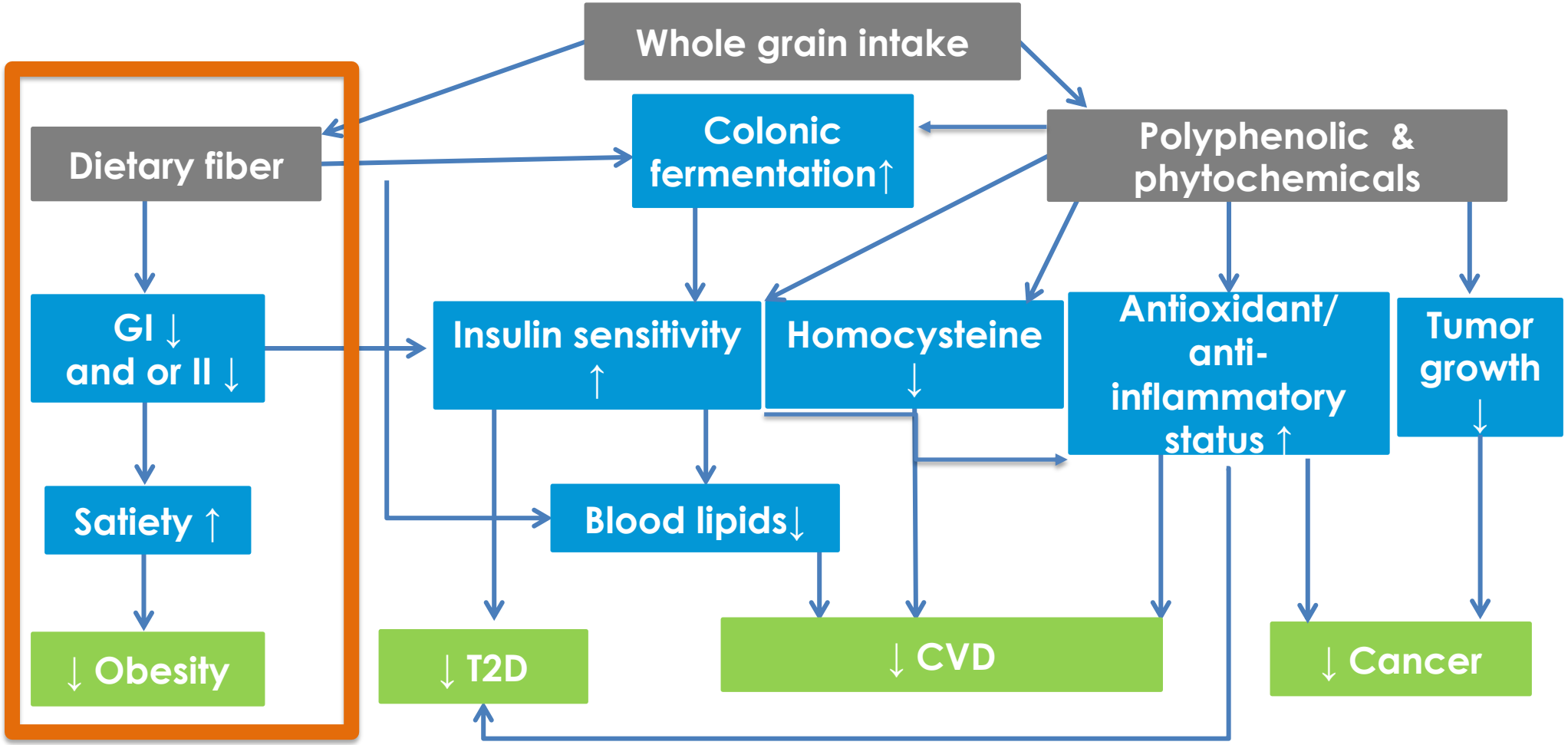
Image: Brouns et al. (2012); adapted from Surget & Barron (2005)

Whole vs Refined Grain



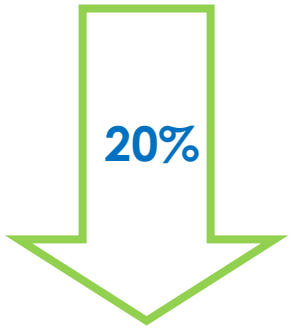
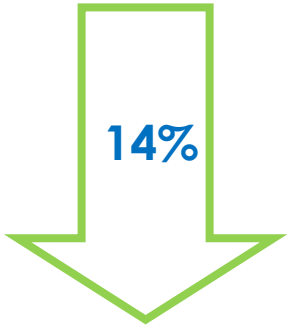
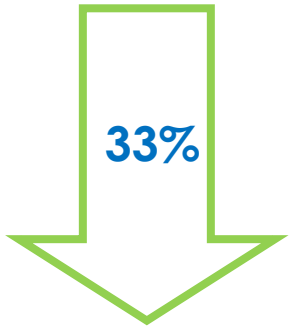
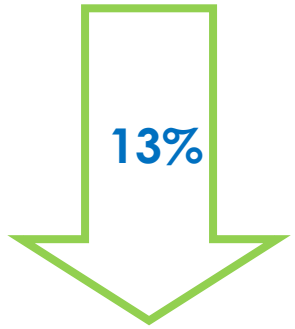
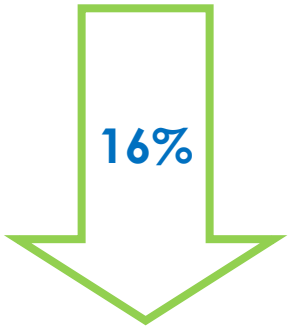
https://wholegrainscouncil.org/whole-grains-101/whats-whole-grain-refined-grain

Potential Mechanisms



Björck et al. Trends in Food Science & Technology 2012; 25(2): 87-100.

Health Benefits of Whole Grains: Observational Evidence

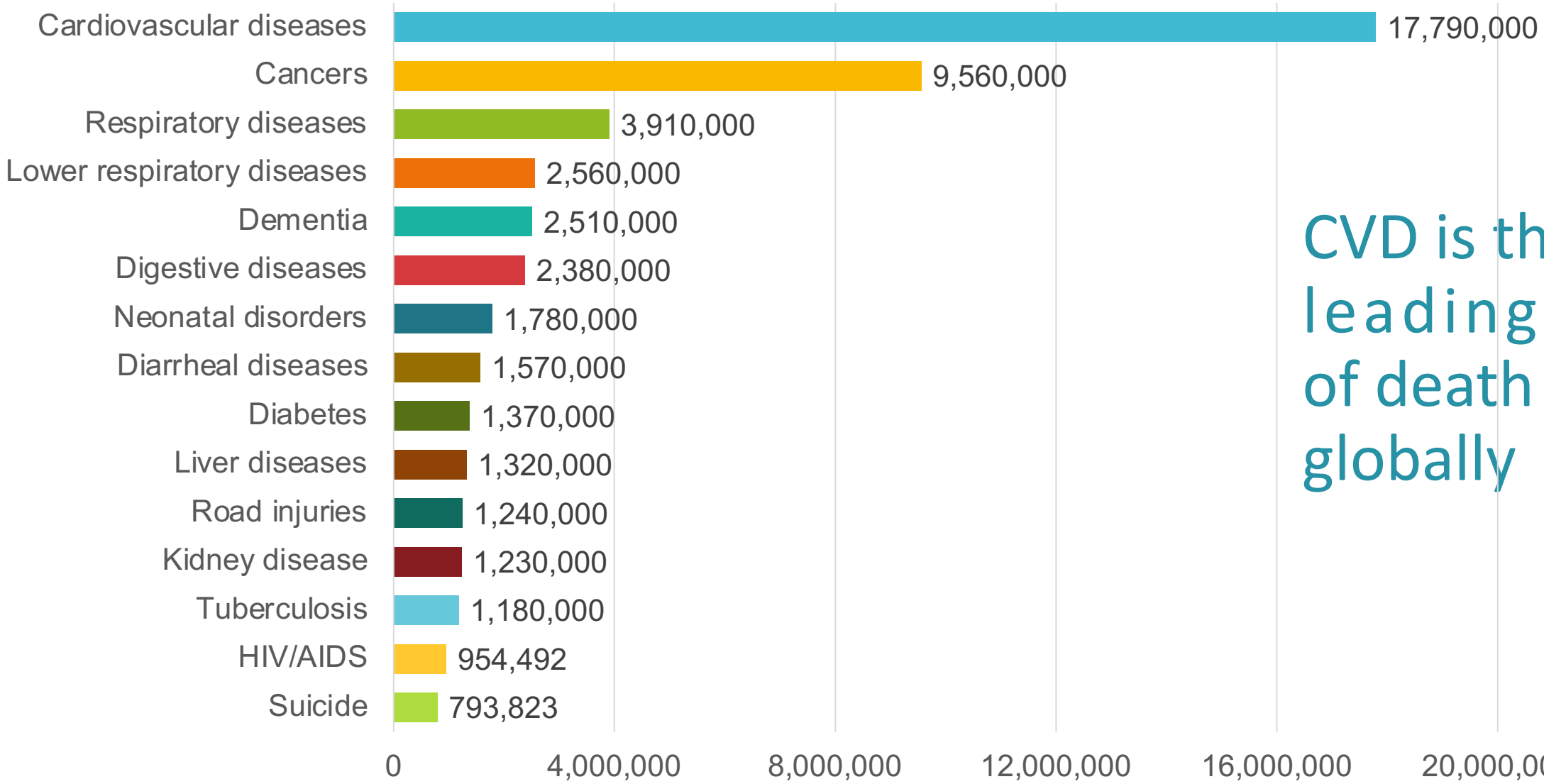
All Cause Mortality (n=11)	Coronary Heart Disease Incidence (n=6)	Stroke Incidence (n=3)	Type 2 Diabetes (n=8)	Colorectal Cancer (n=7)	Cancer Mortality (n=5)
					
19%	20%	14%	33%	13%	16%

Independent of other risk factors: physical activity, BMI, smoking, alcohol, energy intake, education

Reynolds et al. 2019 Lancet

Whole grains and CVD

Number of deaths by cause, World, 2017



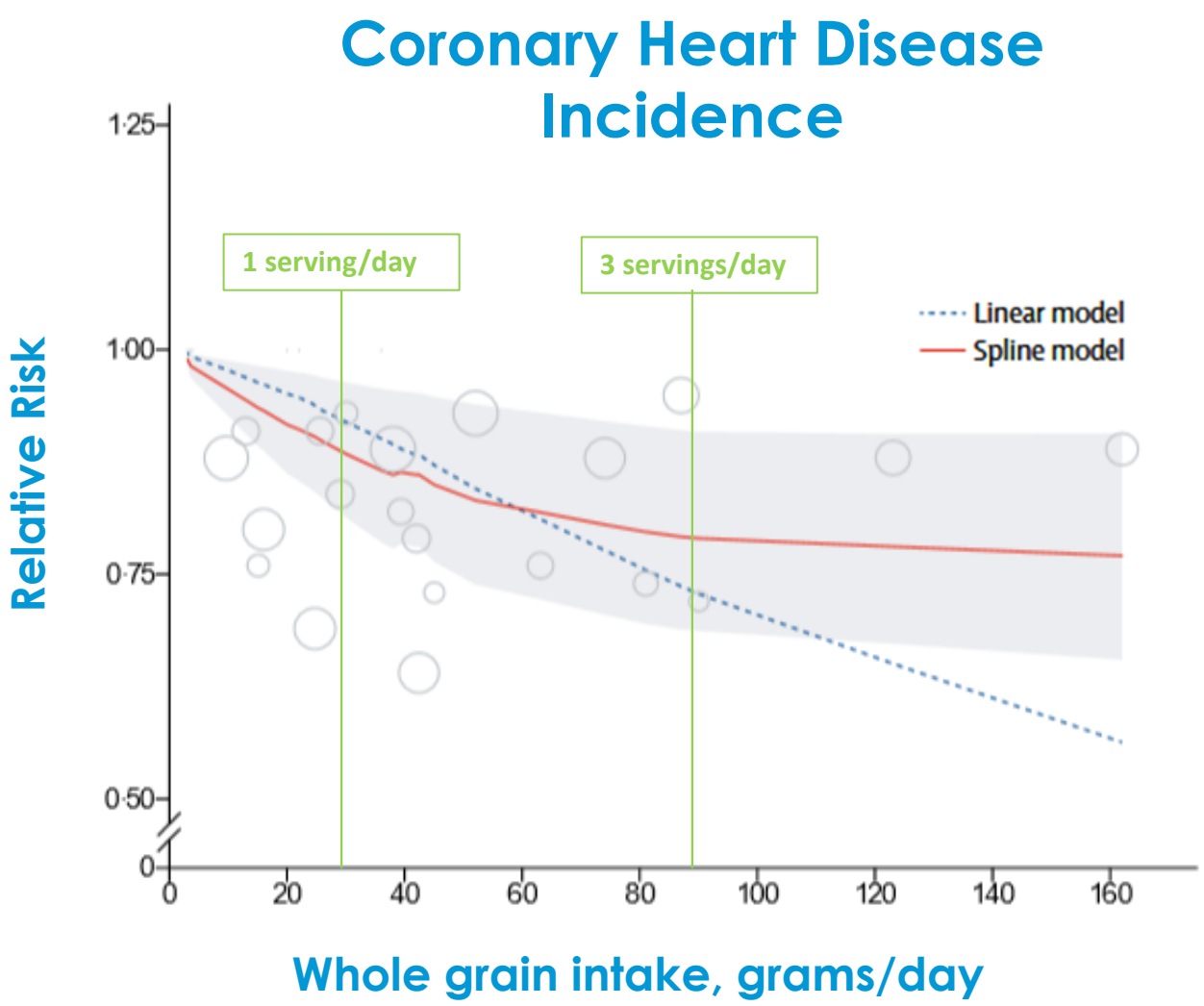
CVD is the leading cause of death globally

Our World in Data

Source: IHME, Global Burden of Disease (GBD)

Roth et al. 2017, The Lancet

Whole Grain Intake & Risk of Coronary Heart Disease



- Risk reduction begins even at the lowest intakes of whole grain and benefit continues with higher intakes
- Supports current dietary guidelines >3 servings per day

Mechanisms

○ Lipids ○ Blood pressure
○ Body weight ○ Inflammation
○ Insulin resistance ○ Glucose homeostasis

Reynolds et al. 2019 Lancet

Whole Grain and CVD Risk Factors

- **Whole grains and blood lipids →**

  Compared to control diets, those consuming more whole grain had a 2% reduction in total cholesterol and 5% reduction in LDL cholesterol
  *attributed to whole grain oats

  (Hollaender et al. 2015, meta-analysis of 24 randomized controlled trials)

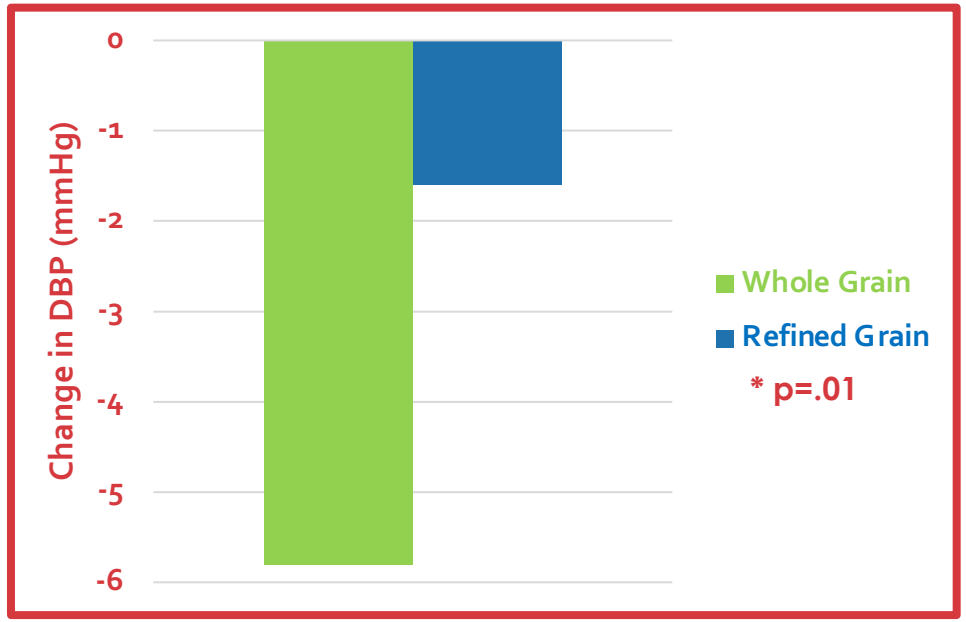
- **Whole grains and hypertension→**

  Increased whole grain intake by 30g/d was associated with 8% reduction in risk of hypertension

  (Schwingshackl et al. 2017, dose-response meta-analysis of 4 prospective studies, n=28,069 cases)

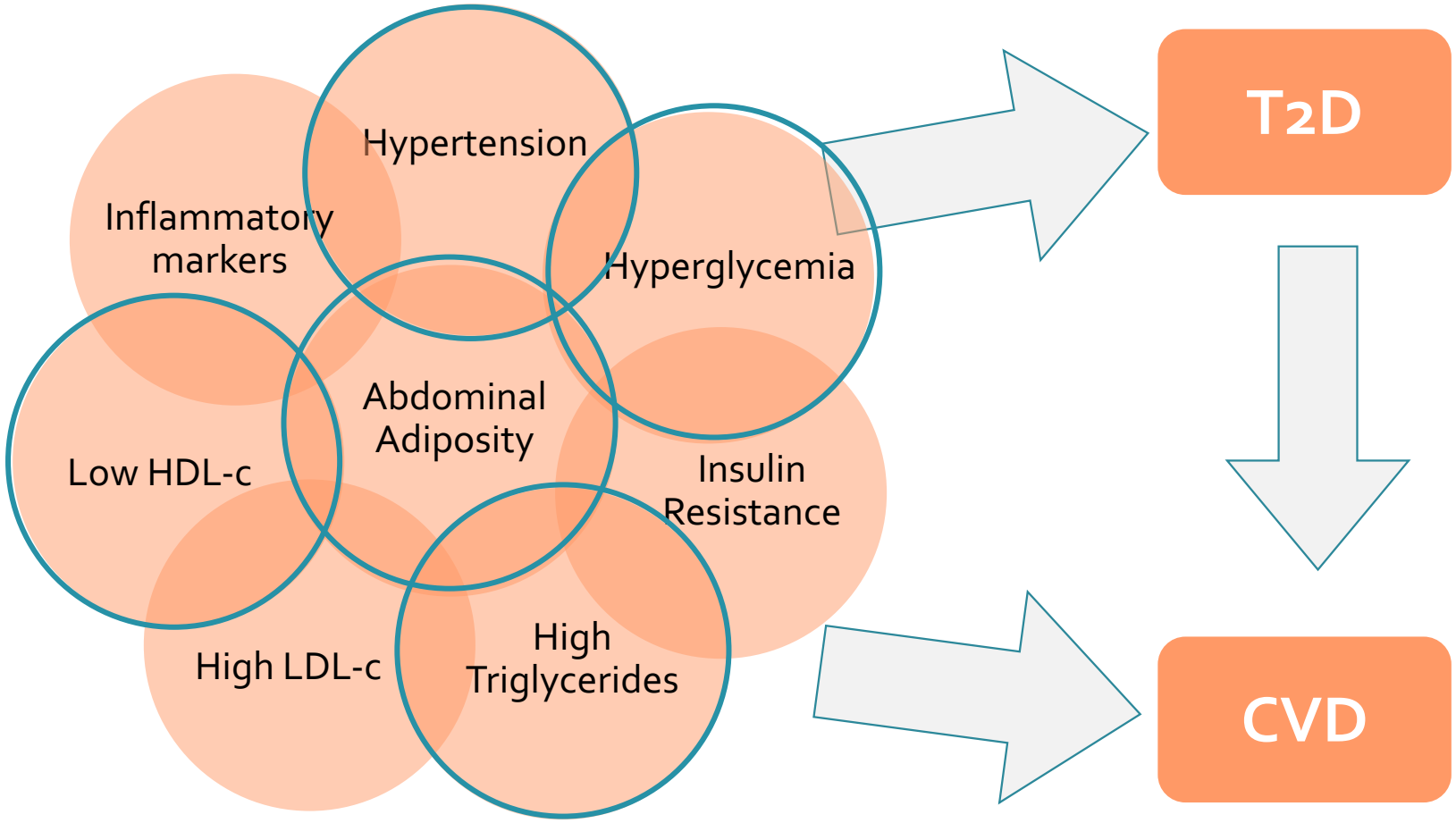
A whole grain diet led to a reduction in diastolic blood pressure by 8% in overweight and obese subjects

(Kirwan et al. 2016, randomized controlled trial)



"In population studies this improvement approximates to a 40% lower risk of dying from stroke and a 30% lower risk of dying from ischemic heart disease or other vascular causes"

Associated clinical risk factors



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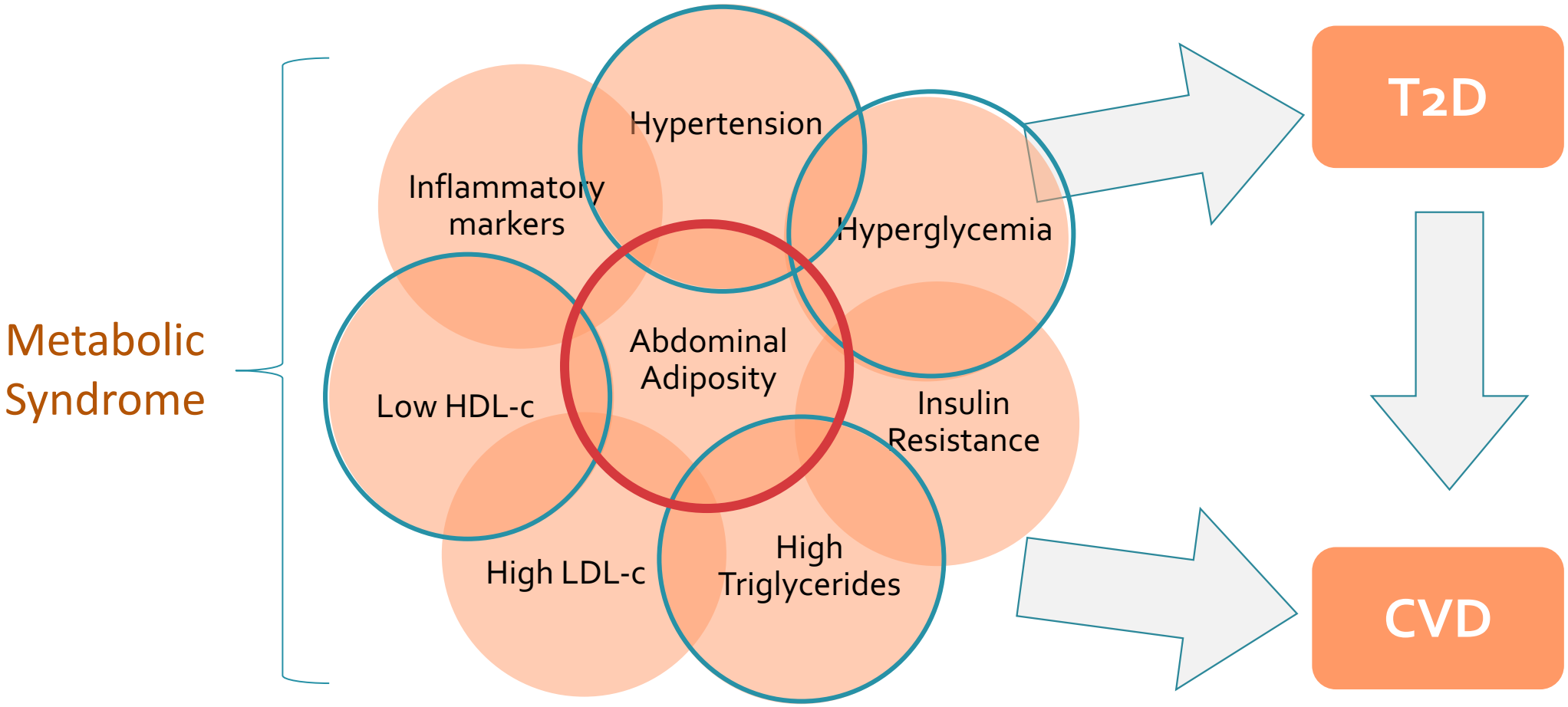


Whole grains and adiposity

Whole Grains and Adiposity

- **Meta-Analysis of 15 Cross-Sectional Studies→**
  Weighted mean difference in body mass index (BMI) was 0.63 kg/m^2 less in high-WG consumers compared with low or non-WG consumers
  (Harland et al. 2005)

- **Prospective Cohorts→**
  Higher daily whole grain intake is associated with less weight gain
  (Liu et al. 2003; Koh-Banerjee et al 2004; Mozaffarian et al. 2011; Winkvist et al. 2017)

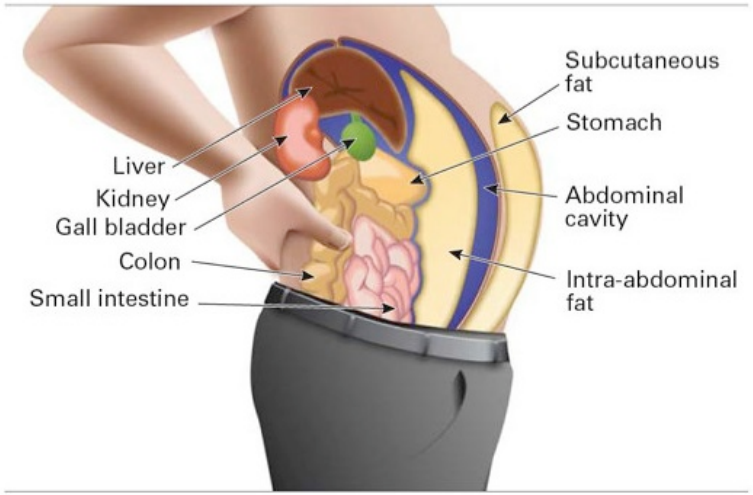
- **Meta-Analysis of 26 RCT→**
  No effect on body weight but a small effect on percent of body fat
  (Pol et al. 2013)

- **Meta-Analysis of 11 RCT→**
  Effect on change in body weight (mean difference -0.62 kg)
  (Reynolds et al. 2019)

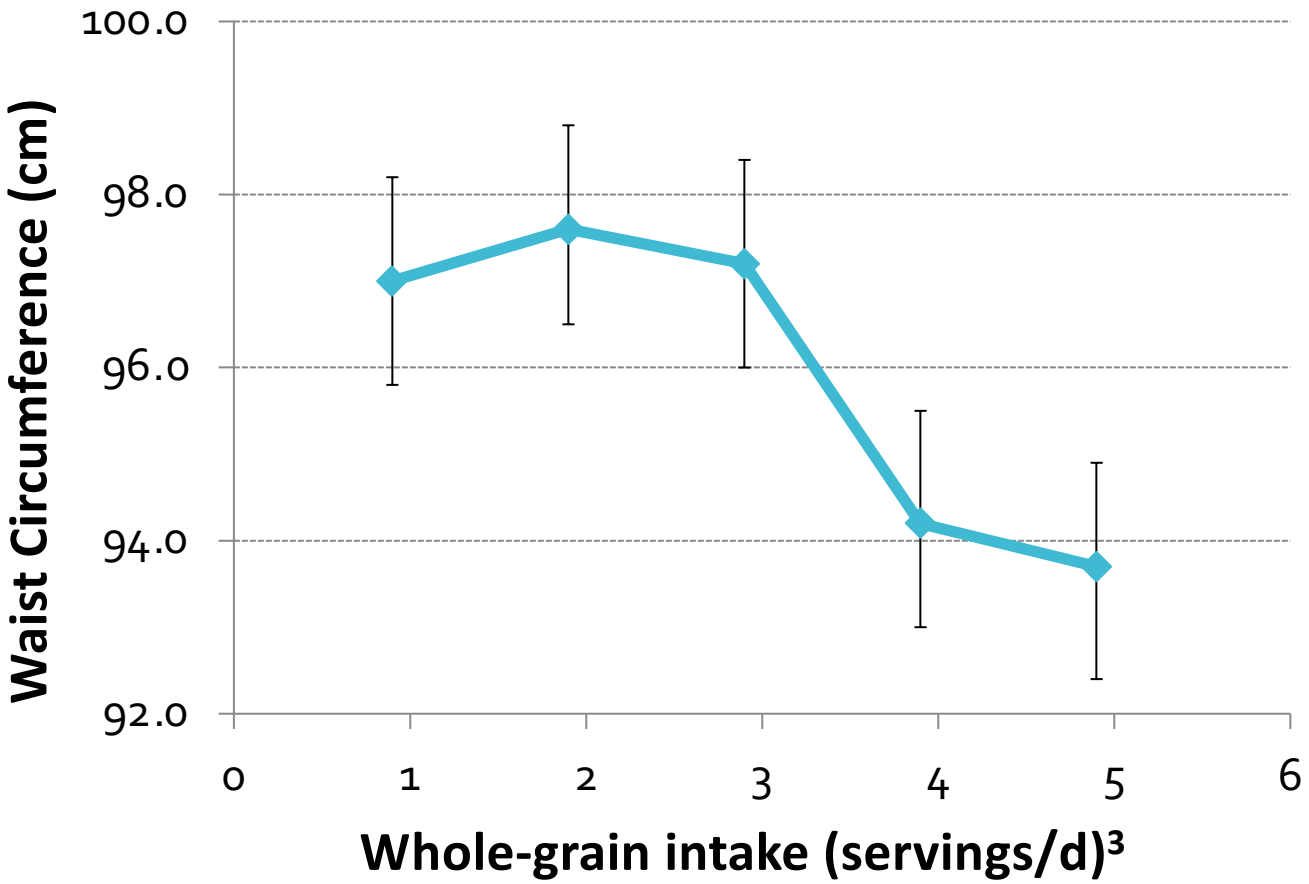
Abdominal Adiposity

- Waist Circumference (WC)
  - ↑T2D and CVD risk (Casanueva 2010)
  - By 2030 56% of men and 80% of women will be abdominally obese (Wang 2020)

- Visceral vs Subcutaneous adipose tissue
  - ↑T2D and CVD risk, independent of BMI or WC (Fox 2007, Rosenquist 2013, Abraham 2015)
  - ↑ Insulin resistance, dyslipidemia, oxidative stress, inflammation (Wagenknecht 2003, Nicklas 2003, Pou 2007)



Whole Grain and Waist Circumference



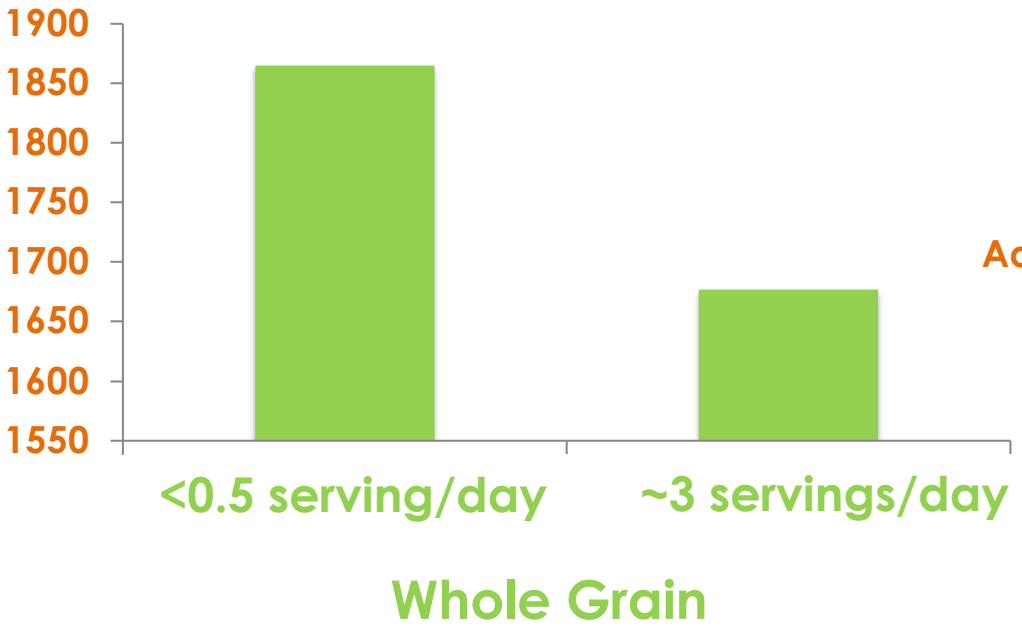
Whole grain
P-trend <0.001

Adjusted for :
age
sex
smoking status
total energy
alcohol intake

McKeown et al. Am J Clin Nutr 2010 92(5):1165-71

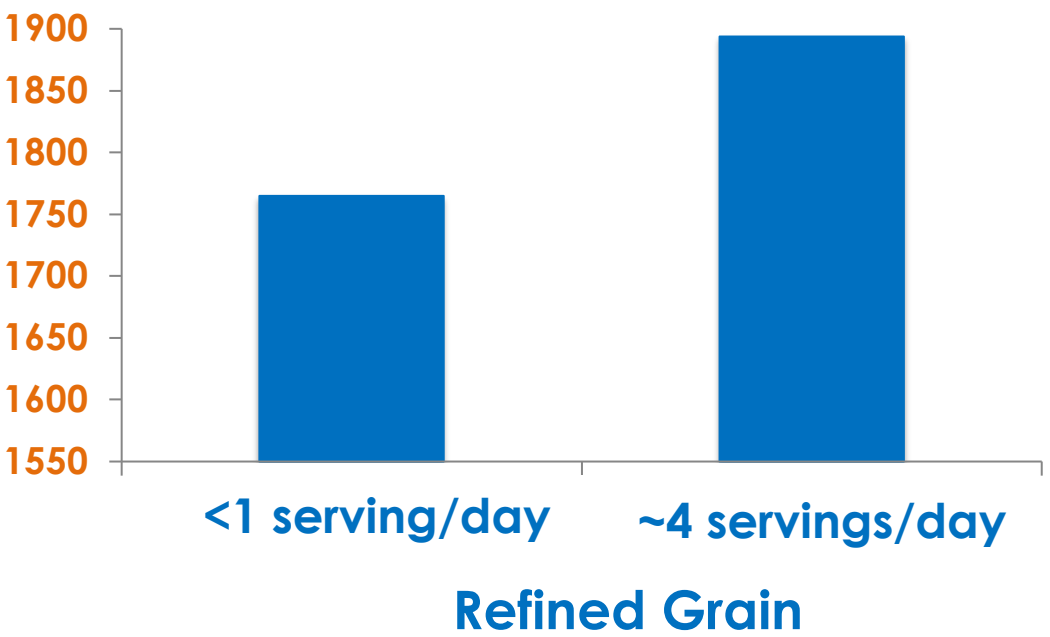
Whole and refined grain and VAT

↑ Whole Grain Intakes Associated with ↓Visceral Adiposity



Volume of Visceral Adipose Tissue (cm^3)

↑ Refined Grain Intakes Associated with ↑ Visceral Adiposity



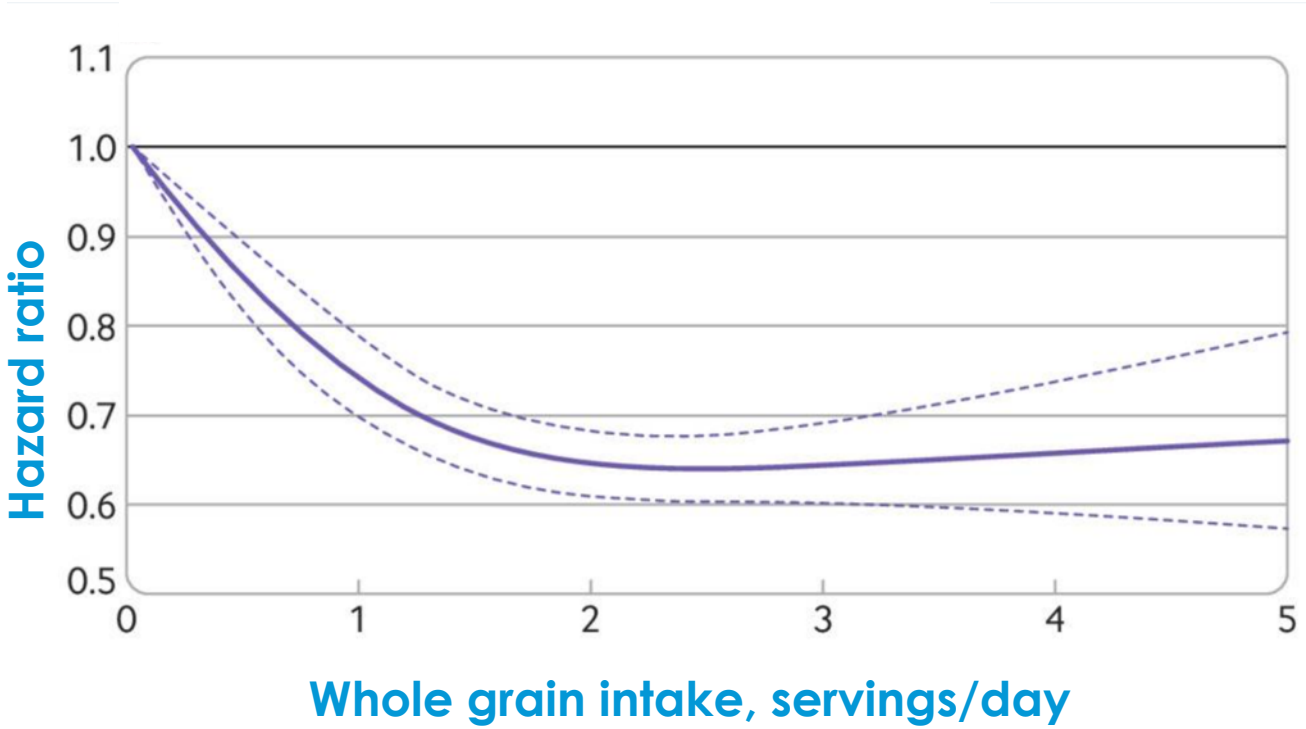
*P for trend < 0.001

- *Mean Volume of VAT is adjustment for age, sex, smoking status, total energy, alcohol intake, subcutaneous adipose tissue*
- *Associations remained significant in statistical models after accounting for other aspects of diet*

McKeown et al. Am J Clin Nutr 2010 92(5):1165-71

Whole grains and T2D

Whole Grain Intake & Risk of Type 2 Diabetes



- 29% lower rate of T2D among those in the highest vs lowest category of WG intake
- Greatest reduction in risk at 2 servings/d of whole grains

Mechanisms

○ Body weight ○ Inflammation
○ Insulin resistance ○ Glucose homeostasis

Hu et al. 2020 BMJ

Conclusions

Public Health Implications

Cardiovascular Disease

- 92 million Americans living with CVD or consequences of stroke
- $329.7 billion annual direct & indirect costs

Diabetes

- 100 million Americans with diabetes or pre-diabetes, 90-95% being T2D
- $245 billion annual direct & indirect costs

Leading Causes of Preventable Death

AHA 2018 Heart Disease and Stroke Statistics; CDC 2016 Report

Conclusions

- Observational studies consistently observe that higher whole grain intake is associated with lower risk of chronic diseases and mortality
- A diet rich in a variety of whole grains may lead to better maintenance of waist circumference and improvement in several CVD risk factors
- Whole grain rich diets may influence body fat deposition
- Higher consumption of whole grain foods is associated with lower risk of type 2 diabetes
- Whole grains are more than just fiber

Acknowledgments

- Nutrition Epidemiology Department
  - Dr. Nicola McKeown
- Funding support

JEAN MAYER USDA HUMAN NUTRITION RESEARCH CENTER ON AGING
HNRCA

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bell institute OF HEALTH AND NUTRITION GENERAL MILLS

How Food Processing can Increase the Consumption of Whole Grains

Eric Decker

Department of Food Science

University of Massachusetts

What Consumers Expect in Their Foods

- Drivers of Food Purchases:
  - Health and Wellness
  - Value
  - Ease of Cooking
  - Taste
- Whole grains attributes:
  - Health and Wellness
  - Are more expensive
  - Are more difficult to cook
  - Taste different

Whole Grains Come From Seeds

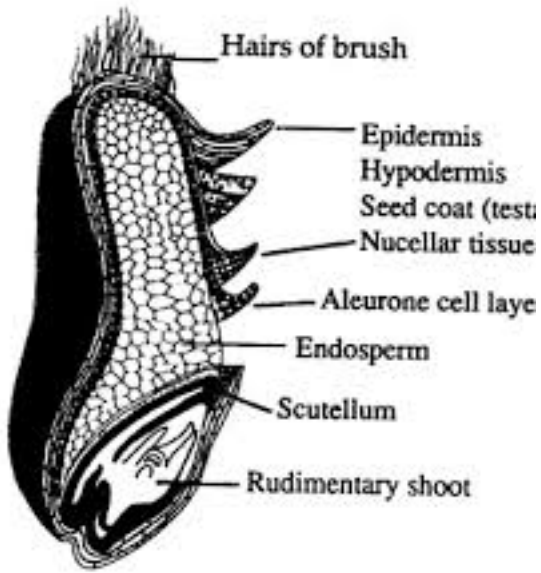
Corn

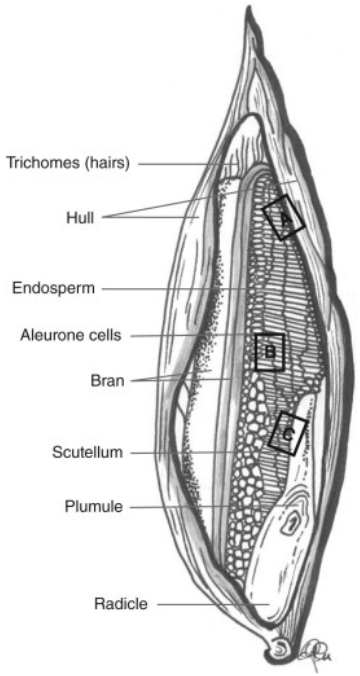
Wheat

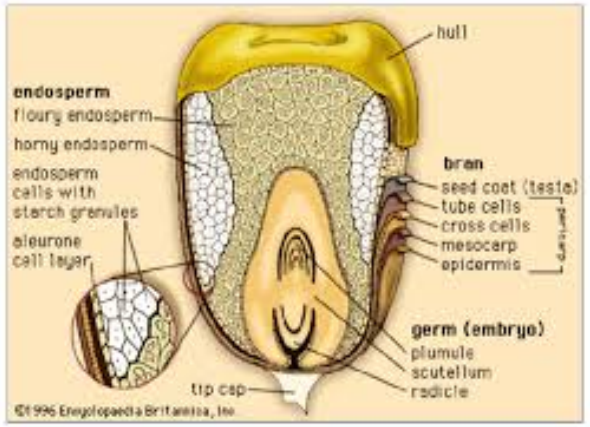
Oats

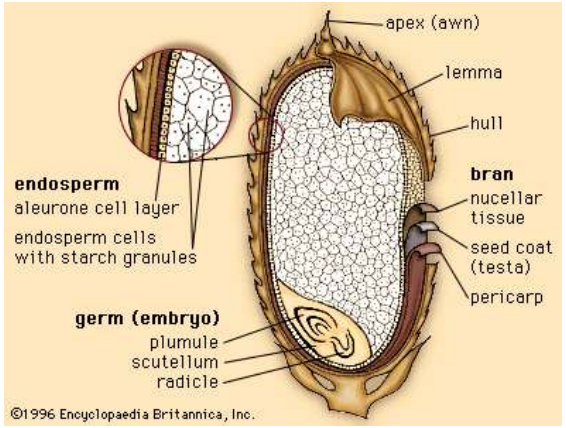
Rice

Seeds Evolved to Survive Harsh Environmental Conditions









Seed are Genetic Dispersal Agents = Designed for Minimal Digestibility = Minimal Nutritional Value

Processing is the Key to Increasing the Nutritional Value of Seeds (Whole Grains)

Dehulling and Cutting

Steel Cut Oats

Minimal Digestibility

Dehulling and Polishing

Brown Rice

Increasing the Digestibility of Whole Seeds

Cooking

Steel Cut Oats =
30 min

Brown Rice =
30 min

Ease of Preparation:

Average Cooking Time/Day in US is 37 min

Processing to Increase Ease of Preparation

Wheat

Cracked

Cooked and Dried

Farro = 40 min

Cracked Wheat = 20 min

Bulgar= 12 min

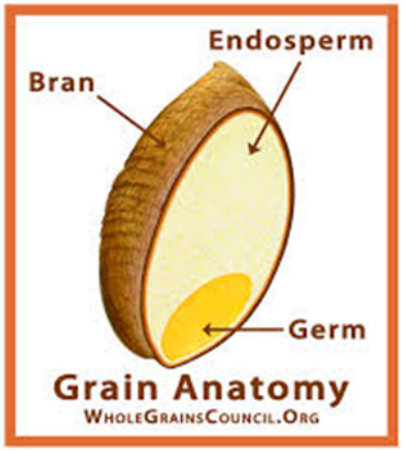
Processing to Increase Ease of Preparation

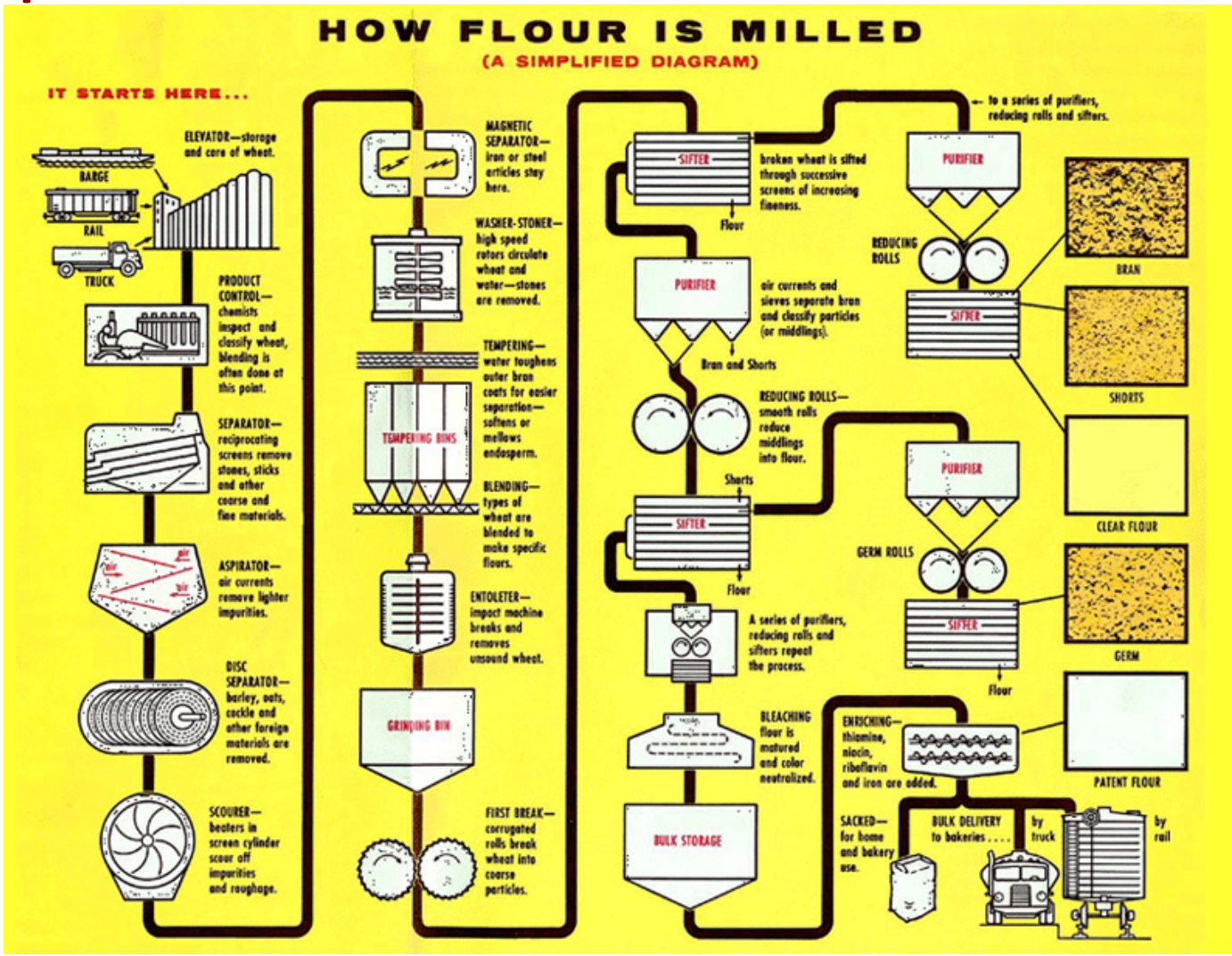
Pre-Gelatinization

- Pre-cook grain and then dry
- Dried grain is more porous allowing for rapid absorption of water and quicker cooking
- Usually fortified with minerals and vitamins lost during processing

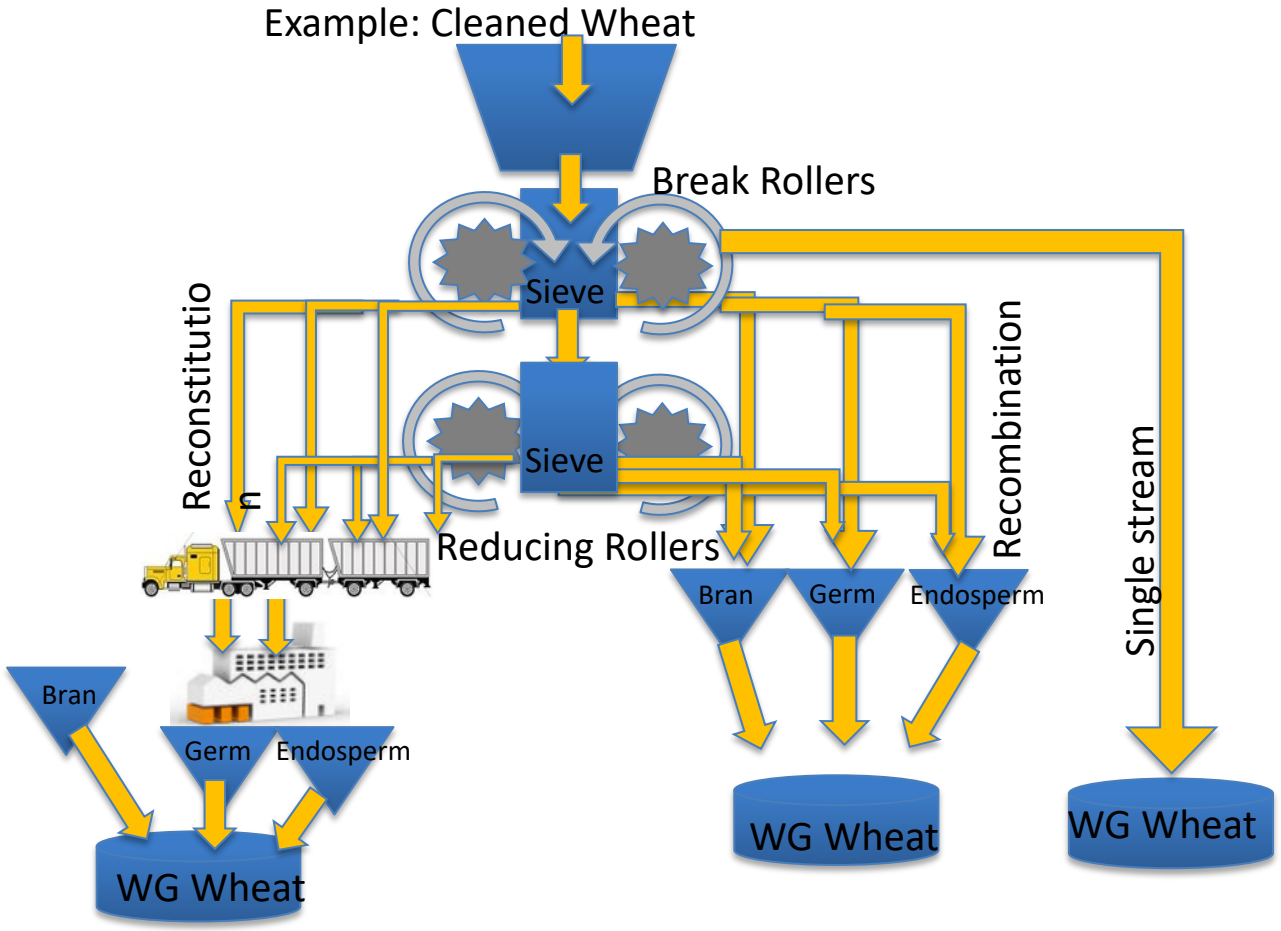
Processing to Increase Ease and Diversity of Preparation

- Milling Wheat
  - Cleaning
  - Grinding
  - Aging/Bleaching
  - Separating
    - Bran
    - Endosperm
    - Germ





“Whole Grain”: Milling / Processing

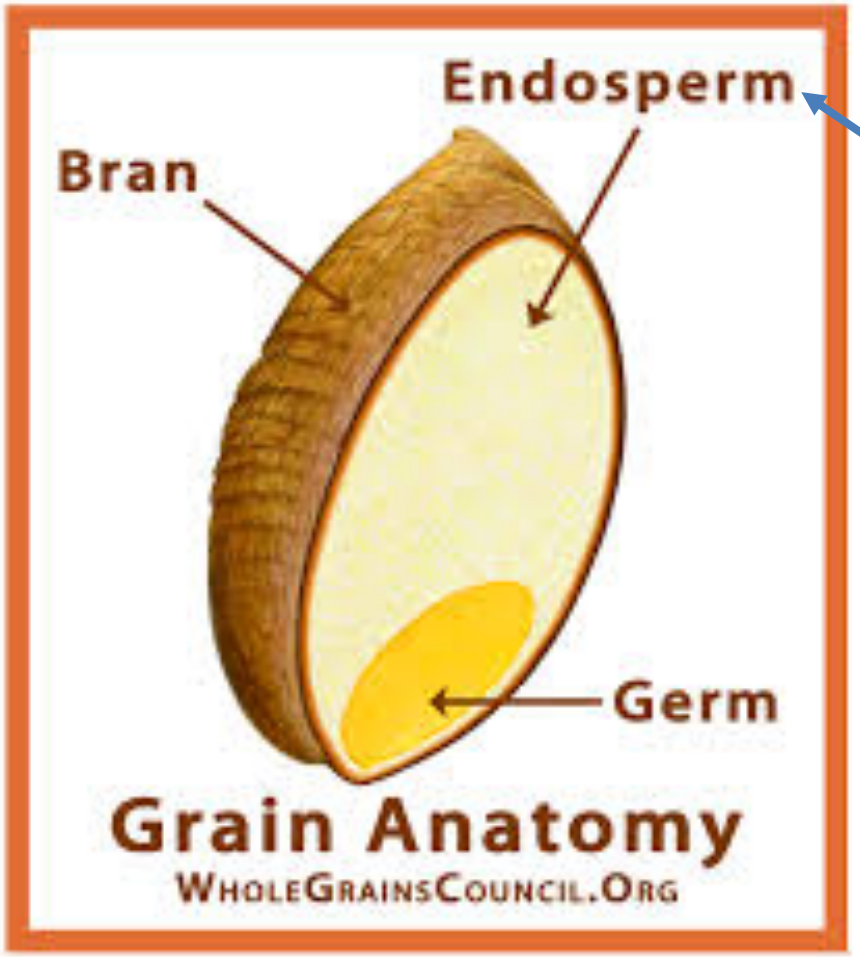


Courtesy Kevin Miller, General Mills

- **Wheat bran is difficult to mill to The fine particle sizes needed for flour so it is often milled separately**
- **Single stream milling can damage germ because milling is longer and harsher**
- **Both milling processes produce similar nutritional compositions and bioactivity**

Roles of Whole Grains Components on Food Quality

Endosperm



Starch (84%), fiber (3%) and protein (11%)

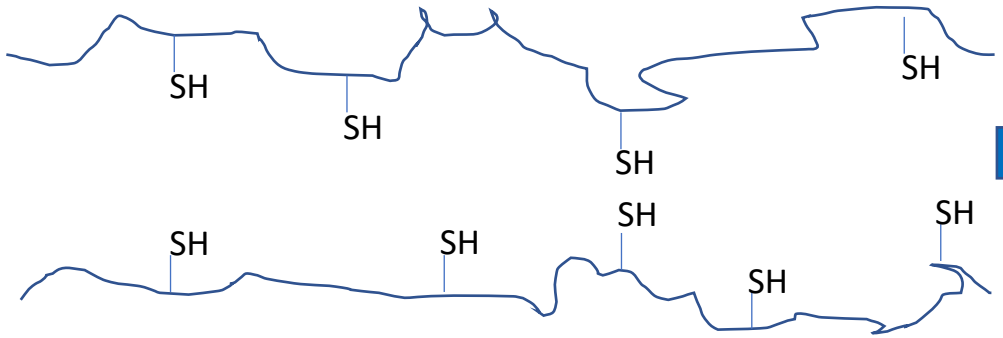
This is the major key to wheat functionality attributes because it's the source of gluten and starch.

- **Gluten provide dough elasticity = volume**
- **Starch provides crumb = moistness**

The additional components in whole wheat flour decrease the concentration of gluten and starch which changes functionality

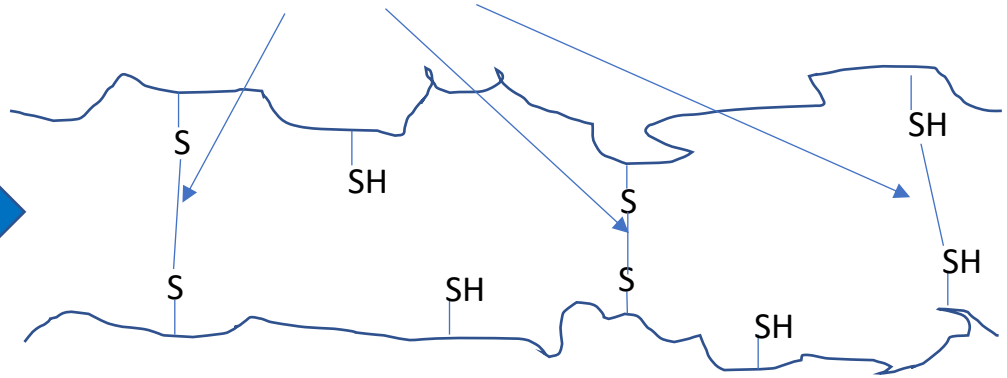
Bread Production

Gliadins and Glutenins



Kneading

Disulfide bonds: elasticity = structure



www.bakewithjack.co.uk

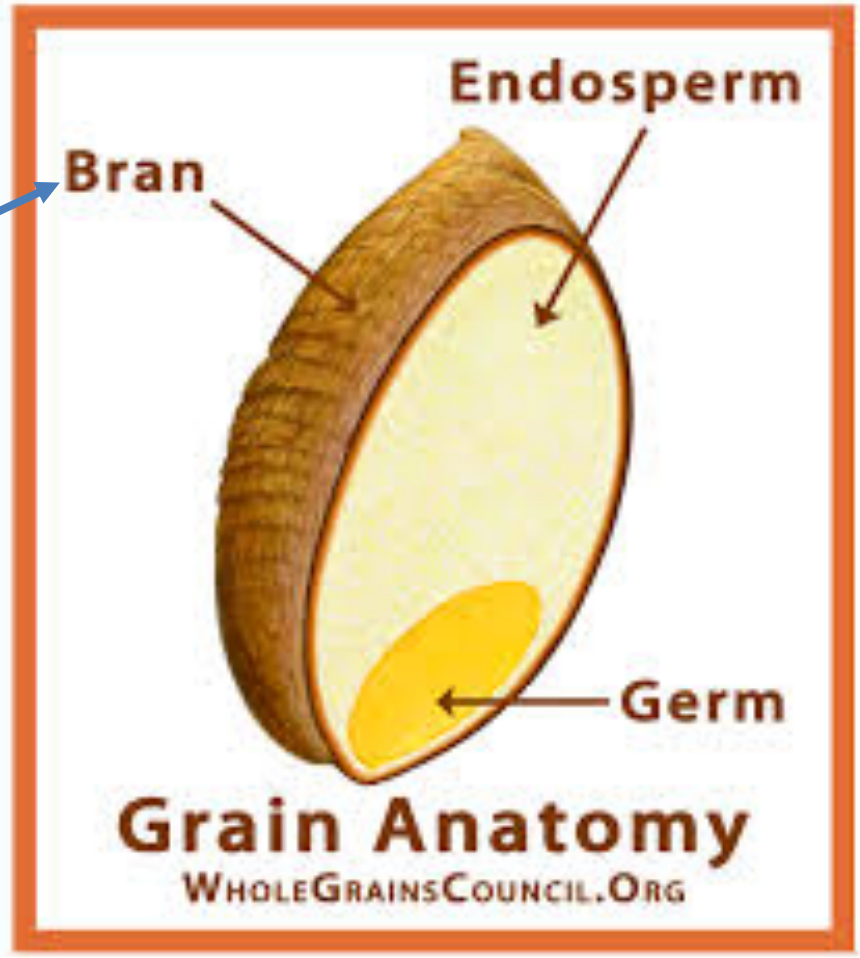
Gluten

Roles of Whole Grains Components on Food quality

Fiber (43%), 4% fat and flavonoids

Flavonoids impact taste, color and the functionality of gluten

Fiber absorbs water and impacts texture

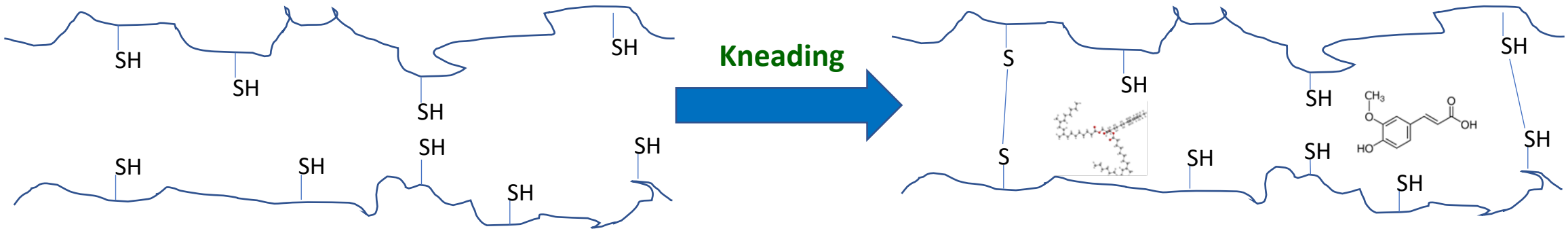


Impact of Bran on Preparation, Taste and Dough Properties

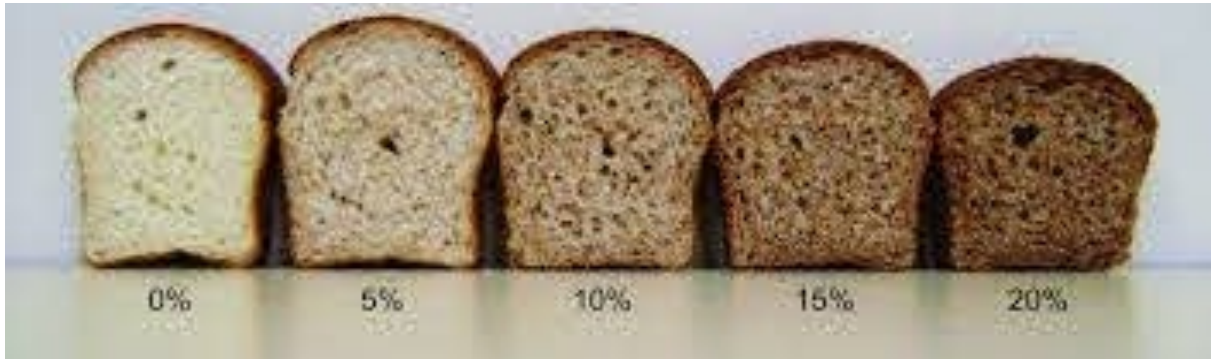
- Fibers compete with starch for water
  - More water needed to make dough
  - Dough production longer due to increased hydration time
  - Can produce different texture and staling due to different water binding properties
- Flavonoids produce astringency
  - A feeling of dryness in the mouth: e.g. tea and unsweetened chocolate
  - Mainly caused by flavonoids forming complexes with saliva proteins
  - Can be masked with sweetness
- Flavonoids and lipids also alter gluten functionality

Whole Wheat Bread Production

Flavonoids inhibit disulfide bonds formation

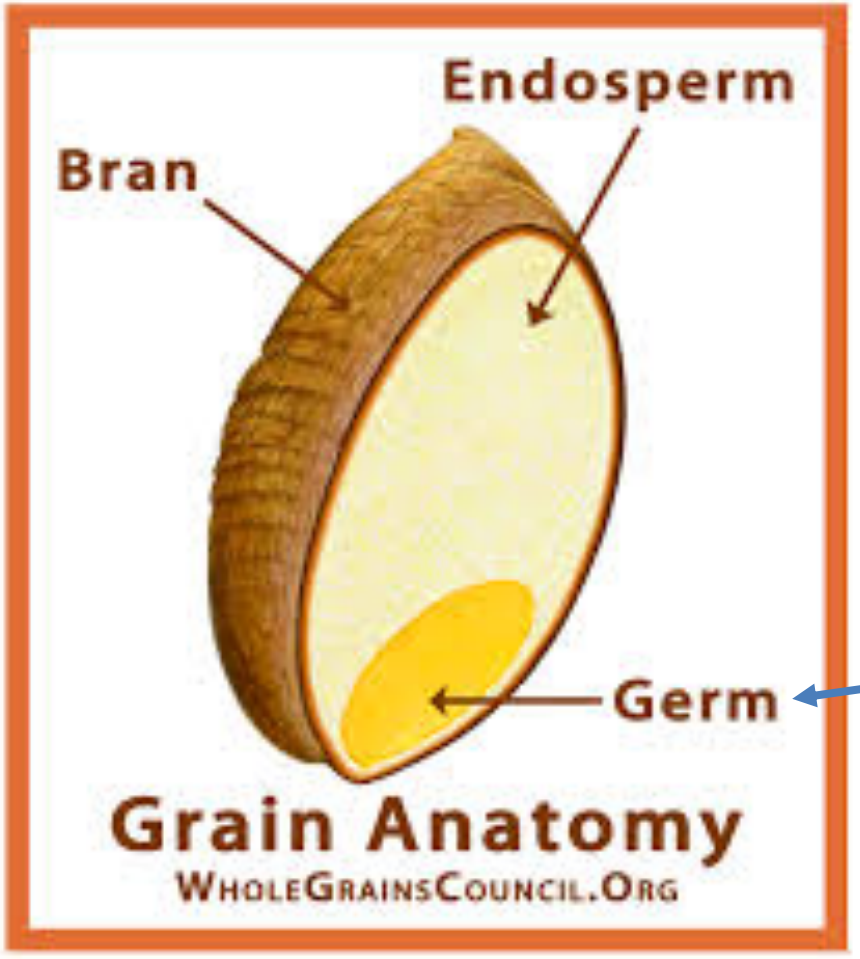


Gluten



Addition of Wheat Fiber to Bread: Hemdane et al., 2015

Roles of Whole Grains Components on Food quality

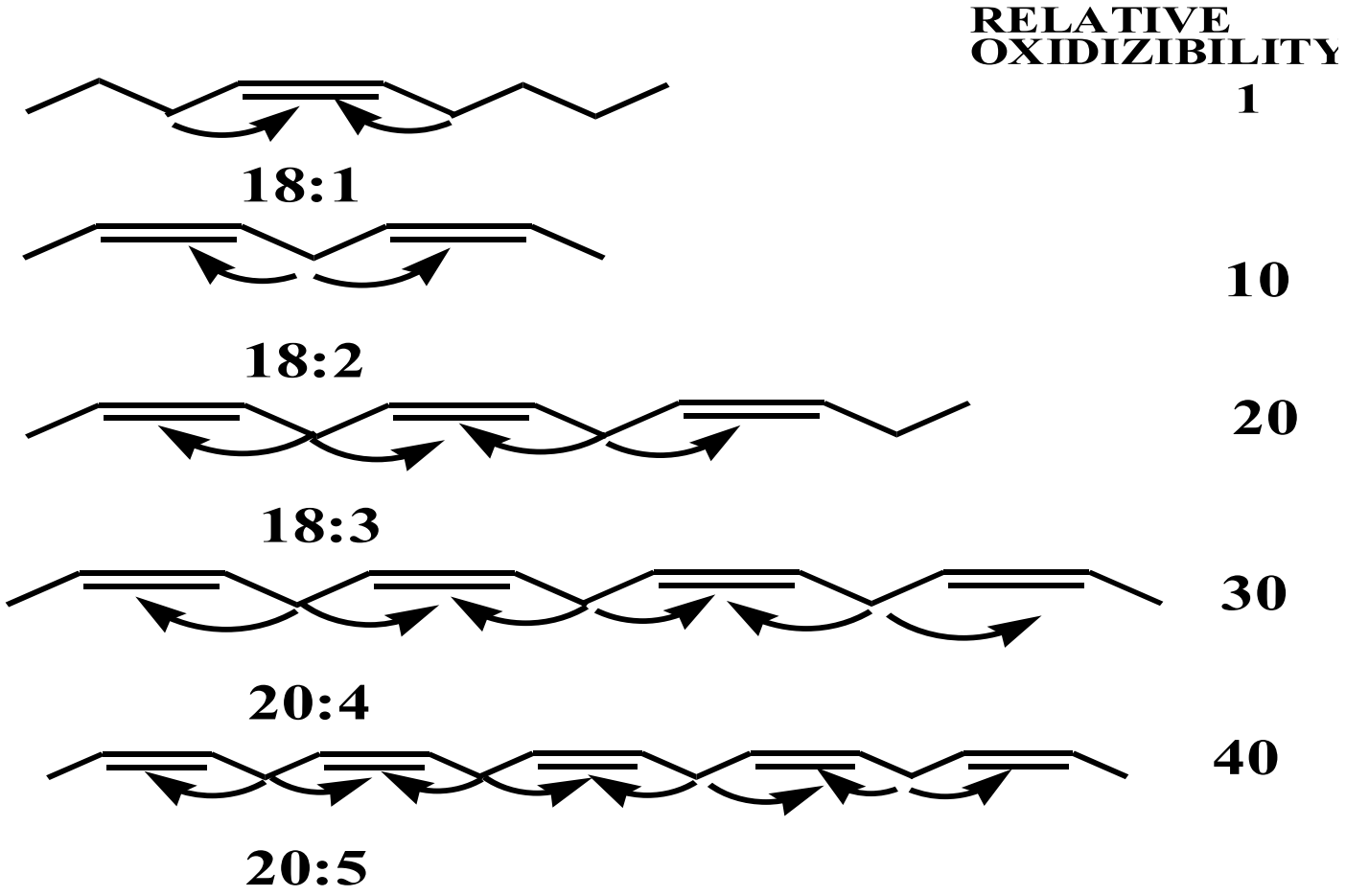


Lipids (10%) Fiber (13%), Minerals, Vitamin E

Lipids decrease air pocket size and interfere with gluten formation

Lipids are high in 18:3 which is easily oxidized to decrease shelf life due to off flavor formation

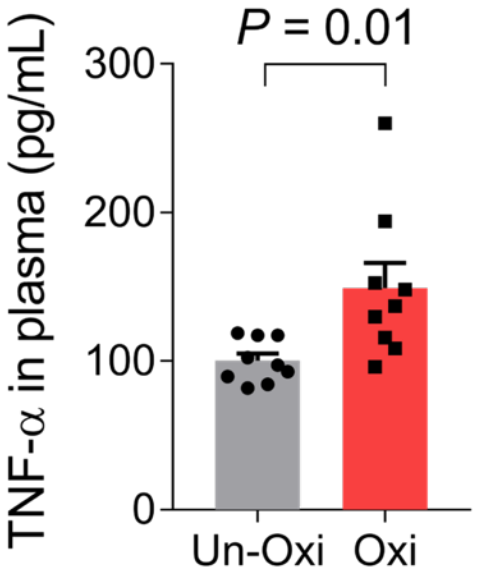
Impact of Unsaturation on Susceptibility to Lipid Oxidation

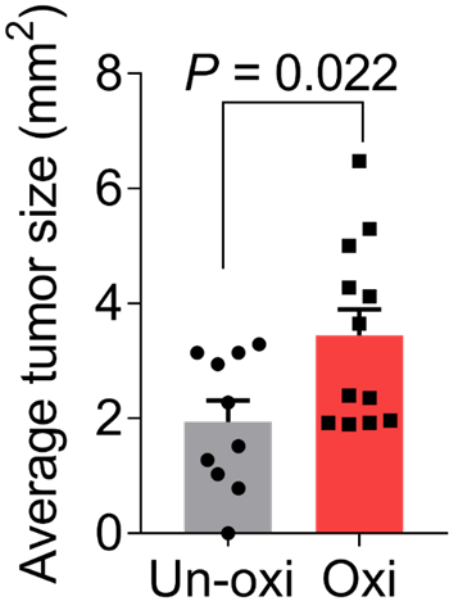


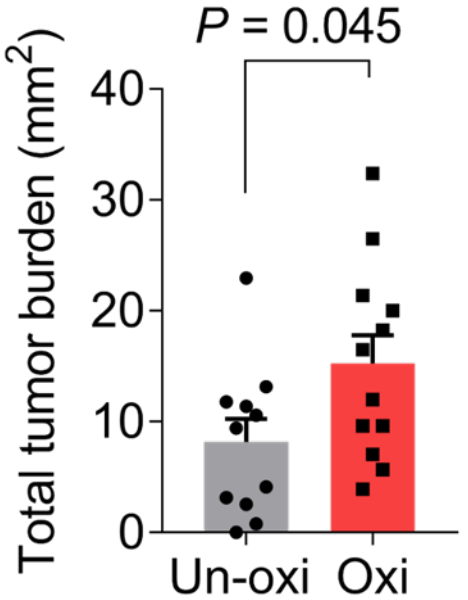
Newspapers soaked in linseed oil caused fire due to spontaneous combustion

(Hampshire Gazette; Northampton, MA)

Impact of Mildly Oxidized Oil on Mouse Model of Inflammatory Bowel Disease







Increased Gut Inflammation

Increased tumor size and number

Improving the Functionality of Whole Wheat Bread

- Enzyme Treatments - Xylanase
  - Breakdown fiber to improve dough properties by reducing water absorption
- Emulsifiers – Monoglycerols, lecithin, Datem (tartaric + acylglycerols)
  - Decrease staling and increase loaf volume
- Mold inhibitors – Propionic and Sorbic acids
  - All breads are susceptible to mold growth
  - Whole wheat breads can have higher moisture content making them more susceptible to mold growth
  - Sometimes refrigerated to decrease mold but this increases staling

Economic Accessibility

- Healthy Food should be accessible to all
  - Even more important with Covid
- Food Budget –
  - Lower 20%of income spends $79/week for family of four
  - Middle 20% of income spends $144/week
  - Upper 20% of income spends $257/week
- Cost of Whole Wheat Bread
  - Artisan = 35¢/serving
  - Name Brand = 27¢/serving
  - Store Brand = 18¢
  - Store brand white bread = 9¢/serving
- Shelf-life – determined by mold growth and staling
  - Artisan bread = 3-4 days
  - Major brands = 5-7 days – due to food additives
- Is the benefit of whole grains breads greater than perceived risk of food additives?

Ready to Eat Breakfast Cereals

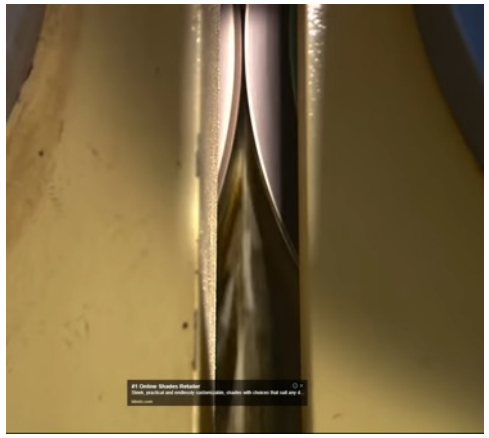
- Can be an excellent source of whole grain
- Meet many consumer criterial for food purchases
  - Convenient
  - Good value
  - Good Taste
  - Sustainability = Long Shelf-life (low water activity) and little waste
- Are produced by:
  - Mixing whole grains (Muesli and Granola)
  - Flakes (Wheaties)
  - Extrusion (Cheerios)

Cereal Flakes

From how Cereal is made
https://www.youtube.com/watch?v=a0Y5J_pgiFY

Porridge/dough
Add vitamins

Roll



Flake

Dry

Spray on Heat Liable
Vitamins and Flavors

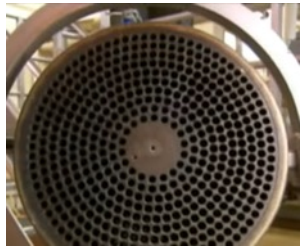
Package

Extruded Oat Cereal

How It's Made, Oat Cereal
https://www.youtube.com/watch?v=vxnT2Z0k3ew

Grind and cook into porridge/batter

Shape with forming die



Cut Long Tubes

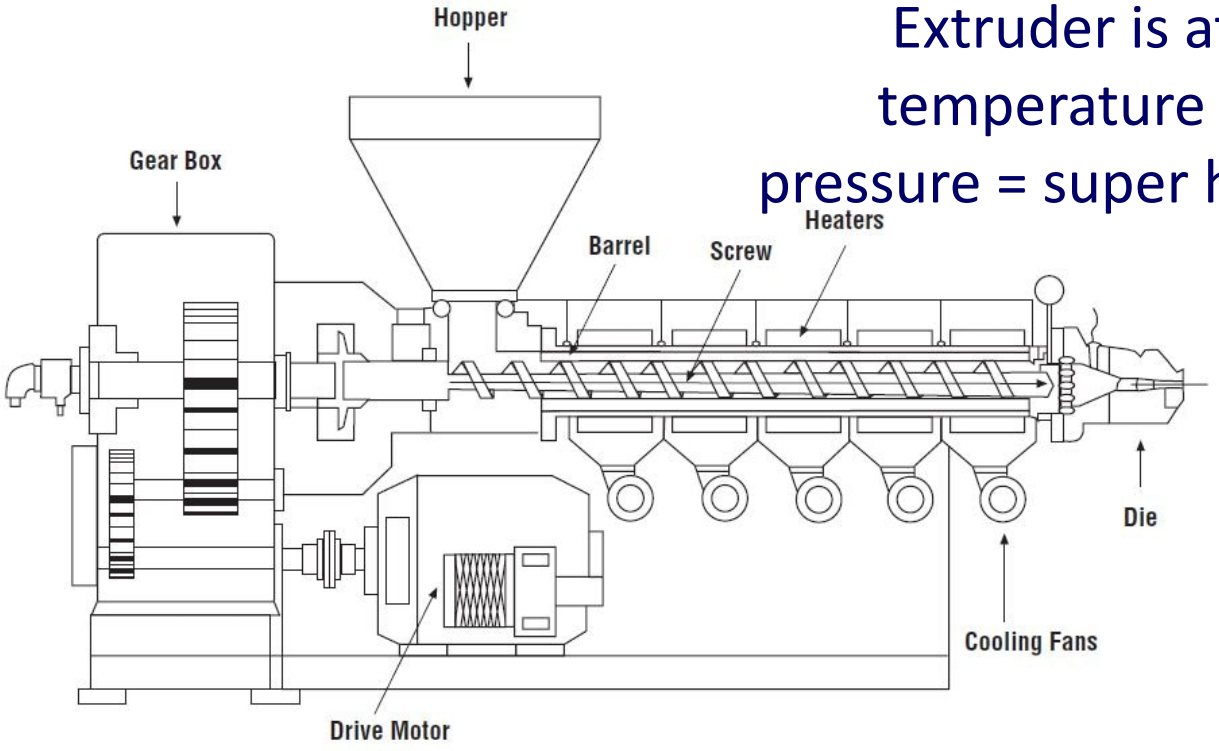
Steam Expansion

Spray on Vitamins and Flavors

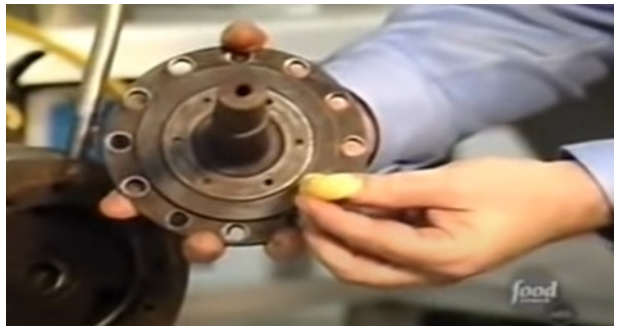
Dry and Package

Extruded Puffed Cereals

Cereal ingredients are mixed water in passed through extruder



Extruder is at high temperature under pressure = super heats water



- Product exits die
- Water flash evaporates to make an expanded and porous structure

Economic Accessibility

- Cost of Wheat Flakes
  - Organic = 36¢/serving
  - Name Brand = 22¢/serving
  - Store Brand = 17¢/serving
- Cost of Oat Rings
  - Organic = 36¢/serving
  - Name Brand = 22¢/serving
  - Store Brand = 17¢/serving
- With Milk = $1.16-1.92/day for family of 4
- Shelf-life determined by rancidity
  - Organic brands often do not have added antioxidants and will have a shorter shelf-life

Added Sugar

- Many Whole Grain Products have added sugar
  - Name brand whole wheat breads = 1-4 g sugar/serving
  - Name brand ready to eat cereal = 0.2-12 g sugar/serving
- Sugar often added to counteract astringency from wheat flavonoids
- Sugar is useful in increasing palatability and acceptability of healthy foods
- For example: sweetened chocolate milk is included in school lunch programs to increase milk consumption
  - 8-12 g/serving
  - 70% of milk consumed in schools
- Is there a benefit of added sugar to whole grain foods to increase consumption
- How do we make risk assessment of how the benefits of whole grains outweigh the risks of added sugar

Conclusions

- Foods are only healthy if they are regularly consumed
- Foods will be more readily purchased and consumed if they:
  - Taste Good
  - Are easily prepared
  - Have good value
  - Nutritious
  - Sustainable

Conclusions

- Seeds are designed to not be digestible so unless they are processed they have little nutritional value
- Cooking increases digestibility by hydrating the seed and breaking down the seed coating
  - This is a long process so it often does not fit into current lifestyles
- Cooking time can be decreased by decreasing particle size and using technologies such as pre-gelatinization

Conclusions

- Processing such as milling into flour can further increase the ease of preparation of whole grains
- Whole wheat is a much more complex ingredient than white flour due to the presence of:
  - Fiber
  - Lipids
  - Flavonoids
- These components change taste and color and negatively impact bread properties and shelf life

Processing is a major key to increasing the consumption of Whole Grains

Practice Applications for RDs: Communicating WG Benefits

- DGSAC report identifies whole grains "with almost the same consistency as vegetables and fruits as beneficial for the outcomes examined, suggesting that these 3 plant-based food groups are fundamental constituents of a healthy dietary pattern."
  - Epi research done on commonly eaten foods (mostly cereal, bread)
  - RCTs further strengthen these findings
- CVD risk reduction begins at even lowest levels of whole grain intake. Every bite counts!

Dietary Guidelines Advisory Committee. 2020. *Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and the Secretary of Health and Human Services.* U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

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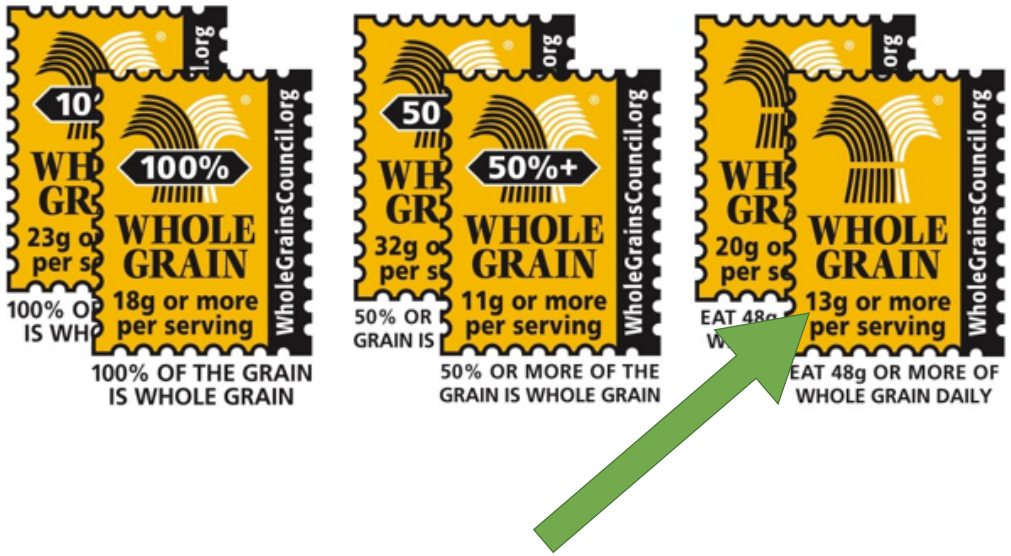
Practice Applications for RDs: Finding Whole Grains

- Help your clients identify healthy whole grain options across a range of processing levels. Use the nutrition label to find products with lower sodium, sugar, saturated fats, etc.
  - Ex: brown rice, quinoa, whole wheat pasta, breakfast cereal, whole wheat bread, etc.
- Help your clients identify whole grains at the store:
  - Look for the Whole Grain Stamp
  - Look for the word “whole” on the ingredient listing



The different gram amount on each Stamp tells you how many grams of whole grain are in one serving of a product.

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Thank you!

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