Health Benefits of Whole Grains
The Newest Evidence

Food, Nutrition, and Health Update 2014

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Disclosures

- Supported in part by an Investigator-Initiated Research Grant from the General Mills Bell Institute of Health and Nutrition
- Scientific Advisor for the Whole Grains Council
- All views expressed in this talk are my own
Presentation Roadmap

- Background
  - What is a whole grain?
  - Effect of processing
  - Current intakes
  - Potential health mechanisms

- Review of the scientific evidence

- Conclusions and practical recommendations
American Association of Cereal Chemists (AACC) International definition:

“Whole grains shall consist of the intact, ground, cracked or flaked kernel (caryopsis), whose principal anatomical components – the starchy endosperm, germ and bran – are present in the same relative proportions as they exist in the intact kernel”

This definition means that 100% of the original kernel – all of the bran, germ, and endosperm – must be present to qualify as a whole grain

No universally accepted definition of a whole grain
Types of Whole Grains

True Grains (*Poaceae* or *Gramineous* family)
- Wheat
  - (includes Spelt, Farro, Kamut, Emmer, Durams, Einkorn)
- Oats
- Rice
- Corn (maize, popcorn)
- Barley (hulled)
- Rye
- Canary Seed

Pseudocereal Grains
- Buckwheat
- Amaranth
- Quinoa

- Millet
- Wild rice
- Triticale
- Sorghum
- Teff
- Fonio
- Job’s Tears
The Whole Grain Kernel

Brouns et al. (2013); Surget & Barron (2005)
Effects of Processing on the Grain (i.e. the removal of bran and germ)

% gained in enrichment & fortification

% lost in refining


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# Health Benefits of Whole Grains

<table>
<thead>
<tr>
<th>Health Benefit</th>
<th>Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular Disease</td>
<td>~21% ↓</td>
</tr>
<tr>
<td>Type 2 Diabetes</td>
<td>~26% ↓</td>
</tr>
<tr>
<td>Weight Management</td>
<td>0.5 kg/m² ↓</td>
</tr>
<tr>
<td>Colorectal Cancer</td>
<td>17% ↓</td>
</tr>
<tr>
<td>Blood Pressure</td>
<td>23% ↓</td>
</tr>
</tbody>
</table>

Whole Grains and Chronic Disease Reduction: Potential Mechanism

Whole grain intake ↑

Dietary fiber ↑

Colonic fermentation ↑

Bioactive components ↑

(Viscosity/food structure)

GI ↓ and or II ↓

Insulin sensitivity ↑

Satiety ↑

Blood lipids ↓

Type 2 diabetes ↓

Obesity ↓

Tumour growth ↓

Homocysteine ↓

Antioxidant/anti-inflammatory status ↑

Cardiovascular diseases ↓

Cancer ↓

Whole Grain and Dietary Fiber Intakes in US Adults

<table>
<thead>
<tr>
<th>Whole Grains</th>
<th>Dietary Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended Intake</strong></td>
<td>At least half of all grains be consumed as whole grains</td>
</tr>
<tr>
<td><strong>Current Intake</strong></td>
<td><strong>2009-2010:</strong></td>
</tr>
<tr>
<td>~8%</td>
<td>14 g/d women</td>
</tr>
</tbody>
</table>

Consumer Confusion over Whole Grains and Fiber

- 7 out of 10 consumers are trying to consume more fiber and whole-grains *
- Of consumers reporting they choose “whole grains” in an effort to get more fiber, 85% assumed the product was an excellent source of fiber **

*2010 Food and Health Survey conducted by the International Food Information Council
Comparison of Fiber Content of Equivalent Amount of Whole Grains

EAT A VARIETY OF WHOLE GRAINS!

<table>
<thead>
<tr>
<th>Whole Grain</th>
<th>Fiber (g/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulgur</td>
<td>18.5</td>
</tr>
<tr>
<td>Barley (hulled)</td>
<td>16.2</td>
</tr>
<tr>
<td>Rye</td>
<td>14.5</td>
</tr>
<tr>
<td>Wheat (hard white)</td>
<td>11.9</td>
</tr>
<tr>
<td>Oats</td>
<td>10.6</td>
</tr>
<tr>
<td>Corn (yellow)</td>
<td>7.7</td>
</tr>
<tr>
<td>Sorghum</td>
<td>6.8</td>
</tr>
<tr>
<td>Wild rice</td>
<td>5.9</td>
</tr>
<tr>
<td>Brown rice</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Presentation Roadmap

- Background
- Review of the Scientific Evidence
  - Obesity
    - Gut microbiota
  - Surrogate risk factors for CVD
    - Glucose and Insulin Metabolism
    - Lipids
    - Blood Pressure
- Cognition
Abdominal Obesity: The Critical Adipose Depot

Men: >40 inches
Women: >35 inches

↑ Insulin resistance
↑ Inflammation
↑ Atherogenic dyslipidemic

### Prospective Evidence: Higher Whole Grain Intake lower Gains in Weight and Waist Circumference

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Exposure of Interest</th>
<th>Higher WG Intake Associated with</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Less Weight Gain</td>
</tr>
<tr>
<td>Adults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liu et al. (2003)</td>
<td>USA</td>
<td>Whole Grain</td>
<td>✓</td>
</tr>
<tr>
<td>Koj-Banerjee et al. (2004)</td>
<td>USA</td>
<td>Whole Grain</td>
<td>✓</td>
</tr>
<tr>
<td>Bazzano et al. (2005)</td>
<td>USA</td>
<td>WG RTEBC</td>
<td>✓</td>
</tr>
<tr>
<td>Du et al. (2010)</td>
<td>Europe</td>
<td>Cereal Fiber</td>
<td>✓</td>
</tr>
<tr>
<td>Mozaffarian (2011)</td>
<td>USA</td>
<td>Whole Grain</td>
<td>✓</td>
</tr>
<tr>
<td>McKeown (in preparation)</td>
<td>USA</td>
<td>Whole Grain</td>
<td>X</td>
</tr>
<tr>
<td><strong>Adolescents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheng et al. (2009)</td>
<td>Germany</td>
<td>Whole Grain</td>
<td>X</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>USA: 5/7</td>
<td>WG: 5/7</td>
<td>5/7</td>
</tr>
</tbody>
</table>
Greater Intake of Whole Grains is Linked to Smaller Annual Gain in Waist Circumference: Data from the Framingham Heart Study

Unpublished data

- n=3,440
- Median follow-up time of ≈13 years
- Q1: 0.78 cm; Q5: 0.62 cm

Adjusted for baseline waist circumference, medication, energy intake, sex, smoking, PA, DGAI
Whole- and Refined- Grain Intakes are Differentially Associated with Abdominal Visceral and Subcutaneous Adiposity

Framingham Heart Study (n=2,834)

Visceral Fat

Subcutaneous Fat

Mean multivariate-adjusted* VAT by whole and refined intake quintile categories

Grain intake category

Whole grain (p trend <0.001)

Refined grain (p trend <0.001)

*adjusted for age, sex, smoking status, total energy, alcohol intake, SAT

McKeown et al. AJCN 2010 Nov;92(5):1165-71
The association between high whole-grain intake and VAT was diminished in people consuming 4 servings refined grains/d, indicating that refined grain may offset any potential benefits of whole grain on abdominal adiposity.

McKeown et al. AJCN 2010 Nov;92(5):1165-71
Effects of a Whole Grain Enriched Hypocaloric Diet on Measures of Body Composition in Adults with the Metabolic Syndrome

- Obese middle-aged adults (25 M, 25 F) with metabolic syndrome
- Randomized, open-label, parallel study for 12 weeks
- Energy restricted study
- Reach target for daily whole-grains (4, 5, 6 or 7 daily servings) or avoid whole grains
  - Whole grain diet = \( \approx 5 \) serving/d whole grains
  - Refined grain diet = 0.2 servings/d whole grains

Katcher et al. (2008) Am J Clin Nutr 87;79-90
Effects of a Whole Grain Enriched Hypocaloric Diet on Measures of Body Composition in Adults with the Metabolic Syndrome

Katcher et al. (2008) Am J Clin Nutr 87;79-90
Whole grain and body weight changes in apparently healthy adults: a systematic review and meta-analysis of randomized controlled studies\(^1\textsuperscript{-3}\) 


*Korrie Pol, Robin Christensen, Else M Bartels, Anne Raben, Inge Tetens, and Mette Kristensen*

- Data from 26 studies (n=2,060 participants)
  - Body weight
  - Body fat – 7 studies
  - Waist circumference – 9 studies

**Conclusion:** Whole - grain consumption *does not decrease body weight compared to the control*, but a small beneficial effect on body fat may be present. The relatively short duration of intervention studies (<16 weeks) may explain the lack of difference in body weight and fat.
Potential Mediating Effects of Whole Grains On Body Weight

- Decreased dietary energy density
- Increased satiety
  - Slower gastric emptying
  - Slower digestion and absorption
- Reduce postprandial glycemic response
- **Modulation of the gut microbiota**

Prebiotic Effect

- Prebiotics are non-digestible carbohydrates resistant to stomach and small intestine secretions.
- Reach the large intestine intact where they undergo selective fermentation and stimulate the growth and/or activity of healthy bacteria (i.e. bifidobacteria and lactobacilli).
- Formal definition
  “A selectively fermented ingredient that allows specific changes, both in the composition and/or activity of the gastrointestinal microbiota that confers benefits upon the host well-being and health” (Gibson, 2004)
Whole-grain wheat breakfast cereal has a prebiotic effect on the human gut microbiota: a double-blind, placebo-controlled, crossover study

Adele Costabile¹*, Annett Klinder¹, Francesca Fava¹, Aurora Napolitano², Vincenzo Fogliano², Clare Leonard³, Glenn R. Gibson¹ and Kieran M. Tuohy¹

- A 3 week double blind cross-over study in 32 adults
- Diet
  - Whole grain wheat (48g/d)
  - Wheat bran (48g/d)
- A significant increase in bifidobacteria on whole grain wheat arm
- A significant increase in lactobaccilli on both arms

Determination of the *in vivo* prebiotic potential of a maize-based whole grain breakfast cereal: a human feeding study

Andrew L. Carvalho-Wells\(^1\), Kathrin Helmolz\(^2\), Cecelia Nodet\(^2\), Christine Molzer\(^2\), Clare Leonard\(^3\), Brigid McKeveith\(^3\), Frank Thielecke\(^3\), Kim G. Jackson\(^1\) and Kieran M. Tuohy\(^2\)

- A 3 week double blind cross-over study in 32 healthy adults

- **Diet**
  - Non-whole grain (48g/d)
  - Whole grain cereal (48g/d)

- A significant increase in bifidobacterium after WG cereal consumption

  Br J Nutr. 2010;104:1353-1356
Whole Grain Consumption (60g/4weeks) Induces Immunological & Metabolic Improvements

Plasma IL-6 levels decreased on the brown rice and whole grain barley diets. Reduction was highest in overweight.

Lower postprandial glucose levels during the combined brown rice and whole grain barley diets.

These Whole-Grain Associated Improvements are Coincident with Altered Gut Microbiota

Table 2 Abundance of dominant bacterial taxa (% of total microbiota) in fecal samples as determined by 454 pyrosequencing (values are presented as mean ± s.d.)

<table>
<thead>
<tr>
<th>Genus</th>
<th>Baseline</th>
<th>BR</th>
<th>BR + WGB</th>
<th>WGB</th>
<th>P-value</th>
<th>Confirmation by linear model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteroides</td>
<td>28.55 ± 15.73</td>
<td>22.89 ± 10.37</td>
<td>21.19 ± 11.87</td>
<td>23.48 ± 12.62</td>
<td>0.022</td>
<td>Yes</td>
</tr>
<tr>
<td>Blautia</td>
<td>5.68 ± 3.15</td>
<td>7.61 ± 4.47</td>
<td>8.14 ± 3.97</td>
<td>8.61 ± 4.32</td>
<td>0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>Ruminococcus</td>
<td>4.20 ± 4.91</td>
<td>5.35 ± 5.05</td>
<td>4.171 ± 5.75</td>
<td>3.46 ± 4.32</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Faecalibacterium</td>
<td>2.82 ± 2.38</td>
<td>3.06 ± 2.29</td>
<td>3.86 ± 3.22</td>
<td>3.86 ± 3.19</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Prevotella</td>
<td>2.79 ± 8.89</td>
<td>1.99 ± 6.24</td>
<td>3.34 ± 9.84</td>
<td>2.02 ± 6.30</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Dorea</td>
<td>2.59 ± 2.01</td>
<td>3.12 ± 2.22</td>
<td>3.08 ± 1.80</td>
<td>2.75 ± 1.86</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Parabacteroides</td>
<td>2.58 ± 3.05</td>
<td>2.06 ± 3.23</td>
<td>2.10 ± 3.14</td>
<td>1.59 ± 1.44</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Roseburia</td>
<td>1.98 ± 1.35</td>
<td>1.70 ± 1.25</td>
<td>2.42 ± 1.58</td>
<td>3.06 ± 2.91</td>
<td>0.01</td>
<td>Yes</td>
</tr>
<tr>
<td>Akkermansia</td>
<td>1.85 ± 4.58</td>
<td>0.77 ± 1.53</td>
<td>0.68 ± 1.28</td>
<td>0.59 ± 0.80</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Coprococcus</td>
<td>1.82 ± 2.09</td>
<td>1.91 ± 2.08</td>
<td>1.47 ± 2.22</td>
<td>1.35 ± 1.78</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Alistipes</td>
<td>1.76 ± 2.08</td>
<td>1.67 ± 1.85</td>
<td>1.11 ± 1.05</td>
<td>1.34 ± 1.67</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Oscillibacter</td>
<td>1.27 ± 1.04</td>
<td>1.24 ± 1.00</td>
<td>1.08 ± 0.83</td>
<td>0.96 ± 0.61</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Bifidobacterium</td>
<td>0.99 ± 1.88</td>
<td>1.02 ± 1.64</td>
<td>1.95 ± 3.16</td>
<td>1.84 ± 2.54</td>
<td>0.011</td>
<td>No</td>
</tr>
<tr>
<td>Subdoligranulum</td>
<td>0.94 ± 1.03</td>
<td>1.17 ± 1.43</td>
<td>1.42 ± 1.73</td>
<td>1.09 ± 1.02</td>
<td>NS</td>
<td>Yes</td>
</tr>
<tr>
<td>Dialister</td>
<td>0.75 ± 1.17</td>
<td>0.60 ± 0.89</td>
<td>0.94 ± 1.21</td>
<td>1.14 ± 1.69</td>
<td>0.027</td>
<td>No</td>
</tr>
<tr>
<td>Odoribacter</td>
<td>0.26 ± 0.24</td>
<td>0.28 ± 0.35</td>
<td>0.28 ± 0.41</td>
<td>0.15 ± 0.18</td>
<td>0.002</td>
<td>No</td>
</tr>
</tbody>
</table>
Presentation Roadmap

- Background
- Review of the Scientific Evidence
  - Obesity
    - Gut microbiota
  - Surrogate risk factors for CVD
    - Glucose and Insulin Metabolism
    - Lipids
    - Blood Pressure
- Cognition
No Improvement in Fasting Measures of Insulin Sensitivity with Higher Whole Grain Intake in Intervention Studies

Ye et al, J Nutr 2012;142: 1304 – online supporting material
Concentrations of Fasting Glucose Lower with Higher Whole Grain Intake in Intervention Studies

Weight mean difference in post-intervention concentration of fasting glucose
≈ 1 mmol/L (18 mg)

Ye et al, J Nutr 2012;142: 1
304 – online supporting material
Effects of rye and whole wheat versus refined cereal foods on metabolic risk factors: A randomised controlled two-centre intervention study

Rosalba Giacco\textsuperscript{a,*}, Jenni Lappi\textsuperscript{b}, Giuseppina Costabile\textsuperscript{c}, Marjukka Kolehmainen\textsuperscript{b}, Ursula Schwab\textsuperscript{b,d}, Rikard Landberg\textsuperscript{e}, Matti Uusitupa\textsuperscript{b}, Kaisa Poutanen\textsuperscript{b,f}, Giovanni Pacini\textsuperscript{g}, Angela A. Rivellese\textsuperscript{c}, Gabriele Riccardi\textsuperscript{a,c}, Hannu Mykkänen\textsuperscript{b}

Evaluate differences in glucose and insulin metabolism, as assessed by FSIGTT (frequently sampled intravenous glucose tolerance test) in response to whole-grain diets
Conclusion: Wholegrain cereal foods consumption compared with refined cereals for 12 weeks did not affect peripheral insulin sensitivity.

Elevated postprandial glucose and insulin independent risk factors for CVD events

Hypothesized that WG exert a metabolic effect mainly during postprandial period with minimum impact, at least in the short/medium term, on fasting parameters

**Conclusion**: A twelve week whole-grain cereal-based diet, compared to refined cereals, reduced postprandial insulin (by 29%) and triglyceride responses.
Mechanisms By Which Whole Grains May Attenuate Postprandial Blood Glucose

- Degree of processing/ particle size and structure
- Energy density
- Fiber composition
- Grain variety
- Food matrix
- Prior meal
- Meal volume
Whole Grains and Blood Lipids

- “Consistent with prior studies, our meta-analysis indicated an increase intake of whole-grains for 4 to 16 weeks significantly improved an individual’s lipid profile, reducing total cholesterol by 0.33 mmol/L and LDL cholesterol by 0.72 mmol/L” (Ye et al. 2012)

- “Intervention studies have demonstrated an overall effect of whole grains on total- and LDL- cholesterol, however, these cholesterol lowering effects were largely based on intervention studies in oats and barley” (Sinclair et al. 2013)
## Whole Grains and Blood Pressure

### Weight mean differences after whole grain intervention vs. control in RCTs

<table>
<thead>
<tr>
<th>Study</th>
<th>Lower Intervention Group</th>
<th>Lower Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltzman (59)</td>
<td>-0.40 (-1.00, 0.20)</td>
<td></td>
</tr>
<tr>
<td>Keenan (61)</td>
<td>-0.19 (-1.12, 0.74)</td>
<td></td>
</tr>
<tr>
<td>Pins (64)</td>
<td>-0.23 (-0.85, 0.19)</td>
<td></td>
</tr>
<tr>
<td>Andersson (54)</td>
<td>-0.07 (-0.57, 0.44)</td>
<td></td>
</tr>
<tr>
<td>Katcher (57)</td>
<td>-0.23 (-0.80, 0.35)</td>
<td></td>
</tr>
<tr>
<td>Brownlee (55)</td>
<td>-0.05 (-0.34, 0.24)</td>
<td></td>
</tr>
<tr>
<td>Brownlee (55)</td>
<td>0.16 (-0.13, 0.45)</td>
<td></td>
</tr>
<tr>
<td>Overall (95% CI)</td>
<td>-0.06 (-0.21, 0.10)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Lower Intervention Group</th>
<th>Lower Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltzman (59)</td>
<td>0.11 (-0.49, 0.71)</td>
<td></td>
</tr>
<tr>
<td>Keenan (61)</td>
<td>-1.02 (-2.01, -0.03)</td>
<td></td>
</tr>
<tr>
<td>Pins (64)</td>
<td>-0.27 (-0.69, 0.15)</td>
<td></td>
</tr>
<tr>
<td>Andersson (54)</td>
<td>0.00 (-0.51, 0.51)</td>
<td></td>
</tr>
<tr>
<td>Katcher (57)</td>
<td>-0.06 (-0.63, 0.51)</td>
<td></td>
</tr>
<tr>
<td>Brownlee (55)</td>
<td>-0.05 (-0.34, 0.24)</td>
<td></td>
</tr>
<tr>
<td>Brownlee (55)</td>
<td>0.08 (-0.21, 0.37)</td>
<td></td>
</tr>
<tr>
<td>Overall (95% CI)</td>
<td>-0.05 (-0.21, 0.11)</td>
<td></td>
</tr>
</tbody>
</table>

Ye et al, J Nutr 2012;142: 1
Reduced systolic blood pressure after consumption of 48g whole grain per day

N=226

Reduced systolic blood pressure after consumption of 48g whole grain wheat per day for three weeks.

Background

Review of the Scientific Evidence

- Obesity
  - Gut microbiota
- Surrogate risk factors for CVD
  - Glucose and Insulin Metabolism
  - Lipids
  - Blood Pressure
- Cognition
High intake of fruit, vegetables, & grains
Olive (canola) oil as primary source of oil/fat
Fish intake at least weekly
Moderate intake of meat
Daily physical activity
Prospective study of Dietary Approaches to Stop Hypertension– and Mediterranean-style dietary patterns and age-related cognitive change: the Cache County Study on Memory, Health and Aging

Heidi Wengreen, Ronald G Munger, Adele Cutler, Anna Quach, Austin Bowles, Christopher Corcoran, JoAnn T Tschansz, Maria C Norton, and Kathleen A Welsh-Bohmer

AJCN 2013;98:1263-71

<table>
<thead>
<tr>
<th>DASH DIET Type of Food</th>
<th>Servings on a 2000 calorie diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains &amp; grain products</td>
<td>7-8</td>
</tr>
<tr>
<td>(include at least 3 WG foods each day)</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>4-5</td>
</tr>
<tr>
<td>Vegetables</td>
<td>4-5</td>
</tr>
<tr>
<td>Low fat or non fat dairy foods</td>
<td>2-3</td>
</tr>
<tr>
<td>Lean meats, fish, poultry</td>
<td>2 or less</td>
</tr>
<tr>
<td>Nuts, seeds, &amp; legumes</td>
<td>4-5/week</td>
</tr>
<tr>
<td>Fats &amp; sweets</td>
<td>Limited</td>
</tr>
</tbody>
</table>

![DASH Diet Diagram]

[Graph showing estimated mean 3MS score over years after baseline interview]
Conclusion: Higher levels of accordance with both the DASH and Mediterranean dietary patterns were associated with consistently higher levels of cognitive function in elderly men and women over 11 y period. Whole grains and nuts and legumes were positively associated with higher cognitive functions and may be core neuroprotective foods common to various healthy plant-centered diets around the globe.
Presentation Roadmap

- Background
- Review of the Scientific Evidence
- Conclusions
  - Summary of the science
  - Practical advice
Based on the available evidence, we conclude that whole-wheat consumption cannot be linked to increased prevalence of obesity in the general population

OBESITY HAS A MULTIFACTORIAL CAUSATION !!!!
Changes in Food & Beverage Consumption and Weight Changes Every 4 Years

• NHS: n=50,422; 20 year follow-up
• NHS II: n=47,898; 12 year follow-up
• HPFS: n=22,557; 20 year follow-up

“We found that multiple lifestyle changes were independently associated with long-term weight gain, including changes in the consumption of specific foods and beverages, physical activity, alcohol use, television watching, and smoking habit”

Summary of the Scientific Evidence

- Prospective cohort studies
  - Show consistent findings for most health outcomes
  - Supported by trials of surrogate outcomes for total and LDL cholesterol and fasting glucose.
- Inconsistency between cohort and trial finding
  - Lack of consistency between trials (interventions)
  - Variation in study design, study population, whole grain sources, study duration
  - Different paradigm/different hypotheses
- Emerging mechanisms on whole-grains and health
  - Gut microbiota
  - Post-prandial excursions
Increasing Whole Grain Consumption

- Encourage incorporating whole grains as part of a healthy diet
- Eat a variety of whole grains
- Good sources of fiber (3 g fiber); excellent sources (>5g)
- Whole grains contribute to the dietary deficit (but so do fruits/veg/legumes)
- Substitute refined grains for whole grains
- Check out: supertracker.usda.gov

“Ease up on the dinosaur meat and eat more whole grains.”
Many Refined Grains Come Packaged in Sugar, Salt, and Fat (and lack fiber)

- Replacing whole grains with refined or processed counterparts usually changes the nutrient profile of the food
- Compare the nutrient profiles for **1 serving** of each the following:

<table>
<thead>
<tr>
<th>Oatmeal, 1 cup (whole oats cooked in water)</th>
<th>Popular Breakfast Cereal Made of Rice that Crackles, 1 cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sugar – 0.63g</td>
<td>• Sugar – 2.86g</td>
</tr>
<tr>
<td>• Sodium – 9mg</td>
<td>• Sodium - 153mg</td>
</tr>
<tr>
<td>• Fat – 3.56g</td>
<td>• Fat – 0.59g</td>
</tr>
<tr>
<td>• Fiber – 4.0g</td>
<td>• Fiber – 0.1g</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Whole Grain Bread, 1 large slice</th>
<th>Croissant, 1 medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sugar – 2.62g</td>
<td>• Sugar – 6.42g</td>
</tr>
<tr>
<td>• Sodium – 156mg</td>
<td>• Sodium – 266mg</td>
</tr>
<tr>
<td>• Fat – 1.73g</td>
<td>• Fat – 11.97g</td>
</tr>
<tr>
<td>• Fiber – 3.0g</td>
<td>• Fiber – 1.5g</td>
</tr>
</tbody>
</table>

## Whole Wheat Family

- Wheat or whole grains related to wheat
- WW relations contain less gluten than regular wheat, but are not gluten free
- Delicious flavor and packed with vitamins, minerals, and fiber compared to processed grains!

<table>
<thead>
<tr>
<th>Whole Wheat Family</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheatberries</td>
<td>Use as the base for cold salads</td>
</tr>
<tr>
<td>Spelt</td>
<td>Add to soups</td>
</tr>
<tr>
<td>Kamut / Khorasan wheat</td>
<td>Make warm savory dishes</td>
</tr>
<tr>
<td>Farro</td>
<td>Add to salads or soups</td>
</tr>
<tr>
<td>Whole wheat and spelt flours</td>
<td>Use in baking like white flour, just add a little extra leavening</td>
</tr>
</tbody>
</table>
Ancient Grains

- Commonly considered grains even though some do not come from grasses
- Do not contain gluten so are safe for people with celiac disease
- Making a comeback in modern cooking!

<table>
<thead>
<tr>
<th>Ancient Grains</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amaranth</strong></td>
<td>Staple grain of the Aztecs, eat toasted or puffed as cereal</td>
</tr>
<tr>
<td><strong>Quinoa</strong></td>
<td>Cultivated in pre-Columbian Andes region. Eat as a grain dish like rice</td>
</tr>
<tr>
<td><strong>Buckwheat</strong></td>
<td>Used as a breakfast grain, in soba noodles, or in cold salad</td>
</tr>
<tr>
<td><strong>Millet</strong></td>
<td>Millet porridge, millet flour, or in savory stews</td>
</tr>
<tr>
<td><strong>Teff</strong></td>
<td>Ethiopian injera bread, often used as a gluten-free four</td>
</tr>
</tbody>
</table>
Acknowledgments

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Questions?