The state of research on carbohydrates

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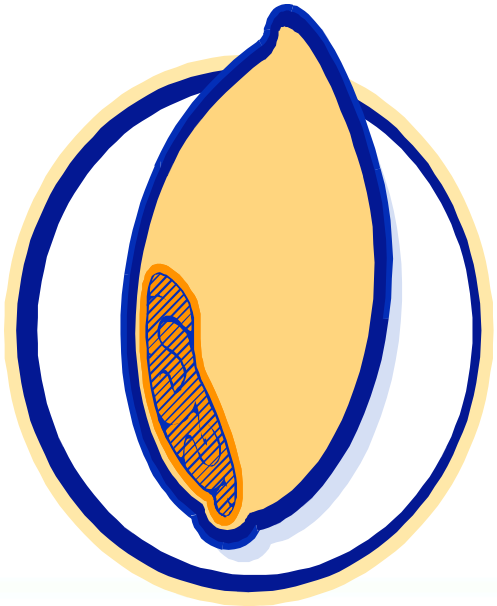


Dietary Guidelines 2005

- Carbohydrates part of healthy diet
- Positive association between consumption of sweetened beverages and weight gain
- Reduced intake of added sugars may be helpful in weight control and in achieving recommended intakes of nutrients
- To reduce risk of CHD and promote laxation, recommends intake of 14 g dietary fiber/1000 kcal

Carbohydrate Categories From a Chemical Perspective

- Monosaccharides
- Sugar alcohols
- Disaccharides
- Trisaccharides
- Oligosaccharides
- Polysaccharides

Carbohydrate Categories From a Nutritional Perspective

- Absorbable
- Digestible
- Fermentable
- Non-fermentable/poorly fermentable

Food sources of CHO

- Grains*
- Fruits*
- Vegetables*
- Legumes*
- Dairy*
- Isolated sugars or starches
- Many of these have known health benefits*

Of what use are carbohydrates?

- Sweeteners
- Food preservation
- Functional attributes (viscosity, texture, body, browning capacity)
- Energy
- Fermentable substrates

Existing dietary guidance on carbohydrates (DRI)

- RDA for carbohydrates – 130 g/day
- 45 – 65% of calories from carbohydrate
- Added sugar – 25% or less of calories
- Dietary fiber – 38 grams for men, 25 grams for women
- Support for carbohydrate foods as the primary calorie source in the diet

What is fiber?

- Concept – carbohydrates and lignin that escape digestion in the upper GI tract but may be fermented in the gut
- Nutrient – according to 2002 DRIs
- On the Nutrition Facts panel – 25 g DV
- Marker of a healthy diet
- Health claims for oats, barley and psyllium

Definition of fiber FNB, IOM, 2002

- *Dietary fiber* consists of nondigestible carbohydrates and lignin that are intrinsic and intact in plants
- *Functional fiber* consists of isolated, nondigestible carbohydrates that have beneficial physiological effects in humans

Total fiber is the sum of *Dietary fiber* and *Functional fiber*

Dietary fiber intake is low

- Typical fiber intake in US is 15 grams per day – recommended levels are 25 – 38 g/day
- Most fiber-containing foods – 1 – 3 g of fiber
  - Apple – 3 grams
  - Lettuce – 1 gram
  - WW bread – 2 grams
  - Oatmeal – 3 grams
- White flour and white potatoes provide the most fiber in the US diet, not because they are concentrated fiber sources, but because they are widely consumed
- Interest in the addition of functional fibers to the food supply to increase fiber intake
- Slavin. Health implications of dietary fiber. *J Am Diet Assoc* 2008;108:1716.

New carbohydrate information relevant to 2010 DG

- Sugar, especially fructose
- Glycemic index/Glycemic load
- Dietary fiber/Whole grains
- Food form, liquid vs. solid

Macronutrients and obesity

- No clear evidence that altering the proportion of total carbohydrate in the diet is an important determinant of energy intake
- There is evidence the sugar-sweetened beverages do not induce satiety as much as solid carbohydrate
- Findings from studies on dietary glycemic index on body weight have been inconsistent
- Dietary fiber intake is linked to less weight gain
- Van Dam and Seidell. *Eur J Clin Nutr* 2007;61 Supple 1:S75.

Does type of sugar matter?

- No evidence that ratio of fructose and glucose consumed from sugars has changed over the past 4 decades as a result of high fructose corn syrup (HFCS) replacing sucrose in many applications (Anderson. *Am J Clin Nutr* 2007;86:1577)
- HFCS does not appear to contribute to overweight and obesity any differently than other energy sources (Forshee et al. *Cr Rev Food Sci Nutr* 2007;47:561)

Sugar-sweetened beverages (SB) and body mass index in children and adolescents: a meta-analysis

- Examined all trials (n=12, 10 longitudinal and 2 RCT) of SB and weight gain in children and adolescents
- The quantitative meta-analysis and qualitative review found that the association between SB consumption and BMI was near zero
- Forshee et al. *Am J Clin Nutr* 2008;87:1662

Intake of calorically sweetened beverages and obesity

- Reviewed associations between intake calorically sweetened beverages and obesity, relative to adjustment for energy intake
- 14 prospective and 5 experimental studies were identified
- A high intake of calorically sweetened beverages can be regarded as a determinant for obesity
- No support that the association between intake of calorically sweetened beverages and obesity is mediated via increased energy intake – alternative biological mechanisms should be explored
- Olsen & Heitmann. *Obesity Rev* (2008)

How discretionary can we be with sweetened beverages for children?

- Research editorial
- *Based on cumulative evidence, it is recommended that children consume no more than one sweetened beverage per week.* There is little room if any in the diets of children to replace healthy foods with the empty calories from 'liquid sugar'.
- Crawford et al. *J Am Diet Assoc* 2008;108:1440

Low calorie diets tend toward high protein

- On low calorie diets, higher protein intakes are recommended (up to 35% of kcal)
- Potential advantages over carbohydrates: increased satiety, increased thermogenesis, maintenance of fat-free mass
- Paddon-Jones et al. *Am J Clin Nutr* 2008;87(suppl):1558S)

Glycemic response and health – a systematic review and meta-analysis

- Among GI studies, observed reductions in glycemic load are most often not solely due to substitution of high for low glycemic carbohydrate foods
- Available carbohydrate intake is a confounding factor
- The role of unavailable carbohydrate remains to be accounted for
- Livesey et al. *Am J Clin Nutr* 2008;87(suppl):223S

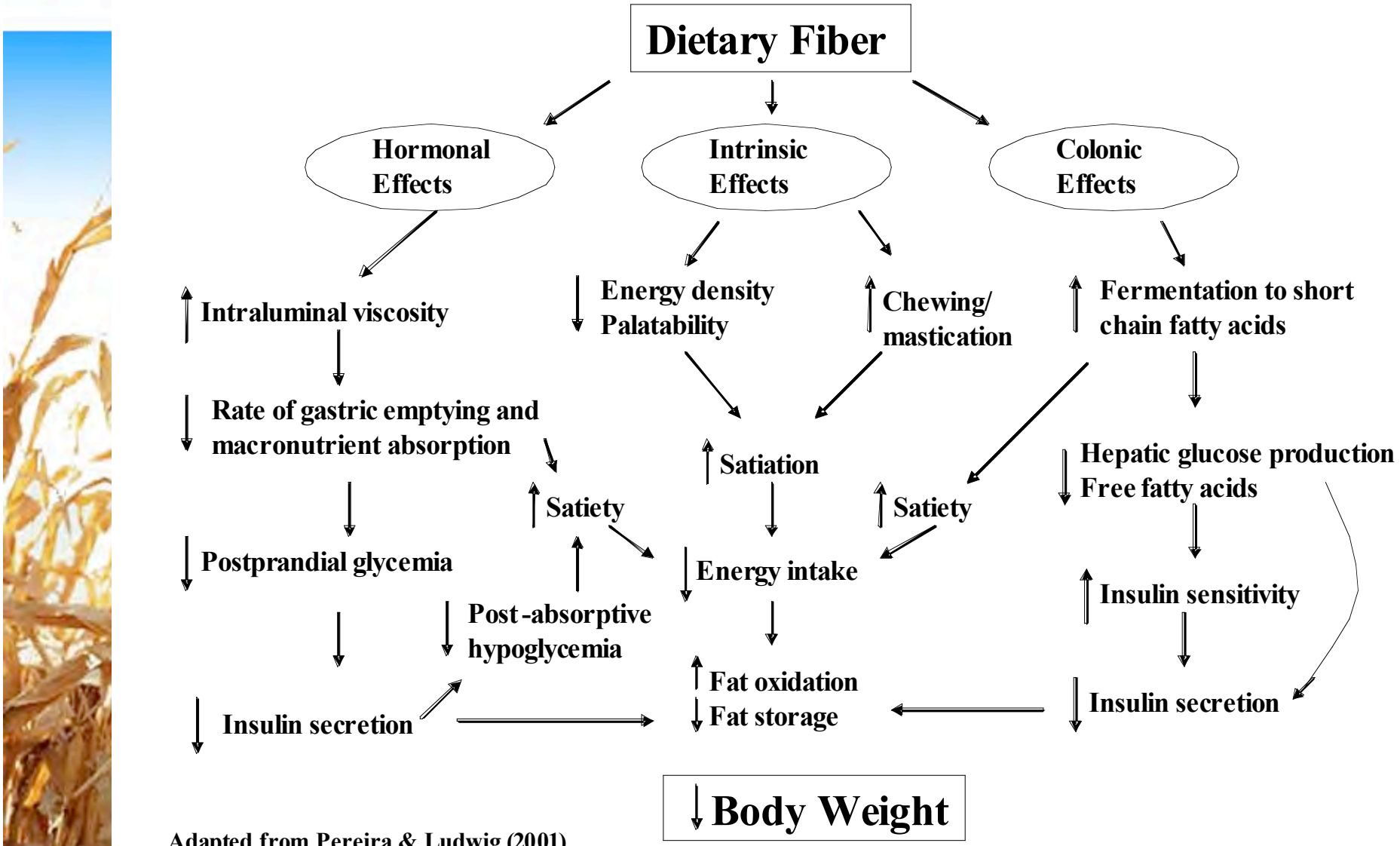
Dietary carbohydrate, GI, and GL and Colorectal cancer (CRC) in Women's Health Initiative

- Over an average of 7.8 yrs of follow-up, 1476 incident cases identified
- Total carbohydrate intake, glycemic index, glycemic load, and intake of sugars and fiber showed no association with CRC
- These results do not support that diet characterized by high glycemic index or load plays as role in CRC in postmenopausal women
- Kabat et al. *Cancer Causes Control* (2008)

Glycemic index and glycemic load in dietary recommendations

- Review of epidemiological data on GI and GL and heart disease, insulin sensitivity, type 2 diabetes, dyslipidemia, and obesity among initially healthy people
- Mixed results – only the positive association between GI and the development of Type-2 diabetes was consistent
- Seems premature to include GI-GL in dietary recommendations
- Hare-Bruun et al. *Nutr Rev* 2008;66:569

How Dietary fiber Affects Physiological Measures



Adapted from Pereira & Ludwig (2001)

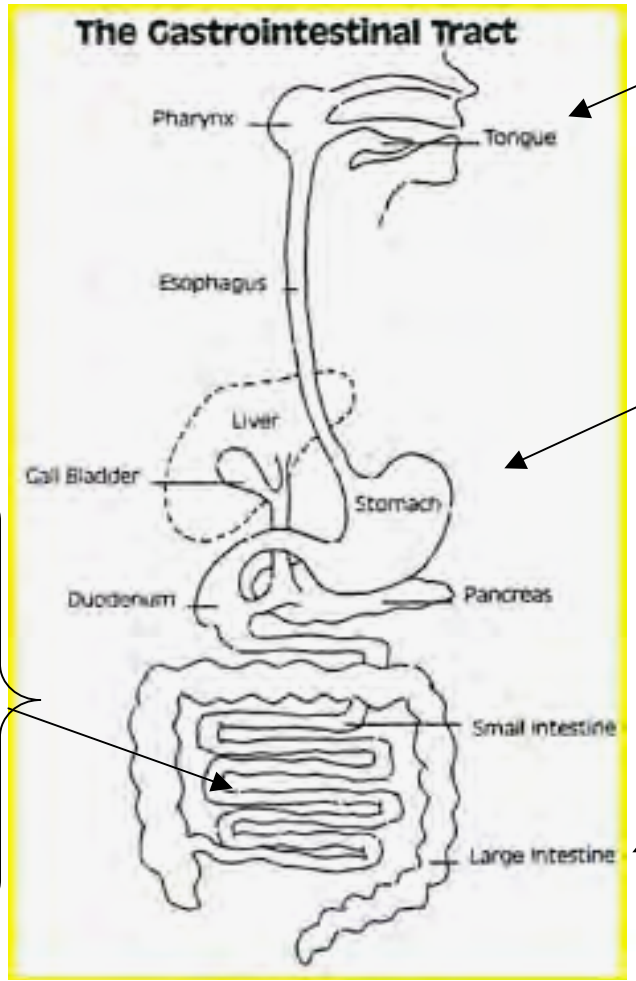
Cereal grains and weight management

- Strong evidence a diet high in whole grains is associated with lower BMI, smaller waist circumference, and reduced risk of being overweight
- Whole grains can prevent weight gain
- Energy controlled diets with grains are associated with weight loss
- Williams et al. *Nutr Rev* 2008;66:171-182.

What is satiety?

- A feeling that comes after eating a meal and inhibits a person from eating again
- Many people feel 'satiated' between meals
- Often determined by asking a combination of questions about hunger, satisfaction, fullness, desire to eat

Fiber and Satiety: Proposed Mechanisms



Increased chewing and more saliva production

Increased gastric distention and delayed emptying

Delayed nutrient absorption, blunted glucose and insulin response

Change in gut hormones (GLP-1, PYY, ghrelin)

Ileal break

Fatty acid fermentation

Adapted from Howarth et al *Nutr Reviews* 2001; 59(5).

Depletion and disruption of dietary fiber

- 10 subjects
- 60 g available carbohydrate as apples, apple puree, or apple juice
- Juice could be consumed 11X faster than intact apples and 4X faster than puree
- With rate of ingestion equalized, juice was less satisfying than puree, and puree than apples
- Haber et al. *Lancet* 1977;2:679.

Effect of fruit in different forms on energy intake and satiety

- Different forms of fruit (apples, applesauce, apple juice) and added fiber (low-viscosity, apple-derived pectin)
- Once per week for 5 weeks, 58 adults consumed one of four preloads followed by a test meal
- Whole apple increased satiety more than applesauce or apple juice – adding fiber to juice did not alter satiety
- Flood-Obbagy & Rolls. *Appetite* 2009;52:416

Different responses with food form

- Compared white bread, wholemeal wheat bread, and whole kernel bread
- Whole kernel bread resulted in significantly higher satiety than wholemeal wheat bread and white bread
- No differences in blood glucose response
- Hiebowicz et al. *Nutr J* 2008;7:12

Does fiber dose matter?

- Small doses often yield no effect
  - 4.5 g guar had no effect when given in a breakfast bar (Mattes et al, Appetite, 2007)
- Larger doses probably work better
  - 30 g fiber in cereal improved fullness compared to low fiber cereal (Samra & Anderson, Am J Clin Nutr, 2007)
  - 41 g insoluble fiber reduced food intake (Freeland et al, Appetite, 2008)

Fibers shown to decrease food intake

- Guar gum – intact, not hydrolyzed
- Psyllium
- Wheat bran
- Pea fiber
- Cellulose, soy polysaccharide
- Generally in high doses
- Slavin and Green, *Nutr Bulletin*, 2007

Does type of sweetener make a difference on satiety?

- Compared commercial beverages containing sucrose or HFCS on hunger, satiety, and energy intake at the next meal with repeated measures design (n=38)
- No differences between sucrose and HFCS
- Diet cola and no-beverage condition did not suppress energy intake at lunch
- Monsivais et al. *Am J Clin Nutr* 2007;86:116

Carbohydrate summary

- High carbohydrate (45 – 65% of kcal) diet recommended by DRIs
- Dietary fiber intakes less than half of recommended levels
- Choosing carbohydrates wisely means more whole grains, vegetables, fruits, and legumes and less sugar-sweetened beverages and desserts
- 2005 Dietary Guidelines recommends that at least half of all grains come from whole grains
- Measures of carbohydrate quality remain elusive