Physiology and psychology underlying food choices

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Understanding Dietary Patterns: A step toward devising a global nutrition strategy
Conflict of Interest Disclosure

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The present results were not supported by any company.
Dietary Guidelines for Americans 1980 - 2015
### The 40 year DGAs fat-sugar seesaw

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The diet books seesaw

Lipids are bad

Sugar is worse
The research seesaw

Fat is bad

Dietary fat and obesity: a review of animal, clinical and epidemiological studies
George A. Bray*, Sahsomborn Paentikul, Barry M. Popkin

Letters to the Editor

Dietary fat affects obesity rate

Dear Sir:

Recently we published an article titled ‘Dietary fat affects obesity rate’: a review of animal, clinical and epidemiological studies. We believe that when readers from medical and clinical studies, from controlled trials, and from epidemiology and eco-

logy analysis, provides strong evidence that dietary fat affects the rate of development and treatment of obesity. A reduction in dietary fat intake reduces the gap between total energy intake and total energy expenditure and thus is an effective strategy for reducing the present epidemic of obesity worldwide. A review of the results from 21 clinical trials that studied the effects of a reduc-

tion in the amount of energy from fat in the diet showed that a reduction of 15% in the proportion of energy from fat was associ-

ated with a reduction in weight of 10 g. We thus conclude that dietary fat plays a role in the development of obesity. To

Sugar is worse

Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity

George A. Bray, Samara Joy Melson, and Barry M Popkin

ABSTRACT

Obesity is a major epidemic, but its causes are still unclear. In this article, we investigate the role of high-fructose corn syrup (HFCS) and the development of obesity. We analyzed food consumption patterns by using US Department of Agriculture food consumption tables from 1965 to 2000. The con-

sumption of HFCS increased >100% between 1970 and 1990. For covering the changes in intake of any other food, the group HFCS as a percentage, >40% of caloric sweeteners added to foods inner. Added sugar is sugar added to a food and includes sweeteners such as sucrose, HFCS, honey, and other fructose. Naturally occurring sugar is sugar occurring in food and not added in processing, preparation, or at the table. Total sugars represents the total amount of sugars present in a food and in-

cludes both naturally occurring and added sugars. From fructose is fructose that enters in foods in the monosaccharide. Fructose refers to both the free and bound forms of fructose (5).

Circulation

Sugar-Sweetened Beverages, Obesity, Type 2 Diabetes Mellitus, and Cardiovascular Disease Risk

Vasanti S. Malik, Barry M. Popkin, George A. Bray, Jean-Pierre Després and Frank B. Hu

Circulation 2016;135-1364
Main drivers of food choice

- Taste (sweet, not bitter)
- Cost
- Nutrient density
- Convenience
- Cultural appeal
- Safety
- Health

Food choices
The formation of dietary patterns:

- **Childhood:**
  - Sweet taste (not bitter),
  - energy density, familiarity.
- **Adolescence:**
  - Energy density, variety,
  - attitudes, motivations, peer group.
- **Adult life:**
  - Taste, cost, convenience,
  - health, variety.
Classic data: Infants like sweet taste

Facial expressions of 3-day old infants
Steiner, 1977

Infants prefer sugary liquids to plain water

Desor, Maller and Greene, 1978
Children like energy-dense foods

- Energy density (ED) is driven by *water* content.
- Energy-dense foods are *dry*.
- Energy-dense foods can be sweet and fatty.
- Energy-dense foods can be *nutrient-poor*.
Low water content = high energy density
Low water content = high energy density
Low water content = high energy density
Low water content = high energy density

![Energy vs Water Content Graph](chart.png)
Low water content = high energy density
Children hate bitter taste

- Plant-based phenols, polyphenols (tannins), flavonoids, isoflavones, terpenes and glucosinolates are bitter, acrid, or astringent.
- These compounds impart a bitter taste to plant foods.
- Many of these compounds are toxic – bitter taste is a signal for dietary danger.
- Children hate bitter foods; older people do not mind them (esp. coffee, alcohol).

Drewnowski and Gomez-Carneros, AJCN 2000;72: 1424-35
The value of culinary science

- Fat, sugar and salt can mask bitter taste.
- Taste illusions
  - Salt makes grapefruit sweeter
  - Parmesan cheese makes red wine sweeter.
  - Broccoli tastes better with butter – or cheese sauce
- Food processing involves the senses and psychology.
From physiology to psychology and economics

Energy dense foods (grains, sugar, vegetable oils) have become very inexpensive
From foods to food patterns:
The economics of sugar and fat

Nutrients are expensive. Calories are not.

<table>
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<tr>
<th>Low nutrient density, 2000 kcal</th>
<th>High nutrient density, 2000 kcal</th>
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<td>$3.52</td>
<td>$36.32</td>
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28 g of sugar

34 g of sugar
Obesity promoting diets driven by low global prices of sugar and fat

- World and US prices for sugar and for fats and oils 1961-2011
- Fats and sugars provide 20,000 kcal per dollar
- Nutritionists equate 3,500 kcal with 1 lb of body weight
- The “economic cost” of gaining 1 lb body wt is 12 cents – if the energy comes from added sugar and fat

Graph 1: EU vegetable oil prices and Brent crude prices (dollar/ton).
The global nutrition imbalance

- Human taste preferences run toward energy-dense grains, sugar, and fat.
- Calories are cheap; nutrients are not.
- Global diets are becoming energy-dense but also nutrient-poor.
- The global poor suffer from different forms of malnutrition – both undernutrition and overweight.
- Can food processing and food *fortification* help to improve global food patterns?
Is global obesity caused by low-cost diets?
Linking food, health, and incomes

Poverty and obesity may be linked by the low cost, high reward value, and easy access to energy-dense foods.
What is the nutrition transition?

- Low and middle income countries undergoing the **nutrition transition** shift from a traditional diet high in staple grain crops to a dietary pattern with more **animal foods**, more **vegetables and fruit** – but more added **sugars**, and more added **fats**.

- The nutrition transition – the result of economic development - occurs in parallel with demographic, and epidemiologic changes at population level.
The nutrition transition: from cereals to animal foods

Cereals: dark green >1400 kcal/d

Milk, fish, meat, eggs: dark green >700 kcal/d

WHO interactive maps apps.who.int/bmi/index.jsp.
Classic relation: GDP and diet quality 1970


Uncoupled by 2000

Shift to animal protein – but not everywhere

More vegetable oils

More added sugar
What can we learn from *geo-located* food patterns and health data?

This is where spatial epidemiology science crosses into public policy – and food politics!
Spatial nutritional epidemiology:

Heat maps of diet quality (HEI 2010 scores) and obesity by Seattle census block
Megacities will become future obesity hotspots
Populations will depend on safe, low-cost, energy-dense foods

- Assume that 10 million people each consume 2,000 kcal/d.
- Given ED 1.0 kcal/g, then each person needs 2 kg of food daily.
- Then 20,000 tons of food need to be distributed daily.
- But if ED is 4 kcal/g, then each person needs to 0.5 kg/d.
- Distribution drops to 5,000 tons.
- Cost per calorie will also decrease but nutrient density will suffer.
The search for solutions?

**Adult Obesity Rate by State, 2014**

Percent of obese adults (Body Mass Index of 30+)

- 0 - 9.9
- 10 - 14.9
- 15 - 19.9
- 20 - 24.9
- 25 - 29.9
- 30 - 34.9
- 35+

**Chart by @DrAdamDrew**

*Bubble size = electoral votes by state*

Percent obese adults by state 2014 (%)

Percent voting for Trump by state

Time for a paradigm shift

Dietary Guidelines
- Nutrients
- Individual foods
- Dietary ingredients

Covariates
- Diet cost
- Demographics
- Socioeconomic status
- Culture
- Behavior
- Environment
Time for a paradigm shift

Socio-demographics
- Diet cost
- Demographics
- Education, incomes
- Culture
- Behavior
- Environment

Food patterns
- Nutrients
- Individual foods
- Dietary ingredients

Dietary Guidelines
Thank you

www.cphn.org