The science behind our desire for sweet-tasting foods and drinks

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How we make food choices

Taste
Cost
Access
Satisfaction
Satiety
Nutrient density
Health
Weight concerns
Energy density
Food Selection
Eating behavior
Preferences for sweet are innate

- A single taste cell has many receptors for sweet and bitter.
- Humans have 3-4 different taste receptors for sweet.
- Sugars and low-calorie sweeteners have similar chemical structures.
- Humans have 40-80 different taste receptors for bitter.
- Compounds that elicit bitter taste are completely unrelated.
- Bitter compounds are often toxic.
- Bitterness = dietary danger!

Infants like sweet taste

Facial expressions of 3-day old infants
Steiner, 1977

Infants prefer sweet liquids to plain water

Desor, Maller and Greene, 1978

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Children like foods that are familiar and sweet (Birch 1979)

- Children ages 3-4 y tasted open faced sandwiches on whole wheat bread
  - margarine, margarine and mint jelly, peanut butter, peanut butter and grape jelly, cream cheese, cream cheese and honey, cream cheese and caviar, cheddar cheese spread
- “Point to the sandwich you would like to eat the very best”
  - Sandwiches removed one by one - to give a metric scale

<table>
<thead>
<tr>
<th>Best liked (-2 to +2)</th>
<th>Least liked (-2 to +2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.91   Chocolate</td>
<td>-0.62   Avocado</td>
</tr>
<tr>
<td>1.88   Chocolate biscuits</td>
<td>-0.59   Leeks</td>
</tr>
<tr>
<td>1.88   Crisps</td>
<td>-0.56   Courgette</td>
</tr>
<tr>
<td>1.88   Yogurt</td>
<td>-0.49   Melon</td>
</tr>
<tr>
<td>1.84   Ice cream</td>
<td>-0.45   Cottage cheese</td>
</tr>
<tr>
<td>1.83   Ice lolly</td>
<td>-0.44   Sweet peppers</td>
</tr>
<tr>
<td>1.83   Fruit squash</td>
<td>-0.31   Onion</td>
</tr>
<tr>
<td>1.77   Bread</td>
<td>-0.29   Liver</td>
</tr>
<tr>
<td>1.67   Chicken</td>
<td>-0.25   Cabbage</td>
</tr>
<tr>
<td>1.63   Plain biscuits</td>
<td>-0.05   Parsnips</td>
</tr>
</tbody>
</table>

Wardle et al., Appetite 2001;37:217-223)
Children like energy dense fruit!


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Nutrient density

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Food Selection

Eating behavior
Energy density (kcal/100g) and water content
Data for 1387 foods from USDA FNDDS 1.0

Energy density (kcal/100g) is the opposite of water content:
Data for 1387 foods by USDA food group
Fats and sweets taste better and are cheaper! ($/100 kcal):
Data for 1387 foods by USDA food group

Are energy dense fats and sweets craveable or “addictive”?
Opioid peptides and food intakes
Drewnowski et al. AJCN, 1995

- Opioid antagonists (naloxone, naltrexone) suppress food intake in humans and rats.
- Opioid agonists (morphine, butorphanol) promote fat intake in rats.
- Pleasure response to sweet solutions – in rats – involves endorphins.
- Opiate withdrawal in humans is sometimes helped by sweet foods (ice cream and chocolate).

Food consumption after naloxone
(as % saline control)
Comparing the effects of aspartame and sucrose on motivational ratings, taste preferences, and energy intakes in humans

Adam Drewnowski, Christine Mamin, Joanne Louis-Sylvestre, Jacques Fricker, Didier Chapela, and Marian Apfelbaum

ABSTRACT This study compared the effects of four breakfast preload preparemotivational ratings, taste preferences, and energy intakes in 24 normal-weight women. The preloads, a high-sucrose variety (50% of energy), were either plain or increased in sucrose. The energy value was either 125% or 160% of the usual energy level. The preload was consumed in a randomized order. The preferred preload was the one with the highest sucrose content. The preload was either plain or increased in sucrose. The energy value was either 125% or 160% of the usual energy level. The preload was consumed in a randomized order. The preferred preload was the one with the highest sucrose content. The preload was either plain or increased in sucrose. The energy value was either 125% or 160% of the usual energy level. The preload was consumed in a randomized order.

KEY WORDS Sucrose, appetitive, hunger, satiety, energy intake.

The effects of aspartame versus sucrose on motivational ratings, taste preferences, and energy intakes in obese and lean women

Adam Drewnowski, Christine Mamin, Joanne Louis-Sylvestre, Jacques Fricker, Didier Chapela, and Marian Apfelbaum

Program in Human Nutrition, School of Public Health, University of Michigan, Ann Arbor, Michigan 48109, USA; Laboratoire de Recherche de la Nutrition, Ecole Pratique des Hautes Etudes, Université de Paris V, 75006 Paris, and INSERM U588, Nutrition Humaine, Faculté de Médecine Xavier Bichat, 75018 Paris, France.

This study examined the effects of four breakfast preloads of different sweetness and energy content on motivational ratings, taste preferences, and energy intakes in 12 obese and 12 lean women. The preloads consisted of a glass of sucrose (50% of energy) or a glass of water (50% of energy). The preload was consumed in a randomized order. The preferred preload was the one with the highest sucrose content. The preload was either plain or increased in sucrose. The energy value was either 125% or 160% of the usual energy level.

Keywords: aspartame, sucrose, hunger, desire to eat, taste preferences, energy intakes, obese women, lean women.
Solids and liquids – a complex story

<table>
<thead>
<tr>
<th></th>
<th>Calories</th>
<th>Satiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Liquids</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Effects of physical state (liquid-solid) of foods on food intake: procedural and substantive contributions

Harry R. Krieger, PhD

Liquid versus solid carbohydrate: effects on food intake and body weight

DP Spiegelman and RD Masters

Tulane University - Department of Food and Nutrition, New Orleans, LA 70118, USA

ABSTRACT

Objective: To evaluate the impact of physical state (liquid-solid) on food intake and energy expenditure. The purpose of the present study was to evaluate a randomized parallel, double-blind, cross-over design in which subjects ate meals containing the same type of food (n=5), with either the majority of energy from a beverage or from a solid food. Each of the 10 test meals contained the same amount of energy and was consumed within a 15-minute period. Total daily energy expenditure was assessed by indirect calorimetry in the post-dinner period. The effect of physical state on food intake, energy expenditure, and energy balance was evaluated with paired t-tests.

DESIGN: A randomized parallel, double-blind, cross-over design was used. Each subject received five test meals containing the same type of food (solid or liquid), with the majority of energy from a beverage or from a solid food. Each of the 10 test meals contained the same amount of energy and was consumed within a 15-minute period. Total daily energy expenditure was assessed by indirect calorimetry in the post-dinner period. The effect of physical state on food intake, energy expenditure, and energy balance was evaluated with paired t-tests.

RESULTS: The study included 5 healthy subjects (2 men and 3 women) who were given test meals containing the same type of food (solid or liquid), with the majority of energy from a beverage or from a solid food. Total daily energy expenditure was assessed by indirect calorimetry in the post-dinner period. The effect of physical state on food intake, energy expenditure, and energy balance was evaluated with paired t-tests. The study found that liquid carbohydrate intake was associated with a decrease in energy expenditure and a decrease in energy balance. No significant difference was observed in food intake between the solid and liquid test meals.

CONCLUSION: This study indicates that liquid carbohydrate intake results in a decrease in energy expenditure and a decrease in energy balance, which may have implications for weight management.

Liquids, solids and satiety: A direct test

No difference in satiety or subsequent energy intake between a beverage and a solid food

Composition | Cola | Raspberry cookie
---|---|---
Carbohydrate (g) | 81.5 | 69.0
Sugar (g) | 81.5 | 48.0
Protein (g) | 0 | 3.0
Fat (g) | 0 | 0
Fiber (g) | 0 | 1.5
Serving size | 710 ml (24 oz) | 87 g (6 units)
Total kcal | 300 | 300

Almiron-Roig, Flores, Drewnowski, Physiol & Behav 2004;82:671
Temporal profile of hunger ratings

Are liquid sugar calories not satiating?
How we make food choices

- Cost
- Taste
- Energy density
- Access
- Satiety
- Nutrient density
- Health
- Weight concerns

Food Selection → Eating behavior

Energy dense sweets and fats cost less
Data from USDA composition and price datasets for 1387 foods by food group

- Milk and milk products
- Meat, poultry, fish
- Eggs
- Milk and milk products
- Sugars, sweets, beverages
- Dry beans, legumes, nuts, seeds
- Grains
- Fats and oils

Energy cost per 100 kcal ($/100 kcal)
Energy density kcal per 100 g
Energy Dense Foods (kcal/100g) Cost Less ($/1000 kcal)
Data from USDA FNDDS 1.0 and CNPP prices database

Energy density (kcal/100g)

Energy cost ($/1000 kcal)

Log scale

Lower cost

Higher cost
Energy Dense Foods (kcal/100g) Cost Less ($/1000 kcal)
Data from USDA FNDDS 1.0 and CNPP prices database

Energy Dense Foods (kcal/100g) Cost Less ($/1000 kcal)
Data from USDA FNDDS 1.0 and CNPP prices database
Fats and sweets keep down daily diet costs

Drewnowski, Darmon and Briend, American Journal of Public Health 2004
Fats and sweets keep down daily diet costs

Drewnowski, Darmon and Briand, American Journal of Public Health 2004
Fats and sweets keep down daily diet costs

A cruel dilemma

Pay less – but eat more?
or
Pay more and eat less?

Drewnowski, Darmon and Briend, American Journal of Public Health 2004
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We have mapped grocery stores in Seattle-King County, WA

Data source: Washington State Geospatial Archive, Corporate Websites and United States Census Bureau
Density of convenience stores in Seattle-King County, WA

Density of fast food outlets in Seattle-King County, WA

Data source:
Washington State
Geographic archives
Geographic websites
Federal websites
Commonwealth
How we make food choices

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Linking food, incomes and health

Poverty and obesity may be linked by the low cost, high reward value, and easy access to energy-dense foods

Special Article

Poverty and obesity: the role of energy density and energy costs1,2

Adam Drewnowski and EE Specter

Abstract

Many health disparities in the United States are linked to nutritional deficiencies and excesses. In particular, obesity is associated with low cost, high reward value, and easy access to high-energy dense foods (HEDF). These foods are low in nutrient density and relatively high in energy, particularly from simple sugars and other energy-dense macronutrients. A variety of analytic tools have suggested that these specific features of health-dense foods may contribute to obesity through changes in energy balance, energy expenditure, and dietary patterns. However, a causal link between low cost, high reward value, and easy access to HEDF and obesity has not been established. The purpose of this special article is to review the evidence for a causal relationship between low cost, high reward value, and easy access to HEDF and obesity.


Food costs (log)
The paradox – Saving on food costs leads to energy dense diets
Energy dense diets permit overeating
Spend less – eat more
First basic question: Where do calories come from?

Soda, sports drinks, sweetened waters & energy drinks, 5.5%

Where do sugar calories come from?

- Sugar is the universal flavoring; its applications have an infinite variety...
- Mixed with water, sugar produces sugar water, a refreshing, healthy pleasant drink.
- Sugar harms only the pocketbook

Jean Anthelme Brillat-Savarin 1825

From 1825 France to 1948 USA

Uniformly positive attitudes toward sugar! Then what happened?

- Sugar is the universal flavoring; its applications have an infinite variety...
- Mixed with water, sugar produces sugar water, a refreshing, healthy pleasant drink.
- Sugar harms only the pocketbook

Jean Anthelme Brillat-Savarin 1825
Taste and nutrition: Then and now

Whatever is the most delicious is also the most nutritious.

*Magninus of Milan, 17th century*

If the human body is healthy, then all the foods that taste the best are also the most nutritious.

*Aldebrandin of Siena, 1606*