Nut Consumption: Acceptability, Satiety and Metabolism

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NUTS: PROPERTIES AND HEALTH EFFECTS
Various Components of the Almond Have the Potential to Affect Diabetes Risk

**Polyphenols/Phytates**
- amylase, trypsin
- starch, protein digestibility, antioxidant, anti-inflammatory

**Protein**
- 7-9 g/serving
- gastric emptying
- Insulin sensitivity

**Arginine**
- enhances NO production
- anti-inflammatory

**Dietary Fiber**
- 5-14 g/serving
- available carbohydrate
- cholesterol

**Fatty Acid Composition**
- 59-67% MUFA
- 25-30% PUFA

**Magnesium**
- Insulin sensitivity

**Vitamin E**
- Reduced oxidative damage
Various Components of the Peanut Have the Potential to Affect Diabetes Risk

Polyphenols/Phytates
- amylase, trypsin
- starch, protein digestibility, antioxidant, anti-inflammatory

Dietary Fiber
- ~14 g/serving
- available carbohydrate, cholesterol

Protein
- 7 g/serving
- gastric emptying
- Insulin sensitivity

Fatty Acid Composition
- 59% MUFA
- 30% PUFA

Vitamin E
- 15% of DV
- Reduced oxidative damage

Magnesium
- 10% of DV
- Insulin sensitivity
NUTS: ACCEPTABILITY
How much of an impact do the following have on your decision to buy foods and beverages? (% Rating 4 to 5 on 5-point scale, from “No impact” to “A great impact”)

All (n=1,057)

<table>
<thead>
<tr>
<th>% High Impact By Age</th>
<th>18-34</th>
<th>35-49</th>
<th>50-64</th>
<th>65-80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>83%</td>
<td>85%</td>
<td>88%</td>
<td>92%</td>
</tr>
<tr>
<td>Price</td>
<td>77%</td>
<td>78%</td>
<td>69%</td>
<td>62%</td>
</tr>
<tr>
<td>Healthfulness</td>
<td>58%</td>
<td>60%</td>
<td>59%</td>
<td>74%</td>
</tr>
<tr>
<td>Convenience</td>
<td>59%</td>
<td>54%</td>
<td>46%</td>
<td>52%</td>
</tr>
<tr>
<td>Sustainability</td>
<td>33%</td>
<td>33%</td>
<td>34%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Bolded figures are significantly higher than counterpart groups.

International Food Information Council Foundation
2012 Food & Health Survey
The impact of taste on food choices has remained steady. However, price, healthfulness, and sustainability dropped from peaks in 2011.

How much of an impact do the following have on your decision to buy foods and beverages?
(% Rating 4 to 5 on 5-point scale, from “No impact” to “A great impact”)

- Taste: 87%, 87%, 87%, 86%, 87%, 87%, 87%
- Price: 79%, 73%, 73%, 73%, 66%, 73%, 73%
- Healthfulness: 61%, 62%, 61%, 58%, 58%, 61%, 53%
- Convenience: 55%, 55%, 52%, 56%, 58%, 52%, 35%
- Sustainability: 48%, 72%, 70%, 74%, 79%, 79%, 79%

Bolded 2012 figures are significantly different than 2011 percentages.

International Food Information Council Foundation
2012 Food & Health Survey
Determinants of Food Purchasing Practices

- 88% Taste > Price
- 52% Price > Health

(N=1109 Random Households)

Sensory Properties

- Inherent flavor
- Processing
  - New flavors
  - Added flavors
Sensory Properties

- Inherent flavor
- Processing
  - New flavors
  - Added flavors (e.g., NaCl, sugar, cinnamon, capsaicin)
Change of Palatability

N=51

Palatability (0=did not like at all, 10=liked extremely)
Sensory Properties

- Inherent flavor
- Processing
  - New flavors
  - Added flavors
  - Altered physical properties
Mean values of the sensory scores evaluated by the consumer panel (n = 100). Above: acceptability scores, overall and texture. Below: 'Just about right' scale scores for hardness and crispness. In each attribute, from left to right: raw, 1.5-min roasted sample, 3-min roasted, 4.5-min roasted, 6-min roasted. Identical letters in each attribute indicate that there is no significant difference at p > 0.05 (Tukey’s test).

Varela P et al., Food Res Intl 2008;41:544-551.
Fig. 6. Crushing, Mush and Clearance Phases of the chewing sequence: 3D traces of mandibular incisor movement though a whole chewing sequence: a single almond chewed by a subject with complete dentures. The X trace shows anterior movement upwards, the Y trace (lateral) shows right movement upwards, the Z trace shows gape, vertical incisor opening downwards. Extensive initial difficulty fracturing the almond is seen on the z trace, followed by a Crushing phase during which closure gets progressively nearer tooth-tooth contact. The rhythmic cycles during the following Mush phase are interrupted by W cycles that are characteristic of almond chewing, which may include intercalated swallows. At the end of the sequence, the Clearance Phase, there are irregular cycles as the tongue clears particles from the teeth and aggregates them before a final swallow.
Binary images of fragments of the samples after fracturing, from left to right: raw, 1.5-min roasted, 3-min roasted, 4.5-min roasted, 6-min roasted sample. (a) Fractured by instrumental compression, test speed 1 mm/s; (b) fractured by instrumental compression, test speed 30 mm/s; (c) in-mouth fracture by one of the assessors.

Varela P et al., Food Res Intl 2008;41:544-551.
**Fig. 9.** Gradient-Recalled-Echo (GRE) images of peanuts in gastric juice (the blue color indicates moisture, and red color indicates samples with less moisture). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

**Fig. 11.** Swelling ratios of peanuts at the end of 6 h soaking.
Nuts and Body Weight

- Appetite/Intake
- Energy Absorption
- Energy Expenditure
APPETITE
Appetitive Effects of Nuts

- Suppress Hunger:
  - Eating initiation
- Suppress Desire to eat:
  - Eating in the absence of hunger
- Fullness:
  - Meal size
## Dietary Compensation

<table>
<thead>
<tr>
<th>Study</th>
<th>Nut</th>
<th>% Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser et al., 2002</td>
<td>Almonds</td>
<td>54, 75</td>
</tr>
<tr>
<td>LoveJoy et al., 2002</td>
<td>Almonds</td>
<td>63</td>
</tr>
<tr>
<td>Hollis &amp; Mattes</td>
<td>Almonds</td>
<td>76</td>
</tr>
<tr>
<td>Curb et al., 1992</td>
<td>Macadamia</td>
<td>58, 113</td>
</tr>
<tr>
<td>Kirkmeyer &amp; Mattes, 2000</td>
<td>Peanuts</td>
<td>104%</td>
</tr>
<tr>
<td>Alper &amp; Mattes, 2001</td>
<td>Peanuts</td>
<td>66%</td>
</tr>
<tr>
<td>Almario et al., 2001</td>
<td>Walnuts</td>
<td>96%</td>
</tr>
<tr>
<td>Abbey et al., 1994</td>
<td>Walnuts</td>
<td>55%</td>
</tr>
<tr>
<td>Tey et al., 2011</td>
<td>Hazelnuts</td>
<td>100%</td>
</tr>
</tbody>
</table>
Factors Contributing to Satiety

- Energy
- Fatty Acids
- Rheology
- Macronutrient Profile
- Fiber
- Cognition
Factors Contributing to Satiety

- Energy
- Fatty Acids
- Rheology
- Macronutrient Profile
- Fiber
- Cognition
FIG 1. Percent of absorbed $^{13}$C excreted in breath CO$_2$ after oral administration of $[1-^{13}$C]stearic, $[1-^{13}$C]oleic, and $[1-^{13}$C]linoleic acids. (a) Significantly different from stearic acid ($p < 0.025$). (b) Significantly different from oleic acid ($p < 0.05$).
Effects of Fat Sources on Appetite

Effects of Peanut Oil on Appetite

Figure 1  Mean bite force, number of chews to deglutition, time to deglutition and chewing rate (number of chews/s) by almond form and test session (fasted: black bars; satiated: striped bars) measured by electromyographic recordings. Values are means±s.e. of the mean, n = 24. Letters denote significant differences between almond forms (P<0.05). *Denotes significant differences between fasted and satiated sessions.

Table 3B. Change in biomarkers after 4 days of treatment with walnut or placebo (data based on subjects who completed both visits)

<table>
<thead>
<tr>
<th>Area Under the Curve</th>
<th>Walnut</th>
<th>Placebo</th>
<th>p^1</th>
<th>p^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>-785.09 ± 657.60</td>
<td>-2208.21 ± 456.59</td>
<td>0.09</td>
<td>0.08</td>
</tr>
<tr>
<td>Insulin</td>
<td>2000.64 ± 812.30</td>
<td>1178.89 ± 854.01</td>
<td>0.25</td>
<td>0.37</td>
</tr>
<tr>
<td>FFA</td>
<td>-12.65 ± 5.64</td>
<td>-10.87 ± 3.28</td>
<td>0.93</td>
<td>0.71</td>
</tr>
<tr>
<td>A GH</td>
<td>-6691.38 ± 3055.74</td>
<td>-9598.96 ± 3953.04</td>
<td>0.76</td>
<td>0.47</td>
</tr>
<tr>
<td>T GH</td>
<td>-17904.84 ± 3969.25</td>
<td>-22198.79 ± 7133.54</td>
<td>0.50</td>
<td>0.57</td>
</tr>
<tr>
<td>GLP</td>
<td>68.39 ± 24.02</td>
<td>55.55 ± 61.58</td>
<td>0.63</td>
<td>0.83</td>
</tr>
<tr>
<td>GIP</td>
<td>-4544.81 ± 3815.86</td>
<td>-4139.68 ± 4540.23</td>
<td>0.84</td>
<td>0.92</td>
</tr>
<tr>
<td>PYY</td>
<td>395.87 ± 1288.87</td>
<td>-566.11 ± 1168.63</td>
<td>0.80</td>
<td>0.46</td>
</tr>
</tbody>
</table>
Serum GLP-1 concentration after almond consumption

Change from baseline (pmol/L)

Post-almond consumption (min)

Cassady et al., AJCN 2009;889:794-800.
Peanut and Peanut Butter Consumption

Fig. 3. Fasting and postprandial (a) glucagon-like peptide-1 (GLP-1), (b) peptide YY (PYY) and (c) cholecystokinin (CCK) responses to the breakfast meals containing peanuts (→), peanut butter (↔) or control (↔, no peanuts). Values are means, with their standard errors represented by vertical bars. * Mean values were significantly different (P<0.05).
The Satiety value of nuts appears to stem from the synergy of their components.
ABSORPTION 
EFFICIENCY
Degree of Mastication of the Nut Determines Lipid Bioavailability

Ellis et al., AJCN 2004; 80:604-613.
Almond particle size after mastication by number of chews

Cassady et al., Am J Clin Nutr 2009;89:794-800
Fecal fat and energy lost by number of chews

Cassady et al., Am J Clin Nutr 2009;89:794-800
Inefficient Absorption

% Fecal fat excretion

Levine and Silvas, 1980
Haddad and Sabate, 2000
Zemaitis and Sabate, 2001
Ellis et. al., 2004

Peanuts= 95% dietary fat for 6 d
Pecans=31% dietary fat for 4wk
Almonds= 40% dietary fat for 4wk
Almonds approx 30-45% dietary fat for 3 d

Control
Nut Treatment
Inefficient Absorption

7-9 day controlled diet with 70 g of peanuts/ peanut butter/ peanut flour/ peanut oil

Inefficient Absorption

Kendall et. al., 2003 - 423 kcal/d supplement for 4 wks
Food Form and Metabolizable Energy Value

- **Almonds**
  - Calculated Energy Density: ~6.0 kcal/g
  - Measured Energy Density: ~4.6 kcal/g
  - Error = ~32%

- **Pistachios**
  - Calculated Energy Density: ~5.7 kcal/g
  - Measured Energy Density: ~5.4 kcal/g
  - Error = ~5%

Novotny et al., AJCN 2012; 96:2096-301.
ENERGY EXPENDITURE
## Nuts and Energy Balance

<table>
<thead>
<tr>
<th>Component of Energy Balance</th>
<th>% Almond Energy Dissipated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted body weight gain (kg)</td>
<td>3.1</td>
</tr>
<tr>
<td>Actual body weight gained (kg)</td>
<td>0</td>
</tr>
<tr>
<td>Dietary compensation (KJ)</td>
<td>802</td>
</tr>
<tr>
<td>Fecal excretion (kJ)</td>
<td>84</td>
</tr>
<tr>
<td>Energy Expenditure (KJ)</td>
<td></td>
</tr>
<tr>
<td>REE</td>
<td>184</td>
</tr>
<tr>
<td>TEF</td>
<td>13</td>
</tr>
<tr>
<td>Physical Activity</td>
<td>-79</td>
</tr>
<tr>
<td>Total Energy (DLW)</td>
<td>180</td>
</tr>
<tr>
<td>Total Energy Explained</td>
<td>95</td>
</tr>
</tbody>
</table>

EATING PATTERN
FIGURE 1  Percent of U.S. individuals consuming snacks over a 2-d period (% of snackers on d 1, 2, or both).
FIGURE 2  Contribution of snacking to total daily energy intake by year and age group. Numbers within solid dark bars in the bottom represent the mean percent of energy from snacks. *Different from the previous year, $P < 0.01$; **different between 1977–78 and 2003–06, $P < 0.01$ (t test).
Dietary Energy Compensation: Meal VS. Snack

![Graph showing dietary energy compensation for meals and snacks with different conditions.](image_url)
45 overweight/obese Males

12 week intervention
Summary

- The chemosensory and physical properties of nuts influence their ingestion and metabolism.
- Nuts have strong satiety properties and elicit strong compensatory dietary compensation.
- Energy absorption from nuts is less than predicted.
- Nuts are associated with elevated resting energy expenditure.
- Nuts may be a useful snack option.
<table>
<thead>
<tr>
<th>Approx. Age</th>
<th>Development Sequence</th>
<th>Texture Attitudes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Only a shallow, rudimentary outline of the temporomandibular articulation; no dentition and poor coordination of tongue and lip movements</td>
<td>Liquids</td>
</tr>
<tr>
<td>4 months</td>
<td>Greater mobility of tongue and lips</td>
<td>Semi-solids</td>
</tr>
<tr>
<td>6-1/2 months</td>
<td>Teeth eruption begins with mandibular central incisor</td>
<td></td>
</tr>
<tr>
<td>10 months</td>
<td>Eruption of first primary molars; beginning of lateral chewing movements</td>
<td>Solid foods are beginning to be accepted</td>
</tr>
<tr>
<td>21 months</td>
<td>Jaw and tongue movement well-developed</td>
<td></td>
</tr>
<tr>
<td>2 yr</td>
<td>Eruption of second primary molars</td>
<td>Tendency to greater acceptance of chewy foods</td>
</tr>
<tr>
<td>2-4 yr</td>
<td>Good development of lateral chewing movements</td>
<td>Preference for moist/soft or crisp/crunchy</td>
</tr>
<tr>
<td>4 yr</td>
<td>5/6 mature width of the palatal arch</td>
<td></td>
</tr>
<tr>
<td>5 yr</td>
<td>Premolars begin to move toward eruption</td>
<td>Dislike of soft, mushy</td>
</tr>
<tr>
<td>6 yr</td>
<td>Eruption of first permanent teeth; eruption of mandibular first molar; beginning of very rapid rate of growth of muscles of mastication</td>
<td>Refusal of lumpy, stringy; preference for raw vegetables</td>
</tr>
<tr>
<td>8-9 yr</td>
<td>Eruption of permanent maxillary incisors</td>
<td>Dislike of greasy, slippery</td>
</tr>
<tr>
<td>10 yr</td>
<td>Eruption of permanent maxillary first premolars</td>
<td>Preference for firm/chewy/rough; aversion to soft/smooth/slicky</td>
</tr>
</tbody>
</table>

(Szczesniak 1972. Published with permission of Food and Nutrition Press.)