EATING LIKE A PIG: INVESTIGATING THE ROLE OF MEAT IN THE HUMAN DIET USING THE PIG BIOMEDICAL MODEL

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American consumers say they ate less beef and pork in 2013 in their efforts to adopt healthier eating habits, according to new research from Mintel.

In the survey, 90 percent of consumers reported eating some kind of red meat at least once a month. But 39 percent of red meat eaters said they ate less beef in 2013 than they did in 2012, and 25 percent of pork consumers claimed to have eaten less pork last year than the year before.

Only 10 percent of beef eaters are eating more, and only 13 percent of pork consumers are eating more.

“Health trends motivating consumers to cut fat and cholesterol intake are by far the most dominant factors affecting the red meat market,” said Patty Johnson, global food analyst at Mintel. “For many of those who are cutting back, they are very well trading up to a higher quality meat product.”

“The red meat category is facing a difficult future, as both health trends and price are working to discourage consumer demand for red meat products. The industry also has done little to innovate since the recession and therefore has offered consumers little to get excited about,” Johnson said.
U.S. per capita meat consumption

Pounds per capita, retail weight

Broilers
Beef
Pork

(USDA, 2013)
Per Capita consumption of red meat vs. poultry/fish; boneless equivalent (1970 – 2009)
Obesity in America

Percentage of people age 65 and over who are obese, by sex and age group, selected years 1960-2002

Reference population: These data refer to the civilian noninstitutionalized population.
Source: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health and Nutrition Examination Survey.
Obesity in America

Figure 1. Trends in obesity among children and adolescents: United States, 1963–2008

NOTE: Obesity is defined as body mass index (BMI) greater than or equal to sex- and age-specific 95th percentile from the 2000 CDC Growth Charts.

Obesity Worldwide
Obesity-related disorders

- 18.8 million diabetics (8.3% of U.S. population)
- 7 million undiagnosed
- 79 million “are thought to possess symptoms” of pre-diabetes

American Diabetes Association, 2011

46.3%
Population Consumption Trends

• What makes U.S. fat/diabetic?
  - Red Meat, Eggs, Dairy?
  - Fast Food?
  - Total Calories?
  - Exercise?
**Per capita soda consumption**

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<th>Rank</th>
<th>Country</th>
<th>Per Capita (litres)</th>
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<tr>
<td>#2</td>
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<td>119.8</td>
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<td>Japan</td>
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**FIGURE 1.** Sugar intake per capita in the United Kingdom from 1700 to 1978 (30, 31; ○) and in the United States from 1975 to 2000 (32; ◆) is compared with obesity rates in the United States in non-Hispanic white men aged 60–69 y (17; ●). Values for 1880–1910 are based on studies conducted in male Civil War veterans aged 50–59 y (18).
2011 consumption (Beverage Digest)
• 15.65 oz carbonated beverage/day (down 1.9%)

• Energy Drinks =16%
• Monster, Red Bull, & Rockstar “posted double-digit volume growth”

<table>
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<tr>
<th>Supplement Facts</th>
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<td>Serving Size 8.9 fl oz (240 ml)</td>
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<td>Serving Per Container 3</td>
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<th></th>
<th>Calories</th>
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<tr>
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<td>Vitamin B3</td>
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<td>Taurine</td>
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<td>Panax Ginseng</td>
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<td>Energy Blend</td>
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<tr>
<td>L-Carnitine, Glucose, Caffeine, Guarana Inositol, Glucuronolactone, Maltodextrin</td>
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<td>Percent Daily Values are based on a 2000 calorie diet.</td>
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52g sugar

81g sugar
Obesity-related disorders

Number and Percentage of U.S. Population with Diagnosed Diabetes

- **Number with Diabetes**
- **Percent with Diabetes**

![Graph showing the increase in number and percentage of U.S. population with diagnosed diabetes from 1958 to 2006.](image)

- **Fats, Oils & Sweets**: Use sparingly
- **Milk, Yogurt, & Cheese Group**: 2-3 servings
- **Vegetable Group**: 3-5 servings
- **Meat, Poultry, Fish, Dry Beans, Eggs, & Nuts Group**: 2-3 servings
- **Fruit Group**: 2-4 servings
- **Bread, Cereal, Rice, & Pasta Group**: 6-11 servings
Does obesity cause diabetes?

Does eating fat make us fat?
COMPARISON OF RED MEAT VS. HIGH CARBOHYDRATE DIET USING A GILT BIOMEDICAL MODEL
Objective 1

Determine if consumption of a highly refined carbohydrate-based diet leads to physiological and chemical imbalance associated with adiposity and risk factors for type II diabetes and metabolic syndrome
Background for Objective 1

How are Americans getting more obese/diabetic?

Physiology of INSULIN

- Chief hormone controlling intermediary metabolism
- Effects virtually every tissue in the body
  - Principally liver, muscle, & adipose tissue
- Short-term effects: ↓ blood glucose & conserve body fuel supplies
- Regulation of gene transcription & cell replication
Background for Objective 1

How are Americans getting more obese/diabetic?

- Affects of chronic insulin exposure
  - Glycogen saturation in muscle & liver
  - Down-regulation of insulin receptor
  - Adipocytes remain receptive to insulin
  - Increased adiposity
Background for Objective 1

Insulin promotes triglyceride synthesis & deposition AND inhibits lipolysis in fat cells

Released in response to low blood glucose/insulin

- Glucagon
- ACTH
- Growth Hormone
- Glucocorticoid
- Norepinephrine
- Epinephrine

Insulin

Blood Glucose

Glucagon

Time (hours)
Objective 1

Determine if consumption of a highly refined carbohydrate diet leads to physiological & chemical imbalance associated with adiposity & risk of diabetes & metabolic syndrome

- Chronic elevated blood glucose
- Hyperinsulinemia
- Energy saturation of muscle & insulin resistance
- Fat cells remain insulin sensitive & increased adiposity (Metabolic Syndrome)
- Fat cells become insulin resistant (Type II Diabetes)
Methods

• Samples were collected from a study done by Wellnitz et. al.

• Yorkshire × Duroc × Hampshire gilts (N = 21) provided *ad libitum* access to low lysine diet

• After reaching 3 cm subcutaneous backfat (N = 10), allocated to treatments control (CON) or ground beef (GB)
Methods

- **CON (N = 5)**
  - 70.55% ground corn, 15% vegetable oil, 8.5% DDGS, 4.25% soybean meal

- **GB (N = 5)**
  - One gilt removed due to foot infection (not treatment related)
  - 99.9% cooked ground beef (65:35 lean:fat), 0.1% calcium carbonate

- Intake and orts recorded daily
- NRC Requirements
Methods

- Blood draws on d0, d28, d56 and d84
- Blood analysis using iSTAT
  - Sodium, Potassium, Ion Ca, Glucose, Hematocrit, Hemoglobin, pH, PCO$_2$, PO$_2$, TCO$_2$, HCO$_3$, base excess and SO$_2$
- Blood lipid panel assays
  - Total cholesterol (CHOL), LDL, HDL, TRIGS
Figure 2.1. Average daily intake (kg) by week (wk) for gilts fed *ad libitum* corn-soybean control (CON) and 65:35 (lean:fat) blend ground beef (GB) dietary treatments (TRT) for 84 days (12 weeks).

TRT: $P = 0.003$

WK: $P = 0.158$

TRT×WK: $P = 0.656$
Figure 2.2. Average daily caloric intake (calculated kcats$^1$) by week (wk) for gilts fed \textit{ad libitum} corn-soybean control (CON) and 65:35 (lean:fat) blend ground beef (GB) dietary treatments (TRT) for 84 days (12 weeks).

![Graph showing average daily caloric intake by week for gilts fed \textit{ad libitum} corn-soybean control (CON) and 65:35 (lean:fat) blend ground beef (GB) dietary treatments (TRT) for 84 days (12 weeks). The graph includes error bars for each data point.]

- **TRT:** $P = 0.05$
- **WK:** $P = 0.123$
- **TRT$\times$WK:** $P = 0.632$
Figure 2.3b. Body weight change expressed as the percentage change from day 0 (start on test) for gilts fed *ad libitum* corn-soybean control (CON) and 65:35 (lean:fat) ground beef (GB) dietary treatments (TRT).
Figure 2.4b. Subcutaneous backfat (cm) expressed as the percentage change from day 0 (start on test) for gilts fed *ad libitum* corn-soybean control (CON) and 65:35 (lean:fat) blend ground beef (GB) dietary treatments (TRT).

TRT: $P = 0.09$

DAY: $P < 0.001$

TRT×DAY: $P = 0.761$
### Total Cholesterol

- **GB**
- **CON**

- **Trt**: $P = 0.02$
- **Day**: $P = 0.14$
- **Trt*Day**: $P = 0.28$

### HDL Cholesterol

- **GB**
- **CON**

- **Trt**: $P = 0.24$
- **Day**: $P = 0.35$
- **Trt*Day**: $P = 0.29$

### LDL Cholesterol

- **GB**
- **CON**

- **Trt**: $P = 0.02$
- **Day**: $P = 0.13$
- **Trt*Day**: $P = 0.36$

### Triglycerides

- **GB**
- **CON**

- **Trt**: $P = 0.81$
- **Day**: $P = 0.02$
- **Trt*Day**: $P = 0.82$
Meats do not have a glycemic index because they do not raise blood glucose levels. As with all the meal planning options, include a source of lean protein at each meal.

*American Diabetes Assoc. webpage*
Fasting Insulin

![Graph showing insulin levels over time with CON and GB groups, and a p-value of 0.61.](image)

- **Insulin IU/mL**
- **Day**: d0, d28, d56, d84
- **p = 0.61**
Objective 2

Determine if red meat consumption reverses tissue-specific down-regulation of insulin receptors in muscle tissue

Hypoinsulinemia

Stabilized blood glucose

Adipocyte lipolysis (fat loss)

Return of muscle cell insulin sensitivity

Meats and fats don’t have a GI because they do not contain carbohydrate.

American Diabetes Assoc. webpage
Image analysis of photomicrographs of longitudinal section of GR muscle stained for insulin receptor for gilts fed *ad libitum* CON (a) and GB (b)
Let’s Switch to Eating Like a Cow

Figure 1. Serum insulin concentration (ng/mL) across USDA marbling score

![Bar chart showing serum insulin concentration across different USDA marbling scores](chart.png)
Value of Proposed Research to Animal Agriculture?

- Promote meat consumption for *improved* health
- A new look at marbling deposition
What about Exercise?
## Exercise During Gestation

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<th>67</th>
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<td>Arrival</td>
<td>Observation</td>
<td>Exercise Acclimation</td>
<td>Pulse Ox</td>
<td>Pulse Ox</td>
<td>Pulse Ox</td>
<td>Observation</td>
</tr>
</tbody>
</table>
**Question**: Why is there less interfascicular space in the semitendinosus of gilts born to exercised dams?

Semitendinosus x-section taken from neonate born to sow who did NOT receive exercise 3x/week (CON).

Semitendinosus x-section taken from neonate born to sow who DID receive exercise 3x/week (EX).
Backfat % Change of Offspring from Exercised vs. Control Sows
Eating Red Meat?

Goodbye Pyramid.......Hello My Plate

HEALTHY EATING PLATE

- Use healthy oils (like olive and canola oil) for cooking, on salad, and at the table. Limit butter. Avoid trans fat.
- The more veggies—and the greater the variety—the better. Potatoes and french fries don’t count.
- Eat plenty of fruits of all colors.

DRINK WATER

- Drink water, tea, or coffee (with little or no sugar). Limit milk/dairy (1-2 servings/day) and juice (1 small glass/day). Avoid sugary drinks.

EAT WHOLE GRAINS

- Eat whole grains (like brown rice, whole-wheat bread, and whole-grain pasta). Limit refined grains (like white rice and white bread).

EAT FRUITS

Choose fish, poultry, beans, and nuts; limit red meat; avoid bacon, cold cuts, and other processed meats.

Stay Active!

Harvard School of Public Health
The Nutrition Source
www.hsph.harvard.edu/nutritionsource

Harvard Medical School
Harvard Health Publications
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Eating Red Meat?