THE EFFECTS OF THE FORM OF FOOD
ON ENERGY INTAKE AND SATIETY

A Thesis in
Nutrition

By
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ABSTRACT

In light of the current epidemic of overweight and obesity, identifying factors that promote energy balance is imperative for developing effective strategies for weight management. Several dietary factors that have been suggested to affect energy intake and weight status, including the form of food (i.e. solid, puree, or liquid). However, the literature on this topic is mixed, and more work is needed to test how the form of food influences satiety. A series of studies was developed to further examine how beverages, soup, and different forms of fruit affect energy intake and satiety. The findings from these experiments provide additional insight into the relationship between different forms of food and energy intake and satiety, and how consuming different forms of food can be used to manage energy intake.

Study 1 examined the impact of increasing beverage portion size on beverage and food intake. In a cross-over design, 33 subjects, 18 women and 15 men consumed lunch in the laboratory once a week for six weeks. At each test lunch, the same foods were served, but the beverage served was varied in type (cola, diet cola, or water) and portion size (360 g/12 fl. oz or 540 g/18 fl. oz). Increasing beverage portion size significantly increased the weight of beverage consumed, regardless of the type of beverage served (p<0.05). As a consequence, for the caloric beverage, energy intake from the beverage increased by 10% for women and 26% for men when there was a 50% increase in the portion served (p<0.01). Food intake did not differ between conditions, thus when the energy from the caloric beverage was added to the energy from food, total energy intake at lunch was significantly increased (p<0.001) compared to the non-caloric beverages.

Study 2 tested the effects on meal intake of consuming different forms of soup as a preload: broth and vegetables served separately, chunky vegetable soup, chunky-pureed
vegetable soup, or pureed vegetable soup. Normal-weight men and women (n = 60) came to the laboratory for lunch once a week for five weeks. Each week, one of four compulsory preloads, or no preload, was consumed prior to lunch. A test meal was consumed ad libitum 15 min after the soup was served. Results showed that consuming soup significantly reduced test meal intake and total meal energy intake (preload + test meal) compared to having no soup. When soup was consumed, subjects reduced meal energy intake by 20% (134±25 kcal; 561±105 kJ). The type of soup had no significant effect on test meal intake or total meal energy intake.

Study 3 tested how consuming preloads of apple, applesauce, and apple juice with and without fiber affect energy intake and satiety. Adults (n=58) ate breakfast and lunch in the laboratory once a week for 5 weeks. Before lunch, one of 4 preloads (152 kcal, 266 g), or no preload (control), was served. Apple (peeled segments), applesauce, and apple juice with pectin had similar fiber contents. An entrée was consumed ad libitum 15 min after the preload was served. All preloads reduced entrée intake compared to control (p<0.0001). Apple reduced total energy intake (preload + lunch) and increased satiety (fullness) ratings compared to all other preloads and control (p<0.0001). Eating apple segments reduced total energy intake by 164±36 kcal (12%) compared to control. Applesauce reduced total energy intake and increased satiety ratings compared to apple juice (p<0.02). Intakes did not differ following the juice preloads.

The findings from these three studies suggest that varying the form of food can affect energy intake and satiety at a meal. While beverages and soup are both considered to be liquids, they seem to affect energy intake and satiety differently. Beverages have a low satiating capacity and consuming caloric beverages with meals could increase energy intake. Conversely, soup tends to be highly satiating, and energy intake can be reduced by consuming various types of low-energy-dense soup as a first course. It is also likely that solid food can be more satiating than
beverages. These results suggest several dietary strategies that can be used to decrease energy intake and enhance satiety at meals, 1) consume low-calorie or non-caloric beverages with meals, 2) choose smaller portions of caloric beverages, and 3) consume low-energy-dense soup or fruit as a first course. Using these strategies on a regular basis may assist with the prevention and management of overweight and obesity.
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CHAPTER I

INTRODUCTION
In recent decades the prevalence of overweight and obesity in the United States has increased dramatically across all segments of the population. The most recent data obtained through the National Health and Nutrition Examination Survey (NHANES) 1999-2002 suggest that approximately 65.7% of adults in the US are either overweight or obese (BMI ≥ 25.0), with about 30.6% of adults being obese (BMI ≥ 30.0). Similar trends are seen in children and adolescents. Among children 6 through 19 years of age, 31.5% are estimated to be either at risk for becoming overweight or overweight (BMI ≥ 85th percentile of the sex-specific BMI-for-age growth chart), and about 16.5% of those children are considered to be overweight (BMI ≥ 95th percentile of the sex-specific BMI-for-age growth chart) (1-3).

These high rates of overweight and obesity have serious health and economic implications for American society. Several studies have shown associations between excess weight and a host of chronic diseases, including type 2 diabetes mellitus, cardiovascular disease, and some cancers (4). Corresponding to the relationship between weight status and disease-risk, researchers have found that overweight and obesity are related to significant increases in health care costs (5, 6).

The accumulation of excess weight is multi-factorial, and is primarily due to an imbalance between energy consumed and energy expended. Scientists suggest that the current obesity epidemic is the result of an environment that promotes over-eating, while discouraging physical activity (7). In light of the serious health consequences and increasingly burdensome health care costs associated with overweight and obesity, identifying factors that promote energy balance, particularly dietary constituents that reduce energy intake, is imperative for developing effective strategies for weight management.
The Form of Food

The form of food (i.e. solid, puree, or liquid) is one of several dietary factors that have been suggested to affect energy intake and weight status (8-10). The increasing prevalence of obesity that has occurred in recent decades has been paralleled by increased consumption of sweetened, caloric beverages (11), and much attention has been given to the role liquid energy sources may play in promoting excess energy intake and weight gain. It has been suggested that compared to energy in solid form, energy in liquid form is not effectively compensated for, leading to increases in energy intake and body weight (8-10). However, the literature on this topic is mixed, and the complexity of this issue was illustrated by the 2005 Dietary Guidelines Advisory Committee Report. The committee determined that the body of literature related to the question, “What is the evidence to support caloric compensation for liquids versus solid foods?” was not sufficient to make conclusive dietary recommendations, and the issue was deemed “unresolved” (12). While a number of studies have investigated the effects of consuming energy in different forms on energy intake and satiety, the results, along with study design and methodology, are varied. Several studies have found solid calories to be more satiating than liquid calories, some suggest that liquid calories are more satiating than solid calories, and others have reported solid and liquid calories to have similar effects on food intake and satiety (9, 10).

Satiety is typically assessed using a preloading paradigm, in which a fixed amount of a test food is consumed, and satiety is measured using subsequent energy intake and/or ratings of satiety. It can then be determined whether subsequent energy intake was adjusted to account for the test food that was consumed leading to energy compensation. However, variations in study design could affect the relationship between preload intake and subsequent energy intake and/or ratings of satiety. For example, variations in the types of test foods being compared,
characteristics for which test foods were matched, methods used to measure satiety, and timing of test food intake (Table 1) may explain why the results of studies done to test the effects of food form on energy intake and satiety are inconsistent.

<table>
<thead>
<tr>
<th>Type of test food</th>
<th>Test food characteristics</th>
<th>Time interval: preload to meal</th>
<th>Measures of satiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid food</td>
<td>Energy content</td>
<td>Consumed with the meal</td>
<td>Rating scales</td>
</tr>
<tr>
<td></td>
<td>(13-17)</td>
<td>(64, 65, 91)</td>
<td></td>
</tr>
<tr>
<td>Beverage</td>
<td>Weight</td>
<td>Consumed &lt; 30 min before the meal</td>
<td>Weighed food intake</td>
</tr>
<tr>
<td></td>
<td>(13, 15-20)</td>
<td>(14, 65, 66)</td>
<td>(67-69)</td>
</tr>
<tr>
<td>Soup</td>
<td>Energy density</td>
<td>Consumed &gt; 60 min before the meal</td>
<td>Self-reported food intake</td>
</tr>
<tr>
<td></td>
<td>(17, 21-26)</td>
<td>(20, 65, 66)</td>
<td>(67, 71)</td>
</tr>
<tr>
<td></td>
<td>Volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(30-34, 91)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Macronutrient content</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(34-39, 44-48)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fiber content</td>
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<td></td>
<td>(49-51, 91)</td>
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<td></td>
<td>Palatability</td>
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<td></td>
<td>(52-57)</td>
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</tr>
<tr>
<td></td>
<td>Temperature</td>
<td></td>
<td></td>
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<td></td>
<td>(58, 59)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Viscosity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(60-63)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Type of Food Tested**

The types of solid and liquid test foods that have been used to examine the effects of the form of food on energy intake and satiety have varied widely (Table 2). In the studies that have investigated food form, solid foods (ex. fruit, cookies, or mixed dishes) have been compared to liquids (beverages and soup). However, beverages and soup can be further differentiated;
beverages are liquids that are usually consumed from a glass, while soup can be classified as a food, or an item that is typically chewed, eaten with a utensil, or consumed to replace a meal (72). It has also been suggested that individuals perceive the effects beverages and soup have on hunger and thirst differently: beverages are expected to satisfy thirst, while soup is perceived to be a food that satisfies hunger (10, 17, 20, 66). The different cognitive impressions associated with beverages and soup could influence ratings of hunger and fullness, as well as subsequent food intake. Therefore, because it is possible that different types of liquids could have different effects on energy intake and satiety, the type of liquid test food used is an important factor to consider when interpreting the literature regarding food form and satiety.

When the literature is categorized by the type of liquid test food used, some patterns emerge. A number of studies compared the satiating effects of solid foods and beverages, and the majority of these studies found that solid foods increased ratings of satiety and reduced energy intake compared to beverages (14-20, 25, 73, 91). Conversely, several studies compared the satiating effects of solid foods and soup, and the majority of these studies found that soup enhanced satiety ratings and decreased energy intake compared to solid foods (17, 21, 22, 24).

Numerous other studies offer additional support for the hypothesis that beverages have a low satiating capacity and soup has a high satiating capacity. For example, several short-term laboratory-based studies have tested the effects on energy intake and satiety of consuming beverages either before or during a meal. Results have shown that drinking beverages has little influence on the amount of test meal consumed. Therefore, when a caloric beverage is consumed, the calories add on, leading to increased total energy intake (beverage + test meal) (64, 65, 74, 75). Long-term clinical trials have also observed that regularly consuming caloric beverages can increase daily energy intake and body weight (76-78). Conversely, a number of
short-term laboratory-based studies have tested the effects of consuming soup before a meal on energy intake and satiety. The findings of these studies show that consuming soup can lead to reductions in subsequent test meal intake and increases in satiety (21-24). In addition, several clinical trials have shown that including soup in the diet can reduce daily energy intake, increase satiety, and promote weight loss (79-81).

The results of the body of literature previously discussed suggest that different types of liquids can have different effects on energy intake and satiety. Beverages have a low-satiating capacity, and drinking caloric beverages may increase energy intake. On the other hand, soup has a high-satiating capacity, and eating soup may reduce energy intake. These key differences highlight the importance of considering the type of test food or beverage used when interpreting the studies done to test the effects of food form on energy intake and satiety. Therefore, the table summarizing this body of literature (Table 2) has been organized by the type of liquid that was tested.

**Test Food Characteristics**

While it is important to consider which types of food were used to investigate the form of food, there are also several characteristics of solid foods, beverages, and soup, in addition to food form, that have been shown to affect energy intake and satiety (Table 1). In order to isolate the effects of food form on satiety, test foods and beverages should be matched for as many of these properties as possible. In several of the studies designed to test the effects of food form on satiety, the test foods were not matched for a number of these characteristics; energy content (15, 16), macronutrient content (13, 18, 20, 73), fiber content (15-17, 73), weight (14, 17, 19, 21, 66, 73, 91), volume (17, 19, 21, 66), energy density (14-17, 19, 21, 66, 73, 91), palatability (14, 17,
18, 26, 91), temperature (17, 21, 22), and viscosity (24) (Table 1; Table 2). Variations in any one of these test food properties could affect study outcomes, making it difficult to attribute differences in satiety to any one test food characteristic. For example, when Haber et al. compared satiety ratings following intake of whole fruit or fruit juice matched only for weight, they found that ratings of satiety were greater following fruit compared to juice (15). However, fiber content of the test foods differed, and fiber content has been shown to affect energy intake and satiety (49). Therefore, it is unclear whether the differences in satiety that were found between whole fruit and fruit juice were due to variations in form or fiber content.

**Methods Used to Measure Satiety**

While test food type and characteristics are important factors to consider when investigating the effects of food form on human ingestive behavior, there are several other aspects of experimental design that could affect the primary study outcomes of energy intake and sensations of satiety. For example, a number of different methods were used to measure energy intake and satiety in the studies done to test the effects of consuming solid foods, beverages, and soup (Table 2). Variations in these methods could influence how the findings of studies were interpreted and limit the degree to which these studies can be compared and contrasted. As was described earlier, satiety is usually measured using a preloading paradigm; a fixed amount of test food is consumed, and satiety is measured by subsequent food intake and/or ratings of satiety. However, there are two different methods that are primarily used to measure subsequent food intake; weighed food intakes or self-reported food intake (food records or diet recalls). Weighed food intakes are considered to be the most highly controlled method for the assessment of energy and nutrient intakes, while self-reported food intake is associated with varying degrees of
measurement error (70, 71). Rating scales are also commonly used to assess hunger, fullness, and 
satiety, but this type of measure is highly subjective, and responses can be difficult to validate 
and compare between different individuals (67-69). While ratings scales have been shown to 
correlate significantly with food intake on a number of occasions, they should not be used as a 
substitute for measuring food intake (69).

The studies done to test the effects on satiety of varying the form of food used a variety 
of methods to assess satiety, which could influence the interpretation of study results (Table 2). 
A few studies measured satiety using only rating scales (15, 16, 73), one used only weighed food 
intakes (13), several used rating scales and weighed food intakes (14, 20-24, 26, 66, 91), and 
others used rating scales and self-reported food intake (17-19, 25, 82, 91). In studies that used 
only one method to measure satiety, it is unknown whether the same results would have been 
obtained using an alternative method (13, 15, 16, 73). For example, Bolton et al. found that 
ratings of satiety were greater following intake of whole fruit compared to juice, but because 
subsequent food intake was not assessed, it is unknown whether the differences in ratings of 
satiety would have translated into differences in energy intake (16). In studies that used two 
methods to measure satiety, the results of the two methods did not always agree; one method 
showed differences in satiety following test food ingestion, while the other method showed no 
differences in satiety (14, 17-21, 25, 91). For instance, Tournier & Louis-Sylvestre found self-
reported 24 hr energy intake to be higher after a beverage meal compared to the solid meal, but 
found no differences in hunger ratings (25). Variations in the methods used to measure satiety 
could affect how the findings of a study are interpreted, making it difficult to reliably conclude 
whether different forms of food affected satiety.
**Timing of Test Food Intake**

The timing of intake of various forms of food is another aspect of experimental design that could influence study outcomes. There are two main kinds of timing to consider; the rate at which the test food is ingested and the time interval between test food ingestion and subsequent food intake. Because of differences in the oro-sensory activity (chewing) required by solid and liquid foods, it is likely that the rate of which different forms of food could be consumed would vary. Haber et al found that subjects took more time to consume whole apple (17 min) compared to applesauce (6 min) and apple juice (2 min) (15). Based on these findings, additional conditions were added in which ingestion rate was matched and only the conditions for which ingestion rate was matched were used in analyses. Variations in ingestion rate and differences in chewing could influence cephalic-phase responses that play a role in digestion and metabolism, which could impact food intake (14, 83, 84). A few studies did not match test food ingestion rate (14, 26), and these differences in ingestion rate could have affected satiety and subsequent food intake (85, 86).

The time interval between test food ingestion and subsequent food intake is another important factor to consider when interpreting study results, as different time intervals could reflect different eating situations. For example, eating a test food with a meal could determine how the test food influences intake of other foods served at the meal. On the other hand, eating a test food <30 min before a meal would examine how consuming the test food as a first course influences energy intake at the subsequent meal. Finally, consuming a test food >60 min prior to a meal would test how eating that food between meals (as a snack) would influence the energy consumed at a later meal. Booth suggests that varying the time interval between consumption of a preload and subsequent food intake can affect the satiating capacity of the preload, and that
preloads ingested between meals are least likely to be compensated for at the subsequent meal (87).

In the studies done to test the effects on energy intake of consuming different forms of food, the time interval between test food intake and the measurement of subsequent food intake differed between studies (Table 2). For example, in a study by Almiron-Roig et al., preloads of regular cola or cookies were given to subjects either 20 min or 2 hr before lunch, and results showed that the preloads did not differ in their effects on subsequent lunch intake or satiety ratings (66). However, energy intakes at lunch were lower when the test foods were consumed 20 min before lunch, compared to when they were consumed 2 h before lunch, and the authors suggested that the timing of preload consumption may have more important influences on energy intake than food form. It is possible that consuming a test food immediately before a meal may have the greatest impact on reducing subsequent energy intake, while a longer time-interval between test food intake and the next meal may obscure differences in subsequent energy intake (9, 65, 66). Therefore, the degree of energy compensation that can be achieved by different forms of food may depend on the timing of intake.

Based on the results of the previously described experiments and those outlined in Table 2, it is likely that foods and beverages of different forms can have an impact on energy intake and satiety. However, because many of these studies differed in basic design elements, more work is needed to test how the form of food influences satiety. Thus, the following series of studies was developed to further examine how beverages, soup, and different forms of fruit affect energy intake and satiety. The findings from these experiments will generate additional information regarding the relationship between different forms of food and energy intake and
satiety, and will provide insight into how consuming different forms of food can be used to manage energy intake.

Study 1: How does varying the type and portion of beverage served with a meal affect energy intake and satiety at that meal?

Energy-containing beverages have been implicated in the promotion of excess energy intake and weight in adults (8, 11, 88). Also, secular trends in increasing beverage portion sizes have paralleled growing rates of obesity (11, 89). However, little is known about how increasing beverage portion size effects beverage intake. In addition, beverages are frequently consumed with meals, but only a few studies have employed a design that tests the effects of consuming beverages with a meal on food intake and total energy intake at that meal (64, 65, 74, 91). Therefore, the aim of this study was to test the effects of ad libitum beverage intake on beverage intake, food intake, and satiety at lunch. The beverages were varied in type (regular cola, diet cola, and water) and portion size, and were consumed alongside a standard lunch meal.

Specific Aims and Hypotheses for Study 1:

Aim 1: To test the effects on ad libitum beverage intake of increasing beverage portion size.

Hypothesis 1: Beverage portion size will significantly affect the weight of beverage consumed; as portion size is increased, ad libitum beverage intake will increase.

Aim 2: To test the effects of consuming beverages varied in type (regular cola, diet cola, and water) and portion size with a meal on ad libitum food intake.

Hypothesis 2: Food intake at lunch will not be affected by beverage type or portion size.
**Aim 3**: To test the effects of consuming beverages varied in type (regular cola, diet cola, and water) and portion size with a meal on total energy intake at the meal (beverage + food).

**Hypothesis 3**: Total energy intake at the meal will be significantly higher when caloric beverages are consumed with the meal. Consuming a larger portion of a caloric beverage will increase total energy intake at the meal compared to consuming a smaller portion of caloric beverage.

**Study 2: How do soups of varying form influence energy intake and satiety when consumed before a meal?**

A number of studies have found that consuming soup before a meal can reduce subsequent energy intake and enhance satiety (21-24). However, few studies employed a study design that tested whether consuming soup before a meal effects total energy intake (soup + test meal) at the meal. In addition, only a few studies have tested whether the form of soup affects energy intake and satiety, and the results are mixed (24, 26, 90). Therefore, the aim of this study was to test the effects of consuming soup preloads in various forms on subsequent food intake and satiety. The soups were made using identical ingredients, and varied in form by altering preparation method, and they were served 15 min prior to a standard lunch meal.

**Specific Aims and Hypotheses for Study 2:**

**Aim 1**: To test the effects of consuming soup as a preload on subsequent test meal intake.

**Hypothesis 1**: Consuming soup as a preload will significantly reduce subsequent test meal intake compared to when no soup is consumed.
Aim 2: To test the effects of consuming soup as a preload on total energy in a meal (soup + test meal).

Hypothesis 2: Total energy intake at the meal will be significantly reduced when soup is consumed compared to when no soup is consumed.

Aim 3: To test the effects of consuming different forms of soup on subsequent test meal intake and total energy at the meal (soup + test meal).

Hypothesis 3: Consuming chunky soup will reduce subsequent test meal intake and total energy intake at lunch compared to consuming other forms of soup.

Study 3: How do whole fruit, pureed fruit, and fruit juice affect energy intake and satiety when consumed before a meal?

The results of studies done to test the effects of food form on energy intake and satiety are mixed (Table 2), but several studies have shown that beverages are less satiating than solid foods (14-16, 19, 91). A few studies have shown that consuming whole fruit increased ratings of satiety compared to fruit juice (15-17), but little is known about how consuming different forms of fruit affects energy intake. In addition, the amount of fiber differed in the whole fruit and fruit juice tested in previous studies, so it is unclear whether differences in satiety were due to the form of food or fiber content (15-17). Therefore, the aim of this study was to test the effects of the form of fruit on subsequent food intake and satiety. The preloads were matched on a number of parameters (energy content, weight, energy density, and fiber content) and were served 15 min prior to a standard lunch meal.
Specific Aims and Hypotheses for Study 3:

**Aim 1:** To test the effects on subsequent test meal intake and total energy intake (preload + test meal) of consuming preloads of apple, applesauce, and apple juice with and without fiber.

**Hypothesis 1:** Consuming different forms of fruit as preloads will significantly reduce subsequent test meal intake and total energy intake, such that apple will have the highest satiating capacity, applesauce will be less satiating than apple, but more satiating than the juice preloads, and the juice preloads will have the lowest satiating capacity.

**Aim 2:** To test the effects on energy intake and satiety of consuming juice with and without fiber.

**Hypothesis 2:** Juice supplemented with naturally-occurring levels of fiber will be more satiating than fiber-free juice.
Table 2. Studies done to test the effects of the form of food on energy intake and satiety

<table>
<thead>
<tr>
<th>Study and sample</th>
<th>Test foods and beverages</th>
<th>Measures of satiety</th>
<th>Time interval: preload to meal</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solid food compared to beverages</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pliner (13)</strong> n=96</td>
<td>Solid: Strawberry cake: 200 and 600 kcal&lt;br&gt;<strong>Liquid:</strong> Strawberry milk: 200 and 600 kcal&lt;br&gt;<strong>Matched:</strong> Energy, volume</td>
<td>Lunch intake</td>
<td>1 hr</td>
<td>Not measured&lt;br&gt;No differences in normal-weight subjects&lt;br&gt;Milk reduced intake compared to cake in obese subjects</td>
</tr>
<tr>
<td><strong>Haber et al. (15)</strong> n=10</td>
<td>Solids: Apples and apple puree: 482g&lt;br&gt;<strong>Liquid:</strong> Apple juice: 469g&lt;br&gt;<strong>Matched:</strong> weight</td>
<td>Rating scales</td>
<td>Not measured</td>
<td>Apples increased satiety more than puree and juice. Puree increased satiety more than juice&lt;br&gt;&lt;br&gt;Not measured</td>
</tr>
<tr>
<td><strong>Bolton et al. (16)</strong> n=10</td>
<td>Solids: Grapes: 339g&lt;br&gt;Orange: 626g&lt;br&gt;&lt;br&gt;<strong>Liquids:</strong> Grape juice: 323ml&lt;br&gt;Orange juice: 610ml&lt;br&gt;<strong>Matched:</strong> weight</td>
<td>Rating scales</td>
<td>Not measured</td>
<td>Grapes and oranges increased satiety more than grape juice and orange juice&lt;br&gt;&lt;br&gt;Not measured</td>
</tr>
<tr>
<td><strong>Tournier &amp; Louis-Sylvestre, (25)</strong> Test 1: n=13 Test 2: n=13</td>
<td>Test 1: 538.8g/679 kcal&lt;br&gt;Solid: Terrine + tomato juice&lt;br&gt;<strong>Liquid:</strong> Soup + tomato juice w/ gelatin&lt;br&gt;<strong>Test 2:</strong></td>
<td>Rating scales</td>
<td>4 hrs</td>
<td>Test 1: No differences&lt;br&gt;Test 2: No differences&lt;br&gt;Test 1: No differences&lt;br&gt;Test 2: Energy intake was greater after the tomato juice meal compared to the terrine meal</td>
</tr>
<tr>
<td>Study</td>
<td>Solid</td>
<td>Liquid</td>
<td>Rating</td>
<td>Time</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>--------</td>
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<td>------</td>
</tr>
<tr>
<td>Hulshof et al. (18)</td>
<td>Solid: Formula + locust bean gum or gelatin: 550 ml</td>
<td>Rating scales</td>
<td>3 hr 45 min</td>
<td>No differences</td>
</tr>
<tr>
<td></td>
<td>Liquid: Formula: 550 ml</td>
<td>Self-reported food records</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0g fat/100 kcal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33g fat/400 kcal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>77g fat/800 kcal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Matched: Energy, weight, volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mustad et al. (82)</td>
<td>Solid: Average American whole-food diet</td>
<td>Rating scales on days 2, 12, 23</td>
<td>Not measured</td>
<td>No differences</td>
</tr>
<tr>
<td></td>
<td>Liquid: Liquid-formula diet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Each diet was consumed for 23-days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Matched: Energy, macronutrient content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Treatment Summary</td>
<td>Rating</td>
<td>Intake Summary</td>
<td>Findings</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| DiMeglio & Mattes (19) | Solid: Jelly beans: 112.5g/450 kcal  
Liquid: Soda: 818 -1154 ml/ 450 kcal  
*Each treatment was consumed every day for 4 wks | Rating scales  
24-hr recall  
Body weight | Jelly beans: 82% as a snack, 9% with a meal  
Soda: 45% as a snack, 49% with a meal | No differences  
Jelly beans reduced energy intake from baseline; soda increased energy intake from baseline  
Body weight increased during the soda treatment |
| Lavin et al. (14) | Solids: Jelly + water: 150g/60 kcal  
Pastilles + water: 150g/60 kcal  
Liquid: Sweet drink: 150g/60 kcal  
Matched: Energy, weight, energy density, macronutrient content | Rating scales  
Weighed lunch intake | 15 min: Jelly  
10 min: Pastilles  
7 min: Sweet drink | No differences  
Energy intake was reduced after the pastilles compared to the sucrose drink |
| Mattes (17) | Solids: Apple:508g/300 kcal  
Liquids: Apple juice: 652g/300 kcal  
Apple soup: 652g/300 kcal  
Matched: Energy | Rating scales  
Self-reported food records | Not measured | Fullness was increased more by the apples and apple soup compared to apple juice  
No differences in self-reported energy intake |
| Almiron-Roig, et al. (66) | Solid: Cookies: 87g/300 kcal  
Liquid: | Rating scales  
Weighed lunch | 20 min  
2 hr | Fullness ratings were higher after cola compared to cookies  
No differences |
<table>
<thead>
<tr>
<th>Study</th>
<th>Solids</th>
<th>Rating scales</th>
<th>Preload type</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drewnowski et al.</strong></td>
<td><strong>Cola</strong>: 710ml/291 kcal</td>
<td>(n=32)</td>
<td>Yogurt preloads increased satiety ratings more than the drink preloads</td>
<td>No differences</td>
</tr>
<tr>
<td></td>
<td><strong>Solids</strong>: Peaches yogurt: 378 g/200 kcal Semisolid peach yogurt: 378g/ 200 kcal</td>
<td>90 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Liquids</strong>: Peaches fruit drink: 400ml/200kcal Peaches dairy drink: 40 ml/200kcal</td>
<td></td>
<td>Yogurt preloads increased satiety ratings more than the drink preloads</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Matched</strong>: Energy, weight, energy density, volume, palatability, temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Campbell et al.</strong></td>
<td><strong>Solid</strong>: Meal replacement bar: 138g/540 kcal</td>
<td>(n=9)</td>
<td>Satiety ratings were higher following the solid meal replacement bar compared to the liquid meal replacement shake</td>
<td>Not measured</td>
</tr>
<tr>
<td></td>
<td><strong>Liquid</strong>: Meal replacement shake: 138g/ 540 kcal</td>
<td>Rating scales Not measured</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Matched</strong>: Energy, weight, energy density</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mattes et al.</strong></td>
<td><strong>Solid</strong>: Cheese Watermelon Coconut</td>
<td>Rating scales Consumed with the meal</td>
<td>No differences</td>
<td>Daily energy intake was greater when beverages were consumed compared to solids</td>
</tr>
<tr>
<td></td>
<td><strong>Liquid</strong>: Milk Watermelon juice Coconut juice</td>
<td>Weighed lunch intake Self-reported food records</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lean: 125 kcal Obese: 225 kcal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Type</td>
<td>Solids</td>
<td>Liquid</td>
<td>Rating scales</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Kissileff et al. (21)</td>
<td>Solid food compared to soup</td>
<td>Cheese/crackers + juice: 277g/256 kcal</td>
<td>Tomato soup: 303g/109 kcal</td>
<td>Rating scales</td>
</tr>
<tr>
<td>n=10</td>
<td></td>
<td>Liquid: Tomato soup: 303g/109 kcal</td>
<td></td>
<td>Weighed lunch intake</td>
</tr>
<tr>
<td>Rolls et al. (22)</td>
<td></td>
<td>Solids: Cantaloupe: 140g/50 kcal and 561g/200 kcal</td>
<td>Tomato Soup: 135g/50 kcal and 540g/200 kcal</td>
<td>Rating scales</td>
</tr>
<tr>
<td>n=12</td>
<td></td>
<td>Cheese/crackers: 12g/50kcal and 46g/200 kcal</td>
<td></td>
<td>Weighed lunch intake</td>
</tr>
<tr>
<td>Himaya &amp; Louis-Sylvestre (24)</td>
<td></td>
<td>Solid: Vegetables + glass of water: 300g/95 kcal</td>
<td>Pureed soup: 300g/95 kcal Chunky soup: 300g/95 kcal</td>
<td>Rating scales</td>
</tr>
<tr>
<td>n=22</td>
<td></td>
<td>Liquid:</td>
<td></td>
<td>Weighed lunch and dinner intake</td>
</tr>
<tr>
<td>Rolls et al. (23)</td>
<td></td>
<td>Solids: Chicken-rice</td>
<td></td>
<td>Rating scales</td>
</tr>
<tr>
<td>Study</td>
<td>n</td>
<td>Solids</td>
<td>Liquid</td>
<td>Fullness</td>
</tr>
<tr>
<td>--------------------</td>
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<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td>Laboure et al. (26)</td>
<td>12</td>
<td>Solid: Solid rusk + glass of milk: 357g/423 kcal</td>
<td>Liquid rusk: 357g/423 kcal</td>
<td>Dinner was available at the request of the subject</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sandwich loaf + glass of milk: 357g/423 kcal</td>
<td></td>
<td>Inter-meal interval duration</td>
</tr>
<tr>
<td>Mattes (17)</td>
<td>31</td>
<td>Solids: Apple: 508g/300 kcal, Chicken Breast: 199g/300 kcal, Peanuts: 51g/300 kcal</td>
<td>Liquid:</td>
<td>Not measured</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td>Weight (g)</td>
<td>Calories (kcal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
<td>-----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple juice</td>
<td>652</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple soup</td>
<td>652</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken soup</td>
<td>670</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut soup</td>
<td>169</td>
<td>300</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Matched: Energy

previous section of the table
REFERENCES


35. Bell EA, Roe LS, Rolls BJ. Energy density influences energy intake across varying levels of fat content in both lean and obese women. Obesity Research 2000;8:268.
66. Almiron-Roig E, Flores SY, Drewnowski A. No difference in satiety or in subsequent energy intakes between a beverage and a solid food. Physiology and Behavior 2004;82:671-677.


CHAPTER II

STUDY 1:

THE EFFECTS OF BEVERAGE PORTION SIZE

ON BEVERAGE AND LUNCH INTAKE

INTRODUCTION

Increasing portion size is one of the many factors that may be contributing to the current obesity epidemic. Secular trends of increasing portion sizes have been found for a wide variety of foods and beverages, and these increases have occurred in parallel with rising rates of obesity (1-3). Several short-term studies have shown that serving a larger portion of food results in increased food intake. This has been shown in a range of foods, including various lunch entrées, a snack, all foods eaten over two consecutive days, and in a restaurant setting (4-8).

The effect of the portion size of beverages on beverage intake has not been systematically studied. One previous study examined the impact of increasing beverage portion size on food intake, and found that increasing the portion of beverage did not affect food intake (9). However, the beverage intake was compulsory, and thus, the effects of increasing beverage portion size on ad libitum beverage intake could not be examined.

Consumption of energy-containing beverages is another possible contributor to the current obesity epidemic. Epidemiological research with nationally representative data has shown that consumption of sweetened beverages increased 135% between 1978 and 2001, contributing an average of 278 kcal to daily energy intake (10). This increase in beverage intake was parallel to an increase in body weight among adults and children during the same time period (11-13).

A small number of longer-term experimental studies have implicated caloric beverages in the promotion of positive energy balance and weight gain in adults (14,15). These studies found that regular consumption of caloric beverages was associated with greater daily energy intakes, increased body weight, or increased body mass index (BMI) when compared with habitual consumption of non-caloric beverages. While these data suggest that consuming caloric
beverages could lead to over-consumption, data from short-term laboratory-based studies on the impact of caloric and non-caloric beverages on food intake are inconsistent. Some controlled studies found that energy consumed from caloric beverages was compensated for by a reduction in food intake (16,17). Others, however, found that beverages, whether caloric or non-caloric, had no significant effect on food intake (9, 18, 19); thus, consuming calorie-containing beverages with a meal resulted in increased total energy intake. Although there is some inconsistency in the results, in general these studies provide support for the hypothesis that habitual consumption of energy-containing beverages increases energy intake, and may lead to increased body weight.

The aim of the present study was to examine the effects of increasing beverage portion size on beverage intake, as well as on food and energy intake, during a meal. We hypothesized that subjects would consume a greater weight of beverage when they were served a larger portion size. A second hypothesis was that food intake at a meal would not be influenced by beverage intake, so that when a caloric beverage was served, total energy intake at the meal would be increased.

METHODS

Subjects

Subjects for this study were recruited from The Pennsylvania State University community by informational flyers, electronic mailing lists, and newspaper advertisements. Individuals who responded to the advertisements were interviewed by telephone to ensure that they met the following criteria: 18-45 years of age, not taking medications that are known to affect appetite or food intake, non-smokers, regularly consume 3 meals a day, not dieting to gain or lose weight, not athletes in training, not pregnant or breastfeeding, and free from food
allergies and food restrictions. Only subjects who reported liking both regular and diet soda were eligible (APPENDIX A).

Potential subjects who met these initial criteria then came to the laboratory to and gave consent (APPENDIX B) to complete additional screening materials (APPENDIX C). Included in the screening materials were the Eating Inventory (APPENDIX D) (20), which measures dietary restraint, disinhibition, and hunger; the Zung Questionnaire (APPENDIX E) (21), which measures depression; and the Eating Attitudes Test (EAT-26) (APPENDIX F) (22), which measures attitudes towards food and eating. These measures were included in order to ensure that subjects did not exhibit symptoms of depression or disordered eating that might influence food intake and study outcomes. Trained laboratory personnel took height and weight measurements (model 707; Seca Corp., Hanover, MD) at this time. Potential subjects who had a BMI of 18-40 kg/m$^2$, scored < 40 on the Zung Questionnaire, and scored < 20 on the EAT-26 were eligible for participation in the study. Subjects gave signed consent (APPENDIX G); and were told that the purpose of the study was to examine the effects of consumption of various foods and beverages. Subjects were financially compensated for participation in the study. The study was approved by the Pennsylvania State University Office for Research Protections.

**Experimental design**

A cross-over design with repeated measures was used in this study. Subjects came to the laboratory to eat lunch once a week for six weeks, for a total of six test sessions. On each test day, a standard breakfast of bagels and yogurt was served in order to ensure a consistent level of hunger across sessions. At each lunch, the same foods were served, but the beverage served was varied in type and portion size. At all meals, subjects could eat or drink as much or as little as
they wanted from the amount of food and beverage that was served. The order of experimental conditions was counterbalanced across subjects.

The sample size for this study was based on previous data from our laboratory. According to the power calculations, a sample size of 40 subjects would allow the detection of a difference in energy intake of 73 to 80 kcal at a significance level of 0.05 and a power of 80%. This represents about 8 to 10% of typical lunch energy intakes in our laboratory, which was considered to be a clinically significant change.

**Foods and beverages**

At each lunch, one of three beverages was served (regular cola, diet cola, or water; PepsiCo, Inc., Purchase, NY) in one of two portion sizes (360 g or 540 g). These beverages are among the most commonly-consumed beverages in the United States, and the portion sizes chosen are representative of average portions consumed by Americans (1, 10). The 360 g portion had a volume of 12 fluid ounces, and the 540 g portion had a volume of 18 fluid ounces. The nutritive properties of the beverages are shown in Table 3 (Photograph 1). The regular cola was sweetened with high fructose corn syrup, and the diet cola was sweetened with aspartame. Subjects were not given information about the beverage type or portion size that they were served. The two portion sizes were served in two different-sized glasses. All beverages were served chilled at 36° F.
Table 3. The nutrient properties of the beverages served during lunch in a study to test the effect of increasing beverage portion size on beverage intake and food intake at lunch

<table>
<thead>
<tr>
<th>Beverage</th>
<th>Portion (g)</th>
<th>Energy (kcal)</th>
<th>Energy density (kcal/g)</th>
<th>Carbohydrate (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (tap)</td>
<td>360</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water (tap)</td>
<td>540</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Regular cola</td>
<td>360</td>
<td>150</td>
<td>0.4</td>
<td>39.6</td>
</tr>
<tr>
<td>Regular cola</td>
<td>540</td>
<td>225</td>
<td>0.4</td>
<td>59.4</td>
</tr>
<tr>
<td>Diet cola</td>
<td>360</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Diet cola</td>
<td>540</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1 PepsiCo, Inc., Purchase, NY

Photograph 1. Test Beverages.

The lunch meal (Photograph 2) consisted of an entrée of rotini pasta (450 g for females, 650 g for males; Reinhart Foodservice, Northumberland, PA) and tomato sauce (250 g for females, 375 g for males; Campbell Soup Co., Camden, NJ). The entrée was accompanied by a salad of romaine lettuce (50 g) and cherry tomatoes (6 each), a roll (38 g; Pepperidge Farm, Inc.,
Norwalk, CT), and chocolate chip cookies (80 g; Kraft Foods, Inc., East Hanover, NJ). Subjects were also given a choice of salad dressings (43 g each, T. Marzetti Company, Columbus, OH), butter spread (20 g; Land O’Lakes, Inc., Arden Hills, MN), and parmesan cheese (15 g; Kraft Foods, Inc., Glenview, IL). All foods and beverages served in the study were commercially available. Portions for males and females were based on food intake data from previous studies in our laboratory, and provided more energy than most subjects were likely to consume.

Photograph 2. Test meal.

All foods and beverages were weighed prior to being served to subjects, and re-weighed after the subjects had finished eating to determine the amount of food and beverage consumed by each subject to the nearest 0.1 g. The energy and macronutrient intakes at each meal were calculated using nutrition information provided by the food and beverage manufacturers, and food composition tables (23).
**Procedures**

On test days, subjects were instructed to consume only foods and beverages provided by the laboratory from the time they woke up in the morning until after the lunch session. Subjects were permitted to consume water between meals up to one hour before the test session. Subjects were instructed not to drink alcohol in the 24 hours prior to coming to the laboratory, and not to consume dinner in a restaurant the evening before the test session. Subjects were also told to keep the amount of food eaten and physical activity performed the day before coming to the laboratory as consistent as possible across sessions, and completed a food and activity diary the day before each test session to encourage compliance with this protocol (APPENDIX H).

On test days, subjects came to the laboratory at their assigned meal time and were seated in an individual cubicle. Before each meal, subjects filled out a report to evaluate their compliance with study protocol and to ensure that they were feeling well (APPENDIX I). After completing the report, lunch was served, and subjects were instructed to eat and drink as much or as little of the foods and beverages as they wanted.

**Ratings of hunger, satiety, and food and beverage characteristics**

Before and after each meal, subjects filled out a series of 100-mm visual analog scales (24) to assess hunger, thirst, fullness, prospective consumption, and nausea. For example, subjects answered the question “How full do you feel right now?” by marking the 100-mm line anchored by “Not at all full” on one side, and “Extremely full” on the other (APPENDIX J).

At the beginning of each lunch, subjects also used 100-mm visual analog scales to rate the characteristics of both the entrée and the beverage (APPENDIX K). Subjects were instructed to first rate the appearance of the entrée and beverage, and then take a bite of the entrée or sip of
the beverage and rate the pleasantness of the taste. Subjects also rated prospective consumption (how much of the food or drink they thought they could consume), the size of the portion compared to their usual portion, and perceived caloric content. For example, subjects recorded their answer to the question “How does this portion size compare to your usual portion?” by marking a 100-mm line anchored on one side by “A lot smaller” and anchored on the other side by “A lot larger.”

**Statistical analysis**

A mixed linear model with repeated measures was used to analyze the main outcomes of energy intake (kcal), food and beverage intake (g), ratings of hunger and satiety, and ratings of entrée and beverage characteristics (SAS System for Windows, version 9.1; SAS Institute, Cary, NC). The fixed factor effects in the model were beverage type, beverage portion size, and subject sex; awareness of the purposes of the study was also tested as an independent factor in the model. Analysis of covariance was performed to determine whether any continuous variables, including subject characteristics and beverage taste ratings, affected the relationship between the experimental variables and the main outcomes. Results were considered significant at p<0.05.

**RESULTS**

**Subjects**

Forty subjects were enrolled in the study; 20 women and 20 men. Of these subjects, one woman and three men were excluded because they consumed the entire entrée served during a test meal. In addition, one woman and two men were excluded because of non-compliance with study
protocol or inability to attend scheduled meals. Therefore, a total of 33 subjects completed the study (18 women and 15 men). The characteristics of these subjects are shown in Table 4.

**Beverage Intake**

Beverage portion size significantly affected the weight of beverage that was consumed, independent of beverage type (Figure 1). The effect of beverage portion size on intake was stronger in men than in women, resulting in an increase in beverage intake of $31 \pm 15$ g for females ($p<0.025$) and $83 \pm 19$ g for males ($p<0.0001$). Because a greater weight of beverage was consumed when a larger portion size was served, subjects consumed significantly more energy from the caloric beverage (regular cola) when served the large portion ($151 \pm 8$ kcal) compared to the small portion ($128 \pm 4$ kcal) ($p<0.004$). Thus, a 50% increase in portion size resulted in a 10% increase in beverage energy intake for women, and a 26% increase in intake for men.
Table 4. Characteristics of subjects participating in a study to test the effect of increasing beverage portion size on beverage intake and food intake at lunch (mean ± standard error; range)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Females (n = 18)</th>
<th>Males (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>22.0 ± 0.2 (20.0 - 25.7)</td>
<td>23.3 ± 0.3* (19.6 - 30.3)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>61.5 ± 0.9 (49.1 - 85.7)</td>
<td>78.7 ± 1.0* (59.3 – 93.4)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>165.1 ± 0.5 (151.1 – 174.0)</td>
<td>179.1 ± 0.8* (166.4 - 193.0)</td>
</tr>
<tr>
<td>Body mass index (kg/m(^2))</td>
<td>22.6 ± 0.3 (18.6 - 29.1)</td>
<td>24.5 ± 0.3* (18.8 - 28.5)</td>
</tr>
<tr>
<td>Dietary restraint score (^1)</td>
<td>6.4 ± 0.3 (1 - 14)</td>
<td>5.1 ± 0.3* (0 - 13)</td>
</tr>
<tr>
<td>Disinhibition score (^1)</td>
<td>4.9 ± 0.2 (0 - 11)</td>
<td>4.4 ± 0.3 (1 - 11)</td>
</tr>
<tr>
<td>Perceived hunger score (^1)</td>
<td>4.2 ± 0.2 (1 - 9)</td>
<td>4.8 ± 0.3 (1 - 11)</td>
</tr>
<tr>
<td>Eating attitudes score (^2)</td>
<td>3.2 ± 0.3 (0 - 10)</td>
<td>1.8 ± 0.3 (0 - 6)</td>
</tr>
<tr>
<td>Depression score (^3)</td>
<td>29.1 ± 0.4 (22 - 38)</td>
<td>27.9 ± 0.5 (22 - 35)</td>
</tr>
</tbody>
</table>

\(^1\) Eating Inventory (20)
\(^2\) Eating Attitudes Test (22)
\(^3\) Self-Rating Depression Scale (21)
* Based on the results of a T test, means differ significantly between sexes (p<0.01)
Figure 1: Beverage weight (mean ± standard error) consumed by women and men in the conditions of portion size used to test the effect of increasing the portion size of 3 types of beverages consumed with a standard meal. Subjects consumed significantly more beverage when served the larger portion size compared to the smaller portion size, and this effect did not differ by beverage type: *p<0.05; ***p<0.0001.

Beverage type also significantly influenced mean beverage intake. Subjects consumed significantly more water (380 ± 10 g) than regular cola (335 ± 11 g) and diet cola (298 ± 12 g), and significantly more regular cola than diet cola (all p<0.0001).

Food Intake

Breakfast intake did not differ significantly across experimental conditions; mean energy intakes at breakfast were 659.4 ± 14.3 kcal for men and 512.9 ± 14.0 kcal for women. Men consumed a mean of 12.9 ± 0.6% energy from fat, 75.0 ± 0.5% energy from carbohydrate, and 12.1 ± 0.1% energy from protein. Women consumed a mean of 14.9 ± 0.6% energy from fat, 72.8 ± 0.6% energy from carbohydrate, and 12.3 ± 0.1% energy from protein.

Food intake at lunch did not differ significantly by either type or portion size of the beverage served. There were no differences in macronutrient intakes at lunch by condition (data
not shown). Men consumed 19.2 ± 0.7% energy from fat, 68.8 ± 0.6% energy from carbohydrate, and 11.9 ± 0.1% energy from protein. Women consumed 23.1 ± 0.8% energy from fat, 65.3 ± 0.7% energy from carbohydrate, and 11.6 ± 0.2% energy from protein. Men ate a mean of 51 ± 1% of the food that was served to them at lunch, and women ate a mean of 42 ± 1%.

When the energy from beverages was added to the energy consumed from food, the mean total energy intake at lunch was significantly greater when regular cola was served, regardless of portion size (p<0.001; Figure 2). Therefore, even though subjects consumed significantly more energy from the caloric beverage than the non-caloric beverages, they did not compensate for this additional energy by reducing food intake. Outcomes were not different in subjects who completed the beverages.

**Figure 2:** Energy from food and beverages (mean ± standard error) in the conditions of beverage type and portion size (small = 360 g, large = 540 g) used to test the effect of increasing the portion size of 3 types of beverages consumed with a standard meal. Energy intake from food did not differ across conditions. Mean total meal intakes with different letters are significantly different: p<0.001.
Analysis of covariance showed that the relationship of beverage type and portion size to total energy intake was not influenced by any of the measured subject characteristics (age, height, weight, or body mass index; tendency for dietary restraint, disinhibition, or hunger; or scores for depression or eating attitudes). However, ratings of pleasantness of taste of the beverage did differentially influence the weight of beverage consumed. As the taste rating of the diet cola increased, the intake of diet cola also increased significantly; the same result was not seen for water and regular cola (Figure 3).

**Figure 3.** Analysis of covariance showed that ratings of pleasantness of taste for diet cola influenced beverage intake (g). As the taste rating of the diet cola increased, ad libitum intake of the diet cola also increased significantly (p<0.0001).

**Ratings of hunger, satiety, and food and beverage characteristics**

There were no significant differences across experimental conditions in ratings of hunger, fullness, thirst, prospective consumption, or nausea before lunch was served (data not shown). In addition, there were no differences across conditions in hunger, fullness, nausea, or prospective consumption following lunch, despite differences in meal energy intake. Ratings of thirst after
lunch, however, were reduced significantly more after the large water was served than after all other beverages were served (p<0.05; Figure 4).

![Graph of thirst ratings](image)

**Figure 4:** Ratings of thirst (mean ± standard error) before and after lunch in the conditions of beverage type and portion size (small = 360 g, large = 540 g) used to test the effect of increasing the portion size of 3 types of beverages consumed with a standard meal. The mean rating of thirst after lunch was significantly lower after the large portion of water was served compared to the other beverages: *p<0.05.

There were significant differences in ratings of beverage characteristics across conditions. Female subjects rated the pleasantness of the taste of regular cola (75 ± 3) higher than both diet cola (59 ± 3) and water (60 ± 3; p<0.05). Male subjects rated the pleasantness of the taste of both regular cola (66 ± 5) and water (67 ± 4) higher than diet cola (53 ± 5; p<0.05). There were no significant differences across conditions in ratings of characteristics of the entrée, which was not varied. For both women and men, ratings of prospective beverage consumption (how much of the beverage they thought they could consume) were greater for the small portion (73 ± 2) than for the large portion (62 ± 2), and portion size ratings were lower for the small portion (52 ± 2) than those for the large portion (65 ± 2; p<0.0001).
Ratings of beverage calorie content were significantly different for the various beverage types for both women and men. Subjects rated the regular cola as having the highest calorie content (57 ± 3), followed by diet cola (35 ± 4), and water (3 ± 1; p<0.0001). Although some subjects (n=6) recognized the diet cola, as indicated by rating the calorie level less than 15 on a visual analog scale, most subjects (n=27) were not aware that diet cola was served, as evidenced by greater calorie ratings. The main outcomes of beverage and food intake did not differ between subjects who recognized that diet cola was served and those who were unaware that diet cola was served.

**Discharge questionnaire**

On the discharge questionnaire (APPENDIX L), 27 subjects (82%) noticed that the type of beverage changed across sessions, and 7 subjects (21%) noticed a change in beverage portion size during the study. Two subjects (6%) correctly reported that the purpose of the study was to examine the effect of changing beverage portion size on beverage intake, one subject (3%) correctly reported that the purpose of the study was to examine the effects of changing beverage portion size on food intake, and 13 subjects (39%) correctly reported that the purpose of the study was to examine the impact of changing beverage type on food intake. No subjects correctly reported all three study purposes. The mixed linear analysis showed that the primary study outcomes were not significantly influenced by whether subjects had correctly or incorrectly ascertained any purposes of the study (data not shown).
DISCUSSION

This study found that when the portion size of a beverage was increased by 50%, both women and men consumed a significantly greater weight of beverage, as well as significantly more energy when served a caloric beverage. In addition, when a caloric beverage was consumed with a meal, food intake was not reduced and energy from the beverage added on to energy from food, resulting in a significant increase in total energy consumed at a meal. When served either the caloric beverage or the larger portion sizes, subjects did not report feeling more full or less hungry after the lunch meal. These results suggest that drinking caloric beverages is associated with excess energy intake at a meal, and that consuming larger portions of caloric beverages will result in increased energy intake from the beverage.

Previous studies examining the effect of increasing portion size on energy intake focused on foods, and did not investigate the effect of beverage portion size on the amount of beverage consumed. The present study demonstrates that, as with foods, portion size of beverages affects beverage intake, such that when beverage portion size was increased by 50%, consumption increased by 10% in women and 26% in men. These findings are important in light of several epidemiological studies that have pointed to an increase in average portion sizes of beverages consumed by Americans of all ages and sexes. For example, Nielsen & Popkin (10), found that between 1977 and 1996, the average portion size of a sweetened beverage consumed per eating occasion increased from 386 g to 595 g (54%). Smiciklas-Wright et al. (1) found that between 1989-1991 and 1994-1996, average soft drink intake for all ages and sexes increased from 363 grams to 423 grams per eating occasion (17%), but that men in the 20-39 year age range had a significantly greater increase in the amount of soft drink consumed per eating occasion compared to women. Therefore, epidemiological evidence suggests that the portion sizes used in the
present study fall in the range of typical portions reportedly consumed by Americans. The differences in the percent increase in beverage intake for women (10%) and men (26%) following a 50% increase in portion size may be the result of men regularly consuming larger beverage portions than women. With the increases in beverage portion size over recent decades, it is important to better understand how beverage portion size influences beverage and food intake, as it may be an important contributor to energy intake and the current obesity epidemic.

The results of the present study demonstrated that subjects did not significantly compensate for the energy in the caloric beverage by reducing food intake. In addition, ratings of hunger and fullness did not differ across conditions, although subjects consumed more energy from the regular cola and a greater weight of beverage when served a larger portion. Similarly, a study by DellaValle et al. (18), with a wider range of caloric beverages (regular cola, orange juice, and 1% milk) served in compulsory 12 oz portions, found that the energy from the beverage was not compensated for by reduced food intake, and that hunger and fullness ratings did not differ after the meal. Similar results were found in several additional studies (9,19), both when beverage intake was compulsory and ad libitum, and when the beverage was served before or with the meal. Therefore, the present study supports available evidence that suggests energy from caloric beverages is poorly regulated, and may add excess calories to daily energy intake.

There were significant differences in taste ratings of the beverages served during this study; diet cola was rated significantly less pleasant in taste than regular cola by both women and men. Analysis of covariance found that as the taste rating for the diet cola increased, so did the amount of diet cola consumed. Despite the differences in beverage taste ratings, and the impact of these ratings on weight of diet cola consumed, there was no effect of beverage taste rating on total energy intake at lunch. In future studies using diet cola, it may be important to include
subjects who find diet cola equally palatable to regular cola in order to minimize any potential palatability effects on study outcomes.

Several limitations of the present study should be addressed in future studies examining the contribution of beverage energy to overall energy intake, such as extending the beverage manipulation to multiple meals, increasing the portion sizes of beverage to reflect the larger sizes available to consumers in the marketplace, and examining these effects in different populations varying in age or ethnicity. Also, further work elucidating how liquid energy is regulated is essential to better understand the contribution of beverage energy to the diet. This information could also be used to develop dietary strategies to reduce energy intake.

The results of the present study suggest several dietary strategies for individuals aiming to decrease daily energy intake and manage their weight. Consumers may decrease energy intake by choosing water, low-calorie beverages, or non-caloric beverages to accompany a meal, or by choosing smaller portions of caloric beverages.
REFERENCES


7. Kral TVE, Meengs JS, Wall DE, Roe LS, Rolls BJ. Effect on food intake of increasing the portion size of all foods over two consecutive days. FASEB J. 2003;17:A809.


CHAPTER III

STUDY 2:

SOUP PRELOADS IN A VARIETY OF FORMS

REDUCE MEAL ENERGY INTAKE
INTRODUCTION

Identifying dietary factors that influence energy intake is important for developing effective weight management strategies. The form of food, i.e. solid or liquid, has been suggested to be involved in the regulation of food intake, but the literature on this topic is mixed. Several studies suggest that liquids consumed as beverages are less satiating than solid foods (1-3), while other studies have found that liquids in the form of soup can be more satiating than solid foods (4, 5). Several studies have found that eating soup as a preload can decrease hunger, increase fullness, and reduce subsequent test meal intake (4-7). However, while it has become clear that consuming soup before a meal can reduce subsequent food intake, few studies have been designed to test whether consuming soup as a preload may help reduce total energy intake (soup + test meal) at the meal. The results from studies that have examined total meal energy intake are varied (4, 6-9). In addition, little is known about the specific properties of soup that are involved in reducing food intake and increasing satiety.

Several characteristics of soup have been suggested to be involved in enhancing satiety, including the amount consumed, temperature, fat content, energy content, and viscosity (4, 5, 9, 10). In addition, the form of soup (the way in which ingredients are blended) may influence energy intake and satiety. Soup form has been investigated in only a few previous studies, and the results from these studies are mixed, suggesting both that the form of soup influences satiety (6, 11) and that it does not (12).

The purpose of this study was to examine further the effects of consuming different forms of a low-energy-dense soup as a preload on subsequent test meal intake and total energy intake at the meal (soup preload + test meal). The soups were all prepared from identical ingredients, and included separate broth and vegetables, chunky vegetable soup, chunky-pureed
vegetable soup, and pureed vegetable soup. We hypothesized that consuming soup at the start of a meal would decrease subsequent intake and total meal energy intake, compared to when no soup was consumed. We also hypothesized that, based on previous findings, chunky soup would be the most satiating form of soup.

METHODS

Subjects

Subjects for this study were recruited from a university community by informational flyers, electronic mailing lists, and newspaper advertisements. Individuals who responded to the advertisements were interviewed by telephone to ensure that they met the following criteria: 18 to 45 years of age, not taking medications that are known to affect appetite or food intake, non-smokers, regularly consume 3 meals a day, not dieting to gain or lose weight, not athletes in training, not pregnant or breastfeeding, and free from food allergies and food restrictions (APPENDIX M). Subjects with a range of ages and body mass indices were recruited in order to extend the relevance of the findings to the general population. Only subjects who reported liking the vegetable soup ingredients, and who were willing to consume the soup, were eligible.

Potential subjects who met these initial criteria came to the laboratory and gave consent (APPENDIX N) to complete additional screening materials (APPENDIX C). Included in the screening materials were the Eating Inventory (APPENDIX D) (13), which evaluates dietary restraint, disinhibition, and perceived hunger; the Zung Questionnaire (APPENDIX E) (14), which measures depression; and the Eating Attitudes Test (EAT-26) (APPENDIX F) (15), which assesses attitudes towards food and eating. The Zung Questionnaire and the Eating Attitudes Test (EAT-26) were included in order to ensure that subjects did not exhibit symptoms of depression.
or disordered eating that might influence food intake and study outcomes. The information collected using the Eating Inventory was to be used in later analyses. Also at this time, trained laboratory personnel took height and weight measurements (model 707; Seca Corp., Hanover, MD, USA). Potential subjects who had a body mass index of 18 to 40 kg/m², scored < 40 on the Zung Questionnaire, and scored < 20 on the EAT-26 were eligible for participation in the study. Subjects were told that the purpose of the study was to examine the effects of consumption of various foods and beverages. Subjects gave signed consent (APPENDIX O) and were financially compensated for participation in the study. The study was approved by the Pennsylvania State University Office for Research Protections.

**Experimental design**

This study used a cross-over design with repeated measures. Subjects came to the laboratory once a week for five weeks, for a total of five test sessions consisting of breakfast and lunch. On each test day, a standard breakfast of bagels and yogurt was consumed *ad libitum* in order to ensure a consistent level of hunger before lunch sessions. Lunch was scheduled at least 3 hours after breakfast. At the beginning of each lunch meal, subjects were served one of four vegetable soup preloads or no preload. Subjects were required to consume the entire preload within a period of 12 minutes; when no preload was served, subjects were asked to sit and read quietly for 12 minutes. The test meal was served 15 minutes after the preload was served. At each meal, the same test meal was served and subjects could eat or drink as much or as little as they wanted. The order of experimental conditions was randomized across subjects.

The sample size to be enrolled in this study was based on previous research with a similar subject population and test meal. According to the power analysis, a sample size of 53 subjects
would allow the detection of a 45 kcal (188 kJ) difference in meal energy intake at a significance level of 0.05 and a power of 80%. This represents about 5 to 7% of typical lunch energy intakes in our laboratory, which was considered to be a clinically significant change.

**Foods and beverages**

All soup preloads contained the same ingredients (broth, vegetables, and butter) and had the same energy density (0.33 kcal/g; 1.4 kJ/g), but each was prepared using a different method. The ingredients and nutritive properties of the preloads are shown in Table 5 (Photograph 3). The broth and vegetable preload consisted of a bowl of broth alongside a plate of vegetables in butter. The chunky soup preload consisted of the broth, vegetables, and butter combined into a chunky soup. The chunky-pureed soup preload consisted of the broth, butter, and half of the vegetables blended for 10 sec using a commercial blender (Drink Machine, Model VM0101, Vita Mix Corp., Cleveland, OH, USA), with the remainder of the vegetables added after blending, making a pureed soup containing vegetable chunks. The pureed soup preload consisted of the broth, vegetables, and butter blended together for 15 sec using the same commercial blender. One and a half cups (350 ml) of soup were served to women, and two cups (475 ml) of soup were served to men. All preparation methods were standardized in order to ensure that the preloads were of the same consistency for every subject. The preloads were served in a bowl with a spoon, at a temperature of 65º C.
Table 5. Nutrient properties of soup preloads served as a first course in a study to test the effects of varying the form of soup on lunch intake

<table>
<thead>
<tr>
<th>Amount (g)</th>
<th>Energy (kcal (kJ))</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
<th>Energy Density (kcal/g (kJ/g))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken Broth(^1)</td>
<td>220</td>
<td>9 (36)</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Broccoli(^2)</td>
<td>58</td>
<td>21 (88)</td>
<td>0.7</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>Potato(^3)</td>
<td>58</td>
<td>50 (209)</td>
<td>1</td>
<td>0</td>
<td>11.6</td>
</tr>
<tr>
<td>Cauliflower(^4)</td>
<td>35</td>
<td>8 (33)</td>
<td>0.8</td>
<td>0</td>
<td>1.2</td>
</tr>
<tr>
<td>Carrots(^5)</td>
<td>20</td>
<td>8 (33)</td>
<td>0.2</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>Butter(^6)</td>
<td>4.7</td>
<td>33 (138)</td>
<td>0</td>
<td>3.7</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total preload</strong></td>
<td><strong>396</strong></td>
<td><strong>129 (540)</strong></td>
<td><strong>3.7</strong></td>
<td><strong>4.2</strong></td>
<td><strong>18.1</strong></td>
</tr>
</tbody>
</table>

| **Men**              |                     |             |         |                  |                                |
| Chicken Broth        | 293                | 12 (50)     | 1.3     | 0.7              | 1.3                           |
| Broccoli             | 77                 | 27 (113)    | 0.9     | 0                | 3.6                           |
| Potato               | 77                 | 67 (280)    | 1.3     | 0                | 15.4                          |
| Cauliflower          | 47                 | 11 (46)     | 1.1     | 0                | 1.6                           |
| Carrots              | 27                 | 11 (46)     | 0.3     | 0                | 2.1                           |
| Butter               | 6                  | 44 (184)    | 0       | 4.9              | 0                             |
| **Total preload**    | **527**            | **172 (720)** | **4.9** | **5.6**          | **24.0**                      | **0.33 (1.4)**                |

\(^1\)Swanson’s Chicken Broth, 33% Less Sodium, Campbell’s Soup Co., Camden, NJ, USA
\(^2\)Baby Broccoli Florets, Birds Eye Foods, Inc., Rochester, NY, USA
\(^3\)White potatoes, Sterman Masser Inc. for Foodhold U.S.A., LLC, Landover, MD, USA
\(^4\)Cauliflower Florets, Hanover Foods Corporation, Hanover, PA, USA
\(^5\)Crinkle Cut Carrots, Foodhold U.S.A., LLC, Landover, MD, USA
\(^6\)Salted Sweet Cream Butter, Land O’Lakes, Inc., Ander Hills, MN, USA

Photograph 3. Soup preloads.
Viscosity of the liquid component of the soups was measured using an ARES-RFS rheometer (TA Instruments, New Castle, DE, USA). All viscosity measurements were taken at a temperature of 37°C and a rate of 10 s⁻¹. The viscosity of the broth used in the broth and vegetables, as well as in the chunky soup was 0.7 cps, the viscosity of the chunky-pureed soup was 55 cps, and the viscosity of the pureed soup was 235 cps. The size of the vegetable chunks in the chunky and chunky-pureed soup condition was approximately 0.5 inch².

The test meal (Photograph 4) consisted of cheese tortellini (460 g for females, 612 g for males; Ralzoni and Bros., Dover, NJ, USA) and tomato sauce (210 g for females, 280 g for males; Campbell Soup Co., Camden, NJ, USA). The test meal was accompanied by parmesan cheese (15 g; Kraft Foods, Inc., Glenview, IL, USA) and a liter of water. The test meal contained 64% of energy from carbohydrate, 16% energy from fat, and 20% of energy from protein, and had an energy density of 2.6 kcal/g (10.9 kJ/g). All foods and beverages served in the study were commercially available. Portions for males and females were based on lunch intake data from previous studies in our laboratory, and provided more energy than most subjects were likely to consume. Pre-determined exclusion criteria were used to identify subjects who ate extreme amounts of the lunch entrée. Subjects who consumed the entire entrée on more than one occasion were excluded from the study.

All foods and beverages were weighed prior to being served to subjects, and were re-weighed after the subjects had finished eating to determine the amount of food and beverage consumed by each subject to the nearest 0.1 g. Energy intakes at each meal were calculated using nutrition information provided by the food manufacturers.
Procedures

On test days, subjects were instructed to consume only foods and beverages provided by the laboratory from the time they woke up in the morning until after the lunch session. Subjects were permitted to consume water between meals until one hour before each test session. Subjects were instructed not to drink alcohol in the 24 hours prior to coming to the laboratory, and not to consume dinner in a restaurant the evening before the test session. Subjects were also told to keep the amount of food eaten and physical activity performed the day before coming to the laboratory as consistent as possible across sessions. They completed a food and activity diary the day before each test session to encourage compliance with this protocol (APPENDIX H).

On test days, subjects came to the laboratory at their assigned meal times and were seated in individual cubicles. Before each meal, subjects completed a report to evaluate their compliance with the study protocol and to ensure that they were feeling well (APPENDIX I). At the lunch meal, after the report was completed, the preload was served and subjects were instructed to consume the entire preload within 12 minutes. When subjects received no preload, they were given a magazine and asked to sit quietly and read for 12 minutes. Subjects indicated
when they had finished the soup preload, and the empty bowl was removed from the cubicle. If subjects finished their soup in less than 12 minutes, the time taken to consume the soup was recorded and they were asked to sit quietly for the remainder of the 12 minutes. Following the 12 minute preload period, subjects were given 3 minutes to rate hunger and satiety. Then, after a total of 15 minutes, the test meal was served. Subjects were instructed to eat and drink as much or as little of the foods and beverages as they wanted. The amount of time taken to consume the test meal was recorded for each subject.

**Ratings of hunger, satiety, and food characteristics**

During each test session, subjects completed a series of 100-mm visual analog scales (16) to assess hunger, thirst, fullness, prospective consumption, and nausea (APPENDIX J). For example, subjects answered the question “How full do you feel right now?” by marking the 100-mm line anchored by “Not at all full” on one side, and “Extremely full” on the other. Subjects completed these ratings before and after breakfast, before and after the preload time period, and after lunch.

Subjects were also given 100-mm visual analog scales to rate the characteristics of the soup preload and the lunch test meal (APPENDIX P). Subjects were instructed to first rate the appearance of the preload or test meal, and then take a bite of the preload or test meal and rate the pleasantness of the taste. Subjects also rated perceived calorie content, how filling they thought the preload would be, pleasantness of texture, and thickness of the soup preloads, as well as prospective consumption, perceived calorie content, and portion size of the test meal. For example, subjects recorded their answer to the question “How pleasant is the taste of this food right now?” by marking a 100-mm line anchored on one side by “Not at all pleasant” and
anchored on the other side by “Extremely pleasant.” In the condition where vegetables and broth were served separately, subjects were asked to rate each component separately.

**Statistical analysis**

A mixed linear model with repeated measures was used to analyze the main outcomes of energy intake, food intake (g), ratings of hunger and satiety, and ratings of preload and test meal characteristics (SAS System for Windows, version 9.1; SAS Institute, Cary, NC, USA). The fixed factor effects in the model were preload type and subject sex; awareness of the purposes of the study was also tested as a factor in the model. Analysis of covariance was performed to determine whether subject characteristics affected the relationship between the experimental variables and the main outcomes. Results were considered significant at p<0.05.

**RESULTS**

**Subjects**

Seventy-three subjects were enrolled in the study; 35 women and 38 men. Based on the previously defined criteria, one woman and five men were excluded for consuming the entire test meal on more than one occasion. In addition, four women and three men were excluded because of non-compliance with study protocol or inability to attend scheduled meals. Thus, a total of 60 subjects completed the study: 30 women and 30 men. The characteristics of these subjects are shown in Table 6.
Food and Energy Intake

Mean entrée intake differed significantly by experimental condition (Table 7); subjects ate significantly less energy from the test meal when a soup preload was consumed, compared to when no soup was consumed (p<0.0001). The different types of soup had no significant effect on intake of the test meal. There was no interaction between condition and sex, indicating that women and men responded similarly to the conditions. However, men had a significantly higher energy intake from the test meal than women (p<0.001) (Table 7).

Table 6. Characteristics of subjects (n=60) participating in a study to test the effects of varying the form of soup on lunch intake (mean ± standard error; range)

<table>
<thead>
<tr>
<th></th>
<th>Females (n =30)</th>
<th>Males (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>26.9 ± 0.6 (20 - 46)</td>
<td>25.4 ± 0.4 (20 - 39)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>67.4 ± 0.9 (48.5 – 94.8)</td>
<td>75.3 ± 0.8* (61.2 – 97.5)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.9 ± 0.2 (158 - 180)</td>
<td>177.5 ± 0.2* (163 - 189)</td>
</tr>
<tr>
<td>Body mass index (kg/m^2)</td>
<td>24.1 ± 0.3 (19.3 - 34.6)</td>
<td>23.9 ± 0.3 (18.8 - 33.4)</td>
</tr>
<tr>
<td>Dietary restraint score</td>
<td>8.2 ± 0.4 (1 - 16)</td>
<td>6.4 ± 0.4* (0 - 19)</td>
</tr>
<tr>
<td>Disinhibition score</td>
<td>5.8 ± 0.3 (1 - 13)</td>
<td>3.7 ± 0.1* (1 - 8)</td>
</tr>
<tr>
<td>Perceived hunger score</td>
<td>4.7 ± 0.2 (0 - 11)</td>
<td>3.9 ± 0.2* (0 - 8)</td>
</tr>
<tr>
<td>Eating attitudes score</td>
<td>4.4 ± 0.3 (0 - 19)</td>
<td>3.6 ± 0.3 (0 - 19)</td>
</tr>
<tr>
<td>Depression score</td>
<td>28.8 ± 0.4 (22 - 37)</td>
<td>28.9 ± 0.3 (22 - 38)</td>
</tr>
</tbody>
</table>

1 Eating Inventory (Stunkard & Messick, 1985)
2 Eating Attitudes Test (Garner et al., 1982)
3 Self-Rating Depression Scale (Zung, 1986)

* Based on the results of a T-test, means differ significantly between sexes (p<0.01)
### Table 7. Intakes of women and men participating in a study to test the effects of varying the form of soup on lunch intake (mean ± standard error).

<table>
<thead>
<tr>
<th>Preload condition</th>
<th>Broth and vegetables</th>
<th>Chunky soup</th>
<th>Chunky-pureed soup</th>
<th>Pureed soup</th>
<th>No soup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women (n=30)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Entrée intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kcal</td>
<td>557 ± 45</td>
<td>555 ± 46</td>
<td>580 ± 49</td>
<td>545 ± 50</td>
<td>786 ± 47</td>
</tr>
<tr>
<td>(kJ)</td>
<td>(2332 ± 188)</td>
<td>(2323 ± 193)</td>
<td>(2424 ± 205)</td>
<td>(2278 ± 209)</td>
<td>(3285 ± 197)</td>
</tr>
<tr>
<td>g</td>
<td>251 ± 21</td>
<td>250 ± 211</td>
<td>261 ± 22</td>
<td>246 ± 23</td>
<td>356 ± 21</td>
</tr>
<tr>
<td><strong>Total lunch intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kcal</td>
<td>686 ± 45</td>
<td>684 ± 46</td>
<td>709 ± 49</td>
<td>674 ± 50</td>
<td>786 ± 47</td>
</tr>
<tr>
<td>(kJ)</td>
<td>(2867 ± 188)</td>
<td>(2859 ± 193)</td>
<td>(2964 ± 205)</td>
<td>(2817 ± 209)</td>
<td>(3285 ± 197)</td>
</tr>
<tr>
<td>g</td>
<td>647 ± 21</td>
<td>646 ± 21</td>
<td>657 ± 22</td>
<td>642 ± 23</td>
<td>356 ± 21</td>
</tr>
<tr>
<td><strong>Men (n=30)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Entrée intake</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>kcal</td>
<td>853 ± 76</td>
<td>760 ± 68</td>
<td>804 ± 69</td>
<td>762 ± 66</td>
<td>1086 ± 76</td>
</tr>
<tr>
<td>(kJ)</td>
<td>(3571 ± 318)</td>
<td>(3182 ± 285)</td>
<td>(3257 ± 289)</td>
<td>(3190 ± 276)</td>
<td>(4547 ± 318)</td>
</tr>
<tr>
<td>g</td>
<td>338 ± 30</td>
<td>345 ± 31</td>
<td>341 ± 29</td>
<td>484 ± 34</td>
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</tr>
<tr>
<td></td>
<td>380 ± 34</td>
<td>907 ± 34</td>
<td>865 ± 34</td>
<td>932 ± 68</td>
<td>907 ± 34</td>
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<td><strong>Total lunch intake</strong></td>
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<tr>
<td><strong>kcal</strong></td>
<td>1025 ± 76</td>
<td>932 ± 68</td>
<td>950 ± 69</td>
<td>934 ± 66</td>
<td>1025 ± 76</td>
</tr>
<tr>
<td><strong>g</strong></td>
<td>907 ± 34</td>
<td>865 ± 30</td>
<td>872 ± 31</td>
<td>868 ± 30</td>
<td>907 ± 34</td>
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<tr>
<td><strong>All Subjects (n=60)</strong></td>
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<td></td>
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<tr>
<td><strong>Entrée intake</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>kcal</strong></td>
<td>704 ± 48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>658 ± 43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>677 ± 44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>654 ± 44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>704 ± 48&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>(kJ)</em></td>
<td>(2948 ± 201)</td>
<td>(2755 ± 180)</td>
<td>(2834 ± 184)</td>
<td>(2738 ± 184)</td>
<td>(2948 ± 201)</td>
</tr>
<tr>
<td><strong>g</strong></td>
<td>312 ± 22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>290 ± 19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>299 ± 20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>290 ± 20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>312 ± 22&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td><strong>Total lunch intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>kcal</strong></td>
<td>855 ± 49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>808 ± 44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>827 ± 45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>804 ± 45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>855 ± 49&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>(kJ)</em></td>
<td>(3580 ± 205)</td>
<td>(3383 ± 184)</td>
<td>(3462 ± 188)</td>
<td>(3366 ± 188)</td>
<td>(3580 ± 205)</td>
</tr>
<tr>
<td><strong>g</strong></td>
<td>774 ± 26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>752 ± 24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>759 ± 24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>751 ± 24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>774 ± 26&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> Based on the results of a mixed linear analysis, means for a given outcome that have different letters are significantly different (p<0.0001).
There was a similar pattern of results for total energy intake at lunch (soup and test meal intake combined). Lunch energy intake was significantly decreased when any type of soup was eaten as a preload (p<0.0001) (Table 7), compared to when no soup was eaten. Total energy intake at lunch did not vary significantly according to the type of soup eaten (Figure 5). Subjects reduced total energy intake at lunch by 20% (134 ± 25 kcal; 561 ± 105 kJ) when a soup preload was eaten compared to when no soup was eaten (p<0.0001). In addition, subjects consumed a significantly greater total weight of food at the meal when soup was consumed compared to when the test meal was consumed without soup (p<0.0001). Therefore, mean total meal energy density was lower when a soup preload was consumed (1.0 kcal/g, 4.2 kJ/g), compared to when no soup was consumed (2.2 kcal/g, 9.2 kJ/g). There were no significant differences in water intake at lunch across experimental conditions (data not shown).

![Figure 5](image-url)

**Figure 5.** Mean (± SEM) energy intake at lunch (soup and entrée intake) for women and men combined (n=60). Subjects consumed significantly less total energy at lunch when soup was eaten as a first course, compared to when no soup was eaten *(p<0.0001).*
Breakfast intake did not vary by condition. Women ate a mean of 550 ± 15 kcal (2303 ± 63 kJ) and men ate a mean of 694 ± 14 kcal (2906 ± 59 kJ) at breakfast. There were also no differences in the time taken to eat the soup preloads or test meal by soup type. However, men took a significantly longer time to consume their larger portion of soup (p<0.05). Women ate the soup in a mean time of 6.9 ± 0.1 min, and men ate the soup in a mean time of 7.8 ± 0.2 min.

Analysis of covariance showed that the relationship between type of preload and energy intake at lunch was not significantly influenced by any of the measured subject characteristics (age, sex, height, weight, body mass index, restraint, disinhibition, or depression).

**Ratings of hunger and satiety**

Before the preloads were consumed, there were no significant differences in ratings of hunger (Figure 6), fullness, thirst, prospective consumption, or nausea.

Ratings of hunger (Figure 6) immediately before the lunch test meal was served (36 ± 1) were significantly lower when soup had been eaten as a preload, compared to when subjects did not consume soup (65 ± 2, p<0.001). Fullness ratings were significantly higher immediately before the lunch test meal was served when a soup preload was eaten (56 ± 1) compared to the no soup condition (26 ± 3; p=0.04). Ratings of prospective consumption were significantly lower before the test meal was served when participants ate soup as a preload (40 ± 1) compared to when no soup was consumed (63 ± 2; p<0.04). There were no significant differences in ratings of hunger, thirst, fullness, and prospective consumption across the different types of soup at any time point.
After lunch, ratings of hunger, thirst, fullness, and prospective consumption were not significantly different across experimental conditions, although subjects consumed less energy and a greater weight of food when a preload of soup was eaten (Table 7; Figure 6).

**Figure 6.** Mean (± SEM) hunger ratings across the lunch meal for women and men combined (n=60). There were no differences in subjects’ hunger ratings “before soup” across experimental conditions. Subjects’ ratings of hunger “after soup” were significantly lower when soup had been consumed as a first course, compared to when no soup was eaten *(p<0.001)*. There were no differences in hunger ratings “after lunch” across experimental conditions.

**Ratings of soup and entrée characteristics**

All of the preloads were rated as acceptable although there were small but significant differences in ratings of soup characteristics according to the type of the preload (Table 8). Taste ratings were significantly higher for the chunky and chunky-pureed soup compared to the broth and vegetables (p<0.004), but varied by only 1 mm. Appearance ratings for the chunky, chunky-pureed, and pureed soup were significantly higher than broth and vegetables, and those for the chunky and chunky-pureed soup were significantly higher than the pureed soup (p<0.001). The ratings of calorie content for chunky-pureed and pureed soups were significantly higher than
those for broth and vegetables and chunky soup (p<0.01). In addition, ratings of thickness varied significantly across soup types; broth and vegetables were rated least thick compared to all other soups, chunky soup was rated less thick than chunky-pureed and pureed soup, and chunky-pureed soup was rated lower in thickness than pureed soup (p<0.0001). These ratings of thickness corresponded with the differences in measured viscosity for the soups. Subjects also rated the broth and vegetables as less filling than the other soups, and the chunky soup as less filling than the chunky-pureed, and pureed soup (p<0.004). Analysis of covariance showed that the relationship between type of preload and energy intake at lunch was not influenced by any of the soup characteristic ratings.

| Table 8. Ratings of soup characteristics (mm) for subjects in a study to test the effects of varying the form of soup on lunch intake (mean ± standard error) |
|---------------------------------------------------------|----------------|----------------|----------------|----------------|
|                                                        | Broth and vegetables | Chunky soup      | Chunky-pureed soup | Pureed soup   |
| How pleasant is the appearance of this food right now?   | 23.5 ± 2.5<sup>a</sup> | 53.2 ± 3.0<sup>b,c</sup> | 53.6 ± 3.0<sup>b,c</sup> | 34.8 ± 2.8<sup>b</sup> |
| How pleasant is the taste of this food right now?        | 52.7 ± 3.1<sup>a</sup> | 61.2 ± 2.8<sup>b</sup> | 61.2 ± 2.7<sup>b</sup> | 52.0 ± 3.0<sup>a</sup> |
| How many calories do you think this food has?            | 25.9 ± 2.5<sup>a</sup> | 27.6 ± 1.8<sup>a</sup> | 39.0 ± 2.2<sup>b</sup> | 36.7 ± 2.6<sup>b</sup> |
| How filling do you think this food will be?              | 26.9 ± 3.0<sup>a</sup> | 44.1 ± 2.8<sup>b</sup> | 57.7 ± 2.5<sup>b,c</sup> | 55.5 ± 2.8<sup>b,c</sup> |
| How thick do you think this food is?                     | 7.9 ± 1.6<sup>a</sup> | 31.5 ± 2.7<sup>b</sup> | 56.6 ± 2.2<sup>b,c</sup> | 62.9 ± 2.8<sup>b,c,d</sup> |

<sup>a,b,c,d</sup> Based on the results of a mixed linear analysis, means for a given characteristic that have different letters are significantly different.
Discharge questionnaire

On the discharge questionnaire (APPENDIX Q), 38 subjects (63%) correctly reported that the purpose of the study was to examine the effects of soup on food intake. In addition, 53 subjects (88%) noticed that the type of soup served changed between sessions. However, the mixed linear analysis showed that the primary study outcomes, test meal and total lunch intake, were not significantly influenced by whether subjects correctly or incorrectly ascertained any purposes of the study.

DISCUSSION

Consuming a low-energy-dense soup as a preload led to a significant reduction in test meal intake compared to consuming no soup as a preload. However, the type of soup consumed did not significantly affect test meal intake. Overall, when soup was eaten as a preload, subjects reduced total energy intake at lunch by 20%. This reduction in energy intake was not associated with increased ratings of hunger or decreased fullness at the end of the meal. These results show that consuming low-energy-dense soup in a variety of forms at the start of a meal can reduce subsequent food intake, leading to significant reductions in total energy intake at the meal.

Several studies have established that soup is more satiating than some other types of food. For example, when women and men consumed a preload of soup, subsequent test meal intake was reduced compared to when solid foods, such as cheese and crackers or cantaloupe, were eaten as a preload (4, 5, 7). However, even if consuming a soup preload reduces subsequent test meal intake, it is possible that total energy consumed at the meal (soup and test meal energy combined) may be greater when a soup preload is eaten compared to when no soup is consumed. Few studies have employed a study design that includes a no preload control condition in order
to test the effects of consuming soup on total meal energy intake. Of those studies that have, some reported no differences in total meal energy intake with and without a soup preload (4, 8), while others, including the present study, reported a decrease in total meal energy intake when a soup preload was consumed compared to when no soup was consumed (6, 7). These conflicting findings may be the result of variations in preload characteristics, such as volume, energy content, or energy-density, or differences in subject characteristics. In addition, variations in the test meal used to measure subsequent food intake may have affected outcomes; a single-food test meal may be more sensitive to changes in satiety than a mixed-food test meal (17).

In the present study, the effects of soup form were isolated, and results showed that varying the form of soup by changing the way in which identical ingredients were blended did not significantly affect food intake or satiety. In a similar study, Himaya & Louis-Sylvestre (6) measured satiety in lean and overweight men (n=22) following intake of 300 g (95 kcal; 397 kJ) preloads prepared from identical ingredients: vegetables with a glass of water, chunky vegetable soup, and pureed vegetable soup. In lean men, there were no significant differences between the preloads, while in overweight men, chunky soup significantly reduced lunch intake compared to vegetables with a glass of water. Based on these results, the authors suggested that chunky soup may be the most satiating form of soup. However, it is not clear that simply drinking water along with a food is an appropriate control condition for variations in volume and energy density between preloads. Previous work indicates that water consumed as a beverage has different effects on satiety than water incorporated into a food (7, 11). For example, drinking a glass of water alongside a casserole was not as satiating as the same ingredients combined into soup (7). This difference in satiety may have occurred because water consumed from a glass was perceived as a beverage intended to satisfy thirst, not hunger. In the present study, instead of
separating only the water from the vegetables in the soup, subjects consumed a bowl of broth alongside the vegetables. The separate broth and vegetables had similar effects on satiety as identical ingredients combined into soup. Therefore, differences in ingestion method may explain why the present findings differ from those found in overweight men by Himaya & Louis-Sylvestre; the glass of water may have been perceived as a thirst-quenching beverage, while the bowl of broth may have been perceived as a food that satisfies hunger. These perceptions may have had different effects on food intake and satiety. Further research is needed to determine whether ingestion method and perceptions of a liquid as either a food or a beverage influence food intake and satiety.

There are a number of physiological mechanisms that may be involved in the satiating effects of soup. While liquids empty from the stomach at a faster rate than do solids, viscous solutions with particles of varying size may differentially influence gastric distension and gastric emptying rate (18, 19). Increased gastric distension and decreased rate of gastric emptying have been shown to be associated with enhanced sensations of satiety (20). Some studies have shown that consuming pureed tomato soup before a meal can increase gastric distension and decrease the rate of gastric emptying, resulting in increased satiety compared to consuming nothing prior to the meal (21, 22). These data suggest that the increased satiety and reduced intake that occurred when the soup preloads were consumed in the present study may have been due to enhanced gastric distension and a decreased rate of gastric emptying.

The effect of the form of soup on physiological responses has also been investigated. One study tested the effects of chunky and pureed soups, prepared from identical ingredients (591 g; 499 kcal, 2090 kJ), in men (N=12), and found that while there were no differences in satiety, the pureed soup increased insulin response and energy expenditure compared to the chunky soup
In another set of studies, a pureed vegetable soup (660 g; 615 kcal, 2573 kJ) was found to be more satiating than the same ingredients served as vegetables with a glass of water (360 g + 300ml water; 615 kcal, 2573 kJ) (11, 23). The pureed vegetable soup decreased gastric emptying time, increased insulin response, and increased diet-induced thermogenesis compared to the vegetables with a glass of water. Therefore, consuming soup can have gastrointestinal, endocrine, and metabolic consequences that may influence food intake and satiety, and the form of soup may influence these responses. Future work should focus on determining how these various mechanisms combine to reduce food intake and increase satiety.

Increased viscosity has been shown to be associated with increased sensations of satiety and reduced food intake (24, 27). However, the relationship between viscosity and satiety has been studied primarily using beverages, and few data exist to suggest that varying the viscosity of soup can influence satiety and food intake. The liquid components of the soups used in the present study differed in viscosity, and participants noticed these differences; thickness ratings for the pureed soup were highest, followed by the chunky-pureed soup, chunky soup, and broth and vegetables. Subjects also perceived the thicker soups to be higher in calories and more filling than the less viscous soups. However, neither the variations in viscosity, nor the differences in ratings of thickness, calorie content, or how filling the soups would be, led to systematic differences in subsequent food intake. In particular, the most viscous soup (the pureed soup) did not decrease subsequent intake compared to the less viscous soups. Therefore, our hypothesis that increased viscosity would enhance satiety and decrease total meal intake was not supported. Because the presence of solid vegetable chunks varied along with the viscosity, this study did not isolate soup viscosity as an experimental variable. Interpretation of these findings is also limited due to the likelihood that the effects of increasing viscosity on satiety depend on a number of
post-ingestive factors, in addition to the oro-sensory characteristics. Future studies should systematically test how variations in both oro-sensory viscosity and post-ingestive viscosity influence food intake and satiety.

The results from the present study offer additional support for recommending the inclusion of low-energy-dense soup in the diet as a strategy for controlling energy intake for weight management. In this study, subjects ate significantly less total energy and consumed a significantly greater total weight of food at lunch when soup was consumed at the start of a meal. Several studies that have tested the effects of consuming soup on a regular basis for several months found that routinely eating soup can reduce energy intake, enhance satiety, and promote weight loss (28-30). In one dietary intervention, meals that contained soup had fewer total calories than meals without soup, and total daily energy intake was lower when soup had been consumed (29). Taken together, these data suggest that consuming low-energy-dense soup is a strategy that can be used to decrease energy intake and enhance weight loss, while allowing individuals to consume satisfying amounts of food.

The findings from this study confirm previous reports that consuming soup as a preload can significantly reduce subsequent entrée intake, as well as total energy intake at the meal. The present study expanded upon prior investigations to show that varying the form and viscosity of soup, by changing the way in which identical ingredients were blended, did not significantly affect energy intake or satiety. Therefore, consuming a preload of low-energy-dense soup, in a variety of forms, is one strategy that can be used to moderate energy intake in adults.
REFERENCES

CHAPTER IV

STUDY 3:
WHOLE FRUIT INCREASES SATIETY
MORE THAN FRUIT JUICE
INTRODUCTION

Identifying properties of food that influence energy intake and satiety is important for developing effective weight management strategies. The form of food (solid, puree, or liquid) is one property that has been suggested to affect energy intake. While the literature on this topic is inconclusive (1-5), a number of studies have suggested that liquids consumed as beverages are less satiating than solid foods (3-5). Fruit is particularly useful for investigating the effects of food form on satiety, because it is frequently consumed as part of a meal, and is readily available in different forms (solid, puree, and juice).

A few studies have tested whether consuming fruit is more satiating than consuming fruit juice (3, 5, 6). All of these studies found that fruit reduced hunger ratings more than fruit juice. Based on these findings, consuming fruit rather than fruit juice is often recommended as a strategy for managing energy intake. However, in these studies, satiety was assessed with rating scales (3, 5); only one study measured subsequent food intake and that study used self-reported food diaries (6). Therefore, it is unclear whether the differences in satiety ratings would translate into reduced energy intake at a subsequent meal. In addition, these previous studies matched the preloads on only some of the parameters that could affect satiety, such as weight (3, 5) or energy (6). Differences in other characteristics, such as fiber content and energy density, could also influence satiety. Therefore, the results of these previous studies are difficult to interpret, as it is not clear which food characteristics affected satiety. For example, the amount of fiber in the fruit and fruit juice served in earlier studies differed (3, 5, 6), and it is not known whether the differences in satiety were related to the form of food or the variations in fiber content.

The purpose of this study was to examine the effects of consuming different forms of fruit as a preload on subsequent test meal intake and total energy intake at the meal (preload +
test meal). The preloads were matched for energy content, weight, and energy density, and included apple (peeled segments), applesauce, apple juice, and apple juice with added fiber. Three of the preloads contained similar amounts of fiber: apple, applesauce, and apple juice with fiber. We hypothesized that the form of fruit would affect satiety and subsequent energy intake, such that apple would have the highest satiating capacity, applesauce would be less satiating than apple, but more satiating than the juice preloads, and the juice preloads would have lowest satiating capacity. We also hypothesized that juice supplemented with naturally-occurring levels of fiber would be more satiating than fiber-free juice.

METHODS

Subjects

Subjects for this study were recruited from a university community by informational flyers, electronic mailing lists, and newspaper advertisements. Individuals who responded to the advertisements were interviewed by telephone to ensure that they met the following criteria: 18 to 45 years of age, not taking medications that are known to affect appetite or food intake, non-smokers, regularly consume 3 meals a day, not dieting to gain or lose weight, not athletes in training, and free from food allergies and food restrictions (APPENDIX R). Only subjects who reported liking apples, applesauce, and apple juice, and who were willing to consume these foods and drinks, were eligible.

Potential subjects who met these initial criteria came to the laboratory, and gave consent (APPENDIX S) to complete additional screening materials (APPENDIX C). Included in these materials were the Eating Inventory (APPENDIX D) (7), which evaluates dietary restraint, disinhibition, and perceived hunger; the Zung Questionnaire (APPENDIX E) (8), which
measures depression; and the Eating Attitudes Test (EAT-26) (APPENDIX F) (9), which assesses attitudes towards food and eating. The Zung Questionnaire and the Eating Attitudes Test (EAT-26) were included as screening tools to ensure that subjects did not exhibit symptoms of depression or disordered eating that might influence food intake and study outcomes. Also at this time, trained laboratory personnel took height and weight measurements (model 707; Seca Corp., Hanover, MD, USA). Potential subjects who had a body mass index of 18 to 40 kg/m$^2$, scored $< 42$ on the Zung Questionnaire, and scored $< 20$ on the EAT-26 were eligible for participation in the study. Subjects were told that the purpose of the study was to examine the effects of consumption of various foods and beverages. Subjects gave signed consent (APPENDIX T) and were financially compensated for participation in the study. The study was approved by the Pennsylvania State University Office for Research Protections.

**Experimental design**

This study used a cross-over design with repeated measures. Subjects came to the laboratory once a week for five weeks, for a total of five test sessions consisting of breakfast and lunch. On each test day, a standard breakfast of bagels and yogurt was consumed *ad libitum* in order to ensure a consistent level of hunger before lunch sessions. Lunch was scheduled at least 3 hours after breakfast. At the beginning of each lunch meal, subjects were served one of four preloads or no preload. The condition in which no preload was served was considered to be subjects’ control intake. Preload ingestion rate was controlled by requiring subjects to pace consumption of the preload over the course of 10 minutes; when no preload was served, subjects were asked to sit and read quietly for 10 minutes. The test meal was served 15 minutes after the preload was served. At each session, the same test meal was served and subjects could eat or
drink as much or as little as they wanted. The order of experimental conditions was randomized across subjects.

The sample size to be enrolled in this study was based on previous research with a similar subject population and test meal. According to a power analysis, a sample size of 51 subjects would allow the detection of a 50 kcal difference in meal energy intake at a significance level of 0.05 and a power of 80%. This represents about 5 to 7% of typical lunch energy intakes in our laboratory, which was considered to be a clinically significant change.

Foods and beverages

All preloads were derived from apples and were matched for energy content (152 kcal) and weight (266 g), but each differed in form (Photograph 5). The properties of the preloads are shown in Table 9. The apple preload consisted of a plate of apples with the skin removed and cut into approximately 12 wedges. The applesauce preload was prepared from the same batch of apples used in the apple condition, and was eaten from a bowl with a spoon. In order to make the applesauce, apples were peeled and baked in a covered dish for 45 minutes at 177°C. Water was then added to the apples to account for any water loss that occurred during baking, and the apples were mashed to produce applesauce. All apples used in the apple and applesauce conditions were from the same farm, and were picked during the fall of 2006 (Ida Red apples; Way Fruit Farm, Port Matilda, PA); the same amount of apple was used to make both the apple and applesauce preloads.

The apple juice was commercially available and contained no measurable fiber (Mott’s Natural Apple Juice, Rye Brook, NY). The apple juice with fiber preload consisted of apple juice combined with a low-viscosity, apple-derived pectin supplement (100% apple pectin, Herbstreith
& Fox, Elmsford, NY). Both juice preloads were served in a clear plastic glass. The soluble fiber found in the pectin supplement differs from the insoluble fiber found in apple skin. Since different types of fiber could affect satiety differently, the apple and applesauce preloads were prepared and served without the skin. Therefore, both the amount and type of fiber (pectin) were similar in the apple, applesauce, and apple juice with fiber preloads. Viscosity of the apple juice and apple juice with fiber was measured using an ARES-RFS rheometer (TA Instruments, New Castle, DE, USA). All viscosity measurements were taken at a temperature of 37°C and a rate of 10 s⁻¹. There was a small, but detectable difference in the viscosity of the two juices; the apple juice had a viscosity of 1.5 x 10⁻³ Pa-s, and the apple juice with fiber had a viscosity of 8.5 x 10⁻³ Pa-S.

### Table 9. Properties of preloads in a study to test the effects of varying the form of apple on lunch intake

<table>
<thead>
<tr>
<th></th>
<th>Amount (g)</th>
<th>Energy (kcal)</th>
<th>Fiber (g)</th>
<th>Energy Density (kcal/g)</th>
<th>Volume (ml [fl oz])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appleᵃ</td>
<td>266</td>
<td>152</td>
<td>4.8</td>
<td>0.57</td>
<td>325 (11)</td>
</tr>
<tr>
<td>Applesauceᵇ</td>
<td>266</td>
<td>152</td>
<td>4.8</td>
<td>0.57</td>
<td>266 (9)</td>
</tr>
<tr>
<td>Apple juiceᶜ</td>
<td>266</td>
<td>146</td>
<td>0</td>
<td>0.55</td>
<td>266 (9)</td>
</tr>
<tr>
<td>Apple juice with fiberᵈ</td>
<td>266</td>
<td>152</td>
<td>4.8</td>
<td>0.57</td>
<td>266 (9)</td>
</tr>
</tbody>
</table>

ᵃ Ida Red apples, Way Fruit Farm, Port Matilda, PA
ᵇ Prepared from Ida Red apples, Way Fruit Farm, Port Matilda, PA
ᶜ Natural Apple Juice, Mott’s, Rye Brook, NY
ᵈ Natural Apple Juice, Mott’s, Rye Brook, NY with 100% apple pectin, Herbstreith & Fox, Elmsford, NY
The test meal consisted of cheese tortellini (612 g; Ralzoni and Bros., Dover, NJ, USA) and tomato sauce (280 g; Traditional Prego, Campbell Soup Co., Camden, NJ, USA), and was accompanied by a liter of water. The test meal contained 64% of energy from carbohydrate, 16% energy from fat, and 20% of energy from protein, and had an energy density of 2.6 kcal/g. All foods and beverages served in the study were commercially available. Portions were based on lunch intake data from previous studies in our laboratory, and provided more energy than most subjects were likely to consume.

**Photograph 5.** The preloads.

**Photograph 6.** The test meal.
All foods and beverages were weighed prior to being served to subjects, and were re-weighed after the subjects had finished eating to determine the amount of food and beverage consumed by each subject to the nearest 0.1 g. Energy intakes at each meal were calculated using nutrition information provided by the food manufacturers.

**Procedures**

On test days, subjects were instructed to consume only foods and beverages provided by the laboratory from the time they woke up in the morning until after the lunch session. Subjects were permitted to consume water between meals until one hour before each test session. Subjects were instructed not to drink alcohol in the 24 hours prior to coming to the laboratory, and not to consume dinner in a restaurant the evening before the test session. Subjects were also told to keep the amount of food eaten and physical activity performed the day before coming to the laboratory as consistent as possible across sessions. They completed a food and activity diary the day before each test session to encourage compliance with this protocol (APPENDIX H).

On test days, subjects came to the laboratory at their assigned meal times and were seated in individual cubicles. Before each meal, they completed a report to evaluate their compliance with the study protocol and to ensure that they were feeling well (APPENDIX I). At the lunch meal, after the report was completed, the preload was served and subjects were instructed to take 10 minutes to consume the food or beverage, using a timer to pace themselves. When subjects received no preload, they were given a magazine and asked to sit quietly and read for 10 minutes. Following the 10-minute preload period, they were given 5 minutes to rate their hunger and satiety and characteristics of the preload. Then, after a total of 15 minutes, the test meal was served. Subjects were instructed to eat and drink as much or as little of the foods and beverages
as they wanted. The amount of time taken to consume the test meal was recorded for each subject.

**Ratings of hunger, satiety, and food characteristics**

During each test session, subjects completed a series of 100-mm visual analog scales (10) to assess hunger, thirst, fullness (satiety), prospective consumption, and nausea (APPENDIX J). For example, they answered the question “How full do you feel right now?” by marking the 100-mm line anchored by “Not at all full” on one side, and “Extremely full” on the other. Subjects completed these ratings before and after breakfast, before and after the preload time period, and after lunch.

Subjects were also given 100-mm visual analog scales to rate the characteristics of the preloads (APPENDIX U). They were instructed to take a bite or sip of the preload and rate the pleasantness of the taste. They then rated perceived calorie content and how filling they thought the preload would be. For example, subjects recorded their answer to the question “How pleasant is the taste of this food right now?” by marking a 100-mm line anchored on one side by “Not at all pleasant” and anchored on the other side by “Extremely pleasant.”

**Statistical analysis**

A mixed linear model with repeated measures was used to analyze the main outcomes of energy intake (kcal), food intake (g), ratings of hunger, fullness, and thirst, and ratings of preload characteristics (SAS System for Windows, version 9.1; SAS Institute, Cary, NC, USA). The fixed factor effects in the model were preload type and subject sex; awareness of the purposes of the study was also tested as a factor in the model. When pairwise comparisons of means were
made between preload conditions, the overall error rate was controlled using the SIMULATE adjustment in the SAS mixed model; comparisons to the control condition were made using the Dunnett-Hsu adjustment. Intake criteria were established such that any subject who consumed <100 kcal at one or more lunch sessions would be excluded from analysis. Analysis of covariance was performed to determine whether any subject characteristics affected the relationship between preload type and the main outcomes. For each subject, energy intake in each condition was expressed as a percent of the energy consumed in the control condition as follows: total energy intake (preload + test meal) was divided by total energy intake in the control condition and multiplied by 100%. All results were considered significant at p<0.05.

RESULTS

Subjects

Thirty men and twenty-nine women were enrolled in the study. However, based on the criteria established for minimum lunch intake, one female subject was excluded from the analysis. Therefore, the final sample consisted of 30 men and 28 women; the characteristics of these subjects are shown in Table 10.

Food and Energy Intake

Mean test meal intake differed significantly by experimental condition (Table 11); the response to the conditions did not differ between men and women. Subjects ate significantly less energy from the test meal when any preload was consumed before lunch compared to control (p<0.0001). They consumed significantly less energy from the test meal after eating apple segments compared to either the applesauce (p<0.03) or the juice preloads (p<0.0001). They also
consumed less energy after eating applesauce compared to after drinking apple juice (p<0.02). Across all preload types, energy intake at lunch was significantly greater for men (1031 ± 32 kcal) than for women (672 ± 25 kcal; p<0.0001). Men also ate significantly more at breakfast (666 ± 13 kcal) than women (533 ± 11 kcal; p<0.001), but ad libitum breakfast intake did not vary across conditions.

| Table 10. Characteristics of subjects (n=58) participating in a study to test the effects of varying the form of apple on lunch intake (mean ± SE; range) |
|---------------------------------|-----------------|-----------------|
| **Men (n = 30)**                | **Women (n=28)**|
| Age (y)                         | 26.8 ± 0.5 (20 - 45) | 27.1 ± 0.6 (19 - 43) |
| Weight (kg)                     | 76.7 ± 0.7; (58.5 – 94.8) | 65.7 ± 1.0; (45.8 – 96.8) |
| Height (m)                      | 1.8 ± 0.005; (1.8 – 1.9) | 1.6 ± 0.005; (1.5 – 1.8) |
| Body mass index (kg/m^2)        | 23.7 ± 0.2 (19.1 - 29.4) | 24.3 ± 0.4 (19.3 - 36.4) |
| Dietary restraint score ^a       | 4.5 ± 0.3 (0 - 12) | 7.7 ± 0.3 (2 - 17) |
| Disinhibition score ^a           | 4.4 ± 0.2 (1 - 8) | 5.6 ± 0.3 (1 - 12) |
| Hunger score ^a                  | 4.8 ± 0.2 (1 - 11) | 4.8 ± 0.2 (1 - 11) |

^a Eating Inventory (Stunkard & Messick, 1985)

^b Based on the results of a T-test, means differ significantly between sexes (p<0.01)
Table 11. Food and energy intakes of 58 subjects participating in a study to test the effects of varying the form of apples on lunch intake (mean ± SE).

<table>
<thead>
<tr>
<th>Preload Type</th>
<th>Control (No preload)</th>
<th>Apple</th>
<th>Applesauce</th>
<th>Apple juice with fiber</th>
<th>Apple juice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entrée intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kcal</td>
<td>1024 ± 49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>709 ± 50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>800 ± 49&lt;sup&gt;c&lt;/sup&gt;</td>
<td>866 ± 52&lt;sup&gt;d&lt;/sup&gt;</td>
<td>890 ± 51&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>g</td>
<td>473 ± 22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>327 ± 23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>369 ± 23&lt;sup&gt;c&lt;/sup&gt;</td>
<td>400 ± 24&lt;sup&gt;d&lt;/sup&gt;</td>
<td>411 ± 24&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Total lunch intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kcal</td>
<td>1024 ± 49&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>861 ± 50&lt;sup&gt;c&lt;/sup&gt;</td>
<td>952 ± 49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1018 ± 52&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>1041 ± 51&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>g</td>
<td>473 ± 22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>593 ± 23&lt;sup&gt;d&lt;/sup&gt;</td>
<td>635 ± 23&lt;sup&gt;c&lt;/sup&gt;</td>
<td>666 ± 24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>677 ± 24&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>% of control energy intake</td>
<td>100 ± 0 %&lt;sup&gt;a&lt;/sup&gt;</td>
<td>88 ± 4 %&lt;sup&gt;b&lt;/sup&gt;</td>
<td>97 ± 4 %&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>103 ± 4 %&lt;sup&gt;a&lt;/sup&gt;</td>
<td>106 ± 4 %&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b,c,d</sup> Based on the results of a mixed linear analysis, means for a given outcome that have different letters are significantly different (p<0.0001).
When the energy intakes from the preload and test meal were considered together, apple was the only preload that significantly reduced total energy intake compared to control (Figure 7). Total energy intake at lunch was 88 ± 4% of that in the control condition when apple was eaten as a preload; therefore, compared to control, subjects reduced total energy intake at lunch by 12% (164 ± 36 kcal) when apple was eaten (p<0.0001; Table 11). Lunch energy intake decreased significantly when apple was eaten compared to when any of the other preloads was consumed (p<0.02). Although lunch intake was significantly lower when applesauce was consumed compared to apple juice (p<0.02), intake in the applesauce and juice conditions did not differ significantly from control intake.

Figure 7. Mean (± SE) energy intake at lunch (preload + entrée) of 58 women and men in a study testing the effects of varying the form of apple on lunch intake. Means with different letters are significantly different. Total energy intake at lunch was significantly lower following apple compared to all other conditions (p<0.0001), and after applesauce compared to apple juice (p<0.001).
Analysis of covariance showed that the relationship between type of preload and energy intake at lunch was not significantly influenced by any of the measured subject characteristics (age, height, weight, body mass index, or scores for restraint, disinhibition, and hunger).

**Ratings of hunger, fullness, and thirst**

Before the preloads were consumed, there were no significant differences in ratings of hunger, fullness, or thirst by condition. Hunger ratings (Figure 8a) after consumption of any preload were significantly lower compared to control (p<0.001). Hunger was lower following consumption of apple segments than after applesauce, apple juice with fiber, or apple juice (p<0.0001). Ratings were also lower after eating applesauce than after drinking apple juice (p<0.01). Hunger ratings after lunch were similar after consumption of all preloads. Compared to control, however, there were small but significant differences in hunger ratings after lunch for apple and applesauce. Ratings were lower when apple segments and applesauce were eaten compared to when no preload was consumed (p<0.05).

Fullness ratings (Figure 8b) were significantly higher after any preload was consumed compared to control (p<0.0001). Fullness ratings were also significantly greater after consumption of apple segments compared to applesauce, apple juice with fiber, and apple juice (p<0.0001), and when applesauce was eaten compared to apple juice with fiber and apple juice (p<0.001). After lunch, ratings of fullness did not differ significantly between preloads, but fullness ratings were significantly higher after apple segments compared to control (p<0.05).

Ratings of thirst (Figure 8c) were significantly lower following intake of apple segments, apple juice with fiber, and apple juice compared to control (p<0.0001), and following the juice preloads compared to applesauce (p<0.0001) and apple (p<0.001). Corresponding to these
differences in thirst ratings, subjects consumed significantly less water at lunch when any preload was consumed (328 ± 12 g) compared to control (412 ± 26 g; p<0.0001). However, differences in thirst ratings did not correspond to differences in water intake at lunch by type of preload; there were no significant differences in water intake at lunch across the different preload types (data not shown). Thirst ratings after lunch were not significantly different across experimental conditions.

a.

![Graph showing hunger ratings](image)

b.

![Graph showing fullness ratings](image)
Figure 8a-c. Mean (± SE) hunger, fullness, and thirst ratings across the lunch meal for subjects (n=58) in a study testing the effects of varying the form of apple on lunch intake.

8a. Hunger ratings did not differ across conditions before preloads were eaten, but after preload intake, hunger ratings were lower for all preloads compared to control (p<0.0001). Apple decreased hunger more than all other preloads (p<0.0001), and applesauce reduced hunger more than apple juice (p<0.01). After lunch, hunger ratings were lower when apple and applesauce were eaten compared to control (p<0.05).

8b. Fullness ratings did not differ across experimental conditions before consumption of the preloads, but ratings after preload consumption were higher for all preloads compared to control (p<0.0001), and for apple compared to the other preloads (p<0.0001), and for applesauce compared to the juice preloads (p<0.001). After lunch, fullness ratings were higher when apple was eaten compared to control (p<0.05).

8c. Thirst ratings did not differ across experimental conditions before consumption of the preloads, but ratings after preload consumption were lower for apple and the juice preloads compared to applesauce and no preload (p<0.0001). The juice preloads reduced thirst more than apple (p<0.001). There were no differences in thirst ratings after lunch.

Ratings of preload characteristics

There were some small, but significant, differences in ratings of preload characteristics according to preload type (Table 12). Ratings for pleasantness of taste were significantly higher for the apple and apple juice compared to applesauce (p<0.05), and for apple compared to apple juice with fiber (p<0.0001). Although the preloads were equal in calories, subjects rated the
apple preload as being significantly lower in calories compared to all other preloads (p<0.001). Subjects also rated the apple segments as more filling than apple juice (p<0.05) and applesauce as more filling than the juice preloads (p<0.05). Analysis of covariance showed that the relationship between type of preload and energy intake at lunch was not influenced by any of the ratings of preload characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Apple</th>
<th>Applesauce</th>
<th>Apple juice with fiber</th>
<th>Apple juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>How pleasant is the taste of this food right now?</td>
<td>75 ± 2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>66 ± 3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>59 ± 3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>74 ± 2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>How many calories do you think this food has?</td>
<td>25 ± 2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33 ± 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37 ± 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>34 ± 2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>How filling do you think this food will be?</td>
<td>44 ± 3&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>47 ± 3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>36 ± 3&lt;sup&gt;a,c&lt;/sup&gt;</td>
<td>33 ± 3&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> Based on the results of a mixed linear analysis, means for a given characteristic that have different letters are significantly different.

Discharge questionnaire

On the discharge questionnaire (APPENDIX L), 48 subjects (83%) reported that the type of preload changed between sessions. Forty-seven subjects (81%) correctly reported that the purpose of the study was to examine the effects of different forms of apple on hunger or fullness, or energy intake. Four subjects (7%) noticed that there were different types of juice served in the study, but none attributed the difference to fiber content. The mixed linear analysis showed that the primary study outcomes, test meal and total lunch intake, were not significantly influenced by whether subjects correctly or incorrectly ascertained any purposes of the study.
DISCUSSION

Consuming apple, applesauce, or apple juice at the start of a meal significantly reduced intake of the subsequent main course compared to having no preload. In addition, eating apple segments before the main course significantly reduced total meal energy intake compared to consuming applesauce, apple juice with and without fiber, or no preload. When ~1.5 apples were eaten at the beginning of lunch, subjects reduced total energy intake by 12% (164 kcal) compared to having no preload. Eating apple was also associated with higher ratings of fullness and lower ratings of hunger compared to other forms of apple. These results suggest that consuming fruit before a meal may enhance satiety and reduce subsequent food intake, leading to substantial reductions in total energy intake at the meal.

Earlier studies investigated the effects on satiety of consuming various forms of fruit. Haber et al. (5) compared subjects’ satiety ratings after consumption of apple (482 g; 14 g of fiber), applesauce (482 g; 14 g of fiber), or fiber-free apple juice (469 g) and Bolton et al. (3) compared satiety ratings following intake of oranges (626 g; 16 g of fiber), orange juice (610 g), grapes (339 g; 5 g of fiber), or grape juice (323 g). In these studies, satiety ratings were significantly higher following intake of fruit compared to juice. Mattes et al. (6) also found that satiety ratings were higher after consumption of apple (300 kcal) compared to apple juice (300 kcal), but reported no differences in subsequent energy intake as measured by 24-hour food diaries. Because these studies measured satiety using rating scales and, in one case, self-reported intake, the effect of different forms of fruit on energy intake was not clear. In addition, the preloads were only matched for some of the parameters that could affect satiety, weight (3, 5) or energy (6); differences in fiber content and energy density may also have influenced satiety. The present study, by matching preloads for energy content, weight, fiber content, energy density,
and ingestion rate, extended the results of the previous studies by isolating the effects of the
form of fruit on measured food intake in a controlled laboratory setting.

The hypothesis that the form of food affects satiety has been investigated by studies in
which foods other than fruit were tested. The results of these studies are mixed (2-5, 11-14), but
several have found solid foods to be more satiating than beverages (3-5, 11). Many studies
examining the effect of beverage consumption on satiety have shown caloric beverages to have
little effect on food intake, resulting in increased energy intake (15-18); however, a few studies,
including the present one, report reduced energy intake following beverage consumption (15, 19,
20). This variability in outcomes may be due to differences in beverage characteristics and
experimental design. Taken together, these findings suggest that solid foods can be more
satiating than beverages.

There are a number of possible explanations for the high satiating capacity of whole fruit.
Typically, whole apple and apple juice differ in fiber content, and some studies have shown that
consuming fiber reduces energy intake and enhances satiety (21, 22). Previous studies comparing
fruit and juice varied both fiber content and form, so the relative contributions of these factors to
satiety were unclear (3, 5, 6). In the present study, in which preload fiber content was similar, the
results suggest that the form of fruit influences energy intake independently from fiber content.
A previous study found that orange juice (448 ml) with added fiber (pectin) (5 – 20 g) increased
satiety more than fiber-free orange juice (23). However, the authors noted that adding pectin
noticeably increased viscosity, and it has been suggested that increasing beverage viscosity can
reduce sensations of hunger (24). In the present study, contrary to expectations, there were no
differences in satiety between apple juice with and without fiber; adding fiber to the juice,
however, reduced ratings of taste. Therefore, simply adding naturally-occurring levels of fiber to
a beverage with only small, relatively undetectable changes to viscosity may not enhance satiety, and may have undesirable consequences on taste.

Perceptions of the satiating capacity of foods and drinks could also influence satiety and food intake. Subjects in this study rated apple segments and applesauce to be more filling and less thirst-quenching than juice. Based on visual stimulation, subjects may have perceived the plate of apples to be a larger volume of food, and therefore more filling, than the glass of juice. It is also possible that subjects perceived the beverages to be more effective at reducing thirst, while they expected the apple segments and applesauce to satisfy hunger, leading to differences in food intake and satiety (25, 26). A difference in the amount of chewing may also have influenced the satiating effect of the different forms of food. Increased chewing has been shown to initiate cephalic-phase responses involved in digestion and metabolism that could affect food intake (27-29). In the present study, ingestion rate was controlled, but chewing varied; the apple segments required a lot of chewing, applesauce required minimal chewing, and the juice preloads required no chewing. As a result, the increased chewing that was required to eat the apple segments may have contributed to subsequent increases in satiety and reductions in food intake. In addition, if the apple had not been peeled, it is possible that the amount of chewing required would have been greater. More research is needed to test whether leaving the apple skin on, which could affect chewing and fiber content, affects satiety.

Decreased gastric emptying rates and increased gastric distension have been associated with increased satiety and decreased food intake (30, 31), and research has shown that solids empty from the stomach at a slower rate than liquids, resulting in prolonged gastric distension (31-35). In this study, juice preloads may have emptied from the stomach faster than apple, and the greater volume of apple (325 ml) compared to the other preloads (266 ml) may have enhanced gastric distension, possibly contributing to enhanced satiety and reduced food intake.
Incorporating fiber into food may also reduce gastric emptying rates (36, 37), so adding fiber to juice could slow gastric emptying rates and affect satiety. However, in the present study, juice with and without fiber had similar effects on satiety, suggesting that adding naturally-occurring levels of fiber to a beverage may not affect satiety through changes in gastrointestinal function. The fiber content and form of whole fruit and fruit juice may also affect glucose and insulin responses differently (3, 5), which could impact food intake and satiety. Future work should explore how these cognitive, oro-sensory, gastrointestinal, and endocrine responses interact to affect food intake and satiety when different forms of fruit are consumed.

In the present study, the effect of the different forms of fruit was similar in both men and women with a range of anthropometric and psychosocial characteristics. In particular subjects who ate 1.5 apples at the start of the meal reduced energy intake compared to consuming no first course. It is likely, however, that for a given individual the optimal size of the first course depends on several factors, including the amount of food they usually consume at a meal (38). Further research is needed to investigate the characteristics of a first course (such as weight, volume, energy, and energy density) that lead to a maximal decrease in energy intake at the meal.

The results from this study suggest that eating whole fruit at the start of a meal may be an effective strategy for consuming less energy while increasing satiety. The results from clinical trials offer additional support for the inclusion of fruit in the diet; routinely consuming fruit has been associated with significant weight loss (39, 40). Fruit consumption has also been associated with diets lower in energy density (41), and research has shown that consuming a diet lower in energy-density is related to reduced energy intake and body weight (42-45). These data suggest that incorporating whole fruit into the diet, particularly at the start of a meal, may be one strategy that individuals can use to increase satiety while decreasing energy intake.
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CHAPTER V

CONCLUSIONS
**Summary of Findings**

The results of the present three studies provide further insight into the effects that various forms of food (beverages, soup, and different forms of fruit) have on energy intake at a meal. When caloric beverages were consumed with a meal, subjects did not compensate for the energy in the regular cola by reducing food intake, leading to a 9% (90 ± 26 kcal) increase in total energy intake at lunch (Study 1). On the other hand, when juice was consumed 15 min before a meal, subjects compensated for the energy in the juice by reducing subsequent intake, and total energy intake did not differ from control (Study 3). In addition, consuming various forms of soup or whole apple as a preload led to substantial reductions in subsequent energy intake compared to control, such that consuming soup led to a 20% (134 ± 25 kcal) decrease in total energy intake (Study 2), and consuming whole apple led to a 12% (164 ± 36 kcal) decrease in total energy intake (Study 3). Consuming whole apple as a preload also reduced subsequent energy intake and increased ratings of satiety compared to applesauce and apple juice with and without fiber (Study 3).

Taken together, these results offer further support for the hypothesis that the form of food can influence energy intake and satiety. The findings suggest that solid food can be more satiating than beverages. Also, different types of liquids might affect energy intake and satiety differently. In particular, beverages have a low satiating capacity and consuming caloric beverages may increase energy intake. Conversely, soup has a high satiating capacity, and consuming various types of low-energy-dense soup as a first course is likely to reduce energy intake.
Mechanisms

There are a number of mechanisms, both cognitive and physiological, that are likely to be involved in the satiating effects of different forms of food. For example, perceptions of the satiating effects of solid food, soup, and beverages could affect energy intake and satiety. A number of authors have suggested that the cognitive impressions associated with solid food, soup, and beverages may partially explain differences in satiety ratings and subsequent food intake (9-11). It is possible that beverages are expected to be thirst-quenching, while solid food and soup are expected to satisfy hunger. However, little is known about how these perceptions influence satiety and food intake. In one study by Rolls et al., the effects of mode of presentation on satiety were investigated by having subjects consume vegetable juice either as a beverage or as a soup (12). Results showed that the mode of presentation had no effect on satiety or subsequent food intake. Therefore, while it has been suggested that cognition may play a role in satiety, little data exists to substantiate that hypothesis.

There are also several physiological mechanisms that could be involved with the satiating effects of solid food, soup, and beverages. The degree of chewing required to consume foods and beverage could affect energy intake and satiety. Several studies have shown that cephalic-phase responses related to digestion and metabolism are initiated by the act of chewing, which could influence energy intake (13-15). Consuming solid food and soup is likely to require more chewing than drinking a beverage. This difference may partially explain why solid food and soup have different effects on energy intake and satiety than beverages.

Gastric distension and gastric emptying are physiological processes that control food intake and stimulate sensations of satiety (16), and it is possible that these processes respond differently to various forms of food, thereby affecting food intake and satiety (16). For example, there is clear evidence that consuming larger volumes of food can reduce food intake and
stimulate sensations of satiety (17-19) and that the relationship between volume, energy intake, and satiety is mediated by gastric distention (20-22). Furthermore, in a study by Sturm et al., gastric distension was measured after subjects consumed 400 ml of either water or yogurt (23), and results showed that yogurt significantly increased stomach area compared to water, suggesting that semi-solid food may cause greater gastric distension than a fluid beverage. Therefore, it is possible that the same volume of food, varied in form, may distend the stomach to different degrees, leading to differences in energy intake and satiety.

Several studies have also shown that different forms of food empty from the stomach at different rates. Solid food has been shown to empty from the stomach more slowly than liquids (24-28), and slower emptying rates for solid food have been associated with increased intensity and duration of satiety (29). Furthermore, data from a few studies suggest that soup also reduces gastric emptying rate, possibly more than solid food. Speigel et al. showed that consuming soup immediately before a meal significantly delayed gastric emptying, compared to when soup was consumed 20 min prior to a meal, or when no soup was consumed (30). In addition, Santangelo et al. found that consuming soup increased gastric distension and slowed gastric emptying compared to consuming a solid meal prepared from identical ingredients (31). The authors also reported that satiety was increased following the soup compared to the solid meal. The results of these two studies suggest that the higher satiating capacity of soup compared to solid food, as well as the low satiating capacity of beverages, could be partially due to differences in gastric emptying rates.

In summary, it appears that eating solid food and soup requires more chewing than drinking a beverage, which could affect food intake and satiety. Also, solid food and soup may increase gastric distension more than beverages, while beverages may empty from the stomach at a faster rate than solid foods and soup. Thus, solid foods and soup could remain in the stomach
longer than beverages, lengthening the time of gastric distension, and leading to reductions in food intake and increased sensations of satiety. In support of these hypotheses, a series of studies by Cecil *et al.* have shown that satiety increases the most when oro-sensory, gastric, and intestinal stimulation are combined, as compared to when each physiological process is manipulated independently (32-34). Therefore, consuming soup and solid food may activate a number of physiological mechanisms to a greater degree than beverages, and the combined effects of those mechanisms could lead to decreases in energy intake and increases in satiety.

**Implications**

One of the primary goals of the current research was to identify dietary strategies that could be effective for moderating the amount of energy that is consumed at a meal. Based on the findings of the present studies, and the results reported in the supporting body of literature, a number of dietary strategies involving foods of various forms are evident.

The results of study 1 suggest that changing patterns of beverage intake could be used to control energy intake. By choosing to consume water, low-calorie, or non-caloric beverages to accompany a meal, instead of caloric beverages, consumers may consume less energy at that meal. In addition, choosing smaller portions of caloric beverages may also help to decrease energy intake at a meal.

While study 1 only tested the effects of consuming beverages with a single meal, a few long-term trials suggest that employing these strategies for a longer period of time could be effective for managing body weight. Tordoff & Alleva found that consuming caloric soda on a daily basis for 3 weeks resulted in increased energy intake and body weight, while consuming non-caloric soda led to reductions in energy intake and body weight (1). Raben *et al.* investigated the effects on energy intake and body weight of consuming caloric or non-caloric drinks over a
period of 10 weeks (2). Results showed that consuming caloric drinks led to increased energy intake and body weight compared to consuming non-caloric drinks. Also, Reid et al. found that consuming supplementary caloric drinks over 4 weeks led to increased energy intake compared to consuming non-caloric drinks (3). However, the results of this study showed only a trend for those drinking the caloric drinks to gain weight. Overall, the results of study 1, along with the results of several long-term clinical trials, suggest that incorporating low-calorie or non-caloric beverages into the diet is one strategy that may be used to moderate energy intake and control body weight in adults.

The findings from study 2 suggest that incorporating soup into the diet may help decrease energy intake. Consuming a first course of low-energy-dense soup, in a variety of forms, may be a useful strategy for reducing energy intake at a meal without increasing hunger or decreasing fullness. Although study 2 only tested the effects of soup on energy intake at a single meal, the results from several longer-term clinical trials lend additional support for using soup as a tool for weight management. Jordan et al. tested the effects of consuming soup at least 4 times a week for 10 weeks and found that increasing the amount of soup consumed each day was related to reductions in both energy intake and body weight (4). The authors also observed that consuming soup slowed the rate at which meals were ingested, which was associated with consumption of fewer calories at meals. In a 12 week clinical trial testing the effects of soup consumption on weight loss, Foreyt et al. also found that the amount of soup consumed per day was correlated with weight loss, and that individuals who consumed soup were better able to maintain weight losses over time (5). In another study, Rolls et al. found that over the course of 12 months, subjects who consumed 2 servings of soup per day lost more weight than those who consumed the same amount of energy as snack food (6). Taken together, the results from study 2 and these
long-term clinical trials suggest that regularly consuming low-energy-dense soup, particularly before meals, may be an effective way to reduce energy intake and manage body weight.

The results of study 3 suggest that incorporating whole fruit into the diet is another strategy that could be used to decrease the amount of energy consumed at the meal, while at the same time decreasing hunger and increasing fullness. The use of this strategy for managing energy intake is supported by a few clinical trials. Conceicao de Oliviera et al. found that women who ate apples or pears as a snack every day for 12 weeks lost more weight than those who ate the same amount of energy as oat cookies (7). Fujioka et al. also found that eating grapefruit three times a day before each meal for 12 weeks was associated with significant weight loss (8). The results of study 3, combined with the findings from these clinical trials suggest that consuming fruit, primarily before meals, can be used therapeutically to decrease energy intake and body weight.

**Future Research**

While the results of the present three studies provide additional insight into the effects on energy intake and satiety of consuming various forms of food, the findings also raise a number of issues that should be addressed in future work.

**Timing of intake**

Studies done to test the short-term effects of caloric and non-caloric beverages on energy intake and satiety have reported mixed results. Some short-term studies have shown that consuming caloric beverages increases total energy intake at a meal (beverage + test meal) (35-38), while others have reported that drinking a caloric beverage leads to reductions in subsequent
food intake, so total energy intake was not affected (39, 40). Two of the present studies, study 1 and study 3, show similar contradictory results. In study 1, consuming regular cola, diet cola, and water with a meal did not displace food intake, so that total energy intake (beverage + test meal) increased when regular cola was consumed. Conversely, in study 3, when apple juice with and without fiber was consumed 15 min prior to a meal, subsequent food intake decreased, so that total energy intake (juice + test meal) was similar to control.

One of the primary differences between study 1 and study 3 was the timing of beverage intake; in study 1 the beverages were consumed with the meal, and in study 3 the beverages were consumed 15 min before the meal. Therefore, it is possible that the relative time interval between drinking a beverage and meal consumption may be an important predictor of whether or not beverage energy will be compensated for by reductions in food intake. Several previous short-term studies support this hypothesis: in a few studies, beverages consumed with meals were found to increase total energy intake (35, 39, 41), while some other studies showed that energy compensation occurred when beverages were consumed 15-30 min prior to a test meal (38, 40). Furthermore, when beverages were consumed > 60 min prior to a test meal, increases in total energy intake were also reported (36, 37, 42). Therefore, beverages consumed with meals and in between meals may be more likely to increase energy intake than beverages consumed immediately before a meal. However, more research is needed to systematically test how the timing of beverage intake affects energy intake and satiety.

It is also unknown whether the effects on energy intake and satiety of consuming soup or whole fruit would be affected by the timing of consumption. It seems likely that consuming soup or fruit immediately before a meal could be the most effective way to reduce subsequent intake and total energy consumed at the meal. However, the timing of soup or fruit intake has not been studied systematically in the laboratory setting. The clinical trials that tested the effects of
regularly consuming soup or fruit on energy intake and body weight instructed subjects to consume the soup or fruit immediately before meals (4-8, 43) so again, it is unknown whether consuming soup or fruit at different time points would have long-term consequences on energy intake and body weight. So, while the results of study 2 and study 3 show robust reductions in energy intake when soup and whole fruit were consumed 15 min before a meal, an important next step would be to determine how consuming these foods at different times (with a meal or in between meals) would affect energy intake and satiety.

*Modifying the portion size and energy density of various forms of food*

The results of the present studies show that consuming certain types of preloads can reduce subsequent energy intake as well as total energy intake. However, this is not always the case, as previous studies have shown that consuming preloads can increase total energy intake (preload + test meal) (17, 44). Thus, it is important to consider characteristics of food, besides food form, that affect energy intake and satiety, and in particular, properties that could promote excess energy intake. In particular, previous research has shown that varying portion size and energy density can affect energy intake and satiety (45-52), and it is possible that varying the portion size and energy density of beverages, soup, and fruit could modify the effects these types of food have on energy intake and satiety. Researching the effects that portion size and energy density have on various forms of food could provide additional insight into how consuming different forms of food can be used therapeutically to prevent excess energy intake.

Several studies have shown that increasing the portion size of several types of food, including soup, tends to increase *ad libitum* energy intake (49, 50, 53-56). The results of study 1 expand these prior findings to include beverages. However, one study found that increasing the portion size of fruit served as a snack did not increase *ad libitum* fruit intake (55).
In addition, a few previous studies have shown that increasing the portion size of a compulsory preload can lead to decreases in subsequent energy intake (17, 57). A number of studies have tested the effects of increasing preload portion size using soup and fruit, but the results are varied. One study found that consuming a larger portion of soup (285 g) led to greater reductions in subsequent energy intake compared to a smaller portion of soup (100 g) (58). However, this effect was observed only in women, and not in men. Conversely, a different study found no differences in subsequent energy intake after women and men consumed different portions of soup as a preload (59). Another study tested the effects of consuming different portions of fruit (cantaloupe), and found that consuming a larger portion of fruit (561 g) decreased subsequent energy intake compared to a smaller portion of fruit (140 g) (60). Also, while the results of study 1 showed that consuming different portions of beverages with a meal did not affect food intake, little is known about how consuming different portions of a beverage as a preload affects subsequent energy intake. Overall, more work is needed to test whether consuming different portions of beverages, soup, and fruit as a preload would influence subsequent energy intake, as well as total energy intake at a meal.

As with portion size, several studies have established that increasing the energy density of food tends to increase *ad libitum* energy intake (45, 51), but little is known about how increasing energy density of beverages, soup, or fruit would influence *ad libitum* energy intake. In addition, some studies have shown that decreasing the energy density of a preload, including soup, can lead to reductions in energy intake at a meal (44, 58, 61, 62). For example, Rolls et al. tested the effects of manipulating the energy density of soup preloads on subsequent energy intake (61). Results showed that subsequent food intake did not differ following consumption of soups varied in energy-density; so, when the energy intake from the soup and test meal were considered together, consuming high-energy-dense soup significantly increased total energy
intake (soup + test meal). Kissileff et al. manipulated the energy density of soup, and found that higher-energy-dense soup was more effective at reducing subsequent energy intake than lower-energy-dense soup (58). However, it is unknown how varying the energy density of beverage and fruit preloads would affect energy intake. Additional research is needed to determine how consuming preloads of soup, fruit, or beverages varied in energy density affects total energy intake at a meal.

While portion size and energy density work independently to influence energy intake, research has also shown that when these properties of food are manipulated simultaneously, their effects on energy intake are additive (63-65). A previous study by Rolls et al. investigated the effects of varying the portion size and energy density of a first-course salad (65). Total energy intake at the meal (salad + test meal) was affected by both portion size and energy density, and the effects added together. Maximal reductions in total energy intake were achieved when the large portion of low-energy-dense salad was consumed as a first course. Therefore, it has been suggested that one way to reduce energy intake and enhance satiety at a meal is to combine the effects of portion size and energy density by consuming a large portion of a low-energy-dense food (57, 65). Because soup and fruit are commonly consumed low-energy-dense foods, it would be of interest to test the independent and combined effects of portion size and energy density with soup and fruit preloads, using a study design similar to that employed by Rolls et al. (65).

Implications for weight management

As was previously discussed, the results of the present studies and others suggest a number of dietary strategies involving foods of various forms that could be used to control energy intake and body weight. Even though the results of a number of long-term clinical trials support the strategies suggested by the present studies, more work is needed to determine how
the strategies discussed earlier can be used most effectively for weight management. For example, while choosing low-calorie or non-caloric beverages to accompany a meal may be effective for reducing energy intake (1-3), little is known about how consuming smaller portions of caloric beverages could be used therapeutically for managing energy intake and body weight. Also, a number of the clinical trials mentioned earlier (1-8) ranged in length from only 3 weeks to 12 weeks, and more work is needed to investigate how consuming beverages, soup, and fruit is related to weight status over longer periods of time.

**Mechanisms**

As was formerly discussed, there are a number of plausible physiological mechanisms that are likely to be involved in the satiating effects of various forms of food. However, many of the physiological studies are subject to the same limitations as the body of literature regarding the effects of the form of food on energy intake and satiety (i.e. variations in the type of test food used, test food characteristics, methods used to assess satiety, time interval between preload and meal) (23, 24, 27, 29, 30). Therefore, more research is needed to systematically examine how varying food form alters both cognitive and physiological processes, while employing a study design that reduces confounding factors. For example, the results of study 3 have established that different forms of fruit can affect energy intake and satiety, so a logical follow-up study would be to use a similar study design to measure the physiological consequences (effects of chewing, gastric distension, and gastric emptying rate) of consuming different forms of fruit.

**Testing different subject populations**

Previous research suggests that subject characteristics such as weight status (66-68) or sex (12, 58) may influence the effects on energy intake and satiety of consuming different forms
of food. In the present studies, analysis of covariance showed that study outcomes were similar for men and women with a range of anthropometric (BMI, height, weight) and psychosocial characteristics (restraint, disinhibition, hunger, depression). However, there may not have been enough variability in subject characteristics or sample sizes may not have been large enough to detect differences in the results of these studies by subject type. Thus, the possibility that subject characteristics could affect the relationship between the form of food and energy intake and satiety cannot be eliminated. Further hypothesis-driven research is needed to investigate the effects of food form on energy intake and satiety in larger samples of subjects of varying age, weight status, race and ethnicity, and restraint and disinhibition.

**Final Conclusions**

Based on the findings of the present studies and the results reported by the supporting body of literature, consuming different forms of food can have different effects on energy intake and satiety at a meal. Although beverages and soup are both considered to be liquids, they appear to have different effects on energy intake and satiety. Beverages have a low satiating capacity and energy intake may be increased when caloric beverages are consumed. On the contrary, soup can be highly satiating, and when various types of low-energy-dense soup are consumed as a first course, energy intake can be reduced. In addition, it is likely that solid food may be more satiating than beverages. These results suggest several dietary strategies that can be used to decrease energy intake and enhance satiety at meals, including the following: 1) consume low-calorie or non-caloric beverages with meals, 2) choose smaller portions of caloric beverages, and 3) consume low-energy-dense soup or fruit as a first course. Using these strategies on a regular basis could assist with the prevention and management of overweight and obesity.
REFERENCES


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APPENDIX A

TELEPHONE SCREENING QUESTIONS

STUDY 1
Pre-screening Questionnaire

Date: _____________

Age: ____________ (range 20-45) Date of Birth: ____________

Height: _______ Weight: ____________

Do you smoke?  No  Yes

Are you currently taking any prescription medications?  No  Yes
   If yes, what? _______________________________

Are you currently taking any OTC medications regularly?  No  Yes
   If yes, what? _______________________________

Are you currently dieting to gain or lose weight? No  Yes

Are you an athlete in training? No  Yes

Do you have any food allergies?  No  Yes

Do you have any sugar/sweetener restrictions?  No  Yes

Do you have any sodium restrictions?  No  Yes _______________________________

Do you have any food restrictions related to religious practices? No  Yes: _______________________

Are you willing to drink?
   Orange juice?  No  Yes
   Regular Pepsi?  No  Yes
   Lemonade?  No  Yes
   Iced Tea?  No  Yes
   Milk?  No  Yes
   Diet Pepsi?  No  Yes

Do you regularly eat 3 meals per day?  No  Yes
   If no, what is your usual daily pattern of meals? _______________________________

Would you refrain from drinking alcoholic beverages on the evening before your session? No  Yes

(FEMALE) Are you pregnant or breast feeding? No  Yes

Where did you hear about the study?___________________________________________

Have you participated on any other studies in our lab? No  Yes
   If yes, what study and when? ____________________________________________

Are you a:    _____Penn State Student  _____Undergraduate
               _____Penn State Staff  _____Graduate
               _____State College Resident  _________________  Major
APPENDIX B

QUESTIONNAIRE CONSENT FORM

STUDY 1
Questionnaire Consent Form: IRB# 18834

Title of Investigation: Effects of consumption of foods and beverages

Investigator: Barbara Rolls, Ph.D.     Telephone: 863-8481

Purpose of today's visit: To determine if you meet the criteria to be a participant in this laboratory’s human ingestive behavior studies.

Procedure: It will take you approximately 45 minutes to complete this packet of questionnaires. These questionnaires are to determine whether or not the studies conducted at our laboratory are appropriate for you. You will be weighed and your height measured. Our studies require a considerable amount of preparation and, in order to assure reliable results for the studies, it is very important that participants fulfill all criteria of the studies. There is no compensation for completing this set of questionnaires.

Because of strict subject criteria, it may be determined that we cannot have you participate in the current study. There are a variety of reasons why an individual may not be chosen for a particular study. Often the number of responses from potential participants exceeds the number of individuals needed for the study. If you are not chosen to participate at this time, your information will be kept on file and you may be called later to participate in another study.

Risks: There are no major risks involved in filling out the questionnaires and having your body measurements taken. To protect subject identity, all information obtained is filed according to an assigned participant number. Participants' names and personal information are kept in locked file drawers to which only researchers involved in the project have access.

Your responses to the questionnaires will be reviewed by a staff member. If any of the questionnaires indicate that you may benefit from professional treatment (i.e. counseling or physician's care), you will be notified by a staff member via telephone within 3 days of review of your questionnaire packet.

If, as a result of filling in the questionnaires, you feel that you would benefit from individual counseling, you may contact: Psychological Clinic of the Penn State University
314 Moore Building
University Park, PA 16802
Phone: (814) 865-2191

Benefits: If you qualify to become a participant in a study at the Human Ingestive Behavior Laboratory, you will be contributing to our understanding of human eating behavior.
Contact Person: Jennifer Meengs
226 Henderson Building
University Park, PA 16802
814-863-8481

If you agree to fill out the questionnaires and have your body measurements taken, please sign the consent form at the bottom of this page.

This is to certify that, I ________________, hereby agree to participate as a volunteer in this study as an authorized part of the education and research program of the Pennsylvania State University under the supervision of Barbara Rolls, Ph.D.

The investigation and my part in the investigation have been defined and fully explained to me on the reverse of this consent form, and I understand this explanation.

I have been given an opportunity to ask whatever questions I may have had, and all such questions and inquiries have been answered to my satisfaction. Any further questions I have may be addressed to the research technician or Jennifer Meengs at 863-8482.

I understand that I am free to deny any answers to specific items or questions in interviews or questionnaires.
I understand that any data or questions will remain confidential with regard to my identity.
I understand that medical care is available in the event of injury resulting from this investigation, but that neither financial compensation nor free medical treatment is provided. I also understand that I am not waiving any rights that I may have against the University for injury resulting from negligence of the University or investigators.
I certify that to the best of my knowledge and belief, I have no physical condition or dietary requirements, such as food allergies or food restrictions, that would increase the risk to me of participation in this investigation.
I certify that I am at least 18 years of age.

I FURTHER UNDERSTAND THAT MY PARTICIPATION IS VOLUNTARY AND I AM FREE TO WITHDRAW MY CONSENT AND TERMINATE MY PARTICIPATION AT ANY TIME.

__________________________  ___________________________  ___________________________
Date                      Date of Birth                  Subject's Signature

I, the undersigned, have defined and fully explained the investigation to the above subject.

__________________________  ___________________________
Date                      Investigator's Signature

You may contact the Penn State University Office for Research Protections, 212 Kern Graduate Building, University Park, PA 16802, (814) 865-1775 for additional information concerning your rights as a research subject.
APPENDIX C

DEMOGRAPHIC AND HEALTH HISTORY QUESTIONNAIRE
<table>
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<tr>
<th>Name</th>
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Subject Profile
Age: ______________________  Date of Birth: ________________  Sex: M  F

Height: _________________  Weight: _________________

Do you smoke: ☐ Yes  ☐ No  If yes, how many cigarettes per day? ___________

Ethnicity (please check only one):
☐ HISPANIC OR LATINO
☐ NOT HISPANIC OR LATINO

Race (please check only one):
☐ AMERICAN INDIAN/ALASKAN NATIVE  ☐ WHITE
☐ ASIAN  ☐ HAWAIIAN/PACIFIC ISLANDER
☐ BLACK OR AFRICAN AMERICAN

What time do you usually eat the following meals?

Breakfast: _________________  Dinner: _________________

Lunch: _________________  Snack(s): _________________

Are there foods you don’t eat because they are not good for you or disagree with you?

☐ Yes  ☐ No

If yes, what foods? _________________________________________________________

Are there any foods you don’t eat because of medication you are on? ☐ Yes  ☐ No

If yes, what foods? _________________________________________________________

Are there any foods you make it a point to eat because you feel they are good for your health?

☐ Yes  ☐ No

If yes, what foods? _________________________________________________________

Are there any foods you don’t eat because they are difficult to chew? ☐ Yes  ☐ No

If yes, what foods? _________________________________________________________

Are you currently under a physician’s care? ☐ Yes  ☐ No

Do you have, or have you had any of the following?

☐ High blood pressure  ☐ Diabetes
☐ Heart trouble  ☐ Ulcers (of the digestive system)
☐ Thyroid or other glandular disorders  ☐ Other stomach/intestinal disorder
☐ Liver disease  ☐ Kidney disease
☐ Anemia  ☐ Depression
☐ Cancer  ☐ Respiratory illness (asthma, etc.)
☐ Other, please specify ______________________________________________________
Are you presently taking medication (over the counter and/or prescription)? □ Yes □ No

If yes, please specify: ________________________________________________________________

Have you ever received radiation therapy? □ Yes □ No

Have you ever received chemotherapy? □ Yes □ No

Please answer the following questions concerning your weight history:

Current weight: ________________________________________________________________

Highest past adult weight (excluding pregnancy): ________________________________

When did this occur? ____________________________________________________________

Lowest past adult weight: ______________ When did this occur? ______________

Have you experienced any weight change in the last 6 months? □ Yes □ No

If yes, did you gain or lose? ______________ How much? ______________

When did this weight change occur? ____________________________________________

Do you have any of the following eating related problems? Please check all those that apply:

- □ Sore mouth
- □ Swallowing problems
- □ Nausea
- □ Chewing problems
- □ Vomiting
- □ Swallowing problems
- □ Diarrhea
- □ Choking problems
- □ Constipation
- □ Salivation problems
- □ Other, please specify ______________________________________________________

Are you currently on any kind of special diet? □ Yes □ No

If yes, what kind (low-salt, low-fat, etc.)? __________________________________________

What type of exercise do you participate in regularly? _______________________________

How many times a week do you exercise? ___________________________________________

How long is each exercise session? _______________________________________________

Do you take any kind of vitamin/mineral supplement? □ Yes □ No

If yes, what kind do you use and how often do you take them?

FOR FEMALES ONLY:
1) In the previous 12 months, has your menstrual cycle been (please check only one):

- □ Regular (normal cycles of approximately equal length)
Irregular (missed cycles, cycles of varying length, marked changes in flow)

Please explain

I did not menstruate in the last 12 months

2) How many days does your menstrual cycle last (from the beginning of the menstrual period to the beginning of the next period)?

3) Have you taken any hormones (birth control pills, Depo-Provera®, hormone replacement therapy, etc.) in the past year?

4) Have you given birth in the past 12 months? ☐ Yes ☐ No

5) Are you planning to become pregnant within the next 12 months? ☐ Yes ☐ No

ALL SUBJECTS:
Below are statements that you will answer about your current eating habits and then about your eating habits when you were in elementary school. Please indicate the extent to which you agree with each, using the following scale. (Circle one number for each statement.)

1 – Never    2 – Rarely    3 – Sometimes    4 – Often    5 – Always

Current eating habits:
I clean my plate: 1 2 3 4 5
I eat my meals about the same time each day: 1 2 3 4 5
I decide how much food is served to me: 1 2 3 4 5

Now think back to your Elementary school eating habits:
I was required to clean my plate: 1 2 3 4 5
I ate my meals about the same time each day: 1 2 3 4 5
I decided how much food was served to me: 1 2 3 4 5

What do you think is the purpose of the research conducted in this lab?
APPENDIX D

EATING INVENTORY
Read each of the following 36 statements carefully. If you agree with the statement or feel that it is true as applied to you, answer true by circling the appropriate answer. If you disagree with the statement, or feel that it is false as applied to you, answer false by circling the appropriate answer.

1. When I smell a freshly baked pizza, I find it very difficult to keep from eating, even if I have just finished a meal. (T) (F)

2. I usually eat too much at social occasions, like parties and picnics. (T) (F)

3. I am usually so hungry that I eat more than three times a day. (T) (F)

4. When I have eaten my quota of calories/fat, I am usually good about not eating any more. (T) (F)

5. Dieting is so hard for me because I just get too hungry. (T) (F)

6. I deliberately take small helpings as a means of controlling my weight. (T) (F)

7. Sometimes things just taste so good that I keep on eating even when I am no longer hungry. (T) (F)

8. Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat. (T) (F)

9. When I feel anxious, I find myself eating. (T) (F)

10. Life is too short to worry about dieting. (T) (F)

11. Since my weight goes up and down, I have gone on reducing diets more than once. (T) (F)

12. I often feel so hungry that I just have to eat something. (T) (F)

13. When I am with someone who is overeating, I usually overeat too. (T) (F)

14. I have a pretty good idea of the number of calories/grams of fat in common foods. (T) (F)

15. Sometimes when I start eating, I just can't seem to stop. (T) (F)

16. It is not difficult for me to leave something on my plate. (T) (F)

17. At certain times of the day, I get hungry because I have gotten used to eating then. (T) (F)

18. While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it. (T) (F)

19. Being with someone who is eating often makes me hungry enough to eat also. (T) (F)

20. When I feel blue, I often overeat. (T) (F)

21. I enjoy eating too much to spoil it by counting calories, counting grams of fat, or watching my weight. (T) (F)

22. When I see a real delicacy, I often get so hungry that I have to eat right away. (T) (F)

23. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat. (T) (F)

24. I get so hungry that my stomach often seems like a bottomless pit. (T) (F)

25. My weight has hardly changed at all in the last two years. (T) (F)

26. I am always hungry so it is hard for me to stop eating before I finish the food on my plate. (T) (F)
27. When I feel lonely, I console myself by eating.  
   (T)   (F)
28. I consciously hold back at meals in order not to gain weight.  
   (T)   (F)
29. I sometimes get very hungry late in the evening or at night.  
   (T)   (F)
30. I eat anything I want, any time I want.  
   (T)   (F)
31. Without even thinking about it, I take a long time to eat.  
   (T)   (F)
32. I count calories/grams of fat as a conscious means of controlling my weight.  
   (T)   (F)
33. I do not eat some foods because they make me fat.  
   (T)   (F)
34. I am always hungry enough to eat at any time.  
   (T)   (F)
35. I pay a great deal of attention to changes in my figure.  
   (T)   (F)
36. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.  
   (T)   (F)
Each question in this section is followed by a number of options. After reading each question carefully, choose one option which most applies to you, and circle the appropriate answer.

37. How often are you dieting in a conscious effort to control your weight?
   1 rarely  2 sometimes  3 usually  4 always

38. Would a weight fluctuation of 5 lbs affect the way you live your life?
   1 not at all  2 slightly  3 moderately  4 very much

39. How often do you feel hungry?
   1 only at meal times  2 sometimes between meals  3 often between meals  4 almost always

40. Do your feelings of guilt about overeating help you to control your food intake?
   1 never  2 rarely  3 often  4 always

41. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?
   1 easy  2 slightly difficult  3 moderately difficult  4 very difficult

42. How conscious are you of what you are eating?
   1 not at all  2 slightly  3 moderately  4 extremely

43. How frequently do you avoid "buying large" on tempting foods?
   1 almost never  2 seldom  3 usually  4 almost always

44. How likely are you to shop for low calorie or low fat foods?
   1 unlikely  2 slightly  3 moderately  4 very
45. Do you eat sensibly in front of others and splurge alone?
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>never</td>
<td>rarely</td>
<td>often</td>
<td>always</td>
</tr>
</tbody>
</table>

46. How likely are you to consciously eat slowly in order to cut down on how much you eat?
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>unlikely</td>
<td>slightly</td>
<td>moderately</td>
<td>very likely</td>
</tr>
</tbody>
</table>

47. How frequently do you skip dessert because you are no longer hungry?
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>almost</td>
<td>seldom</td>
<td>at least</td>
<td>almost never</td>
</tr>
</tbody>
</table>

48. How likely are you to consciously eat less than you want?
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>unlikely</td>
<td>slightly</td>
<td>moderately</td>
<td>very likely</td>
</tr>
</tbody>
</table>

49. Do you go on eating binges even though you are not hungry?
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>never</td>
<td>rarely</td>
<td>sometimes</td>
<td>at least once a week</td>
</tr>
</tbody>
</table>

50. To what extent does this statement describe your eating behavior?
   "I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow."

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>not like</td>
<td>little like</td>
<td>pretty good</td>
<td>describes perfectly</td>
</tr>
</tbody>
</table>

51. On a scale of 1 to 6, where 1 means no restraint in eating (eat whatever you want, whenever you want it) and 6 means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>eat whatever you want, whenever you want it</td>
<td>usually eat whatever you want, whenever you want it</td>
<td>often eat whatever you want, whenever you want it</td>
<td>often limit food intake, but often &quot;give in&quot;</td>
<td>usually limit food intake, rarely &quot;give in&quot;</td>
<td>constantly limiting food intake, never &quot;giving in&quot;</td>
</tr>
</tbody>
</table>
APPENDIX E

ZUNG QUESTIONNAIRE
Please answer the questions by marking in the box that best describes your response. If a question does not apply, mark the box that is closest to answering the question.

<table>
<thead>
<tr>
<th></th>
<th>None or a little of the time</th>
<th>Some of the time</th>
<th>Good Part of the time</th>
<th>Most or all of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I feel downhearted, blue, and sad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Morning is when I feel the best</td>
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<td></td>
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<tr>
<td>3.</td>
<td>I have crying spells or feel like it</td>
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<td></td>
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<tr>
<td>4.</td>
<td>I have trouble sleeping through the night</td>
<td></td>
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<tr>
<td>5.</td>
<td>I eat as much as I used to</td>
<td></td>
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<td></td>
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<tr>
<td>6.</td>
<td>I enjoy looking at, talking to, and being with attractive women/men</td>
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<tr>
<td>7.</td>
<td>I notice that I am losing weight</td>
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<tr>
<td>8.</td>
<td>I have trouble with constipation</td>
<td></td>
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<tr>
<td>9.</td>
<td>My heart beats faster than usual</td>
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<tr>
<td>10.</td>
<td>I get tired for no reason</td>
<td></td>
<td></td>
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<tr>
<td>11.</td>
<td>My mind is as clear as it used to be</td>
<td></td>
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<tr>
<td>12.</td>
<td>I find it easy to do the things I used to</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>13.</td>
<td>I am restless and can't keep still.</td>
<td></td>
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<tr>
<td>14.</td>
<td>I feel hopeful about the future</td>
<td></td>
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<tr>
<td>15.</td>
<td>I am more irritable than usual</td>
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<td>16.</td>
<td>I find it easy to make decisions</td>
<td></td>
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<tr>
<td>17.</td>
<td>I feel that I am useful and needed</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>18.</td>
<td>My life is pretty full</td>
<td></td>
<td></td>
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<tr>
<td>19.</td>
<td>I feel that others would be better off if I were dead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>I still enjoy the things I used to do</td>
<td></td>
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</tbody>
</table>
APPENDIX F

EATING ATTITUDES TEST
**Instructions:** Please place an (x) under the column which applies best to each of the numbered statements. All of the results will be strictly confidential. Most of the questions relate to food or eating, although other types of questions have been included. Please answer each question carefully. Thank you.

<table>
<thead>
<tr>
<th>ALWAYS</th>
<th>VERY OFTEN</th>
<th>OFTEN</th>
<th>SOMETIMES</th>
<th>RARELY</th>
<th>NEVER</th>
</tr>
</thead>
<tbody>
<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>1 Am terrified about being overweight.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>2 Avoid eating when I am hungry.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>3 Find myself preoccupied with food.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>Have gone on eating binges where I feel that I may not be able to stop.</td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>4 Cut my food into small pieces.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>5 Aware of the caloric content of foods that I eat.</td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>6 Particularly avoid foods with a high carbohydrate content (e.g. bread, potatoes, rice, etc.).</td>
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<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>7 Feel that others would prefer if I ate more.</td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>8 Vomit after I have eaten.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>9 Feel extremely guilty after eating.</td>
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<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>10 Am preoccupied with a desire to be thinner.</td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>11 Think about burning up calories when I exercise.</td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>Other people think that I am too thin.</td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>12 Engage in dieting behavior.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>13 Like my stomach to be empty.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>14 Enjoy trying rich new foods.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>15 Other people think that I am too thin.</td>
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<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>16 Eat diet foods.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>17 Eat diet foods.</td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>18 Feel that food controls my life.</td>
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<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>19 Display self control around food.</td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>Feel that others pressure me to eat.</td>
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<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>20 Give too much time and thought to food.</td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>21 Feel uncomfortable after eating sweets.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>22 Engage in dieting behavior.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>23 Like my stomach to be empty.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>24 Enjoy trying rich new foods.</td>
<td></td>
<td></td>
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<tr>
<td>( ) ( ) ( ) ( ) ( ) ( ) ( )</td>
<td>25 Have the impulse to vomit after meals.</td>
<td></td>
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</tbody>
</table>
APPENDIX G

STUDY CONSENT FORM

STUDY 1
Study Consent Form: IRB #18834

Title of investigation: Effects of Consumption of Foods and Beverages

Investigator: Barbara Rolls, Ph.D.   Telephone: 863-8481

Purpose: We are looking at the effects of consumption of various foods and beverages.

Procedure: This study involves eating lunch and breakfast in the lab for a total of 6 sessions, with a minimum of 3 days in between each session. During these meals you will be provided with a variety of foods which you may eat as little or as much as you wish. On test days, you will only be permitted to eat and drink foods that are provided to you by the lab. You may drink water between meals, but we ask that you not drink any water one hour before the next meal. Throughout the test days you will be asked to rate your hunger, thirst and other sensations. You will also be asked to rate the sensory qualities of food items throughout the sessions. You will be asked to complete a Food and Activity Diary the day before each session. You will be asked to keep the amount of food eaten at dinner the night before each session as consistent as possible and to refrain from eating or drinking (other than water) after 10:00 p.m. on the evening before each session. You will also be asked to refrain from drinking alcohol and maintain your usual activity level the night before each session and on each test day. Questionnaires at meals will ask if you have consumed any alcohol. If you are a minor and admit to alcohol use, that information will remain confidential. All foods served are commercially available.

You will complete a questionnaire about your general well being during each session. You may also be asked to rate the sensory properties (i.e. taste, texture) of various foods and to record your hunger, thirst, fullness and nausea periodically during test days. At the end of the study, you will be asked to complete two questionnaires, one about eating habits and one about the study.

If you need to cancel or miss a scheduled meal due to illness, etc. the session will need to be rescheduled. Since each participant can have a great impact on the study, it is important that you carefully adhere to the guidelines of the study. If you feel that this is not possible, please do not join the study.

If during any session you think that some factor may have influenced your behavior or responses, please notify the experimenter immediately. Since we have specific requirements for participants in this study, we reserve the right to reschedule or drop you from the study at any time. If that happens, you will be compensated for any time that you have already given to the study.

Each test meal will take approximately 30 minutes, for an approximate 1 hour each test day. It will take approximately 15 minutes to record food intake and physical activity before each session.

Risks: There are no risks involved in eating the test meals and filling out questionnaires.

Compensation: In addition to test meals, you will be paid $5.00 for each completed test day, consisting of a breakfast and lunch, for $30.00; and a $15.00 bonus if you complete all 6 test sessions, for a possible total of $45.00. Payment will not be made until the completion of the study, unless you withdraw from the study, and then you will be paid for sessions completed. If you are an employee of Penn State University, the compensation you receive for participation will be treated as taxable income and therefore taxes will be taken from the total amount. If you are not employed by Penn State University, total payments within one calendar year that exceed $600 will require the University to annually report these payments to the IRS. This may require you to claim the compensation that you receive for participation in this study as taxable income.
Benefits: You will be aiding in our understanding of human eating behavior.

Contact person: Jennifer Meengs
226 Henderson Building
University Park, PA 16802
(814) 863-8482

* If you agree to participate in this study please sign the consent form at the bottom of this page.

This is to certify that, I _____________________________, hereby agree to participate as a volunteer in this study as an authorized part of the education and research program of the Pennsylvania State University under the supervision of Barbara J. Rolls, Ph.D.

The investigation and my part in the investigation have been defined and fully explained to me on the reverse side of this consent form and I understand this explanation.

I have been given an opportunity to ask whatever questions I may have had, and all such questions and inquiries have been answered to my satisfaction. Any further questions I have may be addressed to the research assistant or Jennifer Meengs at (814)863-8482.

I understand that I am free to deny any answers to specific items or questions in interviews or questionnaires.

I understand that any data or question will remain confidential with regard to my identity.

I understand that medical care is available in the event of injury resulting from this investigation, but that neither financial compensation nor free medical treatment is provided. I also understand that I am not waiving any rights I may have against the University for injury resulting from negligence of the University or investigators.

I certify that to the best of my knowledge and belief, I have no physical condition or dietary requirements, such as food allergies or food restrictions, that would increase the risk to me or participation in the study.

I certify that I am at least 18 years of age.

I FURTHER UNDERSTAND THAT PARTICIPATION IS VOLUNTARY AND I AM FREE TO WITHDRAW MY CONSENT AND TERMINATE MY PARTICIPATION AT ANY TIME.

You may contact the Penn State University Office for Research Protections, 212 Kern Graduate Building, University Park, PA 16802, (814) 865-1775 for additional information concerning your rights as a research subject.

____________________          ____________________          ____________________
Date               Date of birth            Subject’s signature

I, the undersigned, have defined and fully explained the investigation to the above subject.

____________________                ____________________
Date            Investigator’s signature
APPENDIX H

FOOD AND ACTIVITY DIARY
Food and Activity Diary

ID ____________

Date ____________

Please record all foods and beverages that are consumed the day before your session begins. Please remember to not eat anything after 10:00pm and do not eat in a restaurant the night before your session begins. In completing this worksheet, please try to be as accurate as possible and include as much detail as you can (e.g. the brand names of foods, amounts, meal or snack times, beverages). Do not forget to include condiments such as butter, ketchup, mustard, and jelly. If you run out of spaces, please use the back of this form. Also, please leave excess spaces blank. For example, if you have not eaten an appetizer at dinner, please leave that space blank.

Breakfast - Foods and beverages (including brand names):

Time: ________________ Place: ________________

Foods: __________________________________________________________

Beverages: _______________________________________________________

Lunch - Foods and beverages (including brand names):

Time: ________________ Place: ________________

Main Dish: _______________________________________________________

Side Dishes (ex. Vegetables, salads, etc.): ____________________________

Desserts/sweets:
Beverages: ________________________________

Dinner - Foods and beverages (including brand names):

Time: _______________  Place: ____________________

Main Dish: ________________________________

Side Dishes (ex. Vegetables, salads, etc.): ________________________________

Desserts/sweets: ________________________________

Beverages:

Snack/Time Consumed:

Snack/Time Consumed:

Snack/Time Consumed:

Physical Activity

Please record all physical activity for the test day before your test session. Please remember to keep it as consistent as possible each week. Thank you.
APPENDIX I

MEAL REPORTS
Breakfast Report

Subject ID: _______________ Date: _____________ Week: ____________

1. Have you felt well in the last 24 hours?
   ___ Yes ___ No
   If no, please explain:

_____________________________________________________________________

2. Have you consumed alcohol in the last 24 hours?
   ___ Yes ___ No
   If yes, what type and how much:

_____________________________________________________________________

3. Have you taken any medication in the last 24 hours?
   ___ Yes ___ No
   If yes, what type and how much:

_____________________________________________________________________

4. Did you get a good night’s sleep last night?
   ___ Yes ___ No
   If no, please explain:

_____________________________________________________________________
Lunch Report

Subject ID: _______________ Date: _____________ Week: ____________

1. Have you felt well since your last meal in the lab?
   ___ Yes  ___ No
   If no, please explain:
   _____________________________________________________________

2. Have you consumed alcohol since your last meal in the lab?
   ___ Yes  ___ No
   If yes, what type and how much:
   _____________________________________________________________

3. Have you taken any medication since your last meal in the lab?
   ___ Yes  ___ No
   If yes, what type and how much:
   _____________________________________________________________

4. Have you consumed any foods or beverages since your last meal that were not provided by this lab?
   ___ Yes  ___ No
   If no, please indicate what food(s) and approximate amount(s):
   _____________________________________________________________
   _____________________________________________________________
   _____________________________________________________________
APPENDIX J

VISUAL ANALOG SCALES – SATIETY
How hungry do you feel right now?

Not at all _________________________________ Extremely hungry
Hungry

How thirsty do you feel right now?

Not at all _________________________________ Extremely thirsty
thirsty

How much food do you think you could consume right now?

Nothing _________________________________ A large amount
at all

How nauseated do you feel right now?

Not at all _________________________________ Extremely nauseated
nauseated

How full do you feel right now?

Not at all _________________________________ Extremely full
full
APPENDIX K

VISUAL ANALOG SCALES – PALATABILITY

STUDY 1
BEVERAGE

How pleasant is the taste of this drink right now?

Not at all ___________________________ Extremely pleasant

How pleasant is the appearance of this drink right now?

Not at all ___________________________ Extremely pleasant

How much of this drink do you think you could consume right now?

Nothing at all ___________________________ A large amount

How many calories do you think this beverage has?

No calories ___________________________ Extremely high in calories

How does the size of this serving of drink compare to your usual portion?

A lot ___________________________ A lot larger

smaller ___________________________ larger
ENTREE

How pleasant is the appearance of this food right now?

Not at all ___________________________ Extremely pleasant

How pleasant is the taste of this food right now?

Not at all ___________________________ Extremely pleasant

How much of this food do you think you could consume right now?

Nothing ___________________________ A large amount

How many calories do you think this food has?

No calories ___________________________ Extremely high in calories

How does the size of this serving of entree compare to your usual portion?

A lot ___________________________ A lot larger

smaller ___________________________
APPENDIX L

DISCHARGE QUESTIONNAIRE
Consumption of Foods and Beverages Study
Discharge Questionnaire

Use the back of this questionnaire if additional space is needed.

1. What do you think the purpose of this study was?

2. Were there any factors that affected how much food you ate?  Yes  No
   If yes, please explain:

3. Were there any factors that affected how much of the beverages you drank?  Yes  No
   If yes, please explain:

4. Were there any factors that affected what foods you chose to eat?  Yes  No
   If yes, please explain:

5. Did you notice any differences between the sessions?  Yes  No
   If yes, please explain:

6. Did you find that the food/beverage choices were appropriate?  Yes  No
   If no, please explain:

7. Do you have any specific comments about this study?  Do you have any comments that may help us with future studies?

Thanks so much for your participation!
Food Lab Staff and Students
☺
APPENDIX M

TELEPHONE SCREENING QUESTIONNAIRE

STUDY 2
Pre-screening Questionnaire

Date: _____________

Age: ___________ (range 20-45)  Date of Birth: _____________

Height: ________  Weight: ________________

Do you smoke?  No    Yes

Are you currently taking any prescription medications?  No    Yes
    If yes, what? __________________________________________________________________________

Are you currently taking any OTC medications regularly?  No    Yes
    If yes, what? __________________________________________________________________________

Are you currently dieting to gain or lose weight? No    Yes

Are you an athlete in training? No    Yes

Do you have any food allergies? No    Yes

Do you have any sugar/sweetener or sodium restrictions? No    Yes ________________

Do you have any food restrictions related to religious practices? No    Yes: ________________

Are you willing to consume a vegetable soup that contains potatoes, broccoli, cauliflower, and carrots? No    Yes

Do you like cheese tortellini in tomato sauce? No    Yes

Are you a vegetarian? No    Yes

Do you regularly eat 3 meals per day? No    Yes
    If no, what is your usual daily pattern of meals? __________________________________________________________________________

Would you refrain from drinking alcoholic beverages on the evening before your session? No    Yes

(FEMALE) Are you pregnant or breast feeding? No    Yes

Where did you hear about the study? __________________________________________________________________________

Have you participated on any other studies in our lab? No    Yes
    If yes, what study and when? __________________________________________________________________________

Are you a:   _____Penn State Student    _____Undergraduate
               _____Penn State Staff   _____Graduate
               _____State College Resident   ________Major

Name: ___________________________________  Phone (H): ______________________
    (W): ______________________________
APPENDIX N

QUESTIONNAIRE CONSENT FORM

STUDY 2
Title of Investigation: Effects of the Consumption of Foods and Beverages at Lunch

Investigator: Barbara Rolls, Ph.D.
226 Henderson Building
814-863-8481
bjr4@psu.edu

Contact Person: Julie Flood
226 Henderson Building
University Park, PA 16802
814-863-8482

Purpose of today's visit: To determine if you meet the criteria to be a participant in this laboratory’s human ingestive behavior studies.

Procedure: It will take you approximately 45 minutes to complete this packet of questionnaires. These questionnaires are to determine whether or not the studies conducted at our laboratory are appropriate for you. You will be weighed and your height measured. Our studies require a considerable amount of preparation and, in order to assure reliable results for the studies, it is very important that participants fulfill all criteria of the studies.

Because of strict subject criteria, it may be determined that we cannot have you participate in the current study. There are a variety of reasons why an individual may not be chosen for a particular study. Often the number of responses from potential participants exceeds the number of individuals needed for the study. If you are not chosen to participate at this time, your information will be kept on file and you may be called later to participate in another study.

Risks: There are minimal risks associated with participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort. If at any time you feel uncomfortable completing any of the surveys, please feel free to discontinue survey completion.

If, as a result of filling in the questionnaires, you feel that you would benefit from individual counseling, you may contact:

Psychological Clinic of the Penn State University
314 Moore Building
University Park, PA 16802
Phone: (814) 865-2191

Your responses to the questionnaires will be reviewed by a staff member. If any of the questionnaires indicate that you may benefit from professional treatment (i.e. counseling or
physician's care), you will be notified by a staff member via telephone within 3 days of
review of your questionnaire packet.

**Benefits:** If you qualify to become a participant in a study at the Human Ingestive Behavior
Laboratory, you will be contributing to our understanding of human eating behavior.

You will not receive any compensation for this part of the study.

Data and questions will remain confidential with regard to your identity. All data collected
during this pre-screening section will be kept in locked and secure storage locations within the
laboratory. The Office for Research Protections and the Biomedical Institutional Review Board
may review records related to this project.

Medical care is available in the event of injury resulting from this investigation, but neither
financial compensation nor free medical treatment is provided. You are not waiving any rights
that you may have against the University for injury resulting from negligence of the University
or investigators.

To the best of your knowledge and belief, you have no physical condition or dietary
requirements, such as food allergies or food restrictions that would increase the risk of
participation in this investigation.

**YOUR PARTICIPATION IS VOLUNTARY.** YOU ARE FREE TO WITHDRAW YOUR
CONSENT AND TERMINATE PARTICIPATION AT ANY TIME. YOU DO NOT HAVE
TO ANSWER ANY QUESTIONS YOU DO NOT WANT TO.

You must be 18 years of age or older to take part in this research study.
If you agree to take part in this research study and the information outlined above, please sign
your name and indicate the date below.
You will be given a copy of this signed and dated consent for your records.

<table>
<thead>
<tr>
<th>Date</th>
<th>Date of Birth</th>
<th>Subject's Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Person Obtaining Consent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*You may contact the Penn State University Office for Research Protections, 212 Kern Graduate
Building, University Park, PA 16802, (814) 865-1775 for additional information concerning
your rights as a research subject.*
APPENDIX O

STUDY CONSENT FORM

STUDY 2
Title of Investigation: Effects of the Consumption of Foods and Beverages at Lunch

Principal Investigator: Barbara J. Rolls, Ph.D.
226 Henderson Building
814-863-8482

Other Investigator(s): Jennifer Meengs and Julie Flood
226 Henderson Building
814-863-8482

1. Purpose of the study: The purpose of this research is to investigate the effects of consuming various foods and beverages at a lunch meal.

2. Procedures to be followed: You will be asked to eat breakfast and lunch in our lab on 5 different test days. At the beginning of each lunch meal, you will be asked to consume a serving of vegetable soup in full. You will then be served a lunch meal, of which you may eat as little or as much as you wish. On test days, you will only be permitted to eat and drink foods that are provided to you by the lab until after the lunch meal. You may drink water between breakfast and lunch, but we ask that you not drink any water one hour before lunch. Throughout the test days you will be asked to rate your hunger, thirst and other sensations. You will also be asked to rate the sensory qualities of food items, such as taste and appearance, throughout the sessions. You will be asked to complete a Food and Activity Diary the day before each test day. You will be asked to keep the amount of food eaten at dinner the night before each test session as consistent as possible each week and to refrain from eating or drinking (other than water) after 10:00 p.m. on the evening before each test day. You will also be asked to refrain from drinking alcohol and maintain your usual activity level the night before and the day of each testing session. Questionnaires at meals will ask if you have consumed any alcohol. If you are a minor and admit to alcohol use, that information will remain confidential. All foods served are commercially available.

You will complete a questionnaire about your general well being during each session. You may also be asked to rate the sensory properties (i.e. taste, texture) of various foods and to record your hunger, thirst, fullness and nausea periodically during test days. At the end of the study, you will be asked to complete two questionnaires, one about eating habits and one about the study.

Since each participant can have a great impact on the study, it is important that you carefully adhere to the guidelines of the study. If you feel that this is not possible, please do not join the study.

If, during any session, you think that some factor may have influenced your behavior or responses, please notify the experimenter immediately. Since we have specific requirements for participants in this study, we reserve the right to reschedule or drop you from the study at any time. If that happens, you will be compensated for any time that you have already given to the study.

3. Discomforts and risks: There are no risks involved in eating the test meals and filling out questionnaires. It may be possible that someone could have an allergic reaction to one of the food items or food item ingredients, but this risk is minimized by providing all subjects with a food list prior to beginning the study, and by asking questions regarding allergies during the screening process. There is also a risk of embarrassment, stress, or psychological distress when filling out screening questionnaires. However, individuals are free to discontinue participation at any time, including during the screening process if they become uncomfortable.
4. Benefits: You will be aiding in our understanding of human eating behavior.

5. Duration/time of the procedures and study: Each test meal will take approximately 30 minutes, for an approximate 1 hour each test day. It will take approximately 15 minutes to record food intake and physical activity before each test day. The entire study will take an approximate total of 8 hours to complete.

6. Statement of confidentiality: Your participation in this research is confidential. You will be identified by subject number and an assigned dot color. Only the investigator and her assistants will have access to your identity and to information that can be associated with your identity. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. The Office for Research Protections and the Biomedical Institutional Review Board (IRB) may review records related to this project.

7. Right to ask questions: You can ask questions about this research. Contact Jennifer Meengs at 863-8482 with questions. If you have questions about your rights as a research participant, contact The Pennsylvania State University’s Office for Research Protections at (814) 865-1775.

8. Compensation: In addition to test meals, you will be paid $7.00 for each completed test day, consisting of a breakfast and lunch, for a total of $25; and a $15 bonus if you complete all 5 test sessions for a total of $50.00. Payment will not be made until the completion of the study, unless you withdraw from the study, and then you will be paid for sessions completed. If you are an employee of Penn State University, the compensation you receive for participation will be treated as taxable income and therefore taxes will be taken from the total amount. If you are not employed by Penn State University, total payments within one calendar year that exceed $600 will require the University to annually report these payments to the IRS. This may require you to claim the compensation that you receive for participation in this study as taxable income. There is no compensation for screening activities.

9. Voluntary participation: Participation is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Since we have specific requirements for participants in this study, we reserve the right to reschedule or drop you from the study at any time. If that happens, you will be compensated for any time that you have already given to the study.

10. Injury Clause: In the unlikely event you become injured as a result of your participation in this study, medical care is available but neither financial compensation nor free medical treatment is provided. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent for your records.

______________________________________________  _____________________
Participant Signature       Date

_____________________________________________  _____________________
Person Obtaining Consent      Date
APPENDIX P

VISUAL ANALOG SCALES – PALATABILITY

STUDY 2
**SOUP**

How pleasant is the taste of this food right now?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Extremely pleasant</th>
</tr>
</thead>
</table>

How pleasant is the appearance of this food right now?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Extremely pleasant</th>
</tr>
</thead>
</table>

How much of this food do you think you could consume right now?

<table>
<thead>
<tr>
<th>Nothing at all</th>
<th>A large amount</th>
</tr>
</thead>
</table>

How many calories do you think this food has?

<table>
<thead>
<tr>
<th>No calories at all</th>
<th>Extremely high in calories</th>
</tr>
</thead>
</table>

How does the size of this serving of entree compare to your usual portion?

<table>
<thead>
<tr>
<th>A lot smaller</th>
<th>A lot larger</th>
</tr>
</thead>
</table>
ENTREE

How pleasant is the appearance of this food right now?

Not at all _______________________________ Extremely pleasant

How pleasant is the taste of this food right now?

Not at all _______________________________ Extremely pleasant

How much of this food do you think you could consume right now?

Nothing _______________________________ A large amount

How many calories do you think this food has?

No calories _______________________________ Extremely high in calories

How does the size of this serving of entree compare to your usual portion?

A lot _______________________________ A lot larger

smaller _______________________________
APPENDIX Q

DISCHARGE QUESTIONNAIRE

STUDY 2
Consumption of Foods and Beverages Study
Discharge Questionnaire

1. What do you think the purpose of this study was?

2. Were there any factors that affected how much food you ate? Yes No
   If yes, please explain:

3. Did you notice any differences between the sessions? Yes No
   If yes, please explain:

4. Did you find that the food/beverage choices were appropriate? Yes No
   If no, please explain:

5. How many times per month do you consume the following?
   Soup (any kind) ________
   Broth-based Soup (ex. Chicken noodle) ________
   Cream-based Soup (ex. Chowder) ________
   Pureed Soup (ex. Tomato) ________

6. Do you have any specific comments about this study? Do you have any comments that may help us with future studies?

Thanks so much for your participation!
Food Lab Staff and Students
APPENDIX R

TELEPHONE SCREENING QUESTIONNAIRE

STUDY 3
Pre-screening Questionnaire

Date: _____________

Age: __________ (range 20-45)  Date of Birth: _____________

Height: _______  Weight: ______________

Do you smoke?  No  Yes

Are you currently taking any prescription medications?  No  Yes
If yes, what?  ______________________________

Are you currently taking any OTC medications regularly?  No  Yes
If yes, what?  ______________________________

Are you currently dieting to gain or lose weight?  No  Yes

Are you an athlete in training?  No  Yes

Do you have any food allergies?  No  Yes

Do you have any sugar/sweetener restrictions?  No  Yes

Do you have any sodium restrictions?  No  Yes  ______________

Do you have any food restrictions related to religious practices?  No  Yes:  ______________________

Are you willing to consume apples, applesauce, and apple juice?

Do you regularly eat 3 meals per day?  No  Yes
If no, what is your usual daily pattern of meals?  ______________________________

Would you refrain from drinking alcoholic beverages on the evening before and the day of your session?  
No  Yes

(FEMALE) Are you pregnant or breast feeding?  No  Yes

Where did you hear about the study?  ______________________________

Have you participated on any other studies in our lab?  No  Yes
If yes, what study and when?  ______________________________

Are you a:  _____Penn State Student  _____Undergraduate
     _____Penn State Staff  _____Graduate
     _____State College Resident  _______________  Major

**************************************************************************************************

Name: ___________________________  Phone (H): ______________________
(W): __________________________

**************************************************************************************************
APPENDIX S

QUESTIONNAIRE CONSENT FORM

STUDY 3
Questionnaire Consent Form
The Pennsylvania State University

Title of Investigation:  *Effects of the Consumption of Foods and Beverages at Lunch*

Investigator:  Julie Flood  
Barbara Rolls, Ph.D.  
226 Henderson Building  
814-863-8481  
bjr4@psu.edu

Contact Person:  Julie Flood  
226 Henderson Building  
University Park, PA  16802  
814-863-8482

Purpose of today's visit:  To determine if you meet the criteria to be a participant in this laboratory’s human ingestive behavior studies.

Procedure:  It will take you approximately 45 minutes to complete this packet of questionnaires. These questionnaires are to determine whether or not the studies conducted at our laboratory are appropriate for you. You will be weighed and your height measured. Our studies require a considerable amount of preparation and, in order to assure reliable results for the studies, it is very important that participants fulfill all criteria of the studies.

Because of strict subject criteria, it may be determined that we cannot have you participate in the current study. There are a variety of reasons why an individual may not be chosen for a particular study. Often the number of responses from potential participants exceeds the number of individuals needed for the study. If you are not chosen to participate at this time, your information will be kept on file and you may be called later to participate in another study.

Risks:  There are minimal risks associated with participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort. If at any time you feel uncomfortable completing any of the surveys, please feel free to discontinue survey completion.

If, as a result of filling in the questionnaires, you feel that you would benefit from individual counseling, you may contact:

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<tr>
<td>314 Moore Building</td>
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<td>University Park, PA 16802</td>
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<td>Phone: (814) 865-2191</td>
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Your responses to the questionnaires will be reviewed by a staff member. If any of the questionnaires indicate that you may benefit from professional treatment (i.e. counseling or...
physician's care), you will be notified by a staff member via telephone within 3 days of review of your questionnaire packet.

**Benefits:** If you qualify to become a participant in a study at the Human Ingestive Behavior Laboratory, you will be contributing to our understanding of human eating behavior.

You will not receive any compensation for this part of the study.

Data and questions will remain confidential with regard to your identity. All data collected during this pre-screening section will be kept in locked and secure storage locations within the laboratory. The Office for Research Protections and the Biomedical Institutional Review Board may review records related to this project.

Medical care is available in the event of injury resulting from this investigation, but neither financial compensation nor free medical treatment is provided. You are not waiving any rights that you may have against the University for injury resulting from negligence of the University or investigators.

To the best of your knowledge and belief, you have no physical condition or dietary requirements, such as food allergies or food restrictions that would increase the risk of participation in this investigation.

**YOUR PARTICIPATION IS VOLUNTARY. YOU ARE FREE TO WITHDRAW YOUR CONSENT AND TERMINATE PARTICIPATION AT ANY TIME. YOU DO NOT HAVE TO ANSWER ANY QUESTIONS YOU DO NOT WANT TO.**

You must be 18 years of age or older to take part in this research study.

If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent for your records.

_________________________________________  ___________________________  ___________________________
Date                  Date of Birth               Subject's Signature

_________________________________________  ___________________________
Date                  Person Obtaining Consent

You may contact the Penn State University Office for Research Protections, 212 Kern Graduate Building, University Park, PA 16802, (814) 865-1775 for additional information concerning your rights as a research subject.
APPENDIX T

STUDY CONSENT FORM

STUDY 3
Title of Investigation: Effects of the Consumption of Foods and Beverages at Lunch
Principal Investigator: Julie Flood
Barbara J. Rolls, Ph.D.
226 Henderson Building
814-863-8482
Other Investigator(s): Jennifer Meengs
226 Henderson Building
814-863-8482

1. Purpose of the study: The purpose of this research is to investigate the effects of consuming various foods and beverages at a lunch meal.

2. Procedures to be followed: You will be asked to eat breakfast and lunch in our lab on 5 different test days. At the beginning of each lunch meal, you will be asked to consume a serving of apples, applesauce, or apple juice in full. You will then be served a lunch meal, of which you may eat as little or as much as you wish. On test days, you will only be permitted to eat and drink foods that are provided to you by the lab until after the lunch meal. You may drink water between breakfast and lunch, but we ask that you not drink any water one hour before lunch. Throughout the test days you will be asked to rate your hunger, thirst and other sensations. You will also be asked to rate the sensory qualities of food items, such as taste and appearance, throughout the sessions. You will be asked to complete a Food and Activity Diary the day before each test day. You will be asked to keep the amount of food eaten at dinner the night before each test session as consistent as possible each week and to refrain from eating or drinking (other than water) after 10:00 p.m. on the evening before each test day. You will also be asked to refrain from drinking alcohol and maintain your usual activity level the night before and the day of each testing session. Questionnaires at meals will ask if you have consumed any alcohol. If you are a minor and admit to alcohol use, that information will remain confidential. All foods served are commercially available.

You will complete a questionnaire about your general well being during each session. You may also be asked to rate the sensory properties (i.e. taste, texture) of various foods and to record your hunger, thirst, fullness and nausea periodically during test days. At the end of the study, you will be asked to complete two questionnaires, one about eating habits and one about the study.

Since each participant can have a great impact on the study, it is important that you carefully adhere to the guidelines of the study. If you feel that this is not possible, please do not join the study. If, during any session, you think that some factor may have influenced your behavior or responses, please notify the experimenter immediately. Since we have specific requirements for participants in this study, we reserve the right to reschedule or drop you from the study at any time. If that happens, you will be compensated for any time that you have already given to the study.

3. Discomforts and risks: There are no risks involved in eating the test meals and filling out questionnaires. It may be possible that someone could have an allergic reaction to one of the food items or food item ingredients, but this risk is minimized by providing all subjects with a food list prior to beginning the study, and by asking questions regarding allergies during the screening process. There is also a risk of embarrassment, stress, or psychological distress when filling out screening questionnaires. However, individuals are free to discontinue participation at any time, including during the screening process if they become uncomfortable.
4. **Benefits:** You will be aiding in our understanding of human eating behavior.

5. **Duration/time of the procedures and study:** Each test meal will take approximately 30 minutes, for an approximate 1 hour each test day. It will take approximately 15 minutes to record food intake and physical activity before each test day. The entire study will take an approximate total of 8 hours to complete.

6. **Statement of confidentiality:** Your participation in this research is confidential. You will be identified by subject number and an assigned dot color. Only the investigator and her assistants will have access to your identity and to information that can be associated with your identity. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. The Office for Research Protections and the Biomedical Institutional Review Board (IRB) may review records related to this project.

7. **Right to ask questions:** You can ask questions about this research. Contact Jennifer Meengs at 863-8482 with questions. If you have questions about your rights as a research participant, contact The Pennsylvania State University’s Office for Research Protections at (814) 865-1775.

8. **Compensation:** In addition to test meals, you will be paid $7.00 for each completed test day, consisting of a breakfast and lunch, for a total of $25; and a $15 bonus if you complete all 5 test sessions for a total of $50.00. Payment will not be made until the completion of the study, unless you withdraw from the study, and then you will be paid for sessions completed. If you are an employee of Penn State University, the compensation you receive for participation will be treated as taxable income and therefore taxes will be taken from the total amount. If you are not employed by Penn State University, total payments within one calendar year that exceed $600 will require the University to annually report these payments to the IRS. This may require you to claim the compensation that you receive for participation in this study as taxable income. There is no compensation for screening activities.

9. **Voluntary participation:** Participation is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Since we have specific requirements for participants in this study, we reserve the right to reschedule or drop you from the study at any time. If that happens, you will be compensated for any time that you have already given to the study.

10. **Injury Clause:** In the unlikely event you become injured as a result of your participation in this study, medical care is available but neither financial compensation nor free medical treatment is provided. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below. You will be given a copy of this signed and dated consent for your records.

____________________________________________  _____________________
Participant Signature       Date

____________________________________________  _____________________
Person Obtaining Consent      Date
APPENDIX U

VISUAL ANALOG SCALES – PALATABILITY

STUDY 3
PRELOAD

How pleasant is the taste of this food right now?
Not at all _____________________________ Extremely pleasant

How many calories do you think this food has?
No calories at all _____________________________ Extremely high in calories

How filling do you think this food will be?
Not filling at all _____________________________ Extremely filling

ENTREE

How pleasant is the appearance of this food right now?
Not at all _____________________________ Extremely pleasant

How pleasant is the taste of this food right now?
Not at all _____________________________ Extremely pleasant

How many calories do you think this food has?
No calories at all _____________________________ Extremely high in calories
Vita

Julie Elisabeth Flood

EDUCATION

2007 The Pennsylvania State University, PhD, Nutritional Sciences, University Park, PA

2003 Brown University, B.A. Biology, B.A. Modern United States History, Providence, RI

PROFESSIONAL EXPERIENCE

2003-Present The Pennsylvania State University, University Park, PA
Graduate Student under Dr. Barbara Rolls, The Food Lab

2003 The Pennsylvania State University, University Park, PA
Graduate Research Assistant under Dr. Leanne Birch

2001 Rhode Island Memorial Hospital: Brown University Medical School, Pawtucket, RI
Research Assistant: Center for Primary Care and Prevention, Nutrition Academic Award

TEACHING EXPERIENCE


HONORS AND AWARDS

Award, The Nina V. Federoff Teaching Assistant Award, The Pennsylvania State University, 2004
Representative, College of Health and Human Development Graduate Student Association, The Pennsylvania State University, 2005-2007
Treasurer, Nutrition Graduate Student Association, The Pennsylvania State University, 2004-2005

PUBLICATIONS

Flood JE, Rolls BJ. Whole fruit increases satiety more than fruit juice. Submitted.

Flood JE, Rolls BJ. Does changing the form of soup affect energy intake and satiety? Experimental Biology 2007, Abstract (Oral presentation).

Flood JE, Rolls BJ. Does changing the form of soup affect energy intake and satiety? Appetite. In press.


