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FACTORS THAT MODERATE ENERGY INTAKE: INVESTIGATING PROTEIN, ENERGY DENSITY AND PRE-PORTIONED ENTRÉES

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ABSTRACT

The rates of overweight and obesity in America continue to increase along with the need for effective dietary strategies that can help people to reduce energy intake, enhance satiety, and facilitate weight management. Research has suggested strategies such as consuming a high protein diet, reducing dietary energy density, or consuming pre-portioned meals to help lower energy intake. The literature testing these strategies, however, is either inconsistent or incomplete. A series of studies have been conducted that examine the effects of these strategies on energy intake in order to provide better recommendations for controlling energy intake.

The purpose of Study 1 was to determine whether increasing the protein content of meals reduced daily energy intake and enhanced satiety. The satiating effects of protein were investigated by varying the protein content of meals consumed *ad libitum* across a range of commonly consumed amounts over a day. In this crossover experiment, 18 normal-weight women consumed *ad libitum* lunch and dinner entrées one day a week that were covertly varied in protein content (10, 15, 20, 25, or 30% energy). Entrées were manipulated by substituting animal protein for starchy ingredients and were matched for energy density, fat content, palatability, and appearance. Unmanipulated breakfasts and evening snacks were consumed *ad libitum*. Participants rated their hunger and fullness before and after meals as well as the taste and appearance of entrées. Results showed that mean 24-hour protein intake increased significantly across conditions, from 44±2 g/d in the 10% protein condition to 82±6 g/d in the 30% condition. Daily energy intake, however, did not differ significantly across the 10% to 30% protein conditions (means 1870±93, 1887±93, 1848±111, 1876±100, and 1807±98 kcal). There were no significant differences in hunger and fullness ratings across conditions or in taste and appearance ratings of the manipulated entrées.

Study 2 tested the recommendation of substituting low-energy-dense foods (vegetables) for foods higher in energy density to reduce energy intake. Puréed vegetables were incorporated into entrées at multiple meals to decrease the energy density and the effects on daily energy and vegetable intakes were investigated. In this crossover study, 20 men and 21 women ate *ad libitum* breakfast, lunch, and dinner in the laboratory once a week for three weeks. Across conditions, entrées at meals were varied in energy density (100%, 85%, or 75%) by covertly incorporating 3 or 4.5 times the amount of puréed vegetables. Entrées were accompanied by unmanipulated side dishes. Participants rated their hunger and fullness before and after meals. The results showed that subjects consumed a consistent weight of food across conditions of energy density; thus, daily energy intake significantly decreased by 202±60 kcal in the 85% condition ($p<0.001$) and 357±47 kcal in the 75% condition ($p<0.0001$). Daily vegetable consumption significantly increased from 270±17 g in the 100% condition to 487±25 g in the 75% condition ($p<0.0001$). Despite differences in energy intake, ratings of hunger and fullness did not differ significantly across conditions. Entrées were rated similar in palatability across conditions.

Study 3 determined how the effects of energy density and energy content of pre-portioned entrées combine to influence daily energy intake. In a crossover design, 28 men and 40 women were provided with breakfast, lunch, and dinner on one day a week for 4 weeks. Each meal included a compulsory, manipulated pre-portioned entrée and a variety of unmanipulated discretionary foods that were consumed *ad libitum*. Across the 4 weeks, the entrées were varied in both energy density and energy content between a standard level (100%) and a reduced level (64%). In men, reducing both the energy density and the energy content of the pre-portioned entrées led to independent decreases in total meal energy intake (both $p<0.01$). A 36% decrease in energy density led to a 6% decrease in energy intake (154±46 kcal), and a 36% decrease in energy content led to an 11% decrease in energy intake (291±75 kcal). Thus, decreases in the energy density and energy content of pre-portioned entrées acted independently and added together to reduce total meal energy intake. Women showed similar effects on daily energy intake as men, however, this outcome was influenced by the interaction of energy density and energy content to reduce total meal energy intake ($p<0.01$).

The findings from these studies suggest that energy density plays a major role in the regulation of energy intake. When energy density is held constant, variations in the protein content of entrées consumed *ad libitum* are not likely to influence daily energy intake or affect ratings of satiety. On the other hand, variations in energy density lead to changes in energy intake and may influence satiety. One way to reduce energy density is by increasing the amount of vegetables or fruits in foods. Puréed vegetables can be incorporated into various sweet and savory foods in large amounts; a strategy that can not only reduce energy intake, but can also increase vegetable intake without increasing hunger. A reduction in energy intake can also be found when the fruit and vegetable content of pre-portioned entrées is increased. Furthermore, reducing the energy density in addition to reducing the energy content leads to further decreases energy intake while maintaining satiety. In summary, the results of these studies support the recommendation of decreasing energy density, but not increasing protein content, to reduce energy intake and make an impact on the growing rates of obesity.

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Chapter 1

Introduction

The prevalence of overweight and obesity continues to increase, currently representing 68% of the American adult population.[1] Being overweight has been associated with an increased risk for various health conditions such as heart disease, diabetes, sleep apnea, and osteoarthritis.[2] One contributing factor to rising rates of overweight and obesity is excessive energy intake which makes reducing energy intake an important component in weight management. People over-eat for various biological, genetic, or cultural reasons, but a major contributor is the influence of the environment. Along with decreases in physical activity, the accessibility to large portions of inexpensive, high energy-dense foods has increased.[3] Losing body weight can greatly reduce the risk of chronic diseases and promote health[2]; however, effective strategies are needed to help people reduce energy intake while enhancing or maintaining satiety.

There are a variety of strategies that claim to reduce energy intake or enhance satiety including increasing protein intake, reducing energy density, and consuming pre-portioned foods. Research has suggested that protein is the most satiating macronutrient[4], however, there is limited research investigating the effects of an increased protein intake on energy intake and satiety when foods are consumed *ad libitum*. Another strategy is decreasing the energy density of foods, such as reducing the fat content or increasing the vegetable content, which has been shown to reduce energy intake.[5] The incorporation of puréed vegetables into food to reduce the energy density may be a method that not only reduces energy intake, but also increases vegetable intake. Pre-portioned foods are commonly consumed and have been shown to be an effective strategy for weight loss.[6] There is little evidence, however, suggesting how the energy content and energy density of these foods influence energy intake and satiety. This dissertation encompasses three studies that examine the effects of increasing the protein content of foods, reducing the energy density of foods with puréed vegetables, and varying the energy content and energy density of pre-portioned entrées on energy intake and satiety.

PROTEIN

In the average American adult diet, 14-16% of energy consumed is from protein, an intake equivalent to 65-100 grams of protein per day.[7] This amount of protein falls within Acceptable Macronutrient Distribution Range (AMDR) for protein of 10-35% of energy, which is defined as the range "associated with reduced risk of chronic disease while providing intakes of essential nutrients". Protein intakes greater than this range, however, increases the potential risk of chronic diseases. The Recommended Dietary Allowance for protein is currently set at the lower end of the AMDR at 0.8 grams of protein per kilogram of ideal body weight.[8] The average American consumes 1.0-1.5 g/kg ideal body weight.[7] In studies that investigate the effects of protein, meals or diets with a protein content of 10-15% of energy is often defined as "normal" or "adequate" protein and a high protein meal or diet is typically considered anything greater than 15% of energy.[9] High protein meals have been shown to reduce energy intake, however, when reviewing studies that test variations in the protein content of foods on energy intake and satiety, it is critical to compare amounts of protein tested to the amounts of protein recommended for health. The amounts of protein tested in studies, in addition to other factors, will be discussed.

Effects of protein on satiety

It has been suggested that protein is the most satiating macronutrient compared to iso-caloric amounts of carbohydrate or fat[4, 9] and that consuming a high protein meal enhances satiety and reduces energy intake.[10-14] This suggestion is based primarily on studies that used a preloading design testing the effects of a compulsory amount of food on subsequent energy intake after an interval of time. Satiety is also measured using subjective ratings of hunger and fullness at particular time intervals after the preload is consumed. A summary of studies investigating the satiating effects of protein can be found in **Table 1-1**. Although several of these studies have found satiating effects of protein[10-14], many other studies have not. Some of these inconsistencies may be explained by differences in methodology between studies. For example, the type of preload can vary from liquid beverages to solid meals, the amount of protein tested can range from 20 to 145 grams, the source of protein tested can vary from whole meat sources (i.e. chicken) to dry protein isolates added to foods (i.e. whey), and the time period in which these preloads are investigated can range from minutes to days.

Studies investigating the satiating effects of protein preloads can be categorized into several topics including liquid beverages, and solid foods or meals; there are advantages and disadvantages to these different types of preloads. In studies that manipulate the protein content of beverages, the manipulation is often covert and energy density is matched, suggesting that the effects are due to variations in the protein content. Research has suggested, however, that beverages have weaker satiating capacities compared to solid foods[15, 16] and may actually add to energy intake.[17] This is evidenced in several studies that compared high protein beverages to low protein beverages and found that subsequent energy intake was lower following the high-protein beverage; however, when the energy content from the preload was included, total energy intake was higher.[18, 19] Additionally, the effect on ratings of satiety was often not different.

Conversely, in studies that test the satiating effects of preloads comprised of solid foods or meals, there are often obvious differences in the amount of meat, the foods are entirely different, or the energy density varies. For example, one study compared meatballs to baked macaroni[14] and another study compared an egg meal to a bagel meal.[10, 11] These differences in appearance, palatability, or energy density are problematic because they may independently influence satiety and energy intake.[20-23] In a study that matched the energy density, for example, there were no differences in subsequent energy intake or satiety between the meals that were higher or lower in protein content.[24]

In addition to differences in the type of preload, the protein content of preloads varies widely and is often greater than a person needs to consume over one day. Furthermore, there is no pattern to the amount of protein that enhances satiety. For example, one study compared a low-protein meal with 15% of energy from protein to a high-protein meal with 31% of energy from protein and found enhanced ratings of satiety.[25] Another study, however, compared a low-protein meal with 15% of energy from protein to a high-protein meal with 54% of energy from protein and found no differences in ratings of satiety.[26] Effects on subsequent energy intake also vary; a meal with 21% of energy from protein was found to reduce subsequent energy intake by 22%[11], whereas a meal with 59% of energy from protein did not influence energy intake.[27]

Studies on protein have tested various sources of protein ranging from commonly consumed mixed protein sources such as meat and dairy products[10, 11, 14, 25, 26] to less commonly consumed powdered protein isolates such as whey or casein.[28-30] Most studies that test liquid preloads use the powdered sources of protein because they can be easily absorbed and are easy to manipulate. The effects of different isolated protein sources on satiety, however, are inconsistent.[31-33] Additionally, because most individuals consume a diet with mixed protein sources, it is difficult to extrapolate the findings from these studies to a free-living environment.

The time period in which satiety is measured after a high- or low-protein preload is consumed varies from 30 minutes[29] to greater than 24 hours[34] and varies with no defined pattern. Several studies even showed an effect on ratings of satiety, but no effect on energy intake, or vice versa.[26, 27, 32] The most consistent results, however, have come from studies that investigated the effect of protein on satiety in a controlled environment where participants were fed a high- or low-protein diet in energy balance over a day and feelings of satiety were measured. Several of these studies compared high-protein diets with 30% energy to adequate-protein diets with 10% energy and consistently found enhanced ratings of satiety.[34-38] There are several advantages to these studies: the amount of protein tested fell within recommended ranges and the sources of protein were from commonly consumed mixed protein sources. However, because the meals in these studies were compulsory, it is not known how consistently consuming high protein meals composed of mixed protein sources influences energy intake. Few studies have extended study designs such as these and tested the effects on satiation.

Effects of protein on satiation

Satiation is defined as the process that brings eating to an end during a meal and is tested by measuring *ad libitum* energy intake. In satiation studies, participants are provided with a manipulated food and instructed to consume the food *ad libitum*, or until they feel comfortably full. The effect of the manipulation on satiation is determined by the amount of food and energy consumed within the meal.[39] Similar to preloading studies, in satiation studies, it is important that factors such as palatability and appearance are similar so they do not influence intake.[22, 23] For example, if participants prefer the taste or appearance of a food in one condition, they may consume more of that food. To help disguise the manipulation, the foods served are often mixed dishes and the ingredients are chopped so that each bite of the food is uniform.

Compared to preloading studies, satiation studies are more representative of a free-living environment because participants are not required to consume a compulsory amount of food. Unfortunately, little is known about the effect of consuming a high-protein meal on *ad libitum* energy intake. The few satiation studies on protein found that consuming high-protein meals reduced energy intake.[26, 40] These studies, however, are not without limitations. In one study, an isolated source of protein (calcium caseinate) was incorporated into the food and the total amount of protein in the food was not described.[40] Another study compared two meals that not only varied in protein content but also varied in energy density with the high protein meal lower in energy density than the low-protein meal. The effect on energy intake from the increased protein content cannot be disentangled from the reduction in energy density. Additionally, the high protein meal contained 55 grams of protein or 54% of energy, an amount that exceeds recommendations for many individuals.[26] The limitations in these few studies make it difficult to conclude how varying the protein content of foods made with mixed protein sources influences *ad libitum* energy intake.

An investigation is needed to determine whether increasing protein intake should be recommended as a strategy to reduce energy intake and enhance satiety. It is imperative, however, that this investigation be applicable among free-living individuals by: 1) testing amounts of protein within recommendations, 2) using commonly consumed sources of protein, 3) allowing *ad libitum* consumption, and 4) testing multiple meals over one day. In addition to applicability, the investigation should also control for known factors that may influence intake including the energy density, palatability, and texture of the meals. Finally, the protein manipulations should be covert in order to prevent preconceived notions about protein from influencing intake; this is especially important when testing foods consumed *ad libitum*.

ENERGY DENSITY

Methods to modify energy density

Energy density is defined as the amount of energy in a given weight of food (kcal/g) and is highly influenced by the macronutrient and moisture content of a food. The macronutrient fat (9 kcal/g) and water (0 kcal/g) are most influential on energy density while the macronutrients carbohydrate and protein (both 4 kcal/g) have a moderate influence. Thus, there are several ways to lower the energy density of a food including reducing the amount of fat or sugar or increasing the amount of water or water-rich fruits and vegetables.[5] Experimental studies have investigated the effects of energy density on satiety and satiation using one or a combination of these methods (**Table 1-2**).

Effects of energy density on satiety

The effects of energy density on satiety have been investigated by manipulating the water content of preloads as well as manipulating a combination of the vegetable and fat contents of preloads. The effects of these different energy density manipulations on satiety, however, are dependent on other properties of food that influence satiety. For example, increasing the water content of a preload to reduce energy density increases the weight or volume. Although this strategy has been shown to reduce energy intake and enhance satiety[41-43], the mechanisms underlying this effect are complicated and not yet fully understood. It has been postulated that some of these mechanisms may be related to cognitive and orosensory factors or physiological controls involving gastric distention and gastric emptying.[44] The complexity of these mechanisms is evidenced by a study in which participants consumed either a chicken rice casserole (1.03 kcal/g), a chicken rice casserole with a glass of water (as a beverage), or a chicken rice casserole with the same amount of water incorporated into the casserole to make a soup (0.44 kcal/g). Consuming the soup reduced energy intake and enhanced satiety whereas consuming the casserole with a glass of water as a beverage had no additional effect; this suggests that satiety is more affected when water is incorporated into a food rather than when consumed as a beverage.[43] The effect of consuming a salad varying in energy density and portion size has also been investigated; energy density was manipulated by altering the fat content as well as the vegetable content. The salads lowest in energy density reduced total energy intake at the meal and enhanced satiety compared to when no salad preload was served.[45] Although the satiety enhancing mechanisms related to energy density remain complex, the consumption of a first course, such as a soup or salad, which is reduced in energy density by adjusting the amount of water, fat, or vegetables, is a strategy that can help to moderate energy intake within a meal.

Effects of energy density on satiation

Separating energy density and macronutrients

Previous studies have shown that reducing energy density by decreasing fat reduces energy intake[46, 47]; however, it was difficult to differentiate whether the effects were due to the reduction in energy density or the reduction in fat content. In order to separate the effects, the energy density and fat content must be examined independently which requires adjustments in fat content as well as other methods of reducing energy density. For example, one study compared entrées that were low-fat of low energy density, low-fat of high energy density, and high-fat of high energy density. In the two low-fat conditions, energy density was manipulated by adjusting the ratio of vegetables to pasta.[21] This study and several others found that energy density, but not fat, affected energy intake, concluding that dietary energy density has a greater effect on energy intake than the macronutrient content.[48, 49] This has been confirmed in (1) studies that held energy density constant while adjusting the macronutrient content and found no effect on energy intake[24, 27, 50], and (2) in studies that held the macronutrient content constant and varied energy density and found energy intake was positively associated with energy density.[51-53]

Reducing energy density with a combination of methods

Reducing the energy density of a food, regardless of the method, typically results in the food changing in palatability or texture, two factors previously discussed that may influence energy intake.[22, 23] To minimize these obvious changes, a combination of methods of reducing energy density has been utilized. In a study examining the effects of energy density and portion size of foods served over two days, energy density was manipulated by using the low-fat versions of foods as well as increasing the amount of fruit and vegetables and decreasing the amount of fat in recipes. Reducing the energy density of all foods by 25% resulted in a 24% decrease in energy intake. Additionally, for most foods, there were no significant differences in ratings of taste between the normal or reduced energy density foods.[54] Other experimental studies that reduced energy density using a combination of methods have found that people tend to consume a consistent weight of food, and therefore, less energy when the food is reduced in energy density.[51, 52, 55-57] Despite consuming less energy, participants do not typically rate feelings of satiety after meals any differently.[21, 51]

Reducing energy density with vegetables

Although there are several methods of decreasing energy density that can reduce energy intake, the method of increasing the vegetable content is of particular interest because vegetables have a high nutrient density and have many health benefits. Despite these known health benefits of vegetables, Americans continue to consume less than the recommended amount.[58] One barrier that prevents many people from eating vegetables, and using them to reduce energy density is that they dislike the taste or texture of vegetables.[59-61] The use of puréed vegetables could help to overcome this barrier. Puréed vegetables can be covertly incorporated into a variety of foods without changing the palatability. Using this method as a strategy to reduce energy density could not only lead to decreased energy intakes but could also increase vegetable intakes. Little is known, however, whether this strategy is effective in adults.

A study in preschool children that reduced the energy density of entrées by incorporating puréed vegetables and reducing fat found, similar to previous studies, a decrease in energy intake.[62] It is not known whether a similar strategy would be effective in adults. A different study in adults found that increasing the portion size of vegetable side dishes increased vegetable intake and that when the vegetables were substituted for the grain and meat components of the meal, energy intake decreased and vegetable intake increased.[63] Several government agencies have recommended the substitution of foods high in energy density with those low in energy density, such as vegetables as a strategy for weight management.[64, 65] Puréeing vegetables and incorporating them into a variety of sweet and savory foods is a strategy that could have multiple benefits. It is also possible that the implementation of this strategy over a period of time could lead to an increased liking of vegetables in adults and children.[66] Using puréed vegetables to reduce dietary energy density could not only lead to reduced energy intakes, but also increased vegetable intakes and a better diet quality. Simple strategies, such as this, are needed that can be used in multiple ways in order to make a large impact on the growing rates of overweight and obesity.

PRE-PORTIONED ENTRÉES

What are pre-portioned foods?

Pre-portioned foods are commercially available products that encompass a variety of single-serving meals and snacks in the form of beverages or solid entrées, and are consumed by a wide range of individuals including dieters and non-dieters. When substituted for one or two meals per day, these products have been successful for weight management because they help people to control portions and energy intake by providing a structured eating.[6, 67, 68] Pre-portioned entrées, in particular, are also consumed by non-dieters because they offer convenience at a reasonable price. Although there is an abundance of research investigating the effects of consuming pre-portioned foods on weight management, little is known about how specific characteristics such as the energy content and energy density of these foods influence energy intake and satiety (**Table 1-3**).

What is known about pre-portioned foods in weight management?

Many studies have tested the strategy of consuming pre-portioned foods as a method for weight loss. These studies can be divided by the type of pre-portioned foods consumed: beverages or solid entrées. The beverages used in studies are often fortified with vitamins and minerals and prescribed to replace 2 meals per day for 3 to 12 months, often referred to as meal replacements.[69-72] After 3 months, the prescription is decreased in some studies to 1 meal per day for an additional few months to several years.[68, 71, 73, 74] Several studies also provide solid bars to replace 1-2 snacks per day.[68-70, 72-74] Because the beverages and snack bars are fortified and intended to replace meals, no other foods are allowed except for the one remaining meal of the day. This type of eating pattern has been shown to enhance weight loss and maintenance of weight lost compared to control groups that consume conventional reduced calorie diets.[68, 70, 71] Studies often conclude that it is the structured eating plan that makes weight management more successful.[74] Unfortunately, the effects of consuming liquid meal replacements on satiety were not measured in these studies. Findings from several studies that compared the consumption of liquid meal replacements (beverages) to solid meal replacements have found, however, that the solid foods reduced hunger more than the beverages.[71, 75-77] Therefore, it is possible that a similarly structured eating plan using solid foods may be more effective. In addition, an eating plan with solid entrées may be more enjoyable than beverages because it is less monotonous.

Weight loss studies investigating solid pre-portioned entrées have used products such as Uncle Ben's rice bowls[78, 79] and specially made entrées similar to commercially available frozen foods.[80-82] The diet prescription for these studies often requires 2-3 pre-portioned entrées to be consumed per day in addition to pre-defined servings of fruit, vegetables, and dairy for periods of 2 to 52 weeks.[75, 78-83] Participants in these studies are often allowed to select from a variety of pre-portioned entrées. Similar to weight loss studies using liquid beverages, the participants consuming the pre-portioned solid entrées achieved greater weight loss than the control group who consumed a conventional reduced calorie diet.[75, 78, 79, 81, 83, 84] In the few studies that measured feelings of hunger, there was either no difference between groups[83] or slightly higher hunger when consuming the pre-portioned foods.[84]

When it comes to weight loss, consuming pre-portioned foods in the form of beverages or solid foods are both effective strategies because they offer a structured eating plan. Studies suggest, however, that solid pre-portioned foods may be more satiating than beverages.[71, 75-77] In addition to weight loss, consuming pre-portioned foods on a regular basis could also help to maintain lost weight[83] or help with weight maintenance in general. Outside of research studies, however, the availability of pre-portioned foods varies greatly in characteristics such as energy content, energy density and portion size. The primarily focus of many studies was the strategy of using pre-portioned foods and therefore, little is known about the specific characteristics of pre-portioned foods that influence energy intake and satiety. Data from short-term experimental studies that use the preloading paradigm, however, can provide an indication of how these characteristics influence energy intake and satiety.

The effects of energy content on energy intake and satiety

The energy content of pre-portioned foods consumed in weight loss studies often has not been reported. When reported it varied from 100-200 kcal for liquid beverages[68-70, 72-74, 85] to almost 400 kcal for some solid pre-portioned foods.[78, 79] It is not possible to determine from these studies the energy content of these foods that has the greatest influence on reducing energy intake and enhancing satiety. Several preloading studies have investigated the satiating effects of variations in the energy content of foods. These studies have compared preloads of low, moderate, and high energy contents ranging from 0 kcal to 600 kcal and found that higher energy preloads reduce subsequent energy intake.[86-88] It is important to note, however, that several of these studies also found that total energy intake (preload + test meal) was higher with the high-energy preloads compared to the low-energy preloads.[86, 89] Although these studies find that the high-energy preloads typically enhance satiety, they may also increase total energy intake and, thus, would not be beneficial in the context of weight management. It is also important to keep in mind that as the energy content of the preloads changed, so did the volume/weight or energy density of preloads, which has independently been shown to influence energy intake and satiety. Several studies found that these characteristics were had a greater influence on energy intake and satiety than the energy content.[88]

The effects of energy density on energy intake and satiety

As discussed previously, the energy density of a food greatly influences energy intake and satiety with reductions in the energy density of preloads leading to reduced energy intakes and increased satiety.[43, 45] Reducing the energy density of a food typically results in changes in either the portion size or the energy content of the food. In studies of pre-portioned foods, the energy density or weight of the foods is often unknown, so the most satiating combination of the energy density and weight (portion size) is also unknown. Although there has been an abundance of research on the energy density of preloads, few of these studies have tested preloads similar to a pre-portioned entrée. The few studies that did, however, can give an idea as to how the energy density of a pre-portioned entrée influences energy intake and satiety. In one study, participants consumed iso-caloric meals that were either a standard meal high in energy density or a healthy meal low in energy density followed by an *ad libitum* dessert. Total energy intake (meal + dessert) was significantly lower and ratings of hunger were significantly lower after consuming the healthy meal.[90] These meals each were 500 kcal and had an energy density of 2.7 kcal/g for the standard meal and 1.25 kcal/g for the healthy meal. A different study tested preload casseroles with 270 kcal and an energy density of either 1.03 kcal/g or 0.44 kcal/g. This study found the reduced energy density casserole reduced energy intake and enhanced satiety.[43] These studies demonstrate the effects of reducing energy density while maintaining the energy content and thus, increasing the weight (or portion size). Another study tested three preloads consisting of a breakfast porridge and morning milkshake that were varied in energy density, weight, and energy content. The preloads were 1) low energy density (588 kcal, 613 g, ED 0.96), 2) high energy density (1175 kcal, 613 g, ED 1.91), or 3) 2- low energy density preloads (1175 kcal, 1226 g, ED 0.96). This study found that daily energy intake was highest after consuming the preloads of high energy content suggesting that the smaller portion of the low energy density preload of low energy content is likely to prevent overeating.[91] Additional research is needed, however, to determine if the findings from this study would be consistent if the preloads were pre-portioned entrées. The consumption of pre-portioned entrées provides a structured meal plan that makes weight management easier for many individuals who are surrounded by an environment filled with large portions of high energy density foods. By investigating how the energy content and energy density of these foods combine to influence energy intake and satiety, new products and recommendations can be developed to make this strategy more accessible and more successful.

SUMMARY

The current literature suggests that strategies such as increasing protein intake, reducing energy density, and consuming pre-portioned entrées may influence energy intake and satiety. For reasons previously described, it is difficult to conclude whether these strategies affect energy intake and satiety. The following experiments are designed to fill gaps in the literature in order to create a better understanding of how these factors influence energy intake and satiety.

Study 1: Increasing the protein content of meals and its effect on daily energy intake

Research suggests that protein is the most satiating macronutrient with studies showing that consuming increased amounts of protein enhance satiety and reduce energy intake. Many of these studies, however, are preloading studies requiring the consumption of a compulsory amount of protein. The type of protein tested is often isolated sources such as whey or casein and the amounts of protein tested are often greater than what is recommended as the daily intake. Few studies have investigated the effects of protein when foods are consumed *ad libitum* and the amount of protein in the foods is more typical. The purpose of this study was to test the effects of protein when meals are consumed *ad libitum* and the amount of protein is varied within dietary recommendations (10-30% of energy).

Specific Aims and Hypotheses for Study 1:

Aim 1: To test the effects on daily *ad libitum* energy intake of increasing the amount of protein in lunch and dinner entrées.

> **Hypothesis 1:** Daily *ad libitum* energy intake will decrease as the amount of protein in the entrées increased.

Aim 2: To test the effects on ratings of hunger and satiety of increasing the amount of protein in lunch and dinner entrées consumed *ad libitum.*

> **Hypothesis 2**: Ratings of hunger will decrease and ratings of satiety will increase as the amount of protein in the entrées increases.

Study 2: Hidden vegetables: an effective strategy to reduce energy intake and increase vegetable intake in adults

The over-consumption of energy-dense foods has led to excessive energy intakes contributing to America's obesity epidemic. Substituting low energy-dense foods such as vegetables for foods higher in energy density is a strategy recommended to help reduce energy intake. Vegetable intake has also been shown to increase when whole vegetables were substituted for the meat and grain components of a meal. For the many American's who dislike the taste or texture of vegetables, however, this strategy is not likely to be effective. The aim of this study was to determine whether reducing the energy density of entrées by substituting puréed vegetables for other energy-dense ingredients while keeping palatability similar would influence energy and vegetable intakes. The effects of manipulating the energy density of the main entrée at breakfast, lunch, and dinner meals by varying the amount of puréed vegetables was investigated over a day.

Specific Aims and Hypotheses for Study 2:

Aim 1: To test the effects on daily energy intake of reducing the energy density of entrées at main meals by increasing the amount of puréed vegetables.

> **Hypothesis 1:** Daily energy intake will decrease as the energy density of the entrées is reduced and the amount of puréed vegetables increases.

Aim 2: To test the effects on daily vegetable intake of reducing the energy density of entrées at main meals by increasing the amount of puréed vegetables.

> **Hypothesis 2**: Daily vegetable intake will increase as the energy density of the entrées is reduced and the amount of puréed vegetables increases.

Study 3: Effects of energy density and energy content of entrées

Pre-portioned entrées are commonly consumed either by dieters to help control portion sizes and energy intake or by non-dieters for their convenience. Previous research has investigated the effects of various pre-portioned meals including beverages as well as solid foods and has shown that these products can be effectively used to achieve weight loss. Few of these studies, however, have examined the effects of solid pre-portioned entrées and even less is known about the characteristics of these foods that influence energy intake and satiety. The purpose of this study was to determine how variations in the energy content and energy density of pre-portioned entrées act independently and in combination to influence energy intake and satiety.

Specific Aims and Hypotheses for Study 3:

Aim 1: To test the independent effects of variations in the energy content and energy density of pre-portioned entrées on energy intake over a day.

Hypothesis 1: Reducing the energy content and energy density of pre-portioned entrées will act independently and additively to decrease total energy intake over a day.

Aim 2: To test the effects of variations in the energy content and energy density of pre-portioned entrées on ratings of satiety.

Hypothesis 2: Ratings of satiety will be greater when the entrées are reduced in energy density and will be lower when the entrées are reduced in energy content.

Table 1-1. Short-term studies examining the effects of protein on satiety and satiation.

Effects of protein on satiety – Beverage preloads					
Paper and subjects	Preload	Amount of protein	Satiety measurement	Energy intake (EI)	Satiety
Blom WAM, et al.[28] (2006) N=15	HP yogurt (whey protein isolate) HC yogurt	57g (58%) pro Energy Density (ED): 0.99 19g (19%) pro ED 0.97	3h	No differences.	No differences.
Dove ER, et al.[92] (2009) N=34	HP skim milk HC fruit drink	25g (39%) <1g (2%) ED constant.	4h	↓ (9%)	↑
Vozzo R, et al.[18] (2003) N=16	HP yogurt HC yogurt HF yogurt Control	51g (29%) 25g (14%) 25g (14%) No Preload ED constant	8h	↓ 29% compared to control . ↑ total (preload + meal)	No differences
Bertenshaw EJ, et al.[19] (2008) N=18	HP fruit drink (whey) HC fruit drink Control fruit drink	38g (50%) pro ED 0.92 2g (2%) pro ED 0.92 2g (12% pro) ED 0.25	2h	↓ test meal ↑ total energy intake (preload + meal)	No differences

Paper and subjects	Preload	Amount of protein	Satiety measurement	Energy intake	Satiety
Bertenshaw EJ, et al.[29] (2009) N=28	HP fruit drink (whey protein isolate) MP fruit drink LP fruit drink Control fruit drink	34g (50%) ED 0.93 17g (25%) ED 0.92 9g (13%) ED 0.92 2g (12%) ED 0.26	30 minutes	↓ (linear relationship)	No differences
Latner JD, et al.[30] (1999) N=12	HP beverage (Promod) HC beverage (Polycose) Mixed beverage (combined)	80g (72%) ED 4.24 0g (0%) ED 3.80 40g (36%) ED 4.01	4.5-4.75h	↓ after HP beverage compared to HC beverage only (24%)	↑ after HP beverage only compared to other beverages

Effects of protein on satiety – Solid food preloads					
Paper and subjects	Preload	Amount of protein	Satiety measurement	Energy intake	Satiety
Poppitt SD, et al.[13] (1998) N=12	Standard meal (fish and potato pie) + 239 kcal of High Protein (HP) High Carbohydrate (HC) High Fat (HF) High Alcohol (HA)	 68g (59%) 15g (11%) 14g (11%) 14g (11%)	2 hours (h)	↓ (20% or less)	↑

Paper and subjects	Preload	Amount of protein	Satiety measurement	Energy intake	Satiety
Porrini M, et al.[14] (1995) N=12	HP meatballs HC baked macaroni	122g (55%) ED: 1.32 41g (17%) ED 1.46	2h	↓ (46%) in test meal intake.	↑
Barkeling B, et al.[12] (1990) N=20	HP meat casserole with wholemeal spaghetti HC vegetable casserole with ordinary spaghetti	65g (43%) pro ED 1.09 16g (10%) pro ED 0.93	4h	↓12% (38 kcal)	↑
Ratliff J, et al.[10] (2010) N=21	HP eggs HC bagel	23g (23%) 16g (16%) ED unknown.	3h	↓ (17%)	↑
Vander Wal JS, et al.[11] (2005) N=28	HP meal (egg) HC meal (bagel)	18g (21%) ED 1.87 14g (16%) ED 1.85	3.5h	↓ (22%)	↑
Porrini M, et al.[26] (experiment 2) (1997) N=10	HP omelet (large and small) HC omelet (large and small) No preload	Large: 54g (54%) Small: 27g (54%) ED: 1.55 Large: 27g (15%) Small: 13g (15%) ED: 1.89	2.5h	No differences in intake of test meal ↓ EI of total (preload + test meal) (22%)	No differences

Paper and subjects	Preload	Amount of protein	Satiety measurement	Energy intake	Satiety
Hill A, et al.[25] (1986) N=13	HP turkey sandwich with peanuts HC turkey sandwich with chocolate biscuits	41g (31%) pro ED 2.37 18g (15%) pro ED 2.18	60 minutes	Not measured.	↑
Stubbs RJ, et al.[27] (1996) N=6	HP meal HC meal HF meal	186g (59%) ED 1.12 57g (19%) ED 1.08 65g (21%) ED 1.17	5h	No differences.	↑ (over 24h)
Raben A, et al.[24] (2003) N=19	HP meal HC meal HF meal HA meal	48g (32%) 18g (12%) 17g (12%) 18 (12%) ED constant	5h	No differences	No differences
Leidy HJ, et al.[93] (2010) N=13	HP diet AP diet	138g (25%) 79g (14%)	11h	Eucaloric diets.	↑
Leidy HJ, et al.[94] (2009) N=9	HP diet (eggs/pork) AP diet	149g (18%) 86g (11%)	15h	Eucaloric diets.	No differences

Effects of protein on satiety – Preloads testing various protein sources					
Paper and subjects	Preload	Amount of protein	Satiety measurement	Energy intake	Satiety
Bowen J, et al.[32] (2007) N=28	HP (whey) HC (fructose) HC (glucose) Mixed (whey+fructose)	57g (85%) 7g (11%) 7g (11%) 32g (49%) ED constant.	4h	No differences.	↑
Bowen J, et al.[31] (2008) N=72	HP beverage (whey) HP beverage (soy) HP beverage (gluten) HC beverage (glucose)	51g (71%) 50g (71%) 501g (71%) 1g (1.5%) ED constant	3h	↓ after gluten compared to glucose only	No differences.
Borzoei S, et al.[33] (2006) N=23	HP lunch meal (fish) HP lunch meal (beef)	71g (47%) 71g (47%) ED constant	4h	↓ after fish meal (11%)	No differences.

Effects of protein on satiety – Studies conducted in controlled environments					
Study and subjects	Preload	Amount of protein	Satiety measurement	Energy intake	Satiety
Smeets AJ, et al.[35] (2008) N=30	HP pasta lunch AP pasta lunch	25% 10% ED constant	4h	Fed for energy balance.	↑

Study and subjects	Preload	Amount of protein	Satiety measurement	Energy intake	Satiety
Lejune MP, et al.[36] (2006) N=12	HP diet AP diet	~163g (30%) ~54g (10%) ED constant	24h	Fed for energy balance.	↑
Westerterp-Plantenga MS, et al.[37] (2009) N=10	HP diet AP diet	~182g (30%) ~61g (10%) ED constant	24h	Fed for energy balance.	↑
Westerterp-Plantenga MS, et al.[38] (1999) N=8	HP diet AP diet	154g (29%) ED of solid food: 1.65 48g (9%) ED of solid food: 2.10	24h	Fed for energy balance.	↑
Johnstone AM, et al.[34] (1996) N=6	HP diet HC diet HF diet	342g (37%) ED 1.29 94g (10%) ED 1.26 94g (10%) ED 1.35	24h	Fed for energy balance. No differences in EI next day.	↑

Effects of protein on satiation					
Study and subjects	Protein meal	Amount of protein	Satiety measurement	Energy intake	Satiety
Booth DA, et al.[40] (1970) N=6	HP meal, pudding, and spread (calcium caseinate) LP meal, pudding, and spread	Not disclosed.	3h	↓	↑

Study and subjects	Protein meal	Amount of protein	Satiety measurement	Energy intake	Satiety
Porrini M, et al.[26] (experiment 1) (1997) N=13	HP omelet HF omelet	55g (54%) ED 1.55 26g (15%) ED 1.90	2h	↓ 42%	No differences.

Table 1-2. Short-term studies examining the effects of energy density on satiety and satiation

Effects of energy density on satiety - Manipulating energy density with water						
Study and subjects	ED manipulation	Preloads	Test meal	Satiety measurement	Energy intake	Satiety
Rolls BJ, Roe LS.[41] (2002) N=54	Water Milk based liquid, infused through naso-gastric tube	200ml/200kcal (ED 1.0) 400ml/200kcal (ED 0.5) 400ml/400kcal (ED 1.0) No preload No NG inserted (5 conditions) 30% fat, 55% CHO, 15% protein 15 minutes	Buffet-style meal	Before/after meals, hourly for 3h after lunch.	↓ with larger volume preload but not with higher energy content	↑ with all preloads. Prospective consumption ↓ with high volume/low-energy preload only
Rolls BJ, et al.[42] (1998) N=20	Water Milk based drink	300 ml (ED 1.5) 450 ml (ED 1.1) 600 ml (ED 0.8) No preload 499 kcal, 30% fat, 55% CHO, 15% protein. 15 minutes	Buffet-style meal	Before/after preload and meals, hourly for 3h after lunch.	↓ with largest volume (preload + lunch + dinner) when no preload excluded.	↑ after largest preload (in interval between preload and lunch)

Study and subjects	ED manipulation	Preloads	Test meal	Satiety measurement	Energy intake	Satiety
Mattes R.[95] (2005) N=31	Water Various foods in solid and liquid form	Apple juice (ED 0.46) Apple soup (ED 0.46) Apple (ED 0.59) Chicken soup (ED 0.45) Chicken breast (ED 1.51) Peanut soup (ED 1.78) Peanuts (ED 5.88) 300 kcal 10 minutes	Self-reported	Every 15 minutes for first hour, every 30 minutes for an addition 3h.	Comparable between solids and soups.	↓ with soups compared to solids.
Rolls BJ, et al.[43] (1999) N=24	Water Chicken rice casserole	Chicken rice casserole (ED 1.03) Chicken rice casserole with 12oz water (ED 1.03) Chicken rice casserole with 12oz water incorporated to make a soup (ED 0.44) 270 kcal, 33% fat, 50% CHO, 17% protein 12 minutes	Buffet-style meal	Before/after meals, hourly for 4h after lunch.	↓ (preload + lunch) when served soup	↑ with soup preload

Study and subjects	ED manipulation	Preloads	Test meal	Satiety measurement	Energy intake	Satiety
Norton GNM, et al. [96] (2006) N=30	Water Tomato soup	Low volume ED 0.9 High volume ED 0.44 Men ~265 kcal, 300 or 600ml Women ~215 kcal, 240 or 480ml.	Single filling sandwiches Variety filled sandwiches	Before/after preload and lunch.	No effect of soup, variety filled sandwiches ↑ intake	↑ after high volume soup

Effects of energy density on satiety - Manipulating energy density with a combination of methods						
Study and subjects	ED manipulation	Preloads	Test meal	Satiety measurement	Energy intake	Satiety
Rolls BJ, et al.[45] (2004) N=42	Fat, vegetable	6 Salads, no preload ED 0.33, 0.67, or 1.33 Portion size: 150g or 300g 50-400 kcal 20 minutes	Cheese tortellini with tomato sauce	Before/after preload, after test meal	↓ with larger portion size (test meal) ↓ as ED decreased (preload + test meal)	↑ with larger portion size

Study and subjects	ED manipulation	Preloads	Test meal	Satiety measurement	Energy intake	Satiety
Gray RW, et al.[88] (2002) N=20	Maltodextrin, milk, aspartame	Soup 1: 50 kcal, 150ml, ED 0.33 Soup 2: 150 kcal, 150ml, ED 1.0 Soup 3: 150 kcal, 450ml, ED 0.33 Soup 4: 450 kcal, 450ml, ED 1.0	Pasta with sauce.	Before/after preload. Every 50g of test meal. 3 hours after test meal.	Intake of pasta meal not significantly different between soups, 1, 2, or 3, but all significantly greater than soup 4. No significant differences post-lunch or on total daily energy intake between conditions.	Significant differences in hunger and fullness between soups 2 & 3 (volume differences), hunger marginally different between soups 3 & 4 (energy differences).
Mazlan N, et al.[91] (2006) N=16	Water, fat, sugar	Breakfast meal Porridge and then milkshake 2h later. 1. No food 2.Low ED (LED) (588 kcal, ED 0.96) 3.High ED (HED) (1175 kcal, ED 1.91) 4. 2 x LED (1175 kcal, ED 0.96) All 13% protein, 40% fat, 47% CHO.	2h later *ad libitum* access to various foods.	Hourly every waking hour.	Lunch intake significantly different in the order of No food > LED > HED > 2x LED. Daily energy intake significantly higher on HED and 2 x LED diets. Energy intake lowest on the no food diet.	Hunger greater after no food and LED vs either the HED or 2 x LED.

Effects of energy density on satiation - Manipulating energy density with a combination of methods						
Study and subjects	ED manipulation	Foods	Manipulation	Satiety measurement	Energy intake	Satiety
Rolls BJ, et al.[54] (2006) N=24	Fat, sugar, fruit, vegetable	Variety of foods 3 meals and evening snack served over 2 days	100% or 75% portion size 100% or 75% ED	Before/after each meal.	↓ with reduced ED and portion size independently	No significant differences.
Kral TVE, et al.[52] (2002) N=40	Fruit, vegetable, carbohydrate	Breakfast, lunch and dinner manipulated entrées served with compulsory low-energy side dishes	ED 1.25 ED 1.50 ED 1.75 25% fat, 60% CHO, 15% protein.	Before/after meals	↓ as ED decreased	No significant differences.
Stubbs RJ, et al.[53] (1998) N=6	Fat, carbohydrate	*Ad libitum* access to various foods for 14 days	LED: 38% fat, 49% CHO, 13% protein, ED 0.85 MED: 40% fat, 47% CHO, 13% protein, ED 1.3 HED: 39% fat, 48% CHO, 13% protein, ED 1.8	15 minutes after meals	↓ on LED	No significant differences

Study and subjects	ED manipulation	Foods	Manipulation	Satiety measurement	Energy intake	Satiety
Stubbs RJ, et al.[46] (1995) N=6	Fat	*Ad libitum* access to various foods for 7 days	Low fat (LF): 20% fat, 67% CHO, 13% protein, ED 1.15 Moderate fat (MF): 40% fat, 49% CHO, 13% fat, ED 1.3 High fat (HF): 60% fat, 29% CHO, 12% protein, ED 1.77	Hourly.	↓ with lowest ED (low fat) diet Consumed consistent weight of food across conditions.	↑ with low fat, low ED diet
Rolls BJ, et al.[21] (1999) N=33	Fruit, vegetable, carbohydrate	Portion of meal compulsory and manipulated in ED or fat, served with various *ad libitum* sides. 4 days	LF, LED (ED 1.1, 17% fat, 67% CHO, 16% protein) LF, HED (ED 1.6, 16% fat, 67% CHO, 16% protein) HF, HED (ED 1.6, 37% fat, 48% CHO, 16% protein)	Before/after meals.	↓ after LED, no difference between HED diets	No significant differences.

Study and subjects	ED manipulation	Foods	Manipulation	Satiety measurement	Energy intake	Satiety
Bell EA, Rolls BJ.[48] (2001) N=46	Fruit, vegetable, carbohydrate	*Ad libitum* manipulated entrées served with compulsory side dishes (B, L, D) and evening snack.	LF (25% fat) MD (35% fat) HF (45% fat) Low ED (1.25) or high ED (1.75). ~13% protein	Before/after meals.	↓ in LED Consumed similar volume across conditions.	↓ in LED (small differences)
Leahy KE, et al.[56] (2008) N=77 (Preschool children)	Fat, water	Lunch meal manipulated, macaroni and cheese, served with sides, all foods consumed *ad libitum*	LED (ED 1.4, 43% fat, 40% CHO, 18% protein) HED (ED 2.0, 60% fat, 28% CHO, 13% protein)	Not measured.	↓ when served LED entrée	N/A
Leahy KE, et al.[62] (2008) N=61(Preschool children)	Puréed vegetables, fat	Lunch meal manipulated, pasta with red sauce, served with sides, all foods consumed *ad libitum*	LED (ED 1.2, 28% fat, 54% CHO, 18% protein) HED (ED 1.6, 35% fat, 48% CHO, 17% protein) Small portion (300g) or large portion (400g)	Not measured.	↓ when served LED entrée, also increased vegetable intake. No effect of portion size.	N/A

Effects of energy density on satiation - Manipulating energy density with vegetables						
Study and subjects	ED manipulation	Foods	Manipulation	Satiety measurement	Energy intake	Satiety
Bell EA, et al.[20] (1998) N=18	Vegetables, carbohydrate	*Ad libitum* manipulated entrées served with compulsory low-energy sides (L,D) and evening snack.	LED (0.8) MED (1.1) HED (1.3) 22% fat, 59% CHO, 19% protein	Before/after meals.	↓ with LED Consumed consistent weight of food across condition.	No significant differences.
Chang UJ, et al.[97] (2010) N=30	Vegetable	*Ad libitum* manipulated lunch meal.	Parboiled rice with radish leaves (ED 0.86) Parboiled normal rice (ED 1.42)	Before/after meals, hourly after lunch for 4h.	↓ after rice with vegetables Consumed consistent volume across condition.	↑ after rice with vegetable

Table 1-3. Studies examining the effects of pre-portioned foods and various food characteristics on energy intake and satiety.

Effects of pre-portioned foods on energy intake and satiety- liquid pre-portioned foods						
Paper and subjects	Pre-portioned food group	Frequency of consumption	Control group	Effects on weight loss	Effects on energy intake	Effects on satiety
Wadden TA, et al. [73] (2009) N=5145	Liquid shake: Slimfast, Optifast, Glucerna, or HMR (snack was a bar)	2 meals/day and 1 snack 16 weeks 1 meal, one snack/day 5 months	Education on diet and activity	Meal replacement group lost more weight (first year of study)	Not measured	Not measured
Ashley JM, et al.[69] (2007) N=70	Meal replacement drinks or bars (Slimfast) Drink: 220 kcal, 7-10g protein, 40-46g CHO, 5g fiber, 1.5-3g fat Bars: 220 kcal, 8g protein, 33-36g CHO, 2g fiber, 5g fat	2 meals/day 12 months	USDA food guide pyramid	Not significantly different between groups	Both groups reduced EI but did not reach goal of 1200 kcal/day (~1350-1450 kcal).	Not measured.
Ashley JM, et al.[70] (2001) N=74	Meal replacement shakes or bars (Slimfast) Drink: 220 kcal, 7-10g protein, 40-46g CHO, 5g fiber, 1.5-3g fat Bars: 220 kcal, 8g protein, 33-36g CHO, 2g fiber, 5g fat Rx: 1200 kcal/day	2 meals/day 12 months	USDA food guide pyramid, Rx: 1200 kcal/day	Pre-portioned foods group lost significantly more weight at 1 year.	Not measured.	Not measured.

Paper and subjects	Pre-portioned food group	Frequency of consumption	Control group	Effects on weight loss	Effects on energy intake	Effects on satiety
Flechtner-Mors M, et al.[68] (2000) N=75 Ditschuneit HH, et al.[74] (1999) N=100	Meal replacement shakes, soups, or hot chocolate (meals) and bars (snacks) (Slimfast) Drinks: 200-220 kcal, 14-17g pro, 27-34g CHO, 5-7g fat, 4.5-6.5g fiber. Bars:90-110 kcal, 1-2 g protein, 16-18g CHO, 2-4g fat, 1.1g fiber. Rx: 1200-1500 kcal/day, 19-21% protein, 48-54% CHO, 25-34% fat.	2 meals, 2 snacks/day 3 months (Phase 1) 1 meal, 1 snack/day 48 months (Phase 2)	Conventional foods Rx: 1200-1500 kcal, 19-21% protein, 48-54% CHO, 25-34% fat. 1 meal, 1 snack/day (48 months – Phase 2)	At 4 years, both groups significantly lost weight, pre-portioned group had a greater percentage of change due to more weight lost during first 3 months.	Significant only for men in pre-portioned foods group at end of 3 months.	Not measured.
Rothacker DQ, et al.[71] (2001) N=75	Liquid meal replacements (powder mixed with skim milk) 220 kcal, 1.5g fat, 5g fiber, 15-19g protein. Plus fresh fruits and vegetables Rx: 1200 kcal/day, 55% CHO, 15% protein, < 30% fat.	1-3 meals/day 12 months	Traditional diet plan of low-fat, low-energy foods. Rx: 1200 kcal/day, 55% CHO, 15% protein, < 30% fat.	Both groups significantly lost weight from baseline at 3 months. At 1 year, pre-portioned foods group maintained initial weight loss, traditional diet group regained weight.	Not measured.	Not measured.

Paper and subjects	Pre-portioned food group	Frequency of consumption	Control group	Effects on weight loss	Effects on energy intake	Effects on satiety
Rothacker DQ.[85] (2000) N=134 Community based study	Liquid meal replacement 200-220 kcal	2 meals/day 3 months 1-2 meals/day until ideal weight achieved (5 year study)	Control weight data obtained from medical records (self-reported baseline weights, measured weight 5 years later)	Pre-portioned foods group regained significant weight but remained less than baseline weight at 5 years.	Not measured.	Not measured.
Noakes M, et al.[72] (2004) N=55	Meal replacement shakes and bars (Slimfast) 430 kcal Rx: 1400 kcal, 20% protein, 23% fat, 57% CHO, 24.4g fiber.	2 meals/day Plus low-fat evening meal, 5 servings of fruit and vegetables (~830 kcal) 3 months (stage 1) +3 months (stage 2)	Low kcal/low-fat diet Rx: 1400 kcal, 22% protein, 17% fat, 62% CHO, 27.8g fiber.	Both groups significantly lost weight over 6 months.	No significant differences between groups.	Not measured.

Effects of pre-portioned foods on energy intake and satiety- solid pre-portioned foods						
Paper and subjects	Pre-portioned food group	Frequency of consumption	Control group	Effects on weight loss	Effects on energy intake	Effects on satiety
Davis LM, et al.[83] (2010) N=90	Medifast 5&1 Plan 90-110 kcal/each 5-7 oz lean protein 1 ½ c non-starchy vegetables 2 fat servings Rx: 800-1000 kcal/day	5 meal replacements/day for 16 weeks (weight loss) 3-5 meal replacements/day for 24 weeks (weight maintenance)	USDA food guide pyramid 3oz grains 1c vegetables 1c fruit 2c milk 5-7 oz lean protein 3 tsp fat Rx: ~1000 kcal/d	Meal replacement group lost more weight	Not measured	No differences between groups

Paper and subjects	Pre-portioned food group	Frequency of consumption	Control group	Effects on weight loss	Effects on energy intake	Effects on satiety
Hannum SM, et al.[78] (2004) N=53	Uncle Ben's bowls 24 options 2 bowls provided: 733 kcal, 13g fat, 43g protein, 113g CHO Rx: 1365 kcal, 55% CHO, 25% pro, 20% fat	2/day Plus 2 c salad vegetables, 2 c nonfat milk or yogurt, 2 servings of fruit, 3 servings of whole grains, 8 cups water 8 weeks	Self-selected diet USDA food guide pyramid 2 servings of meat, 2 servings of nonfat dairy, 2 servings of fruit, 3 servings of vegetables, 6 servings of grain, 8 cups of water Rx: 1365 kcal, 55% CHO, 25% pro, 20% fat	Both groups lost significant weight over 8 weeks but greater in pre-portioned foods group.	Not significantly different between groups, both groups reduced energy intake.	Not measured.
Hannum SM, et al.[79] (2005) N=51	Uncle Ben's bowls 24 options 2 bowls provided: 733 kcal, 13g fat, 43g protein, 113g CHO Rx: 1700 kcal, 55% CHO, 25% pro, 20% fat	2/day Plus 1 serving of meat, 2 c nonfat milk or yogurt, 2 ½ c salad vegetables, 3 servings of fruit, 4 servings of whole grains, 8 cups water 8 weeks	Self-selected diet USDA food guide pyramid 3 servings of meat, 2 servings of nonfat dairy, 3 servings of fruit, 4 servings of vegetables, 7 servings of grain, 8 cups of water Rx: 1700 kcal, 55% CHO, 25% pro, 20% fat	Both groups significantly lost weight but was greater in the pre-portioned foods group.	Not significantly different between groups, but both groups reduced energy intake.	Not measured.

Paper and subjects	Pre-portioned food group	Frequency of consumption	Control group	Effects on weight loss	Effects on energy intake	Effects on satiety
Metz JA, et al.[80] (1997) N=560	Campbells Center for Nutrition and Wellness meal program Options: 6 breakfast, 8 lunch, and 10 dinner entrées, 6 snacks Rx: 15-20% fat, 55-60% CHO, 15-20% protein.	3 meals/day Plus one serving each of fruit, vegetables, and low-fat dairy 10 weeks	Self-selected diet Fixed number of servings from the American Dietetic Association and American Diabetes Association exchange lists. Rx: 15-20% fat, 55-60% CHO, 15-20% protein.	Significantly greater weight loss among compliant participants in both groups	Both groups significantly decreased energy intake. Pre-portioned foods group more compliant with meeting diet Rx.	Not measured.
Mattes RD.[84] (2002) N=133	Ready-to-eat cereal (Special K or a variety) plus 2/3c skim milk and 100 kcal portion of fruit	2 meals/day 14 days Weeks 3-7 educated on "Volumetrics"	2 groups received no intervention. 1 of these groups received "Volumetrics" education weeks 3-7	Significant weight loss in the pre-portioned foods group, greater in Special K group than variety group.	Pre-portioned foods group consumed significantly less energy during the cereal intervention.	Higher hunger during cereal phase and Volumetric diet phase.
Pi-Sunyer FX, et al.[82] (1999) N=202	Campbells Center for Nutrition and Wellness meal program Options: 6 breakfast, 8 lunch, and 10 dinner entrées, 6 snacks Rx: 55-60% CHO, 15-20% protein, 20-30% fat	3 meals and 1 snack/day Plus one serving each of fruit, vegetables, and low-fat dairy/day 10 weeks	Self-selected diet Fixed number of serving from the American Dietetic Association and American Diabetes Association exchange lists.	Not significantly different between groups. Pre-portioned foods group achieved weight loss goals.	Energy intake decreased significantly in both groups, but a larger decreased in the control group.	Not measured.

Paper and subjects	Pre-portioned food group	Frequency of consumption	Control group	Effects on weight loss	Effects on energy intake	Effects on satiety
Metz JA, et al.[81] (2000) N=302	Prepared meal plan Options: 7 breakfast, 13 lunch, 12 dinner, 8 snack selections. Rx: 1200-1400 kcal, 22% fat, 58% CHO, 20% protein	3 meals/day Plus one serving each of fruit, vegetable, and low-fat dairy/day 52 weeks	Usual care diet Fixed number of serving from the American Dietetic Association and American Diabetes Association exchange lists Rx: 1200-1400 kcal, 22% fat, 58% CHO, 20% protein	Pre-portioned foods group lost significantly more weight than the usual care diet over 52 weeks.	Changes in energy intake did not differ between groups.	Not measured.

Short-term effects of pre-portioned foods on energy intake and satiety - comparing solid and liquid pre-portioned foods						
Paper and subjects	Solid test food	Liquid test food	Discretionary food	Satiety measurement	Effects on energy intake	Effects on satiety
Rothacker DQ, Watemberg S.[98] (2004) N=108 (Solid) Mattes RD, Rothacker D.[75] (2001) N=84 (Liquid)	Meal replacement bar replaced 1-2 meals/day over 6 weeks 250 kcal, 4g fiber, 8g fat	Meal replacement shakes (thick or thin) 220 kcal, 325 ml, 10g protein, 40g CHO, 3g fat.	N/A (Rothacker) Self-reported intake (Mattes)	Hourly for 4-5 hours	Not measured (Rothacker) No differences in energy intake between shakes (Mattes)	Hunger remained below baseline for 5h with the bar, for 3 hours with the thin shake, and for 4 hours with the thick (viscous) shake

Paper and subjects	Solid test food	Liquid test food	Discretionary food	Satiety measurement	Effects on energy intake	Effects on satiety
Stull AJ, et al.[76] (2008) N=24	Solid meal replacement Ensure Cinnamon Oat'n Raisin energy bar ED 3.83 Provided 25% of each subjects daily energy needs. Consumed within 15 minutes	Liquid meal replacement Vanilla Ensure ED 0.98	Oatmeal served at 120 minutes and consumed *ad libitum*	Every 15 minutes for 120 minutes after meal replacement, 30 minutes after oatmeal.	Consumed 13% more oatmeal after liquid vs solid meal replacements.	Hunger AUC higher for liquid vs solid meal replacements.
Tieken SM, et al.[77] (2007) N=9	Solid meal replacement Slimfast bars 540 kcal, 138g, ED 3.91, 86g CHO, 20g protein, 15g fat, 2g fiber. Provided 25% of each subjects daily energy needs Consumed within 15 minutes	Liquid meal replacement Slimfast shakes 540 kcal, 553g, ED 0.98, 98g CHO, 24g protein, 6g fat, 12g fiber.	N/A	15, 60, 12, 180, 240 minutes after meal.	Not measured.	Hunger AUC significantly lower after solid vs liquid meal replacement.

Short-term effects of various food characteristics on energy intake and satiety						
Paper and subjects	Food Characteristics	Preload	Test food	Satiety measurement	Effects on energy intake	Effects on satiety
De Graaf, et al.[86] (1996) N=37	Energy content vs. weight	Water (0 kcal conditions), ED 0 Yogurt 26g protein, 31g CHO, 8 (300 kcal) or 41g fat (600 kcal); ED 0.4-2.4 Weight: 250g, 500g, or 750g, consumed within 5-8 minutes	2h later *ad libitum* access to various foods, plus food diary remainder of day.	VAS before/after preload, 15, 45, 60, 90, 120 minutes	Energy intake at test meal significantly decreased as energy intake in preload increased. Energy intake (preload + test meal) higher with highest energy preload, but not significantly different over the day (preload through evening snack)	Ratings of hunger significantly higher with water preloads and significantly lower with the 600 kcal preload compared to the 300 kcal preload, only at 2 hours post consumption.
Yeomans MR, et al.[87] (2001) N=24	High vs. low energy meals	Low-energy soup 63 kcal, ED 0.21, 2g fat, 10g CHO, 1.5g protein. High-energy soup (fat) 362 kcal, ED 1.2, 37g fat, 10g CHO, 1.1g protein High-energy soup (CHO) 359 kcal, ED 1.2, 7g fat, 89g CHO, 1.1g protein 300 ml servings	Pasta shells with sauce.	2h after lunch	Ate significantly less test meal after high energy soups but had higher daily energy intakes with the high-energy soups.	Hunger significantly less 30 minutes after high-energy soups than low-energy soup.

Paper and subjects	Food Characteristics	Preload	Test food	Satiety measurement	Effects on energy intake	Effects on satiety
Gray RW, et al.[88] (2002) N=20	Volume vs. energy content	Soup 1: 50 kcal, 150 ml, ED 0.33 Soup 2: 150 kcal, 150 ml, ED 1.0 Soup 3: 150 kcal, 450 ml, ED 0.33 Soup 4: 450 kcal, 450 ml, ED 1.0	Pasta shells with sauce.	Before/after preload. Every 50g of test meal. 3 hours after test meal.	Intake of pasta meal not significantly different between soups, 1, 2, or 3, but all significantly greater than soup 4. No significant differences post-lunch or on total daily energy intake between conditions.	Significant differences in hunger and fullness between soups 2 & 3 (volume differences), hunger marginally different between soups 3 & 4 (energy differences).
Kirkmeyer SV, Mattes RD.[99] (2000)	Food attributes	500 kcal portions of peanuts (ED 5.71), peanut butter (ED 7.06), almonds (ED 6.22), chestnuts (ED 2.12), milk chocolate (ED 4.76), dill pickles (matched in weight to peanuts, 90g, ED 0.17), rice cakes (30 kcal, matched in volume to peanuts, ED 4.05), or no preload Consumed within 15 minutes	Dietary records	180 minutes	Energy compensation over the day was accurate in all high energy conditions, not significantly different between conditions.	Hunger AUC significantly lower after higher energy preloads than no load, rice cake, and pickles.

Paper and subjects	Food Characteristics	Preload	Test food	Satiety measurement	Effects on energy intake	Effects on satiety
Poortvliet PC, et al.[90] (2007) N=13	Healthy (low ED) vs. unhealthy (high ED) meal	Chicken stir-fry (healthy meal) 500 kcal, 400g, ED 1.25, 56% CHO, 11% fat, 32% protein, 9g fiber. Fettuccini carbonara (standard meal) 500 kcal, 185g, ED 2.7, 41% CHO, 38% fat, 18% protein, 1.5g fiber. Consumed within 30 minutes	Dessert served 10 min after meal, consumed *ad libitum* within 15 mintues	VAS every 30 minutes for 3h	Energy intake (test meal + dessert) significantly lower after healthy meal than standard meal	Ratings of hunger significantly lower after healthy meal course for duration of 3 hours
Mazlan N, et al.[91] (2006) N=16	ED vs. food weight	Breakfast meal Porridge and then milkshake 2h later. 1. No food 2. LED (588 kcal, 613 g, ED 0.96) 3. HED (1175 kcal, 615 g, ED 1.91) 4. 2 x LED (1175 kcal, 1226 g, ED 0.96) All 13% protein, 40% fat, 47% CHO.	2h later *ad libitum* access to various foods.	Hourly every waking hour.	Lunch intake significantly different in the order of No food > LED > HED > 2x LED. Daily energy intake significantly higher on HED and 2 x LED diets. Energy intake lowest on the no food diet.	Hunger greater after no food and LED vs either the HED or 2 x LED.

Paper and subjects	Food Characteristics	Preload	Test food	Satiety measurement	Effects on energy intake	Effects on satiety
Devitt A, Mattes RD.[100] (2004) N=20	Food unit size vs. ED	Breakfast: omelets (ED 1.09/2.19) Lunch: wraps (ED 1.43/3.04) Dinner: pizza (ED 1.95/2.57) ED: low or high Portion size: small or large		0, 45, 90 minutes.	EI significantly higher in the HED vs LED conditions at breakfast, lunch, and over 24-h. Gram intake constant across treatments.	Hunger and fullness not significantly different across treatments.
Norton GNM, et al.[96] (2006) N=30	Volume and variety	Preload: tomato soup (low volume ED 0.9; high volume ED 0.44) Men ~265 kcal, 300 or 600ml, women ~215 kcal, 240 or 480ml.	Single filling sandwiches Variety filled sandwiches	Before/after preload and lunch.	No effect of soup, variety filled sandwiches ↑ intake	↑ after high volume soup

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Chapter 2

Study 1:

Increasing the protein content of meals and its effect on daily energy intake

Blatt AD, Roe LS, Rolls BJ. Increasing the protein content of meals and its effect on daily energy intake. *J Am Diet Assoc.* 2011;111(2):290-4.

INTRODUCTION

It has been proposed that protein is the most satiating macronutrient and that consuming an increased amount of protein can reduce energy intake.[1,2] This suggestion is based primarily on studies that increased protein intake with a compulsory preload and found a reduction in energy intake at subsequent meals.[3-8] In many of these studies, however, the amounts of protein tested were greater than those commonly consumed at meals.[5-8] It is important to complement preloading studies with investigations of protein intake in more typical eating situations, in which meals are consumed *ad libitum* and protein content is within more commonly consumed amounts.

The few studies that have investigated the influence of protein content on *ad libitum* energy intake have found that consuming high-protein foods decreased energy intake within a single meal.[9,10] In some studies, however, the foods contained single sources of extracted proteins such as whey or casein, rather than mixed sources such as meats and dairy products.[9] Furthermore, in previous work it is often difficult to isolate the effect of protein content on energy intake because of differences in other food properties known to influence intake, such as energy density, fat content, palatability, and appearance.[11-14] Thus, it is unclear whether incorporating common protein sources into meals consumed *ad libitum* will have independent effects on energy intake. The aim of the present study was to vary the protein content of lunch and dinner entrées over a range of commonly consumed amounts and to test its corresponding effects on 24-hour energy intake.

METHODS

Participants

In March through July of 2008, women aged 20 to 40 years were recruited for the study through advertisements in newspapers and campus electronic newsletters at the University Park campus of The Pennsylvania State University. Potential subjects were interviewed by telephone (**Appendix A**) to determine whether they met the initial study criteria, including that they regularly ate three meals per day, did not smoke, did not have any food allergies or restrictions, were not athletes in training, were not dieting, were not taking medications that would affect appetite, and were willing to consume the foods served in the test meals. Potential subjects who met the initial study criteria came to the laboratory to have their height and weight measured (model 707; Seca Corp., Hanover, MD, USA) and to rate the taste of food samples, including the two manipulated study entrées at the 20% protein level. A consent form (**Appendix B**) was signed to complete the following questionnaires: a detailed demographic and weight history questionnaire (**Appendix C**); the Zung Self-Rating Scale[15] (**Appendix D**), which evaluates symptoms of depression; the Eating Attitudes Test[16] (**Appendix E)**, which assesses indicators of disordered eating; and the Eating Inventory[17] (**Appendix F**), which measures dietary restraint, tendency toward hunger, and disinhibition. In order to minimize the effect of differences in body size on energy intake and thus protein intake, potential subjects were excluded if they weighed < 52 kg (115 lb) or > 73 kg (160 lb) or had a BMI < 18.5 or > 25.0 kg/m^2. Additional exclusion criteria included a taste rating for either entrée sample ≤ 30 mm on a 100-mm scale or a difference > 30 mm between the two sample ratings; a score ≥ 40 on the Zung Self-Rating Scale; or a score ≥ 20 on the Eating Attitudes Test. Subjects were also excluded if they reported known health problems or had not maintained their weight within 4.5 kg (10 lb) during the 6 months before the study. During the study, subjects were excluded if they did not meet a minimum energy intake of 200 kcal at each meal. A power analysis estimated that 17 participants were needed to detect a difference in energy intake between conditions of 150 kcal over 24 hours. Subjects were told the purpose of the study was to monitor eating behaviors at different meals. Subjects provided signed consent (**Appendix G)** and were financially compensated for their participation. All aspects of the study were approved by The Pennsylvania State University Office for Research Protections.

Study design

This experiment used a crossover design with repeated measures within subjects and the order of experimental conditions was randomly assigned across participants. Once a week for five weeks, participants were provided with all of their foods and beverages for five consecutive meals (breakfast, lunch, dinner, evening snack, and breakfast the next day). Main meals were served in the laboratory and evening snacks were sent home. All foods were consumed *ad libitum*. Over the weeks, the entrées served at lunch and dinner (shrimp stir-fry and chicken casserole; **Photograph 1**) were manipulated to have a protein content of 10, 15, 20, 25, or 30% energy (**Table 2-1**). These proportions were chosen because they are similar to the daily recommended range for protein intake of 10 to 35% energy.[18] In addition, this was the largest range of protein that could be covertly manipulated in order to prevent obvious changes in the amount of meat, which could influence the outcomes.

Photograph 1. Test meals provided at lunch and dinner: (left) taco casserole served with applesauce and (right) shrimp stir-fry served with a green salad.

Table 2-1. Composition of the manipulated lunch and dinner entrées.

	Protein content (% energy)				
Composition per 100 g	10%	15%	20%	25%	30%
Chicken Casserole					
Energy (kcal)	121	121	121	121	121
Protein (g)	3.1	4.6	6.1	7.6	9.1
Fat (g)	4.0	4.0	4.0	4.1	4.1
Carbohydrate (g)	18.8	17.3	15.9	14.4	13.0
Fiber (g)	1.3	1.3	1.2	1.2	1.1
Energy density (kcal/g)	1.2	1.2	1.2	1.2	1.2
Shrimp Stir-Fry					
Energy (kcal)	124	124	124	124	124
Protein (g)	3.2	4.7	6.2	7.7	9.2
Fat (g)	4.2	4.1	4.1	4.1	4.1
Carbohydrate (g)	20.0	18.5	17.0	15.6	14.1
Fiber (g)	2.2	2.0	1.8	1.6	1.4
Energy density (kcal/g)	1.2	1.2	1.2	1.2	1.2

The protein content of the entrées was modified by altering the proportions of animal protein and starch, so that as the protein content was increased, the carbohydrate content decreased. Recipes for the manipulated entrées can be found in **Appendix H**. To assist in making the protein manipulation covert, all entrée ingredients were finely chopped to be of a similar small size. In addition, chicken and shrimp were selected as the protein sources because their light color blended with the color of the other entrée components. Both entrées contained 30% energy from fat, which fell within daily recommendations of 20-35% energy[19], and had an energy density of 1.2 kcal/g, similar to that used in previous preloading and satiation studies.[6,10,20] The shrimp stir-fry was accompanied by a salad with low-calorie dressing, and the chicken casserole was accompanied by applesauce. In order to balance any effects of the sequence of consuming the entrées, half of the subjects were served the chicken casserole at lunch and the shrimp stir-fry at dinner, and the other subjects were served the entrées in the reverse sequence.

The two un-manipulated breakfast meals (oatmeal on day 1, fruit and yogurt parfait on day 2) provided approximately 15% energy from protein, 30% energy from fat, and an energy density of 1.2 kcal/g. Breakfast on day 1 was provided so that subjects would be at a similar level of satiety before each test lunch. Breakfast on day 2 was included in total 24-hour intake to determine whether the effects of protein persisted to the next main meal. Water was served with each meal (in addition to coffee or tea at the breakfast meals) and bottled water was provided for consumption between meals. After dinner, subjects were provided with three un-manipulated evening snacks (cookies, crackers, and fruit) and bottled water. The time of evening snack consumption was recorded to determine whether the protein manipulation influenced the onset of the next eating occasion. All foods and beverages were weighed before and after meals. Unconsumed evening snacks and bottled water were weighed at the subsequent meal. Energy and macronutrient intakes were calculated using information from food manufacturers and a standard nutrient database.[21]

Procedures

Subjects were instructed to keep their food intake and activity level consistent on the day before each test session, and kept a record of this information to encourage compliance (**Appendix I**). They were also instructed to refrain from consuming alcohol within 24 hours of the test session and to refrain from eating after 10 pm the evening before each test session. During test sessions, subjects were instructed to consume only those foods and beverages provided by the researchers. On test days, subjects came to the laboratory at scheduled meal times and were seated in individual cubicles. Lunch was served at least 3 hours after breakfast, and dinner was served at least 4 hours after lunch. Before each meal, participants completed a brief questionnaire asking whether they had felt ill, taken any medications, or consumed any foods or beverages not provided by the researchers since the last meal (**Appendix J**). At each meal, subjects were instructed to consume as much or as little of the foods and beverages as desired. After consuming the last meal of the study, participants completed a discharge questionnaire to report their ideas about the purpose of the study and any differences they noticed between test weeks (**Appendix K**).

Ratings of hunger, satiety, and food characteristics

Subjects used visual analog scales[22] to rate their hunger, fullness, thirst, prospective consumption (how much they thought they could eat), and nausea immediately before and after each meal, hourly between lunch and dinner, and immediately before consuming the evening snack (**Appendix L**). The characteristics of entrées were assessed using visual analog scales at the start of the meal and immediately after the meal (**Appendix M**). Subjects were instructed to first rate the appearance of the entrée and then take a bite and answer the remaining questions about pleasantness of taste, pleasantness of texture, and calorie content.

Data Analysis

Data were analyzed using a mixed linear model with repeated measures (Statistical Analysis Software, version 9.1, 2003, SAS Institute, Inc., Cary, NC). The fixed effects in the model were experimental condition (protein content of lunch and dinner entrées), study week, and entrée sequence (shrimp stir-fry at lunch and chicken casserole at dinner or vice versa). The primary outcomes for the study were food weight, protein intake, and energy intake at each meal and snack and for the entire 24-hour period (lunch, dinner, evening snack, breakfast on day 2). For the outcome of energy intake, the repeated measures data were analyzed using a random coefficients approach[23], which modeled intake for each subject across the five levels of protein content. The satiating efficiency of protein was characterized by the curve of the relationship of daily energy intake across the levels of protein content for each subject.[24] Secondary outcomes were participant ratings of hunger, satiety, and food characteristics. Subject characteristics were investigated as covariates in the main statistical model. Results are reported as mean ± standard error and were considered significant at $p<0.05$.

RESULTS

Subject characteristics

Twenty-one subjects were recruited for the study; however, 3 were excluded: 1 for noncompliance with the study protocol, 1 for failing to meet the minimum requirement for energy intake, and 1 because of job relocation. The final sample consisted of 18 women who had a mean age of 25.2 ± 0.5 years (range 20-40) and a mean Body Mass Index of 22.3 ± 0.2 kg/m^2 (range 19.5-25.0; **Table 2-2**).

Table 2-2. Characteristics of study participants (n=18 women).

Characteristic	Mean ± standard error	Range
Age (y)	25.2 ± 0.5	20 - 40
Weight (kg)	62.9 ± 0.6	53.0 - 71.9
Height (cm)	170 ± 0.0	150 - 180
Body mass index (kg/m^2)	22.3 ± 0.2	19.5 - 25.0
Dietary restraint score[a]	7.2 ± 0.4	2 - 15
Disinhibition score[a]	4.7 ± 0.2	1 - 8
Perceived hunger score[a]	5.1 ± 0.3	1 - 11
Eating attitudes score[b]	3.0 ± 0.3	0 - 8
Depression score[c]	28.4 ± 0.3	22 - 35

[a] Eating Inventory[17]
[b] Eating Attitudes Test[16]
[c] Self-Rating Depression Scale[15]

Nutrient and energy intake

Protein intakes at lunch and dinner increased significantly as the protein content of the manipulated entrées was increased (p<0.0001). Mean protein intakes at these meals ranged from 10.5 ± 0.9 g in the 10% protein condition to 32.9 ±3.2 g in the 30% protein condition. This led to a significant increase across conditions in 24-hour protein intake from lunch, dinner, evening snack, and breakfast on day 2 (p<0.0001; **Table 2-3**). Subjects ate a consistent weight of food at each meal and over the 24 hours; as a result, 24-hour energy intake did not vary significantly (p=0.70; **Figure 1-1;** Table 2-3). The relationship between protein content and energy intake, a measure of the satiating efficiency of protein, was linear with a slope that was not significantly different from zero (p=0.27). The average slope was -3.4 ± 3.0 kcal for each 1% increase in energy from protein. Daily fiber intake (Table 2-3) averaged 3.5 g/d less in the 30% protein condition than in the 10% protein condition (p=0.0013), an amount that is unlikely to influence energy intake.[26]

Table 2-3. Twenty-four hour food and energy intakes[1] (see **Appendix N** for intakes by meal).

	Protein content of lunch and dinner entrées (% energy)				
	10%	15%	20%	25%	30%
	mean±standard error				
Energy (kcal/d)	1870 ± 93	1887 ± 93	1848 ± 111	1876 ± 100	1807 ± 98
Food weight (g/d)	1391 ± 73	1410 ± 71	1383 ± 82	1441 ± 79	1337 ± 74
Fat (g/d)	58.2 ± 2.8	58.2 ± 3.0	57.2 ± 3.5	57.4 ± 3.3	55.5 ± 3.3
Carbohydrate (g/d)	308.0 ± 15.7[a2]	300.8 ± 14.6[a]	284.0 ± 17.0[ab]	278.7 ± 13.9[ab]	261.6 ± 13.5[b]
Protein (g/d)	43.9 ± 2.4[a]	55.5 ± 3.2[b]	65.0 ± 4.4[c]	77.4 ± 5.0[d]	81.7 ± 5.5[d]
Protein (g/kg/d)	0.7 ± 0.04[a]	0.9 ± 0.05[b]	1.0 ± 0.07[c]	1.2 ± 0.08[d]	1.3 ± 0.08[d]
Protein (% energy)	9 ± 0.1[a]	11 ± 0.2[b]	14 ± 0.2[c]	16 ± 0.3[d]	17 ± 0.4[e]
Fiber (g/d)	24.8 ± 1.3[a]	24.8 ± 1.2[a]	23.8 ± 1.3[ab]	23.5 ± 1.2[ab]	21.3 ± 1.1[b]
Energy density (kcal/g)[3]	1.35 ± 0.02	1.34 ± 0.02	1.34 ± 0.02	1.31 ± 0.02	1.36 ± 0.03

[1] 24-hour intake includes lunch, dinner, evening snack and breakfast on day 2.
[2] Means in the same row with different letters are significantly different (p<0.05).
[3] Dietary energy density was determined using foods only; beverages were not included.[25]

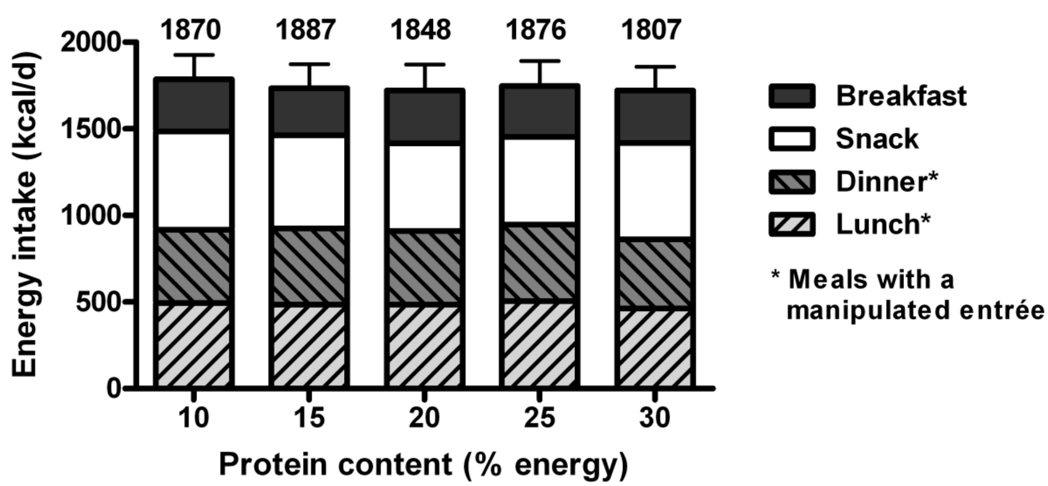

Figure 1-1. Twenty-four hour energy intakes by condition including lunch, dinner, evening snack, and breakfast on Day 2.

Ratings of hunger and satiety and food characteristics

There were no significant differences across conditions in ratings of hunger or fullness (**Figure 1-2**) or in ratings of thirst, prospective consumption, or nausea (data not shown) before meals, after meals, or hourly between the lunch and dinner meals. The timing of consuming the evening snack did not differ significantly across conditions, indicating that manipulating the protein content of lunch and dinner did not affect the onset of the next eating occasion. Ratings of the pleasantness of taste, pleasantness of appearance, pleasantness of texture, and calorie content of the manipulated lunch and dinner entrées and un-manipulated breakfast entrées did not vary across conditions of protein content before or after the meals. Mean taste ratings were 66.1 ± 1.8 (p=0.39) for the chicken casserole and 62.8 ± 2.1 for the shrimp stir-fry (p=0.41).

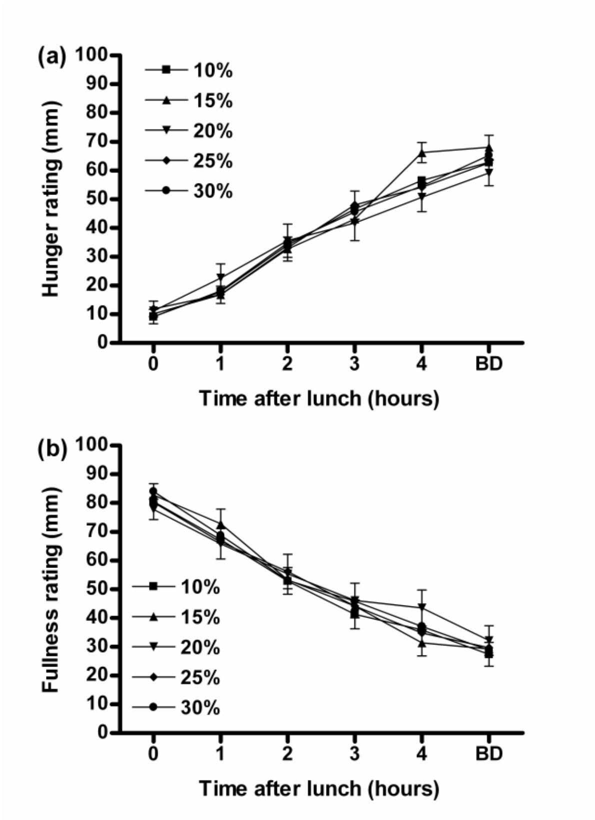

Figure 1-2. Mean (± SEM) ratings of (a) hunger and (b) fullness by condition. The ratings were taken immediately after lunch (hour 0) and every hour until immediately before dinner (BD).

Discharge questionnaire

On the discharge questionnaire, none of the subjects reported the correct purpose of the study. Only one of the 18 subjects reported noticing that the amount of meat in the lunch and dinner entrées was greater one week, suggesting that the protein manipulation was well disguised.

DISCUSSION

The primary finding of this study was that energy intake did not vary at any time point over 24 hours when the protein content of lunch and dinner meals was varied across multiple levels. A number of previous studies tested preloads or meals with a protein content of up to 60% energy[6-8,20,27], an amount unlikely to be consumed in a typical meal and greater than the daily recommended intake.[18] The few studies that tested more commonly consumed amounts often compared preloads with two levels of protein, such as 10-15% energy and 25-32% energy, and found inconsistent effects on satiety and energy intake.[28-30] The present study tested two meals with multiple levels of protein across this range and did not find differential effects on satiation. These findings are more likely to represent the response of free-living individuals to variations in protein intake, because the meals were consumed *ad libitum* rather than being compulsory. Although it is possible that consuming meals with a protein content higher than that tested in this study could influence satiation, it may not be recommended because of the potential for protein to displace other foods in the diet that provide essential nutrients.[18]

The satiating effects of protein are commonly studied by substituting protein for either carbohydrate or fat in test meals. Because protein is less calorically dense (4 kcal/g) than fat (9 kcal/g), substituting protein for fat could reduce the energy density of foods, which in turn could influence energy intake.[11] One study found that a high-protein diet significantly reduced *ad libitum* energy intake over 12 weeks[31]; however, since protein was exchanged for fat, the effects of increased protein are difficult to distinguish from those of reduced energy density. When energy density was controlled, several studies indicated that the satiating effects of the different macronutrients did not differ significantly.[7,11,12,29] The present study is consistent with these studies, demonstrating that when energy density does not vary, increasing protein intake within commonly consumed amounts has little effect on energy intake.

Other meal characteristics that may influence intake in studies of the satiating effects of protein are palatability[13,14] and appearance. Differences in food appearance may have a cognitive influence on intake; for example, a noticeable increase in the amount of meat may affect satiety if individuals regard meat as making a meal more satisfying. In some previous studies, the protein content of the meals was varied by overtly increasing the amount of meat or by serving different types of food, which probably influenced both the palatability and the appearance of the test foods.[6,8,20,28] In the present study, the different versions of the entrées were formulated to minimize differences in palatability and appearance. The achievement of the covert manipulation was confirmed by the similar ratings of pleasantness of taste, texture, and appearance, as well as by the comparable intake of the different versions of the entrées. The results indicated that when differences in the amount of animal protein were not obvious, and energy density was matched, there were no significant effects of protein content on energy intake. It remains possible that the effect of protein on satiation depends on whether the manipulation is overt or covert, and this issue should be explored in future studies.

Previous studies have shown that increases in protein intake can enhance ratings of satiety and that this effect is related to increases in satiety hormones, such as GLP-1, and increases in diet-induced thermogenesis.[1,2,5,32-34] These studies tested preloads with large amounts of protein[5], or tested high-protein iso-caloric diets that were compulsory over 24 hours.[32-34] It is possible that entrées consumed *ad libitum* need a protein content higher than the amounts tested in the present study to influence the release of satiety hormones or increase diet induced thermogenesis in order to enhance satiety.

The investigation of the satiating effects of protein in this study was limited to a population of normal-weight young women. The consumption of increased amounts of protein may have different effects on *ad libitum* energy intake in men or in overweight or obese individuals. In addition, this study tested the effects of protein at two meals over a period of one day. For protein to influence daily energy intake, an increased amount of protein may need to be consumed at all meals and snacks and for time periods longer than one day. The effect of protein on *ad libitum* energy intake is important because it relates to what is likely to occur in everyday situations. Future studies should continue to investigate *ad libitum* protein intakes and consider overtly manipulating all meals for a longer time period, using various animal protein sources, and testing different levels of energy density.

This study showed that varying the protein content of several entrées consumed *ad libitum* did not differentially influence energy intake or affect ratings of satiety over a day. When the appearance, taste, fat content, and energy density were controlled, simply adding meat to lunch and dinner entrées to increase the protein content within commonly consumed amounts was not an effective strategy to reduce daily energy intake.

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Chapter 3

Study 2:

Hidden vegetables: an effective strategy to reduce energy intake and increase vegetable intake in adults

Blatt AD, Roe LS, Rolls BJ. Hidden vegetables: an effective strategy to reduce energy intake and increase vegetable intake in adults. *Am J Clin Nutr*. 2011;93:756-63.

INTRODUCTION

Americans are exposed to an environment filled with easily accessible, energy-dense foods that promote the consumption of excess energy. To reduce energy intake, government agencies recommend substituting low-energy-dense foods such as vegetables for foods higher in energy density.[1,2] Research has shown that this strategy has multiple benefits, since it not only reduces energy intake[3-5] but also increases vegetable intake[6]; it may be difficult, however, for some adults to implement. One barrier that prevents individuals from meeting recommendations to increase vegetable intake is dislike for the taste of vegetables.[7-9] Puréeing vegetables and covertly adding them to foods while maintaining palatability could be an effective strategy to help individuals overcome this barrier. The purpose of the present study was to determine in adults whether covertly incorporating low-energy-dense puréed vegetables into foods increases vegetable intake while decreasing energy intake over a day.

Laboratory-based studies have shown that people tend to eat a consistent weight of food; as a result, if the energy density of food is decreased, they consume less energy.[3,5,10] Several methods can be used to decrease the energy density of foods, including reducing the fat and sugar content and increasing the proportion of water-rich fruits and vegetables. A few studies have focused on the strategy of decreasing energy density by increasing the vegetable content of foods. These studies have shown in adults that overtly substituting vegetables for more energy-dense ingredients in mixed dishes led to reduced energy intake[3-5] and increased vegetable intake.[6] Participants in those studies were screened to ensure that they liked and would eat the vegetables used for the manipulations.[3,5,6] Thus, the question of how to increase intake of low-energy-dense vegetables among people who vary in their liking for vegetables remains unanswered. One study in preschool children, who are often picky about vegetables, indicate that hiding puréed vegetables in foods can both increase vegetable intake and reduce energy intake.[11] In adults, it is not known whether the incorporation of puréed vegetables into foods has similar effects on energy and vegetable intakes.

In the present study, the energy density of the entrées at breakfast, lunch, and dinner was varied by covertly incorporating different amounts of puréed vegetables while maintaining similar palatability. Entrées were accompanied by various unmanipulated side dishes and all foods were consumed *ad libitum*. It was hypothesized that adding puréed vegetables to reduce the energy density of entrées would lead to a reduction in energy intake and an increase in vegetable intake at each meal. Additionally, it was predicted that these effects would persist throughout the day, resulting in a reduction in daily energy intake and an increase in daily vegetable intake.

METHODS

Study design

This experiment used a crossover design with repeated measures within subjects. One day a week for three weeks, participants were provided with all of their foods and beverages for breakfast, lunch, dinner, and evening snack. Across test days, the entrées served at the three main meals were varied in energy density (100%, 85%, or 75%) by changing the vegetable content. The entrées were accompanied by various unmanipulated side dishes. Main meals were served in the laboratory and unmanipulated evening snacks and bottled water were provided for consumption outside of the laboratory. All foods and beverages served in the study were consumed *ad libitum*. The order of experimental conditions was randomly assigned across participants.

Participants

Men and women aged 20 to 45 years were recruited for the study through advertisements in campus electronic newsletters. Potential subjects were interviewed by telephone to determine whether they met the initial study criteria, including that they had a reported body mass index (BMI; in kg/m^2) between 18 and 40, regularly ate three meals per day, did not smoke, did not have any food allergies or restrictions, were not athletes in training, were not dieting, were not taking medications that would affect appetite, and were willing to consume the foods served in the test meals (**Appendix O**).

Potential subjects who met the initial study criteria came to the laboratory to have their height and weight measured (model 707; Seca Corp., Hanover, MD, USA) and to rate the taste of food samples, including the manipulated study entrées at the 85% energy density level. A questionnaire consent form (**Appendix P**) was signed before completing the following questionnaires: a detailed demographic and weight history questionnaire (**Appendix C**); the Zung Self-Rating Scale[12] (**Appendix D**), which evaluates symptoms of depression; the Eating Attitudes Test[13] (**Appendix E**), which assesses indicators of disordered eating; and the Eating Inventory[14] (**Appendix F**), which measures dietary restraint, tendency toward hunger, and disinhibition. Exclusion criteria included a measured BMI < 18 or > 40, a taste rating for any entrée sample ≤ 30 mm on a 100-mm scale; a score ≥ 40 on the Zung scale; or a score ≥ 20 on the Eating Attitudes Test. Subjects were also excluded if they had not maintained their weight within 4.5 kg during the 6 months before the study. During the study, subjects were excluded if they did not meet a minimum intake of 50 kcal from the manipulated breakfast entrée and 100 kcal from the manipulated lunch and dinner entrées. Subjects were told that the purpose of the study was to determine perceptions of different tastes. Subjects provided signed consent

(**Appendix Q**) and were financially compensated for their participation. All aspects of the study were approved by The Pennsylvania State University Office for Research Protections.

The sample size for the experiment was estimated by using data from previous one-day studies in the laboratory. The minimum difference in daily energy intake assumed to be clinically significant was 200 kcal. A power analysis was performed and estimated that a sample size of 37 subjects was needed to detect this difference in daily energy intake with >80% power by using a one-sided test with a significance level of 0.05.

A total of 48 participants were enrolled in the study. Five participants were excluded from the study for failing to meet the minimum entrée intake and one participant was excluded for not following the study protocol. The data of one additional participant was excluded for having undue influence on the outcomes according to the procedure of Littell, et. al.[15]; this individual had extremely low intakes on one test day. Thus, a total of 41 participants were included in the analysis; their characteristics are found in **Table 3-1**.

Table 3-1. Characteristics of study participants.[1]

Characteristic	**Women (n=21)**	**Men (n=20)**
Age (y)	23.9 ± 1.2	24.4 ± 1.0
Height (m)	1.66 ± 0.02	1.79 ± 0.02[2]
Weight (kg)	64.4 ± 2.1	79.2 ± 2.5[2]
BMI (kg/m^2)	23.5 ± 0.8	24.7 ± 0.6
Dietary restraint score[3]	8.4 ± 0.6	6.7 ± 0.9
Disinhibition score[3]	6.0 ± 0.7	5.3 ± 0.7
Hunger score[3]	4.0 ± 0.5	5.4 ± 0.7

[1] All values are means ± SEMs.
[2] Significantly different from women: $p < 0.0001$ (Student’s *t* test).
[3] Score from the Eating Inventory.[14]

Test Foods and Meals

The entrées for each main meal were developed in three versions that differed in energy density: 100% (standard), 85% of the standard, and 75% of the standard (**Table 3-2**). The manipulated entrées were carrot bread at breakfast, macaroni and cheese at lunch, and chicken and rice casserole at dinner (**Photograph 2**). These foods were selected because they are commonly consumed and the vegetable content could be manipulated while maintaining a similar taste, texture, and appearance across energy density levels. The standard entrées were representative of the energy density and vegetable content of commonly used recipes. To reduce the energy density, the amounts of puréed vegetables (carrots, squash, and cauliflower) in the standard recipe were increased by 3 or 4.5 times as the other ingredients were decreased. The recipes for the manipulated entrées can be found in **Appendix R**. Thus, low-energy-dense vegetables were substituted in the recipes for the other ingredients. Substantial portions of entrées were provided at each meal, but participants were allowed to request additional entrée, if desired; in which case, they were served a second dish of the entrée containing half the original amount. This happened infrequently during the study: four participants requested additional breakfast entrée on one or more occasions and one participant requested additional dinner entrée on one occasion. The entrées were accompanied by various unmanipulated side dishes (**Table 3-3)** and one liter of water in addition to the choice of coffee or tea at breakfast. Non-caloric sweeteners were provided for subjects who selected coffee or tea in addition to one creamer (20 kcal) with coffee.

Table 3-2. Composition per 100 g of the manipulated entrées served at breakfast, lunch, and dinner in which the energy density was reduced by varying the amount of puréed vegetables.

	100% energy density	**85% energy density**	**75% energy density**
Breakfast			
Carrot bread			
Energy (kcal)	417	356	315
Carbohydrate (g,%)	57.1 (55)	49.2 (55)	43.9 (56)
Protein (g,%)	2.3 (2)	2.1 (2)	2.0 (2.5)
Fat (g,%)	19.7 (43)	16.7 (42)	14.5 (41)
Vegetable (g)	8.9	23.9	35.2
Fiber (g)	1.1	1.3	1.5
Energy density (kcal/g)	4.17	3.56	3.15
Lunch			
Macaroni and cheese			
Energy (kcal)	212	180	161
Carbohydrate (g,%)	16.2 (31)	14.1 (31)	12.8 (32)
Protein (g,%)	9.9 (19)	8.5 (19)	7.6 (19)
Fat (g,%)	12.1 (51)	10.2 (51)	8.9 (50)
Vegetable (g)	1.4	17.7	28.1
Fiber (g)	0.7	0.9	1.0
Energy density (kcal/g)	2.12	1.80	1.60
Dinner			
Chicken rice casserole			
Energy (kcal)	162	139	122
Carbohydrate (g,%)	19.4 (48)	16.8 (48)	15.3 (50)
Protein (g,%)	7.3 (18)	6.3 (18)	5.7 (19)
Fat (g,%)	6.2 (34)	5.2 (34)	4.4 (32)
Vegetable (g)	13.2	28.2	39.8
Fiber (g)	0.8	1.0	1.3
Energy density (kcal/g)	1.63	1.39	1.23

Unmanipulated evening snacks (Table 3-3) and bottled water were provided after the dinner meal to be consumed outside of the laboratory. Bottled water was also provided for consumption between meals. All foods and beverages were consumed *ad libitum* and were weighed before and after meals in order to determine the amount consumed to the nearest 0.1 g. Energy and macronutrient intakes were calculated using information from food manufacturers and a standard nutrient database.[16]

Table 3-3. Unmanipulated foods served as side dishes at each meal and at the evening snack.

Meal	Food	Amount
Breakfast	Strawberry yogurt[1]	280 g
	Sliced peaches[2]	160 g
Lunch	Buttered broccoli[3,4]	130 g
	Grapes	200 g
	Chocolate pudding[2]	200 g
	Wheat roll[5]	43 g
	Butter[4]	23 g
Dinner	Buttered green beans[4,6]	130 g
	Mandarin oranges[2]	160 g
	Pound cake[7]	63 g
	White roll[8]	43 g
	Butter[4]	23 g
Evening Snack	Fig cookies[9]	95 g
	Popcorn[10]	56 g
	Baby carrots	150 g

[1] Yoplait USA, Inc, Minneapolis, MN
[2] Sysco Corporation, Houston, TX
[3] Birds Eye Foods Inc, Rochester, NY
[4] Land O'Lakes Inc, Arden Hills, MN
[5] Bakery de France, Rockville, MD
[6] Hanover Foods Corp., Hanover, PA
[7] Sara Lee Corp., Downers Grove, IL
[8] Flowers Bakeries Food Service, Tucker, GA
[9] Kraft Foods Global, Inc., Northfield, IL
[10] Frito-Lay, Inc., Plano, TX

Photograph 2. Test meals served at breakfast (left), lunch (middle), and dinner (right).

Procedures

The day before each test day, subjects were instructed to keep their food intake and activity level consistent, refrain from consuming alcohol, and refrain from eating after 10 pm the evening before each test day. Subjects kept a record of their intake and activity in order to encourage compliance with this protocol (**Appendix I**). On test days, subjects came to the laboratory at scheduled meal times, were seated in individual cubicles, and completed a brief questionnaire asking whether they had felt ill, taken any medications, or consumed any foods or beverages not provided by the researchers since the last meal (**Appendix J**). Their meal was then served and they were instructed to consume as much or as little of the foods and beverages as desired. Lunch was served at least 3 hours after breakfast, and dinner was served at least 4 hours after lunch.

Ratings of hunger, satiety, and food characteristics

Subjects used visual analog scales[17] to rate their hunger, fullness, thirst, prospective consumption, and nausea immediately before and after each meal and immediately before consuming the evening snack (**Appendix L**). The characteristics of the entrées were also assessed using visual analog scales (**Appendix S**). Immediately before and after each meal, subjects were provided with a sample of the manipulated entrée and instructed to first rate the appearance of the sample and then eat the sample and answer the remaining questions about pleasantness of taste and pleasantness of texture. After the final meal, subjects completed a discharge questionnaire (**Appendix K**) to report their ideas about the purpose of the study and any differences they noticed between test days. Subjects also completed a questionnaire about food preferences in which they were asked to rate their liking of a variety of foods on a scale of 1 to 7 with 1 representing “Dislike strongly” and 7 representing “Like strongly” (**Appendix T**). Of the various foods listed, the majority were foods that were served in the study.

Data Analysis

Data were analyzed using a mixed linear model with repeated measures (SAS 9.1, SAS Institute, Inc., Cary, NC). The fixed effects in the model were experimental condition (entrée energy density level), study week, and subject sex. The primary outcomes for the study were food intake (g), vegetable intake (g), energy intake (kcal), and energy density (kcal/g) at each meal and over the entire day. Energy density was calculated based on foods only; beverages were excluded.[18] Vegetable intakes were characterized by both weight and volume; the volume of one serving of vegetables was defined as one-half cup (118 mL).[19] Secondary outcomes were participant ratings of hunger, satiety, and food characteristics. Subject characteristics were investigated as covariates in the main statistical model. Analysis of covariance was also used to determine whether participant ratings of hunger and satiety influenced the relation between experimental condition and meal energy intake, as well as whether participant ratings of entrée characteristics influenced the relation between experimental condition and intake of the manipulated entrées. Results are reported as mean ± standard error and were considered significant at $p<0.05$.

RESULTS

Vegetable intake

The incorporation of additional puréed vegetables to reduce the energy density of the entrées significantly increased total vegetable intake at each meal ($p<0.0001$; **Figure 2-1**) and over the day ($p<0.0001$). The amount of vegetables consumed daily from the entrées was 62 ± 3 g in the 100% condition, 198 ± 9 g in the 85% condition, and 288 ± 14 g in the 75% condition. This is equivalent to 1 additional vegetable serving per day in the 85% condition and 2 additional vegetable servings per day in the 75% condition (**Table 3-4**). Although vegetable intake from the entrées increased as their vegetable content was increased, consumption of the vegetable side dishes at the lunch and dinner meals did not change significantly. Intake of carrots at the evening snack was also consistent across conditions. Thus, total vegetable intake over the entire day increased from 270 ± 17 g in the 100% condition, to 401 ± 20 g in the 85% condition (a 50% increase), to 487 ± 25 g in the 75% condition (an 80% increase) ($p<0.0001$; **Table 3-5**).

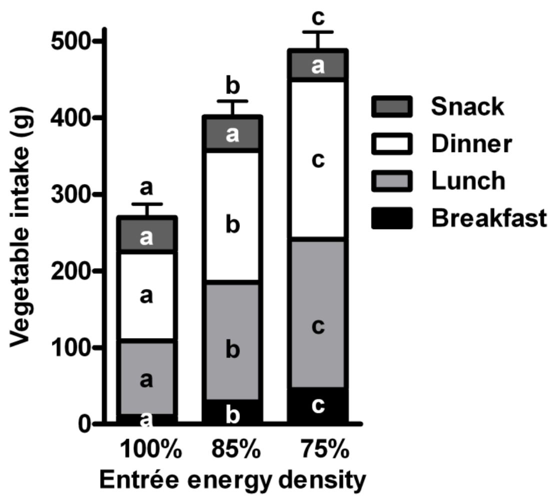

Figure 2-1. Mean (±SEM) vegetable intakes by condition at meals and evening snack. Within each meal and snack, values with different letters are significantly different ($p < 0.0001$).

Table 3-4. Vegetable content of each manipulated entrée per amount of entrée served (180 g carrot bread, 600 g macaroni and cheese and chicken rice casserole) and vegetable intake from each entrée across conditions. One vegetable serving = ½ cup.

Entrée	Vegetables (g)	Vegetable Servings	Vegetables (g)	Vegetable servings
	Served		Consumed	
Carrot bread				
100%	16.0	0.3	10.1	0.2
85%	43.0	0.5	28.9	0.3
75%	63.4	0.7	45.1	0.5
Macaroni and cheese				
100%	8.4	0.1	5.2	0.0
85%	106.2	0.9	65.8	0.6
75%	168.6	1.4	104.3	0.9
Chicken rice casserole				
100%	79.2	1.2	46.3	0.7
85%	169.2	1.9	102.4	1.2
75%	238.8	2.5	138.9	1.5
Total				
100%	103.6	1.5	61.6	0.9
85%	318.4	3.3	197.5	2.1
75%	470.8	4.6	287.9	2.8

Table 3-5. Total food and energy intakes over a day (See **Appendix U** for intakes by meal).[1]

	100% energy density	**85% energy density**	**75% energy density**
Energy (kcal)	3117 ± 132[a]	2915 ± 118[b]	2760 ± 110[c]
Weight (g)	1775.8 ± 73.5	1812.6 ± 74.1	1806.4 ± 76.0
Carbohydrate (g)	390.6 ± 17.6[a]	376.2 ± 16.2[ab]	362.7 ± 15.3[b]
Protein (g)	89.0 ± 3.7[a]	81.6 ± 3.4[b]	75.4 ± 3.2[c]
Fat (g)	133.2 ± 5.6[a]	121.1 ± 4.9[b]	113.0 ± 4.5[c]
Vegetable (g)	269.6 ± 17.4[a]	401.0 ± 20.3[b]	487.4 ± 24.6[c]
Fiber (g)	19.8 ± 0.8[a]	22.0 ± 0.9[b]	23.7 ± 1.0[c]
Energy density (kcal/g)	1.76 ± 0.03[a]	1.62 ± 0.03[b]	1.54 ± 0.03[c]

[1] All values are means ± SEMs. Values in the same row with different superscript letters are significantly different ($p < 0.0002$).

Food intake

The total weight of food consumed at each meal and snack (**Figure 2-2A)** and over the entire day did not differ significantly across conditions of entrée energy density (Table 3-5). Intakes of the manipulated entrées at lunch and dinner were not significantly different across conditions, but intake of the breakfast entrée was higher in the 75% condition than in the 100% condition ($p=0.011$). Participants consumed, on average, 113 ± 9 g of carrot bread in the 100% condition, 121 ± 9 g in the 85% condition, and 128 ± 10 g in the 75% condition (**Table 3-6**). Participants consumed consistent weights of all unmanipulated side dishes and evening snacks across conditions ($p>0.27$ for all items).

Table 3-6. Intakes (g) of each manipulated entrée [1]

	100% ED	**85% ED**	**75% ED**
Carrot Bread	113 ± 9[a]	121 ± 9[ab]	128 ± 10[b]
Macaroni and Cheese	372 ± 19	372 ± 20	371 ± 21
Chicken Rice Casserole	351 ± 20	363 ± 21	349 ± 20

[1] All values are means ± SEMs. Values in the same row with different superscript letters are significantly different ($p< 0.011$).

Energy intake and energy density

Energy intake over the day significantly decreased as the energy density of the entrées was reduced ($p<0.0001$; **Figure 2-2B**; Table 3-5). Compared to the 100% condition, participants consumed 202 ± 60 kcal less in the 85% condition and 357 ± 47 kcal less in the 75% condition. These differences are equivalent to mean decreases in daily energy intake of 6% and 11%, respectively. Energy intake from the unmanipulated side dishes and evening snacks did not differ significantly across conditions. Men consumed a mean of 73 ± 1.8% of the energy provided from the unmanipulated side dishes and evening snacks and women consumed a mean of 51 ± 1.5%. None of the participants consumed the entire amount of side dishes and evening snacks provided over a day. Thus, the decrease in daily energy intake was a result of the reduction in energy intake from the manipulated entrées.

At the lunch and dinner meals, energy intake from the entrées significantly decreased as the energy density was reduced ($p<0.0001$). The reduction in energy intake from the entrées paralleled the reduction in energy density. Energy intake from the breakfast entrée was significantly different only between the 100% and 75% condition ($p<0.01$). Although participants consumed more carrot bread in the 75% condition, reducing the energy density by 25% reduced energy intake from the carrot bread by 14% compared to the 100% condition.

Dietary energy density over the day decreased significantly as the energy density of the three entrées was decreased ($p<0.0001$). Mean dietary energy density was 1.76 ± 0.03 kcal/g in the 100% condition, 1.62 ± 0.03 kcal/g in the 85% condition, and 1.54 ± 0.03 kcal/g in the 75% condition. Thus, reducing the energy density of the entrées by 15% and 25% decreased dietary energy density by means of 8% and 13%, respectively.

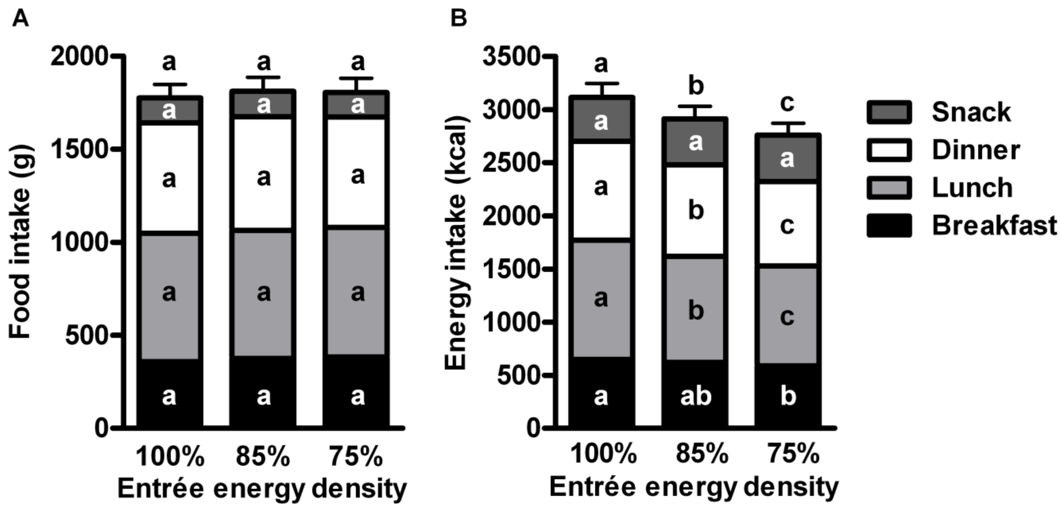

Figure 2-2. Mean (±SEM) (A) food and (B) energy intakes by condition at meals and evening snack. Within each meal and snack, values with different letters are significantly different ($p < 0.02$).

Ratings of hunger, satiety, and food characteristics

Before meals, participant ratings of hunger, fullness, prospective consumption, nausea, and thirst did not vary significantly across conditions (data not shown). After meals, ratings of hunger and satiety were not significantly different across conditions with one exception. After breakfast, ratings of fullness were higher in the 75% condition (82 ± 2 mm) than in the 100% condition (76 ± 3 mm; p=0.014), consistent with the differences in intake. This higher rating did not influence ratings of fullness before the lunch meal. Ratings of fullness before consumption of the evening snack were not significantly different across conditions (**Figure 2-3**).

Ratings of pleasantness of appearance, taste, and texture for each of the manipulated entrées are shown in **Table 3-7**. All entrées were well-liked by participants. Across conditions there were no significant differences in ratings of pleasantness of appearance, taste, or texture for the chicken rice casserole, pleasantness of appearance or texture for the macaroni and cheese, or pleasantness of appearance for the carrot bread. Pleasantness of taste of the macaroni and cheese in the 75% condition was rated significantly lower than in the 100% condition (p=0.0167). For the carrot bread, ratings of pleasantness of taste and pleasantness of texture were significantly higher in the 85% (p<0.001) and 75% (p<0.0001) conditions than in the 100% condition. Analysis of covariance showed that these differences in ratings for both the macaroni and cheese and carrot bread did not significantly influence the relation between experimental condition and intake of the entrées.

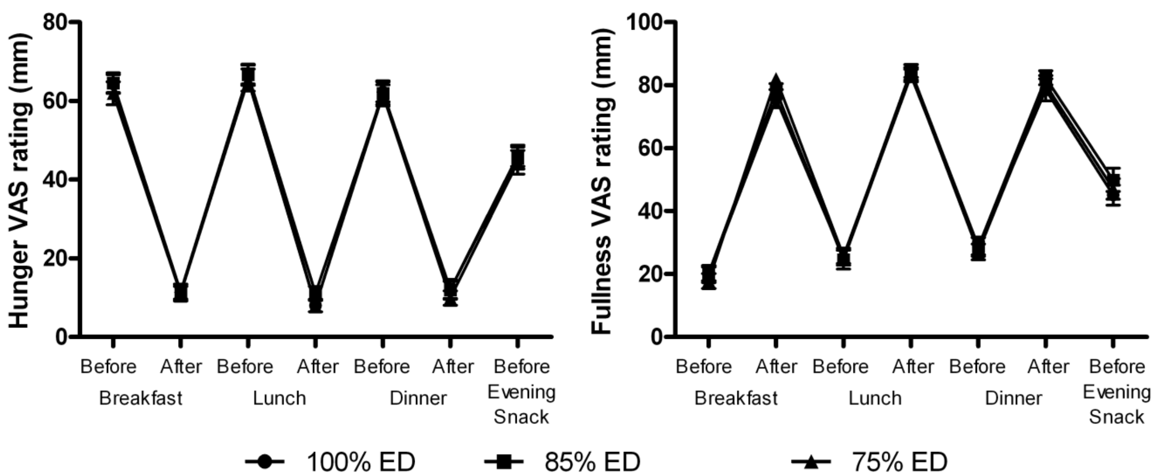

Figure 2-3. Mean (±SEM) hunger and fullness ratings measured with visual analog scales before and after meals and before evening snack in each condition.

Influence of subject characteristics

Analysis of covariance demonstrated that the relation between entrée energy density and the outcomes of total food, vegetable, and energy intakes was not significantly affected by participant age, sex, height, weight, BMI, or scores for dietary restraint, disinhibition, or hunger.

Table 3-7. Ratings of food characteristics for each of the manipulated entrées.[1]

	100% energy density	85% energy density	75% energy density
Carrot bread			
Appearance	63.8 ± 2.9	66.5 ± 2.7	68.9 ± 2.8
Taste	62.6 ± 3.7[a]	75.7 ± 2.3[b]	76.6 ± 2.1[b]
Texture	56.1 ± 3.7[a]	74.5 ± 2.6[b]	77.0 ± 2.3[b]
Macaroni and cheese			
Appearance	65.4 ± 3.1	63.2 ± 3.7	59.0 ± 3.7
Taste	72.9 ± 2.9[a]	68.0 ± 3.1[ab]	66.2 ± 2.9[b]
Texture	64.2 ± 3.7	61.4 ± 3.7	63.2 ± 3.3
Chicken rice casserole			
Appearance	63.2 ± 3.3	63.4 ± 2.9	60.2 ± 3.4
Taste	64.0 ± 3.0	64.8 ± 3.0	62.7 ± 2.8
Texture	67.1 ± 3.0	66.1 ± 2.9	64.7 ± 2.4

[1] All values are mean ± SEMs ratings from 100-mm visual analog scales. Values in the same row with different superscript letters are significantly different ($P < 0.02$).

Ratings of participant liking of the of the puréed vegetables used to manipulate entrée energy density (carrots, yellow squash and cauliflower) and the vegetable side dishes (broccoli and green beans) obtained from the food preference questionnaire can be found in **Table 3-8.** Analysis of covariance revealed that participant liking of the vegetables used to manipulate the entrées did not significantly influence the relation between entrée energy density and intake of the entrées (data not shown). For example, the 75% energy density version of the macaroni and cheese had more puréed cauliflower than the 100% version, but participant liking for cauliflower did not influence how much macaroni and cheese was consumed across conditions.

Table 3-8. Ratings of participant liking[1] of the vegetables used in the study. The puréed vegetables used to manipulate entrée energy density were carrots, yellow squash and cauliflower, and the unmanipulated vegetable side dishes were broccoli and green beans.

	Dislike strongly, dislike, or dislike somewhat		Neither like nor dislike		Like strongly, like, or like somewhat	
Vegetable	*n*	%	*n*	%	*n*	%
Carrots	4	10	7	17	30	73
Yellow squash	14	36	12	31	13	33
Cauliflower	11	28	9	23	19	49
Broccoli	5	12	2	5	34	83
Green beans	11	27	5	12	25	61

[1] Ratings were collected at the end of the study using a 7-point scale.

Comments from the discharge questionnaire showed that 18 participants (44%) noticed differences in the appearance, taste, or texture of the different versions of the entrées, and 2 participants (5%) noticed differences in the vegetable content; in particular, participants commented on the difference in moistness of the carrot bread. The effect of the experimental manipulation on the main outcomes of food, vegetable, and energy intakes did not differ significantly between participants who did and did not notice differences between the entrées.

DISCUSSION

The findings from this study show that incorporating puréed vegetables into meals as a method of decreasing energy density can be an effective strategy to reduce energy intake and increase vegetable intake over a day. Participants consumed a similar weight of food across conditions, and therefore, when the energy density of the breakfast, lunch, and dinner entrées was reduced by 15% and 25%, daily energy intake was reduced by 6% and 11%, respectively. Additionally, vegetable intake over the day increased by about 50% in the 85% condition and

80% in the 75% condition. Despite the reduction in daily energy intake across conditions, participant ratings of hunger and fullness did not differ significantly. Adding puréed vegetables to foods is a simple strategy that can lead to large effects on daily energy and vegetable intakes.

The energy density of foods can be manipulated in a variety of ways such as decreasing the fat and sugar content and increasing the amount of water-rich fruit and vegetables. Many studies have used a combination of these methods[20-24], but only a few have incorporated vegetables as the primary method of reducing energy density.[3-5] In these studies, vegetables were overtly substituted for higher-energy-dense ingredients in a mixed dish. The results showed that participants consumed a similar weight of food across levels of energy density, and thus consumed less energy as the energy density was decreased. Despite these differences in energy intake, ratings of hunger and satiety did not differ across conditions.[3-5] The present study extended these findings by covertly incorporating puréed vegetables into foods to reduce the energy density, and similarly found reductions in energy intake with no differences in hunger and satiety. In contrast to previous studies, the manipulated entrées in the present experiment were served with palatable side dishes that were not varied in energy density and could be consumed *ad libitum*. The finding that intake of these side dishes, as well as the unmanipulated evening snacks, was consistent across conditions demonstrates that the effects of energy density on intake can persist over a day, even when participants are given opportunities to compensate for reductions in energy intake. It is possible that individuals could compensate by consuming more energy on subsequent days, and this should be explored in future studies. The results of this study add to the evidence that decreasing the energy density of foods by increasing vegetable content is an effective strategy to reduce energy intake. Compared to using chopped or whole vegetables, puréed vegetables can be covertly incorporated into a wide variety of sweet and savory foods, and therefore provide more opportunities for influencing energy intake.

Substituting low-energy-dense vegetables for foods higher in energy density is recommended by several government agencies to help reduce energy intake.[1-2] This strategy also has the potential to help increase vegetable intake. One study investigated this approach by increasing the amount of whole vegetables served at a meal while decreasing the amount of grain and meat. The results showed that when the portion of vegetables was increased by 90 g, vegetable intake at the meal increased by about half of a serving; when the portion was increased by 180 g, vegetable intake increased by three-quarters of a serving.[6] A similar substitution strategy was used in the present study, except that puréed vegetables were used rather than whole vegetables. Comparable to the effects found in the previous study, increasing the amount of puréed vegetables in each of the lunch and dinner entrées by 90 or 160 g increased vegetable intake at each meal by half of a serving or three-quarters of a serving, respectively. As a result, the substitution increased vegetable consumption over the day by one additional serving of vegetables in the 85% condition and two additional vegetable servings in the 75% condition. Furthermore, because intake of vegetable side dishes did not change, the puréed vegetables in the entrées added to overall vegetable intake. The strategy of substituting either whole or puréed vegetables for foods higher in energy density can be effective in increasing vegetable intake and reducing energy intake, but using puréed vegetables may be especially beneficial in individuals who dislike the taste of vegetables.

A dislike for the taste or texture of vegetables is a barrier to achieving recommended vegetable intakes for many Americans.[7-9] The incorporation of puréed vegetables into foods may be one way to help individuals overcome this barrier. In the present study, the entrées were formulated so that the taste, texture, and appearance of each entrée remained similar as the amount of puréed vegetables was increased. Subject ratings of the entrée characteristics and comments from the discharge questionnaire revealed that some individuals noticed differences in the taste and texture of some entrées. For example, as the amount of vegetables increased in the carrot bread, ratings for pleasantness of taste and texture increased. Based on participant comments, the higher ratings were likely due to the increased moistness; this could also explain why participants consumed more carrot bread in the 75% condition. Despite consuming a greater amount, participants still consumed less energy from the carrot bread and the entire breakfast meal in the 75% condition than the 100% condition. At the lunch meal, taste ratings of the macaroni and cheese were significantly lower in the 75% condition than in the 100% condition, but this did not affect intake of the entrée across conditions. Participant liking of the vegetables used to manipulate energy density (carrots, squash, and cauliflower) did not influence intake of the entrées. These results suggest that large amounts of puréed vegetables can be incorporated into foods with only slight differences in palatability, and that such differences are unlikely to affect intake. Although covertly incorporating vegetables into entrées should not be advised as the only method of increasing vegetable consumption, this strategy provides an additional opportunity for meeting recommended intakes, particularly among individuals with a low liking for vegetables.

This study showed that substantial amounts of puréed vegetables can be effectively incorporated into a variety of sweet and savory foods to increase vegetable intake and reduce energy intake. In addition, these effects can persist over a day even when subjects are given the opportunity to compensate for decreases in energy intake by consuming other palatable foods. “Hiding” vegetables in foods has been shown to be effective in children to reduce energy intake and increase vegetable intake[11] and the present study shows it is also effective in adults, including those who dislike the taste of vegetables. This simple strategy provides an opportunity that could be implemented in many settings; for example, it can be used by individuals at home, by restaurant chefs, or by the food industry to influence vegetable and energy intakes. The effect of this strategy needs to be investigated over time to determine whether it can have persistent effects on energy intake that could impact the rising rates of obesity.

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Chapter 4

Study 3:

Effects of energy density and energy content of pre-portioned entrées on energy intake

INTRODUCTION

Effective strategies are needed to help individuals manage their food intake in an environment that is filled with large portions of a variety of energy-dense foods. One strategy that has been shown to be useful in moderating energy intake and managing body weight is the consumption of pre-portioned foods, such as liquid meal replacements and solid pre-portioned entrées.[1-10] Although much of the research has used liquid meal replacements, there is some evidence that these are less satiating than their solid equivalents.[11, 12] Additionally, because solid pre-portioned foods offer greater variety than liquid pre-portioned foods, their continued use may be more sustainable and thus more helpful for managing body weight. Several studies have examined the consumption of solid pre-portioned entrées over multiple weeks and showed that participants achieved greater weight loss with the use of entrées than with self-selected diets.[6-10] These studies, however, provided little data on how the characteristics of pre-portioned entrées influence their effectiveness; this information would be useful for optimizing the composition of entrées for weight management. Thus, the present study investigated the characteristics of solid pre-portioned entrées, specifically, how variations in their energy content and energy density enhance satiety and thereby influence energy intake over a day.

The standard paradigm for investigating the effects of food characteristics on satiety is to determine how a fixed amount of food (a preload) affects subsequent intake at a test meal.[13] Research conducted using this paradigm has found that the energy content and energy density of a food can both influence total energy intake at the meal. An ability to compensate for the energy provided from the preload by adjusting energy intake at the test meal is critical to maintaining a stable total energy intake at the meal.[14] Preload studies that varied the energy content have shown variable results for compensation, with higher energy content preloads leading to a decrease in intake at the subsequent test meal[14-16], yet an increase in total energy intake.[14] On the other hand, studies that varied the energy density of preloads have shown more consistently that low-energy-dense preloads lead to decreases in total meal energy intake compared to equicaloric high-energy-dense preloads that are smaller in portion size.[17-19] It is important to recognize that when an equicaloric preload is reduced in energy density, there is a resultant increase in the portion size (weight) of the food. A decrease in total meal energy intake has also been found with the consumption of reduced-energy-dense preloads compared to high-energy-dense preloads, regardless of the portion size.[19] While it is clear that the energy content, energy density, and portion size of a preload can significantly influence satiety, more information is needed about these food characteristics and their effects on energy intake in the entrée portion of a meal.

Most preloading studies have tested foods that are typically consumed as a first course, and little is known about how the characteristics of the main component (entrée) of a meal would affect energy intake at a test meal. Only one study has examined the attributes of entrées and their effects on meal energy intake when a varied selection of additional foods is available.[20] In this study, compulsory entrées were manipulated in energy density and fat content and provided approximately 50% of each individual's usual energy intake. The design of this study is important since individuals receive daily exposure to a variety of tempting and palatable high-energy-dense foods and consumption of these foods can lead to excessive energy intake. The current study extends the previous one by using a similar design but varying the energy content and the energy density of entrées, as well as comparing versions of the entrées that were matched in portion size. We hypothesized that reductions in both the energy content and energy density of compulsory entrées would add together to reduce daily energy intake. We also hypothesized that when the compulsory entrées were matched in portion size, reducing both the energy content and energy density would lead to a decrease in daily energy intake compared to consuming entrées of standard energy content and energy density.

METHODS

Study design

This experiment used a crossover design with repeated measures within subjects. One day a week for four weeks, participants were provided with all of their foods and beverages for breakfast, lunch, and dinner meals. Across test days, the main dish (entrée) at each meal was varied in both energy content and energy density between a standard level (100%) and a reduced level (64% of the standard), as shown in **Table 4-1**. Participants were given 15 minutes to consume the compulsory entrée, and two minutes later a variety of unmanipulated foods were served for *ad libitum* consumption. Water was served with all meals in addition to the choice of coffee or tea with the breakfast meal. All meals were served in the laboratory and bottled water was provided for consumption between meals outside of the laboratory. The order of experimental conditions was counterbalanced across the subjects.

Subjects

Men and women aged 20 to 45 years were recruited for the study through advertisements in newspapers, flyers, and campus electronic newsletters. Potential subjects were interviewed by telephone to determine whether they met the initial study criteria, including that they regularly ate three meals per day, did not smoke, did not have any food allergies or restrictions, were not athletes in training, were not dieting, were not taking medications that would affect appetite, and were willing to consume the foods served in the test meals (**Appendix V**).

Table 4-1. Total energy content, weight, and energy density of compulsory entrées served in the four experimental conditions for men and women.

	Energy content condition Men		Energy content condition Women	
Energy density condition	**Standard**	**Reduced**	**Standard**	**Reduced**
Standard				
Entrée energy (kcal/d)	1570	1000	1100	700
Entrée weight (g/d)	980	615	690	430
Entrée energy density (kcal/g)	1.6	1.6	1.6	1.6
Reduced				
Entrée energy (kcal/d)	1570	1000	1100	700
Entrée weight (g/d)	1570	980	1100	690
Entrée energy density (kcal/g)	1.0	1.0	1.0	1.0

[1] Numbers are rounded to the nearest 10 kcal and 10 grams.

Potential subjects who met the initial study criteria came to the laboratory to have their height and weight measured (model 707; Seca Corp., Hanover, MD, USA) and to rate the taste of food samples, including the entrées that were served in the study (at an energy density of 1.3 kcal/g, half-way between the experimental energy densities). A questionnaire consent form (**Appendix W**) was signed and the following questionnaires were completed: a detailed demographic and weight history questionnaire (**Appendix C**); the Zung Self-Rating Scale[21] (**Appendix D**), which evaluates symptoms of depression; the Eating Attitudes Test[22] (**Appendix E**), which assesses indicators of disordered eating; and the Eating Inventory[23] (**Appendix F**), which measures dietary restraint, tendency toward hunger, and disinhibition. Exclusion criteria included a taste rating for any entrée sample $\leq$ 30 mm on a 100-mm scale; a score $\geq$ 40 on the Zung scale; or a score $\geq$ 20 on the Eating Attitudes Test. Subjects were also excluded if they reported known health problems or had not maintained their weight within 4.5 kg (10 lb) during the 6 months before the start of the study.

The sample size for the experiment was estimated by using data from previous one-day studies in the laboratory. The minimum difference in daily energy intake assumed to be clinically significant was 300 kcal for men and 200 kcal for women, equivalent to about 10% of daily energy intakes based on nationally representative data for men and women. A power analysis was performed and estimated that a sample size of 19 men and 26 women was needed to detect this difference in daily energy intake with >80% power by using a two-sided test with a significance level of 0.05.

Subjects were told the purpose of the study was to monitor eating behaviors at different meals. Each subject provided signed consent (**Appendix X**) and was financially compensated for participating in the study. A total of 31 men and 42 women were enrolled in the study. Three men and one woman were excluded from the study for noncompliance with the study protocol. The data of one additional woman was excluded for having undue influence on the outcomes according to the procedure of Littell, et al.[24] Thus, a total of 28 men and 40 women completed the study; their subject characteristics can be found in **Table 4-2**. All aspects of the study were approved by The Pennsylvania State University Office for Research Protections.

Meals

Across experimental conditions, the compulsory entrée at each of the three meals was varied in both energy content and energy density between a standard level and a reduced level. In addition, the reductions in energy content and energy density were chosen so that each standard entrée was matched in weight to the entrée of reduced energy content and reduced energy density (**Figure 3-1**). On each test day, participants were served breakfast, lunch, and dinner meals that included the compulsory manipulated entrée (**Table 4-3**) and a variety of discretionary foods that were consumed *ad libitum* (**Table 4-4**). The entrées were selected because they could be covertly manipulated in energy density and matched for palatability; the discretionary foods served at the test meal were commonly consumed items that were not varied in energy content or energy density.

Table 4-2. Characteristics of study participants.

Characteristic	Men (n=28)		Women (n=40)	
	Mean ± SEM	Range	Mean ± SEM	Range
Age (y)	26.8 ± 1.1	20-41	27.6 ± 1.1	20-43
Height (m)	1.77 ± 0.01	1.7-1.9	1.65 ± 0.01[a]	1.5-1.8
Weight (kg)	77.9 ± 2.0	62-107	63.5 ± 1.5[a]	49-91
BMI (kg/m^2)	24.9 ± 0.6	20-33	23.3 ± 0.6[a]	19-38
Energy requirement (kcal/d)[1]	2831 ± 38	2464-3164	2196 ± 24[a]	1847-2546
Dietary restraint score[2]	6.3 ± 0.6	1-13	8.3 ± 0.7[a]	1-16
Disinhibition score[2]	4.2 ± 0.4	0-9	4.5 ± 0.4	1-11
Hunger score[2]	4.7 ± 0.6	0-12	4.4 ± 0.5	0-13

[1] Estimated from sex, age, height, weight, and activity level.[30]
[2] Scores from the Eating Inventory.[22]
[a] Mean for women is significantly different from mean for men ($p < 0.0001$).

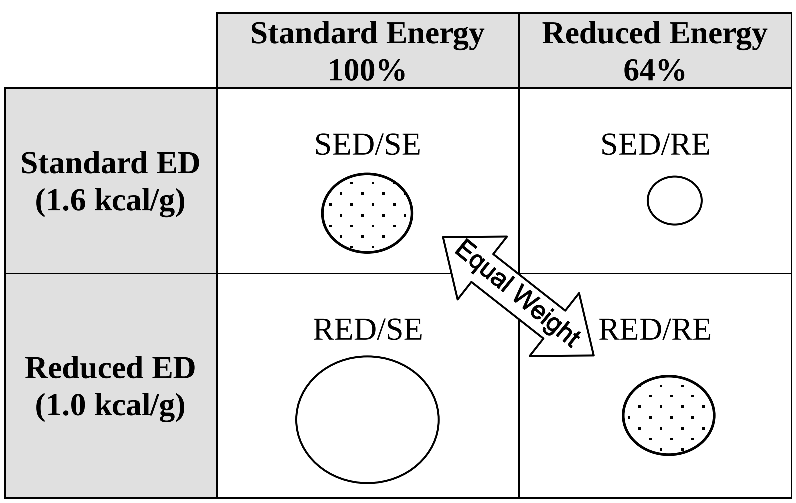

Figure 3-1. Schematic of the manipulated entrées in each condition showing differences in portion size as a result of changes in energy density and energy content.

Table 4-3. Composition of the manipulated entrées served at breakfast, lunch, and dinner (SED: standard energy density; RED: reduced energy density).

	Men				Women			
	Standard energy content		Reduced energy content		Standard energy content		Reduced energy content	
	SED	**RED**	**SED**	**RED**	**SED**	**RED**	**SED**	**RED**
Breakfast: Yogurt parfait								
Weight (g)	272	426	173	272	190	299	120	190
Energy (kcal)	430	430	275	275	300	300	190	190
Fat (g)	14.4	14.3	9.1	9.0	10.0	10.0	6.3	6.2
Carbohydrate (g)	63.2	64.2	40.2	41.1	43.9	44.8	27.7	28.0
Protein (g)	16.2	16.6	10.2	10.3	11.3	11.6	7.1	7.2
Fiber (g)	4.0	5.4	2.5	3.5	2.7	3.8	1.7	2.4
Lunch: Chicken rice casserole								
Weight (g)	356	566	229	356	250	395	160	250
Energy (kcal)	570	570	368	368	400	400	256	256
Fat (g)	18.9	18.9	12.4	12.5	13.2	13.3	8.6	8.7
Carbohydrate (g)	79.7	81.6	52.4	54.0	55.6	57.3	36.3	34.0
Protein (g)	21.7	22.0	14.1	14.6	15.1	15.3	9.8	10.1
Fiber (g)	2.9	7.6	1.8	5.0	2.1	7.1	1.4	4.7
Dinner: Pasta bake								
Weight (g)	356	570	223	356	250	400	157	250
Energy (kcal)	570	570	360	360	400	400	251	251
Fat (g)	19.2	19.1	12.0	12.1	13.5	13.1	8.5	8.3
Carbohydrate (g)	76.8	78.1	48.5	49.6	53.9	55.5	34.0	34.9
Protein (g)	22.0	21.9	14.0	13.7	15.3	15.2	9.6	9.6
Fiber (g)	8.0	11.9	5.1	7.6	5.6	8.4	3.5	5.2

Table 4-4. Unmanipulated discretionary foods served at each meal.

	Men		Women	
	Energy (kcal)	**Weight (g)**	**Energy (kcal)**	**Weight (g)**
Breakfast				
Mandarin oranges[1]	202	349	141	244
Plain bagels[2]	353	143	247	100
Assorted condiments (cream cheese[3], butter[4], jelly[5])	622	220	622	220
Lunch				
Buttered broccoli[4,6]	200	243	140	170
Rice pilaf[7]	314	221	220	155
Grapes	224	324	157	227
Chocolate chip cookies[8]	416	86	290	60
Dinner				
Salad with sliced tomatoes	22	127	17	98
Assorted dressings[9]	760	258	760	258
Croutons[10]	86	20	60	14
Crackers[8]	345	71	243	50
Cubed cheese[8]	344	86	240	60
Peaches[1]	130	323	91	226
Pound cake[2]	316	80	221	56

[1] Independent Marketing Alliance, Houston, TX
[2] Sara Lee Corporation, Downers Grove, IL
[3] Kraft Foods North America, Inc., Glenview, IL
[4] Land O'Lakes Inc, Arden Hills, MN
[5] J.M Sumcker Company, Orville, OH
[6] Birds Eye Foods, Inc., Rochester, NY
[7] MARS Food US, LLC, Carson, CA
[8] Kraft Foods Global, Inc., Northfield, IL
[9] T. Marzetti Company, Columbus, OH
[10] Pepperidge Farm, Inc., Norwalk, CT

The energy density of the standard entrées was 1.6 kcal/g, similar to that of commercially available portion-controlled entrées intended for non-dieters. The energy density of the reduced entrées was 1.0 kcal/g, or ~64% of the standard energy density; the reduction was accomplished by increasing the amount of vegetables or fruit. This energy density is similar to that of commercially available portion-controlled entrées marketed for weight management. The ingredients in the entrées were adjusted to maintain approximately 15% of energy as protein, 30% of energy as fat, and 55% of energy as carbohydrate. Thus, the reduction in energy density was accomplished by increasing the water content of the entrées while maintaining the macronutrient content. Recipes for the manipulated entrées can be found in **Appendix Y**.

The standard-energy versions of the compulsory entrées were designed to provide approximately 50-60% of daily energy intake, based on nationally representative data for men and women.[25] The reduced-energy entrées provided ~64% of the energy in the standard entrées. Across the entire test day, the difference in compulsory energy intake from the standard-energy and reduced-energy entrées was 567 kcal for men and 403 kcal for women. Because energy intake at breakfast meals is typically lower than energy intake at lunch and dinner meals, the energy content from compulsory entrées was distributed to provide approximately 27% of the compulsory energy at breakfast, and 36.5% of the compulsory energy at both lunch and dinner. For the discretionary foods, which were not varied in energy content and were consumed *ad libitum*, the women received 70% of the energy that was served to the men. The foods provided to men and women at each meal can be found in **Photograph 3**.

One liter of water was served with the discretionary foods at each meal in addition to the choice of coffee or tea with the breakfast meal. Bottled water was provided for consumption outside of the laboratory between meals and could be consumed as desired up to one hour before each meal. To allow measurement of bottled water intake, subjects returned the bottles with any remaining water to the laboratory at the following meal. All foods and beverages were weighed before and after meals and the amount consumed was recorded to the nearest 0.1g. Energy and macronutrient intakes were calculated using information from food manufacturers and a standard nutrient database.[26]

Photograph 3. Test meals served at breakfast (top), lunch (middle), and dinner (bottom) for men (left column) and women (right column).

Procedures

The week before the start of the study, subjects participated in a practice test day to familiarize them with the study protocol. The foods served were the same as in the experimental weeks but the entrées had a standard energy content and an energy density of 1.3 kcal/g. During each week of the study, subjects were instructed to keep their food intake and activity level consistent on the day before each test day, and keep a record of this information to encourage compliance (**Appendix I**). They were also instructed to refrain from consuming alcohol within 24 hours of the test day and to refrain from eating after 10 pm the evening before each test day. During test days, subjects were instructed to consume only those foods and beverages provided by the researchers until after the dinner meal. After the dinner meal, subjects were permitted to consume an evening snack as desired. On test days, subjects came to the laboratory at scheduled meal times and were seated in individual cubicles. Lunch was served at least 3 hours after breakfast, and dinner was served at least 4 hours after lunch.

Before each meal, participants completed a brief questionnaire (**Appendix J**) asking whether they had felt ill, taken any medications, or consumed any foods or beverages not provided by the researchers since the last meal. After completing the questionnaire, participants were provided with the entrée portion of the meal and instructed to consume all of the entrée within 15 minutes. Two minutes later, the discretionary items comprising the remainder of the meal were served and subjects were instructed to consume as much or as little of the foods and beverages as desired. After the final meal of the study, subjects completed a discharge questionnaire (**Appendix K**) to report their ideas about the purpose of the study and any differences they noticed between sessions.

Ratings of hunger, satiety, and food characteristics

Subjects used visual analog scales[27] to rate their hunger, fullness, thirst, and nausea immediately before each test meal, 15 minutes after receiving the entrée (before receiving the discretionary foods), and again after the meal (**Appendix L**). The characteristics of the entrées were also assessed using visual analog scales (**Appendix Z**). Subjects were instructed to first rate the appearance of the entrée and then take a bite and answer the remaining questions about pleasantness of taste, pleasantness of texture, and calorie content.

Data Analysis

Data were analyzed using a mixed linear model with repeated measures (SAS System for Windows, version 9.1, SAS Institute, Inc., Cary, NC, USA). The fixed effects in the model were entrée energy content and energy density. Planned comparisons were also performed between the two conditions in which the entrées were matched for weight. Because men and women were provided with different amounts of food, their data were analyzed separately. The primary outcomes for the study were (1) discretionary food and energy intakes over the day (all three meals combined), and (2) total food and energy intakes (entrées plus discretionary foods) over the day. Secondary outcomes were discretionary and total food and energy intakes at each individual meal, dietary energy density at each meal and over the day, and participant ratings of hunger, satiety, and food characteristics. The calculation of dietary energy density was determined using foods only; beverages were not included.[28] Summary measures of hunger and fullness for the entire day were calculated from the area under the curve (AUC) of the ratings across time using the trapezoid formula.[29] Subject characteristics were investigated as covariates in the main statistical model. Daily energy expenditure of participants was estimated from sex, age, height, weight, and activity level.[30] Results are reported as mean ± standard error and were considered significant at $p<0.05$.

RESULTS

Energy intake

Reductions in both the energy content and the energy density of the compulsory entrées resulted in significant decreases in energy intake over the day (**Figure 3-2**). The pattern of effects of the two factors, however, differed in men and women (**Table 4-5**). In men, reductions in entrée energy content and energy density had independent and additive effects on daily energy intake at each meal and for the entire day. In women, the entrée factors also had independent effects on energy intake at breakfast and lunch, but at dinner and for the entire day the effects depended on the interaction of the two factors.

In men, decreasing the energy content of the compulsory entrées resulted in a significant decrease in daily energy intake of 311 ± 37 kcal, or about 12% ($p<0.002$; Table 4-5). Energy intake from discretionary foods increased by 256 ± 37 kcal after men consumed the reduced-energy entrées rather than the standard-energy entrées ($p<0.003$; Table 4-5). This increase in discretionary energy intake, however, was insufficient to fully compensate for the 567 kcal reduction in energy content from the entrées. Independent of the effect of energy content, decreasing the energy density of the compulsory entrées resulted in a significant reduction in energy intake from discretionary foods ($p<0.005$) and over the day ($p<0.01$) of 150 ± 26 kcal, or about 5%. Comparing the entrées of equal weight showed that simultaneously decreasing entrée energy content and energy density resulted in a significant reduction in total energy intake of 445 ± 47 kcal, or about 16% ($p<0.0001$). Analysis of intake at each meal showed that in men, the effects of entrée energy content and energy density on discretionary and total energy intake were independent at each meal ($p<0.03$), although at breakfast only the effect of energy content was significant ($p<0.05$).

In women, the effects on energy intake depended on the interaction of the energy content and energy density of the compulsory entrées. Decreasing the energy content of entrées resulted in significant increases in discretionary energy intake and reductions in daily energy intake, but the magnitude of these changes depended on the level of entrée energy density ($p<0.03$; Table 4-5). Decreasing the energy content of the standard energy density entrées reduced mean daily intake by 239 ± 30 kcal (12%) and decreasing the energy content of the reduced energy density entrées reduced daily intake by 127 ± 39 kcal (7%). In contrast, decreasing the energy density of the entrées led to different effects depending on the energy content of the entrées. In the entrées with standard energy content, decreasing the energy density had significant effects on discretionary and daily energy intake ($p<0.002$; Table 4-5); the reduction in daily intake was 162 kcal ± 34 (8%). In the entrées with reduced energy content, however, decreasing the energy density had no significant effect on discretionary or daily energy intake ($p=0.59$); the 50 ± 33 kcal difference in daily intake was not statistically significant. Comparing the entrées of equal weight showed that simultaneously decreasing entrée energy content and energy density resulted in a significant reduction in total energy intake ($p<0.0001$). The reduction in energy intake was 289 ± 35 kcal (14%) over the day. Analysis of intake at each meal showed that in women, the effects of entrée energy content and energy density interacted to affect discretionary and total energy intake only at the dinner meal ($p<0.003$). At breakfast and lunch, there were significant independent effects of entrée energy content (<0.001) but not energy density.

In comparison to the estimated energy requirements of participants, the standard entrées provided a mean of 56 ± 1% of the daily requirements for men and 50 ± 1% of the daily requirements for women; these proportions were similar to the intended range of 50 to 60% in the study design. When discretionary energy intake was included, men met 100 ± 3% of their daily energy requirements in the standard condition and women met 95 ± 3% of their daily energy requirements.

Food intake

Total food intake (g) over the day varied with the weight of the compulsory entrées, which was determined by the interaction of their energy content and energy density ($p<0.001$; Table 4-5); the pattern of effects was the same for men and women. Participants consumed the greatest daily amount of food when served the entrées of highest weight (standard energy content, reduced energy density), and the least amount of food when served the entrées of lowest weight (reduced energy content, standard energy density). Total food intake was not significantly different when participants consumed the entrées with equal weights (Table 3-2). Similarly, the amount of time it took participants to consume the entrées was greatest when served the largest entrées (standard energy content, reduced energy density), and least when served the smallest entrées (reduced energy content, standard energy density) ($p<0.0001$; data not shown).

Energy density

The overall energy density of the discretionary foods consumed at the test meal was not significantly affected by the variations in the compulsory entrées. Thus, dietary energy density for the entire day was determined by the combination of entrée energy content and energy density ($p<0.02$; Table 4-5). Dietary energy density was highest when participants consumed the entrées of standard energy density, followed by the entrée of reduced energy content and reduced energy density, and lowest when participants consumed the entrée of standard energy content and reduced energy density.

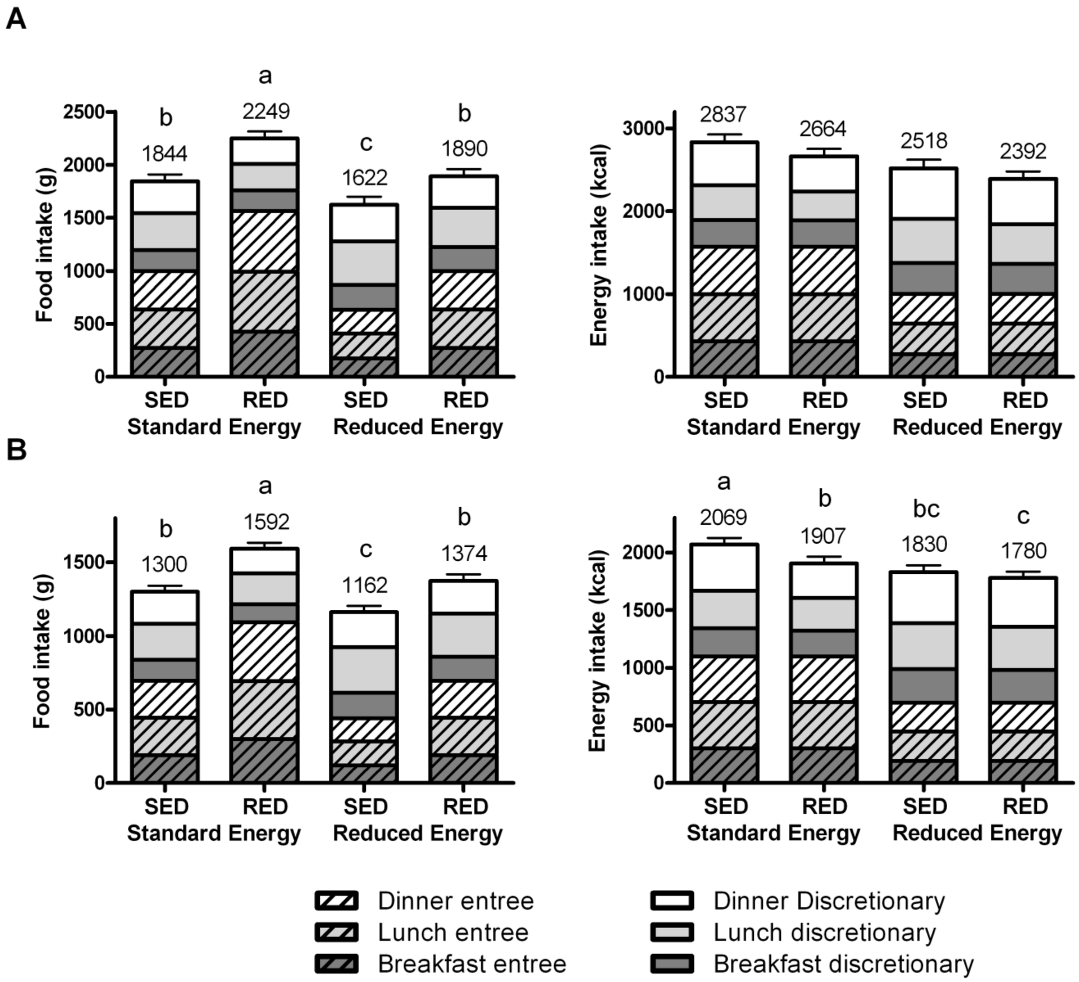

Figure 3-2. Food and energy intakes of compulsory and discretionary foods by meal and over the day for (A) men and (B) women. For total intakes, values with different letters are significantly different ($p < 0.003$). In men, the effects on total energy intake of reducing the energy content ($p<0.002$) and energy density ($p<0.005$) of the compulsory entrées were independent.

Table 4-5. Total food and energy intakes over a day (see **Appendix AA** for intakes by meal).

	Men (n=28)				**Women (n=40)**			
	Standard energy content		Reduced energy content		Standard energy content		Reduced energy content	
	SED	RED	SED	RED	SED	RED	SED	RED
Discretionary food intake (g)[1,2]	847 ± 65	687 ± 63	989 ± 77	893 ± 69	604 ± 41[b]	498 ± 41[a]	721 ± 42[c]	678 ± 44[bc]
Discretionary energy intake (kcal)[1,2]	1267 ± 92	1094 ± 91	1515 ± 105	1389 ± 91	969 ± 58[b]	807 ± 57[a]	1133 ± 60[c]	1083 ± 54[bc]
Discretionary ED (kcal/g)	1.53 ± 0.08	1.66 ± 0.10	1.57 ± 0.07	1.65 ± 0.09	1.67 ± 0.08	1.71 ± 0.09	1.61 ± 0.06	1.69 ± 0.08
Total food intake (g)[3]	1844.0 ± 65.2[b]	2249.2 ± 63.3[c]	1621.7 ± 77.4[a]	1890.3 ± 69.2[b]	1300.3 ± 41.1[b]	1591.7 ± 40.9[c]	1161.5 ± 41.9[a]	1373.7 ± 44.2[b]
Total energy intake (kcal)[1,2]	2837 ± 92	2664 ± 91	2518 ± 105	2392 ± 89	2069 ± 58[c]	1907 ± 57[b]	1830 ± 60[ab]	1780 ± 54[a]
Total ED (kcal/g)[3]	1.54 ± 0.03[c]	1.18 ± 0.02[a]	1.57 ± 0.04[c]	1.27 ± 0.03[b]	1.60 ± 0.03[c]	1.19 ± 0.02[a]	1.58 ± 0.04[c]	1.29 ± 0.03[b]

[a,b,c] All values are means ± SEMs. Values within the same row with different letters are significantly different

[1] Effect of entrée energy content, $p < 0.01$

[2] Effect of entrée energy density, $p < 0.01$

[3] Combined effect of entrée energy content and energy density, $p < 0.01$

Ratings of hunger, fullness, and food characteristics

Ratings of hunger and fullness across the day are shown for men and women in **Figure 3-3**. The factors of entrée energy content and energy density independently influenced ratings of hunger, as assessed by the summary measure of the area under the curve (AUC) of ratings across the day. In both men and women, there was a significant effect of entrée energy content on daily hunger ($p<0.02$), indicating increased hunger when the entrées were of reduced energy content (373.4 ± 10.5 in men; 373.9 ± 8.4 in women) rather than standard energy content (337.5 ± 10.4 in men; 348.5 ± 8.4 in women). In addition, in women there was an independent effect of entrée energy density ($p<0.04$) indicating decreased hunger when the entrées were reduced in energy density and increased in portion size. Mean hunger AUC for the reduced energy density entrées was 349 ± 9.7 and for the standard energy density entrées was 373.1 ± 8.3.

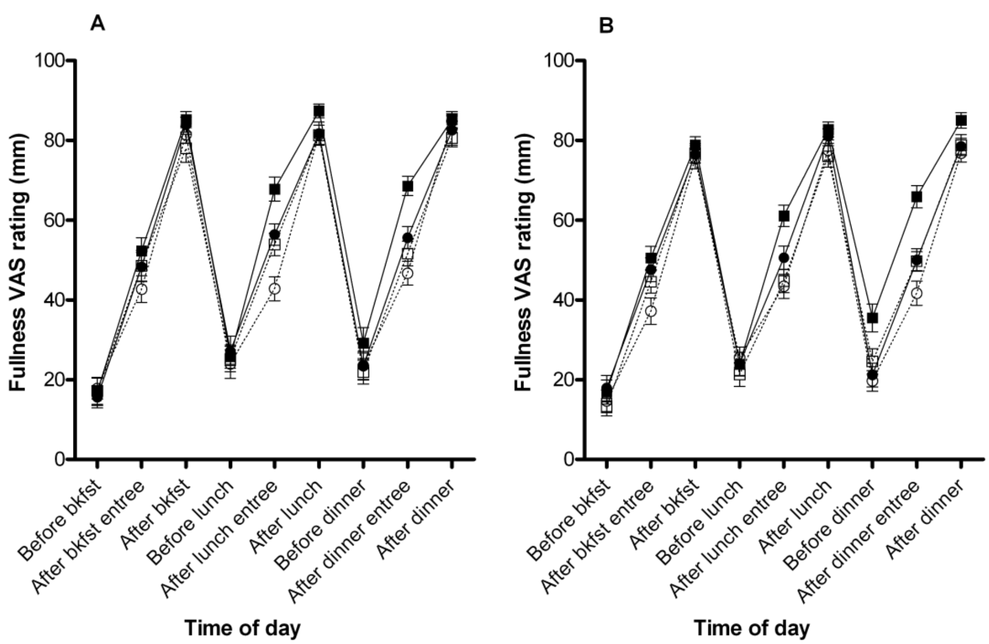

Figure 3-3. Fullness ratings from visual analog scales for (A) men and (B) women before meals, after entrées, and after meals. Legend: ●Standard; ■ Std EN, Red ED; ○ Red EN Std ED; □ Red EN, Red ED.

The daily summary measure of fullness was dependent on the interaction between entrée energy content and energy density. In both men and women, daily fullness was significantly greater when the entrées were of standard energy content and reduced energy density (i.e., greatest weight) than when the entrées were of reduced energy content at either energy density ($p<0.04$). In addition, in women daily fullness in this condition was also greater than in the standard condition ($p<0.01$). Ratings of thirst and nausea did not differ significantly by the experimental factors at any time point or over the day for either men or women (data not shown).

Ratings of pleasantness of appearance, taste, and texture of the manipulated entrées did not differ significantly across conditions for men or women (data not shown). Mean ratings of pleasantness of taste for the breakfast, lunch, and dinner entrées, respectively, were 68 ± 2, 65 ± 2, and 69 ± 2 in men and 78 ± 1, 72 ± 1, and 70 ± 1 in women. For ratings of calorie content of the entrées, there was a significant effect of entrée energy content in both men and women for the lunch entrée and for the dinner entrée only in women. Men and women rated the standard-energy lunch entrées higher in calories than the reduced-energy entrées ($p<0.03$). Mean ratings for men were 57 ± 2 for the standard-energy entrées and 51 ± 2 for the reduced-energy entrées; mean ratings for women were 59 ± 2 for the standard-energy entrées and 55 ± 2 for the reduced-energy entrées. Women rated the standard-energy entrées at dinner higher in calories than the reduced-energy entrées ($p<0.05$), mean ratings were 61 ± 2 for the standard-energy entrées and 58 ± 2 for the reduced-energy entrées.

Subject characteristics

Analysis of covariance demonstrated that the relation between the experimental factors of entrée energy content and energy density and the outcomes of total energy intake over the day was not significantly affected by participant age, height, weight, or body mass index. The outcomes were also not significantly affected by scores for dietary restraint, disinhibition, or hunger in women, nor by scores for dietary restraint and disinhibition in men. In men, the score for tendency toward hunger[23] significantly affected the relation between the experimental factors and the outcome of total energy intake over the day ($p<0.01$). Daily energy intake increased with increasing tendency toward hunger score only when the smallest entrée was consumed ($p=0.006$).

Discharge questionnaire

Comments from the questionnaire provided at discharge revealed that 60 of 63 (95%) participants noticed that the manipulated entrées varied in the amount of food. Twenty-one of 63 (33%) noticed that the amount of vegetables in the entrées was different. When asked about the purpose of the study, 11 of 67 (16%) participants reported that the purpose was to determine how variations in the portion size or volume of entrées affect how much other foods are consumed. No participants accurately discerned the purpose of the study to determine the effect of varying the energy content and energy density of entrées on total energy intake.

DISCUSSION

Consumption of pre-portioned entrées has been shown to be a beneficial strategy for weight loss, but little is known about how the characteristics of these foods, including the energy content, energy density, and portion size, influence satiety. The purpose of this study was to investigate the effects of characteristics of pre-portioned entrées on daily energy intake. We found that in non-dieting men and women, reducing both the energy content and energy density of entrées led to additive decreases in daily energy intake when various other foods were served. Our findings extend previous work that shows these characteristics of food are important in affecting satiety and can influence energy intake. We also found that hunger and fullness ratings varied based on the characteristics of the entrées. The results of this study demonstrate the utility of pre-portioned entrées in moderating energy intake, in part by displacing discretionary intake from a variety of readily available palatable foods.

Reducing the energy content of the entrées led to different effects on consumption of discretionary foods and on daily energy intake. In agreement with preloading studies, our findings showed that compared to lower energy content entrées, consuming entrées of standard energy content reduced hunger[14] and decreased energy intake at the subsequent test meal.[14-16] Although a decrease in discretionary energy intake is desirable, in the context of weight management, the overall energy intake at the meal is a primary concern. Thus, the balance of the energy provided from the entrée and the energy that is consumed from discretionary foods needs to be considered. In the present study, daily energy intake was decreased when the reduced-energy entrées were served since participants did not fully compensate for the reduction in energy provided from the entrées by increasing intake of discretionary foods. It is likely that physiological mechanisms for satiety were not fully engaged within the short time period of the meal, leading individuals to rely on their perception of the entrées as the main component of the meal that should provide a majority of their energy needs. Additionally, although participants rated some of the reduced energy entrées as being lower in energy content, they were unable to judge the magnitude to which the entrées were reduced in energy compared to the standard energy entrées. Our findings showed that the effects on consumption of discretionary foods and daily energy intake were dependent upon the energy content of the entrées.

Reducing the energy density of pre-portioned entrées had a consistent effect on both discretionary and daily energy intake, in contrast to the different effects that reducing the energy content had on these outcomes. These results confirm several preloading studies showing that reducing the energy density of equicaloric preloads results in an increase in fullness ratings[17, 18, 31] and a decrease in test meal or total meal energy intake.[17-20, 31] Multiple experimental studies have also shown that reducing the energy density of an entrée by increasing the proportion of fruits or vegetables decreases meal energy intake when the entrée is consumed *ad libitum*.[32-35] In the present study, reducing the energy density of the entrées led to the consumption of a greater total weight of food over the day, higher ratings of fullness, and decreases in both discretionary and daily energy intake. Furthermore, fullness ratings were greatest after consumption of the entrées largest in portion size (those with standard energy and reduced energy density), suggesting that portion size was an important characteristic influencing fullness. In the current study, it is likely that the decrease in energy intake that accompanied the entrées reduced in energy density was due to enhanced satiety from an increase in the amount of food consumed.

Comparison of the entrées that were matched in portion size showed that energy content and energy density are important characteristics of foods even when portion size is unchanged. Independent of changes in portion size, reductions in the energy density of preloads have been shown to enhance satiety, thereby decreasing subsequent energy intake. One study found that consuming a salad preload that was reduced in energy density decreased total meal energy intake when the portion size was held constant.[19] Another investigation showed that when a compulsory breakfast and mid-morning snack were varied in energy density but provided the same amount of food, daily energy intake was less after consumption of the compulsory foods that were reduced in energy density.[36] Similarly, the results from the present study showed that reducing the energy density of entrées matched in portion size led to a decrease in daily energy intake, even when participants were given the opportunity to compensate for the reduction by consuming a variety of discretionary foods. A comparable total weight of food was consumed by our participants; as a result, dietary energy density was lower with the entrées that were reduced in both energy and energy density compared to the entrées that were standard in both energy and energy density. This finding is important, since diets lower in energy density have been associated with lower weight status.[37] The findings from the current study suggest that when consuming pre-portioned entrées of a specific portion size, it is beneficial to choose entrées that are reduced in both energy and energy density in order to decrease consumption of discretionary foods and moderate energy intake.

The present study showed that the effects of reducing both the energy content and energy density of pre-portioned entrées were additive and resulted in the greatest decrease in daily energy intake. In women, however, we observed a different pattern for how the energy content and energy density of entrées added together to influence energy intake. This difference may be attributable to the smaller incremental changes in portion size of the women's entrées across the experimental conditions. In men, an influence of portion size on satiety was also suggested by the finding that the score for tendency toward hunger influenced energy intake only when the smallest entrée was consumed. It is possible that the increases in daily energy intake that were seen across the continuum of hunger scores were more influenced by consumption of the smallest entrée because of the perception of its size.[38] These findings for both women and men suggest that factors related to the portion size of entrées, such as relative perceptions of size, play a role in determining satiety. Another possibility for the difference in the pattern of the effects of energy content and energy density in women and men is the level of dietary restraint. Women in this study population had a significantly higher level of dietary restraint than the men. The analysis of covariance, however, showed that the restraint score did not have a significant influence on the relationship between the experimental conditions and daily energy intake.

In addition to consuming the pre-portioned entrées, participants in the present study were offered discretionary foods that consisted of a greater variety of items that would typically be consumed at a meal. The results indicate that modifying the entrées decreased energy intake even with the presence of a variety of palatable foods. Participants in this study were not trying to lose weight, however. Individuals who use pre-portioned entrées for the purpose of weight loss may respond differently to alterations in the characteristics of these foods, and it is possible they may decrease energy intake even further. To verify this premise, studies are needed where people who are motivated to lose weight are aware of their energy goals and are provided with information regarding the energy content, energy density, and related attributes of pre-portioned entrées. It also remains to be seen whether the findings from this one-day study would be replicated over a longer duration. Previous research suggests that the effects of reductions in dietary energy density on energy intake can be sustained over time. Two clinical trials of interventions to decrease dietary energy density for weight loss found that greater reductions in dietary energy density resulted in greater weight loss after one year.[39, 40] Analyses from another trial of lifestyle modification to reduce hypertension showed that individuals with the greatest reductions in dietary energy density had the largest decreases in body weight.[41] Future studies are needed to investigate how modifying the characteristics of pre-portioned entrées affects long-term energy intake and weight management.

In conclusion, reductions in both the energy content and energy density of pre-portioned entrées added together to decrease daily energy intake. The findings from the present study suggest that in an environment that regularly exposes individuals to a variety of palatable foods, consuming pre-portioned entrées that are lower in energy density can decrease discretionary energy intake. These findings also suggest that consuming pre-portioned entrées that are lower in both energy density and energy content is beneficial for enhancing satiety. Since pre-portioned entrées are often used for weight management, more systematic exploration into the attributes of these foods is needed. Discovering ways to optimize the components of pre-portioned entrées is crucial to providing consumers with a variety of options that can be used to help enhance satiety and thus moderate energy intake.

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Chapter 5

Conclusions

SUMMARY OF FINDINGS

The objective of the present studies was to provide further insight into three specific strategies that have been suggested to reduce energy intake: increasing the protein content of foods, reducing the energy density of foods, and consuming pre-portioned entrées. Findings from Study 1 showed that increasing the protein content of meals consumed *ad libitum* by covertly adding more meat did not affect daily energy intake or ratings of satiety when energy density was held constant. Study 2 demonstrated that decreasing the energy density of a food by incorporating puréed vegetables reduced daily energy intake and increased vegetable intake without changes in hunger or fullness. In Study 3, decreasing both the energy content and energy density of pre-portioned entrées reduced daily energy intake while maintaining or enhancing satiety.

The findings from these studies suggest that dietary energy density has a major influence on energy intake. When foods were offered *ad libitum*, participants in Studies 1 and 2 consumed similar weights of food across conditions, consistent with the literature.[1, 2] In Study 1, the energy density of the entrées was not varied resulting in similar daily energy intakes despite variations in protein intake. In Study 2, when the entrées were reduced in energy density, daily energy intake decreased confirming previous findings on energy density.[1, 3] Reducing the energy density of compulsory entrées, as in Study 3, also led to decreases in daily energy intake. Studies 2 and 3 showed that energy density can be reduced by incorporating puréed vegetables (Study 2) as well as chopped vegetables and fruit (Study 3) into foods to influence energy intake.

The studies in this dissertation tested three strategies suggested to influence energy intake. These studies were designed to be similar to a typical free-living environment in order to determine whether the strategies could be implemented by the general public. The incorporation of chopped or puréed vegetables into foods as a method to reduce the energy density is a strategy that could be implemented by caregivers, chefs, and food scientists to influence the home eating environment, restaurant meals, as well as pre-portioned and other foods produced by the food industry. The more ways in which these strategies to reduce energy density are implemented, the more opportunities there are to help Americans reduce energy intake, achieve better weight management, and reduce the prevalence of obesity.

STUDY 1: INCREASING THE PROTEIN CONTENT OF MEALS AND ITS EFFECTS ON DAILY ENERGY INTAKE

Research has suggested that protein is the most satiating macronutrient and that a high intake of protein can reduce energy intake and enhance weight management.[4] The studies on which these suggestions are based, however, were not designed so that they could be extrapolated to every-day life. Whether simply consuming high-protein foods is effective in reducing energy intake, therefore, is not clear. For example, many studies used a preloading design that required participants to consume amounts of protein that greatly exceed what is recommended for health.[5-8] Additionally, to achieve consumption of such large amounts of protein, isolated sources of protein in powdered form were often added to foods.[5, 6, 9] There are a few studies that have tested intake of more realistic amounts of protein using commonly consumed protein sources (such as meat and dairy products).[10, 11] In these studies, however, the energy density of the foods was not controlled, making it difficult to differentiate the effect of consuming a high protein meal from that of consuming a reduced energy density meal. Little is known about the effects of consuming a high protein meal on *ad libitum* intake.[12, 13]

Implications

Study 1 was designed to test the satiating effects of protein in a controlled environment, but also in a way that was representative of how the strategy would be implemented by free-living individuals. This study was the first to: 1) test the effects of protein across multiple levels that are within recommendations, 2) use commonly consumed sources of protein, 3) test the effects of protein when foods are consumed *ad libitum*, similar to a typical free-living environment, 4) test multiple meals over one day, 5) control for known factors that may influence intake (energy density, palatability, texture), and 6) use covert manipulations to reduce the influence of preconceived notions about protein on intake. This study showed that regardless of the amount of protein in the entrée, participants consumed a consistent weight of food and because energy density was constant, thus, consumed similar energy intakes across conditions. Additionally, ratings of hunger and fullness were not different across protein levels at any time point over the day. These findings suggest that simply increasing the amount of meat in a meal, within dietary recommendations, may not reduce energy intake or enhance satiety.

Results from short-term studies, such as this one, should not be the basis for nutritional recommendations, but rather be used as a starting point for additional research to investigate different populations over longer periods of time. In Study 1, only women of normal weight status were recruited in order to understand the underlying influence of increasing protein in a homogeneous sample and to prevent large variations in intake related to body size from influencing the outcomes. Because these individuals were not trying to gain or lose weight, the same study design conducted among overweight or obese individuals trying to lose weight may result in different findings, especially if conducted over longer periods of time. Research investigating the effects of a high protein diet during weight loss has suggested that maintaining a constant protein intake while decreasing energy intake (thus increasing the % energy from protein) can enhance weight loss and increase satiety.[14, 15]

Strengths, weaknesses, and future research

This well-controlled study testing the effects of protein had several strengths. The manipulated foods in this study were designed to control for characteristics that have been shown to influence energy intake, including appearance, palatability, and energy density.[1, 16, 17] Participant ratings of appearance and palatability, as well as comments from the discharge questionnaire, confirmed that these factors were well controlled across conditions. The finding that participants consumed a similar weight of food in each condition is consistent with previous research measuring *ad libitum* intake.[1, 2] When energy density was held constant, there were no differences in energy intake, as shown previously.[18] Based on previous literature[7, 11, 19, 20], it was hypothesized that ratings of satiety would increase as the amount of protein in the meals increased. On the contrary, despite consuming an additional 20 grams of protein at one meal in the 30% protein condition compared to the 10% protein condition, there were no differences in these ratings. It was especially surprising that there were no differences in the hourly satiety ratings between the lunch and dinner meals. It is possible, however, that part of the satiating effect of protein in previous studies may have been due to the overt increase in the amount of protein and/or the preconceived notion that the protein part of a meal is more filling. To accept or refute this possibility, research would be needed to compare the covert and overt effects of increasing the amount of protein in a meal.

Another strength of this study is that it manipulated two meals in a day and measured intake over a period of 24 hours. Because it has been shown that the satiating effect of protein can persist to the next day[21], this study was designed to detect such effects. Most of what is known about the effects of protein on energy intake and satiety comes from preloading studies and a few satiation studies. This study adds to the satiation literature by showing the effects of protein when foods were consumed *ad libitum* over a day. The finding that there were no differences in energy intake at any level of protein suggests that the satiating effects of protein may not emerge unless an excessive compulsory amount is consumed. It is also plausible that if the breakfast meal had been manipulated, daily protein intake could have been high enough to generate differences in energy intake. For this reason, the study of the effects of consuming meals *ad libitum* with varying amounts of protein needs to be extended to include multiple meals over several days.

A limitation to Study 1 may be the energy density of the manipulated entrées. The entrées were formulated to have an energy density of 1.2 kcal/g, similar to the energy density tested in previous protein studies.[8, 11, 13] Although baseline intakes were not measured, it is possible that this energy density level was lower than what the participants enrolled in this study typically consume. If so, they may have stopped eating early in response to the low energy density, before the effects of increased protein would have emerged. It would be interesting to know how variations in the protein content and energy density of a meal interact to influence energy intake and determine whether a similar effect of protein would be found if the energy density was higher than 1.2 kcal/g.

STUDY 2: HIDDEN VEGETABLES: AN EFFECTIVE STRATEGY TO REDUCE ENERGY INTAKE AND INCREASE VEGETABLE INTAKE IN ADULTS

People tend to eat a consistent weight of food and when they consume foods reduced in energy density they, therefore, consume less energy. This has been shown in multiple studies that reduced energy density with a variety of methods including reducing fat and sugar or increasing fruits and vegetables.[1, 2] Government agencies have recently suggested reducing dietary energy density by substituting foods high in energy density with foods lower in energy density, such as vegetables, as a strategy for weight management.[22, 23] Only a few studies, have manipulated the energy density of foods solely with vegetables.[1, 2, 24] Although these studies found reductions in energy intake as the vegetable content increased, reducing the energy density of a food by increasing the amount of vegetables may not be a strategy accepted by the many individuals who dislike vegetables. The strategy of puréeing vegetables and hiding them in foods has been a popular method targeted toward parents to help their children consume more vegetables, but may also be a strategy beneficial for adults to both reduce energy intake and increase vegetable intake.

Implications

The purpose of Study 2 was to determine whether vegetables could be puréed and incorporated into the main entrée to reduce the energy density at multiple meals over a day to reduce energy intake and increase vegetable intake. A second purpose was to determine how much puréed vegetables could be incorporated into the entrées covertly to influence intake without affecting palatability. The findings from this study support recommendations to reduce dietary energy density by substituting high energy-dense foods (or ingredients) with low energy-dense vegetables as a strategy to reduce energy intake.[22, 23] Additionally, by puréeing the vegetables, large amounts can be incorporated into a variety of foods to significantly impact vegetable intake with minimal changes in palatability. These findings also support previous studies that showed ratings of satiety did not change despite reductions in energy intake.[1, 2, 24]

Puréeing vegetables and incorporating them into foods is a simple strategy that can be applied in multiple settings and make a large impact on vegetable and energy intakes. For example, care givers can use this strategy at home, restaurants can use this strategy to maintain portion sizes while reducing the calorie content of foods, and the food industry could develop pre-portioned packages of puréed vegetables or ready-made foods with an enhanced vegetable content. Because many different types of vegetables can be puréed and incorporated into a variety of sweet and savory foods without major changes in palatability, there are numerous ways to implement this strategy. The more settings in which this strategy is applied, the greater the impact it can have on America's growing obesity epidemic and inadequate vegetable intakes.

Many people argue that hiding vegetables in foods does not teach children or adults to like vegetables. Research has suggested, however, that repeated exposure to once disliked foods could increase acceptance of those foods.[25] For adults who dislike vegetables, incorporating puréed vegetables into their own meals could be a starting point to increase acceptance of a variety of vegetables. Because this study showed that intake of the vegetable side dishes was consistent across conditions, continuing to purée vegetables and incorporating them into foods, in addition to serving vegetable side dishes, could help to increase vegetable consumption and reach the daily recommended intakes.

Strengths, weaknesses, and future research

Study 2 was one of the first known satiation studies in adults to test the method of using puréed vegetables to reduce energy density and to serve the manipulated entrées with palatable side dishes. A strength of this study was that it was not limited to a single meal, but rather manipulated a portion of multiple meals over an entire day. An interesting finding was that the effect of the manipulation persisted over the day. This shows that large amounts of puréed vegetables can be incorporated into a variety of sweet and savory foods suggesting that this strategy could be implemented at multiple meals using multiple foods. Additionally, the study sample included individuals with a range in their liking of vegetables showing that this strategy can be used among people who dislike vegetables.

Although the study sample included participants with a range of vegetable liking, additional studies should be conducted to determine whether using puréed vegetables to reduce energy density is effective in individuals who dislike vegetables and are told they are eating foods with puréed vegetables incorporated into them. Epidemiological data have shown that rates of overweight and obesity are higher among individuals with lower intakes of vegetables.[26] The present study included individuals across a range of BMI's, but the effect of this strategy needs to be investigated over time, especially among overweight and obese individuals, to determine whether it can lead to a healthier body weight. Additionally, the use of this strategy as a method for weight loss needs to be investigated in a dieting population.

The amount of vegetables added to the entrées in this study was limited to about 25% because amounts greater than this caused noticeable differences in the palatability of the food. For the purpose of the study, the foods needed to be as similar as possible in palatability, but this is not true in other situations. For people who voluntary use this strategy with their own food, it is possible to incorporate larger quantities of puréed vegetables than what was used in the entrées in this study as long as a slight change in the taste or texture is tolerable.

This strategy of incorporating puréed vegetables into foods needs to be extended to a variety of foods and tested in restaurant settings to see how this type of energy density manipulation would be accepted among the general public. It would also be of interest to test whether a pre-portioned package of puréed vegetables along with recipe suggestions would make this strategy easier to implement and make more of an impact on energy and vegetable intakes.

STUDY 3: EFFECTS OF ENERGY DENSITY AND ENERGY CONTENT OF PRE-PORTIONED ENTRÉES ON ENERGY INTAKE

The consumption of pre-portioned meals is a strategy often used by dieters for weight management to help monitor portion sizes and energy intake and that has been shown to enhance weight loss.[27-29] These foods, however, are also commonly consumed by non-dieters because they are convenient, quick meals that are reasonably priced. Although many studies have shown the success of these products in weight management[27, 28, 30, 31], little is known about how the characteristics of these foods influence energy intake and satiety. Multiple studies have concluded that solid pre-portioned meals are more satiating than liquid meals[32, 33], but variations in the energy content and energy density have never been investigated. Findings from short-term experimental studies have suggested that high energy preloads reduce subsequent energy intake but often lead to a greater total energy intake compared to low energy preloads.[34, 35] Reducing the energy density of a preload by adding water or water-rich vegetables, thus increasing the portion size, has been shown to reduce subsequent and total energy intake and enhance satiety compared to iso-caloric high energy-dense preloads.[34, 35] In the context of pre-portioned entrées, however, no studies have directly compared variations in these characteristics on energy intake and satiety.

Implications

Study 3 was designed to investigate how the energy content and energy density of pre-portioned entrées combined to influence daily energy intake and satiety. Pre-portioned entrées were of standard or reduced energy content and standard or reduced energy density. The entrées of standard energy content, standard energy density were matched in portion size to those of reduced energy content, reduced energy density. The findings from this study showed that reducing both the energy content and energy density of the entrées reduced total energy intake over the day in men. Women showed similar independent effects of these factors on intake at breakfast and lunch, but the factors interacted at dinner and for the entire day. In both men and women, the effect of the manipulations added together so that simultaneously reducing the energy content and energy density (comparing the entrées of equal portion size) reduced total energy intake. Ratings of satiety, however, were primarily influenced by entrée portion size with higher satiety ratings after consuming entrées that were large and reduced in energy density.

The findings from this study suggest that consuming pre-portioned entrées that are low in energy density could help to reduce energy intake. Furthermore, when the low energy dense entrée is large in portion size it could enhance satiety and when it is moderate in portion size (thus, reduced in energy content) it could maintain satiety, but lead to a greater reduction in total energy intake. An individual's choice to consume large portions to enhance satiety or moderate portions to help reduce energy intake could depend on whether they are consuming pre-portioned entrées for convenience or as part of a diet plan. If individuals consume pre-portioned entrées for convenience, they are likely trying to maintain weight and may benefit from consuming pre-portioned entrées that are large and low in energy density to enhance satiety. On the other hand, if individuals consume pre-portioned entrées as part of a diet plan for weight loss, they may benefit from consuming pre-portioned entrées that are low in energy density but also slightly smaller in portion size, thus lower in calories. This type of entrée may help to reduce energy intake and maintain satiety without increasing hunger. These suggestions should be investigated in future studies to: (1) help guide consumers in purchasing appropriate pre-portioned entrées for their weight management goals, and (2) provide suggestions to the food industry on how to improve the marketing of their pre-portioned food products.

The entrées in this study were reduced in energy density by increasing the proportion of vegetables and fruit. When comparing the two entrées matched in portion size but differing in energy content and energy density, the findings on food and energy intake are similar to those in Study 2. Although the entrées in Study 3 were compulsory, participants still consumed a consistent weight of food over the day and, therefore, consumed less total energy when the entrées were of reduced energy density. Whether vegetables are chopped or pureed, these findings support government recommendations to substitute low energy dense vegetables for foods higher in energy density to help reduce energy intake.[22, 23]

Data from the PREMIER clinical trial showed that participants who lost the greatest amount of weight were the ones who had the largest reductions in dietary energy density.[36] In Study 3, over the day dietary energy density was lowest when the entrées of reduced energy density were consumed. For individuals trying to lose weight, consuming pre-portioned entrées on a regular basis that are reduced in energy density could make it easier to achieve a diet that is low in dietary energy density. One reason that pre-portioned entrées are found to be useful for weight management is because they offer a structured eating plan.[29] The combination of consuming pre-portioned entrées and reducing dietary energy density has the potential to make a significant contribution to successful weight loss.

Strengths, weaknesses, and future research

Study 3 was one of the first known studies to investigate how the energy content and energy density of solid pre-portioned meals influence energy intake and satiety. Additionally, this study is one of the few that have tested solid pre-portioned foods similar to products that are commercially available. The pre-portioned foods industry continues to grow along with the types of products available for purchase. The energy content, energy density, and portion size of these foods vary greatly and the findings from this study can guide consumers to pay attention to these food characteristics and make the right pre-portioned food purchase for their weight management goals.

In most diet plans that incorporate pre-portioned entrées, there is often a recommendation for the types and amounts of other foods to be consumed along with the pre-portioned entrées, such as servings of fruits and vegetables.[27, 28, 30, 37, 38] In the present study, participants were served a variety of palatable foods after the entrées and were instructed to consume as much or as little as they desired. Despite consuming more energy from these palatable foods when served the reduced energy entrées compared to the standard energy entrées, participants did not fully compensate for the reduction in energy provided from the entrées, and thus, consumed fewer total calories over the day. If the discretionary foods served in the present study were similar to the foods recommended in diet plans, it is possible that the reduction in total energy intake would have been even greater. However, this would need to be investigated in a dieting population and over a longer period of time to determine whether feelings of hunger would increase and lead to compensation.

The energy content of all foods served in this study differed for men and women with women receiving 70% of the calories that the men received. This estimate was based on nationally representative data for men and women.[39] In the present study, it is possible that the participants were not representative of national data. If so, it may provide some explanation to the finding that men and women statistically responded differently to the experimental manipulations. For example, if the energy provided from the compulsory entrées to women was higher than the amounts used in the present study, the findings may have been more statistically similar between men and women.

The energy content of commercially available pre-portioned entrées varies greatly ranging from 100 calories to over 400 calories. In the present study, the reduced energy content entrées provided at lunch and dinner contained 360 calories for men and 250 calories for women. Many pre-portioned entrées that are commercially available contain energy contents that are much lower than those provided in the present study. It is possible that if the energy content of a pre-portioned entrée is too low, it may lead to over-compensation of energy. Studies are needed that examine pre-portioned entrées across a range of energy contents appropriate for both men and women to test this hypothesis. Additionally, these studies should determine if there is an ideal proportion of calories that should be consumed from pre-portioned entrées to enhance weight management.

Similar to studies 1 and 2, the findings from Study 3 are limited to a non-dieting population of young to middle aged men and women. The participants in this study were not trying to gain or lose weight and, therefore, the effect of this strategy should be tested in a population actively trying to lose weight. Additionally, the effects found on intake of consuming entrées varying in energy density and energy content are limited to one day. Studies are needed to investigate the effects of consuming these entrées on intake over a longer period of time. In such a study, participants should be allowed to select from a variety of pre-portioned entrées and be provided with guidance as to the energy content of the entrées they should select. The findings from this sort of study could provide better, more personalized recommendations to the general population on appropriate pre-portioned foods to purchase to aid weight management.

FINAL CONCLUSIONS

This dissertation included three studies that tested various strategies suggested to influence energy intake: Study 1) increasing the protein content of foods, Study 2) reducing the energy density of foods, and Study 3) consuming pre-portioned entrées. The findings from these studies suggest that adjusting the macronutrient content of foods, specifically increasing the protein content, may not influence energy intake or satiety unless the energy density is also varied. Reducing the energy density of foods, however, can reduce energy intake while maintaining or enhancing satiety. Using puréed vegetables as the method of reducing energy density has two benefits: reducing energy intake and increasing vegetable intake. Although successful in an environment where foods are consumed *ad libitum*, it is a strategy that could also be incorporated into commercially available pre-portioned meals and have the added benefit of helping individuals monitor energy intakes and portion sizes. Reducing energy intake is the first step in achieving weight loss and is followed by the challenge of maintaining the lost weight. With more than 68% of the American population overweight or obese[40], this is a critical step that needs to be taken to reduce the risk of chronic diseases and mortality. This dissertation provides just a few suggestions on how to help American's take that step to facilitate weight loss and improve their quality of life.

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Appendix A

Telephone Screening Questionnaire

Study 1

Pre-screening Questionnaire

Date:

Age: __________ Date of Birth: ____________

Height: _________ Weight: _________________

Do you smoke? No Yes

Are you currently taking any prescription or "over the counter" 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 or intolerances? 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 a vegetarian? No Yes
If no, are there any meats that you exclude from your diet?___________

Do you like and are willing to eat:

Eggs	yes	no
Yogurt	yes	no
Granola	yes	no
Chicken	yes	no
Shrimp fried rice	yes	no
Pasta and meat sauce	yes	no
Oatmeal	yes	no
Rice	yes	no
Broccoli	yes	no
Green pepper	yes	no
Onion	yes	no
Tomato	yes	no
Corn	yes	no

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

Would you be willing to refrain from eating after 10:00 pm the evening before test sessions? No Yes

Would you be willing to refrain from drinking alcoholic beverages the before each test session? No Yes

Are you pregnant or breast feeding? No Yes

Where did you hear about the study?__________________________________

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

Are you a: _____Undergraduate semester standing:__________ major:____________
_____ Graduate major:______________
_____Penn State Staff
_____State College Resident

If criteria are satisfied, take their name and ask them to come to the lab to fill out questionnaires and to have their weight & height recorded.

Name: _________________ Phone: ________________ Appointment:___________________

Appendix B

Questionnaire Consent Form

Study 1

Informed Consent Form for Social Science Research
The Pennsylvania State University

ORP USE ONLY: IRB#27924 Doc.#1
The Pennsylvania State University
Office for Research Protections
Approval Date: 03/25/08 JKG
Expiration Date: 03/24/09 JKG
Biomedical Institutional Review Board

Questionnaire Consent Form

Title of Investigation: Eating Behaviors at Different Meals

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

Purpose of today's visit: The purpose of this phase of the research is 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 no risks in participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort.

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.

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

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.

Please contact Jennifer Meengs at 863-8482 with questions, complaints or concerns about the research. You can also call this number if you feel this study has harmed you. Questions about your rights as a research participant may be directed to Penn State University's Office for Research Protections at (814) 865-1775.

You are free to deny any answers to specific items or questions.

You are free to end your participation at any time.

You participation is voluntary. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

Any data or questions will remain confidential with regard to your identity.

The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, the Biomedical Institutional Review Board and the PSU Office for Research Protections, and the U.S, Food and Drug Administration (FDA).

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 form for your records.

___________________ _______________ ___________________________________
Date Date of Birth Participant's Signature

___________________ ___________________________________
Date Investigator's Signature

Appendix C

Demographic and Health Questionnaire

Subject Profile

Name ______________________________ Date ____________________

Address ____

____

____

Phone (w) ______________________________ (h): ____________________

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
☐ ASIAN
☐ BLACK OR AFRICAN AMERCIAN
☐ WHITE
☐ HAWAIIAN/PACIFIC ISLANDER

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
☐ Heart trouble
☐ Thyroid or other glandular disorders
☐ Liver disease
☐ Anemia
☐ Cancer
☐ Diabetes
☐ Ulcers (of the digestive system)
☐ Other stomach/intestinal disorder
☐ Kidney disease
☐ Depression
☐ 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
☐ Chewing problems
☐ Choking problems
☐ Salivation problems
☐ Other, please specify ____________________
☐ Nausea
☐ Vomiting
☐ Diarrhea
☐ Constipation

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?

____

Please circle the statement that best describes you:

I prefer the meat (poultry, fish, beef) part of a meal	I prefer the vegetable part of a meal	I prefer the starch part of a meal	I have no preference

Below are statements that you will answer about your current eating habits. 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

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

____

____

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

6) When was the first day of your last menstrual cycle? ______________________

Appendix D

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.

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

Appendix E

Eating Attitudes Test Questionnaire

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.

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

Appendix F

Eating Inventory Questionnaire

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 <u>one</u> 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	2	3	4
rarely	sometimes	usually	always

38. Would a weight fluctuation of 5 lbs affect the way you live you life?

1	2	3	4
not at all	slightly	moderately	very much

39. How often do you feel hungry?

1	2	3	4
only at meal times	sometimes between meals	often between meals	almost always

40. Do your feelings of guilt about overeating help you to control your food intake?

1	2	3	4
never	rarely	often	always

41. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?

1	2	3	4
easy	slightly difficult	moderately difficult	very difficult

42. How conscious are you of what you are eating?

1	2	3	4
not at all	slightly	moderately	extremely

43. How frequently do you *avoid* "buying large" on tempting foods?

1	2	3	4
almost never	seldom	usually	almost always

44. How likely are you to shop for low calorie or low fat foods?

1	2	3	4
unlikely	slightly likely	moderately likely	very likely

45. Do you eat sensibly in front of others and splurge alone?

1	2	3	4
never	rarely	often	always

46. How likely are you to consciously eat slowly in order to cut down on how much you eat?

1	2	3	4
unlikely	slightly likely	moderately likely	very likely

47. How frequently do you skip dessert because you are no longer hungry?

1	2	3	4
almost never	seldom	at least once a week	almost every day

48. How likely are you to consciously eat less than you want?

1	2	3	4
unlikely	slightly likely	moderately likely	very likely

49. Do you go on eating binges even though you are not hungry?

1	2	3	4
never	rarely	sometimes	at least once a week

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."

1	2	3	4
not like me	little like me	pretty good description of me	describes me perfectly

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?

1 eat whatever you want, whenever you want it
2 usually eat whatever you want, whenever you want it
3 often eat whatever you want, whenever you want it
4 often limit food intake, but often "give in"
5 usually limit food intake, rarely "give in"
6 constantly limiting food intake, never "giving in"

Appendix G

Study Consent Form

Study 1

INFORMED CONSENT FORM FOR BIOMEDICAL RESEARCH
The Pennsylvania State University

ORP USE ONLY: IRB#27924 Doc.#2
The Pennsylvania State University
Office for Research Protections
Approval Date: 03/25/08 JKG
Expiration Date: 03/24/09 JKG
Biomedical Institutional Review Board

Study Consent Form

Title of Project: Eating Behaviors at Different Meals

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

Other Investigator(s): Jennifer Meengs
226 Henderson Building
863-8482

1. Purpose of the study: The purpose of this research is to investigate eating behaviors at different meals.

2. Procedures to be followed: You will be asked to eat breakfast, lunch and dinner in our lab on one day followed by breakfast the next day once per week for 5 weeks. During these meals 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 breakfast meal on the second day. You may drink water between meals, but we ask that you not drink any water one hour before a test 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 test session. 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 session. You will also be asked to refrain from drinking alcohol and maintain your usual activity level the day before 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 will also be asked to rate the sensory properties (i.e. taste, texture) of various foods at each meal and to record your hunger, thirst, fullness and nausea hourly during test days. At the end of the study, you will be asked to complete a debriefing questionnaire.

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. Allergies will be screened prior to study participation.

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 20-30 minutes, for no more than 1 ½ hours the first test day and 30 minutes the second test day. It will take approximately 1-2 minutes to complete each hourly questionnaire and 15 minutes to record food intake and physical activity before each test day.

6. **Statement of confidentiality**: Your participation in this research is confidential. You will be identified by subject number and an assigned dot color. 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 following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, the Biomedical Institutional Review Board and the PSU Office for Research Protections, and the U.S, Food and Drug Administration (FDA).

7. Right to ask questions: Please contact Jennifer Meengs at 863-8482 with questions, complaints or concerns about the research. You can also call this number if you feel this study has harmed you. Questions about your rights as a research participant may be directed to Penn State University's Office for Research Protections at (814) 865-1775.

8. **Compensation** : In addition to test meals, you will be paid $2.50 for each completed meal, consisting of breakfast, lunch, dinner, and the next day's breakfast for $10/week; and a $ 50 bonus if you complete all 5 test sessions, for a possible total of $100.00. 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 may be taken from the total amount. *Total payments within one calendar year that exceed $600 will require the University to report these payments to the IRS on an annual basis. This may require you to claim the compensation that you receive for participation in this study as taxable income.* All compensations will be paid within 1 week of completion.

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**.**

Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

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 H

Recipes for Manipulated Entrées

Study 1

Recipes for manipulated entrées in Study 1.

Mexican Casserole (recipe for 1 subject)

Ingredient		10%	15%	20%	25%	30%
Chili powder	g	4	4	4	4	4
Green pepper, chopped	g	50	50	50	50	50
Red tomato, chopped	g	16	22	28	34	40
Sweet corn, canned	g	99	88	77	66	55
Mild salsa	g	160	156	152	148	144
Mayonnaise, reduced fat	g	83	81	79	77	75
Mayonnaise, regular	g	14	12	10	8	6
Chicken breast, cooked, chopped finely	g	--	34	68	102	136
Shredded cheese, reduced fat	g	18	22	26	30	34
Shredded Monterey Jack cheese, reduced fat	g	18	22	26	30	34
Rice, cooked	g	268	241	214	187	160
Lettuce, shredded	g	60	60	60	60	60
Tortilla chips	g	24	22	20	18	16

Directions: Combine all ingredients except lettuce and tortilla chips. Bake covered in a dish greased with cooking spray at 350F for 20 minutes. Stir and continue baking covered for 10 minutes. After baking, mix with lettuce and tortilla chips and serve.

Shrimp stir-fry (recipe for 1 subject)

Ingredient		10%	15%	20%	25%	30%
Whole grain brown rice, cooked	g	320	291	262	233	204
Shrimp, cooked, frozen	g	15	80	145	210	275
Broccoli, finely chopped	g	130	118	106	94	82
Carrots, grated	g	130	118	106	94	82
Green pepper, finely chopped	g	130	118	106	94	82
Sesame oil	g	25	24.5	24	23.5	23
Soy sauce	g	16	16	16	16	16
Hoisin sauce	g	25	25	25	25	25
Ginger, minced	g	4	4	4	4	4
Garlic, minced	g	6	6	6	6	6
Cayenne pepper	g	0.5	0.5	0.5	1	1

Directions: Cook rice day before and chill. Rinse shrimp in cool water to thaw, set aside. Cut broccoli, pepper, and carrot into small, bite sized pieces. In a large skillet, combine oil, hoisin sauce, soy sauce, ginger, garlic, and cayenne pepper. When heated, add shrimp and stir-fry for 1 minutes. Add vegetables to shrimp and sauce and stir-fry for an additional 2 minutes. Add rice and stir-fry for an additional 3 minutes.

Appendix I

Food and Activity Diary

Food and Activity Diary

ID____________

Date__________ S M T W

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.

If you have any questions about completing this food diary, please call the Food Lab at 863-8482. Thank you for your cooperation.

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.): ____

____

Bread/rolls: ____

Desserts/sweets: ____

Beverages: ____

____

Snacks (all day) -

Snack/Time Consumed: ____

Snack/Time Consumed: ____

Snack/Time Consumed: ____

Physical Activity

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

Before breakfast:

Between breakfast and lunch:

Between lunch and dinner:

After dinner:

Appendix J

Meal Reports

Breakfast Report

Subject ID:__________ Date:___________ Week:__________ Day: _______

1. Have you felt well in the last 24 hours?

 _________Yes _________No

 If No, please explain:____

2. Have you taken any medication in the last 24 hours?

 _________Yes _________No

 If Yes, please list:____

3. Did you get a good night's sleep last night?

 _________Yes _________No

 If No, please explain:____

4. Have you maintained your usual level of physical activity the last 24 hours?

 _________Yes _________No

 If No, please explain:____

5. Have you consumed any foods or caloric beverages since 10 PM last night?

 _________Yes _________No

 If Yes, please indicate what food(s) and approximate amount(s):

____

____

6. Have you consumed alcohol in the past 24 hours?

 __________Yes __________No

 If Yes, what type and how much:________________________________

____

Lunch Report

Subject ID:__________ Date:____________ Week:_____________

1. Have you felt well since breakfast/lunch?

_____ Yes _____No

If No, please explain:

____

2. Have you taken any medication since breakfast/lunch?

_____Yes _____No

If Yes, please list:

____

3. Have you consumed any foods or beverages since breakfast/lunch, other than water?

_____Yes _____No

If Yes, please indicate what food(s) and approximate amount(s):

____

____

Dinner Report

Subject ID:__________ Date:____________ Week:_____________

1. Have you felt well since breakfast/lunch?

 _____ Yes _____No

 If No, please explain:

____

2. Have you taken any medication since breakfast/lunch?

 _____Yes _____No

 If Yes, please list:

____

3. Have you consumed any foods or beverages since breakfast/lunch, other than water?

 _____Yes _____No

 If Yes, please indicate what food(s) and approximate amount(s):

____

____

Appendix K

Discharge Questionnaire

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

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

Thank you for your participation!!!
Food Lab Staff & Students

Appendix L

Visual Analog Scale Questions – Satiety

How hungry do you feel <u>right now</u>?

Not at all hungry ____ Extremely hungry

How thirsty do you feel <u>right now</u>?

Not at all thirsty ____ Extremely thirsty

How much food do you think you could eat <u>right now</u>?

Nothing at all ____ A large amount

How nauseated do you feel <u>right now</u>?

Not at all nauseated ____ Extremely nauseated

How full do you feel <u>right now</u>?

Not at all full ____ Extremely full

Appendix M

Visual Analog Scale Questions – Palatability

Study 1

How pleasant is the appearance of this food right now?

Not at all pleasant ______________________________ Extremely pleasant

How pleasant is the taste of this food right now?

Not at all pleasant ______________________________ Extremely pleasant

How pleasant is the texture of this food right now?

Not at all pleasant ______________________________ Extremely pleasant

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

Nothing at all ______________________________ A large amount

How many calories do you think this total meal has?

No calories at all ______________________________ Extremely high in calories

Appendix N

Food and Energy Intakes by Meal

Study 1

	Protein content (% energy)[1]				
	10%	**15%**	**20%**	**25%**	**30%**
Breakfast Day 1					
Energy (kcal)	301 ± 24	273 ± 23	306 ± 27	293 ± 23	304 ± 21
Food weight (g)	228 ± 18	207 ± 18	231 ± 20	225 ± 18	231 ± 15
Carbohydrate (g)	44.4 ± 3.6	40.4 ± 3.5	45.7 ± 4.0	43.7 ± 3.4	45.1 ± 3.1
Protein (g)	11.5 ± 0.9	10.4 ± 0.9	11.6 ± 1.0	11.3 ± 0.9	11.6 ± 0.8
Fat (g)	10.2 ± 0.8	9.1 ± 0.8	10.1 ± 1.0	9.6 ± 0.8	10.0 ± 0.8
Fiber (g)	4.5 ± 0.3	4.1 ± 0.3	4.6 ± 0.4	4.4 ± 0.4	4.5 ± 0.3
Energy density (kcal/g)	1.33 ± 0.03	1.32 ± 0.02	1.32 ± 0.02	1.31 ± 0.02	1.31 ± 0.02
Lunch					
Energy (kcal)	494 ± 41	273 ± 23	484 ± 51	505 ± 47	462 ± 44
Food weight (g)	462 ± 37	454 ± 43	453 ± 47	474 ± 42	436 ± 40
Carbohydrate (g)	80.3 ± 6.4[a]	73.2 ± 7.1[ab]	67.9 ± 7.0[b]	65.3 ± 5.9[b]	54.6 ± 5.0[c]
Protein (g)	12.1 ± 1.0[a]	17.3 ± 1.7[b]	22.9 ± 2.4[c]	29.7 ± 2.8[d]	32.4 ± 3.1[d]
Fat (g)	15.3 ± 1.2	15.0 ± 1.5	15.1 ± 1.6	15.8 ± 1.5	14.5 ± 1.4
Fiber (g)	7.6 ± 0.4[a]	7.1 ± 0.5[a]	6.7 ± 0.6[a]	6.7 ± 0.5[a]	5.8 ± 0.5[b]
Energy density (kcal/g)	1.07 ± 0.02	1.06 ± 0.02	1.07 ± 0.02	1.06 ± 0.02	1.05 ± 0.02
Dinner					
Energy (kcal)	424 ± 36	441 ± 30	426 ± 34	443 ± 41	401 ± 36
Food weight (g)	410 ± 31	422 ± 25	408 ± 30	430 ± 37	393 ± 31
Carbohydrate (g)	69.5 ± 5.8[a]	67.5 ± 4.5[a]	60.5 ± 4.7[ab]	58.2 ± 5.2[ab]	48.5 ± 4.1[b]
Protein (g)	10.3 ± 0.9[a]	15.7 ± 1.1[ab]	20.0 ± 1.7[b]	25.7 ± 2.5[c]	27.7 ± 2.6[c]
Fat (g)	13.0 ± 1.1	13.6 ± 1.0	13.2 ± 1.1	13.7 ± 1.3	12.4 ± 1.2
Fiber (g)	6.9 ± 0.5[a]	6.9 ± 0.5[ab]	6.2 ± 0.4[ab]	6.3 ± 0.6[ab]	5.3 ± 0.4[b]
Energy density (kcal/g)	1.02 ± 0.02	1.04 ± 0.02	1.03 ± 0.02	1.00 ± 0.04	0.99 ± 0.03
Snack					
Energy (kcal)	566 ± 42	538 ± 36	505 ± 37	506 ± 35	554 ± 36
Food weight (g)	225 ± 28	207 ± 24	187 ± 21	212 ± 21	211 ± 24
Carbohydrate (g)	96.1 ± 7.8	91.6 ± 7.6	85.6 ± 7.5	87.1 ± 5.6	95.8 ± 7.3
Protein (g)	8.3 ± 0.8	7.9 ± 0.8	7.2 ± 0.8	7.5 ± 0.7	8.3 ± 0.8
Fat (g)	19.2 ± 1.3[a]	17.9 ± 1.1[ab]	17.2 ± 1.2[ab]	16.3 ± 1.5[b]	17.9 ± 1.3[ab]
Fiber (g)	3.1 ± 0.3	2.9 ± 0.2	2.7 ± 0.2	2.7 ± 0.2	3.0 ± 0.2
Energy density (kcal/g)	3.01 ± 0.24	3.01 ± 0.25	3.06 ± 0.23	2.74 ± 0.26	3.03 ± 0.27

Breakfast Day 2					
Energy (kcal)	386 ± 30	425 ± 30	433 ± 31	423 ± 30	390 ± 31
Food weight (g)	628 ± 49	629 ± 48	640 ± 54	627 ± 45	607 ± 52
Carbohydrate (g)	62.1 ± 4.8	68.5 ± 4.9	70.0 ± 5.0	68.0 ± 4.7	62.7 ± 5.0
Protein (g)	13.2 ± 1.0	14.6 ± 1.0	14.9 ± 1.1	14.5 ± 1.0	13.3 ± 1.1
Fat (g)	10.7 ± 0.9	11.6 ± 0.9	11.8 ± 0.9	11.7 ± 0.9	10.8 ± 0.9
Fiber (g)	7.2 ± 0.6	8.0 ± 0.6	8.1 ± 0.6	7.9 ± 0.5	7.2 ± 0.6
Energy density (kcal/g)	1.31 ± 0.02	1.30 ± 0.01	1.29 ± 0.01	1.30 ± 0.01	1.31 ± 0.02

[1] Protein content of lunch and dinner entrées

[abcd] All values are means ± SEMs. Values in the same row with different superscript letters were significantly different ($p<0.05$).

* The calculation of dietary energy density was determined using foods only.

Appendix O

Telephone Screening Questionnaire

Study 2

Pre-screening Questionnaire

Date:

Age: ___________ Date of Birth: _____________

Height: _________ Weight: _________________

Do you smoke? No Yes

Are you currently taking any prescription or "over the counter" 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 or intolerances? 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 a vegetarian? No Yes
If no, are there any meats that you exclude from your diet?___________

Do you like and are willing to eat:
Carrot Muffins yes no
Macaroni and Cheese yes no
Cauliflower yes no
Carrots yes no
Chicken and Rice Casserole yes no

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

Would you be willing to refrain from eating after 10:00 pm the evening before test sessions? No Yes

Would you be willing to refrain from drinking alcoholic beverages the evening prior to each test day? No Yes

Are you pregnant or breast feeding? No Yes

Where did you hear about the study?___________________________________

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

Are you a: _____Undergraduate semester standing:__________ major:____________
_____ Graduate major:______________
_____Penn State Staff
_____State College Resident

Are you eligible to work in the United States: Yes No

If criteria are satisfied, take their name and ask them to come to the lab to fill out questionnaires and to have their weight & height recorded.

Name: _________________ Phone: ________________ Appointment:___________________

Appendix P

Questionnaire Consent From

Study 2

Informed Consent Form for Biomedical Research
The Pennsylvania State University

Title of Project: Perceptions of Different Tastes - 3

Principal Investigator: Barbara J. Rolls, Ph.D.
226 Henderson Building, University Park, PA 16802
814-863-8482; bjr4@psu.edu

Other Investigator(s): Jennifer Meengs
226 Henderson Building, University Park, PA 16802
814-863-8482; jas138@psu.edu

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

2. **Procedures to be followed:** 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 these 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.

3. **Discomforts and risks:** There are no risks in participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort.

   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.

4. **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.

5. **Duration/time of the procedures and study:** It will take approximately 30 to 45 minutes to complete the screening materials.

6. **Statement of confidentiality**: Your participation in this research is confidential. 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 following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Dept. of Health and Human Services; The U.S. Food and Drug Administration (FDA) if applicable; The Penn State University Biomedical Institutional Review Board; The Penn State University Office for Research Protections.

7. **Right to ask questions:** Contact Jennifer Meengs at 863-8482 with questions, complaints, concern about this research. You also can call this number you feel this study has harmed you. 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. **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. Refusal to take part in or withdrawing from this study will involve no penalty of loss of benefits you would receive otherwise.

9. **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

____ ____________________
Signature or the Person Obtaining Consent Date

Appendix Q

Study Consent From

Study 2

INFORMED CONSENT FORM FOR BIOMEDICAL RESEARCH
The Pennsylvania State University

Title of Project: Perceptions of Different Tastes - 3

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

Other Investigator(s): Jennifer Meengs
226 Henderson Building
863-8482

1. **Purpose of the study:** The purpose of this research is to investigate the perceptions of different tastes at a meal.

2. **Procedures to be followed:** You will be asked to eat breakfast, lunch and dinner in our lab on 3 different test days. During these meals 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. We will provide you with a variety of snacks after the dinner meal that you may consume the evening of your test days. We ask that you return the snack bags, and any uneaten snack, to the lab the next morning. You may drink water between meals, but we ask that you not drink any water one hour before a test 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 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 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 a debriefing questionnaire.

   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. Allergies will be screened prior to study participation.

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 15-30 minutes, for no more than 1 ½ hour each test day. It will take approximately 15 minutes to record food intake and physical activity before each test day.

6. **Statement of confidentiality**: Your participation in this research is confidential. You will be identified by subject number and an assigned dot color. 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 following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Dept. of Health and Human Services; The U.S. Food and Drug Administration (FDA) if applicable; The Penn State University Institutional Review Board; The Penn State University Office for Research Protections.

7. **Right to ask questions:** Contact Jennifer Meengs at 863-8482 with questions, complaints, concern about this research. You also can call this number you feel this study has harmed you. If you have questions, concerns, or problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University's Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.

8. **Payment for Participation:** In addition to test meals, you will be paid $15.00 for each completed test day, consisting of a breakfast, lunch and dinner for $45; and an additional $30 payment if you complete all 3 test sessions, for a possible total of $75.00. 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.

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. Refusal to take part in or withdrawing from this study will involve no penalty of loss of benefits you would receive otherwise.

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 R

Recipes for Manipulated Entrées

Study 2

Recipes for manipulated entrées in Study 2.

Carrot Bread (recipe for 1 subject)

Ingredient		100% ED	85% ED	75% ED	Directions:
Flour	g	118.2	99.6	86.0	Preheat oven to 350F. Grease jelly-roll pan. Sift together flour, baking powder, salt, spices, and baking soda. In a large bowl, beat eggs until light and fluffy. Add sugar, continue to beat until well blended. Stir in oil, vanilla, carrots, squash. Stir in sifted ingredients. Pour into pans. Bake 50 minutes, or until skewer inserted into the middle comes out clean. Remove pans and cool, chill before cutting.
Baking powder	g	0.4	0.3	0.3	
Salt	g	1.9	1.6	1.4	
Cinnamon	g	0.4	0.3	0.3	
Nutmeg	g	0.4	0.3	0.3	
Baking soda	g	1.5	1.2	1.1	
Egg	g	47.3	39.8	34.4	
Sugar	g	127.1	107.1	92.5	
Vegetable oil	g	70.6	59.5	51.4	
Vanilla extract	g	2.6	2.2	1.9	
Carrots, grated	g	34.7	53.1	72.5	
Squash, puréed	g	--	26.6	45.9	
Carrots, puréed	g	--	13.3	17.2	

Macaroni and Cheese (recipe for 1 subject)

Ingredient		100% ED	85% ED	75% ED	Directions:
Elbow noodles, cooked	g	368.8	308.4	270.0	Preheat oven to 375F. In medium sauce pan, melt butter. Remove from heat, stir in flour, salt, and pepper until smooth. Gradually stir in milk. Bring to boiling, stirring, reduce heat, and simmer mixture 1 minute. Remove from heat. Stir in vegetables, noodles, and cheese, pour into pan. Cover and bake for 15-20 minutes. *Use mild cheddar cheese in 100% ED recipe, ½ mild and ½ sharp in 85% ED recipe, and all sharp cheddar cheese in 75% ED recipe.
Butter	g	51.7	43.2	37.9	
Flour	g	23.7	19.8	17.4	
Salt	g	3.0	2.5	2.2	
Ground white pepper	g	0.2	0.2	0.2	
Skim milk	g	371.8	310.9	272.3	
Shredded cheddar cheese*	g	227.6	190.3	166.7	
Grated parmesan cheese	g	37.9	31.7	27.8	
Cauliflower, puréed	g	7.6	96.4	152.8	
Zucchini, puréed	g	7.6	96.4	152.8	

Chicken Rice Casserole (recipe for 1 subject)

Ingredient		100% ED	85% ED	75% ED	Directions:
Chicken breast, chopped	g	125.7	104.4	88.1	Mix all ingredients, cover, bake at 375F for 50 minutes. Use mild cheddar cheese for 100% and 85% ED recipes, use sharp cheddar cheese for 75% ED recipe.
Cream of chicken soup	g	300.7	249.8	210.6	
Rice,	g	213.2	177.1	149.4	
Tap water	g	246.0	204.4	172.3	
Vegetable oil	g	30.1	25.0	21.1	
Onion powder	g	0.8	0.7	0.6	
Ground white pepper	g	0.4	0.3	0.3	
Carrots	g	65.6	54.5	86.2	
Green peas	g	65.6	54.5	86.2	
Shredded cheddar cheese	g	41.0	34.1	28.7	
Cauliflower, puréed	g	5.5	127.2	153.2	
Squash, puréed	g	5.5	68.1	103.4	

Appendix S

Visual Analog Scale Questions - Palatability

Study 2

How pleasant is the appearance of this food right now?

Not at all pleasant ______________________________ Extremely pleasant

How pleasant is the taste of this food right now?

Not at all pleasant ______________________________ Extremely pleasant

How pleasant is the texture of this food right now?

Not at all pleasant ______________________________ Extremely pleasant

Appendix T

Discharge Food Preference Likert Scale

Study 2

For each of the foods listed below, circle the number that best describes how much you like each food.

	Dislike strongly	Dislike	Dislike somewhat	Neither dislike nor like	Like somewhat	Like	Like strongly
1. Chicken Rice Casserole	1	2	3	4	5	6	7
2. Yellow Squash	1	2	3	4	5	6	7
3. Cheese-flavored Popcorn	1	2	3	4	5	6	7
4. Strawberry Yogurt	1	2	3	4	5	6	7
5. Macaroni and Cheese	1	2	3	4	5	6	7
6. Chocolate Pudding	1	2	3	4	5	6	7
7. Grapes	1	2	3	4	5	6	7
8. Carrots	1	2	3	4	5	6	7
9. Pound Cake	1	2	3	4	5	6	7
10. Fig Newtons	1	2	3	4	5	6	7
11. Broccoli	1	2	3	4	5	6	7
12. White Dinner Roll	1	2	3	4	5	6	7
13. Cauliflower	1	2	3	4	5	6	7
14. Mandarin Oranges	1	2	3	4	5	6	7
15. Carrot Bread/Muffin	1	2	3	4	5	6	7
16. Green beans	1	2	3	4	5	6	7
17. Wheat Dinner Roll	1	2	3	4	5	6	7
18. Canned Peaches	1	2	3	4	5	6	7

Appendix U

Total Food and Energy Intakes by Meal

Study 2

	Condition		
	100% ED	**85% ED**	**75% ED**
Breakfast			
Energy (kcal)	649.2 ± 42.3[a]	618.9 ± 34.5[ab]	589.8 ± 35.9[b]
Weight (g)	357.8 ± 18.5	374.5 ± 18.2	381.7 ± 19.7
Carbohydrate (g)	100.1 ± 6.1	96.9 ± 5.2	93.4 ± 5.4
Protein (g)	7.6 ± 0.5	7.8 ± 0.5	7.9 ± 0.5
Fat (g)	23.6 ± 1.8[a]	21.7 ± 1.4[ab]	20.1 ± 1.4[b]
Vegetable (g)	10.0 ± 0.8[a]	29.0 ± 2.0[b]	45.0 ± 3.5[c]
Fiber (g)	1.3 ± 0.1[a]	1.6 ± 0.1[b]	1.9 ± 0.1[c]
ED (kcal/g)	1.81 ± 0.07[a]	1.67 ± 0.05[b]	1.55 ± 0.04[b]
Lunch			
Energy (kcal)	1122 ± 48[a]	1001 ± 44[b]	940 ± 41[c]
Weight (g)	690.1 ± 29.5	690.4 ± 30.2	698.1 ± 32.1
Carbohydrate (g)	113.0 ± 5.1[a]	105.7 ± 30.2[b]	102.6 ± 4.6[b]
Protein (g)	41.6 ± 1.9[a]	36.4 ± 1.8[b]	33.3 ± 1.7[c]
Fat (g)	56.4 ± 2.5[a]	48.7 ± 2.2[b]	44.8 ± 2.1[c]
Vegetable (g)	98.6 ± 6.6[a]	156 ± 7.5[b]	196.1 ± 10.0[c]
Fiber (g)	6.4 ± 0.2[a]	7.2 ± 0.3[b]	7.8 ± 0.3[c]
ED (kcal/g)	1.63 ± 0.03[a]	1.46 ± 0.02[b]	1.36 ± 0.02[c]
Dinner			
Energy (kcal)	930 ± 40[a]	861 ± 37[b]	794 ± 33[c]
Weight (g)	594.7 ± 27.6	610.7 ± 28.9	594.5 ± 27.5
Carbohydrate (g)	118.6 ± 5.1[a]	111.7 ± 4.8[b]	104.6 ± 4.4[c]
Protein (g)	33.5 ± 1.6[a]	31.0 ± 1.5[b]	27.8 ± 1.3[c]
Fat (g)	36.2 ± 1.6[a]	33.1 ± 1.4[b]	30.4 ± 1.3[c]
Vegetable (g)	116.2 ± 7.4[a]	172.3 ± 10.4[b]	208.5 ± 11.5[c]
Fiber (g)	6.7 ± 0.3[a]	7.6 ± 0.4[b]	8.5 ± 0.4[c]
ED (kcal/g)	1.59 ± 0.03[a]	1.44 ± 0.03[b]	1.37 ± 0.03[c]
Snack			
Energy (kcal)	416 ± 32	434 ± 29	436 ± 28
Weight (g)	133.2 ± 10.9	137.0 ± 9.7	132.0 ± 9.4
Carbohydrate (g)	58.9 ± 5.2	62.0 ± 4.6	62.1 ± 4.5
Protein (g)	6.3 ± 0.4	6.5 ± 0.4	6.5 ± 0.4
Fat (g)	17.0 ± 1.2	17.6 ± 1.2	17.7 ± 1.2
Vegetable (g)	44.8 ± 8.0	43.8 ± 8.2	37.8 ± 7.2
Fiber (g)	5.4 ± 0.4	5.6 ± 0.3	5.5 ± 0.3
ED (kcal/g)	3.41 ± 0.21	3.46 ± 0.19	3.58 ± 0.17

[1] All values are means ± SEMs. Values in the same row with different superscript letters were significantly different ($p<0.05$).

* The calculation of dietary energy density was determined using foods only.

Appendix V

Telephone Screening Questionnaire

Study 3

Pre-screening Questionnaire

Date:

Age: __________ Date of Birth: ____________

Height: _________ Weight: ________________

Do you smoke? No Yes

Are you currently taking any prescription or "over the counter" 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 or intolerances? 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 a vegetarian? No Yes
If no, are there any meats that you exclude from your diet?__________

Do you like and are willing to eat:

Yogurt with strawberries, granola, and almonds	yes	no
Chicken and rice casserole with peas, carrots, and broccoli	yes	no
Pasta and meat sauce with zucchini, green pepper, and onion	yes	no

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

Would you be willing to refrain from eating after 10:00 pm the evening before test sessions? No Yes

Would you be willing to refrain from drinking alcoholic beverages the day before each test session? No Yes

Are you pregnant or breast feeding? No Yes

Where did you hear about the study?________________________________

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

Are you eligible to work in the United States: Yes No

Are you a: _____Undergraduate semester standing:__________ major:____________
_____ Graduate major:______________
_____Penn State Staff
_____State College Resident

If criteria are satisfied, take their name and ask them to come to the lab to fill out questionnaires and to have their weight & height recorded.

Name: ________________ Phone: ________________ Appointment:___________________

Appendix W

Questionnaire Consent Form

Study 3

INFORMED CONESNT FORM FOR BIOMEDICAL RESEARCH
Prescreening Questionnaire

Title of Investigation: Eating Behaviors

Investigator: Barbara Rolls, Ph.D.
Department of Nutrition
226 Henderson Bldg. Penn State University
University Park, PA 16802
EMAIL: bjr4@psu.edu
TELEPHONE: 814-863-8481

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.

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 risks in participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort.

If, as a result of filling in the questionnaires, you feel that you would benefit from psychological assistance, or 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.

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

Confidentiality: Your responses on the questionnaires will remain confidential. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, Penn State University's Biomedical Review Board, and Penn State University's Office for Research Protections.

Voluntary Participation: Your participation in the research is voluntary. You do not have to answer any questions you do not wish to answer. Your participation is voluntary and you are free to withdraw your consent and terminate your participation at any time. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

Right to Ask Questions: Please contact Jennifer Meengs at 863-8482 with questions, complaints or concerns about the research. You can also call this number if you feel this study has harmed you. Questions about your rights as a research participant may be directed to Penn State University's Office for Research Protections at (814) 865-1775.

Injury: In the unlikely event you become injured as a result of your participation in this study, medical care is available. It is the policy of this institution to provide neither financial compensation nor free medical treatment for research-related injury. 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.

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

You must be 20 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, and to have your body measurements taken, please sign your name and indicate the date below. You will be given a copy of this signed and dated consent form for your records.

___________________	___________________	___________________
Date	Date of Birth	Subject's Signature

___________________		___________________
Date		Investigator's Signature

Appendix X

Study Consent Form

Study 3

INFORMED CONSENT FORM FOR BIOMEDICAL RESEARCH
The Pennsylvania State University

ORP OFFICE USE ONLY
DO NOT REMOVE OR MODIFY
IRB#30120 Doc. #2
The Pennsylvania State University
Office for Research Protections
Approval Date: 01/21/2009 DWM
Expiration Date: 01/13/2010DWM
Biomedical Institutional Review Board

Title of Project: Eating Behaviors
IRB# 30120

Principal Investigator: Barbara Rolls, Ph.D.
Department of Nutrition
226 Henderson Bldg. Penn State University
University Park, PA 16802
EMAIL: bjr4@psu.edu
TELEPHONE: 814-863-8481

Other Investigator(s): Jennifer Meengs
226 Henderson Bldg. Penn State University
University Park, PA 16802
814-863-8482

1. Purpose of the study: The purpose of this research is to investigate eating behaviors at different meals.

2. Procedures to be followed: This study will last for 5 weeks. One day each week you will be asked to eat breakfast, lunch and dinner in our lab. The first week of the study you will also be asked to wear a pedometer for 3 days and record your daily number of steps and complete a brief activity questionnaire. You will be required to consume a portion of each meal, but may eat as little or as much as you would like of other foods served with the meal. On test days, you will only be permitted to eat and drink foods that are provided to you by the lab until after the dinner meal. After the dinner meal you will be asked to record your evening snack intake and return it the next day. You may drink the water provided to you between meals, but we ask that you not drink one hour before a test meal. Throughout the test day 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 test session. 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 session. You will also be asked to refrain from drinking alcohol and maintain your usual activity level the day before 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 will also be asked to rate the sensory properties (i.e. taste, texture) of various foods at each meal and to record your hunger, thirst, fullness and nausea during test days. At the end of the study, you will be asked to complete a debriefing questionnaire.

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. Allergies will be screened prior to study participation.

4. Benefits: You will be aiding in our understanding of human eating behavior.

5. Duration/Time Commitment: It will take approximately 1-2 minutes to record daily pedometer steps and 1-2 minutes to complete the activity questionnaire. Each test meal will take approximately 20-30 minutes, for no more than 1 ½ hours each test day. Every test day it will take approximately 1-2 minutes to complete each questionnaire, and 2-3 minutes to record evening snack intake. The day before each test day it will take up to 15 minutes to record food intake and physical activity.

6. **Statement of confidentiality**: Your participation in this research is confidential. You will be identified by subject number and an assigned dot color. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, Penn State University's Biomedical Review Board, and Penn State University's Office for Research Protections.

7. Right to ask questions: You can ask questions about this research. Contact Jennifer Meengs at 863-8482 with questions. You can also call this number if you feel this study has harmed you. 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 $5.00 for recording pedometer steps; $10.00 for completing each day (session) in the lab, consisting of breakfast, lunch, and dinner, for a total of $50 for sessions in the lab; and a $45 bonus for completing all study components, for a possible total of $100.00. 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.

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. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

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 20 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

____ ______________________

Signature of Person Obtaining Consent Date

Appendix Y

Recipes for Manipulated Entrées

Study 3

Recipes for manipulated entrées in Study 3.

Yogurt Parfait (recipe for standard energy content entrées for men)

Ingredient		Standard ED	Reduced ED	Directions:
Plain yogurt	g	73	144	Mix yogurt, strawberries, non-caloric sweetener. Immediately before serving mix in almost all of the granola and almonds, leaving some to sprinkle on top.
Plain non-fat yogurt	g	114	101	
Strawberries, frozen, chopped	g	10	123	
Granola bar, finely chopped	g	72	2	
Almonds, finely ground	g	3	53	
Non-caloric sweetener	g	--	3	

Chicken Rice Casserole (recipe for standard energy content entrées for men)

Ingredient		Standard ED	Reduced ED	Directions:
Chicken, cooked, chopped	g	34.7	20	Preheat oven to 350F. Combine all ingredients in large bowl. Put into greased casserole dish and bake for 40 minutes.
Cream of chicken soup, condensed	g	132.3	146	
Tap water	g	87.2	100.8	
Green peas, frozen	g	10.5	74.6	
Carrots, frozen, chopped	g	10.5	74.6	
Canola oil	g	10.5	8.9	
Rice, uncooked	g	90.3	67.2	
Broccoli florets, frozen	g	7.4	101.9	

Pasta Bake (recipe for standard energy content entrées for men)

Ingredient		Standard ED	Reduced ED	Directions:
Lean beef, cooked	g	13.7	13.7	Preheat oven to 350F. Combine all ingredients in large bowl. Put into greased casserole dish and bake for 20 minutes.
Parmesan cheese, grated	g	8.4	7.4	
Mozzarella cheese, part-skim, shredded	g	8.4	7.4	
Onions, chopped, frozen	g	5.3	33.6	
Squash, frozen, chopped	g	5.3	87.2	
Green pepper, frozen, chopped	g	6.3	104	
Marinara sauce	g	149.1	192.2	
Olive oil	g	5.8	4.7	
Ditalini pasta, cooked	g	156.5	136.5	
Bread crumbs, Italian style	g	18.9	11.6	

Appendix Z

Visual Analog Scale Questions - Palatability

Study 3

How pleasant is the appearance of this food <u>right now</u>?

Not at all pleasant ____ Extremely pleasant

How pleasant is the taste of this food <u>right now</u>?

Not at all pleasant ____ Extremely pleasant

How pleasant is the texture of this food <u>right now</u>?

Not at all pleasant ____ Extremely pleasant

How many calories do you think this food has?

No calories at all ____ Extremely high in calories

Appendix AA

Total Food and Energy Intakes by Meal

Study 3

Men	Standard energy content		Reduced energy content	
	Standard ED	Reduced ED	Standard ED	Reduced ED
Breakfast				
Discretionary food intake (g)	198 ± 22.9	198.2 ± 22.9	234.7 ± 28.5	225.6 ± 25.6
Discretionary energy intake (kcal)[1]	324 ± 35	321 ± 36	375 ± 38	366 ± 34
Discretionary ED (kcal/g)	1.72 ± 0.12	1.69 ± 0.13	1.72 ± 0.12	1.82 ± 0.13
Discretionary fat (g)	5.9 ± 0.9	5.3 ± 0.9	6.5 ± 1.0	6.4 ± 1.0
Discretionary CHO (g)[1]	59.1 ± 6.3	59.3 ± 6.5	68.9 ± 6.9	67.2 ± 6.3
Discretionary pro (g)	9.5 ±1.0	9.6 ± 1.1	11.3 ± 1.1	10.7 ± 1.0
Discretionary fiber (g)[1]	3.3 ± 0.3	3.3 ± 0.3	3.9 ± 0.4	3.7 ± 0.3
Total food intake (g)	470 ± 22.9[a]	624.2 ± 22.9[b]	407.7 ± 28.5[c]	497.6 ± 25.6[a]
Total energy intake (kcal)[1]	754 ± 35	751 ± 36	650 ± 38	642 ± 34
Total ED (kcal/g)	1.60 ± 0.04[a]	1.18 ± 0.03[b]	1.62 ± 0.06[a]	1.28 ± 0.05[c]
Total fat (g)[1]	20.3 ± 0.9	19.6 ± 0.9	15.6 ± 1.0	15.4 ± 1.0
Total CHO (g)[1]	122.3 ± 6.3	123.5 ± 6.5	109.1 ± 6.9	108.3 ± 6.3
Total pro (g)[1]	25.7 ± 1.0	26.2 ± 1.1	21.5 ± 1.1	21.0 ± 1.0
Total fib (g)	7.3 ± 0.3[a]	8.7 ± 0.3[b]	6.4 ± 0.4[c]	7.2 ± 0.3[a]
Lunch				
Discretionary food intake (g)	347.7 ± 30.6[a]	249.3 ± 25.8[b]	407.7 ± 35.1[a]	371.3 ± 32.1[a]
Discretionary energy intake (kcal)[1,2]	423 ± 36	347 ± 35	529 ± 43	473 ± 36
Discretionary ED (kcal/g)	1.27 ± 0.09[a]	1.47 ± 0.12[b]	1.36 ± 0.08[ab]	1.39 ± 0.09[ab]
Discretionary fat (g)[1,2]	14.8 ± 1.4	11.7 ± 1.4	18.3 ± 1.5	16.1 ± 1.5
Discretionary CHO (g)[1,2]	68.8 ± 5.8	58.5 ± 5.5	86.8 ± 7.2	78.1 ± 5.6
Discretionary pro (g)[1,2]	5.2 ± 0.6	3.9 ± 0.5	6.6 ± 0.7	6.1 ± 0.6
Discretionary fiber (g)	5.4 ± 0.5[a]	3.8 ± 0.4[b]	6.4 ± 0.5[c]	5.7 ± 0.5[ac]
Total food intake (g)[1,2]	712.7 ± 30.6	815.3 ± 25.8	642.7 ± 35.1	736.3 ± 32.1
Total energy intake (kcal)[1,2]	993 ± 36	917 ± 35	897 ± 43	841 ± 36
Total ED (kcal/g)[2]	1.41 ± 0.04	1.13 ± 0.03	1.43 ± 0.05	1.16 ± 0.03
Total fat (g)[1,2]	33.7 ± 1.4	30.6 ± 1.4	30.4 ± 1.5	28.3 ± 1.5
Total CHO (g)[2]	148.5 ± 5.8	140.1 ± 5.5	137.9 ± 7.2	130.8 ± 5.6
Total pro (g)[1]	26.9 ± 0.6	25.9 ± 0.5	20.4 ± 0.7	20.3 ± 0.6
Total fib (g)	8.3 ± 0.5[a]	11.4 ± 0.4[b]	8.2 ± 0.5[a]	10.6 ± 0.5[b]

Dinner				
Discretionary food intake (g)[1,2]	303.3 ± 26.3	239.8 ± 27.3	346.3 ± 27.1	296.4 ± 28.6
Discretionary energy intake (kcal)[1,2]	520 ± 49	425 ± 48	611 ± 49	549 ± 47
Discretionary ED (kcal/g)	1.85 ± 0.13	2.00 ± 0.18	1.88 ± 0.13	2.06 ± 0.14
Discretionary fat (g)[1,2]	25.9 ± 2.8	22.0 ± 2.8	31.3 ± 2.9	27.5 ± 2.6
Discretionary CHO (g)	61.5 ± 5.5[a]	48.0 ± 4.8[b]	70.7 ± 5.3[ac]	64.8 ± 5.2[ac]
Discretionary pro (g)	9.9 ± 1.5	8.6 ± 1.5	11.8 ± 1.5	10.5 ± 1.5
Discretionary fiber (g)[1,2]	2.7 ± 0.2	2.1 ± 0.2	3.1 ± 0.3	2.7 ± 0.2
Total food intake (g)	661.3 ± 26.3[a]	809.8 ± 27.3[b]	571.3 ± 27.1[c]	656.4 ± 28.6[a]
Total energy intake (kcal)[1,2]	1090 ± 49	995 ± 48	971 ± 49	909 ± 47
Total ED (kcal/g)	1.66 ± 0.05[a]	1.22 ± 0.04[b]	1.73 ± 0.07[a]	1.40 ± 0.05[c]
Total fat (g)[2]	45.1 ± 2.8	41.1 ± 2.8	43.0 ± 2.9	39.5 ± 2.6
Total CHO (g)	138.3 ± 5.5[a]	126.1 ± 4.8[b]	118.7 ± 5.3[bc]	113.8 ± 5.2[c]
Total pro (g)[1]	31.9 ± 1.5	30.5 ± 1.5	25.6 ± 1.5	24.0 ± 1.5
Total fib (g)	10.7 ± 0.2[a]	14.0 ± 0.2[b]	8.1 ± 0.3[c]	10.2 ± 0.2[a]

All values are means ± SEMs. Values in the same row with different superscript letters were significantly different ($p<0.05$).

[1] Effect of entrée energy content is significant

[2] Effect of entrée energy density is significant

* The calculation of dietary energy density was determined using foods only.

Women	Standard energy content		Reduced energy content	
	Standard ED	Reduced ED	Standard ED	Reduced ED
Breakfast				
Discretionary food intake (g)[1]	143.4 ± 13.8	121.5 ± 12.0	173.4 ± 14.6	163.2 ± 13.3
Discretionary energy intake (kcal)[1]	243 ± 16	224 ± 17	292 ± 18	283 ± 15
Discretionary ED (kcal/g)	1.87 ± 0.10	1.96 ± 0.10	1.81 ± 0.09	1.85 ± 0.10
Discretionary fat (g)	5.0 ± 0.5	4.7 ± 0.5	5.6 ± 0.6	5.8 ± 0.5
Discretionary CHO (g)[1]	42.1 ± 3.0	38.8 ± 3.0	51.7 ± 3.3	49.2 ± 2.9
Discretionary pro (g)[1]	7.7 ± 0.5	7.1 ± 0.5	9.2 ± 0.3	8.9 ± 0.5
Discretionary fiber (g)[1]	2.4 ± 0.2	2.2 ± 0.2	2.9 ± 0.2	2.8 ± 0.2
Total food intake (g)	333.4 ± 13.8[a]	420.5 ± 12.0[b]	293.4 ± 14.6[c]	353.2 ± 13.3[a]
Total energy intake (kcal)[1]	543 ± 16	524 ± 17	482 ± 18	473 ± 15
Total ED (kcal/g)	1.62 ± 0.04[a]	1.21 ± 0.02[b]	1.65 ± 0.05[a]	1.31 ± 0.03[c]
Total fat (g)[1]	15.0 ± 0.5	14.7 ± 0.5	11.9 ± 0.6	12.0 ± 0.5
Total CHO (g)[1]	86.0 ± 0.3	83.6 ± 3.0	79.4 ± 3.3	77.2 ± 2.9
Total pro (g)[1]	19.0 ± 0.5	18.7 ± 0.5	16.3 ± 0.5	16.1 ± 0.5
Total fib (g)	5.1 ± 0.2[a]	6.0 ± 0.2[b]	4.6 ± 0.2[c]	5.2 ± 0.2[a]
Lunch				
Discretionary food intake (g)[1]	244.4 ± 17.3	210.6 ± 18.5	310.3 ± 17.9	292.6 ± 20.4
Discretionary energy intake (kcal)[1]	325 ± 22	281 ± 22	400 ± 22	378 ± 23
Discretionary ED (kcal/g)	1.40 ± 0.10	1.46 ± 0.12	1.33 ± 0.05	1.40 ± 0.08
Discretionary fat (g)	12.0 ± 0.9[a]	9.8 ± 0.9[b]	14.4 ± 0.9[c]	13.8 ± 0.9[ac]
Discretionary CHO (g)[1]	51.4 ± 3.5	46.5 ± 3.6	63.3 ± 3.7	59.8 ± 3.8
Discretionary pro (g)[1,2]	3.8 ± 0.3	3.2 ± 0.4	5.3 ± 0.4	4.7 ± 0.4
Discretionary fiber (g)	4.0 ± 0.3[a]	3.3 ± 0.3[b]	5.0 ± 0.3[c]	4.7 ± 0.3[c]
Total food intake (g)	499.4 ± 17.3[a]	605.6 ± 18.5[b]	473.3 ± 17.9[a]	547.6 ± 20.4[c]
Total energy intake (kcal)[1]	725 ± 22	681 ± 22	656 ± 22	634 ± 23
Total ED (kcal/g)	1.47 ± 0.03[a]	1.13 ± 0.02[b]	1.41 ± 0.03[c]	1.17 ± 0.03[b]
Total fat (g)	25.2 ± 0.9[d]	23.1 ± 0.9[ac]	22.8 ± 0.9[bc]	22.3 ± 0.9[ab]
Total CHO (g)[1]	107.0 ± 3.5	103.8 ± 3.6	98.9 ± 3.7	93.1 ± 3.8
Total pro (g)[1]	18.9 ± 0.3	18.5 ± 0.4	14.9 ± 0.4	14.6 ± 0.4
Total fib (g)	6.1 ± 0.3[a]	10.4 ± 0.3[b]	6.4 ± 0.3[a]	9.3 ± 0.3[c]

Dinner				
Discretionary food intake (g)	216.6 ± 15.6[a]	165.5 ± 16.[b]	236.8 ± 15.5[a]	221.9 ± 16.1[a]
Discretionary energy intake (kcal)	401 ± 30[a]	302 ± 30[b]	442 ± 29[a]	422 ± 29[a]
Discretionary ED (kcal/g)	2.10 ± 0.14	2.19 ± 0.17	2.04 ± 0.13	2.08 ± 0.13
Discretionary fat (g)	20.8 ± 1.9[a]	15.5 ± 1.9[b]	22.5 ± 1.7[a]	21.8 ± 1.8[a]
Discretionary CHO (g)	44.2 ± 3.0[a]	33.8 ± 2.9[b]	49.6 ± 3.2[a]	47.1 ± 3.3[a]
Discretionary pro (g)	9.3 ± 0.9[a]	6.5 ± 0.9[b]	10.0 ± 0.8[a]	9.5 ± 0.8[a]
Discretionary fiber (g)	2.1 ± 0.1[a]	1.5 ± 0.2[b]	2.3 ± 0.1[a]	2.2 ± 0.1[a]
Total food intake (g)[1,2]	467.6 ± 15.6	565.5 ± 16.5	394.8 ± 15.5	472.9 ± 16.1
Total energy intake (kcal)	801 ± 30[a]	702 ± 30[b]	693 ± 29[b]	673 ± 29[b]
Total ED (kcal/g)	1.73 ± 0.05[a]	1.24 ± 0.03[b]	1.79 ± 0.06[a]	1.44 ± 0.05[c]
Total fat (g)	34.3 ± 1.9[a]	28.6 ± 1.9[b]	31.0 ± 1.7[ab]	30.1 ± 1.8[ab]
Total CHO (g)	98.1 ± 3.0[a]	89.3 ± 2.9[b]	83.5 ± 3.2[b]	81.9 ± 3.3[b]
Total pro (g)	24.6 ± 0.9[a]	21.7 ± 0.9[b]	19.6 ± 0.8[bc]	19.1 ± 0.8[c]
Total fib (g)	7.7 ± 0.1[a]	9.9 ± 0.2[b]	5.8 ± 0.1[c]	7.4 ± 0.1[a]

All values are means ± SEMs. Values in the same row with different superscript letters were significantly different ($p<0.05$).

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[2] Effect of entrée energy density is significant

* The calculation of dietary energy density was determined using foods only.

VITA

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2011 Ph.D. Nutritional Sciences, **The Pennsylvania State University, University Park, PA**
2006 M.S. Nutrition, **Case Western Reserve University, Cleveland, OH**
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2004-2005 **Dietetic Intern,** University Hospitals of Cleveland, Cleveland, OH
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Fall 2009 **Teaching Assistant,** The Pennsylvania State University, University Park, PA
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2010 Best Poster Award in Lifestyle Modification & Behavioral Medicine,
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PUBLICATIONS

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