Pre-Meal Beverage Consumption Affects Hunger, Satiety, and Energy Intake

by

Robin M. Welcher

A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
in

Food and Nutritional Sciences

Approved: 6 Semester Credits

Carol Seaborn

Carol Seaborn, Ph.D., RD, CD, CFCS

Committee Members:

Kerry D Peterson

Kerry D. Peterson, Ph.D., RD

Susan Staggs, Ph.D.

The Graduate School

University of Wisconsin-Stout

May, 2009

The Graduate School
University of Wisconsin-Stout
Menomonie, WI

Author: **Welcher, Robin M.**

Title: ***Pre-Meal Beverage Consumption Affects Hunger, Satiety, and Energy Intake***

Graduate Degree: **MS Food and Nutritional Sciences**

Research Advisor: **Carol Seaborn, Ph.D., RD, CD, CFCS**

Month/Year: **May, 2009**

Number of Pages: **62**

Style Manual Used: **American Psychological Association, 5th edition**

ABSTRACT

Obesity is an epidemic in our society. One-third of the U.S. population is obese, not just overweight. One factor contributing to weight gain is the increase in caloric beverage consumption, especially between meals. Because of this beverages that increase satiety and decrease subsequent energy intake may be an effective tool for weight management. The purposes of this study were to determine if consuming orange juice, orange juice with added Benefiber, or 1% milk 30 minutes prior to a meal affects satiety, hunger, and fullness or significantly reduces subsequent energy intake compared to a control of no beverage. Twenty-five college students aged 19-28 years participated in the study. The subjects attended four different test meals, and arrived after an overnight fast. At each meal they were given one of the three different beverages. During the fourth test meal, they were not given a beverage (control). After consuming the beverages, the subjects waited for 30 minutes, and were given a visual analog scale to rate their hunger, satiety, and fullness. Approximately 21 ounces of oatmeal, pre-weighed, was given to the subjects. The remaining oatmeal was then weighed to determine the

amount of energy intake. Energy intake and ratings of hunger, satiety, and fullness were statistically analyzed using SPSS Statistics 17.0 to perform ANOVA tests. The amount of oatmeal (in ounces) consumed post beverage consumption, was not significantly different among the four treatments. However, the subjects did consume the greatest amount of oatmeal (10.58 oz.) with a control of no beverage preload and the least amount of oatmeal (9.66 oz.) with a preload of orange juice with Benefiber. The ratings on the visual analog scales indicated that the orange juice with Benefiber significantly reduced hunger ($p \leq 0.05$), increased fullness ($p \leq 0.05$), and increased satiety ($p \leq 0.01$) compared to the control of no beverage. These results suggest that adding fiber to a beverage can increase feelings of satiety and fullness and decrease hunger. However, adding 6 g fiber does not cause people to have a reduced energy intake at a following meal. Fiber has been shown to delay gastric emptying and increase satiety. The results suggest that the addition of Benefiber to orange juice does increase satiety.

The Graduate School

University of Wisconsin-Stout

Menomonie, WI

Acknowledgments

I would like acknowledge my mom and sisters whom have all achieved great things. I admire their ambition, and they have given me inspiration to dream and motivation to conquer. I would also like to express my gratitude to Dr. Carol Seaborn. She has been my instructor, advisor, supervisor and mentor. Carol continuously provided encouragement and advice and challenged me to be better or go bigger. The gift I appreciate most is that she taught me to believe in myself. Carolyn Barnhart has greatly enhanced my experience at UW-Stout by sharing her wisdom on several occasions and selecting me to be a graduate assistant. This opportunity has allowed me to grow personally and professionally.

I would like to thank the participants in my study. Their time and reliability was greatly appreciated. Thank you to Kelly Samz and Charity Cook who assisted me in the data collection process and to the staff and faculty that allowed me to recruit subjects during their class time. Additionally, thank you to Carol Seaborn, Kerry Peterson, and Susan Staggs for serving on my thesis committee. Without the subjects, assistants, faculty, and committee members this study would not have been possible.

TABLE OF CONTENTS

List of Tables

Chapter 1: Introduction

Currently, one third of the U.S. population is obese (body mass index of 30 kg/m^2 or greater), not just overweight (body mass index of 25-29.9 kg/m^2). This accounts for 72 million Americans. Sixteen percent of the children are obese and this number has tripled since 1980, and the number of adults has doubled (Centers for Disease Control and Prevention [CDC], 2008). The U.S. Department of Health and Human Services established the Healthy People 2010 objectives to address the obesity epidemic. Some of the objectives include increasing the proportion of adults who are at a healthy weight, reduce the proportion of adults who are overweight, and reduce the proportion of children and adolescents who are overweight or obese (U.S. Department of Health and Human Services [HHS], n.d.).

A contributing factor to this obesity epidemic is the increase in consumption of caloric beverages between meals. Dubois, Farmer, Girard, and Peterson (2007) conducted a study in children aged 2.5 years, 3.5 years, and 4.5 years to examine consumption of sweetened beverages between meals. The results showed that children who regularly consumed sweetened beverages between meals were twice as likely to be overweight at 4.5 years of age, with only 6.9% of non-consumers of sweetened beverages being overweight compared to 15.4% of regular consumers. It is crucial that research is conducted to identify easy and effective ways for people to control their energy intake. Since people are consuming caloric beverages, it may be beneficial to identify if specific beverages will naturally increase satiety and decrease subsequent energy intake.

In the past five to ten years, several studies have addressed beverage intake and its effects on energy intake and satiety. These studies have also investigated the possibility that consuming beverages prior to a meal may promote less energy intake. Tordoff and Alleva (1990), Raben,

Vasilaras, Moller, and Astrup (2002), and Monsivais, Perrigue, and Drewnowski (2007) all focused on the types of sweeteners used in soda to investigate the different effects on energy intake. The results suggested that subjects who consumed sweeteners tended to have a higher total energy intake due to the calories from the beverage compared to those who had artificial sweetener. When different sugars in beverages were compared to each other, there was no significant difference in hunger, satiety, or energy intake. A preload of water was studied by Davy, Dennis, Dengo, Wilson, and Davy (2008), and Van Walleghen, Orr, Gentile, and Davy (2007). Both of these studies reported reduced meal energy intake, after the consumption of water, in older subjects. Evidence is lacking that supports these findings in younger adults. There have been several other studies that have investigated beverages with similar caloric value, but with different macronutrient content (Almiron-Roig & Drewnowski, 2003, DellaValle, Roe, & Rolls, 2005, and Harper, Flint, & Astrup, 2007). There appears to be a hierarchy of macronutrients and their effects on satiety in regards to solid foods, but not in liquids. In solid foods, protein has a greater effect than carbohydrates, which has more of an effect than fat.

Almiron-Roig and Drewnowski (2003) found that orange juice, 1% milk, regular cola, and sparkling water showed no significant difference between the caloric beverages (orange juice, milk, and cola) in regards to hunger and satiety; however, the caloric beverages significantly decreased hunger and increased satiety compared to the non-caloric beverage (sparkling water). A subsequent meal was presented to the subjects two hours and 15 minutes after the beverages were consumed. The intake was compared to the control of no beverage. No significant difference was reported in energy intake between the beverage variables. DellaValle, Roe, and Rolls (2005) conducted a similar study that investigated the effects of orange juice, 1% milk, regular cola, diet cola, and water on feelings of hunger and satiety. The ratings of hunger

and satiety on visual analog scales showed no significant difference in hunger and satiety perceptions. The caloric beverages had a higher total energy intake due to the additional calories within the beverage preload; however, there were no significant differences in the subsequent energy intake. Harper, James, Flint, and Astrup (2007) found a chocolate milk drink to have increased satiation effects compared to a carbonated beverage, but no difference in subsequent *ad libitum* lunch intake. These studies suggest that caloric beverages are more satiating than non-caloric, and beverages with protein show more effect on subjective feelings of hunger and satiety than beverages that contain only carbohydrates as an energy source.

When considering the type of sugar or carbohydrate found in the beverages, simple carbohydrates are usually the only component. There is limited research investigating the effects of complex carbohydrates such as fiber. Tiwary, Ward, and Jackson (1997) compared the satiating effects of orange juice to orange juice with added pectin and found that the orange juice with pectin significantly increased the self-reported satiety of the subjects for up to four hours. This study did not measure subsequent energy intake. More research is needed to establish if having a fiber preload in a beverage will affect satiety and energy intake at a subsequent meal.

Statement of the Problem

Americans are more overweight and obese than ever before. The fast-paced lifestyles, convenience foods, increased consumption of sweetened beverages and high calorie snacks from vending machines and decreased physical activity are environmental and social factors that are contributing to this epidemic (Weight-control Information Network [WIN], 2006). Prior research suggests that some beverages are more satiating than others. If additional research strongly suggests that consuming certain beverages or adding a supplement such as Benefiber to a sweetened beverage increases satiety and decreases subsequent energy intake, than the

beverage could be considered a weight management tool. People are often resistant to change, but minor changes may be more effective than encouraging drastic changes in dietary habits.

Purpose of the Study

The purpose of this study was to determine if there is a significant difference in subsequent energy intake and satiety 30 minutes after consuming a preload of orange juice, 1% milk, or orange juice with added Benefiber in comparison to a control of no beverage preload. It is expected that the orange juice with Benefiber would promote a higher satiety rating and would result in less subsequent energy intake due to fiber's ability to delay gastric emptying and the release of the hormones, pancreatic polypeptide and cholecystokinin (Di Lorenzo, Williams, Hajnal, & Valenzuela, 1988, and Kissileff, Pi-Sunyer, Thornton, & Smith, 1981).

Null Hypothesis and Research Objectives

The null hypothesis of this study was that no significant difference would exist in energy intake and satiety following a 30 minute preload of orange juice, orange juice with Benefiber, and 1% milk compared to no beverage preload.

Research Objectives include:

1. To determine if a 30 minute preload of orange juice, orange juice with Benefiber, or 1% milk will result in a higher satiety rating using a visual analog scale compared to no beverage preload.
2. To determine if a 30 minute preload of orange juice, orange juice with Benefiber, or 1% milk will result in a significantly lower subsequent energy intake in comparison to no beverage preload.

Assumptions of the Study

It was assumed that all subjects would follow the guidelines for 24-hours prior to the data collections periods. Each subject was given a list of directions that stated no alcohol consumption 24-hours prior to data collection, no food or beverage consumption the morning of, no exercising the morning of, no use of toothpaste, chewing gum, or mouthwash the morning of, and to keep the dinners the night before consistent in portion and composition. It was assumed that the subjects would adhere to the request to stop eating the oatmeal when they have an initial feeling of being full and that they truthfully rated their feelings of satiety, hunger, fullness, desire for specific foods, and palatability of the oatmeal.

Definition of Terms

Ad libitum. The act of eating without restriction.

Benefiber. A fiber supplement that contains wheat dextrin in powder form; 2 teaspoons provide 3 grams of soluble fiber (Benefiber, n.d.).

Body Mass Index (BMI). "An index for estimating obesity. The weight in kilograms is divided by the height in meters squared" (Thomas, 1993).

Energy intake. The amount of calories consumed.

Macronutrients. Carbohydrates, protein, and fats in the diet that provide the body with energy in the form of kilocalories.

Palatability. The degree to which food is acceptable in taste or agreeable to the palate.

Satiety. "Being full to satisfaction, especially with food" (Thomas, 1993).

Soluble fiber. Dietary fiber that dissolves in water.

Subsequent. Occurring or coming later.

Visual analog scales (VAS). 100-mm horizontal line with phrases anchored at each end that represent opposite extremes of a subjective feeling.

Young adults. Nineteen to 28 years of age.

Limitations of the Study

The limitations of the study were mainly composed of threats to validity. The sample population was a convenience sample, which was not random; therefore, the results may not be generalized for all young adults. A social threat may have existed if a subject was an acquaintance of a student that was in the principle investigator's research class because the acquaintance could have shared details of the study. A subject could have become ill and missed a data collection session or chose to stop participating. An inconsistency could have occurred in the oatmeal from week-to-week, which would affect the palatability and ultimately alter the amount of oatmeal consumed by the subjects.

Methodology

The subjects of this study were college students at the University of Wisconsin-Stout and between the ages of 19 and 28 years. The participants were non-smokers and non-competitive athletes. The subjects were recruited from January 22, 2009, to February 9, 2009. The investigator recruited the subjects by receiving permission from instructors to speak to their classes and pass out contact information to interested students. The students then contacted the principle investigator. Once the subjects were recruited, they attended an introductory meeting. At this time height and weight measurements were taken, consent forms were signed, and guidelines to follow 24-hours prior to the study were explained. On February 16, 2009, the data collection began. The sessions took place every Monday and Wednesday morning through

March 11, 2009. Each participant attended four sessions. They received a different beverage variable at each session; therefore, each subject can be analyzed as their own control.

When the subjects arrived at the data collection session, they were asked if they followed pre-study guidelines. They were instructed to enter a booth in the sensory laboratory where they were given one of the three beverages or no beverage. Once the beverage was consumed, the subject waited for 30 minutes. At that point, they were given a set of visual analog scales to mark their level of satiety and desire for specific foods. Then a large bowl of oatmeal was presented and the subjects were asked to eat until they felt an initial feeling of fullness. Before the subjects exited, they were given a second set of visual analog scales to assess the palatability of the oatmeal. During the sessions that the subjects were not given a beverage, they were not required to wait for 30 minutes before eating. Since they were already in the fasted state, the first visual analog scale was given to them upon arrival. The rest of the session continued in the same manner as when a beverage was served. All of the results were recorded and analyzed.

Chapter II: Literature Review

This chapter will discuss subjects, methodologies, results, and conclusions of research to clarify the rationale for the current study design. The choice of variables will be analyzed as well as the suspected physiological mechanisms of action. As previously stated, the obesity epidemic needs to be addressed. The satiation effects of macronutrients and the potential reduction of subsequent energy intake may assist in effective weight control strategies.

Theories of Obesity

The concept that the obesity epidemic is not attributed to one cause is well-accepted among health professionals. A widely accepted obesity theory is that obesity is the result of environmental and behavioral changes. More specifically, obesity is a result of overconsumption of energy-dense and high-fat meals in conjunction with reduced physical activity (Jequier, 2002). Several other studies have investigated the impact of increased energy intake from foods and beverages and decreased physical activity on weight gain. Mattes and Campbell (2009) theorize that energy-dense snack foods and beverages are more easily accessible and that the consumption of these snacks and beverages has increased outside of the home. It is also suspected that the lower satiation effects of beverages compared to solid foods has played a role in the rise on obesity. Mattes and Campbell conducted a study that examined the effects of apple juice (liquid), apple sauce (semisolid), and an apple (solid) on appetitive response when consumed alone and with a meal. The responses were measured using visual analog scales. It was concluded that the liquid form had the weakest response in increasing satiety and fullness, and decreasing hunger when consumed alone or with a meal.

Even beverage consumption in young children has increased during recent years. Dubois, Farmer, Girard, and Peterson (2007) conducted a study that examined sweetened

beverage consumption between meals of children aged 2.5 years, 3.5 years, and 4.5 years. The results showed that children who regularly consumed sweetened beverages between meals were twice as likely to be overweight at 4.5 years of age. Only 6.9% of non-consumers of sweetened beverages in the Dubois et al. (2007) study were overweight compared to 15.4% of regular consumers. Based on current research, the increase in sweetened beverage consumption is a major contributing factor to the rise in obesity. To counter-act the weight-gain effects of caloric beverages, the consumption could be limited or the composition of the beverage could be altered by adding a supplement that promotes decreased food intake during a subsequent meal.

Beverage Variables

Water was excluded based on the results shown by Van Walleghen, Orr, Gentile, and Davy (2007) and Davy, Dennis, Dengo, Wilson, and Davy (2008). Van Walleghen et al. (2007) compared subjects that were younger (21-35 years of age) versus older (60-80 years of age) and the effects of pre-meal water consumption on subsequent energy intake. Each subject was given multiple options of foods, in large quantities, to choose from. The foods were pre-weighed and once again weighed when the subjects had finished eating. In both the younger and older groups, the reported fullness was increased with the water preload; however, this was not reinforced by a decrease in subsequent energy intake. This study found no difference in energy intake among the younger subjects when comparing no preload to a 30 minute preload of water. However, there was a significant decrease in energy intake in the older group. The older subjects that received the water preload consumed significantly less during a subsequent buffet style lunch. Davy et al. (2008) conducted a study with overweight or obese individuals that ranged in age from 55 to 75 years as the subjects. The subjects reported for the study following a 12 hour fast. They were given either no preload or a preload of 500 mL of chilled bottled water. The results

supported that consuming the preload of water 30 minutes prior, significantly reduced subsequent energy intake. Water does not appear to have an effect on non-obese persons or younger adults.

Multiple studies have used 1% milk as a variable, due to the protein content, to compare against several different caloric beverages comprised of simple sugars. Harper, James, Flint, and Astrup (2007) reported that a 30 minute preload of chocolate milk compared to preload of cola significantly increased satiety and fullness ratings on visual analog scales, but did not significantly reduce energy intake. Monsivais, Perrigue, and Drewnowski (2007) investigated the effects of three different caloric colas, 1% milk, and diet cola on satiety and subsequent energy intake following a preload of 495 mL of a beverage and two hours prior to the meal. The caloric colas were sweetened with sucrose, high fructose corn syrup with 42% fructose, and high fructose corn syrup with 55% fructose. The 1% milk was the only beverage of the five variables that showed a significant decrease in subsequent energy intake compared to the control of no beverage.

Variances in portion size and duration of preload time prior to the test meal can make it difficult for researchers to accurately compare results. Almiron-Roig and Drewnowski (2003) had a similar design in regards to portion size and duration of time between the preload and test meal. The beverages were given two hours and 15 minutes prior to the meal, and were 590 mL (20 oz.) in volume. Almiron-Roig and Drewnowski compared orange juice, 1% milk, and regular cola and found no significant differences in energy intake compared to the control of no beverage or the non-caloric beverages. A non-significant decrease in energy intake was recorded in the groups that consumed the 1% milk as the preload. These contrasting results continue to show that there is not an accepted, established macronutrient hierarchy for liquids. There is

weak evidence showing that protein (1% milk) tends to have a greater effect on satiety and subsequent energy intake compared to simple carbohydrates. As mentioned, stronger results have been presented when comparing 1% milk to cola than to orange juice.

Bolton, Heaton, and Burroughs (1981) conducted a study that investigated the satiation effects of grapes versus grape juice and oranges versus orange juice. Both fruits "evoked considerably more satiety than the corresponding amount of juice" (Bolton et al., 1981, p. 215). This raises the question, was it the solid form of the fruit, the fiber, or a combination that created these results? Stull, Apolzan, Thalacker-Mercer, Iglay, and Campbell (2008) found that solid meal replacements decreased hunger ratings and decreased subsequent energy intake compared to liquid meal replacements of equivalent energy and macronutrient composition. These articles would encourage one to believe that it was the solid form of the fruit or meal replacement that increased the satiation effect.

Tiwary, Ward, and Jackson (1997) compared orange juice and orange with pectin, which is the type of fiber found in peels of fruits. In this study, fasted subjects were given 448 mL of orange juice or orange juice with 5, 10, 15, or 20 g of pectin. Satiety was measured on the hour for four hours after the consumption of the juice. At four hours, the subjects were given 0.473 L of ice cream. Satiety was once again measured at 0, 30, and 60 minutes after the ice cream. The results showed that even the smallest amount of pectin, which was 5 grams, significantly increased satiety. Subsequent energy intake was not measured in this study. After reviewing Tiwary et al. (1997), it would be easily arguable that the fiber was the variable increasing satiety in this study as well as in study conducted on meal replacements by Stull et al. (2008). Because the results were so significant, it was concluded that there is a need to continue this investigation and measure subsequent energy intake of orange juice and orange juice with added fiber.

Satiety-Related Gastrointestinal Peptides

Gastrointestinal peptides play a key role in the feeding process. The macronutrient composition of the food or beverage being ingested has been shown to stimulate or inhibit hormones differently among carbohydrates, fiber, protein, and fat. According to a review of satiety-related gastrointestinal peptides by Karhunen, Juvonen, Huotari, Purhonen, and Herzig (2008), cholecystokinin (CCK), glucagon-like peptide 1 (GLP-1), peptide YY (PYY), and pancreatic polypeptide (PP) have increased secretion in response to carbohydrates, protein, and fat. The ingestion of food initiates satiety through hormones by two mechanisms. The first is the mechanical stimulation, which causes the release of peptides, and the second is the release of peptides in response to the ingested food. CCK is the only peptide that has consistently shown increased secretions in response to fiber consumption. Based on this conclusion, CCK may be a possible mechanism to explain why fiber increases satiety and can decrease subsequent energy intake.

Kissileff, Pi-Sunyer, Thorton, and Smith (1994) conducted a study that investigated the effects of intravenous infusion of C-terminal octapeptide of cholecystokinin (CCK-8), which is a synthetic CCK. They reported that when CCK-8 was slowly infused during a meal time, it decreased energy intake and the duration of the meal compared to a placebo of a saline solution. Belinger (1994) stated two conclusions regarding CCK after conducting a meta-analysis. His first conclusion was that exogenous infusions of CCK in a pharmacologic dose, inhibits gastric emptying of liquid and semi-solid foods. The second comment was that when the CCK antagonist loxiglumide was administered, the antagonist increased gastric emptying. These conclusions support the idea that CCK may play a role in satiety and decreased energy intake.

Dietary Fiber: Roles and Forms

Dietary fiber is defined as "all plant polysaccharides and lignins which are resistant to hydrolysis by the digestive enzymes of man" (Trowell et al., 1976, p. 967). Fiber is typically classified as either soluble (dissolves in water) or insoluble (does not dissolve in water). Soluble fiber is found in apples, citrus fruits, oats, barley, legumes, and other similar foods. This type of fiber tends to gel when mixed with water. Insoluble fiber is found in nuts, seeds, vegetables, whole wheat, wheat bran, and other grains. Insoluble fiber decreases transit time and increases fecal bulk (Mayo Clinic Staff, 2008).

Soluble fiber, particularly pectin, delays gastric emptying (Sandhu, El Samahi, Mena, Dooley, & Valenzuela, 1987). Because fiber delays gastric emptying, it increases satiety and decreases feelings of hunger. This can be beneficial in weight loss because there is an inverse relationship with energy intake and the amount of fiber consumed. Like many other concepts in human nutritional science research, soluble fiber and its ability to delay gastric emptying is somewhat controversial. Results are inconsistent and this may be due to the type of fiber, age and body composition of the subjects, or amount of fiber given. The proposed mechanisms of action of soluble fiber include the gelling effect, which causes an increase in viscosity and the stimulation or release of gut hormones. Sandhu et al. (1987) attempted to clarify the possible mechanisms of action of pectin in normal weight subjects using liquid and solid meals. The body digests fiber more slowly than simple carbohydrates causing a slower release of glucose into the blood stream. Initially, 7.5 grams was assessed and the delay time did not differ significantly from a control solution of 10% glucose. The amount was increased to 15 grams. In the liquid meals the 15 grams of pectin lowered plasma insulin levels at 15, 30, and 45 minutes, but glucagon concentrations were only significantly less at 15 minutes post-meal. The pectin did

not have an effect on postprandial blood glucose levels. The solid meal with pectin did not exhibit a significant effect on any of the hormones. The results showed that 15 grams of pectin added to the liquid or solid meal delayed gastric emptying in all subjects. Sandhu et al. concluded that because gastric emptying of a meal is regulated by its volume, osmolarity, viscosity, chemical composition, physical state, and pH, and since pectin only affects viscosity, then viscosity must be the mechanism of action. Gastroduodenal motility was also investigated in this study and the results were inconclusive.

The Sandhu et al. study was followed up to investigate the effects of pectin on obese subjects. Di Lorenzo, Williams, Hajnal, and Valenzuela (1988) measured the satiation effects of pectin and the postprandial release of cholecystokinin (CCK) and pancreatic polypeptide (PP) due to the consumption of this fiber. The results showed that the rate of emptying was significantly slower in the subjects when they consumed 15 grams of pectin than when they were given methylcellulose as a control. The satiety ratings that were measured on a visual analog scale were significantly higher after the ingestion of the pectin compared to the control. In regards to the hormones, both fibers caused a release of CCK and PP; however, there was no difference in the release between the two fibers.

Benefiber is wheat dextrin, which does not cause gelling or alter taste. Since the viscosity of the fiber supplemented product is speculated to be the mechanism for delayed gastric emptying, wheat dextrin's gelling ability was in question. As stated, wheat dextrin does not form a viscous solution outside of the body. There is limited research done on wheat dextrin; therefore, it is possible that it will gel in the gut, will increase satiety without gelling, or it will promote the release of CCK or PP in higher amounts than pectin. Cellulose is an insoluble fiber that does not cause gelling and was found by Freeland, Anderson, and Wolever (2009) to reduce

energy intake. According to a review of fibers by Slavin, Savarino, Paredes-Diaz, and Fotopolous (2009) cellulose, pectin, and wheat dextrin are classified by different characteristics (see Table 1).

Table 1

Classification Characteristics of Fiber

	Pectin	Wheat Dextrin	Cellulose
Dietary Fiber	X		X
Functional Fiber		X	
Soluble	X	X	
Fermentable	X	X	
Viscous	X		

Pectin and cellulose are considered to be dietary fibers, which are found naturally in foods. Wheat dextrin is a functional fiber, which can be further classified as a resistant dextrin. This means it becomes an indigestible polysaccharide when the starch is heated and treated with enzymes. Cellulose is non-viscous and shares fewer characteristics with pectin than wheat dextrin; however, research investigating the effects of wheat dextrin and cellulose on satiety, hunger, and subsequent energy intake is necessary to fully understand the effects these fibers have on satiety and release of hormones.

Measuring Subjective Feelings of Satiety, Fullness, and Hunger

Visual analog scales (VAS) are used to assess feelings of hunger, satiety, fullness, satisfaction, and desire for specific foods. Visual analog scales are typically 100-mm in length with anchored words at each end that represent opposite extremes. VAS are commonly used in

studies of this nature (DellaValle et al., 2005; Flood et al., 2006; Harper et al., 2007; Rolls et al., 1998; Rolls et al., 1988; Tiwary, 1997; Van Walleghen et al., 2007). Examples of visual analog scales can be located in Appendices A and B. These scales used were tested by Flint, Raben, Blundell, and Astrup (2000) for reproducibility and validity. It was concluded that the reproducibility was relatively low because VAS measure subjective human feelings. The study did investigate if diet standardization prior to the test day increased the reproducibility and validity of the VAS and the results showed that is does not (Flint et al., 2000). When analyzing the validity, it was difficult to determine the extent of validity because there is not an objective measure of appetite. It is reported that the validity can be assessed by correlating pre-meal values to subsequent energy intake. The Flint et al. study found these scales to be valid in that respect.

Test Meals

Several previous studies have chosen to allow the subjects to consume a buffet-style meal *ad libitum* to measure subsequent energy intake (Almiron-Roig & Drewnowski, 2003; Almiron-Roig et al., 2004; Davy et al., 2008; DellaValle et al., 2005; Van Walleghen et al., 2007). During these meals there was typically a variety of foods ranging from sweet to savory. The foods provided were typical items in the American diet such as potato chips, cookies, pasta dishes, sandwiches, and salads. The subjects were free to choose the foods they wanted to eat and how much. Donahoo et al. (2008) investigated the effect of dietary fat on energy intake. Twenty-two, non-obese, subjects participated in a repeated measures study. Each subject followed a controlled diet for four consecutive days for each of the three varying diets. The diets differed by fat content while holding the total kilocalories of each diet consistent. The diets contained 26, 34, or 40 percent of kilocalories from fat. One meal per day was standardized and the other two

meals were *ad libitum* and buffet-style. There was a three week washout period between each four-day test diets. The subjects received the diets in a randomized order. The results showed that when the subjects were exposed to the 26 percent fat diet their energy intake was significantly less than the 34 or 40 percent diets. This suggests that consuming high fat foods may make people consume more calories regardless of their level of hunger, fullness, or satiety. To control for this variable, the present study offered only one low-fat item for the subjects to consume, which was oatmeal.

Hierarchy of Macronutrients

Several studies have indicated that a satiety hierarchy of macronutrients exists for solid foods. Rolls, Hetherington, and Burley (1988) conducted a study that examined different macronutrient preloads and the effect on satiety and an *ad libitum* subsequent meal. A preload of either high protein (chicken), high carbohydrate (pasta – starch), high fat (cream cheese), high carbohydrate (Turkish delight – sucrose), or a mixed composition (chocolate confectionery – fat and sucrose) was given to the subjects. At 2, 20, 40, 60, and 120 minutes after the completion of the preload they were asked to rate their hunger and fullness on a visual analog scale. After the 120 minutes the subjects were presented with a tray of several different pre-weighed items. The subjects were allowed to eat what and as much as they wanted. The energy intake was determined by calculating the difference between the pre-weights and post-weights of the items.

The mean change in hunger rating was significantly lower for the high starch and high protein preloads compared to both the high fat and mixed composition. This showed that a high carbohydrate and a high protein preload had a greater satiation effect compared to the high fat or fat and sucrose preload. Subjects that consumed the high starch and high protein preloads reported higher levels of fullness compared to the other preloads. Subsequent energy intake was

less after the high starch and high protein preloads. These results support that carbohydrates and protein in solid forms have a stronger impact on hunger, fullness, and subsequent energy intake than fats.

Hill and Blundell (1990) reported that when subjects were given a high protein or a high carbohydrate meal and then offered a self-selection meal three hours later. The subjects who previously ate the high protein meal had a reduction in hunger and energy intake compared to the high carbohydrate group. Porrini, Crovetti, Distam, and Silva (1995) had similar results when subjects were given a preload of pasta (carbohydrate) or meatballs (protein); the subsequent energy intake was lower in the group that ate the meatballs. These data suggest that protein in a solid food has a stronger impact on hunger and subsequent energy intake than carbohydrates. Stubbs and Whybrow (2003) confirmed that protein > carbohydrates > fats is an accepted satiety hierarchy of macronutrients for solid foods.

Much less evidence exists that supports an accepted hierarchy for liquids. Research has been conducted; however, the results are very inconsistent. A study conducted by de Graaf, Hulshof, Weststrate, and Jas (1992) reported that feelings of hunger and satiety after preloads of high carbohydrate, high protein, or high fat beverages had similar effects. Harper, James, Flint, and Astrup (2007) showed an increase in satiety after a preload of chocolate milk compared to a preload of sugar-sweetened cola. Satiety was measured 30 minutes after the consumption of the beverages using a visual analog scale. These results suggest that protein in a beverage has a greater effect than simple carbohydrates. Almiron-Roig and Drewnowski (2003) also compared the effects of low-fat milk, cola, orange juice, and sparkling water on hunger and fullness, but found no significant differences. Two unique components of this study make it stand out from similar studies. One is that a piece of toast was served and consumed with the beverage. The

other component is that the subsequent meal was served two hours and 15 minutes after the preload, a meal time much later after the preload than most studies. These components could explain why Almiron-Roig and Drewnoski did not find results that would support a hierarchy for liquids. Almiron-Roig, Flores, and Drewnowski (2004) conducted a study that examined the form of the preload (liquid versus solid) and the timing of the preload in relation to the subsequent meal. The preloads consisted of fat-free raspberry cookies or cola with an equivalent energy composition. The different preloads were given 20 minutes or two hours prior to the subsequent meal. The results concluded that there was no difference in energy intake between the solid and liquid preloads; however, the subjects consumed significantly less during the subsequent meal following the 20 minute preload compared to the two hour.

Summary

In summary, there is a substantial amount of research that supports a macronutrient hierarchy for solid foods, but there is less supporting evidence for liquids. The research that has been conducted has shown inconsistent results between carbohydrates and proteins in liquid form, to have the greatest satiation effect. Of the studies conducted to compare protein to carbohydrate, the carbohydrate has been juice or soda. Fiber has been studied in comparison to a juice equivalent, but has not been measured against a protein (milk) variable. The current study combined these variables by investigating orange juice, orange juice with added fiber, and 1% milk. The control was no beverage. Because fiber has been shown to delay gastric emptying and stimulate the secretion of CCK, it was suspected that the orange juice with fiber would increase satiety and fullness and decrease hunger and subsequent energy intake. Visual analog scales were used to measure satiety, fullness, and hunger because these scales are the most commonly used tool to assess these subjective feelings. A one-item meal of oatmeal was offered

to control for the possibility of overeating due to a variety of options and ingestion of high fat foods.

Chapter III: Methodology

This study was designed to address the possibility that consuming a beverage preload may reduce subsequent energy intake. In addition, the results could potentially contribute to a common acceptance of a macronutrient hierarchy for beverages. The purpose was to determine if a statistically significant difference existed in subsequent energy intake, hunger, and satiety 30 minutes after a preload of orange juice, 1% milk, or orange juice with added Benefiber in comparison to a control of no beverage preload. This chapter will discuss the subjects used and selection process, instrumentation, data collection procedures, data analysis, limitations, and a concluding summary.

Subject Selection and Research Design

This research was approved by the Institutional Review Board of the University of Wisconsin-Stout. The subjects in this study were undergraduate and graduate students at the University of Wisconsin-Stout. They ranged in age from 19 to 28 years, and were non-smokers and non-competitive athletes. All subjects reported liking oatmeal and denied having any intolerances of milk or orange juice.

The subjects were selected on a voluntary basis. The primary investigator contacted instructors in the Food and Nutrition, Psychology, Biology, and Family and Consumer Sciences Departments and asked permission to recruit in their classes. Upon receiving permission, a date and time was established. The investigator presented general information regarding the time commitment, restrictions, and when the study would take place. Business cards with contact information and other details regarding the study were left with the instructors to distribute to interested students (Appendix C). The students then emailed the investigator. The subjects were then given the option to choose one of four time slots for data collection that best fit their

schedules. The choices included Mondays from 7:45 a.m. to 8:45 a.m., Mondays from 9:00 a.m. to 10:00 a.m., Wednesdays from 7:45 a.m. to 8:45 a.m., or Wednesdays from 9:00 a.m. to 10:00 a.m. A maximum of seven subjects were allowed during each time slot due to the number of booths in the sensory evaluation classroom where the data collection took place. A beverage rotation (see Table 2) was created so that each time slot or group would be given one of the four beverage variables each week. This way, not all subjects were served the same beverage in the same week. There was a one-week wash out period between all test meals.

Table 2

Beverage Rotations for Data Collection Sessions

Beverage	Week 1	Week 2	Week 3	Week 4
Orange Juice	Monday	Wednesday	Monday	Wednesday
	9:00-10:00	9:00-10:00	7:45-8:45	7:45-8:45
Orange Juice w/ Fiber	Wednesday	Monday	Wednesday	Monday
	9:00-10:00	7:45-8:45	7:45-8:45	9:00-10:00
1% Milk	Monday	Wednesday	Monday	Wednesday
	7:45-8:45	7:45-8:45	9:00-10:00	9:00-10:00
No Beverage	Wednesday	Monday	Wednesday	Monday
	7:45-8:45	9:00-10:00	9:00-10:00	7:45-8:45

A total of 25 subjects were recruited. Once all subjects were assigned a time and day, two introductory meetings were held with identical content. The subjects were allowed to choose to attend the meeting that best accommodated their schedule. Seventeen of the participants attended. The investigator set up individual meetings with the remaining subjects to

cover the same content that was discussed during the group meetings. Each subject signed a consent form (Appendix D), filled out a screening questionnaire (Appendix E), and was given a list of guidelines to follow 24-hours prior to the data collection sessions (Appendix F). The investigator then answered questions and explained the timeline of the data collection sessions, so the participants would know what to expect upon arrival. It was also explained and requested that each subject consciously be aware of their initial feelings of fullness and satisfaction. They were asked to stop eating at this point. At the end of the meeting, each subject was taken individually into a private room to have a height and weight measurement taken, so the body mass index (BMI) could be calculated.

Instrumentation

The instrument used to obtain the height and weight of the subjects was a Tanita TBF-215GS Body Composition Analyzer. Each subject was asked to remove socks and shoes before stepping onto the scale. The investigator ensured that each subject was in a Frankfort Plane before confirming the height, for consistency and accuracy. This was done by using a straight edge and confirming the tragion was parallel to the lower orbital of the eye. The Tanita provides a print out with a calculated BMI. This is the value that was used in the analysis of the data.

The screening questionnaire was designed to address different variables that may have altered the results. The subjects were asked to list any supplements or medications to identify if anyone was taking a drug that caused a change in appetite. The participants were asked if they were currently trying to gain or lose weight because this could have possibly caused them to eat more or less than someone not dieting. Since subjects were only asked to eat until they had initial feelings of fullness and satisfaction, the responses of this question were not believed to have significant impact on results. Competitive athletes were excluded from the study because

daily vigorous activity could affect appetite; however, subjects that participated in club sports or intramurals were allowed to be in the study. The screening questionnaire also confirmed if the subjects liked oatmeal and that they found 1% milk to be palatable. The screening questionnaire did not ask about the consumption or liking of orange juice; however, it was communicated during the recruitment process that orange would be one of the beverages served.

During the data collection sessions, visual analog scales (VAS) were used to assess hunger, satiety, fullness, satisfaction, and desire for specific foods prior to the presentation of the oatmeal. Another VAS was given to each subject after the consumption of the oatmeal to assess the palatability, taste, aftertaste, and smell. Both scales used were tested by Flint, Raben, Blundell, and Astrup (2000) for reproducibility and validity. It was concluded that the reproducibility was relatively low because the VAS measures subjective human feelings. Flint et al. (2000) investigated the affects of diet standardization the day prior to the test meal. Subjects were either given a standard diet or were allowed to eat freely during the days preceding the test meals. Flint et al. reported that following a standardized diet does not increase the reproducibility or validity of the visual analog scales. When analyzing the validity, it was difficult to determine the extent of validity because there is not an objective measure of appetite. It is reported that the validity can be assessed by correlating pre-meal values to subsequent energy intake. Flint et al. study found these scales to be valid in that respect.

Visual analog scales are typically horizontal lines, 100-mm in length, with anchored words at each end that represent opposite extremes. The pre-meal VAS used in this study can be located in Appendix A. The subjects were asked to place a vertical mark on the horizontal line that corresponded to their feelings at that point in time. The scales were measured by using a metric ruler to record the distance in millimeters from the left end of the line to the vertical mark.

Data Collection Procedures

The data collection took place in the Home Economics Building at the University of Wisconsin-Stout in the sensory evaluation laboratory. This laboratory is composed of two rooms, HE 251 and HE 252. HE 252 is a room that consists of seven divided booths. At each booth there was a green light and a red light that the subjects used to communicate with the investigator and research assistant. Instructions were posted in each booth (Appendix G). Each booth had a window with a metal divider, so items can be passed between HE 251 and HE 252, but the subjects were not able to see into HE 251. This is the location where the investigator and the research assistant prepared the beverages, oatmeal, and served the items to the subjects through the direct opening in each booth.

Upon arrival, the research assistant greeted the subjects and asked for their subject identification number. Then each subject was shown the guidelines to follow 24-hours prior to the data collection and asked if they followed all of them. If the subject was not able to follow all the guidelines a notation was made about the guideline not followed. Each participant was assigned a booth. Once the subjects were seated in the booth, they would turn on the green light. An 8 ounce, pre-measured and poured beverage was served. All beverages were measured individually using a Pyrex liquid measuring cup. The measurement was taken at eye level to avoid a parallax. When the orange juice with Benefiber was prepared, 8 ounces of juice were poured into the glass. Two teaspoons of Benefiber were added. The teaspoons were leveled with a metal pastry knife for consistency and accuracy. The powder was stirred into the juice and two more teaspoons were added and stirred until dissolved. This added a total of six grams of soluble fiber to the orange juice. The orange juice used in this study was Tropicana 100% pure orange juice, not from concentrate, and pulp free. The 1% milk was chosen rather than the

skim milk because Kemps 1% milk had the same energy content as the Tropicana orange juice. Both products, according to manufacturer's labels, contained 110 kilocalories per 8 ounce serving. Once all beverages were poured, they were covered with plastic wrap to ensure that no foreign objects entered the glass and placed in the refrigerator until needed.

Initially, Pomona's Universal Pectin, was tested in orange juice for palatability and dissolving capabilities. It was determined that even 2.5 grams in 8 ounces of orange juice was unpalatable. The pectin did not fully dissolve, the juice became viscous, and the mixture created a thick, pasty mouth-feel. Because Pomona's Universal Pectin was not deemed palatable other soluble fiber options were investigated. After searching for different fibers, it was concluded that Benefiber was the best choice. Benefiber is wheat dextrin and it does not cause gelling or alter taste. Benefiber did fully dissolve in the orange juice with minimal stirring. Each 8 ounce glass of orange juice had 4 teaspoons of Benefiber added, which contributed 6 grams of soluble fiber. This amount was determined on the basis that Tiwary et al. (1997) found 5 grams of pectin to significantly increase satiety, and the subsequent meal of oatmeal was taken into consideration. Oatmeal is high in fiber, so the potential gastrointestinal side effects of large amounts of fiber within one hour might cause discomfort to the subjects later. Since the amount of oatmeal consumed was not regulated, the subjects had the potential to consume up to 30 grams of fiber if they ate the whole bowl of oatmeal and drank the supplemented orange juice. For this reason, the added amount was limited to 6 grams.

The subjects were instructed to drink the beverage at a leisurely pace to prevent feeling bloated. Once the beverage was completely consumed, the subject turned on the red light. The researcher or assistant then recorded the present time and wrote it on a piece of paper. The paper also had an end time, indicating when the oatmeal should be served, which was 30 minutes from

the time the subject finished the beverage. The paper was stuck to the wall above each booth window, so the researchers knew when the VAS needed to be given and when the 30 minutes preload time was completed. The first VAS was given at 28 minutes, so the subject could rate their hunger, satiety, and fullness and be given the subsequent meal at the 30 minute mark. When the subject was completing the scale, the researchers began getting a bowl of oatmeal ready for the subject. A bowl would be placed on a digital scale that was set in ounces. The scale measured the weight to the nearest one-thousandth of an ounce. The scale was then zeroed and approximately three cups of oatmeal was added to the bowl. The weight was recorded. Once the subject completed the VAS, they turned on the green light. The oatmeal was then served on a tray that included the bowl of food, a spoon, a napkin, and a five ounce glass of water. The subject was not required to drink the water, but could if he/she chose. When the subject reached their initial feelings of fullness and satisfaction they turned on the red light. The tray was collected and the second VAS, which measured the palatability of the oatmeal (Appendix B), was given to the subject. Once the second VAS was completed, the subject turned on the red light. The subjects were free to leave at that point. The bowl of oatmeal was once again weighed and the post-weight was recorded. The difference in pre-weight and post-weight was calculated to determine the intake in ounces. The intake in ounces was converted to kilocalories (kcals). The kcals per ounces was determined by the Food Processor SQL software program. During the sessions that the subjects were not given a beverage, they started on step 4 of the instruction sheet (Appendix G), which is when the subjects were given the first VAS and turned on the green light once the VAS was completed. Since the participants were in a fasted state, it was not necessary to have them sit in the booth for 30 minutes prior to receiving the oatmeal.

The researcher pre-labeled each VAS with the subject's identification numbers. This eliminated the possibility that a subject would forget to write down their number or would record an incorrect number. The subjects were assigned to specific booths, so the researchers knew who was sitting where and were able to match the subjects with the correct ID numbers. During the introductory meetings, each subject was given an ID card to carry with them. Each card had the individuals subject ID, the day and time for data collection, the principle investigator's contact information, and the location on it, so the participants could carry the card with them in the event that they would forget any of the listed details.

The oatmeal was prepared in a bulk quantity for each individual session. Once the subjects had completed their beverages, 17 cups of water were measured out and put in a large pot. The burner was turned on high to allow the water to begin heating. For the sessions that were not receiving a beverage the process of making the oatmeal began prior to their arrival. It took approximately 12 minutes to 15 minutes for the water to reach near boiling. At this point, 10 cups of Quaker instant oatmeal was added to the pot and stirred in. Then 1 and 2/3 cup of Sugar Cane light brown sugar and 2 teaspoons of pure maple syrup was added and mixed in. The heat was reduced to low and the oatmeal continued to cook for an additional 2-5 minutes. At this point the subjects were ready to be served.

Data Analysis

The data was analyzed using SPSS Statistic 17.0, Release 17.0.0 (August 23, 2008). ANOVA was the primary statistical test used to determine the significance for the subjective feelings of hunger, satiety, and fullness. The subsequent energy intake was analyzed using an ANOVA and an ANCOVA test. To determine the statistical differences in energy intake only, the ANOVA test was used. The ANCOVA test was run to analyze the energy intake while

considering the ratings for hunger, satiety, and fullness. Because these ratings varied between test meals, an average score was calculated for each feeling and was held as a constant for the covariate used in the ANCOVA test.

Limitations

The study had some methodological limitations. One limitation was that the subjects were not trained to use the visual analog scales. Prior to the study the subjects were unfamiliar with the scales and did not have experience using them. This could have skewed the data if a person marked either end of the line because they may not fully understand the concept of the scale or they are not efficient at interpreting their feelings.

During the first test meal for the group that attended on Mondays at 7:45 a.m. the oatmeal was served 40 minutes after the completion of the beverages due to an unexpected delay in cooking time. This could have caused the subjects to possibly consume more or less oatmeal than they would have at 30 minutes.

Chapter IV: Results

The purpose of this study was to determine if a statistically significant difference existed in subsequent energy intake of oatmeal, satiety, hunger, and fullness after a 30 minute preload of orange juice, 1% milk, or orange juice with added Benefiber in comparison to a control of no beverage preload. There were 25 subjects and 24 completed the study. One subject was removed from the data analysis due to missed attendance of a test meal. The study had a repeated measures design. All subjects attended four test meals and received each beverage variable once. When the subjects arrived they were given an 8 ounce glass of the assigned beverage or they were not given a beverage (control). Once the subject consumed the beverage, a 30 minute timer was set. At 28 minutes the subjects were asked to rate their satiety, hunger, and fullness on a visual analog scale (see below). Then the subject was served a large bowl of pre-weighed oatmeal. The subject was free to eat *ad libitum*. The bowl was then re-weighed to calculate ounces consumed and energy intake.

Subject Descriptions

Five males and 20 females participated in the study (see Table 3). The mean weight of the males was 84.6 kg with a range of 76.5-92.7 kg. The average body mass index (BMI) of the males was 25.8 kg/m^2 with a range of 22.0-29.6 kg/m^2. The females had an average weight of 66.3 kg with a range of 51.2-81.4 kg. The average BMI was 23.8 kg/m^2 with a range of 19.6-28.0 kg/m^2. Eight of the 20 females had BMIs that placed them in the overweight category (25.0-29.9 kg/m^2). Three of the five males had BMIs that placed them in the overweight category. The BMI values of the five males were 22.0, 24.9, 27.4, 29.1, and 29.6. The body fat percentage of the males with the higher BMI values of 29.1 and 29.6 were 20.9 and 18.4 respectively. The body fat percentage was provided by the Tanita TBF-215GS Body

Composition Analyzer, which placed both of them in a desirable range for body fat percentage. The third male that was classified as overweight according to the BMI of 27.4, had a body fat percentage of 24.4. This percentage is above the desirable range. However, if classified solely on BMI, 40% of the females and 60% of the males were overweight based on a BMI of 25.0 or above. No subjects were classified as obese. Overall, 11 of the 25 participants were classified as overweight, which accounted for 44%. The remaining 14 subjects were normal weight according to their BMI status.

Table 3

Subject Demographics: Height, Weight, and BMI

Characteristic	Mean ± SEM	Range
Males (n=5)		
Height (cm)	179.1 ± 7.6	171.5 – 186.7
Weight (kg)	84.6 ± 8.1	76.5 – 92.7
BMI (kg/m^2)	25.8 ± 3.8	22.0 – 29.6
Females (n=20)		
Height (cm)	166.4 ± 15.2	151.2 – 181.6
Weight (kg)	66.3 ± 15.1	51.2 – 81.4
BMI (kg/m^2)	23.8 ± 4.2	19.6 – 28.0

The age of the participants ranged from 19 years to 28 years (see Table 4). Sixty-four percent of the subjects were between the ages of 19-22. The mode age was 22. The average age was 22.4 years old.

Table 4

Age of College Students That Participated in the Investigation of the Effects of Pre-Meal Beverage Consumption

Age	Number	Percentage
19	3	12.0
20	4	16.0
22	9	36.0
23	3	12.0
24	1	4.0
26	4	16.0
28	1	4.0
	Total 25	100.0

Subsequent Energy Intake

The first analysis of subsequent energy intake was done using an ANOVA test to determine if there was statistically significant difference between the three different beverages and the control. Table 5 shows the amount of oatmeal, in ounces, consumed following a preload beverage of orange juice, orange juice with added Benefiber, 1% milk, or no beverage. The subjects consumed an average of 10.58 ounces, which was the greatest amount, when no beverage preload was given. They consumed an average of 9.66 ounces when the orange juice with Benefiber was given as a preload. The subsequent intake was the least following the orange juice with Benefiber preload. The intake range for the control was 3.95 to 19.07 ounces and for the orange juice with fiber the intake ranged from 5.72 to 17.99 ounces. The intake in ounces

was converted to kilocalories (kcals) by using the Food Processor SQL software program to determine the kcals per ounce. Each ounce of oatmeal provides 45 kcals of energy (see Table 6). The mean calorie consumption from oatmeal after no preload was 476.01 kcals versus 434.52 kcals after the orange juice with fiber preload. Kcal intake following the 1% milk was 443.93 and 463.28 following the orange juice.

Table 5

The Mean Intake (in Ounces) of Oatmeal Following a Preload Beverage of Orange Juice, Orange Juice with Benefiber, 1% Milk, or No Beverage

Beverage	Mean ± SD (Ounces)	Range (Ounces)
Control	10.58 ± 3.78	3.95 - 19.07
Orange Juice	10.30 ± 3.85	4.55 – 21.46
Orange Juice w/ Fiber	9.66 ± 3.31	5.72 – 17.99
1% Milk	9.87 ± 2.94	4.89 – 16.21

Table 6

The Mean Intake (in Kilocalories) of Oatmeal Following a Preload Beverage of Orange Juice, Orange Juice with Benefiber, 1% Milk, or No Beverage

Beverage	Mean (kcals)	Range (kcals)
Control	476.01	177.75 – 857.93
Orange Juice	463.28	204.75 – 965.93
Orange Juice w/ Fiber	434.52	257.18 – 809.55
1% Milk	443.93	220.05 – 729.23

An ANOVA test was done using the intake of oatmeal only, which is represented by the darker bars in Figure 1. The second method of analysis was an ANCOVA test. This test took an average score for hunger, satiety, and fullness and held the three averages constant to use as the covariance. This covariance was used in conjunction with the analysis of intake of the oatmeal (see Figure 1). Neither the ANOVA nor ANCOVA test showed a significant difference in intake among any of the beverages or in comparison to the control of no beverage.

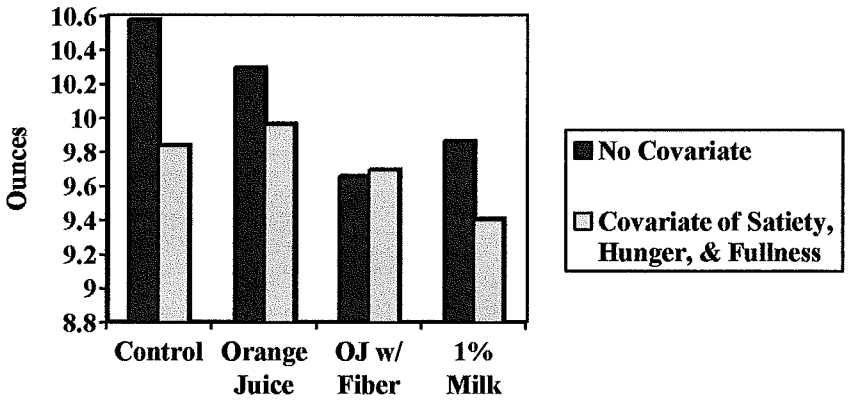


Figure 1. Mean intake of oatmeal using an ANOVA (dark bars) compared to mean intake of oatmeal using an ANCOVA (light bars) holding an average score for satiety, hunger, and fullness constant, as the covariate.

Subjective Feelings of Hunger, Satiety, and Fullness

Approximately 30 minutes after the completion of the beverage, the subjects were given a visual analog scale (VAS) to rate their feelings of hunger, satiety, and fullness. A VAS is a 100-mm line with opposing phrases anchored at each end. For example, to measure hunger, the right end would state "I have never been more hunger" and the left end would state "I am not hungry at all." The VAS used can be found in Appendix A. The subject made a vertical mark on the line and the researcher used a ruler was used to measure the millimeters from the left end of the

100-mm line. Thus for hunger, the more to the right the subject marked, the hungrier the subject was. The average rating of hunger for the control group was 63.00 mm compared to 47.48 mm when the subjects were given orange juice with Benefiber as the preload. Similarly, for satiety and fullness, the further to the right the subject marked the line, the more satiety and fullness were felt (see Table 7). The orange juice with fiber was significantly lower than the control when using an ANOVA to test for significance for the subjective feeling of hunger ($p \leq 0.05$). The orange juice with fiber was significantly higher than the control for the subjective feeling of satiety ($p \leq 0.01$) and also higher than the control for the subjective feeling of fullness ($p \leq 0.05$). The differences measured in millimeters on the VAS can be found in Table 7. The second VAS (Appendix B), which rated the palatability of the oatmeal, was not statistically analyzed due to the consistency of ratings on the VAS, by the subjects, observed by the principle investigator and the research assistants.

Table 7

Means in Millimeters of Hunger, Satiety, and Fullness, after the Consumption of Test Beverage on the Visual Analog Scale

Subjective Feeling	Control	Orange Juice	OJ with Fiber	1% Milk
Hunger	63.00	54.94	47.48*	55.31
Satiety	25.19	32.98	41.83**	33.58
Fullness	22.25	29.08	37.58*	34.04

Note. The Sphericity Assumed test was used to measure the significance. *$p \leq 0.05$ and ** $p \leq 0.01$ compared to the control.

The analysis using an ANOVA test for the subjective feelings of hunger, satiety, and fullness were graphed. Figure 2 displays the differences in the ratings of hunger, satiety, and

fullness amongst the beverages. The bar graph visually shows that the control was rated significantly higher than the orange juice with fiber in hunger perception and the control was rated lower in satiety and fullness perception than orange juice with fiber.

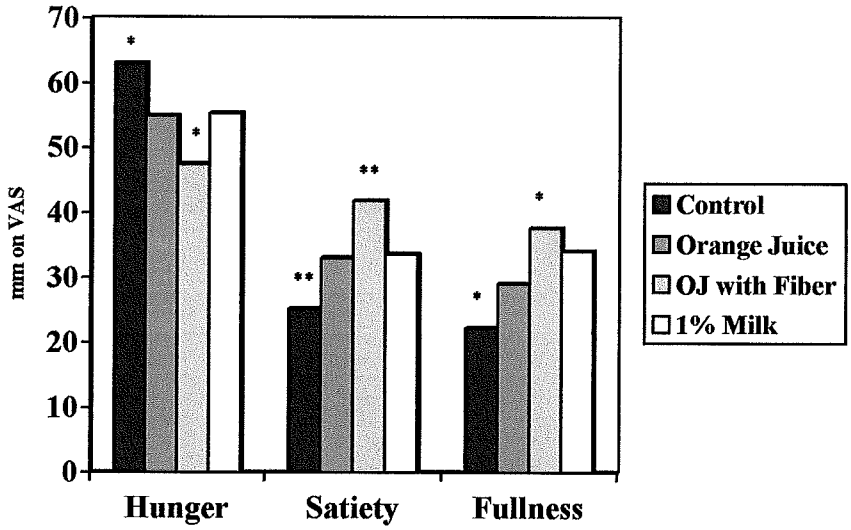


Figure 2. Means in millimeters of hunger, satiety, and fullness on a VAS. The Sphericity Assumed test was used to measure the significance. $*p \leq 0.05$ and $** p \leq 0.01$

In summary, orange juice, 1% milk, and orange juice with fiber did not significantly affect subsequent food intake following a 30 minute preload. However, with a preload of orange juice with 6 grams of fiber, hunger perceptions decreased and perceptions of satiety and fullness increased compared to the control. The significance of these findings will be discussed in Chapter 5.

Chapter V: Discussion

Obesity has become an epidemic and can be partially attributed to the increase in caloric beverage consumption. Several studies have been conducted to analyze the effects of beverages such as colas, water, juice, and milk and/or fiber on energy intake, satiety, hunger, and fullness. To the author's knowledge, no study has investigated the effects of juice, milk, and fiber on satiety and subsequent energy intake, in young adults within the same study. The current study was designed to analyze the above variables and their effects on subsequent energy intake, satiety, hunger, and fullness in college-aged students. Orange juice, orange juice with fiber, 1% milk, or a control of no beverage was given 30 minutes prior to a meal of oatmeal. Before the oatmeal was served the subjects rated their satiety, hunger, and fullness on a visual analog scale. The oatmeal was weighed before and after consumption and the intake was recorded. The results showed that the subjects consumed the least amount of oatmeal after the consumption of the juice with fiber; however, it was not significantly different from the other beverages or the control of no beverage. The orange juice with added fiber statistically increased perceptions of satiety and fullness and decreased the perceptions of hunger.

Limitations

The study had some methodological limitations. One limitation was that the subjects were not trained to use the visual analog scales. Prior to the study the subjects were unfamiliar with the scales and did not have experience using them. This could have skewed the data if a person marked either end of the line because they may not have fully understood the concept of the scale or they were not efficient at interpreting their feelings.

At different points during the study, two subjects admitted to feeling ill, which was not related to consuming the beverage preload or oatmeal. This may have affected their feelings of

hunger or taste perception. Thus, this could have altered their intake and ratings on the visual analog scales. The sense of smell is connected to the cephalic phase of digestion, and if that is impaired due to the flu virus or common cold, then perhaps the secretion of CCK may have been inhibited (Zafra, Molina, & Puerto, 2006).

During the first test meal for the group that attended on Mondays at 7:45 a.m. the oatmeal was served 40 minutes after the completion of the beverages due to an unexpected delay in cooking time. This could have caused the subjects to possibly consume more or less oatmeal that they would have at 30 minutes.

Another limitation is that the subjects were not asked to rate their feelings of hunger, satiety, and fullness prior to receiving the beverage. If this data had been collected, the differences in ratings could have been analyzed. This information could have increased the validity of the results regarding the perceptions of hunger, satiety, and fullness.

Conclusions

Based on the results of the study, it can be concluded that adding a fiber supplement to a beverage will increase feelings of satiety and fullness and decrease hunger. Previous research conducted by Sandhu, El Samahi, Mena, Dooley, and Valenzuela (1987) determined that a dose of 15 grams of pectin fiber can decrease subsequent energy. The 6 gram dose used in the current study decreased energy intake, but it was not a significant amount in comparison to the control of no beverage. It is possible that with a larger dose of fiber, the intake may have been statistically lower. If the dose would have been 15 grams and the intake was not statistically different, it could be concluded that wheat dextrin does not cause a delay in gastric emptying because it does not form a gel or become viscous as pectin does. However, satiety, fullness, and hunger may have still remained similar to the 6 gram dose used in this study.

The significant differences in the perceptions of hunger and satiety support the findings by Tiwary, Ward, and Jackson (1997). Tiwary et al. (1997) and the current study showed that at least 5 grams of fiber added to orange juice significantly decreased hunger and increased satiety. The difference between the two studies is that Tirwary et al. used pectin and the present study used wheat dextrin. The comparable perceptions of hunger, satiety, and fullness between the orange juice and the 1% milk found in the current study are similar to a study done by Almiron-Roig and Drewnowski (2003). Almiron-Roig and Drewnowski found no significant difference in perceptions of hunger, satiety, and fullness between orange juice, 1% milk, and cola. Harper, James, Flint, and Astrup (2007) found milk to be significantly different than cola in regards to enhancing the feeling of fullness and decreasing the feeling of hunger. Harper et al. (2007) also used a 30 minute preload, but used 500 mL of liquid versus the 240 mL that the current study served. Another difference is that Harper et al. used chocolate milk and cola, which have different amounts and types of sugars than that of orange juice and white milk. When Tiwary et al. (1997) found significant results between the orange juice and the orange juice with pectin, a 448 mL preload of beverage was consumed. This is almost twice the amount of liquid than the current study, which also found significant results. The larger serving of a caloric beverage could explain why Tiwary et al. chose not to measure energy intake. The calories from the beverage alone were over 200 kcals.

When attempting to determine a macronutrient hierarchy for liquids, data from the current study suggests that a complex carbohydrate (fiber) has greater effects of satiety than protein (milk); however, protein had a greater effect than the simple carbohydrate (orange juice). This could be attributed to the peptide secretion of CCK or the delay in gastric emptying caused by the ingestion of fiber; however, the current study did not measure satiety hormones. It is

important to note that the fiber used in this study, wheat dextrin, has not been extensively studied; therefore, the conclusion that the fiber causes CCK secretion or a delay in gastric emptying cannot be made with confidence. However, it can be said with confidence that 6 grams of wheat dextrin fiber increased satiety and fullness and decreased ratings of hunger. This fiber may have value as an additive to foods intended to assist college-aged students with weight loss if further tests show that the addition of fiber can decrease subsequent energy intake.

Recommendations

It is recommended that the study be replicated using 15 grams of Benefiber versus 6 grams. Another variation that could be done is to compare orange juice with added fiber to a fiber supplemented non-caloric beverage. This would allow researchers to determine if the fiber alone is causing the changes in perception of satiety, hunger, and fullness, or if it is a combination of the calories and fiber. A VAS should be provided prior to the beverage pre-load as well as after to determine baseline satiety, hunger, and fullness. Some studies did use larger amounts of the preload. It is not recommended to increase the beverage preload, especially if a caloric beverage is being investigated. Several subjects in the current study made casual comments about consuming the beverages. The general consensus was that the subjects did not typically drink a glass of milk or orange juice apart from a meal. It is suspected that asking the subjects to consume twice as much would have made them feel unpleasant and possibly turned off by food. Another reason not to increase the preload volume is because if the beverage does not significantly decrease the subsequent energy intake, it may actually increase the total energy intake.

It is also recommended to have the test meal be at lunch time. The subjects would receive a standardized breakfast and fast for a set number of hours before receiving the beverage

pre-load. The reasoning is that the fasting time would be consistent for all subjects versus the fluctuation in the overnight fasting periods among the subjects in the current study.

Another recommendation is to train participants to recognize the point at which the participant begins to feel full. It is observed that some of these participants were unable to recognize internal clues to stop eating. An underlying cause of the obesity problem may lie in the inability of general population to recognize fullness. This training would be essential in undertaking a similar study. However, little clues as to how to train individuals to recognize fullness exist in the literature. This topic would be a research study of its own. It is recommended to train the subjects on how to properly use a visual analog scale. It would be important to stress that the end points of the line are the extremes of the perception. Also, if the test meal provided is prepared using a standard recipe, the use of a second VAS could be omitted from the study design. Very little fluctuation in the ratings of oatmeal palatability was observed in the current study.

References

Almiron-Roig, E., & Drewnowski, A. (2003). Hunger, thirst, and energy intakes following consumption of caloric beverages. *Physiology & Behavior, 79*, 767-773.

Almiron-Roig, E., Flores, S. Y., & Drewnowski, A. (2004). No difference in satiety or in subsequent energy intakes between a beverage and a solid food. *Physiology & Behavior, 82*, 671-677.

Beglinger, C. (1994). Effect of cholecystokinin on gastric motility in humans. *Annals of the New York Academy of Sciences, 713,* 219-225.

Benefiber. (n.d.). *Benefiber powder*. Retrieved January 5, 2009, from http://www.benefiber.com/products/index.shtml?benefiberPowders

Bolton, R. P., Heaton, K. W., & Burroughs, L. F. (1981). The role of dietary fiber in satiety, glucose, and insulin: Studies with fruit and fruit juice. *The American Journal of Clinical Nutrition, 34*, 211-217.

Centers for Disease Control and Prevention. (2008, December 10). *Obesity: Halting the epidemic by making health easier*. Retrieved January 26, 2009, from http://www.cdc.gov/NCCDPHP/publications/AAG/obesity.htm

Davy, B. M., Dennis, E. A., Dengo, A. L., Wilson, K. L., & Davy, K. P. (2008). Water consumption reduces energy intake at a breakfast meal in obese older adults. *Journal of the American Dietetic Association, 108*, 1236-1239.

de Graaf, C., Hulshof, T., Weststrate, J. A., & Jas, P. (1992). Short-term effects on different amounts of protein, fats, and carbohydrates on satiety. *The American Journal of Clinical Nutrition, 55,* 33-38.

DellaValle, D. M., Roe, L. S., & Rolls, B. J. (2005). Does the consumption of caloric and non-caloric beverages with a meal affect energy intake? *Appetite, 44*, 187-193.

Di Lorenzo, C., Williams, C. M., Hajnal, & Valenzuela, J. E. (1988). Pectin delays gastric emptying and increases satiety in obese subjects. *Gastroenterology, 95*, 1211-1215.

Donahoo, W., Wyatt, H. R., Kriehn, J., Stuht, J., Dong, F., Hosokawa, P., et al. (2008). Dietary fat increases energy intake across the range of typical consumption in the United States. *Obesity, 16,* 64-69.

Dubois, L., Farmer, A., Girard, M., & Peterson, K. (2007). Regular sugar-sweetened beverage consumption between meals increases risk of overweight among preschool-aged children. *Journal of the American Dietetic Association, 107,* 924-934.

Flint, A., Raben, A., Blundell, J. E., & Astrup, A. (2000). Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. *International Journal of Obesity, 24,* 38-48.

Flood, J. E., Roe, L. S., & Rolls, B. J. (2006). The effect of increased beverage portion size on energy intake at a meal. *Journal of the American Dietetic Association, 106,* 1984-1990.

Freeland, K. R., Anderson, G. H., & Wolever, T. M. S. (2009). Acute effects of dietary fibre and glycaemic carbohydrate on appetite and food intake in healthy males. *Appetite, 52,* 58-64.

Harper, A., James, A., Flint, A., & Astrup, A. (2007). Increased satiety after intake of a chocolate milk drink compared with a carbonated beverage, but no difference in subsequent ad libitum lunch intake. *British Journal of Nutrition, 97*, 579-583.

Hill, A. J., & Blundell, J. E. (1990). Comparison of the action of macronutrients on the expression of appetite in lean and obese human subjects. *Annals of the New York Academy of Sciences, 580,* 529-531.

Jequier, E. (2002). Leptin signaling, adiposity, and energy balance. *Annals of the New York Academy of Sciences, 967,* 379-388.

Karhunen, L. J., Juvonen, K. R., Huotari, A., Purhonen, A. K., & Herzig, K. H. (2008). Effect of protein, fat, carbohydrate and fibre on gastrointestinal peptide release in humans. *Regulatory Peptides, 149,* 70-78.

Kissileff, H. R., Pi-Sunyer, F. X., Thorton, J., & Smith, G. P. (1981). C-terminal octapeptide of cholecystokinin decreases food intake in man. *The American Journal of Clinical Nutrition, 34,* 154-160.

Mattes, R. D., & Campbell, W. W. (2009). Effects of food form and timing of ingestion on appetite and energy intake in lean young adults and in young adults with obesity. *Journal of the American Dietetic Association, 109,* 430-437.

Mayo Clinic Staff. (2008, July 1). *Dietary fiber: An essential part of a healthy diet.* Retrieved March 16, 2009, from http://www.mayoclinic.com/health/fiber/NU00033

Monsivais, P., Perrigue, M. M., & Drewnowski, A. (2007). Sugars and satiety: Does the type of sweetener make a difference? *The American Journal of Clinical Nutrition, 86,* 116-123.

Porrini, M., Crovetti, R., Distam, G. T., & Silva, S. (1995). Evaluation of satiety sensations and food intake after different preloads. *Appetite, 25,* 17-30.

Raben, A., Vasilaras, T.H., Moller, A. C., & Astrup A. (2002). Sucrose compared with artificial sweeteners: Different effects on *ad libitum* food intake and body weight after 10 wk of supplementation in overweight subjects. *The American Journal of Clinical Nutrition, 76,* 721-729.

Rolls, B. J., Castellanos, V. H., Halford, J. C., Kilara, A., Panyam, D., Pelkman, C. L. (1998). Volume of food consumed affects satiety in men. *The American Journal of Clinical Nutrition, 67,* 1170-1177.

Rolls, B. J., Hetherington, M., & Burley, V. J. (1988). The specificity of satiety: The influence of foods of different macronutrient content on the development of satiety. *Physiology & Behavior, 43,* 145-153.

Sandhu, K. S., El Samahi, M. M., Mena, I., Dooley, C. P., & Valenzuela, J. E. (1987). Effect of pectin on gastric emptying and gastroduodenal motility in normal subjects. *Gastroenterology, 92,* 486-492.

Slavin, J. L., Savarino, V., Paredes-Diaz, A., & Fotopolous, G. (2009). A review of the role of soluble fiber in health with specific reference to wheat dextrin. *The Journal of International Medical Research, 37,* 1-17.

Stubbs, J., & Whybrow, S. (2003). Beverages, appetite, and energy balance. In T. Wilson & N. J. Temple (Eds.), *Beverages in nutrition and health* (pp. 261-278). Totowa, NJ: Humana Press.

Stull, A. J., Apolzan, J.W., Thalacker-Mercer, A. E., Iglay, H. B., & Campbell, W. W. (2008). Liquid and solid meal replacement products differentially affect postprandial appetite and food intake in older adults. *Journal of the American Dietetic Association, 108(*7), 1226-1230.

Thomas, C. L. (Ed.). (1993). *Taber's cyclopedic medical dictionary* (17th ed.). Philadelphia: F.A. Davis

Tiwary, C. M., Ward, J. A., & Jackson, B. A. (1997). Effect of pectin on satiety in healthy US army adults. *Journal of the American College of Nutrition, 16*(5), 423-428.

Tordoff, M. G., & Alleva, A. M. (1990). Effect of drinking soda sweetened with aspartame or high-fructose corn syrup on food intake and body weight. *The American Journal of Clinical Nutrition, 51*, 963-969.

Trowell, H., Southgate, D. A., Wolever, T. M., Leeds, A. R., Gassull, M. A., & Jenkins, D. J. (1976). Letter: Dietary fibre redefined. *Lancet, 1*(7966), 967.

U.S. Department of Health and Human Services. (n.d.). *Healthy People 2010*. Retrieved January 27, 2009, from http://www.healthypeople.gov/Search/objectives.htm

Van Walleghen, E. L., Orr, J.S., Gentile, C. L., & Davy, B. M. (2007). Pre-meal water consumption reduces meal energy intake in older but not younger subjects. *Obesity, 15*(1), 93-99.

Weight-control Information Network. (2006, March). *Understanding adult obesity*. Retrieved January 30, 2009, from http://win.niddk.nih.gov/publications/understanding.htm#environmental

Zafra, M. A., Molina, F., & Puerto, A. (2006). The neural/cephalic phase reflexes in the physiology of nutrition. *Neuroscience and Biobehavioral Reviews, 30*(7), 1032-1044.

Appendix A: Pre-Meal VAS

Subject ID:_____

Please mark the line according to how you feel at this point in time. Example: 

How hungry do you feel?

I am not hungry at all _____ I have never been more hungry

How satisfied do you feel?

I am completely empty _____ I cannot eat another bite

How full do you feel?

Not at all full _____ Totally full

How much do you think you can eat?

Nothing at all _____ A lot

Would you like to eat something sweet?

Yes, very much _____ No, not at all

Would you like to eat something salty?

Yes, very much _____ No, not at all

Would you like to eat something savory?

Yes, very much _____ No, not at all

Would you like to eat something fatty?

Yes, very much _____ No, not at all

Flint, A., Raben, A., Blundell, J. E., & Astrup, A. (2000).

Appendix B: Post-Meal VAS

Subject ID:_____

Please mark the line according to how you feel at this point in time.

Oatmeal

Smell

Good _____ Bad

Taste

Good _____ Bad

Aftertaste

Much _____ None

Palatability

Good _____ Bad

Flint, A., Raben, A., Blundell, J. E., & Astrup, A. (2000).

Appendix C: Business Card with Researcher's Contact Information

OATMEAL STUDY

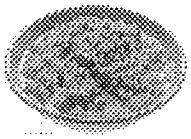
VOLUNTEERS NEEDED:
- 1 hour per week for 4 weeks
- Will be given a beverage and oatmeal

Requesting:
Non-smokers and non-competitive athletes

To volunteer or if you have further questions, please contact Robin by Saturday, January 31, 2009.

Principle Investigator

Robin Welcher
welcherr@uwstout.edu



Appendix D: Consent to Participate

Consent to Participate in UW-Stout Approved Research

Title: Pre-Meal Beverage Consumption Affects Hunger, Satiety, and Energy Intake

Description:
This study will involve four different days of data collection. On each day you will be asked to report to the Home Economics Building, room 252 at 7:45 am. Then you will be given one of three beverages or no beverage. After 30 minutes you will be asked to rate your appetite and desire for specific foods on visual analogue scales. Then you will be given a weighed amount of flavored oatmeal and asked to consume it until you are full. Then you will be asked to rate the palatability of the oatmeal.

Risks and Benefits:
The benefit of this study will be to determine if consuming specific beverages 30 minutes before a meal will decrease energy intake and promote weight loss. There is no direct benefit for participating in this study other than receiving four meals. The possible risks associated with this study could include an upset stomach from consuming orange juice before breakfast. Also, you will be asked not to brush your teeth prior to data collection. This may cause personal discomfort.

Time Commitment and Payment:
You will be asked to attend an informative meeting with other subjects that will last approximately one hour. The data collection will take place one time per week for four weeks. Each data collection will take approximately 75 minutes. The participation in this study is voluntary, and you will not receive monetary compensation.

Confidentiality:
To maintain confidentiality you will be assigned an identification number, and data will be entered using these numbers. All final reports and conclusions will not contain any identifying information. The research records will be kept in a secure location and the principle investigator will be the only one that has access to these records.

Right to Withdraw:
Since your participation in this study is entirely voluntary, you have the right to withdraw at any point. You may choose not to participate at any point without any adverse consequences to you.

IRB Approval:
This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

Investigator:
Robin Welcher
welcherr@uwstout.edu
715-864-1791

Advisor:
Carol Seaborn, PhD, RD, CD
seabornc@uwstout.edu
715-232-2216

IRB Administrator:
Sue Foxwell, Director, Research Services
152 Vocational Rehabilitation Bldg.
UW-Stout
Menomonie, WI 54751
715-232-2477
foxwells@uwstout.edu

Statement of Consent:
By signing this consent form you agree to participate in the study entitled Pre-Meal Beverage Consumption Affects Hunger, Satiety, and Energy Intake.

_____

Signature Date

Appendix E: Screening Questionnaire

ID _____

Screening Questionnaire to Participate in:

Pre-Meal Beverage Consumption Affects Hunger, Satiety, and Energy Intake

Do you smoke? ___Yes ___No

Do you have any food allergies? ___Yes ___No
If yes, please list.

Are you currently taking any medications or supplements? ___Yes ___No
If yes, please list.

Are you currently a member of an athletic team or club? ___Yes ___No

Are you currently trying to gain or lose weight? ___Yes ___No

Do you consume milk? ___Yes ___No
If so, do you like 1%?

Do you like to eat oatmeal? ___Yes ___No
If yes, how often do you consume oatmeal?
____Once a month ____Once a week ____ Multiple times per week

Appendix F: Guidelines to Follow 24-Hours Prior to Data Collection

Guidelines for 24-Hours Prior to Data Collection

1. Do not consume any alcohol 24-hours prior to data collection.

2. Do not use any toothpaste, mouthwash, or similar products on the mornings of data collection.

3. Do not consume any food or beverage prior to participation on the assigned mornings.

4. Keep exercise on the days that precede each data collection consistent.

5. Do not engage in any physical activity before data collection on the morning of. Walking to and from campus is acceptable.

6. On the days prior to data collection, please try to keep the types and amounts of food consistent.

Appendix G: Booth Instructions for Subjects During Test Meals

INSTRUCTIONS

1. When you first sit down, turn on the **green** light.

2. You will be given a beverage. Please consume all of it at a leisurely pace.

3. When you are finished, please turn on the **red** light.

4. In approximately 27 minutes, a visual analog scale will be given to you. Please complete the scales and turn on the **green** light.

5. The scales will be collected and you will be given a large bowl of oatmeal. Please eat until you have initial feelings of fullness and satisfaction. Turn on the **red** light.

6. The oatmeal will be removed and you will be given another set of visual analogs scales. Please complete the scales and turn on the **red** light.

7. You are now finished. Thank you!