

The effect of buckwheat and couscous on food intake and satiety in male adults

By

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Overweight and obesity are associated with a plethora of negative health consequences and rates continue to remain high in adults throughout Canada. The bulk of the Canadian diet is comprised of carbohydrate rich grains, however the majority of grains consumed by Canadians are not considered whole grain and increased consumption of refined grains has been associated with increased risk of developing obesity. Buckwheat is a novel, whole grain food in Canada and its consumption has been hypothesized to help decrease the rising rates of overweight and obesity due to its low glycaemic properties. The objective of this study was twofold; to determine the satiating effect of buckwheat and to determine the palatability and physical comfort following buckwheat consumption. Methods: In a within subject, randomized repeated measures design, 21 healthy, male participants were randomly assigned to consume three different treatments on three separate occasions one week apart: A water control, buckwheat (84 g, 300 kcal, 2 g fat, 10 g protein, 60 g total carbohydrate, 4 g dietary fibre) and couscous (84 g, 300 kcal, 1 g fat, 10 g protein, 62 g total carbohydrate, 2 g dietary fibre). After an overnight fast, participants arrived at the lab in the morning and consumed one of the treatments. Two hours following preload consumption, participants consumed an ad libitum pizza meal. 100 mm Visual Analogue Scales assessing appetite and physical comfort were completed immediately before preload consumption and throughout the two hours leading up to the pizza meal. Results: There was no effect of treatment on subsequent food intake ($p=0.06$). Average appetite ratings were significantly higher in the water control ($p<0.0001$), however there were no differences in appetite scores between the buckwheat and couscous preloads ($p=0.96$). There were no significant differences in palatability between treatments, however buckwheat was rated lower in pleasantness compared to the water control ($p=0.009$). There was no effect of treatment on physical comfort ($p=0.71$). Conclusion: In healthy male adults, buckwheat was not shown to offer enhanced subjective satiety over 120 minutes or to decrease subsequent food intake.

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List of Abbreviations

A

ANOVA = Analysis of Variance

B

BMI = Body Mass Index

C

CCK = Cholecystokinin

CVD = Cardiovascular Disease

F

FI = Food Intake

G

GI = Glycemic Index

GLP-1 = Glucagon-like Peptide 1

N

n = number of participants

P

PFC = Prospective Food Consumption

PYY = Peptide YY

S

SAS = Statistical Analysis Systems

SEM = Standard Error of the Mean

T

T2DM = Type 2 Diabetes Mellitus

V

VAS = Visual Analogue Scales

W

WHO = World Health Organization

Chapter 1: Introduction

Despite prevention and treatment efforts, the prevalence of obesity within Canada has continued to rise. Statistics Canada reported that in 2014, 61.8% and 46.2% of Canadian men and women, respectively, were categorized as being overweight or obese (Statistics Canada, 2015). Excess body fat has been associated with a plethora of negative health effects, and has led to the occurrence of one in ten premature deaths throughout Canada (Lau et al., 2007). It is important to note that these overweight and obesity statistics were based on self-reported weight and heights of Canadians. BMI is an anthropometric measure commonly used to classify individuals as being overweight or obese, however it does have limiting factors, such as the inability to directly measure body fat and to differentiate between muscle mass and body fat (Centres for Disease Control and Prevention, 2009). Additionally, individuals tend to underestimate their weight and overestimate their height in health surveys, which has resulted in an underestimation in rates of overweight and obesity reported in the literature (Statistics Canada, 2015).

Research has demonstrated that chronic diseases including type 2 diabetes, hypertension, dyslipidemia, asthma, gallbladder disease, coronary artery disease, osteoarthritis, stroke and certain types of cancers, are all closely linked with overweight and obesity (Public Health Agency of Canada, 2011; (Lau et al., 2007). Obesity is not only a risk factor for chronic diseases, but it is also associated with an increased risk of depression and a decline in psychological wellbeing (Public Health Agency of Canada, 2011). As obesity rates continue to increase, rates of diabetes follow suit. The Canadian Diabetes Association reported that in 2010, 7.6 % of Canadians were diagnosed with diabetes and rates within the past decade have doubled (Canadian Diabetes Association, 2011).

Rising rates of obesity and associated chronic diseases severely impact the Canadian health care system. In 2010, obesity costs reached 6 billion dollars, while diabetes topped in at 11.7 billion dollars. Moreover, the Canadian Diabetes Association (2011) predicted that healthcare costs will rise to 16 billion dollars annually in 2020 due to the increasing prevalence of diabetes (Canadian Diabetes Association, 2011). If prevention strategies were to be successful, the health care system could see significant cost savings. The Canadian Diabetes Association (2011)

reported that decreasing prevalence of diabetes by as little as two percent could result in a nine percent decline in healthcare costs. Canadians could significantly minimize their risk of chronic diseases by maintaining a healthy weight through physical activity and avoiding excessive energy intake. The Canadian Diabetes Association estimated that over 50 % of cases of type 2 diabetes could have been prevented through adequate diet and frequent physical activity (Canadian Diabetes Association, 2011).

With chronic disease rates continuing to rise in Canada, it is evident that the strategies to reduce obesity rates have been ineffective up to this point (Lau et al., 2007). The majority of the resources have been allocated to treating individual cases of obesity, rather than focusing on prevention strategies that could benefit all Canadians. Although public health strategies have been aimed at preventing overweight and obesity in Canada, particularly among children and youth, prevalence of overweight and obesity has remained sustained (Canadian Task Force on Preventative Health Care, 2015; Lau et al., 2007).

Incorporating whole grains into the Canadian diet could prove to be a key preventative strategy to help decrease excessive energy intake among Canadians (Public Health Agency of Canada, 2011). Statistics Canada reported that grains are the highest food group consumed among Canadians, however recent findings suggest that consumption of whole grain foods is lacking (Albertson, Reicks, Joshi and Gugger, 2016; Statistics Canada, 2004). Recent findings show that although over half of adults met their total grain recommendations, less than 8 % of adults were able to meet their recommendations for whole grains (Albertson et al., 2016). Although whole grain consumption is associated with multiple health effects, the literature addressing the satiating effects of whole grain products appears to be inconclusive. Evidently, there is a need to determine the satiating effects of various whole grain products available to Canadian consumers using an evidenced based approach such as the satiety health claims guidance document (Health Canada, 2012b).

Chapter 2: Literature Review

2.1 Factors Affecting Satiety and Food Intake

2.1.1 Physiological Regulation of Appetite

Appetite is regulated through complex interactions occurring between the peripheral nervous system (PNS) and the central nervous system (CNS). Sensory signals are relayed to the CNS even before ingestion by the smell and sight of food (Lenard and Berthoud, 2008). Appetite hormones produced in gastro-intestinal tract and pancreas play a key role in the regulation of food intake by activating receptors in the appetite regulating regions of the CNS, including the brain stem and hypothalamus. Activation of these regions results in suppression or initiation of appetite (Lenard and Berthoud, 2008). Hormones that influence food intake over the long term include insulin and leptin, while short-term regulatory hormones having the greatest effect on appetite include cholecystokinin (CCK), ghrelin, Peptide YY (PYY), and Glucagon-like peptide-1 (GLP1) (Havel, 2001; Hussain and Bloom, 2013). The following sections will briefly highlight the role that each of these hormones play in appetite regulation.

CCK and Appetite

CCK is a short-term appetite regulating hormone that is produced in the small intestine. CCK is stimulated and released into the stomach following the ingestion of fats and proteins. It initiates feelings of fullness by activating the CCK receptors on the vagus nerve, hypothalamus and brainstem (Hussain and Bloom, 1998). CCK also functions by increasing satiety through slowing the rate of gastric emptying into the small intestine (Hussain and Bloom, 1998).

CCK's role in appetite suppression has been observed in many animal studies. Rats with a CCK deficiency were found to be obese, hyperphagic, and exhibit excessive energy intake (Murphy and Bloom, 2006). Exogenous administration of CCK was shown to decrease meal size in rats and primates, however CCK has been found to be an ineffective long term appetite suppressant (Havel, 2001; Murphy and Bloom, 2006). West, Fey and Woods (1984) determined that exogenous administration of CCK decreased meal size in rats by 44%, however the frequency of meals increased by 162 %, resulting in energy intake equivalent to that prior to CCK

administration. Researchers suspect that because of its short term regulating properties, CCK cannot have a substantial effect on long term appetite and long term weight maintenance.

CCK administration has also been investigated in humans. Healthy individuals of varying ages were given CCK infusions and were found to suppress food intake by 21.6 % in comparison to the control group (MacIntosh et al., 2001). Interestingly, food intake in older participants (ages 67-83 yr) was found to be significantly lower than intake in young participants (ages 18-33 yr) and this was attributed to the significantly higher baseline levels of CCK found in the older participants (MacIntosh et al., 2001). These findings indicate that endogenous CCK concentrations may play a key role in the decline in appetite associated with aging.

Ghrelin and Appetite

Ghrelin is produced in the stomach and it functions by stimulating appetite. Levels tend to rise before food is consumed and fall after food ingestion. Ghrelin exerts its appetite stimulating effects by activating the vagal afferent neurons, the hypothalamus and the brainstem and by increasing gastric motility (Hussain and Bloom, 2013). Low levels of ghrelin promote the suppression of food intake, while higher levels promote food intake (Murphy and Bloom, 2006). People of normal body weight have been found to have higher circulating levels of ghrelin compared to people who are overweight or obese (Havel, 2001). Tschöp and colleagues (2001) supported this notion when they concluded that an inverse relationship existed between circulating ghrelin levels and obesity. In their investigation, they determined that fasting plasma ghrelin concentrations were 27 % lower in obese participants compared to lean participants (Tschöp, et al, 2001).

High levels of ghrelin circulate following weight loss, promoting increased food intake. These increases in circulating ghrelin are considered to contribute to the difficulty of maintaining sustainable weight loss (Hussain and Bloom, 2013). Similarly, research has shown that external administration of ghrelin results in increased appetite, increased energy intake and weight gain (Hussain and Bloom, 2013; Murphy and Bloom). Researchers are currently investigating weight loss strategies that involve decreasing ghrelin levels or 'blocking' the actions of ghrelin.

Bariatric surgery is currently used initiate weight loss in individuals with obesity and it has also

been shown to result in significantly reduced ghrelin levels. Bohdjalian et al (2010) demonstrated that a sleeve gastrectomy performed in 12 obese patients resulted in successful weight loss and significant reductions in plasma ghrelin concentrations for the five year duration of the study (Bohdjalian et al, 2010). Administering ghrelin to patients suffering from anorexia may also prove to be a key strategy in improving health outcomes of this particular group (Hussain and Bloom, 2013).

Leptin and Appetite

Leptin is a long-term acting hormone that functions by regulating body weight and energy homeostasis. Leptin is produced in the adipocytes and production occurs following food intake. It functions by decreasing energy intake, promoting weight loss and increasing energy expenditure (Hemsfield, 1999).

Leptin levels are sensitive to the energy stores present within the body. Increased leptin is produced in people who are overweight or obese to promote decreased energy intake and increased energy output, while decreased leptin is produced in periods of fasting or energy restriction to promote caloric intake (Murphy and Bloom, 2006). It was determined that people who are overweight or obese have chronically elevated levels of leptin and develop leptin resistance, which is characterized by decreased leptin sensitivity (Pan, Guo, and Su, 2014). Consequentially, overweight and obese individuals may not be experiencing feelings of fullness to the same extent that normal weight people would (Heymsfield et al., 1999). On the contrary, people who have leptin deficiencies are marked with hyperphagia and severe obesity (Havel, 2008).

Previous literature supports the anorexigenic effects of leptin in instances where leptin deficiency has been observed. Halaas et al (1995) determined that peripheral leptin administration in ob/ob (leptin deficient) rats saw both decreases in food intake and significant weight loss after as little as four days and over the next 33 days ($P < 0.001$) (Halaas et al., 1995). Findings have been similar in human trials. Forooqi and colleagues (1999) saw significant declines in appetite and weight loss over a 12 month period in an obese, leptin deficient, hyperphagic girl who was injected with leptin on a daily basis (Forooqi et al, 1999).

Insulin and Appetite

Insulin is a long acting hormone that is produced by the beta cells in the pancreas following meal ingestion and it functions by regulating long term energy homeostasis. It is primarily stimulated following ingestion of CHO rich foods, but small amounts are also secreted following protein ingestion (Havel, 2001). Fat intake generally does not initiate insulin release (Havel, 2001).

Although it is generally thought that insulin functions as an anabolic hormone by promoting fat storage during excess CHO and protein ingestion, central insulin production results in decreases in appetite and subsequent food intake by activating insulin receptors in brain regions responsible for the regulation of food intake (Niswender, Baskin and Shawrtz, 2004).

Insulin that is administered directly into the CNS is known as central insulin administration (Hallschmid et al., 2012). Intranasal administration of insulin is a common method of observing the anorexigenic effects of central insulin administration in men and women alike. Hallschmid et al (2012) found insulin to have an appetite suppressing effect in healthy women when they observed declines in appetite and food intake in palatable chocolate chip cookies following intranasal insulin administration. Hallschmid et al (2004) observed significant declines in body weight and body fat in healthy men administered with intranasal insulin in comparison to healthy men given a placebo over an eight week period.

PYY and Appetite

PYY is a polypeptide that is secreted from the enteroendocrine cells (L-cells) following food ingestion (Hussain and Bloom, 2013). Levels rise following food intake, and similar to leptin, levels have been shown to decline in periods of fasting (Hussain and Bloom, 2013). Peripheral administration of the peptide has been found to decrease appetite in normal weight and obese people alike, emphasizing its role in short term energy regulation (Batterham et al., 2003). The anorectic role that PYY exerts is thought to be initiated by activation of appetite receptors in the hypothalamus and vagus nerve and potentially through delayed gastric emptying (Hussain and Bloom, 2013).

GLP1 and Appetite

GLP1 is a peptide hormone that has similar characteristics to PYY. It is also secreted by the L-cells in the gastrointestinal tract and secretion occurs following food ingestion (Hussain and Bloom, 2013). GLP1 functions by increasing insulin secretion, decreasing glucagon secretion and delaying gastric emptying (Naslund, Gutniak, Skogar, Rossner, and Hellstrom, 1998). GLP1 decreases food intake through activation of receptors on the hypothalamus, brain stem and vagus nerve (Hussain and Bloom, 2013). Intravenous administration of GLP1 has been found to increase satiety and decrease food intake in humans (Flint, Raben, Astrup & Holst, 1998). The appetite suppressing effects of GLP1 have recently come to clinical relevance in Canada. In 2016, Health Canada approved the use of a GLP-1 analog, entitled Saxenda, to be used in conjunction with a hypocaloric diet for aiding chronic weight management (CNW, 2015).

Evidently, the physiological regulation of food intake relies on a variety of hormones and digestive and absorptive processes in order to operate effectively. When conducting appetite research, it is important to consider that hormones can play a key role in the initiation or suppression of appetite. However, it should be noted that the regulation of food intake is an extremely complex process that is also influenced by psychological and environmental factors. Appetite regulating hormones on their own cannot necessarily predict subsequent food intake, and studies assessing satiety should be considerate of the all of the factors contributing to appetite.

2.1.2 Psychological Factors Impacting Food Intake

Expected Satiety

The role that psychological factors can play on satiety are commonly underestimated compared to the physiological effects observed following food intake (ie- glycemic response) (Brunstrom, 2014). Expected satiety is the ability to estimate how satiating a food is prior to its consumption (Brunstrom, Brown, Hinton, Rogers and Fay, 2011). These estimations are often subconsciously made by individuals from past eating experiences and can help determine portion sizes (Brunstrom, 2014). Previous literature has found that more familiar foods and foods commonly eaten to fullness are associated with increased expected satiety (Brunstrom,

Shakeshaft and Scott-Samuel, 2008). In other words, people tend to predict enhanced satiety of foods that they have commonly consumed in the past, in comparison to foods they have consumed less often or not at all (Brunstrom, 2014; Brunstrom, Shakeshaft and Scott-Samuel, 2008).

Brunstrom, Brown, Hinton, Rogers, and Fay (2011) indicated how beliefs pertaining to a particular food can influence the expected satiety and actual satiety of a food. In one condition, participants were shown a large amount of fruit that they were told would be in the smoothie they were about to consume, and in the other condition, participants were shown a small amount of fruit that would be in the test smoothie. Although the smoothie given to the two treatment groups was identical in all aspects, expected satiety scores prior to treatment consumption were significantly higher with the treatment group shown the large amount of fruit in comparison to the group shown the small amount of fruit (Brunstrom et al., 2011). Participants in the condition that was shown the large amount of fruit also had significantly higher fullness ratings and significantly lower hunger ratings at each time point following the treatment consumption, which lasted up to 180 minutes (Brunstrom et al., 2011). Following their findings, Brunstrom et al (2011) went as far to state that expectations of satiety were of similar magnitude or even higher than the satiety associated with consumption of high protein foods, emphasizing the psychological role that expected satiety plays in achieving true satiety (Brunstrom, Brown, Hinton, Rogers, and Fay, 2011).

Schiöth and colleagues (2015) also assessed expected satiety by giving participants preloads of smoothies of equal volume containing a low energy content (53 kcal/100g) compared to a high energy content (94 kcals/100g) on different sessions. Participants who consumed the preloads were given no information pertaining to the energy content of the preloads. There were no differences in hunger ratings between caloric treatments following preload consumption and there was also no significant differences in ad libitum food intake 30 minutes later (Schiöth et al., 2015).

Restrained eating is considered to be a key psychological factor that can influence food intake in individuals (Westenhoefer, Broeckmann, Munch and Pudel, 1994). Dietary restraint can be

classified as limiting the amount of food consumed in order to prevent weight gain or to initiate weight loss (Westenhoefer, Broeckmann, Munch and Pudel, 1994). There are two subscales that have been classified under restrained eating; rigid control and flexible control. Rigid control is characterized as attempting to completely cut out foods or entire food groups in an effort to lose weight or prevent weight gain (Timko, 2007). It is also marked by individuals attempting to adhere to extreme diets in order to lose weight and experiencing feelings of guilt if they deviate from their diet (Westenhoefer, Broeckmann, Munch and Pudel, 1994). Studies indicate that rigid control is marked with increased ad libitum food intake, positively related to BMI and has unsuccessful adherence to weight loss diets (Westenhoefer, Stunkard and Pudel, 1998).

Individuals with flexible control tend to consume energy dense foods in moderation, without experiencing feelings of guilt (Meule, Westenhoefer and Kubler, 2011; Westenhoefer, Stunkard and Pudel, 1998). Where rigid control was positively associated with BMI, flexible control was found to be inversely related to BMI, more successful in adherence to weight loss diets and have decreased ad libitum food intake in the literature (Meule, Westenhoefer and Kubler, 2011; Westenhoefer, Stunkard and Pudel, 1998). Both rigid and flexible control can confound satiety research that aims to assess the physiological effects of foods or specific components of the foods in the body (Blundell, 2010). Consequently, it is common for researchers to omit any individuals who display significant levels of restrained eating.

Stress has also been found to influence food intake among individuals. Some research has found that increased stress in a work environment has a hyperphagic effect on food intake in individuals considered to be restrained eaters, however this effect was not seen in non-restrained eaters (Wardle, Steptoe, Oliver, and Lipsey, 2000). This research is indicative that individuals considered to be restrained eaters may respond to stressful situations by consuming more food in comparison to non-restrained eaters. This disinhibitory effect of food intake observed in restrained eaters has been found elsewhere in the literature (Timko, 2007). Due to the effects that stress has on food intake, individuals who indicate high levels of stress are often omitted from satiety research (Anderson et al., 2002).

2.1.3 Environmental Factors and Satiety

Distraction

Other research demonstrates that satiety cues are less apparent when individuals are distracted (Brunstrom and Mitchell, 2006). Participants who consumed cakes without any distraction were found to have significantly higher ratings of fullness and a decreased desire to eat in comparison to participants who were distracted when they ate the cakes (Brunstrom and Mitchell, 2006). Intake has also been shown to increase when people are aware that they will not be consuming food for an extended period of time (Brunstrom and Mitchell, 2006; De Graaf, De Jong, and Lambers, 1999). This is indicative that people are cognisant of consuming more energy to prevent future feelings of hunger from occurring.

Visual Cues

Portion sizes have been found to influence satiety and food intake. Wansink, Painter and North (2005) found that participants (n=54) consumed an average of 73 % more soup when they consumed soup in self-refilling bowls in comparison to consuming a standard bowl of soup. Participants who ate from the self-refilling bowls were unaware that they had consumed more and their ratings of hunger, fullness and desire to eat were no different than the participants with the standard bowl (Wansink, Painter, and North, 2005). Researchers hypothesized that increased consumption occurred in the self-re-filling bowls because of the disproportional visual cues that they were subjected to. The participants were inaccurately making assumptions of how much energy they consumed from the amount of soup that they observed in their bowls.

2.1.4 Food Characteristics and Satiety

Physical State of Food

The physical state of the food consumed has been found to influence satiety. Research has shown that liquid meal replacements are less satiating in comparison to solid meal replacements (Jones et al., 2013; Pan and Hu, 2011). Liquid meal replacements do not tend to stimulate physiological responses to food ingestion to the extent that solid foods do (Jones et al., 2013). However, not all findings in the literature have been conclusive and there is some

evidence indicating that the physical state of food has no effect on satiety. Almiron-Roig, Flores, and Drewnowski (2004) found that physical state of food did not affect satiety when participants consumed preloads of coca cola or fat free sugar cookies before consuming an ad libitum lunch meal that was measured to determine energy intake (Almiron-Roig, Flores and Drewnowski, 2004). These findings have been supported elsewhere in the literature (Hulshof, de Graaf, and Weststrate, 1993).

Sensory Specific Satiety

While satiety refers to the time between meals that prevents further consumption of food due to feelings of fullness, sensory specific satiety refers to a decline in liking and wanting a particular food that has been consumed (Blundell et al., 2010; Havermans, Janssen, Giesen, Roefs, and Jansen, 2009). Havermans and colleagues (2008) found that participants demonstrated less desire to ingest the meal that they had previously consumed in comparison to a food with different sensory characteristics that they had previously only test tasted. Similar findings were also apparent elsewhere in the literature (Brunstrom and Mitchell, 2006). Sensory specific satiety has also been found to be apparent in different foods of similar taste and texture (Rolls, 1986).

Palatability of Food

Research has also examined how the palatability of a preload affects satiety. In one study, researchers found that although palatability of tomato soup (consisting of varying levels of acidity) had an effect on satiation, subjective hunger ratings and an ad lib test meal following the preload did not differ even though the preloads differed in palatability ratings (De Graaf et al., 1999). Anderson and colleagues found similar results when they noted that perceived sweetness and palatability ratings of the different preload beverages had no effect on the food intake of the test meal (Anderson, Catherine, Woodend, and Wolever, 2002). More recently, Carter, Monsivais, Perriquet and Drewnowski (2011) also supported these findings when they observed no changes in test meal intake after consumption of preloads consisting of chicken broth with varying levels of MSG content (Rogers and Blundell, 1990). In the previous studies specified, all preloads were in liquid state and it may be speculated that solid state preloads

might impact food intake differently. Griffioen-Roose, Mars, Finlayson, Blundell, and de Graaf (2011) assessed the effect of palatability on food intake with preloads of sweet and savory flavored rice and also found no effect of palatability on subsequent food intake among participants (Griffioen-Roose, Mars, Finlayson, Blundell, and de Graaf, 2011.)

2.2 Food Composition and Satiety

2.2.1 Macronutrients and Satiety

Literature remains inconclusive regarding which macronutrients elicit the most satiating effect in the body. Even with one specific macronutrient, different sources and structures of the nutrient can elicit different satiety responses (Health Canada, 2012b). In a within- subjects study design, researchers sought to determine what macronutrient had the most satiating effects by administering liquid preload meals exclusively consisting of CHO (50 g), protein (50 g), or fat (22.3 g). It should be noted that the Recommended Dietary Allowance (RDA) is set at 130 g/day and 0.8 g/kg/day for CHO and protein, respectively (Health Canada, 2006).

Therefore, the amounts of macronutrients in the experimental conditions may have overemphasized amounts typically consumed during a single meal. The researchers did not find any significant differences in ad lib energy intake between the three macronutrients. The lack of significant energy intake from the different macronutrient preloads may be due to the unfamiliar and liquid state of the preloads (Potier et al., 2010).

Other literature suggests that protein has the greatest effect on satiety when compared to CHO and fat (Hall et al., 2012; Latner and Schwartz, 1999; Paddon-Jones et al., 2008). When comparing an isocaloric (450 kcal) high protein diet (80.4 g pro, 10.7 g CHO, 9.6 g fat) to a predominantly carbohydrate based diet (113.3 g CHO) and a mixed macronutrient diet (62 g CHO, 40.2 g Pro, 4.8 g fat), Latner and Schwartz (1999) found that consuming a high protein preload resulted in decreased hunger ratings and decreased subsequent food intake compared to the other macronutrients. The mixed CHO and protein preload also resulted in significantly lower hunger ratings in comparison to the CHO preload, while the protein based preload and the mixed preload did not differ significantly between hunger ratings (Latner and Schwartz, 1999).

It should be noted that the experiments were conducted using liquid macronutrients, and research has demonstrated that there are significant differences in satiety ratings between liquid and solid meals (Jones et al., 2013). Additionally, although preloads were isocaloric (450 calories), the high protein preload offered 80.4 grams (71% of total kcals) of protein, while the mixed preload offered 40.2 grams (35% of total kcals) of protein. In general, North American meals do not consist of such high protein proportions. The RDA for protein is set 0.8 g/kg/day for adults, meaning that a 64 kg (141 lb) individual would require 50.9 g of protein for the entire day (Health Canada, 2006). The high protein preload offered significantly more than the RDA and the mixed protein condition almost reached the RDA, suggesting that these results are not very applicable to the Canadian population.

Weigle et al (2005) determined that adhering to a diet with a higher protein distribution (30 % energy from protein, 50 % CHO, 20 % fat) in comparison to following an average protein diet (15 % protein, 50 % CHO, 35 % fat) resulted in significant decreases in hunger and caloric intake, increases in fullness and overall weight loss (Weigle et al., 2005). Although CHO amounts were kept constant in the conditions, the decrease in fat intake in the high protein diet likely contributed to the weight loss effect found. Nevertheless, the high protein diet did initiate significantly higher levels of satiety and was thought to play a key role in reduction of energy intake during the ad libitum phase of the study and subsequent weight loss after the high protein diet was initiated. The mechanism surrounding the satiating effects of protein remains unclear, however Weigle and colleagues reported that it may be due to increased sensitivity of circulating leptin concentrations that were observed after the high protein diet was followed (Weigle et al., 2005). Other researchers speculate that its effects may be mediated through interaction with other macronutrients or decreased gastric emptying rate (Abou-Samra, Keersmaekers, Brienza, Mukherjee and Macé, 2011; Tome, 2004).

It is important to note that different sources of protein may affect satiety differently. Abou-Samra, Keersmaekers, Brienza, Mukherjee and Macé (2011) found that consumption of preloads consisting primarily of casein and pea protein resulted in decreased ad libitum food intake in comparison to whey, egg albumen and maltodextrin preloads (Abou-Samra, Keersmaekers, Brienza, Mukherjee and Macé, 2011). Pal and Ellis (2010) sought to determine

the satiating effects of some different sources of protein. Preloads consisting of 50 g of tuna, turkey, egg albumen, and whey were given to participants on four separate sessions. Food intake at a buffet meal four hours following preload consumption was decreased in the whey protein preload in comparison to the other preload treatments (Pal and Ellis, 2010). Possible mechanisms underlying the satiating effects of whey proteins include an increased circulating concentration of appetite regulating hormones (CCK, GLP-1, PYY) and a rise in plasma amino acid concentration following whey protein ingestion (Chungchunlam, Henare, Ganesh, and Moughan, 2015).

2.2.2 Fibre and Satiety

Fibre has also been demonstrated to increase satiety in the literature. Ingestion of fibre has been found to increase feelings of fullness through increased chewing (decreasing ingestion rate), gastric distention, and delayed gastric emptying (Howarth, Saltzman, and Roberts, 2001; Schroeder, Gallaher, Arndt, and Marquart, 2009). Unfortunately, it has been difficult to conclusively determine the effects of fibre on satiety, because results are dependent on the type of fibre utilized (soluble versus insoluble), the doses applied in the preloads and the methodologies used in the studies. When Holm and Bjork (1991) gave participants different test meals of breads with total dietary fibre ranging from 2 to 13 grams, they found that breads with the higher amounts of dietary fibre elicited significantly higher feelings of fullness compared to white bread (Holm and Bjorck, 1992). It should be noted that satiety responses were not significantly higher after 90 and 180 minutes post preload ingestion and satiety rating scales were only used at 15, 90 and 180 minutes. Lyly et al (2009) found benefits in different satiety measures when they gave participants beverages fortified with different types of fibre and compared them to a beverage that did not contain any fibre. However, not all fibre fortified beverages showed significant differences in the same satiety measures. Only the guar gum beverage offered statistically significant increases in perceived satiety when compared to the beverage without fibre. Although increases were also noted in the wheat bran beverage and oat β glycan beverage, results were not statistically significant. Perceived fullness was only significantly enhanced in the oat β glycan beverage. Finally, only the guar gum beverage saw

significant results in decreasing desire to eat in comparison to the control without fibre (Lyly et al., 2009).

Other research has examined longer term fibre consumption to determine if satiating effects are still apparent. In a between subjects design, Touyarou et al (2011) studied satiety responses in two types of fibre enriched bread for 15 days compared to white bread. The ratio of soluble and insoluble fibre was similar between the fortified breads, however one bread resembled multigrain, while the other resembled traditional white sandwich bread.

Researchers determined that lower hunger sensations were achieved after consuming both experimental breakfasts in comparison to consuming the control breakfast. Energy intake over the 15 days was found to be lower in one type of fibre fortified breads, but not in the other fibre fortified bread when compared to the control group (Touyarou, Sulmont-Rossé, Gagnaire, Issanchou, and Brondel, 2012). Although participants in the experimental conditions were required to consume fibre fortified bread exclusively, liking of the bread did not decline, suggesting sensory specific satiety was not a factor influencing satiety.

Similarly, Schroeder and colleagues found that consumption of whole grain, high fibre barley (12 g fibre/56 g serving of barley) elicited increased feelings of fullness before an ad libitum lunch meal in comparison to whole grain wheat (5g fibre/56 g serving whole grain wheat) and refined rice foods (1g fibre/56 g serving refined rice hot cereal) (Schroeder et al., 2009).

Although food intake was not different among treatments, feelings of fullness were inversely associated with amount of food eaten, suggesting that longer term consumption of the test foods may have resulted in a stronger association between satiety and food intake (Schroeder et al., 2009).

Fibre has also been found to initiate satiety hours following its consumption. Nilsson and colleagues (2008) found that consumption of a high β -glucan barley bread (HBB) in the evening resulted in increased satiety following a breakfast meal the next morning (Nilsson, Östman, Holst, and Björck, 2008). It should be considered that the amount of dietary fibre in the HBB treatment was excessively high at 50.1 g/serving and therefore, it would not provide an accurate representation of a typical amount of fibre consumed in a meal. Nevertheless, breath

hydrogen tests revealed that colonic fermentation strongly correlated with level of satiety observed between treatments, suggesting a mechanism surrounding the delayed satiety observed (Nilsson, Östman, Holst, and Björck, 2008). Supporting these findings, Cani and colleagues (2009) found that ingestion of a prebiotic treatment resulted in significantly lower hunger ratings among participants, along with increased plasma concentrations of GLP-1 and PYY, compared to the control of dextrin maltose (Cani et al., 2009). This suggests that the mechanism responsible for enhanced satiety may be related to increases in circulating levels of appetite suppressing hormones (Cani et al., 2009).

Another study observed that subjects had significantly increased ratings of fullness and decreased ratings of prospective food consumption three hours following consumption of a high fibre meal (4.7 g/ 239 kcals) in comparison to a low fibre meal (1.7/239 kcals) (Raben, Christensen, Madsen, Holst, and Astrup, 1994). It should be noted that the differences in time and treatment effects observed between studies may be due to different mechanisms initiating satiety. For instance, more immediate satiety following fibre consumption could be due to gastric distention, while satiety many hours following fibre consumption could be due to the fermentation of fibre in the colon (Slavin and Green, 2007).

There have also been studies that have not found a relationship between satiety and fibre intake in foods with increasing amount of fibre. Willis and colleagues (2010) did not find any differences in satiety ratings when they gave participants a muffin consisting of increasing amounts of fibre (ranging from 0-12 grams), however previous investigations have used inconsistent scales to measure satiety (Willis et al., 2010). Future studies should be done using the validated methodology proposed by Health Canada in order to conclusively determine the satiating role that fibre plays (Health Canada, 2012b).

2.2.3 The Glycemic Index

Consuming different types of carbohydrates produces a different blood glucose response in the body (Anderson et al., 2002; Jenkins et al., 1981). The glycemic index is a scale that ranks carbohydrate food by how much they raise blood glucose levels in comparison to a reference food, which is either glucose or white bread (Canadian Diabetes Association, 2014).

Carbohydrates (CHO) can be classified as having a high, medium or low glycemic index (GI). Examples of high GI foods include Rice Crispies, soda crackers, and white bread (Canadian Diabetes Association, 2015). These foods tend to be lower in fibre, thus increasing their absorption into the gastrointestinal tract. Consumption of high GI foods results in higher peaks of blood glucose in comparison low GI foods, which results in sustained blood glucose levels (Roberts, 2000). Medium GI foods include oatmeal, couscous and popcorn, while lower GI foods result in more sustained blood glucose levels include most pastas, barley, and lentils (Canadian Diabetes Association, 2015).

2.2.4 Glycemia and Satiety

Low blood glucose levels have been found to stimulate appetite, while high blood glucose levels stimulate satiation and satiety (Anderson et al., 2002; Arumugam et al., 2007). These findings are in agreement with the glucostatic hypothesis, which states that increases in blood glucose result in increased satiety and decreased food consumption (Mayer, 1953). Therefore foods that can sustain blood glucose levels may hold promise for decreasing total daily energy intake and playing a role in weight maintenance.

A variety of research has indicated that lower GI CHO rich foods induce higher levels of satiety within 2- 6 hours after a meal has been consumed (Arumugam et al., 2007; Anderson & Woodend, 2003; Ball et al., 2003 Roberts, 2000). However, the quick rise in blood glucose after consumption of high GI foods has been shown to initiate short term feelings of fullness due to the quick rise in blood glucose levels (Anderson et al., 2002).

Anderson et al (2002) found that high GI liquids reduced subsequent food intake while low GI liquids did not. When researchers preloaded their subjects (n=14) with high glycemic or low glycemic beverages, the subjects that consumed the high glycemic beverages consumed less energy in the following hour in comparison to subjects who consumed the low glycemic index foods (Anderson et al., 2002).

It is important to consider that the study only observed one hour following the CHO preload meal and the duration may have been too short to observe low GI CHO having a significant effect on satiety. The researchers hypothesized that the high glycemic beverages may have

offered short term satiety, while the low GI beverages may have led to increased satiety hours after consumption (Anderson et al., 2002). This is in agreement with various literature that supports high GI offering enhanced satiety 60- 90 minutes following preload consumption and low GI foods offering enhanced satiety over the 90 minute mark (Anderson and Woodend, 2003; Arumugam et al., 2008; Bornet, Jardy-Gennetier, Jacquet, and Stowell, 2007).

Arumugam (2007) and his colleagues measured blood glucose and corresponding satiety levels two hours postprandially. Overweight and obese women were divided into a 'rapid' group, where they consumed an entire CHO containing beverage over the course of two meals or 'slow' group, where they consumed the beverage over eight different periods throughout the day. The 'rapid' group was meant to represent quickly absorbed, high GI foods, while the 'slow' group was meant to represent more slowly absorbed, lower GI foods. The researchers found that the rapid condition produced higher blood glucose and insulin responses immediately following consumption of glucose beverages, compared to the 'slow' group. Three to four hours after the meal, serum glucose and insulin was found to be lower in the rapid condition. Hunger ratings were reportedly 30 % higher for the rapid group four hours after breakfast, and 54 % higher five hours after lunch (Arumugam, 2007). Findings of this study are reflective of those in an earlier study conducted by Jenkins and colleagues (1990). In their study, nine healthy volunteers underwent a very similar protocol where they consumed a bolus of 50 g of sugar mixed with water over 5 to 10 minutes ('fast' group), or they consumed the sugar solution over a period of 3.5 hours ('slow' group). The findings in this study supported those of Arumugam et al (2007). In particular, the average serum insulin area was found to be significantly lower in the slow group in comparison to fast group. Blood glucose levels in the slow group were also more stable over time, while blood glucose levels in the fast group were initially elevated, but then rapidly dropped one hour following consumption. These studies emphasize how a decreased rate of glucose absorption can stabilize blood glucose levels, and as Arumugam and colleagues determined, contribute to enhanced satiety over time (Arumugam, 2007; Jenkins et al., 1990).

Holt and Miller also found evidence to support low GI foods increasing satiety compared to high GI foods two hours following preload consumption. Hunger ratings were found to be lower in

low GI foods such as porridge, all bran, popcorn, brown pasta, and grain bread, compared to high GI foods, such as white bread, French fries, croissants, and cakes (Holt et al., 1995).

Findings regarding blood glucose and satiety have not been conclusive in the research. Stewart and colleagues (1997) did not find any significant differences in motivation to eat and subsequent food intake when they divided participants into two separate groups and gave them identical breakfast cereals that differed only in added glucose or fructose, followed by an ad lib pizza test meal. Fructose is absorbed to a lesser extent than glucose in the bloodstream and consequentially it has a significantly lower GI (Schaefer, Gleason, and Dansinger, 2009). (The University of Sydney, 2015c; Yang et al., 2006). Interestingly, no significant findings were noted in appetite and food intake even when blood glucose levels were significantly higher following the glucose-cereal meal (Stewart et al., 1997). It should be noted that glucose can help to facilitate fructose into the bloodstream and consequentially, fructose is more readily absorbed in the body when combined with glucose (Stewart et al., 1997). However, although fructose was given with a breakfast cereal, blood glucose measurements were found to be significantly different between the glucose and breakfast cereal treatment group (Stewart et al., 1997).

Similarly, Liu and her colleagues (2012) did not find any relationship between GI, glycemic load and satiety. Where GI is indicative of the type of CHO consumed, glycemic load refers to the amount of CHO consumed (Foster-Powell, Holt, and Brand-Miller, 2002). Participants were exposed to mixed macronutrient breakfast, lunch and supper meals of similar caloric and protein content. The experimental conditions were classified as low or high in GI and contained either low or high amounts of available CHO throughout a 12 hour day. Although there were significant differences found in blood glucose and insulin responses following meal consumption, there were no significant differences in satiety ratings between any of the experimental conditions (Liu et al., 2012). Satiety ratings were conducted using the 100 mm VAS scales supported by Health Canada, however participants were considered to be overweight or obese, which could have influenced the satiety ratings observed (Health Canada, 2012b; Liu et al., 2012).

Studies have also been conducted to determine the long term effect diets with differing GI can have on satiety. Aston, Stokes and Jebb (2007) did not find any differences in body weight, body composition, food intake or hunger and fullness ratings in 19 overweight and obese, female participants who were required to consume a medium or low GI diet matched in macronutrient distribution for 12 weeks (Aston, Stokes and Jebb, 2007). It should be noted that postprandial blood glucose responses from the high and low GI groups did not differ, likely contributing to the insignificant differences in satiety ratings between the two groups. Additionally, Aston, Stokes and Jebb (2007) used satiety scales that were inconsistent with Health Canada's recommendations (Health Canada, 2012b).

Another study lasting for 8 days also failed to support the notion that consumption of low GI foods could reduce appetite and subsequent food intake. In this investigation, researchers also matched macronutrient content of low GI test meals with high GI test meals and did not find any differences in appetite ratings or food intake between participants split into low GI and high GI groups (Alfenas and Mattes, 2005).

Evidently, the findings regarding GI and its effects on satiety remain inconclusive in the literature. The largely inconclusive nature surrounding GI and satiety has prompted some researchers to conclude that people seeking weight loss advice should not be counselled on low GI diets (Raben, 2002). In her review, Raben (2002) highlights 31 short term studies (<1 day), where only 15 of the studies were found to reduce hunger or increase satiety (Raben, 2002).

Inconclusive findings reported in the literature are likely due to the lack of consistency regarding the study methodology, palatability and macronutrient distribution of the preloads used (Roberts, 2000). What's more, the majority of these appetite studies were conducted in strictly controlled laboratory settings and may not be representative of typical feeding behaviors in humans (Alfenas and Mattes, 2005).

In one study however, researchers assessed appetite by giving their participants choice in their meal and snack selection and allowing them to eat as much foods as they wanted over an open time period (Alfenas and Mattes, 2005). Diet was closely monitored throughout the study, with the two study groups consisting of (1) participants only consuming a variety of low GI foods and

(2) participants only consuming a variety of high GI foods. Throughout the 8 day duration of the study, there were no significant differences in satiety ratings or food intake even though post meal blood glucose levels were significantly different between the high GI and the low GI groups. This was indicative that the relationship between blood glucose, satiety and appetite is extremely complex and may only be evident in tightly controlled, laboratory studies. However, this study failed to control for macronutrient content in the different test groups, which could have had a significant impact on satiety and it also did not use the 100 mm VAS to assess satiety, as recommended by Health Canada (Health Canada, 2012b).

The regulation of food intake is extremely complex and involves a variety of factors including physiological, environmental and cognitive influences. What's more, appetite studies tend to operate using different methodologies. Consequently, researchers often come to inconclusive results. This conflict is apparent in the case of glycemia and satiety; the bulk of the literature supports low GI foods sustaining satiety for longer time periods, however not all findings have been conclusive. In the future, it will be crucial to conduct appetite studies that follow valid and reliable methodologies in order to produce conclusive findings that can work towards creating effective satiety health claims.

2.3 Methodological Aspects of Satiety Research

Dietary interventions are recognized as one of the key preventative measures to combat rising rates of obesity. Foods that have been identified in the literature as increasing satiety hold promise for easing compliance of hypocaloric dietary interventions by delaying feelings of hunger and increasing feelings of fullness for an extended time period (Lau et al., 2007). Having regulated, evidenced based satiety health claims on front of package food products in grocery stores can help consumers make informed purchasing choices that may work towards decreasing rising rates of obesity.

There has been some disagreement among researchers concerning what scientific evidence substantiates a satiety claim on the front of food packaging (Mela, 2011). Some researchers feel that claims need to be supported by long term studies that have directly linked satiety of a particular food product to a decline in caloric intake and subsequent weight loss (Mela, 2011).

Other researchers argue that satiety claims need only the evidence that a particular food product elicits feelings of fullness, decreases in hunger and that it could play a contributing role in weight loss rather than directly causing the weight loss (Mela, 2011). Health Canada sets the record straight for Canadian satiety claims in their guidance draft document, 'Satiety Health Claims on Food.' Health Canada emphasizes that satiety claims in Canada need not refer to or imply weight loss as a direct result of a particular food's consumption. Although enhanced satiety may help contribute to weight loss, Health Canada recognizes there are a variety of factors that influence weight apart from diet. These specifications set by Health Canada were key in guiding the objectives of the current investigation. Observing significant differences in subjective satiety measures is considered sufficient evidence to make a satiety health claim and consequentially, this is one of the main objectives of our investigation.

Health Canada categorizes satiety claims as functional food claims, where the functional food must show supporting evidence that it elicits specific physiological effects on the functioning of the body in order to support health (Health Canada, 2012b). Additionally, Health Canada reports that satiety claims also need to include comparative claims, where the food being researched is compared to a control food. In regards to circulating hormones following food consumption; hormone levels are not necessarily predictors of subjective satiety measures and subsequent food intake, thus hormone changes after consumption of a particular food cannot be the sole cause for a satiety claim, although they can be used to help support the claim (Health Canada, 2012b). In regards to the methodology surrounding satiety ratings, experimental evidence needs to demonstrate that differences in satiety between two foods are in fact significantly different in the satiety rating using 100 point visual analogue scales as subjective measurement ratings (Health Canada, 2012b). Finally, in order for enhanced satiety of a food to be reported in a health claim, a ten percent difference in satiety ratings between test and control foods must be evident (Health Canada, 2012b). This draft document was open for public comments from September 2012 until November 2012 (Health Canada, 2012c). The online consultation has now closed and there is currently no status as to when the proposed document may be approved.

2.4 Whole Grains and their Known Health Effects

Canada's Food Guide recommends that at least half of the grains consumed in the diet be consumed as whole grains each day and that Canadians should aim to consume whole grains that are low in fat, sugar and salt (Health Canada, 2011). One serving of grains is considered to be half of a cup of cooked grains, such as couscous or pasta and Canada's Food Guide recommends six to eight servings of grain products, depending on the individual's age and gender (Health Canada, 2011). Consuming a diet rich in whole grains has been linked to a plethora of beneficial health outcomes, including cardiovascular health, weight loss and a decreased risk of acquiring type 2 diabetes (Bodinhm, Hitchen, Youngman, Frost, and Robertson, 2011; He, Klag, Whelton, Mo, and et al, 1995; Melanson et al., 2006; Venn and Mann, 2004).

Research has demonstrated an inverse association between whole grain consumption, BMI, waist to hip ratio and fasting insulin levels with confounding factors including age, sex and physical activity being controlled (Venn and Mann, 2004). There is also evidence that consumption of as few as three servings of whole grains per day resulted in a 20-30 % decreased risk of acquiring diabetes mellitus in comparison to minimal consumption of whole grains (Venn and Mann, 2004).

Recent data from the National Health Nutrition and Examination Survey (NHANES) support the link between whole grain consumption and health. Researchers observed an inverse relationship between whole grain intake and anthropometric measures (adiposity, BMI and waist circumference) in adults (Albertson et al., 2016). Increased fibre content, decreased GI and decreased energy density in whole grain foods are mechanisms that are well recognized as factors that influence the inverse relationship observed between whole grain consumption and health (Albertson et al., 2016). However, interestingly, the highest energy intakes from the NHANES data was found to be in groups with the lowest BMI (Albertson et al., 2016). These findings indicate that other mechanisms may be involved in the inverse relationship observed. In recent years, researchers have been exploring the relationship between gut microbiota and human obesity and some evidence suggests that the microbiota may also serve as a mechanism for regulating body weight (Karl and Saltzman, 2012).

The health benefits associated with whole grain consumption can also be observed in other areas around the world. A study conducted in China sought to determine the health effects of an ethnic minority population by examining people who frequently consumed oats or buckwheat in comparison to those that did not. Researchers found that participants who consumed higher amounts of whole grains had improved cardiovascular health parameters (He et al., 1995).

Literature has also found that whole grains are more satiating than refined grains. Schroeder and colleagues (2009) found that high fibre barley (6 g fibre/30 g serving) decreased hunger to a greater extent than refined rice (Schroeder et al., 2009). Researchers identified the high content of soluble fibre in the barley as the mechanism increasing satiety. However, palatability of treatments was not addressed and scales to measure satiety were an unusual combination of 100 point Visual Analogue Scales (VAS) and Satiety Labelled Intensity Magnitude scales, which makes results difficult to compare with previous studies. Kristensen and colleagues (2009) used the recommended 100 point VAS to measure satiety ratings and they came to similar findings. They determined that whole grain bread resulted in decreased hunger and increased feelings of fullness and satiety ratings in comparison refined bread.

Isaksson and colleagues (2012) also demonstrated that long term whole grain consumption could lead to sustained satiety. The researchers found that consuming whole grain rye porridge every morning for three weeks resulted in increased satiety and decreased hunger in comparison to consuming refined wheat bread, however there were no differences in total energy intake (Isaksson et al., 2012). Conversely, some literature has not found a relationship supporting whole grains increasing satiety (Bodinham et al., 2011).

2.5 Gluten and Gluten-Free Grain Products and their Effects on Satiety

The ability of gluten-free (GF) grains to initiate increased satiety in comparison to gluten containing grains has been given little attention in the literature and because couscous and buckwheat represent gluten and GF food sources, comparing their satiating effects was of particular interest in this literature review. Berti and colleagues (2004) reported that grains

containing gluten may result in lower post prandial blood glucose levels by inhibiting the ability of amylase to efficiently breakdown CHO, resulting in a decreased rate of glucose absorption in the small intestine of healthy individuals (Berti et al., 2004). However, although Clemente and colleagues (2001) found that consumption of GF pasta resulted in decreased feelings of fullness in comparison to pasta containing gluten, blood glucose responses measured each hour up to four hours following meal ingestion showed no significant differences in overall plasma glucose concentrations (Clemente et al., 2001). Clemente et al (2001) attributed differences in satiety between treatments to the changes in gastric emptying rate and gastric distention following their consumption. The gastric emptying rate was determined to occur 43 minutes earlier in the gluten-free pasta treatment and gastric distension was found to be smallest in the GF pasta treatment (Clemente et al., 2001). The researchers hypothesized that the decreased gastric distention and gastric emptying rates in the GF pasta was due to the absence of gluten. However, fibre content in the treatments was not accounted for. If the pasta containing gluten contained more fibre than the GF pasta, it would be difficult to determine if the difference observed in satiety between treatments was due to the fibre or gluten content. . It should also be noted that satiety was only measured at one point immediately following pasta ingestion, and responses could have changed significantly with increasing time following food intake. Additionally, macronutrient distribution of the treatments was not completely balanced. The gluten treatment contained 19 more calories and 3.6 more grams of protein than its gluten free counterpart (Clemente et al., 2001).

Berti et al (2004) also examined blood glucose response and satiety in multiple GF foods and their gluten containing counterparts. Although they found significantly higher blood glucose levels in the GF bread versus the gluten containing bread, they found no significant differences in feelings of fullness and desire to eat between the products (Berti et al., 2004). Findings were similar for Kang et al (2001) who found that there were no significantly different satiety responses in buckwheat and whole grain polished rice, however confounding factors such fibre, protein and resistant starch content likely influenced satiety scores (Kang et al., 2001).

Although initial findings pertaining to GF foods and satiety do not suggest any beneficial effects, GF foods may prove to be a promising alternative to gluten containing foods in terms of obesity

prevention. Recent research suggests that gluten may play a key role in inhibiting the binding of leptin to its receptors, thus increasing appetite and subsequent food intake (Jonsson et al., 2015). Leptin resistance has been identified as a primary risk factor for developing obesity in the future (Jonsson et al., 2015). What's more, Jonsson and colleagues (2015) reported that animals injected with gliadin (one of the main proteins found in wheat) experienced up to 20 % increases in weight gain (Jonsson et al., 2015). However, this research is preliminary and it is currently unknown whether gliadin ingestion from food would result in similar findings in humans. Future studies using consistent methodology should be done to conclusively determine the satiating effects of GF products.

2.6 Buckwheat

2.6.1 Buckwheat: Description of Products and Nutritional Characteristics

Buckwheat is considered to be an ancient grain and is hypothesized to originate from Southern China approximately 5000 - 6000 years ago (Ohnishi, 1998). Although it is technically classified as a fruit, buckwheat is commonly referred to as a pseudo cereal crop because the starch found within the buckwheat seeds closely resembles that of cereal grains (Holubec and Stehno, 2004; Stringer, Taylor, Appah, Blewett, and Zahradka, 2013).

Buckwheat is characterized as a tall plant, growing between two to five feet in height and literature reports that it is closely related to rhubarb (Krkošková and Mrazova, 2005). The branches of the buckwheat plant are hollow and their color varies between green, red and brown, depending on the maturity level of the plant (Alberta Agriculture and Rural Development, 2015). It produces pink or white blossoms approximately five to six weeks after being planted, and fully matures within 90 days (Alberta Agriculture and Rural Development, 2015). Seeds will begin to form following pollination. The buckwheat plant requires pollination in order to produce seeds, making it a limiting factor in producing higher yields (Holubec and Stehno, 2004). The buckwheat seeds are triangular shaped and are brown and black in color. The size of the seed is largely dependent on the variety of buckwheat. The seeds are composed of an inedible, hard outer shell, known as the hull, which encapsulates the inner groat (Alberta Agriculture and Rural Development, 2015).

Buckwheat is a staple food in areas of Eurasia, including China, Nepal, Poland, Russia, Ukraine, Japan, the Himalayan Hills and Bhutan (Holubec and Stehno, 2004; Skrabanja, Liljeberg Elmståhl, Kreft, and Björck, 2001). In Canada, wheat is the dominant grain consumed and buckwheat is considered to be an alternative crop (Skrabanja et al., 2001).

Throughout the world, the buckwheat seed has been consumed in a variety of different ways. In Slovenia, Poland, Ukraine and Russia, buckwheat is commonly consumed in the form of buckwheat groats and is used to make porridges, soups and breakfast cereals (Holubec and Stehno, 2004). In Japan, buckwheat is consumed by combining wheat flour with buckwheat flour to create soba noodles (Alberta Agriculture and Rural Development, 2015). In Canada, buckwheat is commonly milled to make buckwheat flour or processed to make buckwheat groats and grits, which can then be toasted (Agriculture and Agri-Food Canada, 2013).

Buckwheat can be used to make pancake mixes, breakfast cereals, breads, stuffing mixes, soups and energy bars and the buckwheat plant itself can produce dark honey (Alberta Agriculture and Rural Development, 2015; Agriculture and Agri-Food Canada, 2013; Holubec and Stehno, 2004).

Buckwheat crops grow well in cool, moist environments and they do not require nutrient dense soil to thrive (Holubec and Stehno, 2004; Agriculture and Agri-Food Canada, 2013). Buckwheat could prove to be an environmentally friendly crop for farmers to invest in; it only requires small amounts of fertilizer, and no pesticides for the crops to successfully grow. It can also grow in significantly harsher climates in comparison to other cereal grains, however buckwheat yields are struggling to compete with other popular cereal grains, such as wheat, rye, and barley (Agriculture marketing resource center, 2014; Holubec and Stehno, 2004).

Production of buckwheat has declined in various countries, due to the cost effective nature and consumer demand of other staple grains (Agricultural marketing resource center, 2013; Holubec and Stehno, 2004). The crop is grown in China, Russia, the United States, Poland, Italy, France, Canada and the Ukraine (Holubec and Stehno, 2004). The largest amount of buckwheat being grown and harvested was in Russia, and was closely followed by China (Krkošková and Mrazova, 2005). Buckwheat cultivation began over a century ago primarily in the eastern prairies and

has declined significantly within the 21st century (Agriculture and Agri-Food Canada, 2013). In 2000, a total of 14,000 tonnes were produced in Canada, and in 2007, production dropped to 2,000 tonnes per year (Agriculture and Agri-Food Canada, 2007b). Promising research geared towards finding ways to increase the buckwheat yield is currently underway in Russia, Ukraine, Belarus, Poland, and most recently, Canada (Holubec and Stehno, 2004).

Buckwheat contains a wide range of micronutrients that work to support human health, including B vitamin, vitamin E, calcium, magnesium, zinc, manganese and potassium (Ahmed et al., 2013; Bonafaccia, Marocchini, and Kreft, 2003; Saldeen and Saldeen, 2005; Wei, Hu, Zhang, and Ouyang, 2003). Having an adequate supply of micronutrients in the diet is particularly important for carrying out physiological functioning of the body including growth, repair and maintenance of body tissues and organs (Ahmed et al., 2014). However, concentration of the minerals in buckwheat is highly variable and dependant on environmental factors such as the nutrient density of the soil (Steadman, Burgoon, Lewis, Edwardson, and Obendorf, 2001a).

Buckwheat appears to have a beneficial fatty acid profile, with over 80 % of the fatty acids being unsaturated, giving buckwheat a fatty acid profile that is reportedly superior to other cereal grains (Steadman, Burgoon, Lewis, Edwardson, and Obendorf, 2001b). Fat has been found to be an insufficient appetite suppressant, however the small amounts of fat in buckwheat and couscous would have a negligible effect on appetite and only a minimal effect on overall fat intake (Darzi, Frost, and Robertson, 2011; Latner and Schwartz, 1999).

Buckwheat contains high amounts of antioxidants that work to promote health and prevent disease (Ahmed et al., 2013). Antioxidants found in buckwheat include polyphenols, tocopherols, rutin, tannins and phytic acid (Holasova et al., 2002; Pandey and Rizvi, 2009; Steadman et al., 2001a; Steadman, Burgoon, Lewis, Edwardson, and Obendorf, 2001c; Thompson, 1993). Other beneficial components in the buckwheat groats include fibre and resistant starch. Due to the glucose lowering properties associated with fibre and resistant starch in buckwheat groats, they will be discussed further in the section addressing mechanisms for glucose control.

Although buckwheat boasts of various health benefits mentioned above, it does prove to be a pricier option in comparison to other grain products. For instance, Superstore's online site advertises one kilogram (kg) of hulled buckwheat groats for \$11.11, which is significantly more than quick oats (\$3.30/kg), couscous (\$3.30/kg) and long grain rice (\$5.00/kg), however less expensive than quinoa (\$16.40/kg)(Real Canadian Superstore, 2016 a,b,c).

2.6.2 Consumer Trends in the Marketplace

Buckwheat holds promise in the marketplace for health conscious consumers and for individuals who exhibit gluten intolerances or celiac disease. Approximately one third of Canadians are seeking gluten-free food products in the Canadian market (Agriculture and Agri-Food Canada, 2014b). Additionally, Agriculture and Agri-food Canada (2014b) reported that Canada's gluten free market has had a growth rate by 26 % from 2008 to 2013 (Agriculture and Agri-food Canada, 2014b). Buckwheat is also seen as a novel food crop and Agriculture and Agri-Food Canada (2013) report that there is an increased interest in purchasing alternative grain options among consumers. Buckwheat is considered to be a gluten-free, whole grain and could prove to be an alternative grain option for individuals adhering to a gluten-free diet (Agriculture and Agri-Food Canada, 2013). Buckwheat's versatile nutrient profile and low GI characteristics may also prove to be beneficial for consumers that are continuously in search of the next 'superfood' that boasts of various health benefits (Agriculture and Agri-Food Canada, 2012; Fox News Health, 2014).

2.6.3 Metabolic Effects of Buckwheat

Buckwheat has been identified as having a low GI and research has supported its role in lowering post prandial blood glucose levels (Foster-Powell et al., 2002). When Kawa et al (2003) ran a series of experiments on rats, they determined that diabetic induced rats showed significant declines in blood glucose 60 to 120 minutes after buckwheat concentrate was administered to them in the fed state. It should be noted that these experiments were conducted using high doses of buckwheat concentrate, and are likely not representative of the effects associated with cooked whole buckwheat groats or buckwheat flour consumption.

Additionally, these experiments were conducted on rats, and the effects observed cannot be generalized to humans.

Skrabanja et al (2001) supported the relationship between buckwheat, blood glucose levels and satiety when they discovered that post prandial blood glucose concentrations were lowered following consumption of boiled buckwheat groats compared to whole wheat bread at 15, 30, 75 and 90 minutes post ingestion ($p < 0.05$). Along with buckwheat groats, bread made with 50 % buckwheat groats was calculated to have a significantly lower GI in comparison to whole wheat bread. Satiety scores of BW groats were in agreement with previous research conducted by Arumugam et al (2001). Hunger scores were significantly lower in buckwheat groats in comparison to whole wheat bread after 70 minutes and up to 120 minutes following ingestion of the test meals ($p < 0.05$). Stringer et al (2013) supported these findings by demonstrating that appetite suppressing hormones following buckwheat consumption were elevated in comparison to rice crackers following buckwheat consumption (Stringer et al., 2013).

On the contrary, Kang and colleagues (2001) did not find increased satiety occurred in 11 normal weight participants following buckwheat consumption (Kang, Kim, Jung, Kim, and Kim, 2001). Although post prandial blood glucose and insulin responses were found to be significantly lowered following buckwheat intake in comparison to whole grain polished rice, researchers found no significant differences in hunger ratings between the two grains among participants (Kang et al., 2001). The lack of consistency between blood glucose levels and satiety in the research may be indicative that other mechanisms in food components may influence satiety apart from blood glucose levels, such as fibre and resistant starch content. Additionally, inconsistent methodology between appetite studies could also lead to inconclusive results. Future research needs to be conducted with consistent methodology to develop a greater understanding of the satiating properties of buckwheat.

Consumption of whole grains, such as buckwheat, hold potential for decreasing prevalence of diabetes, obesity and other chronic diseases throughout Canada through extended satiety. Standardization of methodology continues to be a limitation within the literature and it should

be focussed on in order to increase validity and reliability of the research presented. Future research should be done conducted in order to strengthen the evidence supporting the relationship between GI, satiety and food intake.

2.6.4 Mechanisms for Glucose Control

One proposed mechanism involved in buckwheat's glucose lowering abilities is D-chiro inositol (D-CI). D-CI is a rare isomer of vitamin B8 that is naturally found in lupine, pigeon pea, soybeans, chickpeas, mungbeans and buckwheat, with buckwheat containing the second highest concentrations next to mungbeans (Kawa, 2003). Both common buckwheat and tertiary buckwheat contain significant amounts of D-CI derivatives (known as fagopyritols).

Although its mechanism is not well understood, D-CI is thought to be a component of a secondary messenger for insulin and facilitate a decrease in blood glucose concentrations (Kawa et al., 2003; Yao et al., 2008). The glucose lowering benefits of dietary D-chiro inositol in buckwheat have been demonstrated in animal studies. Kawa (2003) determined that after feeding two groups of diabetic rats in fed state a specific dose of buckwheat concentrate (consisting of 10 or 20 mg/kg of body weight of d-chiro inositol), there was a significant decrease in blood glucose levels at 30, 60, 90 and 120 minute intervals in both buckwheat conditions ($p < 0.05$) compared to the control group. No significant findings were evident in fasted diabetic rats who were given the same dose of buckwheat concentrate prior to glucose administration. The glucose lowering benefits were noted in healthy rats in fed state who had subsequent glucose administration, but significant decreases in blood glucose levels were only seen 30 minutes after a glucose injection occurred. These findings are indicative that D-chiro inositol may only prove to be effective in lowering blood glucose in specific conditions.

Similar findings regarding the beneficial properties of D-CI were supported by Yao and his colleagues (2008). Throughout a five week duration, diabetic induced mice who were treated with various doses of enriched buckwheat bran extract (containing a concentrated source of D-CI inositol), showed visible decreases in blood glucose levels when compared to non-treated diabetic rats in all conditions (Yao et al., 2008).

Buckwheat's glucose lowering abilities shows promising potential as a natural means for people with diabetes to help manage their blood glucose levels. When Min-Jung Kang (2001) compared buckwheat consumption to whole grain polished rice in eleven healthy individuals, buckwheat ingestion resulted in significantly lower blood glucose levels from 30 to 90 minutes post ingestion. Serum insulin demonstrated similar results, with significant decreases occurring 40 to 90 minutes after buckwheat consumption.

Fibre may also serve as another mechanism lowering blood glucose concentrations. Kang and colleagues identified buckwheat as having significantly higher amounts of fibre in comparison to whole grain polished rice (Kang et al., 2001). Fibre's glucose lowering effects have been thought to be due to the fibre matrix minimizing the digestion of available CHO from salivary and gastric enzymes (Giacco et al., 2000).

Resistant starch (RS) can be defined as a type of starch that passes through the body undigested by amylase (Ahmed, 2013). It is another important component involved in lowering post prandial blood glucose concentrations and a key factor influencing the GI of a particular food (Skrabanja et al., 2001; Lin, Shyr and Lin, 2012). RS can decrease blood glucose levels by preventing amylase from hydrolyzing its granules and through binding available glucose molecules, thus decreasing the amount of available CHO converted into glucose (Alexander, 2012). RS can also slow the rate of glucose absorption by increasing the chyme viscosity in the small intestine (Alexander, 2012). Literature supports a negative relationship between RS content and GI (Lin, Shyr and Lin, 2012). Lin, Shyr and Lin (2012) found that when they replaced white flour in bread with increasing amounts of RS (10%,30% and 60%) in three bread products, bread with 60 % RS resulted in the lowest GI of 51 in comparison to the 30 % RS and 10 % RS, which had GIs of 68 and 70, respectively (Lin, Shyr and Lin, 2012).

Due to its plethora of promising glucose lowering properties, buckwheat could prove to be a great natural source for people with diabetes to help manage their blood glucose levels. However, it is important to note that in both of the studies mentioned, D-CI was present in a concentrated form, and the concentration of D-CI would be significantly lower if buckwheat was consumed in its whole form (ie. cooked buckwheat groats).

Starch is the major ingredient in buckwheat, and it is found primarily in the endosperm of the ancient grain (Ahmed et al., 2014). Along with its vitamin and mineral composition, the amount of starch found in buckwheat is dependent on the climate and conditions that the buckwheat is cultivated. Buckwheat has been found to contain a high amount of resistant starch, which has been identified as a key contributing factor to its low GI characteristics (Berti, Riso, Monti, and Porrini, 2004).

Resistant starch is a form of starch that amylase is unable to breakdown, therefore it passes undigested throughout the body and may be used as a nutrient source for gut bacteria while providing a mechanism for blood glucose control (Ahmed et al., 2014). Research has demonstrated that resistant starch may have the ability to act as a prebiotic by fermenting into short chain fatty acids in the large intestine and providing a nutrient source for gut microflora, thus enhancing intestinal growth of 'good' gut bacteria (Christa and Soral-Śmietana, 2008).

Through their observations of *in vitro* starch hydrolysis, Skrabanja et al (2001) found that buckwheat groats contained the highest amount of resistant starch, followed by bread made with 70% buckwheat groats (Skrabanja et al., 2001). The lowest amount of resistant starch was found in 70% buckwheat flour. Resistant starch in buckwheat was also found to contribute to glucose lowering benefits *in vivo*. It has been shown that consumption of buckwheat groats and buckwheat based bread products resulted in significant declines in post prandial blood glucose levels in comparison to post prandial blood glucose levels in the wheat bread (Skrabanja et al., 2001). The results from this study supported the role that buckwheat groats and breads predominantly made with buckwheat flour could play in reducing incidences of diabetes. Christa and colleagues reported that resistant starch in uncooked buckwheat accounted for 33-38% % of total starch present, however the amount of resistant starch declined to approximately seven to ten percent of total starch once it was cooked (Christa and Soral-Śmietana, 2008). Approximately 4-7% of starch in buckwheat can be formed into retrograded starch following the boiling of buckwheat groats (Wijngaard and Arendt, 2006). However, from the findings reported by Christa et al (2008), it can be assumed that other forms of resistant starch (apart from retrograded starch) are present in the BW groats, resulting in the decline in resistant starch content observed.

Isolated buckwheat protein has also been found to offer a plethora of health benefits. Administration of an isolated buckwheat protein product has been found to result in an improved cholesterol profile, offer constipation relief, decrease incidence of gallstone formation and decrease prevalence of cancer cell proliferation (Kayashita, Shimaoka, Yamazaki, and Kato, 1995; Z. Liu et al., 2001; Préstamo, Pedrazuela, Penas, Lasunción, and Arroyo, 2003; Tomotake et al., 2000).

Zhang and colleagues also saw the beneficial effects of buckwheat on decreasing cardiovascular risk factors when they took serum samples of 961 participants who originated from two nearby communities in Mongolia. Both communities shared similar characteristics including rates of smoking, drinking, levels of income, and education. The only significant difference in diet was the staple grain consumed, which was predominantly buckwheat or corn. The community that consumed buckwheat was found to have significantly lower rates of hypertension, and serum glucose concentrations ($p < 0.01$). Researchers also found a significant relationship between cholesterol and LDL levels in males, but not females (Zhang et al., 2007). These results are in support of He et al (1995) and are indicative that incorporating buckwheat into the diet could offer a plethora of health benefits and help minimize chronic disease among the Canadian population.

2.7 Couscous

2.7.1 Couscous: Description of Products and Consumption Patterns

Couscous is a native dish of North Africa is thought to have dated as far back as the 11th century, however the first evidence of couscous in the literature was not found until the 15th century (Oxford Symposium of Cooking, 1989). Couscous can be made in a variety of different ways. Durum wheat is a staple grain in North West African regions and couscous is commonly made from processing durum wheat into semolina flour which is then used to create couscous (Bekhouche, Merabti and Bailly, 2013; Rahmani, 1995; Public Works and Government Services of Canada, 2015). In Canada, Canadian Western Amber Durum Wheat is the staple grain used to make semolina for pasta and couscous (Canadian Grain Commission, 2015). In North America, durum wheat can also be used to make pastas, including macaroni and spaghetti, and

in Africa some durum wheat is used to create breads, however production is limited (Agriculture and Agri-Food Canada, 2007a).

Dried couscous is traditionally made by hand. The process begins by sprinkling a bowl of whole grain flour (commonly durum semolina) with salty water while making circular movements with the bowl to allow the mixture to coagulate into balls (Oxford Symposium of Cooking, 1989, Public Works and Government Services of Canada, 2015). The granules are then rolled by hand and left to dry. Next, the granules are sieved multiple times to create small, uniform granules. Sizes of granules range from 1-3 mm in width, depending on the area that it is made (Oxford Symposium of Cooking, 1989). The granules are then dried and stored for later use, or cooked by steaming in a sealed colander. Other couscous preparations have been reportedly cooked with milk and egg to enhance nutritional value, flavoring and color (Coskun, 2013). Once the couscous is cooked, it is commonly served with meat and vegetable dishes or with vegetable sauces (Public Works and Government Services of Canada, 2015; Debbouz and Donnelly, 1996). Couscous can also be served as a dessert, by sprinkling almonds, sugar and cinnamon on top of it (Coskun, 2013).

Durum wheat grows best in dry climates that have hot days and cool nights. Durum production was originally most common in areas surrounding the Mediterranean Sea. Today, durum wheat continues to be produced in North Africa, southern Europe, and Syria. In the United States, durum production commonly occurs in Dakota and Montana, while in Canada, production is most common in southern Saskatchewan and Alberta (Agriculture and Agri-Food Canada, 2007a).

With the increase in consumer interest in alternative grain options, couscous has seen a steady increase in sales since 2006 (Agriculture and Agri-Food Canada, 2012). In the United States, couscous and dried pasta sales have seen an annual growth rate of 6.6 % between 2006 and 2011, topping in at 3.3 billion in 2011 (Agriculture and Agri-Food Canada, 2014b). In Canada, the total amount of durum semolina produced has risen from 214 124 tonnes to 223 815 tonnes in a span of only two years (Statistics Canada, 2013).

Around the world, couscous is made using a variety of grains, including barley, millet, sorghum and corn (Coskun, 2013). Traditional couscous in Turkey is made by mixing together bulgur, milk and flour (Çelik, Işık, and Gürsoy, 2004). Couscous has also been said to be made of In North America, couscous is commonly purchased pre made and only needs to undergo boiling process similar to rice before it is consumed (Coskun, 2013). Similar to buckwheat, couscous is high in B vitamin and various minerals, and consists of only 100 – 120 calories per serving (1/2 cup) (Çelik et al., 2004; Coskun, 2013).

Couscous and buckwheat also have very similar nutrient profiles. For approximately two servings of grains (equivalent to one cup cooked grains or 84 g of uncooked grains), both couscous and buckwheat are approximately 300 kcals and have identical amounts of protein [(information obtained from Nutrition Facts Label (couscous) and Maxxam Analytics (buckwheat)]. Buckwheat only has minor differences in macronutrient compositions, with one more gram of fat, two more grams of fibre, one less gram of fat and two less grams of total carbohydrates in comparison to couscous.

Couscous does, however, differ in GI in comparison to buckwheat. Prepackaged couscous boiled for five minutes has a GI of 69 and is classified as having an intermediate GI, whereas dehusked buckwheat groats boiled for 12 minutes have a reported GI of 45, which is considered to be well in the low GI range (Skrabanja et al., 2001; University of Sydney, 2015a; University of Sydney, 2015b; Wolever et al., 1994) .

2.7.2 Metabolic Effects of Couscous and Other Grains

The degree of processing in grain products has been found to alter the GI of that particular food. Therefore, processing is an important factor to consider when looking at GIs of particular foods reported in the literature (Capriles, Coelho, Guerra-Matias, and Arêas, 2008; Fardet, Leenhardt, Lioger, Scalbert, and Rémésy, 2006). A higher degree of processing is characterized by grains undergoing higher temperatures and pressures (Brand et al., 1985). As mentioned previously, literature suggests that lower GI foods promote sustained satiety, while higher GI foods only promote satiety for a short time period (Arumugam et al., 2008). When considering

the satiating effects of certain grain products, it's important to not only consider the type of grain used, but to also consider the degree of processing that each grain has undergone.

Brand et al (1985) compared the starch digestibility of factory produced, highly processed grains to their minimally processed counterparts. They found that the less processed foods, including long grain rice, sweet corn and boiled potato, had undergone significantly less starch hydrolysis in comparison to the more highly processed grains that included instant rice, rice bubbles, corn chips and instant potato. In participants, consumption of the less processed grains also resulted in significantly decreased post prandial blood glucose responses (Brand, Nicholson, Thorburn, and Truswell, 1985).

Capriles and colleagues (2008) determined how processing amaranth different ways affected its rate of starch digestibility. The researchers compared the starch digestibility of cooked, popped, roasted, flaked and extruded amaranth seeds. They found that cooked, popped and extruded seeds resulted in a GI similar to that of white bread, while the more processed flaked and roasted seeds resulted in an even higher GI (Capriles et al., 2008).

The type of wheat used in product production also influences the product's GI. Pasta tends to have a low GI due to its ability to use hard wheat, such as Durum wheat, during production (Fardet et al., 2006). The resulting GI is relatively low because the starch hydrolysis of the hard wheat occurs very slowly (Fardet et al., 2006). Breads tend to have a higher GI because they usually require softer wheat that is easier for amylase to degrade (Fardet et al., 2006).

Using intact cereal grains has been found to decrease GI due to its fibrous structure protecting the inner starch granules from enzymatic degradation. The GI of bread with a higher percentage of intact barley grains was found to be lower than that of bread with a small amount of whole barley grains (Fardet et al., 2006) Similarly, boiled buckwheat groats were reported to have a lower GI in comparison to buckwheat bread made with 50 % buckwheat groats (Skrabanja et al., 2001).

When examining buckwheat groats and buckwheat flour breads, Skrabanja and colleagues (2001) found that the lowest rate of starch hydrolysis occurred in breads with the highest percentage of buckwheat groats intact, while the highest rate of starch hydrolysis were found

in the more processed buckwheat flour based breads (Skrabanja et al., 2001). It should be noted that the buckwheat groats in the study underwent hydrothermal treatment prior to being dehusked and then boiled, which played a key role in decreasing the water binding capacity of starch granules, and preventing increased starch hydrolysis (Skrabanja et al., 2001).

Commercially available, prepackaged couscous products tend to have undergone more processing in comparison to homemade couscous. Increased processing of couscous has been associated with increased shelf life, improved texture and a greater overall acceptability (Debbouz and Donnelly, 1996). However, it should be noted that Debbouz and Donnelly evaluated sensory characteristics of the homemade and commercially produced couscous with a sensory panel, and other literature has favored the sensory characteristics of homemade couscous (Coskun, 2013). Commercially produced couscous has been found to have a higher degree of gelatinized starch in comparison to homemade couscous (Debbouz and Donnelly, 1996). Starch gelatinization is characterized by a disruption in chemical structure of starch granules, resulting in increased susceptibility to enzymatic degradation and an increased blood glucose and GI (Brand et al., 1985; Debbouz and Donnelly, 1996). As previously mentioned, prepackaged couscous has been classified as a medium GI whole grain (Foster-Powell et al., 2002). It is likely that if the GI of homemade couscous were examined, it would be even lower. Future studies should aim to compare the GI of homemade and traditional couscous.

2.8 Summary

Buckwheat's reported low glycemic index cannot predict enhanced satiety due to inconclusive findings linking GI and satiety, and due to the inconsistent methodologies used in various studies. Also there is no research available investigating the satiating effects of couscous. In order to better understand the role that buckwheat and couscous play in short-term satiety and food intake they need to be tested through the use of validated methodologies supported by Health Canada (Health Canada, 2012b).

Chapter 3: Objectives and Hypothesis

3.1 Hypothesis

1. Buckwheat and couscous consumption will result in decreased subjective appetite over two hours in comparison to the water control.
2. Buckwheat consumption will increase subjective satiety and decrease subsequent food intake in comparison to the water and couscous.

3.2 Objectives

- To investigate the effect of buckwheat and couscous on *ad libitum* food intake at 120 min and subjective appetite over two hours
- To investigate the effect of buckwheat and couscous on subjective physical comfort and palatability

Chapter 4: Methods

4.1 Study design

This experiment operates using a within subject, randomized repeated measures design, as recommended by Health Canada's guidance document (Health Canada, 2012b). Participants were unaware of which treatment they will receive until the treatment is presented to them during the preload stage of the experiment.

4.2 Participants

This study included 21 healthy males, ages 18-30. This sample size was based on the ability to detect a 10 % difference in satiety rating between the test and control food (Health Canada, 2012b).

4.3 Dietary Treatments

Male participants consumed a treatment of buckwheat (300 kcal), couscous (300 kcal), or 500 mL spring water (0 kcal, energy-free control) for a total of three sessions with at least one week apart. The use of water as a negative control was necessary to observe "pure increase" in appetite and food intake within two hours and assess the caloric compensation for other two treatments that have 300 kcal energy. The calculation for caloric compensation can be found in Appendix N. The volume of water has been determined to be equivalent to the volume of the treatment meal (buckwheat or couscous) combined with the volume of water that accompanies each treatment meal. The cooking methods used to prepare buckwheat and couscous can be found in appendix E. Each test meal is prepared immediately before its consumption. The uncooked test foods were stored in a dry storage cupboard in airtight, sealed plastic bags in the appetite lab. These treatments are supported by Health Canada's Satiety Health Claim draft document, which advises that appetite studies include at least three experimental conditions, including an energy-free control (water), a control food (couscous) and the test food (buckwheat) (Health Canada, 2012b).

4.4 Experimental Protocol

This study involved a screening visit and three sessions of approximately 2.5 hours in length.

Participants were asked to participate in all 3 of the experiments. At the initial contact (over the phone or by e-mail), eligibility requirements were described to potential participants and they were asked for their age, body weight, height, if they smoke and if they are taking any medications. Breakfast skippers, smokers, dieters and individuals with food allergies, diabetes or other metabolic diseases were excluded from the study. This exclusion criteria is supported by Health Canada's Satiety Health Claim draft document, which states that participants of the study must be considered healthy in order to substantiate a functional health claim (Health Canada, 2012b).

Individuals who fulfill the eligibility requirements were asked to come to the department for a second screening and information session to complete the Baseline Information Questionnaire (Appendix B) the Eating Habits Questionnaire Form (Appendix C) and Food Acceptability Questionnaire (Appendix D), as well as the Rigid Control Dietary Restraint Form (Appendix C(i)). Individuals who regularly skip breakfast or follow a restrictive diet (score 11 or more on the Eating Habits Questionnaire) or have higher than average on the rigid control index (Appendix C(i)) were not eligible.

The height and weight were measured using stadiometer and body composition analyzer (TBF-300A, Tanita Corporation, Tokyo, Japan) in order to calculate BMI and body composition (% lean and fat tissues). Eligible individuals were asked to read and sign the Information Sheet and Consent Form (Appendix A). After this screening session, subjects that meet the eligibility criteria were scheduled to meet with us for three experimental sessions.

All male participants arrived to the laboratory between 8 am and 10 am following a 12 hour fast. They were allowed to consume water until 1 h before each session. Each participant arrived at the same chosen time for each session. Participants were instructed to refrain from alcohol consumption and any unusual exercise and activity the night before the study sessions. Upon arrival for each session, participants filled out a Sleep Habits and Stress Factors Questionnaire (Appendix F) and a Recent Food Intake and Activity Questionnaire (Appendix G) to evaluate any possible deviations that could affect the study outcomes.

4.4.1 Baseline Blood Glucose Measurement

Next, a baseline blood glucose level test was conducted with a portable glucose meter. This is the same type of device used by the individuals with diabetes to self-monitor their blood glucose at home. These devices are available to the general public at pharmacy stores and are quite easy to use for self-testing of blood glucose at multiple times throughout the day if necessary. The participants were instructed on how to perform the blood glucose test on themselves during the screening session. To test their blood glucose, participants were required to prick their finger using a lancet device that contained disposable lancet needles. For this study Accu-Chek® Multiclix or Softclix Plus lancing devices were used which contain technology to minimize pain associated with finger pricking (Roche Diagnostics, Canada). These devices have 11 customizable depth settings (0.7 to 2.2 mm) for different skin types and thereby provide virtually painless skin pricking. Participants were instructed to begin their first skin prick with the lowest setting (level 1) and proceed to higher settings until they reach the depth sufficient for the production of a drop of blood: Prior to pricking their finger, the participants were required to wipe their finger with an alcohol swab. Once a drop of blood was produced on their finger, it was blotted away to remove the alcohol and interstitial fluid within the first blood drop (which would affect the blood glucose reading on the monitor). The second drop of blood that emerged from the finger after the first drop was blotted away was placed on a test strip which had been inserted in the glucose meter. After approximately 5 seconds the blood glucose level of the participant appeared on the blood glucose meter screen. After the blood glucose level had been recorded, the test strip was discarded in a Sharps Container. Participants were assisted during the procedure to ensure that they followed previously provided instructions and to ensure that blood glucose readings were accurate. Participants were provided with their own lancet device for the duration of the study. Following each use, participants were required to sterilize the lancet devices to minimize any risk of contamination. If blood glucose concentration was above 5.5 mmol/L (suggesting that the participant has eaten within 12 hours or have glucose intolerance), he was asked to reschedule. Male participants consumed a treatment of buckwheat, couscous, or spring water for a total of three sessions with at least one week apart.

4.4.2 Subjective Appetite, Physical Comfort and Energy/Fatigue

Subjective appetite, physical comfort and energy/fatigue were measured using VAS questionnaires before consumption of the treatment (baseline) and then at 15, 30, 45, 60, 90 and 120 min after consumption of the treatment (Appendices I-K).

4.4.3 Subjective Palatability of Treatments

Following the consumption of treatments, palatability, taste, and texture of the treatments were measured using VAS (Appendix H). VAS are 100 mm lines affixed with opposing descriptions at either end. Participants mark an “X” on the line to depict their feelings at a given moment. Scores are determined by measuring the distance (mm) from the left starting point to the intersection of the “X”. VAS were validated and have been found to be reproducible (Flint, Raben, Blundell, and Astrup, 2000). Although VAS have only been found to be predictive of an isolated eating event, Health Canada emphasizes that appetite-related sensations could help prevent overeating and decrease caloric intake (Health Canada, 2012b).

4.4.4 Food Intake

At 120 min, participants were provided with a lunch meal (Deep and Delicious Pizza, McCain Foods Canada) and they were instructed to eat until they are comfortably full. The food was weighed before and after consumption to determine the weight of food consumed in grams. The amount of ingested food (grams) was converted to energy (kcal) based on the nutrition facts label provided by the manufacturer. Four McCain’s mini pizzas were cut at one time and served on a tray to each participant. Additional pizza was offered to participants 10 minutes after the first pizza tray was presented. Participants can consume as much water as they choose. Water consumption was determined by calculating the difference in the weight of water before and after it has been consumed. Participants consumed the pizza in individual cubicles located in the research food laboratory. Food and drink were presented to them under an opening in the cubicle. Participants were not be permitted to talk to each other during the period that they are consuming food and drink.

4.5 Data Analysis

A two-way repeated measures analysis of variance (ANOVA) was performed to test for time and

treatment effects and for a time-by-treatment interaction on subjective appetite. One-way repeated measures ANOVA was performed to test for the effect of treatment on food intake, average appetite for 2 hrs, physical comfort, and palatability of treatments and pizza meal. A statistical significance of $p < 0.05$ was used in all statistical procedures.

Chapter 5: Results

5.1 Subject Characteristics

24 male participants were recruited in this study. Of the 24 participants, three participants were omitted from the study because they were unable to complete the sessions and two participants were considered outliers. 19 participants successfully completed the screening and all three sessions of the study. Participant characteristics can be viewed in **Table 5.1**. Average age of participants was 22 (\pm 2.85 SD) and mean BMI of participants was 22 kg/m² (\pm 2.19 SD), with average weight of 67 kg (\pm 7.23 SD) and an average height of 1.76 m (\pm 0.08 SD). Average body fat percentage was 12.05 (\pm 3.46 SD), average FFM was 59.04 kg (\pm 5.34 SD) and average total body water was 43.2 kg (\pm 3.91).

5.2 Nutrient Composition of Dietary Treatments

The two caloric treatments were (a) Couscous (Zinda Products Canada Inc.) and (b) Buckwheat groats (East-West Foods Distribution Inc.). The portion size for the couscous treatment was 84 g (dried couscous) and consisted of 300 kcal, 1 g fat, 10 g protein, 60 g available CHO and 2 g dietary fibre. The portion size for the buckwheat groats was 84 g (dried buckwheat groats) and consisted of 300 kcal, 2 g fat, 10 g protein, 56 g available CHO and 4 g dietary fibre. The nutrient composition of the dietary treatments can be viewed in **Table 5.2**.

5.3 Nutrient Composition of Pizza Meal

Participants had their choice of Pepperoni, Cheese or Works pizza for the ad libitum pizza meal. Nutrient composition of the pizza varieties can be viewed in **Table 5.3**. The variety of pizza consumed was required to remain consistent throughout the three study sessions.

5.4 Food and Water Intake

5.4.1 Ad libitum and Cumulative FI (kcal)

There was no effect of treatment on ad libitum food intake observed throughout the study ($p=0.14$) (**Table 5.4, Figure 5.1**). There were, however, significant differences in cumulative FI (preload + test meal) between treatments ($p<0.0001$). Cumulative FI in the buckwheat and couscous treatment groups were higher in energy (kcal) in comparison to cumulative FI in the

water treatment ($p < 0.0005$). There were no differences observed in cumulative energy intake between buckwheat and couscous treatment groups ($p = 0.31$).

5.4.2 Ad libitum and Cumulative WI

There was no effect of treatment on water intake (WI) during ad libitum consumption of the pizza meal ($p = 0.47$). Increased cumulative water intake (CWI) was observed in the water treatment in comparison to CWI in buckwheat and couscous treatments ($p < 0.0001$). There were no differences in CWI observed between couscous and buckwheat treatments (**table 5.4 and figure 5.2**).

5.4.3 Total Area under the Curve Subjective Appetite Scores

There was an effect of treatment observed, where tAUC was significantly higher for the water treatment group in comparison to the buckwheat and couscous treatments ($p < 0.0001$) (**table 5.5**). There was no difference observed in tAUC between buckwheat and couscous treatments ($p = 0.93$).

5.4.4 Caloric Compensation

Average caloric compensation was 5.5 % (± 0.15 SE) for the buckwheat treatment group and 26 % (± 0.19 SE) for the couscous treatment group, however differences in energy compensation between the treatments was not significant ($p = 0.16$) (**table 5.6**).

5.5 Subjective Appetite Scores

5.5.1 Desire to Eat

There was an effect of treatment ($p < 0.0001$), time ($p = 0.0001$) and time \times treatment interaction observed on perceived DTE ($p < 0.0001$) (**Table 5.7**) (**Figure 5.3**). The water treatment resulted in increased DTE scores in comparison to the couscous and buckwheat treatments ($p < 0.001$). There was no difference observed in average DTE ratings between buckwheat and couscous treatments ($p = 0.47$). A time \times treatment interaction was observed from 15 to 60 minutes, with the water preload having a significantly higher DTE in comparison to couscous and buckwheat preloads ($p < 0.05$). At 90 minutes, buckwheat was the only treatment that had significantly lower desire to eat scores in comparison to water ($p < 0.05$). Following the preload, DTE ratings saw increases with time, which continued up to the pizza meal.

5.5.2 Hunger

There was an effect of treatment ($p < 0.0001$), time ($p < 0.0001$) and time \times treatment interactions ($p < 0.0001$) observed with average hunger scores (**Table 5.7**) (**Figure 5.4**). The water preload resulted in higher perceived hunger scores in comparison to buckwheat ($p < 0.0001$) and couscous preloads ($p < 0.0001$). There was no difference observed in perceived hunger scores between buckwheat and couscous preloads at any point in the study ($p = 0.74$). Treatment \times time interactions were observed from 15 to 90 minutes throughout the study. Perceived hunger scores were higher in the water control in comparison to couscous and buckwheat preloads at 30, 60, and 90 minutes ($p < 0.05$). Hunger scores were lower immediately following the couscous treatment in comparison to water however buckwheat did not differ between the two treatments. Following the treatment, increases in time saw increases in perceived hunger and scores continued to rise up to the pizza meal.

5.5.3 Fullness

There was an effect of treatment ($p < 0.0001$), time ($p < 0.0001$) and time \times treatment interaction ($p < 0.0001$) on perceived fullness (**Table 5.7**) (**Figure 5.5**). The water treatment elicited a lower overall perceived fullness compared to the couscous ($p < 0.0001$) and buckwheat treatments ($p < 0.0001$). The water treatment had decreased subjective fullness scores in comparison to couscous and buckwheat during the time between preload and test meal consumption. Fullness scores tended to decrease with time; following the preload, fullness ratings saw a steady decline until the test meal.

5.5.4 Prospective Food Consumption (PFC)

There was an effect of treatment ($p < 0.0001$), time ($p < 0.0001$) and time \times treatment interactions ($p < 0.0005$) on average PFC ratings (**Table 5.7**) (**Figure 5.6**). The water treatment resulted in higher ratings of PFC in comparison to the couscous and buckwheat treatments, however there was no difference in average PFC ratings between couscous and buckwheat treatments ($p = 0.94$). There was a time \times treatment interaction observed following the preload, where the water preload resulted in higher PFC ratings than couscous and buckwheat at 15, 30, 45 and 60 minutes. At 90 minutes, PFC ratings in the water treatment were only

higher than the buckwheat preload. PFC scores saw increases with time following the preload and scores continued to rise until the test meal.

5.5.5 Average appetite over 2 hours

There was an effect of treatment ($p < 0.0001$), time ($p < 0.0001$) and time \times treatment interactions ($p < 0.0001$) observed on AA scores (**Table 5.7**) (**Figure 5.7**, **Figure 5.8**). AA scores in the water treatment were significantly higher than the buckwheat and couscous treatments following preload intake and up until the pizza meal ($p < 0.05$), however AA ratings of buckwheat and couscous did not differ from one another ($p = 0.62$). Regardless of treatment, AA ratings saw increases with time following the preload and scores continued to rise up until the test meal.

5.6 Subjective Physical Comfort

5.6.1 Nausea

There was no effect of treatment on nausea scores ($p = 0.18$) (**Table 5.8**) (**Figure 5.9**). There was an effect of time ($p < 0.02$) observed; ratings of nausea were higher immediately following treatments in comparison to after the pizza meal was consumed.

5.6.2 Diarrhea

There was no effect of treatment ($p = 0.81$), time ($p = 0.34$) or time \times treatment interactions ($p = 0.86$) observed on subjective ratings of diarrhea throughout the study (**Table 5.8**) (**Figure 5.10**).

5.6.3 Gas

There was no effect of treatment ($p = 0.51$), time ($p = 0.89$) or time \times treatment interactions ($p = 0.98$) observed on subjective ratings of gas (**Table 5.8**) (**Figure 5.11**).

5.6.4 Stomach Discomfort

There was no effect of treatment ($p = 0.29$), time ($p = 0.17$) or time \times treatment ($p = 0.96$) interactions on subjective ratings of stomach discomfort observed throughout the study (**Table 5.8**) (**Figure 5.12**).

5.6.5 Wellness

There was no effect of treatment on wellness observed ($p=0.84$). There was a time effect ($p=0.0002$); higher wellness scores were observed after the ad libitum meal compared to all time points following the treatment (**Table 5.8**) (**Figure 5.13**).

5.6.6 Average Physical Comfort

There was no effect of treatment ($p=0.70$) or time \times treatment ($p=0.80$) interaction on average physical comfort scores. A time effect was observed ($p<0.005$), where lower average physical comfort scores were observed at 0, 15, 30, 45 and 90 minutes compared to scores following the test meal (**Table 5.8**) (**Figure 5.14**, **Figure 5.15**, **Figure 5.16**)

5.7 Energy and Fatigue

5.7.1 Energy

There was no effect of treatment ($p=0.20$) or time \times treatment interactions ($p=0.61$) observed on perceived energy levels. There was an effect of time on energy levels ($p=0.0001$), with energy ratings being lower at all time points prior to the test meal in comparison to energy ratings following the test meal ($p<0.05$) (**Table 5.9**) (**Figure 5.17**).

5.7.2 Fatigue

There was an effect of treatment ($p<0.02$) observed, where both buckwheat and couscous treatments resulted in lower ratings of fatigue compared to the water treatment. There was no time \times treatment interaction ($p=0.77$) observed on average fatigue scores, however there was an effect of time observed ($P=0.007$). Significantly higher perceived fatigue scores were observed prior to the preload treatment in comparison to after the pizza meal ($p<0.004$) (**Table 5.9**) (**Figure 5.18**).

5.8 Thirst

There were treatment ($p<0.0001$), and time ($p<0.0001$) effects, however no time \times treatment effect ($p=0.18$) was observed (**Figure 5.19**). Perceived thirst was higher following couscous ($p<0.0001$) and buckwheat ($p<0.0001$) preloads in comparison to the water treatment.

Perceived thirst was also found to be significantly higher following the buckwheat treatment in comparison to the couscous treatment ($p<0.04$). 30 and 60 minutes following the preload, a significant time \times treatment interaction was observed between buckwheat and water, with a

lower subjective thirst rating observed in the water treatment ($p < 0.05$). Average ratings of thirst rose following the preload and continued to increase to the pizza meal.

5.9 Relations among Dependant Measures

5.9.1 Correlations of Subjective Appetite Measures and Food Intake

All average subjective measures of appetite including desire to eat ($r = 0.55$, $P < 0.0001$), prospective food consumption ($r = 0.62$, $p < 0.0001$), and hunger ($r = 0.49$, $p = 0.0001$) were all strongly positively correlated with food intake over 120 min. Subjective fullness had a strong, negative correlation with food intake over 120 min ($r = -0.36$, $P = 0.005$) and average appetite had a strong, positive relationship with food intake over 120 min ($r = 0.54$, $p < 0.0001$) (**Table 5.10**).

5.9.2 Correlations of Average Subjective Appetite and Subjective Energy

Average subjective appetite scores were strongly correlated with subjective energy at 15 ($r = 0.50$, $P = 0.03$) and 45 minutes in the couscous treatment ($r = 0.52$, $P = 0.02$) (**Table 5.11**).

5.9.3 Correlations of Average Subjective Appetite and Subjective Fatigue

Average subjective appetite scores were negatively correlated with subjective fatigue at 0 minutes in the couscous treatment ($r = -0.55$, $P < 0.02$). Average subjective appetite scores were also related to subjective fatigue at 45 ($r = 0.52$, $P = 0.02$) and 60 minutes ($r = 0.47$, $P = 0.04$) in the water treatment (**Table 5.12**).

5.10 Palatability of Treatments and Pizza Meal

There was a treatment effect observed on average palatability scores between buckwheat and water ($p < 0.04$), with buckwheat being rated lower than the water treatment (**Table 5.8**) (**Figure 5.20**). There was also an effect of pleasantness observed ($p = 0.006$) (**Table 5.8**) (**Figure 5.21**). Significantly lower pleasantness scores were observed in the buckwheat and couscous treatments compared to the water control ($p < 0.04$), however there was no difference between caloric treatments ($p = 0.81$). No differences were observed in taste ($p = 0.19$) (**Table 5.8**) (**Figure 5.22**) and texture ($p = 0.09$) (**Table 5.8**) (**Figure 5.23**) between treatment groups. There were also no differences in the perceived pleasantness of pizza meal between the treatments ($p = 0.86$) (**Table 5.8**) (**Figure 5.21**).

Tables

Table 5.1 Participant Characteristics

Original participant number (n)	24
Final participant number (n)	19
Age (years)	22.4 ± 2.85
BW (kg)	67.3 ± 7.23
Height (m)	1.76 ± 0.08
BMI (kg/m²)	21.76 ± 2.19
FM	8.21 ± 0.63
FFM	59.0 ± 5.34
TBW	43.22 ± 3.91
Body fat (%)	12.05 ± 0.79
Restrained eating score	5.84 ± 4.18
Flexible control score	3.47 ± 2.61
Rigid control score	3.05 ± 2.48
Stress in past 24 hrs	44.15 ± 14.68
FI in past 24 hrs	44.44 ± 13.08
PA in past 24 hrs	45.52 ± 12.06

Means ± Standard Deviation, n=19. Abbreviations: BW, body weight; BMI, body mass index; FM, fat mass; FFM, fat-free mass; TBW, total body water; FI, food intake; PA, physical activity

Table 5.2 Nutritional Composition of Dietary Treatments

	Water	Buckwheat	Couscous
Energy (kcal)	0	300	300
CHO (g)	0	60	62
Available CHO (g)	0	56	60
Dietary Fibre (g)	0	4	2
Protein (g)	0	10	10
Fat (g)	0	2	1
Water (mL)	500	168	168
Total volume (mL)	500	500	500
Weight (dry) (g)	500	84	84

Information obtained from Nutrition Facts Table (couscous) and Maxaam Analytics (buckwheat).

Table 5.3 Nutrient Composition of Pizza Meal

	Pepperoni (per 87 g)	Cheese (per 81 g)	Works (per 92 g)
Calories (kcal)	180	180	170
Fat (g)	5	5	5
Sodium (mg)	400	400	400
Carbohydrate (g)	23	23	24
Fibre (g)	1	1	1
Sugar (g)	3	2	2
Protein (g)	9	10	9

Information obtained from McCain Deep 'N Delicious Mini Pizzas' Nutrition Facts Table.

Table 5.4 Food and Water Intake

	Test Meal (kcal)	Cumulative (kcal)	Total Water Intake (mL)
Control	1078.0 ± 73.9	1078.0 ± 73.9 ^a	900.4 ± 53.7 ^a
Couscous	998.6 ± 89.0	1298.6 ± 89.0 ^b	634.0 ± 45.1 ^b
Buckwheat	1059.8 ± 88.3	1409.9 ± 88.1 ^b	660.2 ± 47.7 ^b

Means ± SEM, n=19

One-way ANOVA with a Tukey Kramer post-hoc test.

Values with different letters are significantly different ($p < 0.05$).

Table 5.5 Area under the Curve Subjective Appetite Scores

Treatments	Average Subjective Appetite tAUC (mm VAS*min)
Buckwheat	7620
Couscous	7866
Water*	10,131

Abbreviations: AUC, area under the curve; tAUC, total area under the curve

Data are means ± SEM, n=19

Treatments with (*) are significantly different ($p < 0.05$)

Table 5.6 Caloric Compensation

	Buckwheat	Couscous
Caloric compensation	0.05 ± 0.19	0.26 ± 0.19
Caloric compensation (%)	5%	26%

Data are means ± SEM, n=19

Table 5.7 Average Subjective Appetite Scores over 2 Hours

Scores (mm VAS)	Buckwheat	Couscous	Water
AA over 2 Hours	50.3 ± 2.0 ^a	52.2 ± 1.9 ^a	66.4 ± 1.9 ^b
DTE	49.0 ± 2.2 ^a	51.7 ± 2.1 ^a	64.9 ± 2.0 ^b
Hunger	46.4 ± 2.2 ^a	48.1 ± 2.1 ^a	62.9 ± 2.1 ^b
Fullness	47.0 ± 2.0 ^a	44.8 ± 2.0 ^a	28.2 ± 2.1 ^b
PFC	52.6 ± 2.1 ^a	53.6 ± 2.0 ^a	66.7 ± 1.9 ^b

Data are means ± SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Values with different letters are significantly different ($p < 0.05$).

Table 5.8 Average Subjective Physical Comfort Scores over 2 Hours

Scores (mm VAS)	Buckwheat	Couscous	Water
Average Physical Comfort over 2 Hours	86.1 ± 1.8	87.1 ± 1.5	86.3 ± 1.5
Nausea	10.7 ± 1.2	7.9 ± 0.9	7.9 ± 0.9
Gas	11.0 ± 1.3	8.7 ± 1.4	9.6 ± 1.3
Stomach discomfort	10.3 ± 1.1	9.6 ± 1.1	11.8 ± 1.2
Wellness	65.5 ± 1.7	64.1 ± 1.4	64.6 ± 1.4
Diarrhea	2.8 ± 0.3	2.4 ± 0.2	2.8 ± 0.4

Data are means ± SEM, n=19

Two-way ANOVA

Table 5.9 Average Subjective Energy and Fatigue

Scores (mm VAS)	Buckwheat	Couscous	Water
Energy	52.5 ± 1.6	50.3 ± 1.4	50.7 ± 1.5
Fatigue	36.2 ± 1.8	37.0 ± 1.8	42.0 ± 1.9

Data are means ± SEM, n=19

Two-way ANOVA

Table 5.10. Correlations of Subjective Appetite Measures and Food Intake

Variable	Food Intake
Desire to Eat	r=0.54*
Hunger	r=0.46*
Fullness	r=-0.35*
Prospective Food Consumption	r=0.60*
Average Appetite	r=0.52*

Pearson Correlation Coefficients (r). *Indicates significance (p<0.05)

Table 5.11 Correlations of Average Subjective Appetite and Subjective Energy

Time	Couscous	Buckwheat	Control
0 min	r=0.29	r=0.07	r=0.37
15 min	r=0.50*	r=0.22	r=0.24
30 min	r=0.27	r=0.42	r=0.38
45 min	r=0.52*	r=0.26	r=-0.10
60 min	r=0.12	r=0.42	r=-0.32
90 min	r=-0.01	r=0.23	r=0.04
120 min	r=-0.20	r=0.03	r=-0.10
145 min	r=0.18	r=-0.15	r=0.11

Pearson Correlation Coefficients (r). *Indicates significance (p<0.05)

Table 5.12 Correlations of Average Subjective Appetite and Subjective Fatigue

Time	Couscous	Buckwheat	Control
0 min	r= -0.45*	r=-0.11	r=0.08
15 min	r= 0.08	r=0.02	r=0.32
30 min	r= -0.26	r=0.02	r=0.12
45 min	r=-0.28	r=-0.00	r=0.52*
60 min	r= -0.26	r=-0.03	r=0.47*
90 min	r= 0.06	r=0.01	r=0.26
120 min	r= 0.10	r=0.15	r=0.30
145 min	r=-0.16	r=-0.18	r=0.11

Pearson Correlation Coefficients (r). *Indicates significance ($p<0.05$)

Table 5.13 Average Palatability of Treatments: Pleasantness, Tastiness and Texture

Scores (mm VAS)	Buckwheat	Couscous	Water
Pleasantness	26.8 ± 5.18 ^a	33.8 ± 6.73 ^a	50.69 ± 5.10 ^b
Tastiness	23.7 ± 5.72	25.7 ± 6.70	35.2 ± 5.64
Texture	33.5 ± 5.93	36.7 ± 6.54	48.5 ± 5.18
Average palatability	27.2 ± 5.07	31.9 ± 5.86	45.5 ± 4.48
Average pizza meal pleasantness	76.0 ± 4.73	74.7 ± 3.82	77.6 ± 3.88

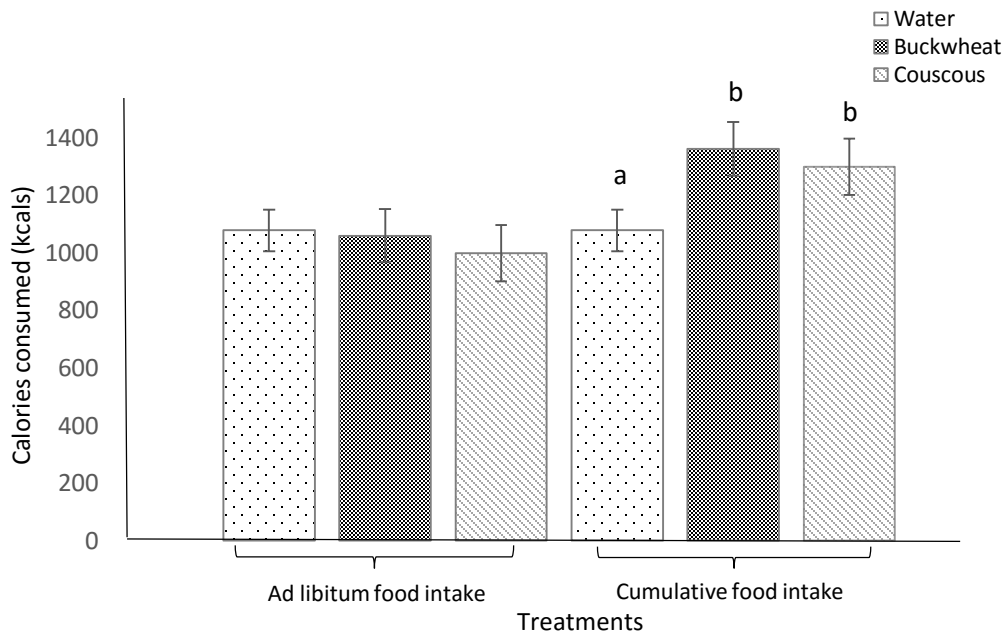
Data are means ± SEM, n=19

One-way ANOVA with a Tukey Kramer post-hoc test.

Values with different letters are significantly different ($p<0.05$).

Figures

Figure 5.1 Ad Libitum and Cumulative Food Intake (kcal)

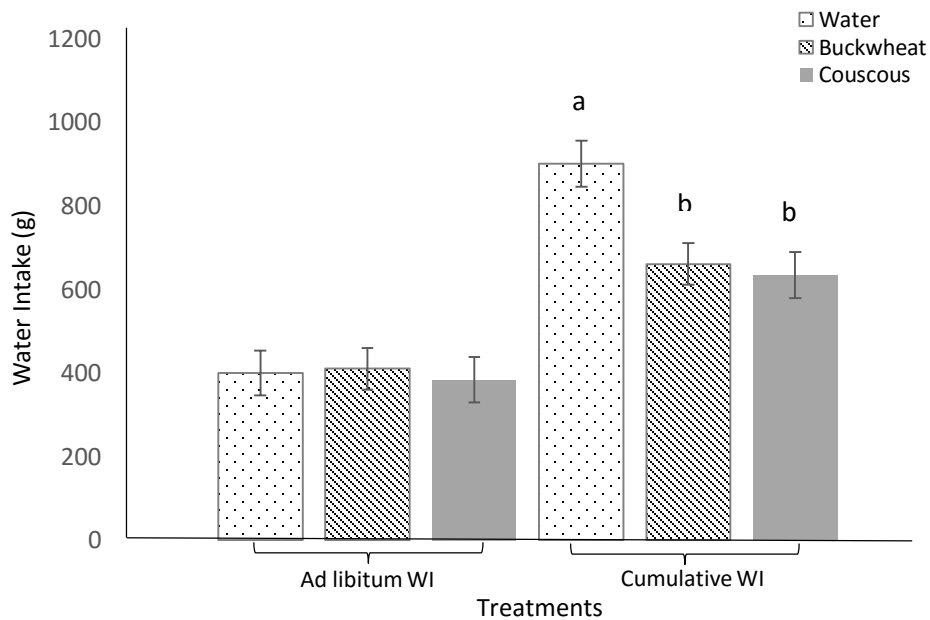


Means \pm SEM, n =19

A one-way ANOVA with Tukey Kramer post-hoc test.

Bars with different superscript letters are significantly different ($p < 0.05$).

Figure 5.2 Ad Libitum and Cumulative Water Intake (g)

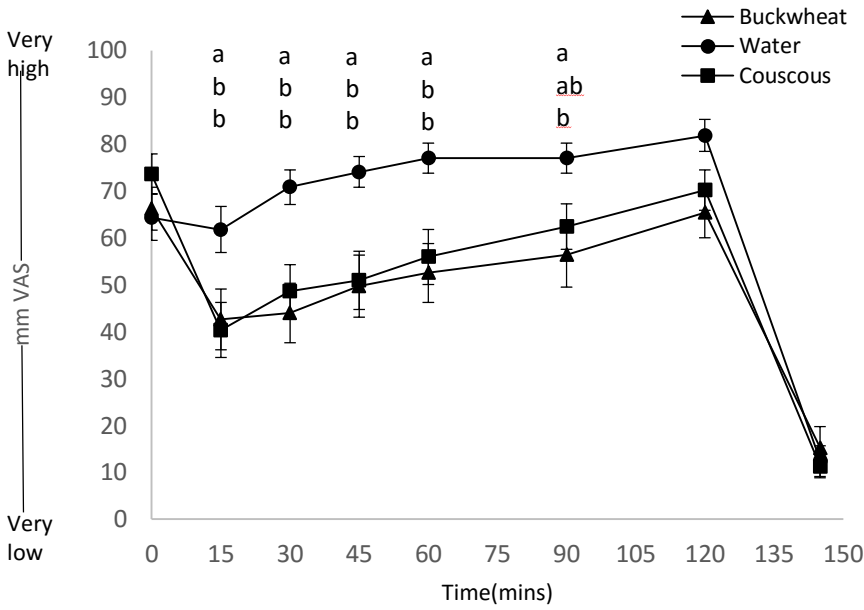


Means \pm SEM, n =19

A one-way ANOVA with Tukey Kramer post-hoc test.

Bars with different superscript letters are significantly different ($p < 0.05$).

Figure 5.3 Subjective Desire to Eat over 2 Hours

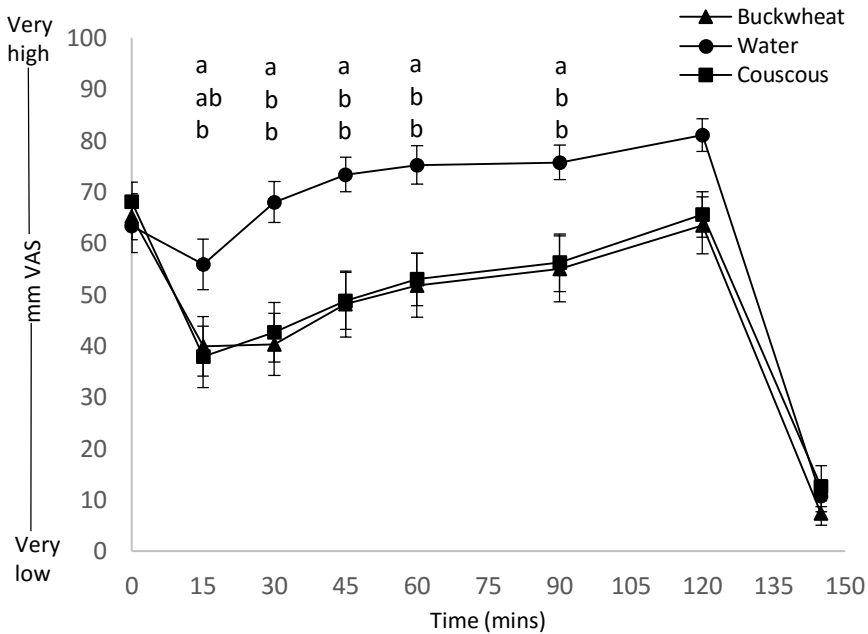


Means \pm SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Values with different superscript letters are significantly different ($p < 0.05$).

Figure 5.4 Subjective Hunger over 2 Hours

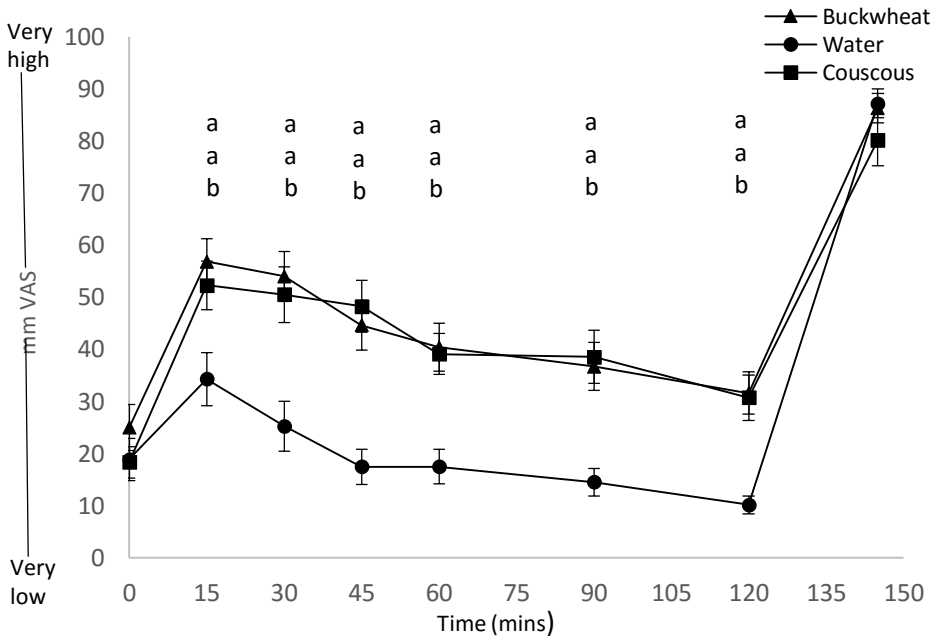


Means \pm SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Values with different superscript letters are significantly different ($p < 0.05$).

Figure 5.5 Subjective Fullness over 2 Hours

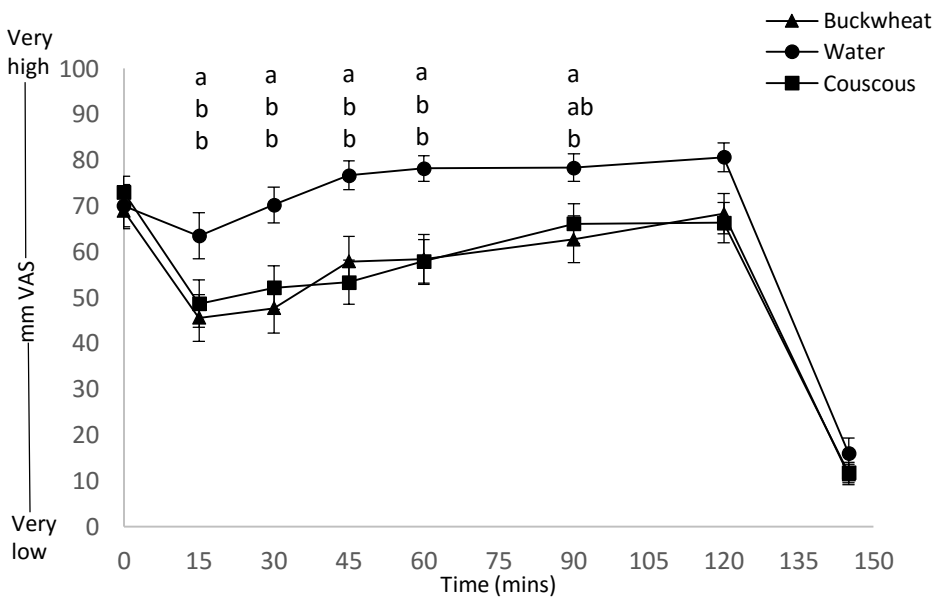


Means \pm SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Values with different superscript letters are significantly different ($p < 0.05$).

Figure 5.6 Subjective PFC over 2 Hours

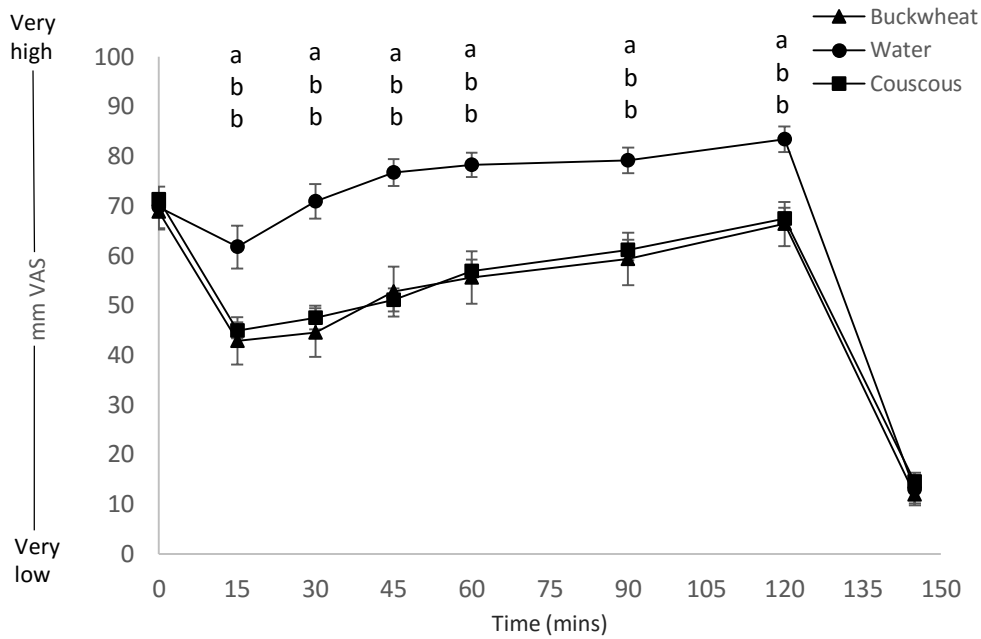


Means \pm SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Values with different superscript letters are significantly different ($p < 0.05$).

Figure 5.7 Subjective Average Appetite over 2 Hours



Means \pm SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Values with different superscript letters are significantly different ($p < 0.05$).

Figure 5.8 Subjective Appetite Variables over 2 Hours

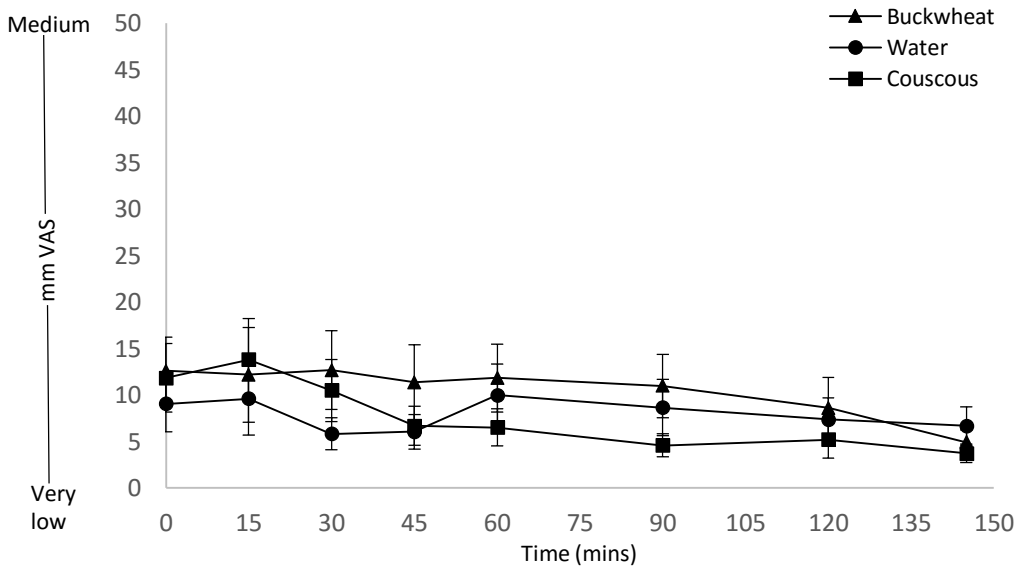


Means \pm SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Bars with different superscript letters are significantly different ($p < 0.05$).

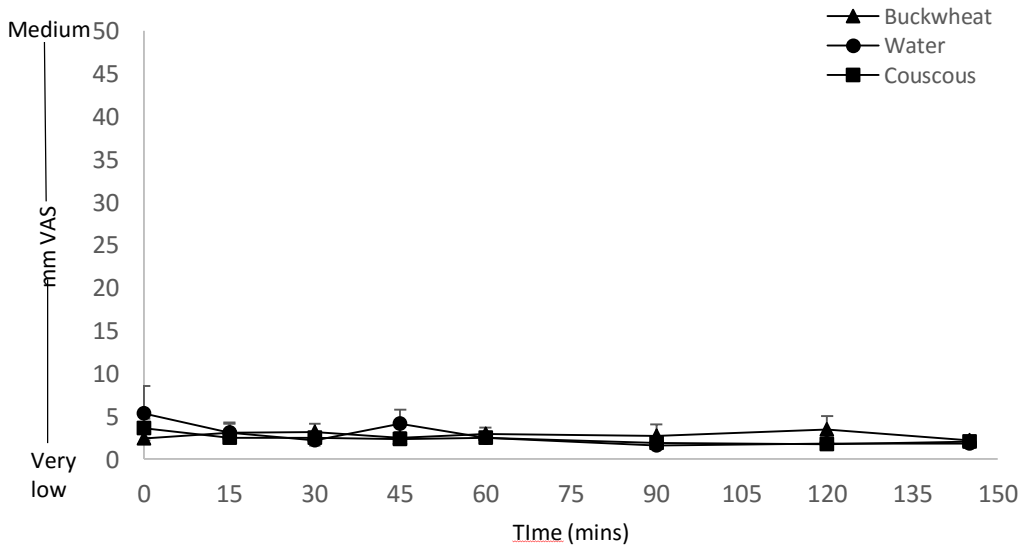
Figure 5.9 Subjective Nausea over 2 Hours



Means ± SEM, n=19

Two-way ANOVA

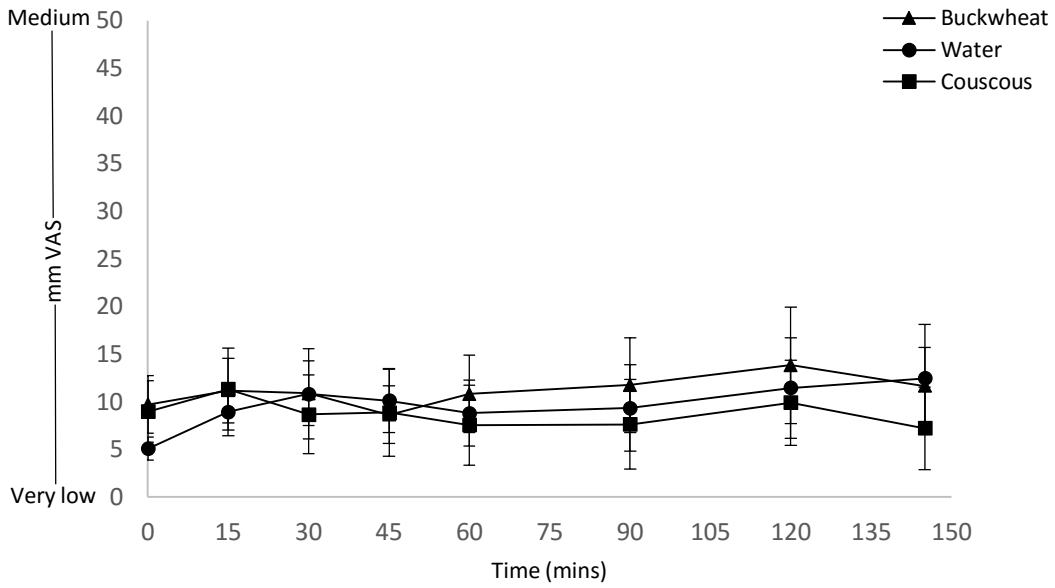
Figure 5.10 Subjective Diarrhea over 2 Hours



Means ± SEM, n=19

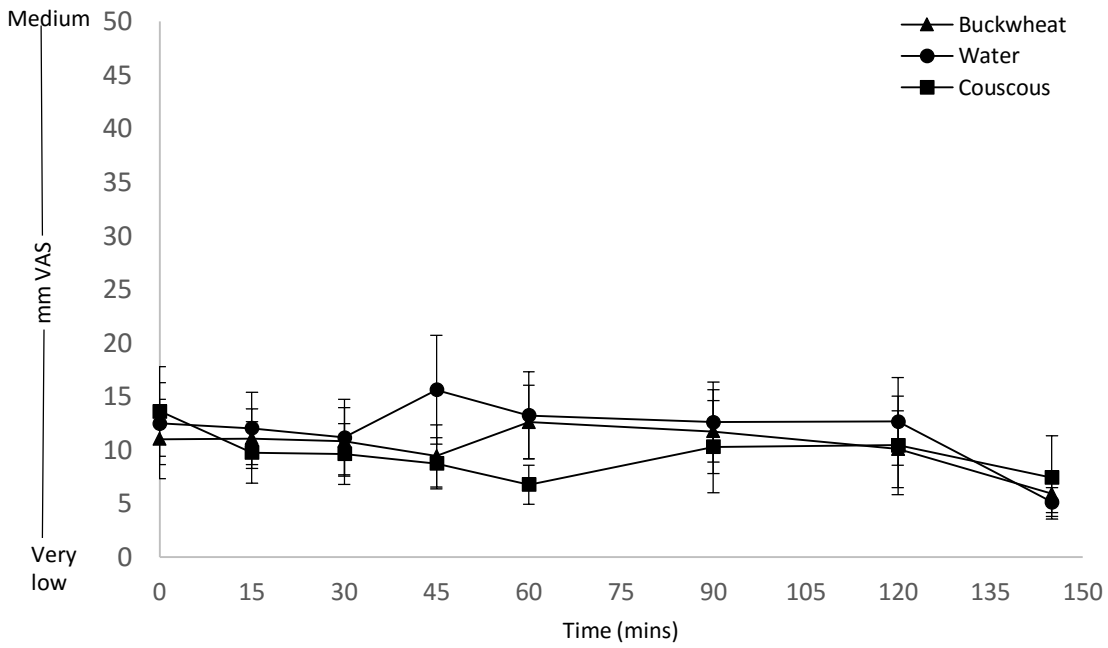
Two-way ANOVA

Figure 5.11 Subjective Gas over 2 Hours



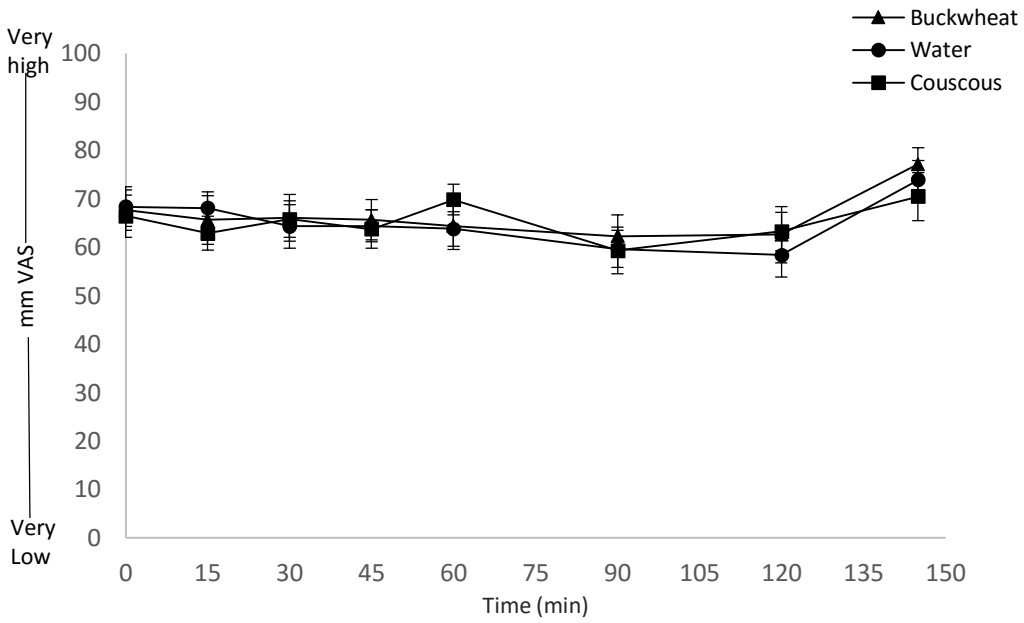
Means \pm SEM, n=19
Two-way ANOVA

Figure 5.12 Subjective Stomach Discomfort over 2 Hours



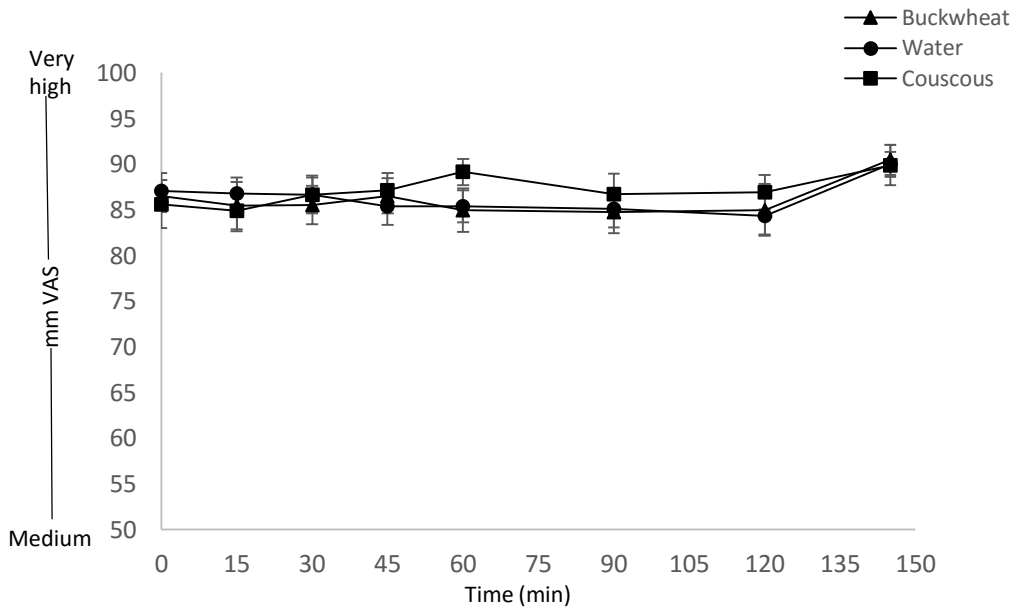
Means \pm SEM, n=19
Two-way ANOVA

Figure 5.13 Subjective Wellness over 2 Hours



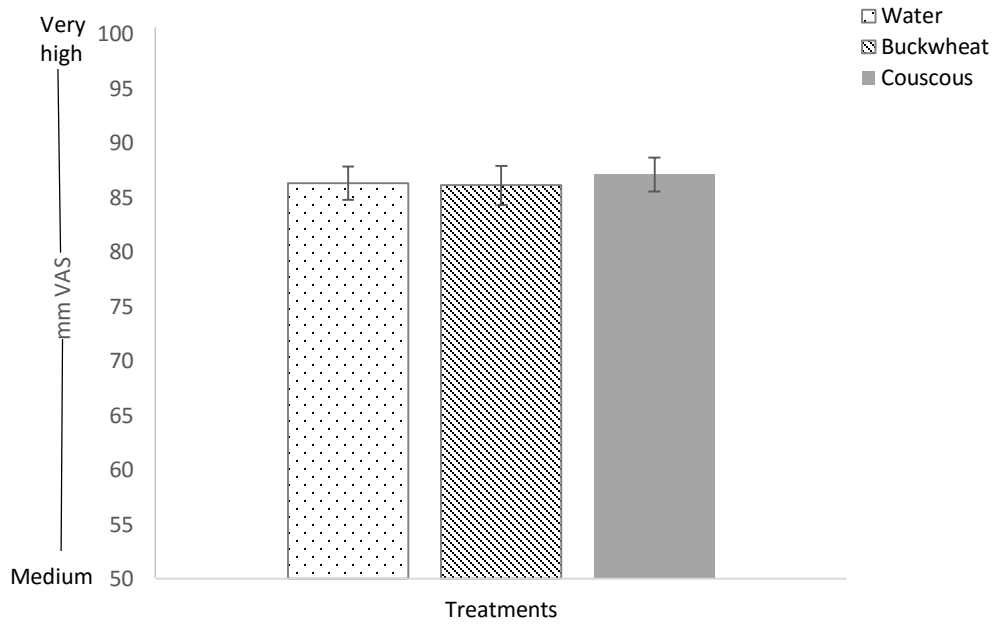
Means \pm SEM, n=19
Two-way ANOVA

Figure 5.14 Subjective Physical Comfort over 2 Hours



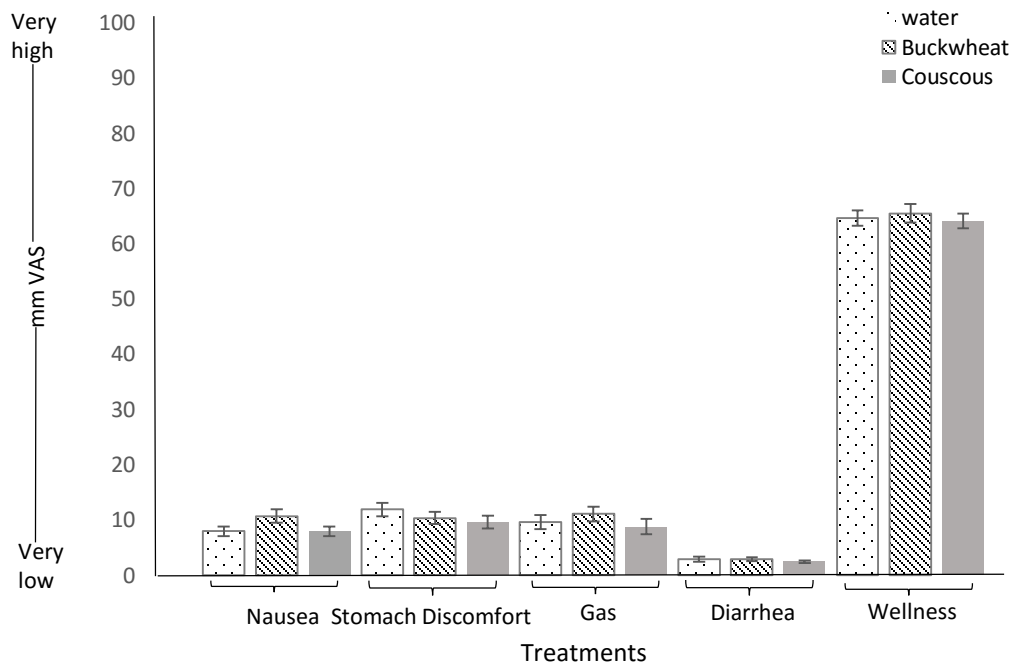
Means \pm SEM, n=19
Two-way ANOVA

Figure 5.15 Average Subjective Physical Comfort over 2 Hours



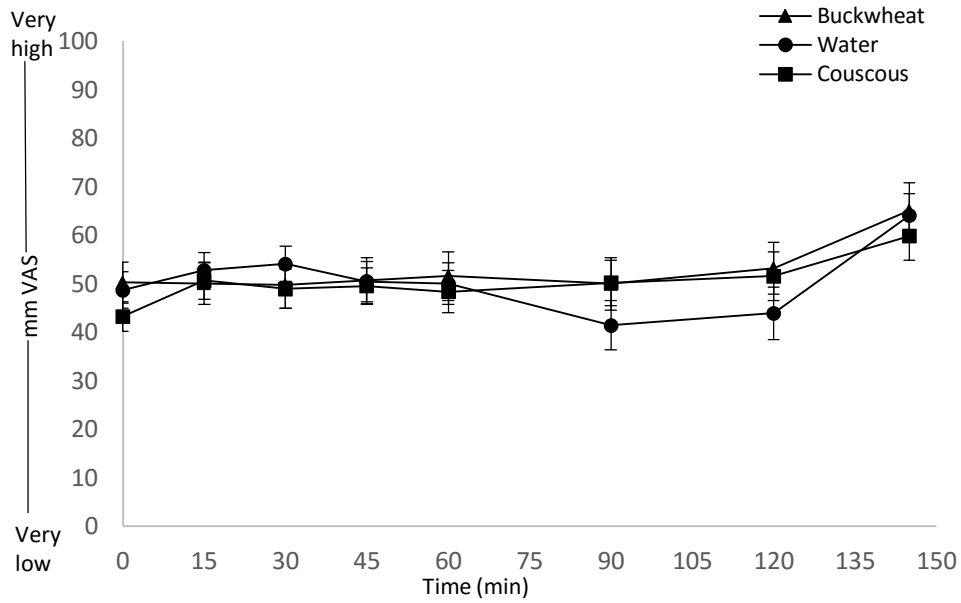
Means ± SEM, n=19
Two-way ANOVA

Figure 5.16 Subjective Physical Comfort Variables over 2 Hours



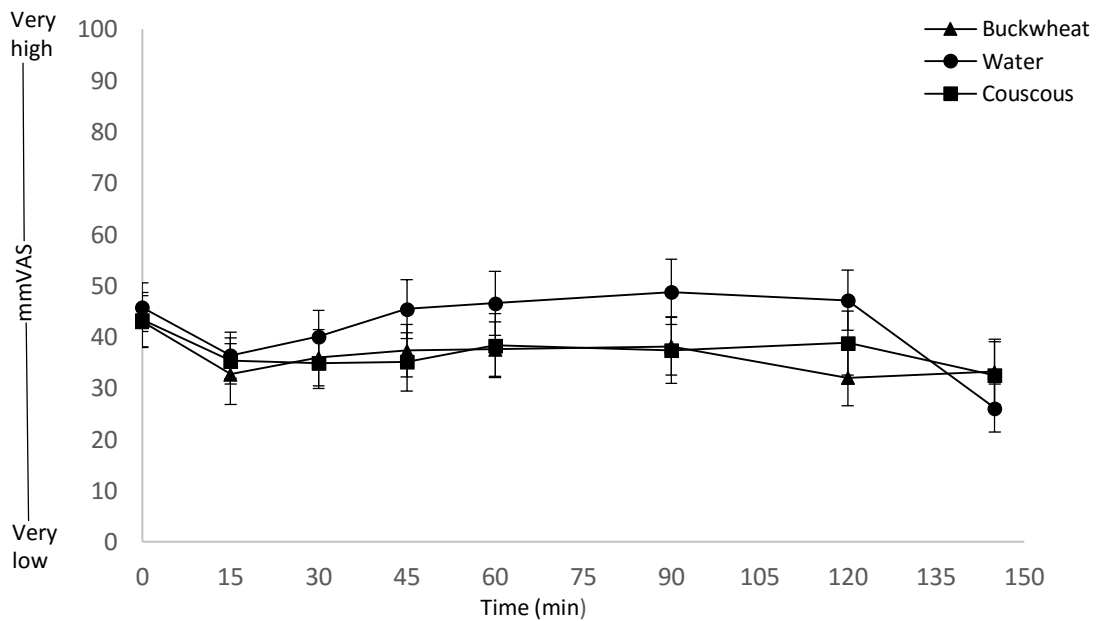
Means ± SEM, n=19
Two-way ANOVA

Figure 5.17 Subjective Energy over 2 Hours



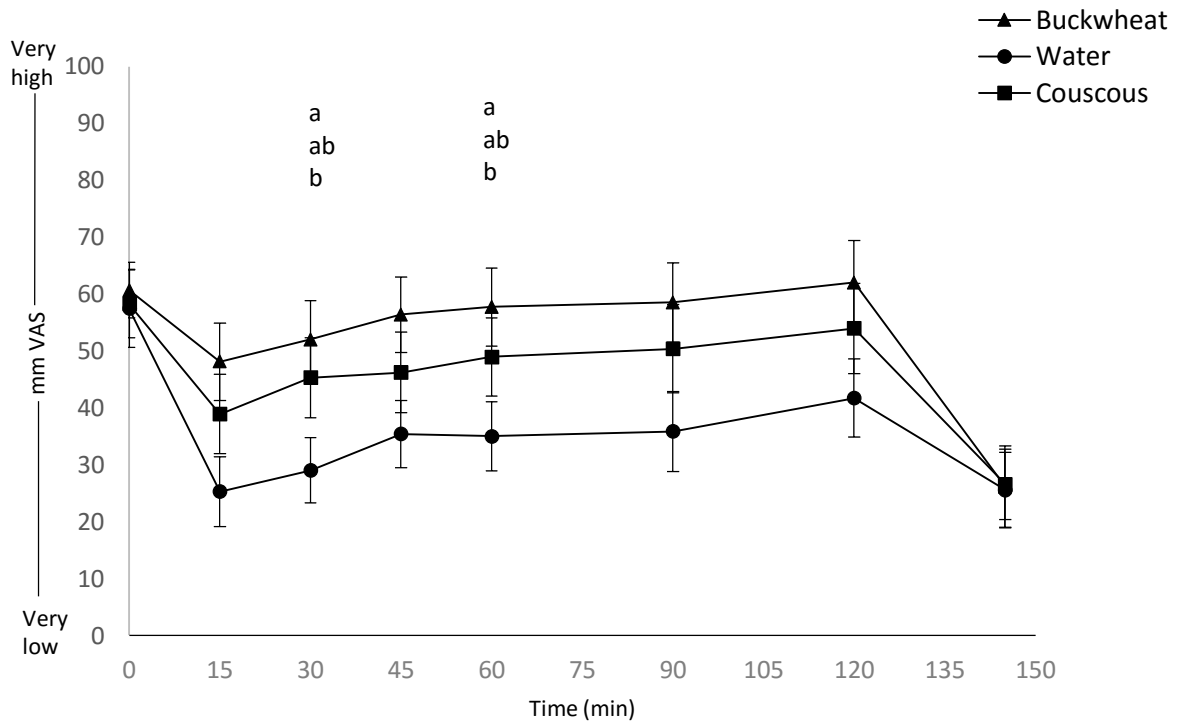
Means \pm SEM, n=19
Two-way ANOVA

Figure 5.18 Subjective Fatigue over 2 Hours



Means \pm SEM, n=19
Two-way ANOVA

Figure 5.19 Subjective Thirst over 2 Hours

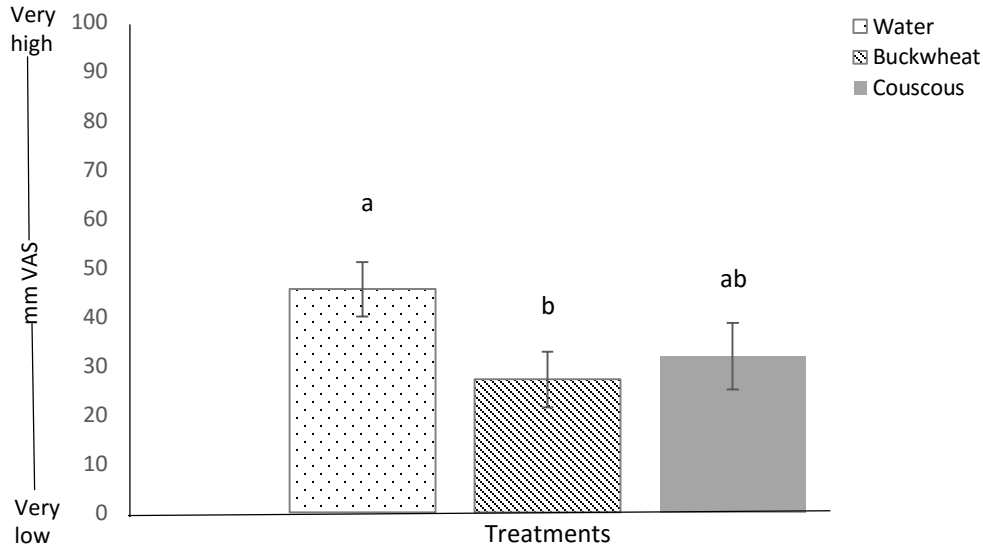


Means \pm SEM, n=19

Two-way ANOVA with a Tukey Kramer post-hoc test.

Values with different superscript letters are significantly different ($p < 0.05$).

Figure 5.20 Average Palatability of Treatments

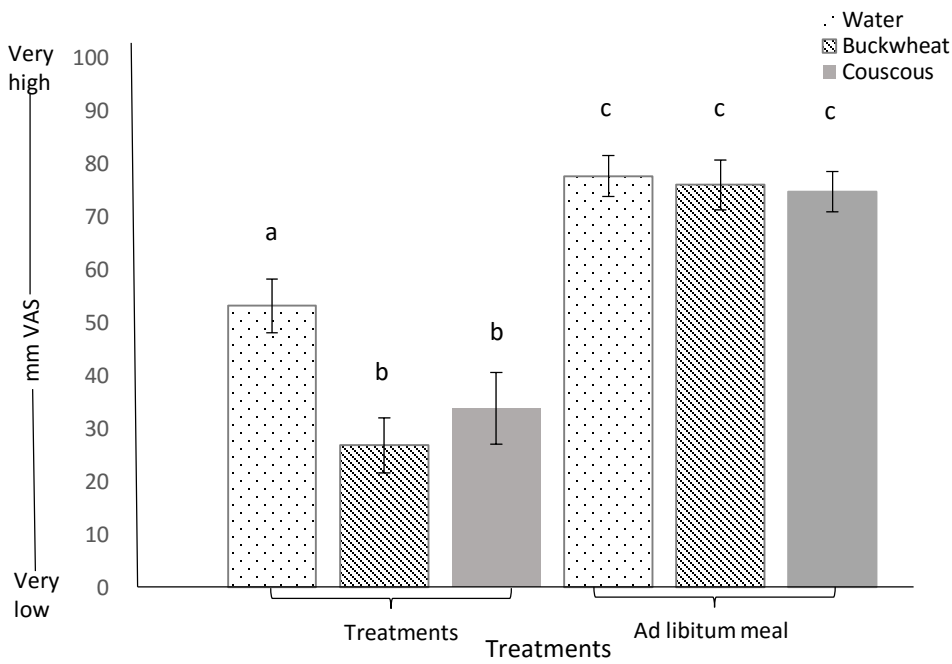


Means \pm SEM, n=19

One-way ANOVA with a Tukey Kramer post-hoc test.

Bars with different superscript letters are significantly different ($p < 0.05$).

Figure 5.21 Average Pleasantness of Treatments and Pizza Meal

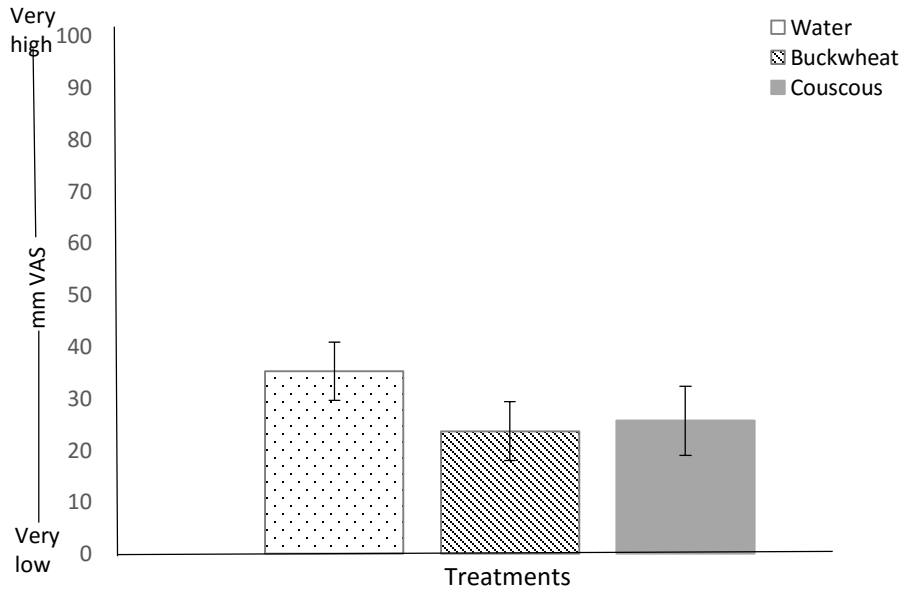


Means \pm SEM, n=21

One-way ANOVA with a Tukey Kramer post-hoc test.

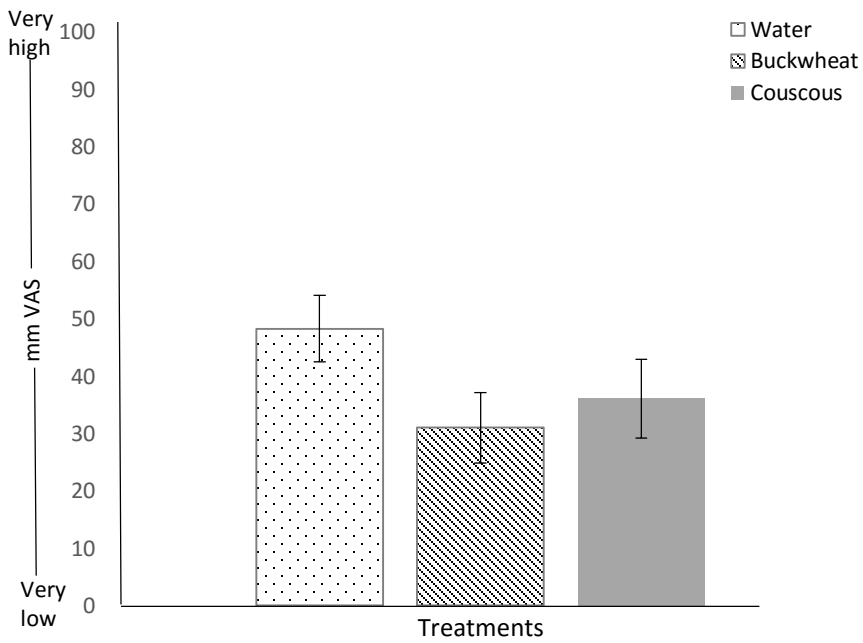
Bars with different superscript letters are significantly different ($p < 0.05$).

Figure 5.22 Average Taste of Treatments



Means \pm SEM, n=19
One-way ANOVA.

Figure 5.23 Average Texture of Treatments



Means \pm SEM, n=19
One-way ANOVA.

Chapter 6: Discussion

6.1 Glycemic Index and Subjective appetite

The results support the first hypothesis of the current investigation, which stated that buckwheat and couscous consumption would result in decreased subjective appetite over two hours. Consumption of both buckwheat and couscous preloads resulted in 23 and 22% lower average appetite ratings compared to water control, respectively. These findings are logical, considering the water preload acted as an energy free control that did not contribute to increased energy intake.

There was no difference observed in average appetite scores between couscous and buckwheat at any point throughout the investigation. These findings did not support our hypothesis that buckwheat, being a low GI food, would initiate increased subjective satiety in comparison to couscous, a medium GI food. There is a possibility that the duration of the study was too short to observe the satiating effects of buckwheat. Literature supports high GI foods having a more satiating short term effect (1 hour) after their consumption, while consumption of low GI foods may result in increased satiety for up to six hours following food intake (Anderson and Woodend, 2003). It was interesting to see in this study that the average subjective appetite returned back to the baseline within 30 minutes after consumption of the energy free control while the appetite ratings following buckwheat and couscous treatments stayed well below the baseline (Fig 5.7). Therefore, it is possible that the suppression of food intake could occur within the first 30 minutes following buckwheat and couscous consumption.

One of the limitations in this study was that the values of GI were used and not experimentally determined for the treatments used in this study. Therefore the values may not accurately reflect the nature and processing of the products used in this study. On the other hand, the cited values of GI for buckwheat and couscous were based on the previous studies that used standardized, validated GI methodology that is recognized internationally (Skrabanja et al., 2001; The University of Sydney, 2015a; The University of Sydney, 2015b; Wolever et al., 1994). Therefore, it was acceptable to use these referenced GI values in our classification of buckwheat as a low GI food and couscous as medium GI food.

6.2 Subjective Satiety and Food Intake

Although there were significant differences in appetite ratings between the energy free and energy containing treatments, these findings were not reflective in the food intake observed during the ad libitum pizza meal. Interestingly, there were no differences in food intake between any of the treatments. These findings contradict the notion that appetite ratings are strongly predictive of subsequent food intake (Holt and Miller, 1995). It is surprising that the water control did not result in increased ad libitum food intake during the pizza meal and these findings do not support the theory that rises in blood glucose following food intake are predictive of declines in subsequent short term food intake (Anderson and Woodend, 2003; Mayer, 1953). However, some literature has come to similar conclusions. Schroeder and colleagues (2009) found that significantly different appetite scores between treatments did not result in differences in ad libitum food intake between treatment groups (Schroeder et al., 2009). There is a possibility that other factors apart from physiological effects were responsible for the unpredictable food intake that was observed and they will be touched on below.

6.3 Ad libitum Food Intake

This study is the first of its kind to assess ad libitum food intake following preloads consisting of a fixed amount of buckwheat groats, couscous and a water control, so it is difficult to compare these findings with others in the literature. However, some literature has not observed any differences in ad libitum food intake between treatments differing significantly in macronutrient and fibre content or GI. For instance, Stewart et al (1997) found no difference in food intake when participants consumed preloads that differed significantly in GI (Stewart et al (1997). Additionally, Schroeder and colleague (2009) found no differences in food intake when comparing preloads primarily consisting of whole grain wheat, whole grain barley and refined rice over a 3.5 hour period (Schroeder et al., 2009). There is also a possibility that the duration of this study may not have been sufficient to observe the satiating effects of fibre, which has been observed to be over two hours in multiple studies (Nilsson, Östman, Holst, and Björck, 2008; Raben, Christensen, Madsen, Holst, and Astrup, 1994; Slavin and Green, 2007). However, it is important to note that dietary fibre in caloric treatments only differed by 2 grams in our

study. Therefore, if fibre were to exert its satiating effects hours following consumption, food intake likely would not differ significantly between the two caloric treatment groups.

There is also a possibility that the underlying mechanisms contributing to satiety are not primarily due to sustained blood glucose levels, but rather other components in food, such as the fibre or protein content. Many studies supporting the satiating benefits of low GI foods failed to control for protein and fibre content, while other studies controlling these factors saw no satiating benefits of low GI foods (Alfenas and Mattes, 2005; Aston, Stokes and Jebb, 2008; Holt and Miller, 1995; Wolever and Brand-Miller, 2006). The latter findings are similar to those of the current investigation; macronutrient composition and fibre content was similar in both caloric treatments, however buckwheat was not shown to offer any enhanced satiety. The most important finding of this study is that both grain treatments, buckwheat and couscous consumed in reasonably high amount (300 kcal), did not lead to lower food intake compared to water control.

6.4 Cumulative Food Intake and Caloric Compensation

The significantly higher cumulative caloric FI in buckwheat and couscous treatment groups compared to the water control is indicative that the caloric treatments failed to reduce ad libitum food intake, and this effect can also be observed when looking at caloric compensation.

Caloric compensation was found to be higher in the couscous treatment in comparison to the buckwheat treatment, however average caloric compensation for couscous was still fairly low, averaging less than 30 %. Caloric compensation in the buckwheat group was 5.5 %, indicating that compensation was almost negligible during the ad libitum meal.

6.5 Ad libitum and Cumulative Water Intake

The insignificant difference in ad libitum WI between treatment groups is indicative that neither buckwheat nor couscous consumption resulted in elevated thirst during the ad libitum phase of the study. Interestingly, there was a time by treatment interaction observed at 30 minutes, where buckwheat was rated significantly higher in thirst compared to water. Average subjective ratings of thirst were found to be higher in buckwheat and couscous overall, however this is likely due to the increased amount of water consumed in the water preload

condition. Cumulative water intake in the water control was found to be higher than cumulative water intake in the buckwheat and couscous preloads ($p < 0.05$), however this can be explained by the extra 250 mL of water consumed in the water treatment in comparison to the buckwheat and couscous preloads.

6.6 Psychological Factors impacting Food Intake

Psychological factors may play an equally important role in satiety research as physiological mechanisms. Schiöth and colleagues (2015) demonstrated how similar expected satiety of preloads with significantly different energy content resulted in negligible differences in hunger scores and ad libitum FI between treatment groups. Other literature has found that the expected satiety of a food increases with familiarity (Brunstrom, Shakeshaft and Scott-Samuel, 2008). With these findings in mind, it could be speculated that if buckwheat was not commonly consumed among the participants, it may have initiated a lower expected satiety among participants, resulting in increased ad libitum food intake. However, this hypothesis does not account for the significant differences observed in subjective satiety ratings between the caloric and energy free preloads.

Another psychological factor that may have influenced our findings in this study was dietary restraint. Although individuals accepted into the study were found to exhibit low dietary restraint in the screening session, there is a possibility that participants who exhibited characteristics of flexible control restrained their food intake during the ad libitum meal. On the other hand, if any participants exhibited rigid control, there is a chance that they could have overeaten in the ad libitum phase of the study. Regardless of the type of dietary restraint that participants may have had, any form of dietary restraint could have impacted our investigation and influenced the negligible differences in FI observed between treatment groups in the ad libitum meal.

Sensory specific satiation may be one key factor influencing food intake in the present investigation. Blundell and colleagues (2010) noted that fullness and boredom with taste were two major reasons people reported termination of an eating event (Blundell et al., 2010). To control for macronutrient intake, the pizza meal was exclusively offered as the ad libitum lunch

meal to each participant. Since there were no other options to choose from in the lunch meal, there is a chance that participants experienced a decline in liking or wanting the pizza meal and consequentially terminated the lunch meal. These findings would support those of Havermans et al (2008) who observed sensory specific satiety among foods that had been previously consumed by participants in the session but not with foods newly introduced to participants (Havermans et al., 2008). If sensory specific satiety was a factor in the present investigation, it was not apparent in the pleasantness ratings of the pizza meal, which averaged 76 (mm VAS). There was also no session effect observed, meaning participants did not rate the pizza any lower on the third session in comparison to the first session ($p=0.83$).

Blundell and colleagues (2010) also emphasized the importance of offering preloads at appropriate times in the day (Blundell et al., 2010). Considering this, there is a possibility that offering couscous or buckwheat in the morning may not have been representative of a typical breakfast meal consumed by the participants, consequently altering the results of the present investigation. Evidently, the findings observed in this study demonstrate how psychological processes may play an equally important role in the regulation of food intake compared to physiological processes.

6.7 Palatability and Physical Comfort

Although there were no differences observed in palatability of treatments, buckwheat narrowly missed significance of being rated lower in palatability compared to the water treatment group ($p=0.059$). Buckwheat was also found to have a lower average pleasantness rating in comparison to water, which was not found with the couscous treatment. These findings indicate that buckwheat may not be accepted as readily as other food products more commonly known to Canadians, however it is important to acknowledge that there were no statistical differences in palatability and pleasantness ratings between buckwheat and couscous preloads.

Since all treatments resulted in low ratings of measures assessing physical discomfort, it can be assumed that both buckwheat and couscous were tolerated well by the participants in our study. The physical comfort ratings following buckwheat consumption were of particular

interest in this study because buckwheat is a relatively novel and under consumed crop in Canada, so it is promising to observe that its consumption does not result in adverse physical symptoms.

6.8 Limitations

A limitation of this study is that blood glucose measurements were not taken. Blood glucose levels could help explain why there was no observed differences in appetite or food intake between buckwheat and couscous throughout the study. Additionally, only males of normal weight participated in this study, therefore our results cannot be generalized to females or the overweight and obese population. Another limitation of this study is that the subsequent food intake was measured in two hours. Although this time frame was important to observe the changes in subjective appetite and find that the subjective appetite is suppressed over the first 30 min, food intake was not measured in 30 min. This could be potentially investigated in another experiment. Finally, all sessions of the investigation took place in the appetite lab and are likely not representative of natural feeding behavior, however previous studies conducted outside of the laboratory come with their own limitations. It should be noted that none of the limitations mentioned here violate the recommended methods for satiety research outlined by the Satiety Health Claims guidance document.

6.9 Practical Application

These findings are important contributions to appetite research and consumers alike. They demonstrate the inconclusive nature of foods claiming to offer appetite suppressing benefits based on their promising physiological effects on the body. These findings are timely, due to our increasing health conscious population that is constantly in search of the next 'miracle' food that can successfully curb appetite and result in sustained weight loss. They further emphasize the complexity of appetite regulation and suggest that successful reduction in appetite is dependent on a variety of processes that involve physiological, psychological and environmental factors. This investigation indicates that appetite suppression and successful reduction of food intake is not necessarily dependant on one particular 'miracle' food, but on adapting a variety of long term dietary practices and physical activity regimens. However it is

important to note that the present finding reflects only the effects observed within a certain time frame and for the certain doses of the products and therefore cannot be generalized for all eating events when buckwheat and couscous is used. These findings also indicate that buckwheat, a novel food to Canadians, could have potential in replacing more commonly consumed processed grains in the Canadian diet.

Chapter 8: Summary and Implications for Future Research

This study is, as far as we know, the first of its kind to investigate the satiating effects of buckwheat while adhering to Health Canada's satiety claims document. We determined that buckwheat, a low GI food, did not demonstrate any enhanced satiety in comparison to couscous, a food with a medium GI. Neither the ad libitum food intake, nor the subjective appetite scores were able to demonstrate that buckwheat consumption resulted in reduced appetite in comparison to the alternative grain, couscous. Although the results of this study contradict literature supporting low GI and enhanced satiety, there is also literature that is comparable to the findings of this study. Evidently, findings in satiety research remain largely inconclusive due to varying methodology conducted. Future research following the methodology proposed by Health Canada is needed to determine if findings are conclusive with our investigation.

From a physiological perspective, the findings of this study are surprising and not in support of our hypothesis that buckwheat would offer enhanced satiety in comparison to couscous. Future research should aim to measure blood glucose levels of participants throughout the study to gain a better understanding of how blood glucose levels influenced the subjective satiety ratings and ad libitum food intake observed.

Limited research has been completed regarding the palatability and physical comfort following buckwheat consumption. It is promising to see that both physical comfort ratings and palatability did not differ between couscous and buckwheat treatments in our investigation. Since buckwheat is a relatively newly introduced crop to Canadians, it is exciting to see that the grain may have potential to replace a more refined and commonly consumed grain, such as couscous, while offering the variety of proposed health benefits boasted in the literature. More studies assessing the palatability of buckwheat are needed to help gather a conclusive understanding of how buckwheat is liked by Canadian consumers.

In conclusion, incidences of overweight, obesity and diabetes continues to remain a major concern among Canadians, despite numerous prevention strategies. Additionally, a high proportion of the Canadian diet is comprised of grains, with the majority of grains consumed

being refined. Dietary interventions have been identified as a key strategy to help decrease these elevated rates, however supportive health claims made by Health Canada must be based on conclusive, evidenced based research findings. Therefore, increased research surrounding buckwheat is warranted to determine if its consumption can successfully suppress appetite in comparison to other refined grains and subsequently promote increased health among the Canadian population.

Chapter 9: Conclusion

In healthy, male adults, intake of buckwheat and couscous decreased subjective appetite for two hours compared to the energy free control, however this did not have an effect on short term food intake. Both buckwheat and couscous are well tolerated and have similar sensory characteristics.

References

- Abou-Samra, R., Keersmaekers, L., Brienza, D., Mukherjee, R., and Macé, K. (2011). Effect of different protein sources on satiation and short-term satiety when consumed as a starter. *Nutrition journal*, 10(1), 1.
- Ahmed, A., Khalid, N., Ahmad, A., Abbasi, N. A., Latif, M. S. Z., and Randhawa, M. A. (2014). Phytochemicals and biofunctional properties of buckwheat: A review. *152*(3), 349-369. doi:10.1017/S0021859613000166
- Agriculture and Agri-Food Canada. (2013). Buckwheat. Retrieved from: <http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops/pulses-and-special-crops-canadian-industry/buckwheat/?id=1174581273612>
- Agriculture and Agri-Food Canada. (2007). Canadian Buckwheat Statistics. Retrieved from: <http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops/pulses-and-special-crops-canadian-industry/buckwheat/canadian-buckwheat-statistics/?id=1174507361599>
- Agriculture and Agri-Food Canada. (2007). *Durum Wheat: 2007-2008 Situation and Outlook*. [Bulletin]. Manitoba: Agriculture and Agri-Food Canada.
- Agriculture and Agri-Food Canada. (2012). The Specialty Food Market in North America. Retrieved from: <http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-region/canada/the-specialty-food-market-in-north-america/?id=1410083148460>
- Agriculture and Agri-Food Canada. (2014). *Consumer Trends-Pasta and Couscous in the United States*. Retrieved from: <http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-region/united-states/consumer-trends-pasta-and-couscous-in-the-united-states/?id=1410083148505>

Agriculture and Agri-Food Canada. (2014b). *'Gluten-Free' Claims in the Marketplace*. Retrieved from: <http://www.agr.gc.ca/eng/industry-markets-and-trade/food-regulations/food-policy-and-regulatory-issues/reports-and-resources/gluten-free-claims-in-the-marketplace/?id=1397673574797>

Agricultural marketing resource center. (2014). Buckwheat Profile. Retrieved from: <http://www.agmrc.org/commodities-products/specialty-crops/buckwheat-profile/>

Alberta Agriculture and Rural Development. (2001). *Common Buckwheat*. Retrieved from: [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex103](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex103)

Albertson, A. M., Reicks, M., Joshi, N., & Gugger, C. K. (2016). Whole grain consumption trends and associations with body weight measures in the United States: results from the cross sectional National Health and Nutrition Examination Survey 2001–2012. *Nutrition Journal*, *15*(1), 1.

Alexander, D. (2012). Postprandial effects of resistant starch corn porridges on blood glucose and satiety responses in non-overweight and overweight adults.

Almiron-Roig, E., Flores, S. Y., and Drewnowski, A. (2004). No difference in satiety or in subsequent energy intakes between a beverage and a solid food. *Physiology and Behavior*, *82*(4), 671-677.

Anderson, G. H., Catherine, N. L., Woodend, D. M., and Wolever, T. M. (2002). Inverse association between the effect of carbohydrates on blood glucose and subsequent short-term food intake in young men. *The American Journal of Clinical Nutrition*, *76*(5), 1023-1030.

Anderson, G., and Woodend, D. (2003). Effect of glycemic carbohydrates on short-term satiety and food intake. *Nutrition Reviews*, *61*(5 Pt 2), S17-26

Arumugam, V., Lee, J., Nowak, J. K., Pohle, R. J., Nyrop, J. E., Leddy, J. J., and Pelkman, C. L. (2008). A high-glycemic meal pattern elicited increased subjective appetite sensations in overweight and obese women. *Appetite*, *50*(2), 215-222. doi:10.1016/j.appet.2007.07.003

- Aston, L. M., Stokes, C. S., and Jebb, S. A. (2008). No effect of a diet with a reduced glycaemic index on satiety, energy intake and body weight in overweight and obese women. *International Journal of Obesity*, *32*(1), 160-165.
- Ball, S. D., Keller, K. R., Moyer-Mileur, L. J., Ding, Y. W., Donaldson, D., & Jackson, W. D. (2003). Prolongation of satiety after low versus moderately high glycemic index meals in obese adolescents. *Pediatrics*, *111*(3), 488-494.
- Batterham, R. L., Cohen, M. A., Ellis, S. M., Le Roux, C. W., Withers, D. J., Frost, G. S., . . . Bloom, S. R. (2003). Inhibition of food intake in obese subjects by peptide YY3–36. *New England Journal of Medicine*, *349*(10), 941-948.
- Berti, C., Riso, P., Monti, L., and Porrini, M. (2004). In vitro starch digestibility and in vivo glucose response of gluten-free foods and their gluten counterparts. *European Journal of Nutrition*, *43*(4), 198-204. doi:10.1007/s00394-004-0459-1
- Blundell, J., De Graaf, C., Hulshof, T., Jebb, S., Livingstone, B., Lluch, A., . . . Westerterp, M. (2010). *Appetite control: Methodological aspects of the evaluation of foods*. Oxford, UK: doi:10.1111/j.1467-789X.2010.00714.x
- Bodinham, C. L., Hitchen, K. L., Youngman, P. J., Frost, G. S., and Robertson, M. D. (2011). Short-term effects of whole-grain wheat on appetite and food intake in healthy adults: A pilot study. *British Journal of Nutrition*, *106*(03), 327-330.
- Bonafaccia, G., Marocchini, M., and Kreft, I. (2003). Composition and technological properties of the flour and bran from common and tartary buckwheat. *Food Chemistry*, *80*(1), 9-15.
- Bornet, F. R., Jardy-Gennetier, A., Jacquet, N., and Stowell, J. (2007). Glycaemic response to foods: Impact on satiety and long-term weight regulation. *Appetite*, *49*(3), 535-553.
- Brand, J. C., Nicholson, P. L., Thorburn, A. W., and Truswell, A. S. (1985). Food processing and the glycemic index. *The American Journal of Clinical Nutrition*, *42*(6), 1192-1196.

- Bohdjalian, A., Langer, F. B., Shakeri-Leidenmühler, S., Gfrerer, L., Ludvik, B., Zacherl, J., & Prager, G. (2010). Sleeve gastrectomy as sole and definitive bariatric procedure: 5-year results for weight loss and ghrelin. *Obesity surgery, 20*(5), 535-540.
- Brondel, L., Romer, M. A., Nougues, P. M., Touyarou, P., and Davenne, D. (2010). Acute partial sleep deprivation increases food intake in healthy men. *The American journal of clinical nutrition, 91*(6), 1550-1559.
- Brunstrom, J. M., Brown, S., Hinton, E. C., Rogers, P. J., and Fay, S. H. (2011). 'Expected satiety' changes hunger and fullness in the inter-meal interval. *Appetite, 56*(2), 310-315.
- Brunstrom, J. M., Shakeshaft, N. G., and Scott-Samuel, N. E. (2008). Measuring 'expected satiety' in a range of common foods using a method of constant stimuli. *Appetite, 51*(3), 604-614.
- Brunstrom, J. M., and Mitchell, G. L. (2006). Effects of distraction on the development of satiety. *British Journal of Nutrition, 96*(04), 761-769.
- Canadian Diabetes Association. (2011). *Diabetes: Canada at the tipping point: Charting a new path* Canadian Diabetes Association.
- Canadian Diabetes Association. (2014). The Glycemic Index. Retrieved from: <http://www.diabetes.ca/diabetes-and-you/healthy-living-resources/diet-nutrition/the-glycemic-index>
- Canadian Grain Commission. (2015). *Canadian Wheat Classes*. Retrieved from: <https://www.grainscanada.gc.ca/wheat-ble/classes/classes-eng.htm>
- Canadian Task Force on Preventative Health Care. (2015). Task force take's on Canada's urgent childhood obesity challenge with new guidelines. Retrieved from: <http://canadiantaskforce.ca/news/2015-03-30/task-force-takes-on-canadas-urgent-child-obesity-challenge-with-new-guidelines/>

- Cani, P. D., Lecourt, E., Dewulf, E. M., Sohet, F. M., Pachikian, B. D., Naslain, D., ... & Delzenne, N. M. (2009). Gut microbiota fermentation of prebiotics increases satietogenic and incretin gut peptide production with consequences for appetite sensation and glucose response after a meal. *The American journal of clinical nutrition*, *90*(5), 1236-1243.
- Capriles, V., Coelho, K., Guerra-Matias, A., and Arêas, J. (2008). Effects of processing methods on amaranth starch digestibility and predicted glycemic index. *Journal of Food Science*, *73*(7), H160-H164.
- Carter, B. E., Monsivais, P., Perrigue, M. M., and Drewnowski, A. (2011). Supplementing chicken broth with monosodium glutamate reduces hunger and desire to snack but does not affect energy intake in women. *British journal of nutrition*, *106*(09), 1441-1448.
- Çelik, İ, Işık, F., and Gürsoy, O. (2004). Couscous, a traditional turkish food product: Production method and some applications for enrichment of nutritional value. *International Journal of Food Science and Technology*, *39*(3), 263-269. doi:10.1111/j.1365-2621.2004.00780.x
- Centres for Disease Control and Prevention. (2009). Body Mass Index: Considerations for Practitioners. Retrieved from: <http://www.cdc.gov/obesity/downloads/bmiforpractitioners.pdf>
- Christa, K., and Soral-Śmietana, M. (2008). Buckwheat grains and buckwheat products—nutritional and prophylactic value of their components—a review. *Czech J.Food Sci*, *26*(3), 153-162.
- Clemente, G., Giacco, R., Lasorella, G., Coppola, S., Trapanese, E., Torre, P., and Greco, L. (2001). Homemade gluten-free pasta is as well or better digested than gluten-containing pasta. *Journal of Pediatric Gastroenterology and Nutrition*, *32*(1), 110-113.
- Chungchunlam, S. M. S., Henare, S. J., Ganesh, S., & Moughan, P. J. (2015). Dietary whey protein influences plasma satiety-related hormones and plasma amino acids in normal-weight adult women. *European journal of clinical nutrition*, *69*(2), 179-186.

- CNW. (2015). Novo Nordisk receives Health Canada approval for Saxenda for the treatment of chronic weight management. Retrieved from: <http://www.newswire.ca/news-releases/novo-nordisk-receives-health-canada-approval-for-saxenda-liraglutide-for-the-treatment-of-chronic-weight-management-516975921.html>
- Coskun, F. (2013). Production of couscous using the traditional method in turkey and couscous in the world. *African Journal of Agricultural Research*, 8(22), 2609-2615.
- Darzi, J., Frost, G. S., and Robertson, M. D. (2011). Do SCFA have a role in appetite regulation? *Proceedings of the Nutrition Society*, 70(1), 119-128. doi:10.1017/S0029665110004039
- De Graaf, C., De Jong, L. S., and Lambers, A. C. (1999). Palatability affects satiation but not satiety. *Physiology and Behavior*, 66(4), 681-688.
- Debbouz, A., and Donnelly, B. (1996). Process effect on couscous quality. *Cereal Chemistry*, 73(6), 668-671.
- Fardet, A., Leenhardt, F., Lioger, D., Scalbert, A., and Rémésy, C. (2006). Parameters controlling the glycaemic response to breads. *Nutrition Research Reviews*, 19(01), 18-25.
- Flint, A., Raben, A., Astrup, A., and Holst, J. J. (1998). Glucagon-like peptide 1 promotes satiety and suppresses energy intake in humans. *The Journal of Clinical Investigation*, 101(3), 515-520. doi:10.1172/JCI990 [doi]
- Flint, A., Raben, A., Blundell, J. E., and 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 and Related Metabolic Disorders : Journal of the International Association for the Study of Obesity*, 24(1), 38-48.
- Foster-Powell, K., Holt, S. H., and Brand-Miller, J. C. (2002). International table of glycemic index and glycemic load values: 2002. *The American Journal of Clinical Nutrition*, 76(1), 5-56.
- Fox News Health. (2013) Is buckwheat the latest superfood? Retrieved from:

- Giacco, R., Parillo, M., Rivellese, A. A., Lasorella, G., Giacco, A., D'Episcopo, L., and Riccardi, G. (2000). Long-term dietary treatment with increased amounts of fiber-rich low-glycemic index natural foods improves blood glucose control and reduces the number of hypoglycemic events in type 1 diabetic patients. *Diabetes Care*, *23*(10), 1461-1466.
- Griffioen-Roose, S., Mars, M., Finlayson, G., Blundell, J. E., and de Graaf, C. (2011). The effect of within-meal protein content and taste on subsequent food choice and satiety. *British journal of nutrition*, *106*(05), 779-788.
- Hall, K. D., Heymsfield, S. B., Kemnitz, J. W., Klein, S., Schoeller, D. A., and Speakman, J. R. (2012). Energy balance and its components: Implications for body weight regulation. *The American Journal of Clinical Nutrition*, *95*(4), 989-994. doi:10.3945/ajcn.112.036350 [doi]
- Hallschmid, M., Benedict, C., Born, J., Fehm, H. L., & Kern, W. (2004). Manipulating central nervous mechanisms of food intake and body weight regulation by intranasal administration of neuropeptides in man. *Physiology & behavior*, *83*(1), 55-64.
- Hallschmid, M., Higgs, S., Thienel, M., Ott, V., & Lehnert, H. (2012). Postprandial administration of intranasal insulin intensifies satiety and reduces intake of palatable snacks in women. *Diabetes*, *61*(4), 782-9.
- Havel, P. J. (2001). Peripheral signals conveying metabolic information to the brain: Short-term and long-term regulation of food intake and energy homeostasis. *Experimental Biology and Medicine (Maywood, N.J.)*, *226*(11), 963-977.
- Havermans, R. C., Janssen, T., Giesen, J. C., Roefs, A., and Jansen, A. (2009). Food liking, food wanting, and sensory-specific satiety. *Appetite*, *52*(1), 222-225.
- Health Canada. (2006). Dietary Reference Intakes. Retrieved from: http://www.hc-sc.gc.ca/fn-an/nutrition/reference/table/ref_macronutr_tbl-eng.php

- Health Canada. (2012a). *Do Canadian Adults Meet Their Nutrient Requirements Through Food Intake Alone?* Retrieved from: <http://www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/art-nutr-adult-eng.php#a321>
- Health Canada. (2012b). Draft Guidance Document- Satiety Health Claims on Food. Retrieved from: <http://www.hc-sc.gc.ca/fn-an/consult/satiety-satiete/document-consultation-eng.php>
- Health Canada. (2011). Eating Well with Canada's Food Guide. Retrieved from: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/order-commander/eating_well_bien_manger-eng.php
- Health Canada. (2012c). Technical Consultation on Health Canada's Draft Guidance Document- Satiety Health Claims on Food. Retrieved from: <http://www.hc-sc.gc.ca/fn-an/consult/satiety-satiete/index-eng.php>
- He, J., Klag, M. J., Whelton, P. K., Mo, J., and et al. (1995). Oats and buckwheat intakes and cardiovascular disease risk factors in an ethnic minority of china. *The American Journal of Clinical Nutrition*, 61(2), 366.
- Heymsfield, S. B., Greenberg, A. S., Fujioka, K., Dixon, R. M., Kushner, R., Hunt, T., . . . Hunt, P. (1999). Recombinant leptin for weight loss in obese and lean adults: A randomized, controlled, dose-escalation trial. *Jama*, 282(16), 1568-1575.
- Holasova, M., Fiedlerova, V., Smrcinova, H., Orsak, M., Lachman, J., and Vavreinova, S. (2002). Buckwheat—the source of antioxidant activity in functional foods. *Food Research International*, 35(2), 207-211.
- Holm, J., and Bjorck, I. (1992). Bioavailability of starch in various wheat-based bread products: Evaluation of metabolic responses in healthy subjects and rate and extent of in vitro starch digestion. *The American Journal of Clinical Nutrition*, 55(2), 420-429.
- Holubec, V., and Stehno, Z. (2004). Advances in buckwheat research.
- Howarth, N. C., Saltzman, E., and Roberts, S. B. (2001). Dietary fiber and weight regulation. *Nutrition Reviews*, 59(5), 129.

- Hulshof, T., de Graaf, C., and Weststrate, J. A. (1993). The effects of preloads varying in physical state and fat content on satiety and energy intake. *Appetite*, 21(3), 273-286.
- Hussain, S., and Bloom, S. (2013). The regulation of food intake by the gut-brain axis: Implications for obesity. *International Journal of Obesity*, 37(5), 625-633.
- Isaksson, H., Tillander, I., Andersson, R., Olsson, J., Fredriksson, H., Webb, D., and Åman, P. (2012). Whole grain rye breakfast—Sustained satiety during three weeks of regular consumption. *Physiology and Behavior*, 105(3), 877-884.
- Jonsson, T., Memon, A. A., Sundquist, K., Sundquist, J., Olsson, S., Nalla, A., . . . Linse, S. (2015). Digested wheat gluten inhibits binding between leptin and its receptor.(research article)(report).16, 3.
- Jenkins, D. J., Wolever, T. M., Taylor, R. H., Barker, H., Fielden, H., Baldwin, J. M., . . . Goff, D. V. (1981). Glycemic index of foods: A physiological basis for carbohydrate exchange. *The American Journal of Clinical Nutrition*, 34(3), 362-366.
- Jenkins, D. J., Wolever, T. M., Ocana, A. M., Vuksan, V., Cunnane, S. C., Jenkins, M., ... and Josse, R. G. (1990). Metabolic effects of reducing rate of glucose ingestion by single bolus versus continuous sipping. *Diabetes*, 39(7), 775-781.
- Jones, L. V., Jones, K. M., Hensman, C., Bertuch, R., McGee, T. L., and Dixon, J. B. (2013). Solid versus Liquid—Satiety study in well-adjusted lap-band patients. *Obesity Surgery*, 23(8), 1266-1272.
- Jones, L., Jones, K., Hensman, C., Bertuch, R., McGee, T., and Dixon, J. (2013). Solid versus liquid—satiety study in well-adjusted lap-band patients. *Obesity Surgery*, 23(8), 1266-1272.
doi:10.1007/s11695-013-0897-z
- Kang, M., Kim, J., Jung, S., Kim, H., and Kim, J. (2001). The effect of buckwheat on postprandial blood glucose and insulin levels in normal subjects. *Age (Yr)*, 23, 2.2.

- Karl, J. P., & Saltzman, E. (2012). The role of whole grains in body weight regulation. *Advances in Nutrition: An International Review Journal*, 3(5), 697-707.
- Kayashita, J., Shimaoka, I., Yamazaki, M., and Kato, N. (1995). Buckwheat protein extract ameliorates atropine-induced constipation in rats. *Cellulose*, 5(5.0), 5.0.
- Kreft, I., Fabjan, N., & Yasumoto, K. (2006). Rutin content in buckwheat (*Fagopyrum esculentum* Moench) food materials and products. *Food Chemistry*, 98(3), 508-512.
- Krkošková, B., and Mrazova, Z. (2005). Prophylactic components of buckwheat. *Food Research International*, 38(5), 561-568.
- Latner, J. D., and Schwartz, M. (1999). The effects of a high- carbohydrate, high- protein or balanced lunch upon later food intake and hunger ratings. *Appetite*, 33(1), 119-128.
doi:10.1006/appe.1999.0237
- Lau, D. C., Douketis, J. D., Morrison, K. M., Hramiak, I. M., Sharma, A. M., Ur, E., and Obesity Canada Clinical Practice Guidelines Expert Panel. (2007). 2006 canadian clinical practice guidelines on the management and prevention of obesity in adults and children [summary]. *CMAJ : Canadian Medical Association Journal = Journal De L'Association Medicale Canadienne*, 176(8), S1-13. doi:176/8/S1 [pii]
- Lenard, N. R., and Berthoud, H. (2008). Central and peripheral regulation of food intake and physical activity: Pathways and genes. *Obesity*, 16, S11-S22.
- Lin, M. H. A., Shyr, C. R., and Lin, J. (2012). BREAD CONTAINING TYPE 3 RESISTANT STARCH REDUCED GLYCEMIC INDEX AND GLYCEMIC RESPONSE IN HEALTHY YOUNG ADULTS. *Current Topics in Nutraceuticals Research*, 10(3/4), 143.
- Liu, A. G., Most, M. M., Brashear, M. M., Johnson, W. D., Cefalu, W. T., and Greenway, F. L. (2012). Reducing the glycemic index or carbohydrate content of mixed meals reduces postprandial glycemia and insulinemia over the entire day but does not affect satiety. *Diabetes Care*, 35(8), 1633-1637. doi:10.2337/dc12-0329 [doi]

- Liu, Z., Ishikawa, W., Huang, X., Tomotake, H., Kayashita, J., Watanabe, H., and Kato, N. (2001). A buckwheat protein product suppresses 1,2-dimethylhydrazine-induced colon carcinogenesis in rats by reducing cell proliferation. *The Journal of Nutrition*, 131(6), 1850-1853.
- MacIntosh, C. G., Morley, J. E., Wishart, J., Morris, H., Jansen, J. B., Horowitz, M., & Chapman, I. M. (2001). Effect of exogenous cholecystokinin (CCK)-8 on food intake and plasma CCK, leptin, and insulin concentrations in older and young adults: evidence for increased CCK activity as a cause of the anorexia of aging. *The Journal of Clinical Endocrinology & Metabolism*, 86(12), 5830-5837.
- Mayer, J. (1953). Glucostatic mechanism of regulation of food intake. *New England Journal of Medicine*, 249(1), 13-16.
- Mela, D. J. (2011). Satiety. let's put claims in the right context. comment on 'Satiety. no way to slim'. *Appetite*, 57(3), 774-777.
- Melanson, K. J., Angelopoulos, T. J., Nguyen, V. T., Martini, M., Zukley, L., Lowndes, J., . . . Rippe, J. M. (2006). Consumption of whole-grain cereals during weight loss: Effects on dietary quality, dietary fiber, magnesium, vitamin B-6, and obesity. *Journal of the American Dietetic Association*, 106(9), 1380-1388.
- Meule, A., Westenhöfer, J., and Kübler, A. (2011). Food cravings mediate the relationship between rigid, but not flexible control of eating behavior and dieting success. *Appetite*, 57(3), 582-584.
- Murphy, K. G., and Bloom, S. R. (2006). Gut hormones and the regulation of energy homeostasis. *Nature*, 444(7121), 854. doi:10.1038/nature05484
- Naslund, E., Gutniak, M., Skogar, S., Rossner, S., and Hellstrom, P. M. (1998). Glucagon-like peptide 1 increases the period of postprandial satiety and slows gastric emptying in obese men. *The American Journal of Clinical Nutrition*, 68(3), 525-530.
- Nilsson, A. C., Östman, E. M., Holst, J. J., and Björck, I. M. (2008). Including indigestible carbohydrates in the evening meal of healthy subjects improves glucose tolerance, lowers

inflammatory markers, and increases satiety after a subsequent standardized breakfast. *The Journal of nutrition*, 138(4), 732-739.

Ohnishi, O. (1998). Search for the wild ancestor of buckwheat III. the wild ancestor of cultivated common buckwheat, and of tatar buckwheat. *Economic Botany*, 52(2), 123-133.

Paddon-Jones, D., Westman, E., Mattes, R. D., Wolfe, R. R., Astrup, A., and Westerterp-Plantenga, M. (2008). Protein, weight management, and satiety. *The American Journal of Clinical Nutrition*, 87(5), 1558S-1561S. doi:87/5/1558S [pii]

Pal, S., and Ellis, V. (2010). The acute effects of four protein meals on insulin, glucose, appetite and energy intake in lean men. *British journal of nutrition*, 104(08), 1241-1248.

Pan, A., and Hu, F. B. (2011). Effects of carbohydrates on satiety: Differences between liquid and solid food. *Current Opinion in Clinical Nutrition and Metabolic Care*, 14(4), 385-390. doi:10.1097/MCO.0b013e328346df36 [doi]

Pan, H., Guo, J., and Su, Z. (2014). Advances in understanding the interrelations between leptin resistance and obesity. *Physiology and Behavior*, 130, 157-169. doi:10.1016/j.physbeh.2014.04.003

Pandey, K. B., and Rizvi, S. I. (2009). Plant polyphenols as dietary antioxidants in human health and disease. *Oxidative Medicine and Cellular Longevity*, 2(5), 270-278. doi:10.4161/oxim.2.5.9498 [doi]

Potier, M., Fromentin, G., Lesdema, A., Benamouzig, R., Tomé, D., and Marsset-Baglieri, A. (2010). The satiety effect of disguised liquid preloads administered acutely and differing only in their nutrient content tended to be weaker for lipids but did not differ between proteins and carbohydrates in human subjects. *British Journal of Nutrition*, 104(09), 1406-1414.

Préstamo, G., Pedrazuela, A., Penas, E., Lasunción, M., and Arroyo, G. (2003). Role of buckwheat diet on rats as prebiotic and healthy food. *Nutrition Research*, 23(6), 803-814.

Public Health Agency of Canada. (2011). *Obesity in Canada*. Retrieved from: <http://www.phac-aspc.gc.ca/hp-ps/hl-mvs/oic-oac/assets/pdf/oic-oac-eng.pdf>

Public Works and Government Services of Canada. (2015). *Couscous*. Retrieved from: [http://www.btb.termiumplus.gc.ca/tpv2alpha/alphaeng.html?lang=eng&idi=1&index=frb&andsrchtxt=SECHER&where=\(vpfr_bj_words+inc+'SECHER'+\)&anddom=TBC&andcomencdomnsubj](http://www.btb.termiumplus.gc.ca/tpv2alpha/alphaeng.html?lang=eng&idi=1&index=frb&andsrchtxt=SECHER&where=(vpfr_bj_words+inc+'SECHER'+)&anddom=TBC&andcomencdomnsubj)

Raben, A., Christensen, N. J., Madsen, J., Holst, J. J., and Astrup, A. (1994). Decreased postprandial thermogenesis and fat oxidation but increased fullness after a high-fiber meal compared with a low-fiber meal. *The American journal of clinical nutrition*, 59(6), 1386-1394.

Real Canadian Superstore. (2016a). Meals and Grains. Retrieved from: <https://shop.superstore.ca/Food/Pantry/Baking-Ingredients/Meals-%26-Grains/plp/RCSS001008002006>

Real Canadian Superstore. (2016b). Polenta and Couscous. Retrieved from: <https://shop.superstore.ca/Food/Pantry/Pasta,-Rice-%26-Beans/Polenta-%26-Couscous/plp/RCSS001008009006?filters=andsort=price-desc>

Real Canadian Superstore. (2016c). Rice. Retrieved from: <https://shop.superstore.ca/Food/Pantry/Pasta,-Rice-%26-Beans/Rice/plp/RCSS001008009004>

Roberts, S. B. (2000). High-glycemic index foods, hunger, and obesity: Is there a connection? *Nutrition Reviews*, 58(6), 163-169.

Rolls, B. J. (1986). Sensory-specific satiety. *Nutrition Reviews*, 44(3), 93-101.

Saldeen, K., and Saldeen, T. (2005). Importance of tocopherols beyond α -tocopherol: Evidence from animal and human studies. *Nutrition Research*, 25(10), 877-889.
doi:10.1016/j.nutres.2005.09.019

- Schmid, S. M., Hallschmid, M., JAUCH-CHARA, K. A. M. I. L. A., Born, J. A. N., and Schultes, B. (2008). A single night of sleep deprivation increases ghrelin levels and feelings of hunger in normal-weight healthy men. *Journal of sleep research*, 17(3), 331-334.
- Schroeder, N., Gallaher, D. D., Arndt, E. A., and Marquart, L. (2009). Influence of whole grain barley, whole grain wheat, and refined rice-based foods on short-term satiety and energy intake. *Appetite*, 53(3), 363-369.
- Schiöth, H. B., Ferriday, D., Davies, S. R., Benedict, C., Elmståhl, H., Brunstrom, J. M., and Hogenkamp, P. S. (2015). Are you sure? Confidence about the satiating capacity of a food affects subsequent food intake. *Nutrients*, 7(7), 5088-5097.
- Skrabanja, V., Liljeberg Elmståhl, H. G., Kreft, I., and Björck, I. M. (2001). Nutritional properties of starch in buckwheat products: Studies in vitro and in vivo. *Journal of Agricultural and Food Chemistry*, 49(1), 490-496.
- Slavin, J., and Green, H. (2007). Dietary fibre and satiety. *Nutrition Bulletin*, 32(s1), 32-42.
- Spiegel, K., Tasali, E., Penev, P., and Van Cauter, E. (2004). Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. *Annals of internal medicine*, 141(11), 846-850.
- Statistics Canada. (2013). *Body Composition of Canadian Adults 2009 to 2011*. Retrieved from: <http://www.statcan.gc.ca/pub/82-625-x/2012001/article/11708-eng.htm>
- Statistics Canada. (2015). Bias in self-reported estimates of obesity in Canadian health surveys: An update on correction equations for adults. Retrieved from: <http://www.statcan.gc.ca/pub/82-003-x/2011003/article/11533-eng.htm>

Statistics Canada. (2013). *Wheat products manufactured in Canada for human consumption, crop year 2010/2011*. Retrieved from: <http://www.statcan.gc.ca/pub/22-007-x/2011011/t080-eng.htm>

Steadman, K. J., Burgoon, M. S., Lewis, B. A., Edwardson, S. E., and Obendorf, R. L. (2001a). Minerals, phytic acid, tannin and rutin in buckwheat seed milling fractions. *Journal of the Science of Food and Agriculture*, 81(11), 1094-1100.

Steadman, K. J., Burgoon, M. S., Lewis, B. A., Edwardson, S. E., and Obendorf, R. L. (2001b). Buckwheat seed milling fractions: Description, macronutrient composition and dietary fibre. *Journal of Cereal Science*, 33(3), 271-278. doi:10.1006/jcrs.2001.0366

Steadman, K. J., Burgoon, M. S., Lewis, B. A., Edwardson, S. E., and Obendorf, R. L. (2001c). Buckwheat seed milling fractions: Description, macronutrient composition and dietary fibre. *Journal of Cereal Science*, 33(3), 271-278. doi:10.1006/jcrs.2001.0366

Stringer, D. M., Taylor, C. G., Appah, P., Blewett, H., and Zahradka, P. (2013). Consumption of buckwheat modulates the post-prandial response of selected gastrointestinal satiety hormones in individuals with type 2 diabetes mellitus. *Metabolism*, 62(7), 1021-1031.

The University of Sydney. (2015a). GI foods advanced search: Couscous. Retrieved from: <http://www.glycemicindex.com/foodSearch.php?num=2211&ak=detail>

The University of Sydney. (2015b). GI foods advanced search: Buckwheat. Retrieved from: <http://www.glycemicindex.com/foodSearch.php?num=924&ak=detail>

The University of Sydney. (2015c). GI foods advanced search: Fructose. Retrieved from: <http://www.glycemicindex.com/foodSearch.php?num=94&ak=detail>

Thompson, L. U. (1993). Potential health benefits and problems associated with antinutrients in foods. *Food Research International*, 26(2), 131-149.

Timko, C. A. (2007). Norms for the rigid and flexible control over eating scales in a United States population. *Appetite*, 49(2), 525-528.

- Tome, D. (2004). Protein, amino acids and the control of food intake. *British Journal of Nutrition*, 92(S1), S27-S30.
- Tomotake, H., Shimaoka, I., Kayashita, J., Yokoyama, F., Nakajoh, M., and Kato, N. (2000). A buckwheat protein product suppresses gallstone formation and plasma cholesterol more strongly than soy protein isolate in hamsters. *The Journal of Nutrition*, 130(7), 1670-1674.
- Touyarou, P., Sulmont-Rossé, C., Gagnaire, A., Issanchou, S., and Brondel, L. (2012). Monotonous consumption of fibre-enriched bread at breakfast increases satiety and influences subsequent food intake. *Appetite*, 58(2), 575-581.
- Tschöp, M., Weyer, C., Tataranni, P. A., Devanarayan, V., Ravussin, E., & Heiman, M. L. (2001). Circulating ghrelin levels are decreased in human obesity. *Diabetes*, 50(4), 707-709.
- Venn, B., and Mann, J. (2004). Cereal grains, legumes and diabetes. *European Journal of Clinical Nutrition*, 58(11), 1443-1461.
- Wansink, B., Painter, J. E., and North, J. (2005). Bottomless bowls: Why visual cues of portion size may influence intake **. *Obesity Research*, 13(1), 93-100. doi:10.1038/oby.2005.12
- Wardle, J., Steptoe, A., Oliver, G., and Lipsey, Z. (2000). Stress, dietary restraint and food intake. *Journal of psychosomatic research*, 48(2), 195-202.
- Wei, Y., Hu, X., Zhang, G., and Ouyang, S. (2003). Studies on the amino acid and mineral content of buckwheat protein fractions. *Food/Nahrung*, 47(2), 114-116.
- Weigle, D. S., Breen, P. A., Matthys, C. C., Callahan, H. S., Meeuws, K. E., Burden, V. R., and Purnell, J. Q. (2005). A high-protein diet induces sustained reductions in appetite, ad libitum caloric intake, and body weight despite compensatory changes in diurnal plasma leptin and ghrelin concentrations. *The American Journal of Clinical Nutrition*, 82(1), 41-48. doi:82/1/41 [pii]
- Wijngaard, H. H., & Arendt, E. K. (2006). Buckwheat. *Cereal Chemistry*, 83(4), 391-401.

Willis, H. J., Thomas, W., Eldridge, A. L., Harkness, L., Green, H., and Slavin, J. L. (2010). Increasing doses of fiber do not influence short-term satiety or food intake and are inconsistently linked to gut hormone levels. *Food and Nutrition Research*, 54, 10.3402/fnr.v54i0.5135. doi:10.3402/fnr.v54i0.5135 [doi]

Wolever, T. M., Katzman-Relle, L., Jenkins, A. L., Vuksan, V., Josse, R. G., & Jenkins, D. J. (1994). Glycaemic index of 102 complex carbohydrate foods in patients with diabetes. *Nutrition Research*, 14(5), 651-669.

Yang, Yue-Xin, et al. "Glycemic index of cereals and tubers produced in China." *World Journal of Gastroenterology* 12.21 (2006): 3430.

Yao, Y., Shan, F., Bian, J., Chen, F., Wang, M., and Ren, G. (2008). D-chiro-inositol-enriched tartary buckwheat bran extract lowers the blood glucose level in KK-ay mice. *Journal of Agricultural and Food Chemistry*, 56(21), 10027-10031.



APPENDICES

Appendix A-2: Information Sheet and Consent Form

The Effect of Buckwheat on Blood Glucose, Satiety and Food Intake

Experiment 2: The effect of buckwheat and couscous on food intake and satiety

Information Sheet and Consent Form

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Background and Purpose of Research:

Buckwheat has been traditionally recognized as a grain product and is popular in Eastern Europe and Japan. Today, buckwheat is grown in Canada but the majority of buckwheat is exported or milled into flour. Therefore buckwheat remains unfamiliar to Canadian consumers while many studies have shown that buckwheat is a healthy food.

The purpose of this study is to determine the effect of cooked buckwheat on appetite and food intake.

Invitation to Participate:

You are being invited to take part in this study. If you chose to take part, you will be asked to eat a treatment of buckwheat, couscous, or plain water three times (three sessions) with at least one week apart. At each session, your blood sugar will be measured initially and your appetite will be measured after eating the treatment. Each session will take up to three hours of your time.

Eligibility:

To participate in this study you must be healthy which for this study is defined as not being overweight or obese and not having any diseases. You must also be between the ages of 18 and 30. You must be a non-smoker and you cannot be taking any medications. You will not be able to participate if you have allergies to any food or if you usually skip breakfast. The study will take place in the Department of Applied Human Nutrition, Rm 365 Evaristus Building, 166 Bedford HWY, Halifax, NS.

Procedure:

To find out if you can take part in this study, you will be asked to fill out questionnaires, which ask questions about your age, if you smoke, exercise, your health, if you are on any medications and your eating habits. Your height and weight will be measured.

If you can take part, you will be asked to fill out questionnaires about the foods you like. You will be scheduled to meet with us for three sessions over three weeks.

You will be asked to arrive at the Evaristus Building between 8:00 a.m. and 10:00 a.m. but your arrival time should be the same for each experimental session. You will be asked to stick to your normal routine, including exercise and to eat a similar meal the night before each session and then stay fasted for at least 12 hours until you arrive to the laboratory the next morning. You can drink water up to one hour before arriving at the session.

At each session you will be asked to eat a treatment and to complete questionnaires at the times outlined in the table below. There will be three sessions one week apart in which you will be served with one of the treatments: cooked buckwheat groats, couscous or spring water. In two hours, you will be asked to eat a lunch meal (pizza) until you feel comfortably full. You will be asked to fill out visual analog scale (VAS) questionnaires measuring your appetite and physical comfort as well as the palatability (pleasantness) of the treatment. Water from the fountain will be provided with the treatments and lunch meals. Each session will last up to three hours.

An Example of a Potential Time and Activity Schedule for Each Session:

Time	Activity
8:45	Arrive at the laboratory
8:50	Fill in Sleep, Stress, and VAS questionnaires and take first blood sample
9:00 - 9:10	Eat the treatment (0 min).
9:10 – 11:10	Fill out VAS questionnaires at 15, 30, 45, 60, 90 and 120 min
11:10 – 11:30	Eat the lunch meal until you feel comfortably full.

VAS: Visual analogue scale

Voluntary Participation and Early Withdrawal:

Participation in this study is voluntary. You may choose to stop being in the study at any point, without any problems.

Risks:

All of the foods that you will be asked to consume will be prepared using practices to ensure food safety. Therefore, your risk of developing a food borne illness from participation in this study is very minimal.

After the overnight fast you may feel faint or dizzy, however the risk of this is minimal.

There is always a possibility that you may become ill following consumption of food, but this is very unlikely. All treatments are freshly prepared at the time of your session.

You may experience flatulence (passing gas) and feelings of gastrointestinal discomfort (bloating) from the treatments if they are high in fibre. This hardly ever happens and there is no health risk linked with these effects.

Benefits:

You will not benefit directly from taking part in this study but in general the study will help to better understand the nutritional properties of the food products that are investigated in this study.

Confidentiality and Privacy:

Confidentiality will be respected and no information that shows your identity will be released or published without your permission unless required by law. Your name, personal information and signed consent form will be kept in a locked filing cabinet in the investigator's office. Your results will not be kept in the same place as your name. Your results will be recorded on data sheets and in computer records that have an ID number for identification, but will not include your name. Your results, identified only by an ID number, will be made available to the study sponsor if requested. Only study investigators will have access to your individual results.

Publication of Results:

The results of the study may be presented at scientific meetings and published in a scientific journal. If the results are published, only average and not individual values will be reported.

Possible Commercialization of Findings:

This study is preliminary. Once these products are tested more widely in future studies, results may lead to commercialization of a product, new product formulation, changes in the labeling of a product and/or changes in the marketing of a product; you will not share in any way from the possible gains or money made by commercial application of findings.

New Findings:

If anything is found during the course of this research which may change your decision to continue, you will be told about it.

Compensation:

You will be paid \$10 per experimental session and \$5 per session for travel. Payment will be in the form of a cheque and will be paid for each session.

Injury Statement:

If you begin to feel sick following participation in the study, please seek medical advice as soon as possible. We will provide your medical specialist with information about the food you have consumed during the session, so take our phone number with you.

Rights of Subjects:

Before agreeing to take part in this research study, it is important that you read and understand your role as described here in this study information sheet and consent form. You waive no legal rights by taking part in this study. If you have questions about

how this study is being conducted and wish to speak with someone not involved in the study, you may contact the Chair of the University Research Ethics Board (UREB) c/o MSVU Research Office, at 457-6350 or via e-mail at research@msvu.ca

Dissemination of findings:

A summary of results will be made available for you to pick up after the study is done.

Copy of informed consent for participant:

You will be given a copy of this informed consent to keep for your own records.

Consent:

I acknowledge that the research study described above has been explained to me and that any questions that I have asked have been answered to my satisfaction. I have been informed of the alternatives to participation in this study, including the right not to participate and the right to withdraw. As well, the potential risks, harms and discomforts have been explained to me. I understand that I will receive compensation for my time spent participating in the study.

As part of my participation in this study, I understand that I may come in contact with other study participants because our session times overlap. I agree to keep anything I learn about other participants confidential and know that other participants have agreed to do the same for me.

I hereby agree and give my authorized consent to participate in the study and to treat confidential information in a restrictive manner as described above. I have been given a copy of the consent form to keep for my own records.

Participant Name

Signature

Date

Witness Name

Signature

Date

Investigator Name

Signature

Date

Appendix B (part 1)
Baseline Information Questionnaire

The effect of buckwheat and couscous on food intake and satiety

Please type

NAME: _____

ADDRESS:

PHONE #: (____) _____ E-MAIL: _____

ID assigned: _____

To be kept separately from part 2 and other study forms

Baseline Information Questionnaire

The effect of buckwheat and couscous on food intake and satiety

(NOTE: After you are recruited for the study, you will be assigned an ID# which will be used on your forms and data throughout the study.)

AGE: _____ **HEIGHT:** _____ **WEIGHT:** _____ **BMI:** _____

Participation in Athletics/Exercise:

ACTIVITY	HOW OFTEN?	HOW LONG? (HOURS)

Do you usually eat breakfast? **YES** **NO**
If YES, what do you usually eat? _____

Health Status:

Do you have diabetes? **YES** **NO**

Do you have any other major disease or condition? **YES** **NO**
If YES, please specify: _____

Are you taking any medications? **YES** **NO**
If YES, please specify: _____

Do you have reactions to any foods? **YES** **NO**
If YES, please specify: _____

Are you on a special diet? **YES** **NO**
If YES, please specify: _____

Have you recently lost or gained weight? **YES** **NO**
If YES, please specify: _____

Do you smoke? **YES** **NO**

On average, how many alcoholic beverages do you consume per day? _____ **Per week?** _____

Appendix C

Eating Habits Questionnaire

The effect of buckwheat on food intake and satiety

Choose the appropriate answer to best describe your personal situation.

1. How often are you restricting the amount of food that you consume?

Never ____ rarely ____ sometimes ____ often ____ always ____

2. What is the maximum amount of weight (in pounds) that you have ever lost within one month?

1 - 4 ____ 5 - 9 ____ 10 - 14 ____ 15 - 19 ____ 20+ ____

3. What is your maximum weight gain within one week?

0 - 1 ____ 1.1 - 2 ____ 2.1 - 3 ____ 3.1 - 5 ____ 5.1+ ____

4. In a typical week, how much does your weight fluctuate?

0 - 1 ____ 1.1 - 2 ____ 2.1 - 3 ____ 3.1 - 5 ____ 5.1+ ____

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

Not at all ____ slightly ____ moderately ____ very much ____

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

Never _____ rarely _____ often _____ always _____

7. Do you give too much time and thought to food?

Never _____ rarely _____ often _____ always _____

8. Do you have feelings of guilt after overeating?

Never _____ rarely _____ often _____ always _____

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

Not at all _____ slightly _____ moderately _____ extremely _____

10. When you were at your highest weight, how many pounds over your desired weight were you?

0-1 _____ 2 - 5 _____ 6 - 10 _____ 11 - 20 _____ 21+ _____

Appendix C (i): Rigid Control Dietary Restraint Form

The effect of buckwheat and couscous on food intake and satiety

Flexible Control (FC12)

Please circle that response that best suits you.

1. When I have eaten my quota of calories, I am usually good about not eating any more.

True – False

2. I deliberately take small helpings as a means of weight control.

True – False

3. 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.

True – False

4. I consciously hold back at meals in order not to gain weight.

True – False

5. I pay a great deal of attention to changes in my figure.

True – False

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

Not at all – Slightly – Moderately – Extremely

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

Unlikely – Slightly unlikely – Moderately likely – Very likely

8. If I eat a little bit more on one day, I make up for it the next day.

True – False

9. I pay attention to my figure, but I still enjoy a variety of foods.

True – False

10. I prefer light foods that are not fattening.

True – False

11. If I eat a little bit more during one meal, I make up for it at the next meal.

True – False

12. Do you deliberately restrict your intake during meals even though you would like to eat more?

Always – Often – Rarely – Never

Rigid Control (RC16) - Please circle that response that best suits you.

1. I have a pretty good idea of the number of calories in common food.

True – False

2. I count calories as a conscious means of controlling my weight.

True – False

3. How often are you dieting in a conscious effort to control your weight?

Rarely – Sometimes – Usually – Always

4. Would a weight fluctuation of 5 lb affect the way you live your life?

Not at all – Slightly – Moderately – Very much

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

Never – Rarely – Often – Always

6. How frequently do you avoid “stocking up” on tempting foods?

Almost never – Seldom – Usually – Almost always

7. How likely are you to shop for low calorie foods?

Unlikely – Slightly unlikely – Moderately likely – Very likely

8. I eat diet foods, even if they do not taste very good.

True – False

9. A diet would be too boring a way for me to lose weight.

True – False

10. I would rather skip a meal than stop eating in the middle of one.

True – False

11. I alternate between times when I diet strictly and times when I don't pay much attention to what and how much I eat.

True – False

12. Sometimes I skip meals to avoid gaining weight.

True – False

13. I avoid some foods on principle even though I like them.

True – False

14. I try to stick to a plan when I lose weight.

True – False

15. Without a diet plan I wouldn't know how to control my weight.

True – False

16. Quick success is most important for me during a diet.

True – False

Appendix D

Food Acceptability

The effect of buckwheat and couscous on food intake and satiety

Please indicate with a rating between 1 and 10 how much you enjoy the following foods (**1 = not at all, 10 = very much**) and how often you eat them (**never, daily, weekly, monthly**).

	Enjoyment?	How often?
1. Pasta	_____	_____
2. Rice	_____	_____
3. Potatoes (mashed, roasted)	_____	_____
4. French fries	_____	_____
5. Pizza	_____	_____
6. Bread, bagels, dinner rolls	_____	_____
7. Sandwiches, subs	_____	_____
8. Cereal	_____	_____
9. Cake, donuts, cookies	_____	_____
10. Protein/breakfast shakes	_____	_____

At the end of each session, you will be provided with pizza. In order to provide you with a meal that you will enjoy, we ask that you rank the following pizzas according to your **personal preferences (i.e. 1st, 2nd, 3rd choice)** in the space provided. If you **do NOT** like a particular type of pizza, then do not rank it but instead write “**I don’t like**” in the space provided.

- Pepperoni (cheese, pepperoni) _____
- Deluxe (cheese, pepperoni, peppers, mushrooms) _____
- Three-cheese (mozzarella, cheddar, parmesan) _____

Appendix E

Recipe and Nutritional Information

Macronutrient information for treatments:

Buckwheat	Per portion
Weight, g	84
Energy, kcal	300
Fat, g	2
Protein, g	10
Carbohydrates, g	60
Total Dietary Fibre, g	4
Available Carbohydrates, g	56

Couscous	Per portion
Weight, g	84
Energy, kcal	300
Fat, g	1
Protein, g	10
Carbohydrates, g	62
Total Dietary Fibre, g	2
Available Carbohydrates ¹ , g	60

Available carbohydrates: total carbohydrate – total dietary fibre

Recipe:

Buckwheat:

In small pan add half of tea spoon of herbs-parmesan powder, 84 g of buckwheat and 168 g of water, cover with lid and put on the high heat until it boils, then reduce the heat and simmer for 15 min. Turn off the heat, stir and let it sit for 10 min. Then it will be ready to serve. Make sure to instruct the participant to eat the entire portion.

Couscous:

In small pan add half of tea spoon of herbs-parmesan powder, 168 g of water, cover with lid and put on the high heat until it boils. Then add 84 g of couscous (medium grains) and stir it, then remove the pan from the heat immediately. Let it sit for 5 min. Then it will be ready to serve. Make sure to instruct the participant to eat the entire portion.

APPENDIX F

Sleep Habits and Stress Factors Questionnaire

The effect of buckwheat and couscous on food intake and satiety

1. Did you have a normal night's sleep last night? Yes _____ No _____
2. How many hours of sleep did you have? _____
3. What time did you go to bed last night? _____
4. What time did you wake up this morning? _____
5. Recount your activities since waking:

Time	Activity
_____	_____
_____	_____
_____	_____
_____	_____

6. Are you experiencing any feelings of illness or discomfort, other than those from hunger?

Today: Yes _____ No _____ Past 24 hours: Yes _____ No _____

If yes, please describe briefly:

7. Are you under any unusual stress? (Exams/reports/work deadlines, personal, etc.)

Today: Yes ____ No____ Past 24 hours: Yes ____ No____

If yes, please describe briefly:

8. Have you been involved in any physical activity within the past 24 hours that is unusual to your normal routine? Yes____ No____

If yes, please describe briefly:

APPENDIX G

Recent Food Intake and Activity Questionnaire

The effect of buckwheat and couscous on food intake and satiety

At what time did you have dinner? _____

Please describe your dinner last night (list all food and drink and give an estimate of the portion size):

The following three questions relate to your food intake, activity and stress over the last 24 hours. Please rate yourself by placing a small “x” across the horizontal line at the point which best reflects your present feelings.

How would you describe your **food intake** over the past 24 hours?

Much LESS than usual _____ Much MORE than usual

How would you describe your **level of activity** over the last 24 hours?

Much LESS than usual _____ Much MORE than usual

How would you describe your **level of stress** over the last 24 hours?

Much LESS than usual _____ Much MORE than usual

To be completed by staff only:

Arrived to the lab at: _____ **Baseline blood glucose** _____ (mmol/L)

Treatment started at: _____

Comments/Notes:

APPENDIX H
Visual Analogue Scales
Palatability: Treatment

This question relates to the palatability of the beverage/food you just consumed. Please rate yourself by placing a small “x” across the horizontal line at the point which best reflects your present findings.

1. How pleasant have you found the beverage/food?

NOT _____ VERY
at all pleasant
pleasant

2. How tasty have you found the treatment?

NOT _____ VERY
at all tasty
tasty

3. How did you like the texture of the treatment?

NOT _____ VERY
at all much

APPENDIX I

**Visual Analogue Scales
Motivation to Eat**

Time point: 0 min (immediately before the treatment)

These questions relate to your “motivation to eat” at this time. Please rate yourself by placing a small “x” across the horizontal line at the point which best reflects your present feelings.

1. How strong is your desire to eat?

VERY _____ VERY
weak strong

2. How hungry do you feel?

NOT _____ As hungry
hungry as I have
at all ever felt

3. How full do you feel?

NOT _____ VERY
full full
at all

4. How much food do you think you could eat?

NOTHING _____ A LARGE
at all amount

5. How thirsty do you feel?

NOT _____ As thirsty
thirsty as I have
at all ever felt

APPENDIX J
Visual Analogue Scales
Energy and Fatigue

Time point: 0 min (immediately before the treatment)

These questions relate to your energy level and fatigue at this time. Please rate yourself by placing a small “x” across the horizontal line at the point which best reflects your present feelings.

1. How energetic do you feel right now?

NOT _____ VERY
at all energetic

2. How tired do you feel right now?

NOT _____ VERY
at all tired

APPENDIX K
Visual Analogue Scales
Physical Comfort

Time point: 0 min (immediately before the treatment)

These questions relate to your “motivation to eat” at this time. Please rate yourself by placing a small “x” across the horizontal line at the point which best reflects your present feelings.

1. Do you feel nauseous?

NOT _____ VERY
at all much

2. Does your stomach hurt?

NOT _____ VERY
at all much

3. How well do you feel?

NOT _____ VERY
well at all well

4. Do you feel like you have gas?

NOT _____ VERY
at all much

5. Do you feel like you have diarrhea?

NOT _____ VERY
at all much

APPENDIX L

Visual Analogue Scales

Palatability: Lunch Meal

Place a small “x” across the horizontal line at the point which best reflects your present findings.

1. How pleasant have you found the beverage/food?

NOT _____ VERY
at all _____ pleasant
pleasant

2. How tasty have you found the treatment?

NOT _____ VERY
at all _____ tasty
tasty

3. How did you like the texture of the treatment?

NOT _____ VERY
at all _____ much

APPENDIX M

Advertisement:

 Department of Applied Human Nutrition <i>Male Participants Needed For Nutritional Study!</i> <i>Examining how food influences appetite and energy intake</i> <i>Requirements: age 18-30 years, non-smoking</i> <i>Involves: screening and three sessions in the lab</i> Compensation and Food will be provided Please contact Heidi at: appetite.study@msvu.ca	
Nutritional Study (ask Heidi) appetite.study@msvu.ca 457-6378	Nutritional Study (ask Heidi) appetite.study@msvu.ca 457-6378
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APPENDIX N

Caloric Compensation:

Caloric Compensation:

Caloric compensation is the ability to compensate for the energy consumed in a meal by consuming less energy in the subsequent meal. 100% compensation would be considered as compensating entirely for the energy in the previous meal. Caloric compensation was calculated from the following equation:

Caloric compensation:

$$\frac{\text{kcal (pizza meal after control treatment)} - \text{kcal (pizza meal after caloric treatment)}}{\text{Kcal (caloric treatment)} - \text{kcal (control treatment)}} \times 100$$

Example: Caloric compensation calculated for participant in buckwheat treatment:

$$\frac{1000\text{kcal} - 700 \text{ kcal}}{300 \text{ kcal}} \times 100 = 100 \% \text{ caloric compensation achieved}$$

