The Effects of Ready Meal Consumption on Self-reported Appetite Ratings and Subsequent Food Intake in Females

Sophie Hannon

Oxford Brookes University, Faculty of Health & Life Sciences

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Abbreviations

AUC	Area Under the Curve
BMI	Body Mass Index
CCK	Cholecystokinin
CHO	Carbohydrate
CNS	Central Nervous System
DEBQ	Dutch Eating Behaviour Questionnaire
DIT	Diet Induced Thermogenesis
DTE	Desire to Eat
ED	Energy Density
EI	Energy Intake
GI	Gastrointestinal Tract
GLP-1	Glucagon-like Peptide-1
HED	High Energy Density
ISAK	International Society for the Advancement of Kinantropometry
LED	Low Energy Density
mm	Millimetres
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
OxBCNH	Oxford Brookes Centre for Nutrition & Health
PHE	Public Health England
PIS	Participant Information Sheet
PYY	Polypeptide YY
RCT	Randomised Controlled Trial
RED-S	Relative Energy Deficiency in Sport
SW	Slimming World
TDEI	Total Daily Energy Intake
TFEQ	Three Factor Eating Questionnaire
VAS	Visual Analogue Scale
WHO	World Health Organisation

Abstract

Introduction: Overweight and obesity are public health concerns and there is a forecast rise in the consumption of ready meals that are generally high in saturated fat and low in fibre (Reimers et al. 2011; WHO, 2018). Slimming World, a commercial weight management organisation has designed a range of ready meals in line with their weight management programme, which advocates an unrestricted intake of low energy dense food in order to aid in weight loss. Hence, it is valuable to understand the satiating properties of ready meals in order to establish if specific ready meals can enhance satiety and contribute to reducing subsequent energy intake. This thesis will explore the effect of ready meals on short-term satiety and food intake among females with a BMI ≥ 25 kg/m^2.

Methods: In two separate studies a total of 38 female participants (Study One: n= 26, Study Two: n= 12), aged between 18-65 years attended Oxford Brookes Centre for Health and Nutrition for two separate testing days. Study One aimed to investigate the effects of energy matched ready meals (calorie-matched but differing quantities of protein and fat), whilst Study Two aimed to explore the effects of fixed portion size (differing in calories and fat, with similar protein) ready meals on appetite and subsequent energy and macronutrient intake. The ready meals (Control = Sainsbury's, Test = Slimming World) differed in energy density and macronutrient composition, with satiety responses investigated in the studies. For both studies, participants consumed a standard breakfast and four hours later consumed either a test ready meal (lasagne, higher energy density) or the control ready meal (lower energy density). Four hours after lunch participants food intake was measured during an ad libitum buffet tea. Additionally, satiety measurements were recorded using visual analogue scales throughout and participants completed a weighed food diary for the remainder of the test day.

Results: Study One revealed that the test meal significantly reduced hunger (p= p<0.001), desire to eat (DTE; p<0.01) and prospective consumption (p=0.001), whilst fullness (p<0.001) increased compared to the control meal between lunch and the

buffet tea. There was no significant difference between energy intake between the two ready meals during the buffet tea ($p=0.10$), however, during the whole testing day the test meal provided significantly less fat and saturated fat (both $p<0.01$), but significantly more carbohydrates, sugars, fibre, protein and salt (all $p<0.01$) compared to the control day. In Study Two, appetite ratings between lunch and buffet tea indicated no difference between the two meals for hunger ($p=0.06$) but fullness was significantly greater ($p<0.01$) after consuming the control meal. DTE and prospective consumption were significantly greater after consuming the test meal ($p=0.01$ & $p=<0.01$, respectively). Whole day food intake showed a significant reduction in energy intake (~873 kcal; $p=0.05$), fat and saturated fat (both $p=0.00$) for the test day but there were no differences between test and control days regarding carbohydrate, sugars, fibre, protein and salt (all $p>0.05$) consumption.

Conclusion: Both of these studies found that in the instance of subsequent short-term energy intake, there was no significant difference between the two ready meals, despite indicating beneficial subjective satiety responses. Nevertheless, these ready meals are important for aiming to improve nutritional guidelines e.g. reduced fat, especially if the forecast increase in ready meal consumption does occur. It may be beneficial for weight management organisations to continue to promote consumption of 'satiety-enhancing' ready meals over standard ready meals in order to lower fat, potentially impacting long-term energy balance and overall health but longitudinal studies would need to be conducted.

Chapter One: Introduction

Overweight (Body Mass Index [BMI] ≥ 25 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) have become global concerns to public health. In 2016, it was estimated that 1.9 billion adults worldwide were overweight, with 650 million obese (World Health Organisation [WHO], 2018). In England, statistics indicated that 64% of adults were overweight or obese in 2017, with men more likely to be overweight than women (40% vs 31%, respectively) but women more likely to be obese compared to men (30% vs 27%, respectively) (National Health Service [NHS] Digital, 2019). Overweight and obesity can increase an individual's risk of developing diseases such as cardiovascular diseases, type 2 diabetes, osteoarthritis and many forms of cancers (WHO, 2018). Additionally, overweight and obesity can also negatively affect mental health, causing a sense of vulnerability and low self-esteem which may lead to depression (Paddon-Jones et al., 2008; Gatineau and Dent, 2011). One of the major causes of overweight and obesity is excessive consumption of energy, without counterbalancing through an increase in physical activity (Hill et al., 2012; Romieu et al., 2017). Current guidelines to reduce obesity suggest diet and lifestyle alterations (National Institute for Health and Care Excellence [NICE], 2014).

Ready meals, defined as, 'main courses that can be reheated in their container, requiring no further ingredients and needing only minimal preparation before consumption' are a vastly profitable sector of the food industry (Remnant and Adams, 2015). Current statistics report that 93% of UK adults consume ready meals, with families being regular users (Mintel Group Ltd., 2019). In 2018, the UK ready meal market entered its fourth year of growth, with estimated forecast growth expected to continue over the next five years, with time-scarcity deemed a major motivation for their use (Celnik et al., 2012; Mintel Group Ltd., 2019).

Alkerwi et al. (2015) found that daily consumption of ready meals was associated with a higher energy intake (EI) and poor compliance to national nutritional guidelines; specifically, high fat intakes and low dietary fibre intakes. Additionally, Alkerwi et al. (2015) reported a positive association between ready- meal consumption and central

obesity, after accounting for other potential confounding variables such as alcohol consumption and physical activity. Considering, the projected forecast increase in ready meal consumption, it is important to understand how ready meal consumption might influence satiety (Mintel Group Ltd., 2018). Briefly, satiety begins at the end of an eating episode and prevents further consumption of food until hunger returns and the next eating episode starts. Satiety enhancing ready meals could impact energy balance via reducing EI.

In addition to reducing hunger and potentially diminishing food intake, there is a psychological benefit to consuming foods that enhance satiety, and this may be partially experienced through the 'promise' of feeling fuller (Chambers et al., 2015). Further, according to Hetherington et al. (2013) products claiming to enhance satiety must also taste pleasant to the consumer not only in order for them to be chosen and consumed in the future but also as the pleasure from consuming the food interacts with satiety. Certainly, enhancing satiety can benefit mood, which may instigate habitual consumption of those foods and ultimately choosing satiety enhancing foods lead to healthier choices (Hetherington et al., 2013).

This thesis will explore the effect of ready meal consumption on short-term satiety and food intake among females with a BMI ≥ 25 kg/m^2.

Chapter Two: Literature Review

The initial section of the literature review will define appetite, satiation and satiety, subsequently introducing the mechanisms via which appetite is controlled. Next the weight management programme Slimming World, with the efficacy of Slimming World in the context of weight management and satiety being explored. Successively, the role of macronutrients and energy density (ED) specific to satiety will be discussed, before concluding with the research justification, aim and hypothesis.

2.1 Appetite & Satiety Definitions

Controlling EI is vital for regulating energy balance and is influenced by appetite, hunger, satiation and satiety, with these systems working together in an important psycho-biological equilibrium (Benelam, 2009; Tremblay and Bellisle, 2015). Appetite is the desire to eat that is psychologically controlled, whereas hunger is a subjective physiological sensation that an individual can sense when they want to consume food (Blundell et al., 2010). Satiation is the process that leads to the cessation of an eating episode; thus, helps with portion control. Satiation is influenced by reduced appetite and hunger during an eating episode (Blundell et al., 2010). This differs from satiety, which is the feeling of being sated after a meal; it impedes further consumption of food in between meals, elevates fullness and reduces appetite and hunger after an eating episode for a variable duration until the next eating episode (Blundell et al., 2010; Bellisle et al., 2012). Thus, total daily energy intake (TDEI) is influenced by the total number of eating episodes and the amount consumed at each episode, which are both influenced by satiation and satiety (Benelam 2009). Controlling food intake is a complex process involving conscious and unconscious decisions supported by composite physiological systems, providing internal signals that result in subjective feelings of hunger and satiety (Bilman, van Kleef and van Trijp, 2017).

When appetite control is efficient, hunger, satiation and satiety develop in succession, ensuring energy intake meets energy needs, i.e. energy balance (Tremblay and Bellisle, 2015). However, the prevalence of those living with

overweight and obesity has highlighted that the factors contributing to appetite control (thus obesity) are complex and multifaceted, involving interactions with aspects of behaviour alongside metabolic processes, influenced by hormones and genetics (Paddon-Jones et al., 2008). Despite the physiological regulation of appetite, hunger, satiation and satiety, external factors can also influence these processes. For example, food supply used to be uncertain, however, the increased availability of food choice, particularly products high calories and fat, tempt consumers to eat irrespective of appetite sensations, challenging the appetite control system (Blundell, 2017). Therefore, there appears to be a 'conflict' between internal signals working to inhibit appetite (e.g. satiation and satiety) and the external environment with ubiquitous stimulatory influences that affects EI and subsequently energy balance (EI vs energy expenditure, as people frequently eat in the absence of hunger (Feig et al., 2018). However, enhancing the satiating 'power' of foods may be a way to intensify postprandial inhibition of appetite, perhaps facilitating weight loss (Tremblay and Bellisle, 2015).

2.2 Appetite: Satiation & Satiety Physiological Mechanisms

Despite nutritional intake and behaviour occupying separate psychobiological domains, they are inextricably linked (Blundell, 2017). Thus, factors that influence eating behaviour, hence nutrients entering the body, have potential to affect overall nutrition and health. Our food choices are not only affected by internal appetite signals, but also external factors including: culture, religion, the time of day (circadian rhythm), the portion size and palatability of the food options, previous experiences with foods, availability of food items and the context of the eating episode, e.g. eating alone or in a group or whilst watching television (Bellisle et al., 2012; Braude and Stevenson, 2014). Further, consuming two foods with matching nutrient contents might cause differing effects on appetite response (irrespective of the metabolic effects caused by the nutrients in the GI tract) due to characteristics of the foods being consumed, such as food texture, contributing to appetite control process (Chambers, 2016). Additionally, it could be suggested that the temperature of a meal may influence satiety e.g. hot food may supress gastric emptying rate, likewise hot

food may raise body temperature and induce satiety comparative to cold meals although this data is sparse (Herman, 1993). Therefore, all of these factors can influence our subjective appetite sensations, physiological satiety response and subsequent EI. Thus, there are various factors influencing eating behaviour that move beyond satiation and satiety, such as hedonic systems i.e. eating for pleasure rather than to obtain energy, consequently making the measurement of satiation and satiety complicated.

The physiological processes that occur between initial food intake, satiation and satiety involve complex systems, which regulates how much individuals consume (Benelam, 2009; Amin and Mercer, 2016). “The Satiety Cascade” characterises the factors affecting satiation and satiety from the beginning of an eating episode right through to the late satiety (Blundell et al., 1987). These factors include sensory (e.g. taste, texture, smell), cognitive, pre-absorptive/post-ingestive and post-absorptive elements. The sensory properties of food, including sight, smell, taste and texture can all trigger a cephalic phase response. This anticipatory physiological response to sensory food stimuli before swallowing any food, initially prepares the gastrointestinal (GI) tract to metabolise the incoming food (McCrickerd and Forde, 2016). Thus, prior to ingesting any food the process of satiation has been instigated from the consumer’s expectations and perceived quality of the meal (Chambers, 2016; Bilman, van Kleef and van Trijp, 2017).

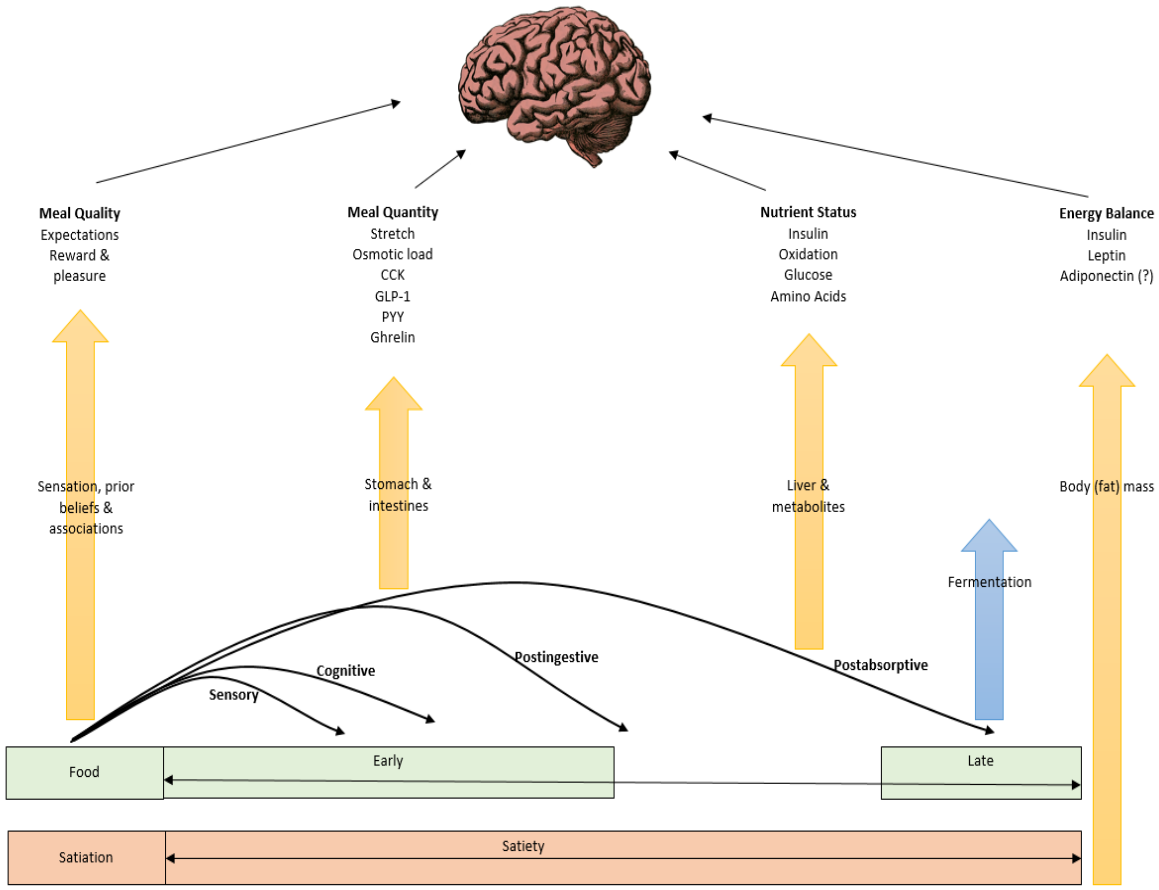

Figure 1: *The Satiety Cascade. First developed by Blundell et al. (1987), amended by Mela (2006). Image adapted from original/recreated image.*

Mastication, or chewing, ensures comminution of food i.e. the reduction in particle size, ensuring it is suitable for GI nutrient digestion and subsequent absorption (Pedersen et al., 2002). Mastication can cause increased bioavailability of nutrients for absorption, subsequently impacting pre- and post-absorptive mechanisms. Consequently, mastication may contribute to stimulating the release of hormones that are involved with neuro-hormonal mechanisms, regulating food intake and ultimately aiding appetite control (Møller, 2014; Miquel-Kergoat et al., 2015). However, current studies do not isolate the effect of chewing, so although evidence may suggest mastication can contribute to the gut hormone response, results are ambiguous in implying that mastication has a direct effect of influencing the gut hormone response (Hollis, 2018).

As ingested food enters the stomach, pre-absorptive processes start to take effect, further contributing to satiation. Gastric distention occurs when food or drink enters

the stomach, causing an increase in gastric volume, which is communicated to the brain via the vagus nerve (Ritter, 2004; Benelam 2009). Initially, receptors in the stomach respond to distension by signalling via the "gut-brain axis". This consists of bidirectional transmission of neurons between the central nervous system (CNS), particularly in the hypothalamus and the enteric nervous system that governs the function of the GI tract in response to food stimuli/bolus (Carabotti et al., 2015). In addition to gastric distention and the rate of gastric emptying, peptides released from the stomach, intestinal tract (e.g. cholecystokinin [CCK] and ghrelin) and adipose tissue (e.g. leptin) also influence appetite regulation (Blundell and Bellisle, 2013; Tremblay and Bellisle, 2015; Chambers, 2016).

CCK is a gut peptide released by the CNS succeeding EI that appears to be involved with satiation (Benelam 2009). In addition to being dose-dependent, gastric distension is required for CCK to be effective in promoting satiation (Lieverse et al., 1995). CCK reacts to the presence of nutrients in the gut, especially fat and protein-rich meals, and is then subsequently released into the circulation (Wren & Bloom 2007). The effects CCK display on satiety appear to be mediated via the vagus nerve. CCK is also involved with secretion of pancreatic acid, intestinal motility and delaying gastric emptying, thus aiding in digestion coordination (Moran, 2000).

Ghrelin, another important peptide hormone, is the only known gut hormone that promotes the feeling of hunger, prompting food intake. Conversely, suppression of ghrelin promotes satiety and it is purported to be proportional to EI at that meal (Wren et al., 2001; Callahan et al., 2004). Indeed, ghrelin levels are inversely related to the level of fat mass i.e. obese individuals have lower ghrelin levels, than lean individuals (Tschöp et al., 2001; Shiyya et al., 2002).

These early satiation signals will integrate with pre-absorptive (gastric distension, gastric emptying rate, hormone release, GI receptor stimulation) and post-absorptive (effects resulting from metabolism of absorbed nutrients) signals to determine satiety (Bellisle, 2008). It is cephalic phase responses such as releasing GI hormones, secretion of acid and changes to gastric and intestinal motility that are believed to magnify postprandial satiety sensations as they influence how well nutrients are

processed in the GI tract (Smeets, Erkner and deGraaf, 2010). Moreover, the volume of the previous meal exerts effects during early satiety phase (due to gastric distension signals), whereas the nutrient content of the meal exerts effects on satiety during the post-absorptive phase (Tremblay and Bellisle, 2015).

Satiety can be influenced by 'episodic' signals i.e. short-term signals in response to food consumption and 'tonic' signals i.e. longer-term signals reflecting energy stores in the body (Benelam, 2009). Both influence satiety by acting on the hypothalamus in the brain and accordingly affect EI or energy expenditure. Hormonal signals are considered episodic (because they happen when food is consumed), but it is important to note that there are interactions between episodic and tonic signals with regards to satiety. Several hormones are secreted from the gut, to indicate to the brain that food has been ingested, promoting satiation and satiety (Benelam 2009). The post-absorptive stage primarily influences satiety via specialist receptors that detect specific nutrients that provides information about nutrient status (Blundell et al., 1987). When incoming energy reaches the intestinal tract and is subsequently absorbed, various hormonal signals are integrated into the brain inducing satiety. In addition to these episodic signals, variations in hormones, such as insulin and leptin can also affect satiety (Benelam 2009).

Long-term, satiety may also be affected by signals such as leptin – a tonic peptide hormone released from fat cells within the adipose tissue (Klok et al., 2006). Leptin will influence long-term food intake, modulating energy balance; hence, ultimately controlling body mass by communicating the levels of fat mass to the brain (Klok et al., 2006; Benelam, 2009). Circulating leptin levels are directly proportional to the levels of fat mass within each individual. Consequently, levels are diminished by weight loss and associated with increased hunger and consequently food intake (Holtzman and Ackerman, 2019). If an increase in adiposity is detected, insulin and leptin are mobilised to prompt satiety (Bilman, van Kleef and van Trijp 2017).

Glucagon-like peptide 1 (GLP-1) is an anorexigenic gut hormone secreted postprandial that affects satiety. GLP-1 is a potent incretin (i.e. it stimulates a decrease in blood glucose), in that it increases insulin production (MacDonald et al., 2002). It is involved with regulating the ileal brake mechanism i.e. a feedback

mechanism resulting in inhibition of proximal gastrointestinal motility and secretion and consequently the transit of food from the stomach into the small intestine, consequently slowing gastric emptying (Maljaars et al., 2008). Thus, GLP-1 seems to contribute to satiety via potentiating insulin secretion and acting on the ileal brake, causing a delay in gastric emptying thus reducing EI and inhibiting appetite (Holst, 2007; Shah and Vella, 2014).

There is a complex network of signals occurring which help to develop satiation and satiety. It is the marriage of tonic and episodic signalling that help control appetite. Anorexigenic pathways inhibit feeding and orexigenic pathways stimulate feeding in the hypothalamus. Both pathways can be stimulated and inhibited by signals from the gut, pancreas and adipose tissue (Benelam, 2009). The brainstem receives information regarding gastric volume and details regarding the nutrients via signalling through the vagus nerve (Carabotti et al., 2015). There are several variables that can impact satiation and consequently the quantity of food eaten during one singular eating episode (Amin and Mercer, 2016). As nutrients enter the small intestine, satiety signalling is instigated. Despite satiation and satiety having distinctions, it is important to note that they are integrally part of a continuum, which may cause some overlap between the latter stages of satiation and the early stages of satiety.

In conclusion, it is apparent that there are multiple determinants - biological, psychological, environmental and social, that will impact satiety regulation. Next, the role of the weight management programme Slimming World in the context of aiding satiety will be explored.

2.3 Slimming World

Slimming World (SW) is classified as a tier 2 weight management programme that supports individuals to take responsibility for their own health through weekly peer-group support sessions led by a mentor (known as consultant) (NICE, 2014). SW supports approximately 800,000 members who are wanting to adopt healthier lifestyles and eating behaviours across the UK and Ireland with trained consultants (Stubbs et al., 2015). SW focuses on lifestyle changes by encouraging members to

adopt healthier lifestyles with three main components that include: eating behaviour - referred to as 'Food Optimising', increasing physical activity levels - referred to as 'Body Magic' and facilitating behaviour change – known as 'IMAGE Therapy'. It is beyond the scope of this thesis to explain the full SW programme for more information see Slimming World (2019a).

Food Optimising, the dietary component of the SW programme places emphasis on ad libitum consumption of low energy dense (LED) foods e.g. lean meats, eggs, fish, pasta, fruits and vegetables, referred to as 'Free Food'. 'Free food' makes up approximately 80% TDEI alongside controlled quantities of high energy dense (HED) foods that are either 'Healthy Extras' (approximately 15% TDEI) and 'Syns' (approximately 5% TDEI). 'Healthy Extras' include milk, cheese and wholemeal bread ensuring essential vitamins and minerals are being consumed alongside the unlimited 'Free Foods' but are in more controlled quantities (Slimming World, 2019a). 'Syns' comprise of foods that are the least filling and are energy dense such as, biscuits, sweets and alcohol. The emphasis of the programme is not to limit any foods and assist members keeping on track with their weight target at weekly weigh-ins, via exercise and group support.

2.4 Slimming World Ready-Meals

In 2015, SW released a range of frozen ready meals with Iceland Food Ltd, with meals designed in response to continued member feedback. With over 35 ready meals, that are in line with their Food Optimising plan, which advocates an unrestricted intake of 'Free Foods' or LED foods whilst simultaneously enabling a controlled intake of 'Healthy Extra's'/'Syns' - HED foods (Slimming World, 2019b). Ultimately, SW aims to strengthen sensations of satiation and satiety to reduce EI both within and between meals to diminish the effect of hunger in compliance within the SW programme (Slimming World, 2019a). Although SW advocates consuming freshly made meals in order to have the most control over macronutrient intake, they have responded to consumer needs by producing their frozen ready meal range.

2.5 Efficacy of Slimming World

Evidence suggests that individuals who consume a high-protein, moderate carbohydrate diet have increased likelihood of maintaining weight lost after 12 months (Clifton, 2006; Leidy et al., 2015). Due et al. (2004) also found that a higher protein diet (25% TDEI) was also easier to comply with compared to a lower protein diet (12% TDEI), highlighted by the 20% lower dropout rate reported. A possible suggestion for the higher protein diet being easier to comply with may be because it was simpler to add in protein rich foods to meet the percentage of daily energy requirements compared to having to be more cautious when following the lower protein diet. There is a general consensus that permanent reduction in weight can be hard to achieve, with most evidence suggesting weight regain to be the case when achieved through radical dieting and lifestyle amendments (Wadden, Stunkard and Leibschutz, 1998; Elfhag and Rössner, 2005). However, long-term adherence to a higher protein intake within an energy-controlled diet and group support may be a feasible way to adapt habits more likely to result in sustained weight management partially due to enhanced satiety (Stubbs et al., 2015; Buckland et al., 2018). The Lighten Up trial investigated an array of weight management programmes and their effectiveness on weight loss (Jolly et al., 2010). Findings indicated that commercial weight loss programmes were more effective than primary care programmes (e.g. GP and pharmacy interventions) in achieving greater weight loss (mean 2.3kg) at the end of 12 weeks comparative to a control group (participants were given access to fitness facilities but were not given appointments to attend or any individual advice on physical activity or nutritional guidance).

Individuals who attended a minimum of 75% (aka 'higher attenders') of weekly SW sessions (n= 478,772) during the first three months of joining SW, had higher levels of weight loss compared with lower rates of attendance. The higher attenders (6.8 kg/7.5%) lost on average 4.8% (4.5 kg) more body weight, which was significantly different compared to the lower attenders (2.3 kg/2.7%) (Stubbs et al., 2015). This may have been due to higher attenders accessing more group support. Using the same dataset as Stubbs et al. (2015), Lavin and colleagues (2013) revealed that weight outcomes continued to improve with long-term engagement. Individuals attending

at least three-quarters of weekly sessions over 12 months lost more than 13% of their starting body weight. This data suggests that individuals who adhere to the SW programme and attend all the sessions will lose more weight compared to individuals who and do not attend all the group sessions.

In a parallel study, Buckland et al. (2018) recruited 96 females who had recently enrolled in a SW or NHS Live Well Programme to a 14-week trial. Buckland and colleagues (2018) investigated if the SW programme, was more effective in controlling appetite, weight loss, body composition, improved health and weight loss experience when compared to a standard self-led calorie restricted programme (NHS Live Well). Individuals following the SW programme lost more body fat and 2.4 kg more weight compared to the NHS Live Well programme. More specifically, on two days during the trial, participants received LED versus HED fixed-calorie breakfast and lunch meals followed by an ad libitum evening dinner and snacks. During these test days, fullness ratings were greater, hunger ratings were lower and TDEI was 1057kcal less on the LED conditions compared to the HED day. Further, researchers found that the SW programme was rated more satisfying and easier to adhere to than the standard care group programme (Buckland et al., 2018). These findings illustrate the effectiveness of LED meals for decreasing subjective appetite ratings and meal EI amongst women with overweight or obesity when they are actively trying to lose weight (Buckland et al., 2018).

In summary, there is evidence supporting the use of sustained LED diets, in addition to adequate protein intake to promote satiety and aid weight loss. The following section will focus on individual macronutrients in the context of satiety.

2.6 Macronutrients & Satiety

Understanding the energy content of differing macronutrients within foods and drinks and how they can consistently produce similar/differing effects on satiety and EI is important. Depending on the food, macronutrient composition will vary from 0-9 kcal/g (Department of Health, 2012). Fat, is the most energy dense macronutrient providing 9 kcal/g, whereas carbohydrate and protein both provide 4 kcal/g

(Department of Health, 2012). When using composite foods (like in a ready meal), aiming to study one aspect of that food in isolation (whilst trying to keep other components the same) is inherently difficult. Certainly, this is not only due to the differing ED of the other macronutrients within the product, but also because there are common methodological matters that may impact results when researching satiety. For instance, it is known that palatability, food weight, ED, fibre and GI all influence satiety (Halton and Hu, 2004; Karhunen et al., 2008; Rolls, 2017). Thus, lowering the fat content of a food would lower the ED and affect the palatability, both of which may impact effects on satiety (Halton and Hu, 2004).

Indeed, if comparing the protein content between two isocaloric meals (e.g. high versus low protein content), the remaining macronutrient profile will need to be manipulated/varied in order to be isocaloric, which might also impact satiety measurements. For example, a study by Moran et al. (2005) compared the effects of isocaloric test meals with differing proportions of protein and fat on several physiological biomarkers, including ghrelin and insulin, in addition to subjective appetite ratings. In a randomised parallel design, 57 males (n=25) and females (n=32) completed 16 weeks following either a high-protein-low-fat diet (34% protein: 29% fat) or a standard-protein-high-fat diet (18% protein: 45% fat). Results found that the higher protein diet was significantly more satiating than the standard-protein meals.

Data suggests that protein exerts a stronger effect on satiety when compared with isocaloric quantities of fat or carbohydrate (Moran et al., 2005). It has long been established that protein has a greater effect on satiety than carbohydrate, with both having a greater effect than fat, despite fat having a high energy content (Westerterp-Plantenga et al., 1999; Astrup, 2005; Lejeune et al., 2006; Bellise 2008). There is a plethora of evidence showing that higher protein foods promote greater levels of satiety compared to energy-matched lower protein meals (Moran et al., 2005; Veldhorst, Westerterp and Westerterp-Plantenga, 2012), subsequently reducing EI (Johnston and Vickers, 1993; Westerterp-Plantenga et al., 2004; Layman, 2004; Westerterp-Plantenga and Lejeune, 2005; Paddon-Jones et al., 2008). However, such findings are not always conclusive (Li et al., 2016). There are several suggested

reasons protein might enhance satiety including increased protein turnover (Raben et al., 2003; Paddon-Jones et al., 2008).

The substantiation of high protein diets might relate to protein exerting a greater thermic effect when compared to other macronutrients i.e. carbohydrate and fat. According to Halton and Hu (2004) the thermic effect of food (also known as diet induced thermogenesis, DIT) is, "the increase in energy expenditure above baseline following consumption". This definition can be expanded further to include energy required for the digestion, absorption and removal of consumed nutrients. This thermic effect is influenced by the composition of macronutrients ingested, with protein typically requiring between 20-35% of total energy consumed to digest protein. In contrast, the thermic effect of carbohydrate is between 5-15% and 0-3% for fat (Westerterp, Wilson and Rolland, 1999; Raben et al., 2003).

Westerterp and colleagues investigated diets composed of extreme macronutrient composition on DIT in a respiratory chamber over a period of 24-hours (Westerterp-Plantenga et al., 1999). In this randomised controlled trial (RCT), eight healthy female participants (23-33 years, BMI 23 ± 3 kg/m^2) ingested two separate isocaloric, isovolumetric foods matching, as closely as possible, organoleptic properties (smell, appearance, taste) at the exact same times on two separate days. Some research has found that these properties may potentially impact the cephalic phase response of DIT (Hashkes, Gartside and Blondheim, 1997). Further, familiarity of food has also been shown to affect DIT (Westerterp-Plantenga et al., 1992), hence why both diets were composed of similar foods. The diets differed by macronutrient composition (high protein-carbohydrate: 29% protein, 61% carbohydrate, 10% fat & high fat: 9% protein, 30% carbohydrate, 61% fat). Results indicated that the high protein-carbohydrate diet significantly increased subjective feelings of fullness compared to the high fat diet, which established significantly greater feelings of hunger, desire to eat (DTE) and prospective consumption. The order of each diet did not affect the results, thus highlighting the impact behaviour might have on affecting EI (Sonneville and Gortmaker, 2008; Benelam, 2009).

Vanderwater (1996), found higher protein foods to cause enhanced satiety compared to a low protein meal, after only two minutes which was found to continue up to 24-

hours in the study period of Westerterp (1999). However, not all research is conclusive regarding the superior satiating effects of protein. After a 13-day period of dietary manipulation, Long (2000) found that a low protein diet produced significantly greater satiety ratings when compared to the high protein diet, thus suggesting that the acute effect of protein seen in most research is inversely proportional to habitual consumption/intake.

In a randomised, single-blind study Vozzo and colleagues (2003) investigated isocaloric yogurt preloads that were rich in either protein (30%), carbohydrate (60%) or fat (40%) on spontaneous subsequent food intake, controlling for weight, volume, ED and palatability. Results indicated that neither the quantity consumed, nor the frequency of the spontaneous eating episodes differed significantly between each pre-load. Thus, this study indicates that those who are able to freely choose when they consume food (most like a real-life situation) as well as the quantity, all three macronutrients exerted similar effects on satiety. These differences may have been observed due to methodological differences between studies and the proportions of macronutrient 'rich' differing. Indeed, this study controlled for volume, whereas multiple other studies have provided a higher dose of protein, however, not controlled for the volume – a known factor to impact gastric distention and thus satiety in addition to ED and palatability (Marmonier et al., 2000). Thus, there is evidence that factors such as ED and palatability, rather than specific macronutrient content of foods (despite hierarchy), may be more important in determining satiating efficacy of foods (Chambers et al., 2015).

Consequently, when aiming to understand satiety in the context of this research, carbohydrate and fat should also be considered. Lab-based studies have concluded that high-fat preloads are less satiating than energy matched high carbohydrate preloads (Rolls, 1995). However, Rolls et al. (1994) found this to occur only in restrained eaters (RE), not unrestrained eaters i.e. those who were unconcerned about body weight were able to accurately compensate for the calories in each preload despite being different. It is important to note that differing preload ingredients and participant characteristics will affect the outcome.

Interestingly, there is evidence to suggest that sensitivity to fat – both orally and in the GI tract, is diminished in those with obesity, making it feasible to suggest that meals higher in fat might be less satiating in individuals with obesity (Stewart et al., 2011). Brennan et al., (2012) conducted a study investigating the acute effect of equally palatable meals that varied in which macronutrient predominated on GI hormones, subjective appetite ratings and EI in lean and obese males. Results indicated that the high protein (45%) meal was most substantial in reducing hunger ratings and EI in lean and obese individuals; thus, maintains the macronutrient hierarchy for satiety and protein – at least acutely. The study also found that the high fat (55%) meal to reduce EI only in the lean individuals when compared with the high-carbohydrate-low-protein (60% carbohydrate: 10% protein) meal. Conversely, individuals with obesity tended to have higher EI after the high fat and high-carbohydrate-low-protein meals but not high protein or adequate protein (30%) meals when compared to lean individuals. These observations indicate that those with obesity remain less able to adjust their EI in response to a meal high in fat compared with lean individuals. Additionally, this study corroborates with the results from the Stewart et al. (2011) study regarding oral and GI receptiveness to dietary fat consumption. In both lean and obese participants, the high protein meal when compared with the low protein meal reduced EI by approximately 14% and 22%, respectively. Among individuals with obesity adequate protein meal also reduced EI suggesting that even a moderate quantity of protein within a meal can impact EI. However, this was not found among the lean participants, perhaps who are less sensitive to the effects. In summary, individuals with obesity may be less sensitive to the perception of fat, whilst lean individuals appear more able to adjust EI after adequate protein diet (Brennan et al., 2012).

Another nutrient exerting beneficial effects on satiety is fibre (Wanders et al., 2011; Clark and Slavin, 2013). Fibre can affect satiety depending on the type of fibre and its ability to increase viscosity, increase bulk of stool increase gastric distension, slow the rate of gastric emptying and impact satiety hormone release (Slavin and Green, 2007; Vuksan et al., 2009; Kolderup, Hervik and Svihus, 2019). Generally, a diet rich in fibre is thought to influence satiety due to high fibre foods usually being LED. For

example, fruit and vegetables are LED foods and if the same quantity was consumed as HED foods, they would be equally satiating but fewer calories would be consumed purporting that processing fibre promotes satiety (Ello-Martin et al., 2005).

There is evidence to suggest that carbohydrate refinement i.e. consuming apple juice versus whole apples, is associated with increased hunger (Haber et al., 1977). Despite this increase in satiety from foods that have not been refined i.e. fibre has not been removed, several studies have discovered no impact on EI (Isaksson et al., 2008; Schroeder et al., 2009). However, according to Hu and Pan (2011) manipulating the physical form of the carbohydrate (liquid versus solid) may affect the satiety process, with evidence suggesting liquid carbohydrates commonly being less satiating than solid forms. Thus, it is difficult to differentiate the independent effects of removing the fibre content from food, from the physical form and which is causing enhanced satiety.

Additionally, larger particle size might enhance satiety to a greater extent than smaller particle size of the same type of fibre (Slavin and Green, 2007). It could be suggested that larger particle size of fibrous ingredients contribute to this effect because they require greater processing time and thus, satiety signals that are instigated before ingestion and/or those activated during mastication, might be stimulated to a greater extent with larger rather than smaller fibre particles (Slavin and Green, 2007). Fibrous foods generally increase mastication, thus oro-sensory exposure time, which is believed to stimulate satiety responses (Chambers, 2016). Indeed, research has found that longer oro-sensory exposure time consistently increases satiation i.e. food intake.

It should be noted that carbohydrate can exert satiating effects quite acutely, whilst the effects/mechanisms via which protein works seem to be more sustained in short-term studies (Paddon-Jones et al., 2008). However, one important point of note is that rarely do individuals consume macronutrients in isolation. Thus, the composition of a meal will inevitably affect satiety differently and this is true for the effect of fat on satiety (Warrilow et al., 2019). Additionally, in scientific research although some confounding factors can be controlled, there will always be differences in study designs and preloads (foods) making comparison difficult.

2.7 Energy Density

The consumption of food provides energy and macronutrients, in addition to other constitutes that can contribute to satiety (Bellisle, 2008). One such constituent is the water content of the food being ingested as this will influence ED, which refers to the number of calories per gram of food (Bellisle, 2008). Hence, water will contribute to the weight of the food without contributing to the energy of the food.

There is evidence to suggest that consuming LED preloads can reduce hunger sensations and subsequent meal EI compared with higher ED preloads or no preloads in healthy weight, overweight, and dieting individuals (Rolls et al., 2006; Flood and Rolls, 2007; Buckland et al., 2013). Consequently, if foods ingested have a LED – commonly foods with a high-water content and low in fat, individuals will reach satiation ceasing an eating episode prior to consuming large quantities of energy. Conversely, consuming foods with a HED, a small quantity of food can be ingested with a large proportion of calories in a relatively short time period, prior to satiation occurring, which can also influence satiety (Bellisle, 2008). However, as a result of the HED of fat, high fat foods will often be provided in smaller quantities than a high carbohydrate food of similar energy, which may impact the length of time to process the nutrients in the gut (Karhunen et al., 2008). There are also psychological implications being that people might believe that a smaller portion will not be enough to stave off hunger irrespective of how much energy the food provides and according to Brunstrom et al. (2008 & 2011) these satiety expectations can play a pivotal role in eating behaviours.

Research into the ED of food has suggested that it may have a beneficial impact on satiety. Studies in which *ad libitum* intake has been long-term (i.e. one year), ED appears to be a greater predictive indicator of EI compared with macronutrient composition, with some evidence that HED foods contribute to greater EI (Rolls, 2009). Similarly, Rolls and Roe (2002) placed preloads directly into the stomach consequently discovering that the volume infused is more important in enhancing satiety and reducing subsequent EI than the energy content of the preload. According to Rolls (2017), it appears individuals consume a constant weight of food, irrespective of calories and so even modest changes in ED will impact EI. Research in which the

concept of a food's ED is explored has indicated that hunger can be controlled, while being flexible enough to guide individuals to makes their own choices, which can encompass their own preference (Rolls, 2017).

Delayed gastric emptying and increased gastric filling, only partially describe the impact of ED on aiding regulation of EI (Keller et al., 2013). Additionally, there is also a complex relationship between cognitive, hormonal, sensory, neural and GI influences. The effect of visual or cognitive signals has been demonstrated by studies in which the volume of the foods investigated had been reformed either by modifying the shape of the food pieces or through aeration. When Rolls et al. (2014) offered participants smaller cereal flakes, those individuals served themselves less compared to larger flakes yet consequently took a greater amount by weight and consumed significantly more calories. Hence, smaller flakes were more compact, and the same weight filled a smaller volume, thus varying the volume of food will affect portion size and EI. Additionally, aeration of a milkshake to enhance volume, increased satiety and diminished subsequent food intake (Rolls et al., 2000). Additionally, aeration also reduced the amount of a snack consumed when provided *ad libitum* (Osterholt et al., 2007). Highlighting that adding air to the milkshake to enhance volume, will increase satiety despite no calories being added to the drink. It is of relevance that these effects were detected in individuals familiar with the foods provided.

Within whole foods it is important to take into consideration other factors that have been shown to influence satiety. Holt et al. (2001), found that when isocaloric portions of different ingredients were consumed, portion size and consequently ED was the greatest predictor of satiety. Further, research has found that the volume of food consumed can influence perceptions of the food's pleasantness compared to ED (Norton 2006). Physical aspects will also influence physiological mechanisms i.e. thicker versus thinner shake, when all other aspects of nutrient composition remain constant (Mattes and Rothacker, 2001).

ED is a valuable way of manipulating food intake e.g. increasing water, decreasing fat; and whilst these sensory and biological effects differ, they are both associated with decreased EI. As highlighted by Williams et al. (2014), EI was reduced via three different methods of reducing ED: increased water, increased fruit and vegetables

and decreased fat. However, some research has shown particular approaches to reducing ED to be more effective than others. Rolls et al. (2010) found that adding vegetables to a meal did not decrease overall EI of that meal, whilst substituting the added vegetables for more ED meat and grains, subsequently reduced EI. Thus, substituting lower ED foods for higher ED foods can also modulate EI. Pai et al. (2005) found high-protein, high-fibre food and food with a greater water content i.e. LED foods, to be most effective in delaying the return of hunger. Moreover, eating time is generally longer when consuming LED foods, one reason being that if the food contains a high fibre content this will require more time to orally process (Chambers, 2016).

Weight loss using LED diets has been established in several trials (Rolls 2009). In a one-year RCT by Ello-Martin and colleagues (2007), 97 women with obesity were counselled to either fruit and vegetable consumption and to reduce fat consumption, or just to reduce fat consumption. Women who increased fruit and vegetable consumption and decreased fat intake had larger decrease in dietary ED and an augmented weight loss than those women who were only advised to reduce fat intake. Several studies have reported increased weight loss with those following (and adhering to) lower ED diets and helped to maintain weight loss (Ledikwe et al., 2007; Raynor et al., 2011). A study by Greene et al. (2006) found those who reported eating a lower ED diet, two years after participation in a weight loss programme, maintained their weight loss when compared to those individuals who regained 5% or more of their bodyweight. This evidence suggests that consuming LED diets is beneficial for weight loss.

Further, a multitude of systematic reviews and meta-analysis' that have established that consuming lower ED diets results in lower bodyweight (Perez-Escamilla et al, 2012; Karl and Roberts, 2014; Stelmach-Madas et al., 2016). However, there is ambiguity regarding chronic accumulation of an energy deficit and the impact on satiety and food intake, in which biological regulatory systems may respond by augmenting hunger and consequently EI (Rolls 2017).

2.8 Research Justification

Due to the prevalence of obesity and the forecast rise in ready meal consumption more attention is being focused on dietary practices such as time spent on preparing food, use of convenience foods including ready meals and the potential for how these may impact EI, weight and diet quality (Monsivais et al., 2014; Wolfson and Bleich, 2015). There is emphasis from The UK Government for the public to concentrate on proactive prevention of avoidable diseases, such as obesity, by urging consumers to take more responsibility for their own health via adopting healthier lifestyles through increased physical activity, improved dietary choices and managing weight (Stubbs et al., 2015; Department of Health and Social Care, 2019). However, spending time on preparing food still remains an issue for many people due to leading busy lives and having more commitments, thus numerous individuals still rely on using ready meals as a frequent source of nourishment (Monsivais et al., 2014). Hence, it is valuable to understand the satiating properties of ready meals, specifically in the context of health and/or weight management meals, for the benefit of the consumer, in order to establish if specific ready meals can enhance satiety and contribute to reducing subsequent EI, ultimately aiding in weight management.

2.9 Aim

In this thesis, two appetite research studies were undertaken. The first study aimed to explore the effects of two ready meals matched for energy content on subjective satiety ratings and subsequent energy and macronutrient intake. The second study aimed to investigate the effects of fixed portion size (grams) ready meals on subjective satiety ratings and subsequent energy and macronutrient intake. Both studies used the same test (Slimming World) and an equivalent commercially available control (Sainsbury's) ready meal.

2.10 Hypothesis

For Study One it was hypothesised that there would be a significantly greater change in favourable subjective feelings of satiety i.e. reduced hunger, DTE and prospective consumption and increased fullness, in addition to reduced energy intake after the consumption of the test ready meal compared to the control ready meal.

For Study Two it was hypothesised that the test ready meal would enhance subjective appetite ratings i.e. increase fullness and reduce hunger, DTE and prospective consumption, in addition to reducing energy intake compared to the control ready meal.

Chapter Three: Methodology

Both studies followed the same protocol. Any specific study details will be explicitly described throughout the methodology section.

3.1 Study Design

A within-subjects, randomised crossover design was used to investigate two ready meals and their subsequent effects on subjective satiety ratings and food intake in two separate studies. For both studies, participants were required to come to the Oxford Brookes Centre for Nutrition and Health (OxBCNH) for one screening session and two test sessions. There was a minimum 24-hour washout period between sessions in order to reduce the likelihood of any carry-over effect (i.e. the response of a treatment from one intervention might be carried-over' influencing the response of the subsequent intervention; Lucey et al., 2016). The two ready meals investigated were a SW lasagne (Slimming World Free Food Beef Lasagne 550 g, Deeside, UK) (test meal) and a Sainsbury's lasagne (Sainsbury's Beef Lasagne 440 g Serves 1, London, UK) (control meal). Lasagne was chosen as the ready meal because it was the simplest out of the SW ready meal range to find a comparative ready meal on the market. For example, SW have various ready meals (e.g. coca-cola chicken) that do not have any market equivalents. The two studies were:

Study One: Examined the effects of energy-matched ready meal consumption at lunch on self-reported subjective appetite ratings and subsequent food intake during an *ad libitum* buffet meal and food intake for the remainder of the day using a weighed food diary.

Study Two: Examined the effects of portion size-matched ready meals at lunch on self-reported subjective appetite ratings and subsequent food intake during *ad libitum* buffet meal and food intake for the remainder of the day using a weighed food diary.

3.2 Participants

Based on preliminary unpublished data with an alpha level of 0.05 and statistical power of 0.8, it was estimated that a sample size of 25 female participants would be required (for each study) to detect a 331kcal difference in TDEI. Females were chosen as they are more likely to engage in weight loss programmes (Crane et al., 2017).

All individuals who enquired (n= 218) received a participant information sheet (PIS) (Appendix B & C) via email, which informed them of the research details and included the inclusion and exclusion criteria. Ethical approval for the studies was approved by the Faculty of Health and Life Sciences at Oxford Brookes University (Appendix D). Participants were healthy, non-smoking females aged between 18-65 years with a BMI ≥ 25 kg/m^2. In addition, other inclusion criteria included females who:

- had no known food allergies to the study foods,
- had no eating disorders,
- were not following a special diet (e.g. vegetarian, halal),
- were not taking any medication or supplements known to affect appetite or weight within the month prior to and/or during the study,
- were not pregnant, planning to become pregnant or breastfeeding,
- had not significantly changed their physical activity in the 2-4 weeks prior to the study or who did not intend on changing them during the study,
- were not receiving systemic or local treatment likely to interfere with the evaluation of the study parameters,
- had a gastric band/had undergone gastric bypass treatment
- and/or females who worked in appetite or feeding related areas.

Thirty-eight female volunteers (Study One: n= 26 & Study Two: n= 12) were recruited via posters placed around Oxford Brookes University campuses (Appendix A), social media platforms (Twitter, Instagram, LinkedIn), local newspaper advertisements, local community council noticeboards, promotion through going to lectures, attending local SW group meetings and word of mouth between April 2019 and

October 2019. Participants were from a diverse range of members in the local community and no participants had been involved with any previous appetite studies. Figure 2 shows the number of enquiries and participants recruited.

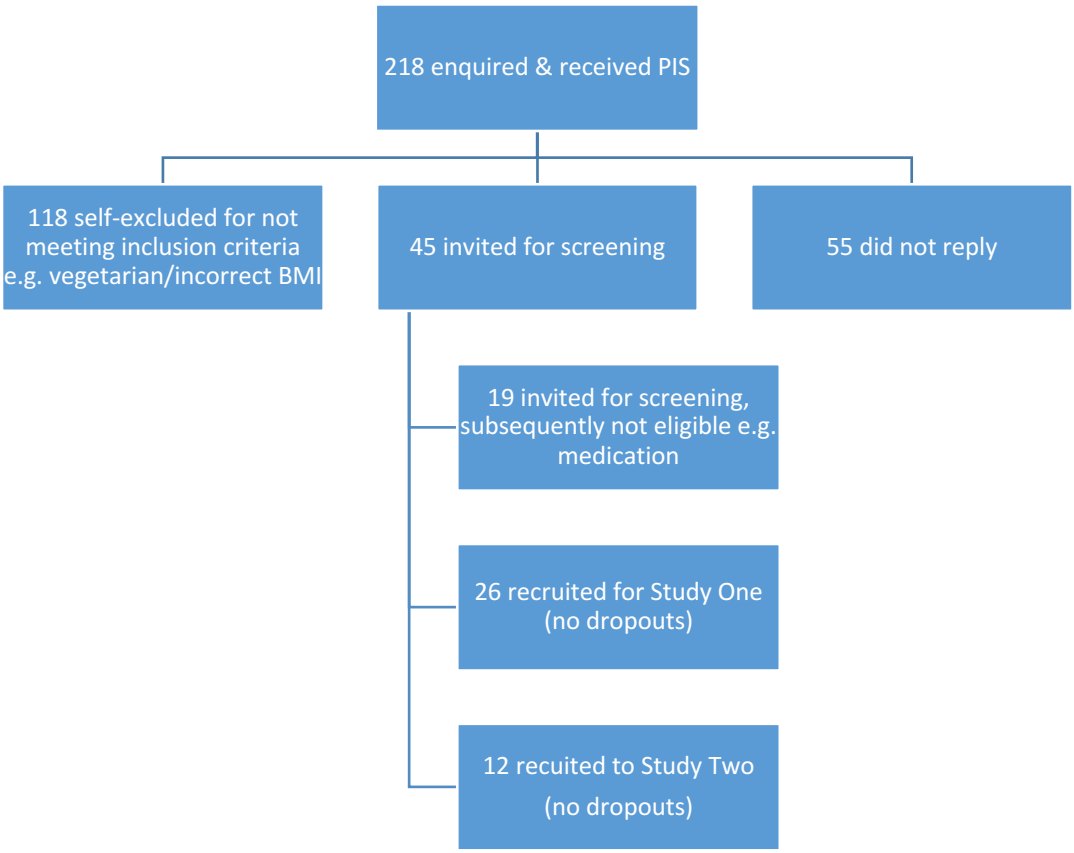

Figure 2: *Volunteer recruitment for Study One and Study Two*

All eligible participants came to the OxBCNH for a screening visit, which comprised of participants completing a Three Factor Eating Questionnaire (TFEQ) (Appendix E), a Dutch Eating Behaviour Questionnaire (DEBQ) (Appendix F), a health questionnaire (Appendix G) and written informed consent (Appendix H & I). TFEQ and DEBQ were used to determine dietary restraint/restrained eating behaviours but the results were not used to exclude participants. Both have been validated in several populations and were used in conjunction to give a more accurate overview of eating behaviours (Westenhoefer et al., 1999; de Lauzon et al., 2004; Anglé et al., 2009; Cappelleri et al., 2009; Kavazidou et al., 2012; Cebolla et al., 2014; Domoff et al., 2014). Restrained eating questionnaires were used to build a picture of participants rather than as an

exclusion criterion. This is due to the likelihood of restrained eating increasing with increased BMI, thus considering the BMI requirements for the study, it was decided not to exclude based on restrained eating scores (Snoek et al., 2008). Each participant's height was measured using a fixed stadiometer (SECA 264, Hamburg, Germany) to the nearest 0.1 cm according to The International Society for the Advancement of Kinanthropometry [ISAK] standards (Stewart et al., 2011). Body composition was measured using bioelectrical impedance (Tanita, BC-418MA, Amsterdam, The Netherlands), provided information on weight (kg), BMI (kg/m^2) and body fat percentage (%). All participants had the opportunity to discuss the PIS and ask any questions regarding the study protocol/procedure prior to providing consent.

The order of each condition for each participant in each study was randomised using an online uniform distribution randomiser (www.randomizer.org). All participants were allocated a number to be used throughout the studies, so their data remained de-identified.

3.3 Overview of Study Protocol

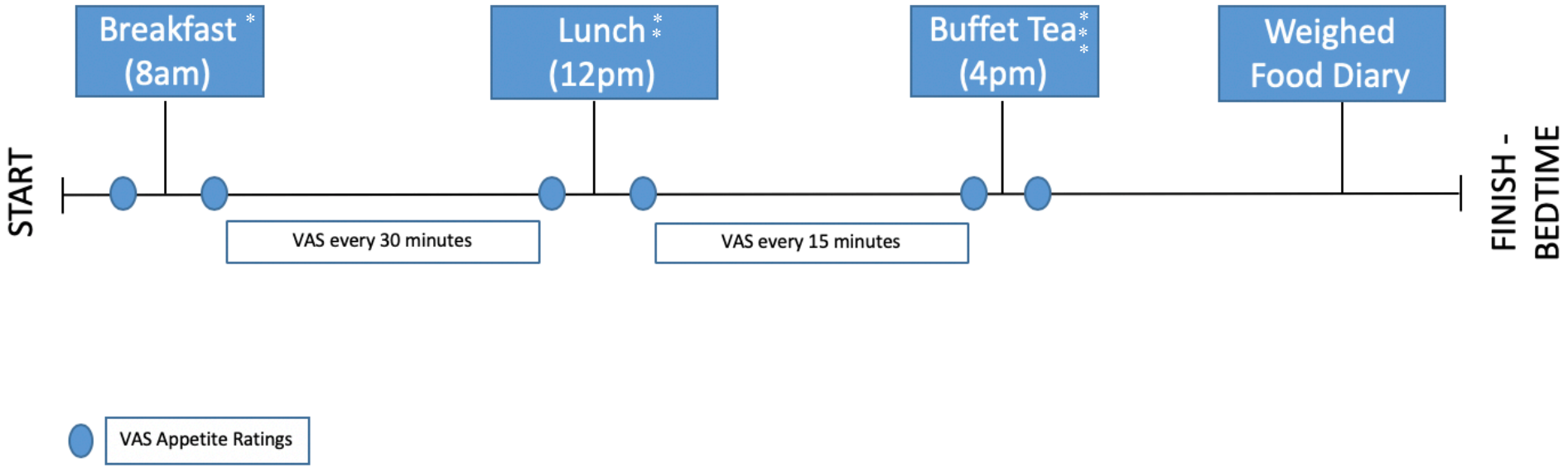

Figure 3: *Timeline of protocol for Study One & Study Two*

* See table 1 for breakfast items | ** See tables 2 & 3 for lunch items | *** See table 4, 5 & 6 for buffet tea

The protocol in Figure 3 was repeated twice; once with the test meal and once with the control meal, with the order of the lunch meal being randomly allocated. For Study One, the meals were calorie-matched but different weights were provided during the test sessions (Control = 380 g & Test = 538 g). In Study Two, the meals were weight-matched (550 g) but different energy content (see table 3). It can be seen in Figure 3 that there were four hours between each meal and mealtimes were determined by the time participants began.

Participants were able to take as long as was required to finish each meal but during all three meals were not allowed to undertake any activity that would distract their focus from the task of eating (e.g. using electronic devices, reading). Water was provided *ad libitum* during the first session of both studies at breakfast, lunch and during the buffet tea and this amount was replicated again during the second session.

All of the ingredients required for each session was prepared in the OxBCNH kitchen and dispensed to participants using safe food hygiene measures. All eating utensils provided to each participant were standardised throughout each condition of both studies.

3.3.1 Pre-trial Standardisation

Participants received a reminder email 24 hours before commencing the study. Participants were instructed to fast for 12 hours prior to their trial start time, limit caffeine intake (maximum two/three cups of tea, coffee and/or caffeinated soft drinks) and avoid alcohol and strenuous exercise (Benelam, 2009). Participants were not required to standardise their diet the day before the study due to the period of fasting and the standard breakfast being received by each participant before the ready meals were consumed.

3.3.2 Breakfast

For both studies, the breakfast was standardised for each participant for both test sessions. The energy content of breakfast (400 kcal) was based on 20% of the standard female UK total daily energy requirements as recommended by Public Health England (PHE). Participants were required to consume the entire contents of breakfast which included toast, jam, margarine and a choice of cereal (Alpen No Added Sugar Swiss Style Muesli, Nestle Cheerios or Special K Original, UK). Plain tea or coffee were provided if desired (as the calories were negligible) and any milk added to the tea or coffee came from the 160 ml provided. The nutritional composition of the breakfast can be found in Table 1.

Table 1: *Nutritional values of the breakfast meal components for Study One and Two*

Nutrients	Nestle Cheerios (33g)*	Alpen Muesli (34g)*	Original Special K (34g)*	Warburton's Medium Sliced Wholemeal Bread (1 slice)	Lichfield's Jam (20g)	Flora Original Margarine (10g)	Tesco's Semi-skimmed Milk (160ml)	Total †
Energy (kJ)	535	531	540	476	51	213	356	1631
Energy (kcal)	128	127	129	114	12	51	85	390
Fat	1.4	2.0	0.5	1.3	0.0	4.5	12.8	19.9
Saturates	0.3	0.3	0.1	0.2	0.0	1.0	1.8	3.2
Carbohydrate	24.0	21.0	27.0	17.0	3.0	0.0	7.7	51.7
Sugars	5.9	5.4	5.1	1.1	2.6	0.0	7.7	16.8
Fibre	2.9	2.8	1.5	2.9	0.0	0.0	0.0	5.3
Protein	3.1	4.0	3.0	4.8	0.0	0.0	5.8	14.0
Salt	0.3	0.1	0.3	0.4	0.0	0.2	0.2	1.0

*participants choose just one cereal

† this total is an average of the cereal choices plus the remaining ingredients

3.3.3 Lunch

The order of the lunch meal was randomly allocated, the Sainsbury's ready meal was chosen as the control because it was the closest existing ready meal that was commercially available to calorie-match with the SW ready meal. In Study One, the ready meals were given to the participants in the portion size in which they were bought. The nutritional composition of the lunch meals for Study One can be found in Table 2.

Table 2: *Nutritional values for test and control ready meal per 100 g and per portion in Study One*

Nutrients	Test Ready Meal		Control Ready Meal		Salad Leaves	Total Meal	
	Per 100g	Per 550g	Per 100g	Per 400g	24g	SW 550g & 24g Salad	Sainsbury's 400g & 24g Salad
Energy (kJ)	430	2313	575	2199	17	2330	2216
Energy (kcal)	102	549	137	525	4.0	553	529
Fat (g)	2.1	11.3	5.7	21.8	0.5	11.8	22.3
Saturates (g)	0.8	4.3	2.5	9.7	0.1	4.4	9.8
CHO (g)	10.7	57.6	11.6	44.5	0.5	58.1	45.0
Sugars (g)	1.6	8.6	2.6	10.1	0.5	9.1	10.6
Fibre (g)	1.7	9.1	1.4	5.4	0.5	9.6	5.9
Protein (g)	9.3	50.0	9.1	34.8	0.5	50.5	35.3
Salt (g)	0.4	2.2	0.4	1.6	0.0	2.2	1.6

CHO = carbohydrates

For Study Two the ready meals provided remained the same, however, the portion provided differed i.e. the same weight (550 g) of the control and test ready meals but the calorie content differed. Nutritional composition of lunch meals for Study Two can be found in Table 3.

Table 3: *Nutritional values for test and control ready meals per 100 g and per serving in Study Two*

Nutrients	Test Ready Meal		Control Ready Meal		Salad Leaves	Total Meal	
	Per 100g	Per 550g	Per 100g	Per 550g	24g	SW 550g & 24g Salad	Sainsbury's 550g & 24g Salad
Energy (kJ)	430	2313	579	3183	17	2330	3200
Energy (kcal)	102	549	138	759	4	553	763
Fat (g)	2.1	11.3	5.7	31.0	0.5	11.8	31.1
Saturates (g)	0.8	4.3	2.5	14.0	0.1	4.4	14.0
CHO (g)	10.7	57.6	12.0	64.0	0.5	58.1	64.1
Sugars (g)	1.6	8.6	2.6	14.0	0.5	9.1	14.1
Fibre (g)	1.7	9.1	1.4	7.7	0.5	9.6	8.2
Protein (g)	9.3	50.0	9.4	52.0	0.5	50.5	52.1
Salt (g)	0.4	2.2	0.4	2.3	0.0	2.2	2.3

CHO = carbohydrates

In both studies meals a green salad was provided (24 g = average serving) (Bender and Bender, 2000) alongside the lasagne, as SW advocate consuming a vegetable or salad with their ready meals (Slimming World, 2019b). For both studies, participants meals were weighed, and participants were required to eat each meal in its entirety.

3.3.4 Buffet Tea

A buffet tea was chosen to measure food intake in order to provide the participants with a choice of foods, purposefully in abundance; also in an environment where the quantity of foods consumed could be measured. For Study One, the *ad libitum* buffet tea included a selection of yogurts, snack bars, fruit, vegetables (see Table 4) and sandwiches (Appendix J), with participants having chosen three from the six sandwich options (two portions of each option, equalling six in total) (see Table 5). After beginning Study One it was decided to alter the buffet tea for Study Two in order to provide more choice to the participants. The buffet tea provided in Study Two differed only in how the sandwiches were presented to the participants (see Table 6). Participant's still had to choose three out of the six sandwich options provided, however, instead of being provided as a pre-made sandwich, they were presented to them 'de-constructed', i.e. the sandwich fillings were provided for them to make their own sandwich rather than being pre-made.

The quantity of food presented to the participants was purposefully in abundance, however, participants were made aware that they were able to request more of anything should they have wanted. Providing participants with options ensured they had a choice to consume foods they preferred. Participants were instructed to eat until they felt comfortably full for both studies. Therefore, termination of the buffet tea was dependent on when the participant felt comfortably satisfied.

Table 4: *Nutritional values of buffet tea Items available to participants in Study One and Study Two*

Nutrients (per 100g)	Go Ahead! Strawberry Yogurt Break Bar	Tesco Raisin Munch Bar	Ms Molly's Chocolate Chip Bar	Muller Light Toffee	Muller Light Vanilla	Muller Light Straw-berry	Muller Light Raspberry & Cranberry	Apple	Blue-berries	Clemen-tine's	Kiwis	Rasp-berries	Tesco Fat Free Cottage Cheese	Red Pepper	Cucumber	Carrot
Energy (kJ)	1691	1780	1663	218	217	218	217	226	289	195	233	133	263	112	66	183
Energy (kcal)	402	423	394	51	51	51	51	53	68	46	55	32	62	27	16	44
Fat (g)	10.3	13.0	7.8	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.5	0.3	0.3	0.0	0.6	0.0
Saturates (g)	4.6	7.2	3.6	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.3	0.0	0.0	0.1
CHO (g)	72.4	68.0	73.4	7.9	7.5	7.8	8.1	11.8	14.5	9.6	10.6	4.6	4.7	4.3	1.3	7.7
Sugars (g)	35.2	33.0	23.9	7.1	7.0	7.1	7.0	11.8	10.0	9.6	10.3	4.6	4.7	4.2	1.2	7.0
Fibre (g)	3.4	4.7	4.3	0.2	0.2	0.2	0.5	1.8	2.4	1.5	1.9	2.5	0.0	2.2	0.7	3.9
Protein (g)	5.2	6.2	5.4	4.1	4.4	4.2	3.9	0.4	0.7	0.7	1.1	1.4	10.1	0.8	1.0	0.0
Salt (g)	0.5	0.1	0.3	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.4	0.0	0.0	0.1

CHO = carbohydrate

Table 5: *Nutritional values of sandwich* choices provided during the buffet tea for Study One (Appendix J)*

Nutrients	Chicken Sandwich	Tuna Sandwich	Ham Sandwich	Beef Sandwich	Egg Sandwich	Houmous Sandwich
Energy (kJ)	304	304	300	299	307	308
Energy (kcal)	72	72	71	70	73	73
Fat (g)	0.6	0.6	1.0	1.2	2.0	1.9
Saturates (g)	0.2	0.1	0.3	0.3	0.5	0.3
Carbohydrates (g)	9.1	8.9	9.4	9.4	8.9	10.1
Sugars (g)	0.7	0.6	1.1	1.1	0.6	1.0
Fibre (g)	1.5	1.4	1.6	1.6	1.4	1.9
Protein (g)	6.2	6.7	5.2	4.2	4.3	3.2
Salt (g)	0.0	0.4	0.5	0.4	0.3	0.3

*the values provided are per quarter of each sandwich

Table 6: *Nutritional values of deconstructed sandwich ingredients (instead of the sandwiches in Study One) provided during the buffet tea for Study Two*

Nutrients (per100g)	Tesco Sliced Roast Chicken	John West No Drain Tuna Steak Brine	Tesco British Cooked Ham	Tesco Roast Beef Slices	Tesco Free-range Egg	Tesco Reduced Fat Caramelised Onion Houmous	Hellman's Lighter than Light Mayon-naise	Tesco Little Gem	Tesco Cucumber	Tesco Salad Tomatoes	Tesco Wholegrain Mustard	Tesco Baby Spinach
Energy (kJ)	486	480	478	640	547	901	302	60	65	71	781	124
Energy (kcal)	115	113	113	152	131	216	72	14	16	17	188	30
Fat (g)	1.5	0.8	2.6	4.9	9.0	12.8	2.9	0.1	0.6	0.1	12.3	0.8
Saturates (g)	0.4	0.3	1.0	2.0	2.5	1.4	0.7	0.0	0.0	0.0	1.4	0.1
CHO* (g)	0.1	0.0	0.6	0.1	0.0	15.7	9.3	1.4	1.2	3.0	9.0	1.5
Sugars (g)	0.1	0.0	0.6	0.1	0.0	4.1	4.2	1.4	1.2	3.0	2.7	1.5
Fibre (g)	0.0	0.0	0.6	0.0	0.0	4.6	0.0	1.5	0.7	1.0	3.3	2.7
Protein (g)	25.2	26.6	21.6	26.9	12.6	7.2	0.7	1.2	1.0	0.5	8.6	2.8
Salt (g)	0.2	1.0	1.6	0.5	0.4	0.5	1.7	0.1	0.0	0.0	3.0	0.4

*CHO = carbohydrate

3.3.5 Weighed Food Diary

Participants were required to complete a weighed food diary for the remainder of the test day for both sessions in both studies. Participants were provided with digital scales (Argos Home Digital Kitchen Scale, UK) and a food diary (Appendix K) to complete until they went to sleep at the end of the test days, which was to be returned either via email to the researcher or in person to OxBCNH. All participants had detailed prior instructions on how to appropriately complete this weight food diary.

3.4 Outcome Measures

3.4.1 Visual Analogue Scale (VAS) Measurements

Subjective appetite ratings were measured by drawing a vertical line through six separate 100 millimetres (mm) VAS (Appendix L), which have been validated and are considered a reliable measurement for subjective appetite sensations (Flint et al., 2000). Individual ratings were made for hunger, fullness, desire to eat (DTE), prospective food intake, thirst and nausea. Ratings were established prior to breakfast (fasted), then every 30 minutes from commencing breakfast (8 am) until lunch (12 pm). VAS ratings continued every 15 minutes from commencing lunch until the buffet tea (4 pm), with the last rating being made after finishing the buffet tea. For both studies participants were required to complete sensory analysis of the lunch meals immediately after consuming them as it is known that palatability can influence subjective appetite sensations (McCrickerd and Forde, 2016; Sørensen et al., 2003). VAS ratings were quantified by measuring the distance from the anchor on the left side of the line to the vertical line participants had marked, using a ruler. All measurements were to the nearest mm (Benelam, 2009).

3.4.2 Food Intake

Food items (Tables 4, 5 & 6) in the *ad libitum* meal were weighed on scales (Metter PC 2000, Greifensee, Zurich, Switzerland) to the nearest 0.1g and recorded by the researcher prior to consumption. Once the participant was finished eating the researcher re-weighed and recorded any food that had been left by the participant. After the amount of food consumed had been quantified, energy, fat, of which saturates, carbohydrates, of which sugars, fibre, protein and salt content of what each participant consumed during the buffet tea was

calculated using the nutritional composition from the label of each ingredient input into Nutritics software (Nutritics Ltd, Ireland) to be analysed.

Weighed food diaries were analysed using Nutritics software (Nutritics Ltd, Ireland) by a qualified nutritionist (Associate Register Nutritionist).

3.5 Statistical Analysis

All statistical analyses were performed on Statistical Package for the Social Scientist (SPSS, version 24.0; IBM Corp, Armonk, NY). Data was tested for normality using the Shapiro-Wilk Test of Normality in order to establish the most suitable statistical test.

Differences between subjective sensory product ratings from VAS scores between ready meals and differences in food intake between the ready meals (during the buffet tea, food diary and combined) were analysed using a paired samples t-test for normally distributed (i.e. parametric data) and the Wilcoxon matched pairs signed rank test for nonnormally distributed data (i.e. non-parametric data). Area under the curve (AUC, Appendix M) from self-reported appetite ratings from VAS (hunger, fullness, DTE, prospective consumption, thirst and nausea) were calculated using the trapezoid rule. If data was non-parametric it was logged firstly (checked for normality) and then a univariate ANOVA using the baseline VAS as a covariate in the analysis was completed to assess differences between the meals. If data was parametric it was not logged. All significance values $p<0.05$ are reported. Data are presented as means ± standard deviation.

Chapter Four: Results Study One

4.1 Participant Characteristics

All participants (n= 26) completed both test days in a within-subject crossover design. Participants characteristics can be found in Table 7. Using the TFEQ scores (≤9 = unrestrained and ≥10 = restrained eating), 12 participants were classified as unrestrained eaters (4.8 ± 1.7) and 14 as restrained eaters (13.1 ± 3.0). Based on the DEBQ (<2.5 = unrestrained and >2.5 restrained eating), there were 8 participants who were classified as unrestrained (1.8 ± 0.7) and 18 restrained (3.3. ± 0.5) eaters.

Table 7: *Participant Characteristics for Study One*

Participant Characteristic (n= 26)	**Mean ± SD**
Age (years)	40 ± 15
Height (m)	1.63 ± 0.07
Weight (kg)	76.7 ± 10.3
BMI (kg/m^2)	28.8 ± 3.0
Body Fat (%)	38.8 ± 5.0

4.2 Self-reported Appetite Ratings

4.2.1 Hunger

Total AUC for the whole day indicated that there was no significant difference between the two test days ($F_{1,49}$ = 0.59, p=0.56; Figure 4). Data analysed from the time of the ready meal consumed (lunch) until the buffet tea, indicated that participants felt more hungry after consuming the control ready meal compared to the test ready meal ($F_{1,49}$ = 6.24, p<0.001).

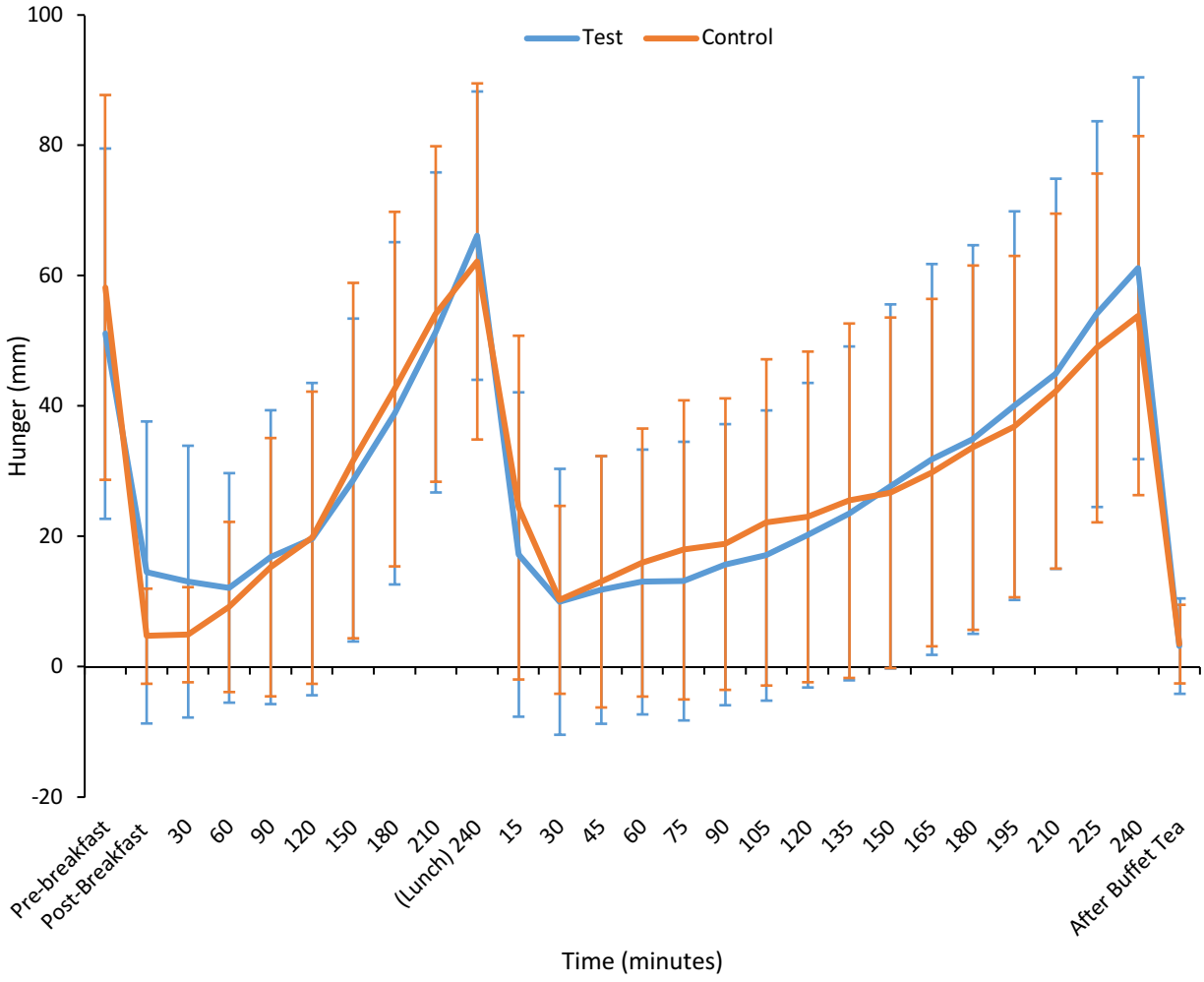

Figure 4: *Mean self-reported hunger ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

4.2.2 Fullness

No significant difference was found for subjective fullness ratings between the test and control meals for the whole day ($F_{1,49}$ = 2.00, p=0.15). However, fullness ratings from lunch until the buffet tea was significantly greater for the test meal compared to the control ($F_{1,49}$ = 2.55, p<0.001; Figure 5).

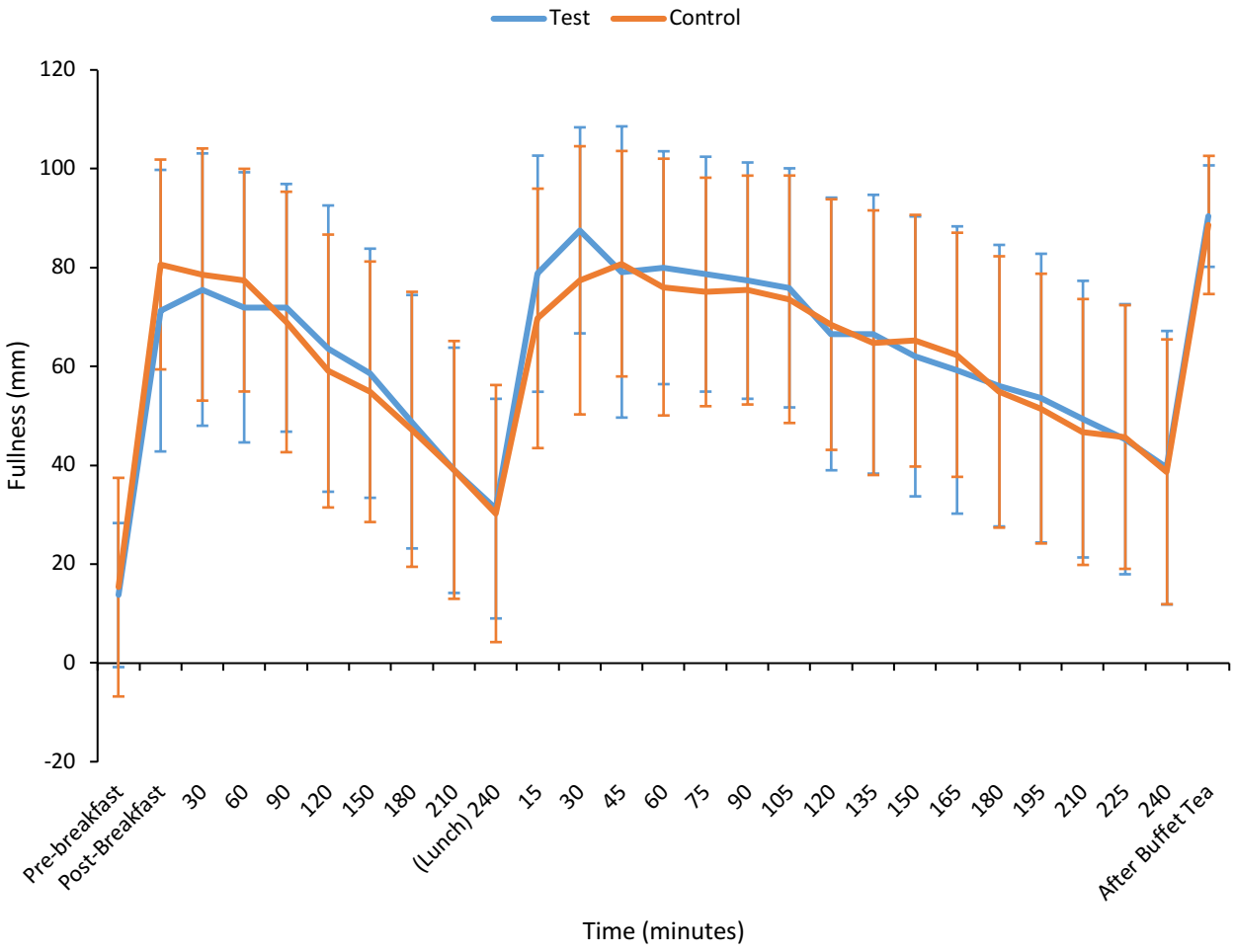

Figure 5: *Mean self-reported fullness ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

4.2.3 Desire to Eat (DTE)

DTE was not significant for whole day ratings ($F_{1,49}$ = 0.49, p=0.62), but analysis between lunch and buffet tea revealed that DTE was significantly greater ($F_{1,49}$ = 8.47, p=0.004) after the control meal when compared with the test meal (Figure 6).

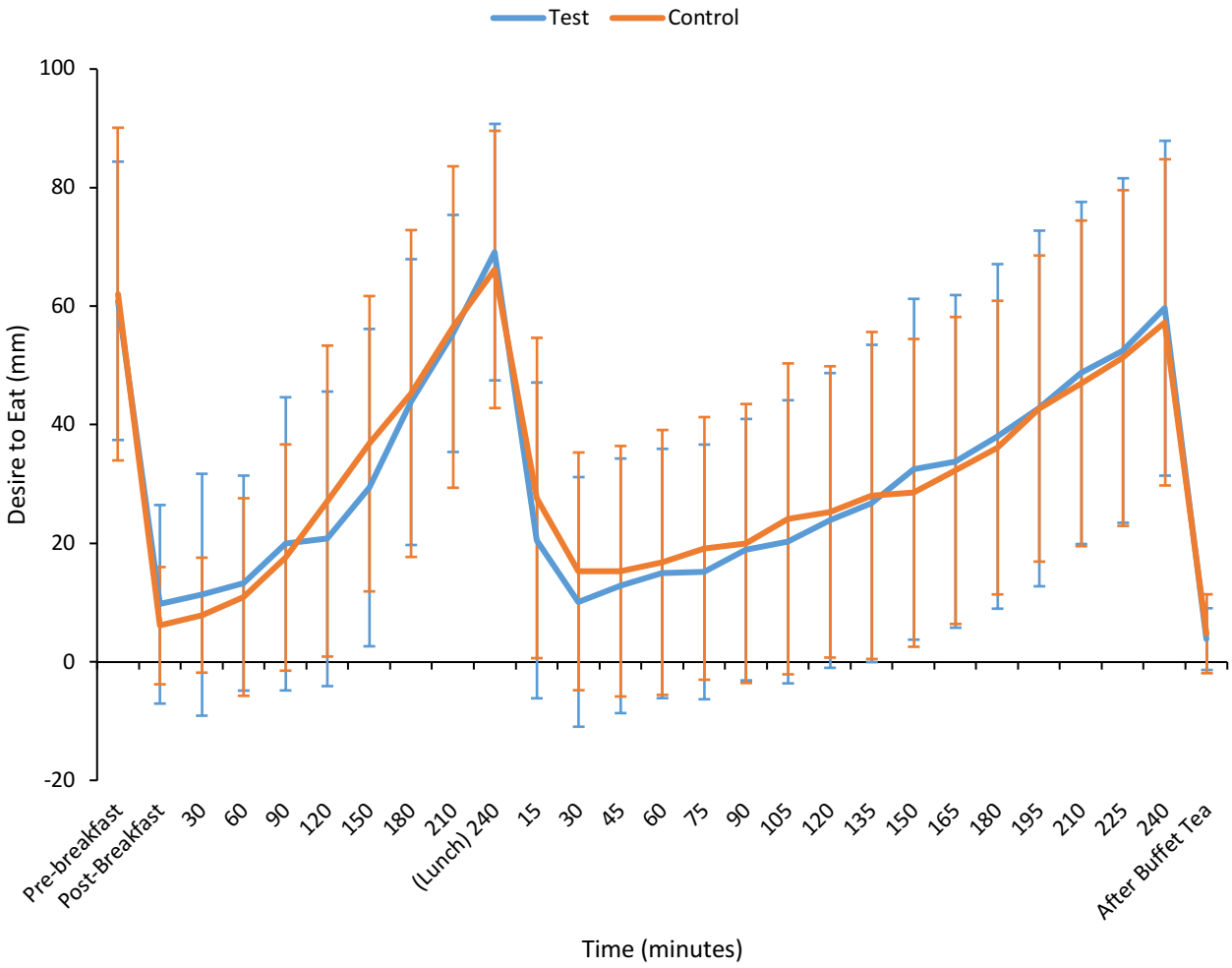

Figure 6: *Mean self-reported DTE ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

4.2.4 Prospective Consumption

Prospective consumption analyses indicated no significant ($F_{1,49}$ = 0.01, p=0.99) differences in prospective consumption of how much participants anticipated they could consume in the immediate future on the test day compared to the control day. When analysed between lunch and the buffet tea, results were significantly greater for the control test day ($F_{1,49}$ = 7.09, p=0.001) compared to the test day (Figure 7).

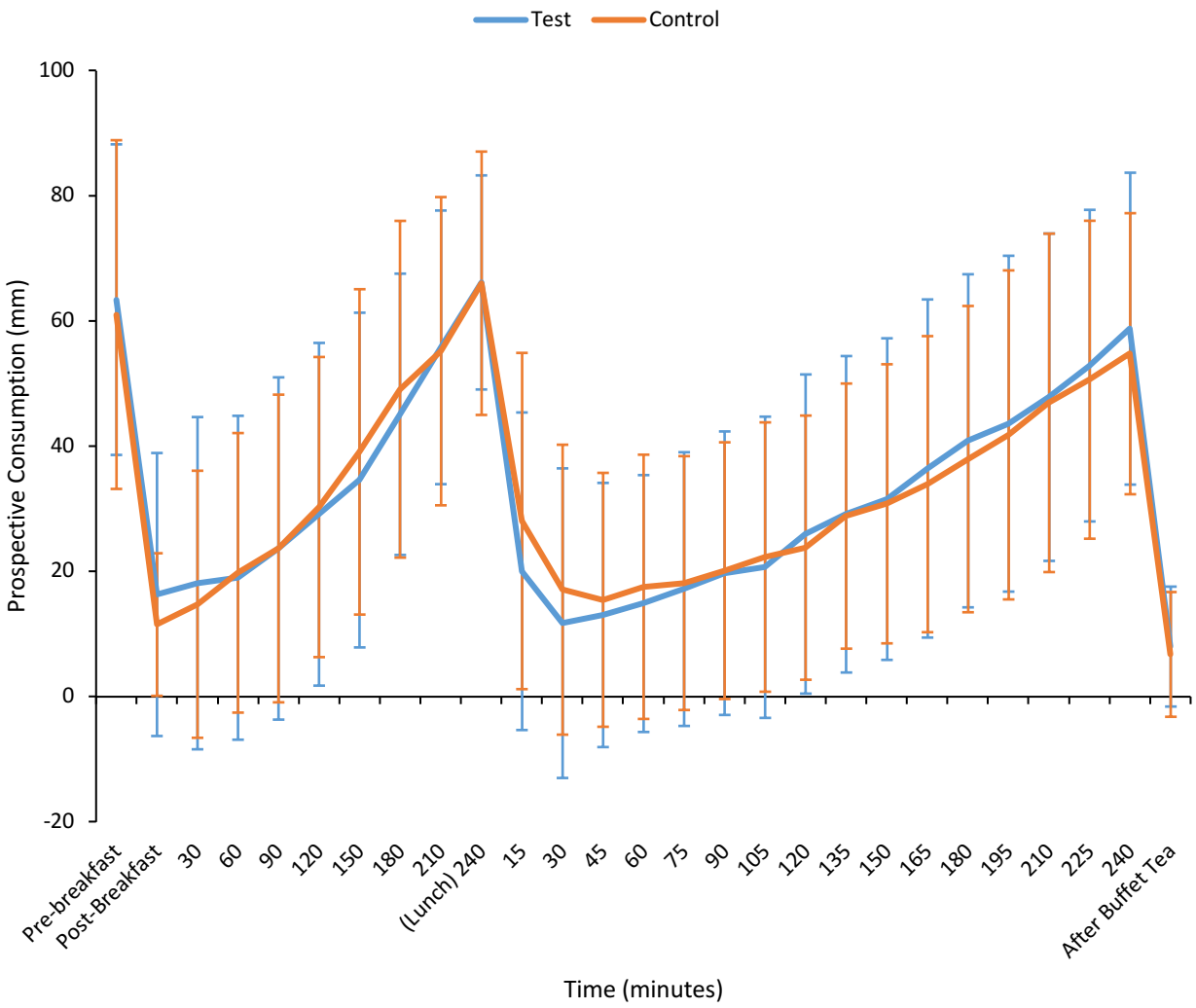

Figure 7: *Mean self-reported prospective consumption ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

4.2.5 Thirst

Thirst was significantly greater ($p<0.01$) for the whole test day compared with the control day. Thirst between lunch and buffet tea was significantly greater ($F_{1,49} = 41.8$, $p<0.001$) after the test ready meal compared to after the control ready meal (Figure 8).

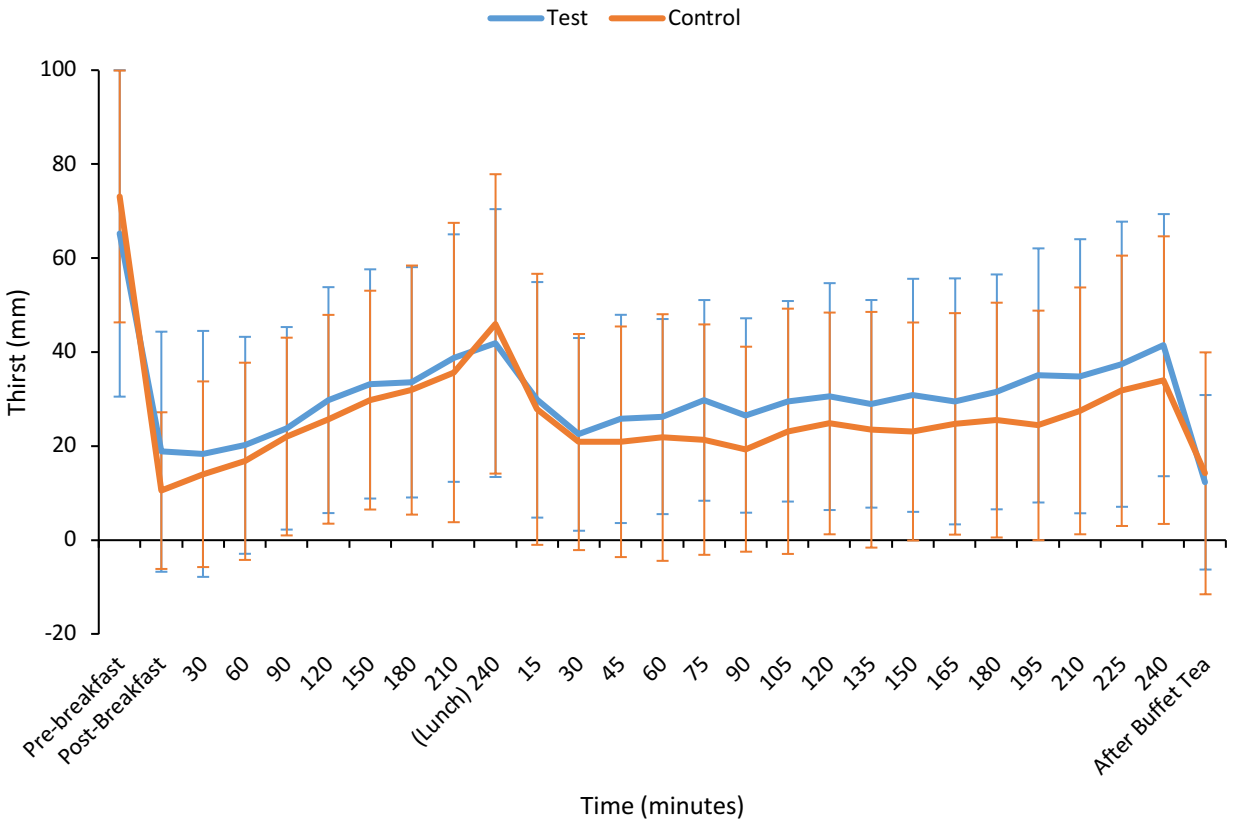

Figure 8: *Mean self-reported thirst ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea*

4.2.6 Nausea

Nausea ratings for the whole day were significant ($F_{1,49}$ = 20.6, p<0.01), with participants measurement's indicating that greater nausea after the control meal compared to the test meal. Nausea ratings between lunch and buffet tea were significant ($F_{1,49}$ = 22.7, p<0.001), indicating that nausea was greater after the control lunch compared with the test meal (Figure 9).

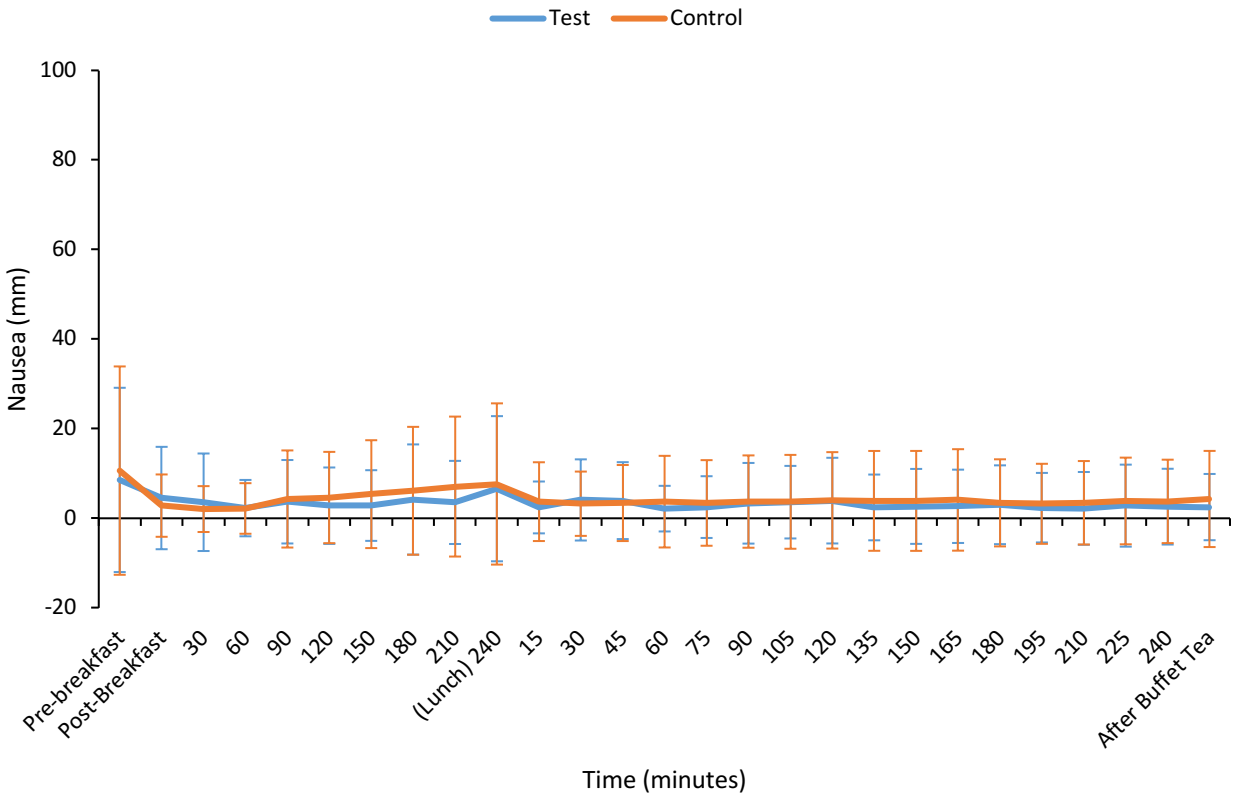

Figure 9: *Mean self-reported nausea ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea*

4.3 Sensory Analysis

Attractiveness was significantly higher in the control meal compared with the test meal, (p=0.01), with no significant difference between the other six sensory characteristics (Figure 10).

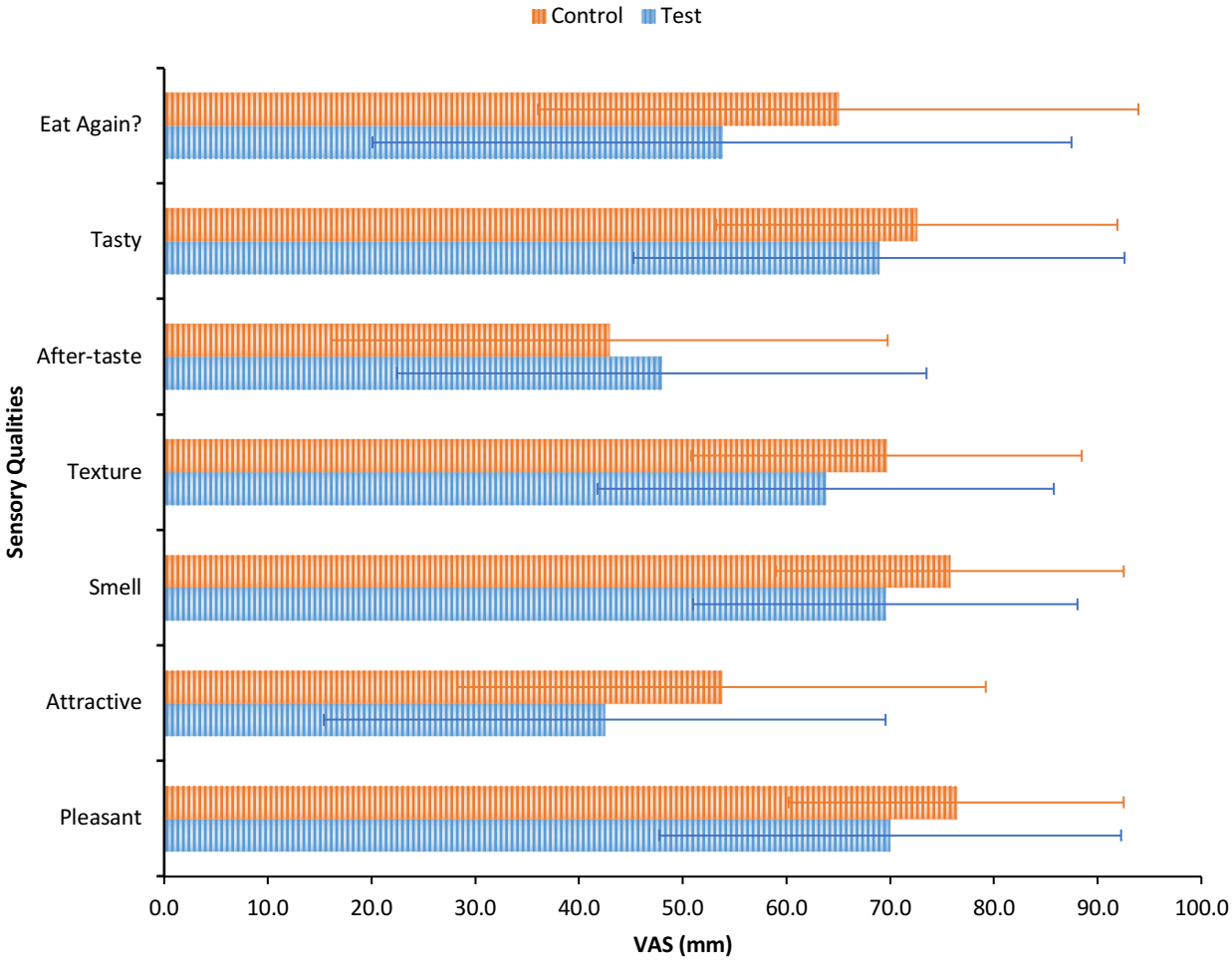

Figure 10: *Mean sensory product VAS evaluation scores between the two test meals*

4.4 Energy Intake

There was no significant difference in energy intake during the buffet tea after the test or control ready meal (Figure 11). Similarly, there was no significant difference between in self-recorded energy intake between the two days (p=0.65; Figure 11).

TDEI for the whole testing day (breakfast, lunch, buffet tea & weighed food diary) was approaching being significantly higher for the test ready meal day (~2035 kcal) compared to the control ready meal (~1874 kcal) (p=0.06; total difference = 161 kcal; Figure 11). There was no order effect during the buffet tea between either of the testing days (p>0.05).

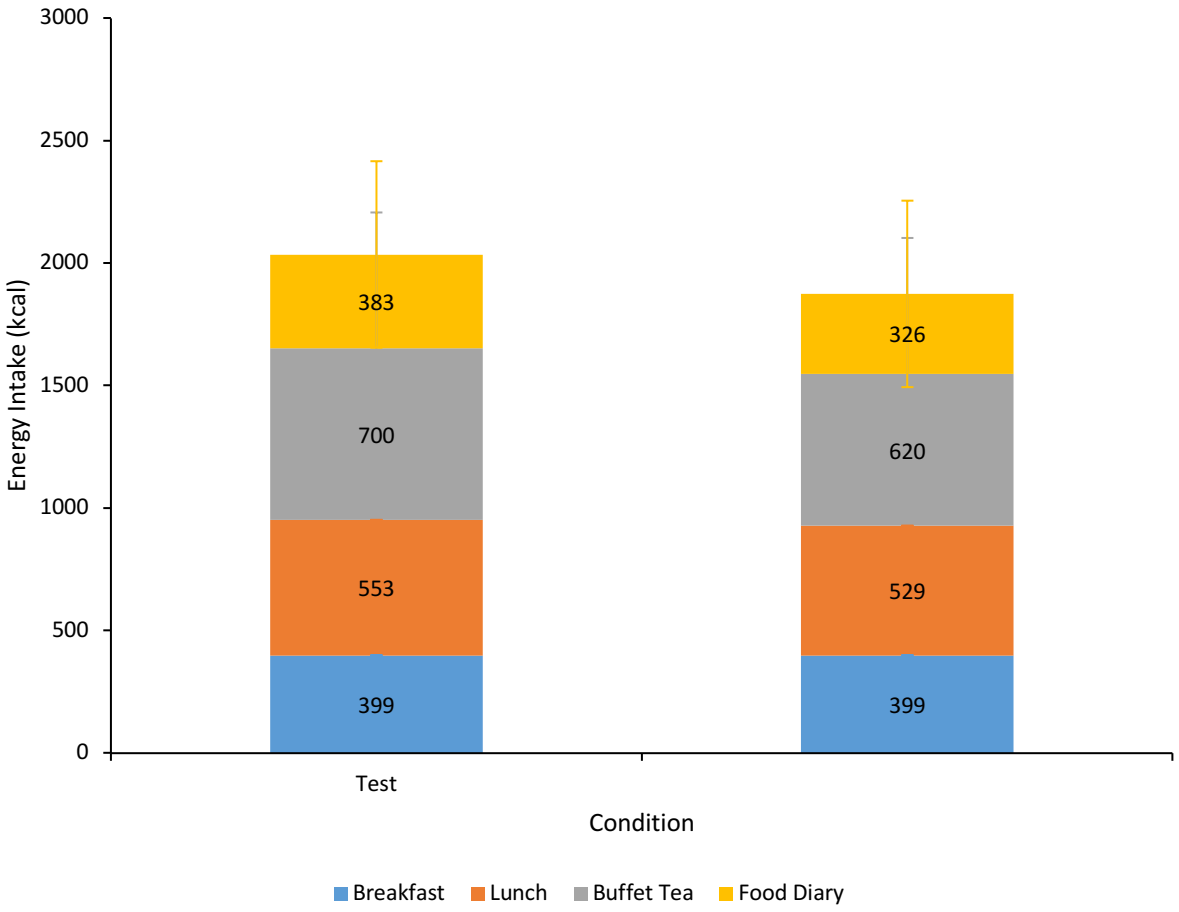

Figure 11: *Mean energy intake (kcal) during the two test days*

4.5 Macronutrients Intake

Participants consumed significantly less fat ($p<0.01$) and saturated fat ($p<0.01$) during the whole test meal day compared to the whole control meal day. Total carbohydrate, sugars, fibre, protein and salt intake between the two test days was significantly greater during the test day compared to the control day ($p<0.01$; Table 8).

Table 8: *Composition of dietary intake during test days (breakfast, lunch, buffet tea and weight food diary combined*

	Test Buffet Tea	Control Buffet Tea	Test Whole Day	Control Whole Day
Energy (kJ)	2931 ± 2302	2605 ± 2302	8359 ± 2759	7859 ± 2452
Energy (kcal)	700 ± 570	620 ± 544	2035 ± 667	1873 ± 582
Fat (g)	11.1 ± 10.7	9.7 ± 10.5	45.8 ± 23.3	57.0 ± 18.5†
Saturates (g)	3.5 ± 3.4†	2.7 ± 3.1	14.9 ± 5.1	21.2 ± 7.6†
CHO (g)	100.2 ± 82. 0	88.4 ± 76.8	260.0 ± 81.5†	220.3 ± 76.4
Sugars (g)	38.6 ± 29.1†	31.4 ± 26.4	91.0 ± 35.0†	76.2 ± 28.7
Fibre (g)	15.6 ± 11.7	14.3 ± 11.6	35.1 ± 13.1†	28.0 ± 11.5
Protein (g)	39.6 ± 29.7	34.9 ± 30.7	119.2 ± 28.3†	101.0 ± 32.4
Salt (g)	2.4 ± 2.0	2.1 ± 1.8	6.5 ± 2.2†	5.6 ± 1.9

CHO = carbohydrate
†indicates significance ($p<0.05$)

Chapter Five: Results from Study Two

5.1 Participant Characteristics

All participants (n= 12) completed both test days in a within-subject crossover design. Participants characteristics can be found in Table 9. Using the TFEQ scores (≤9 = unrestrained and ≥10 = restrained eating), there was an equal divide between individuals classified as unrestrained (4.2 ± 1.2) and restrained (13.2 ± 3.5) eaters. Based on the DEBQ (<2.5 = unrestrained and >2.5 restrained eating), there were five participants who were classified as unrestrained (2.0 ± 0.0) and seven participants as restrained (3.2 ± 0.4) eaters.

Table 9: *Participants Characteristics Study Two*

Participant Characteristic (n= 12)	**Mean ± SD**
Age (years)	46 ± 13
Height (m)	1.6 ± 0.1
Weight (kg)	73.6 ± 10.8
BMI (kg/m^2)	28.3 ± 3.4
Body Fat (%)	38.9 ± 6.0

5.2 Self-reported Appetite Ratings

5.2.1 Hunger

There was no significant difference in hunger for the whole day between either the test or the control days ($F_{1,21}$ = 1.27, p=0.33). There is no difference in hunger between test and control between lunch and buffet tea, however, was approaching significance ($F_{1,21}$ = 3.33, p=0.06), with participants feeling more hungry on the test meal compared to the control meal (Figure 12).

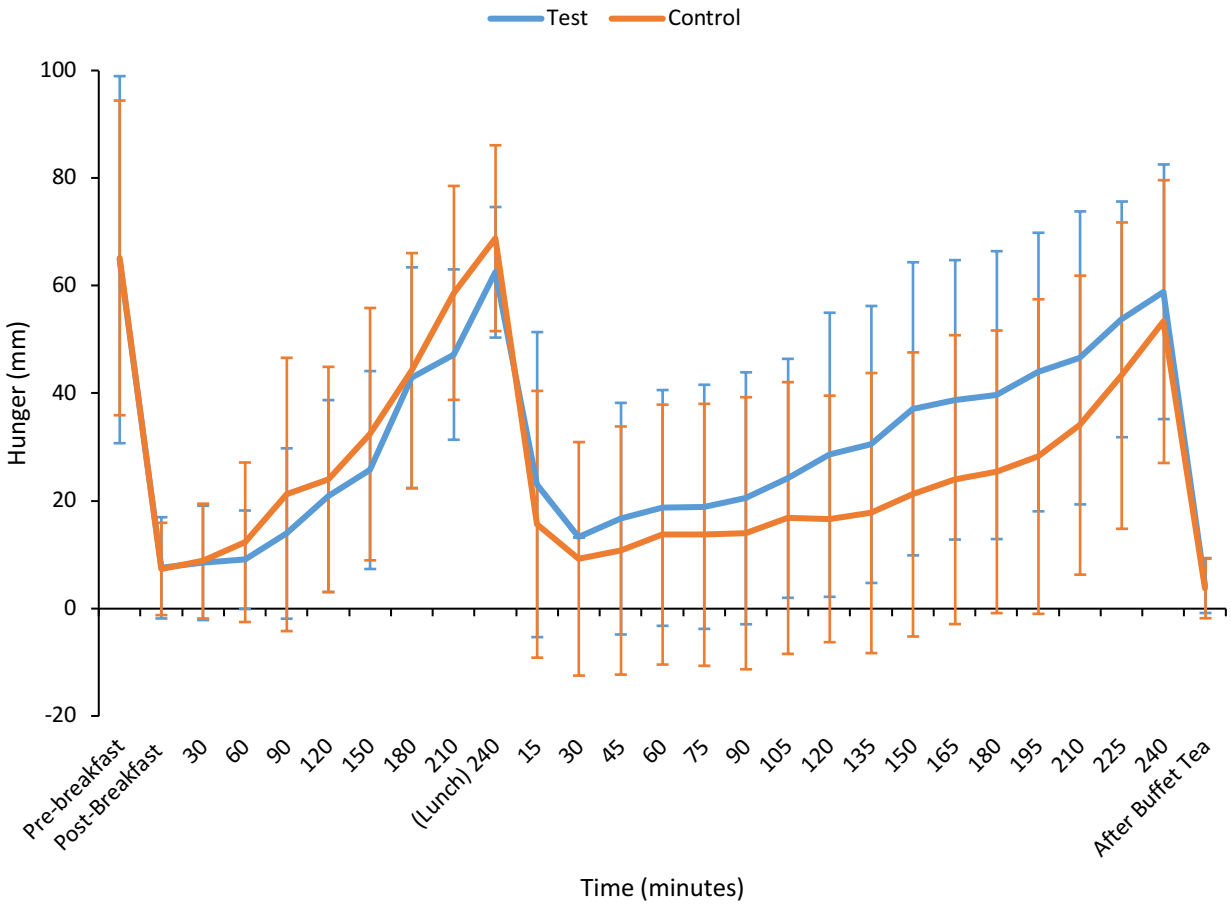

Figure 12: *Mean self-reported hunger ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

5.2.2 Fullness

There was no significance between whole day fullness for control and test days ($F_{1,21}$ = 3.08, p=0.07). Fullness ratings from the lunch until the buffet tea was significantly greater for the control day compared to the test day ($F_{1,21}$ = 11.79, p<0.01; Figure 13).

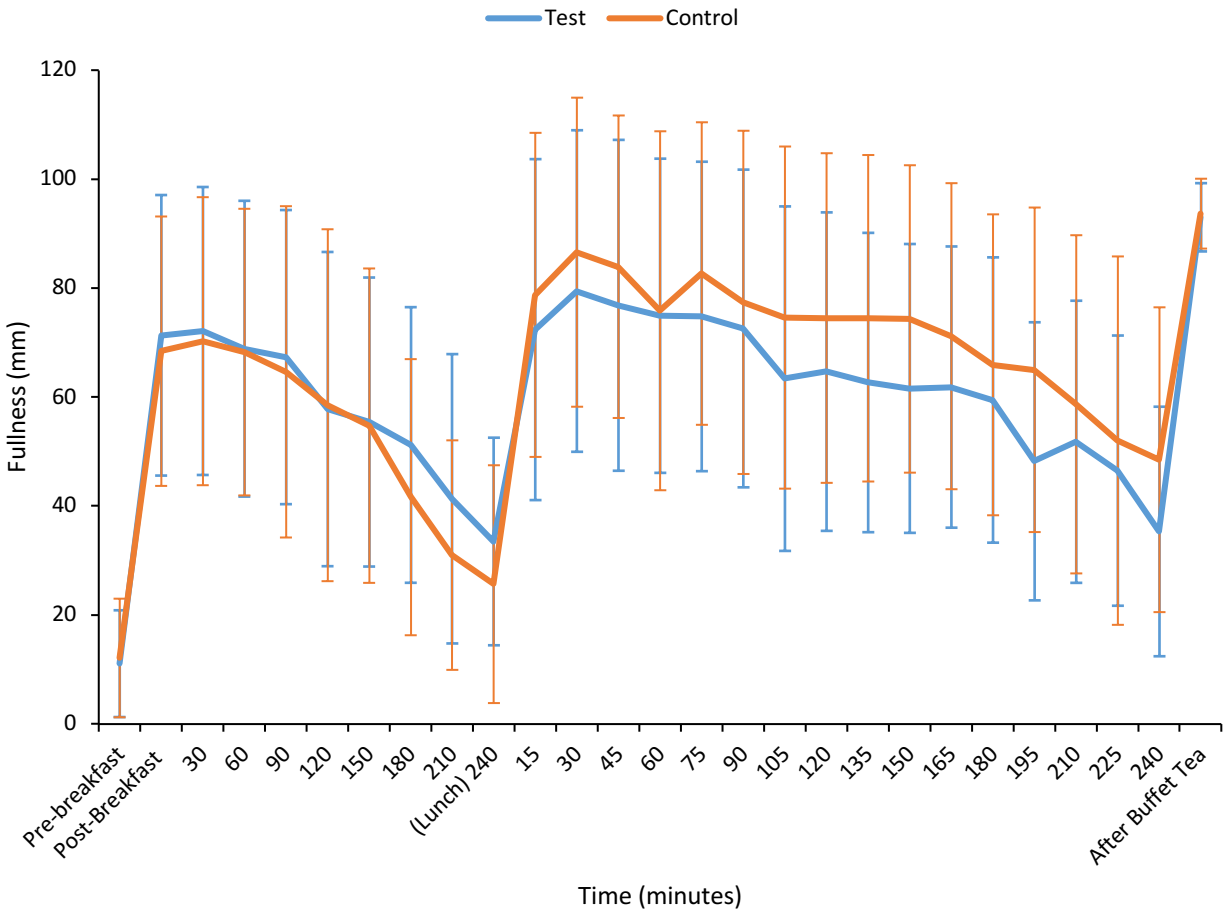

Figure 13: *Mean self-reported fullness ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

5.2.3 Desire to Eat (DTE)

There was no significant difference in DTE between the control and test days ($F_{1,21}$ = 1.90, p=0.17). Findings indicated that DTE between lunch and the buffet tea was significantly greater after the test ready meal ($F_{1,21}$ = 6.58, p=0.01; Figure 14).

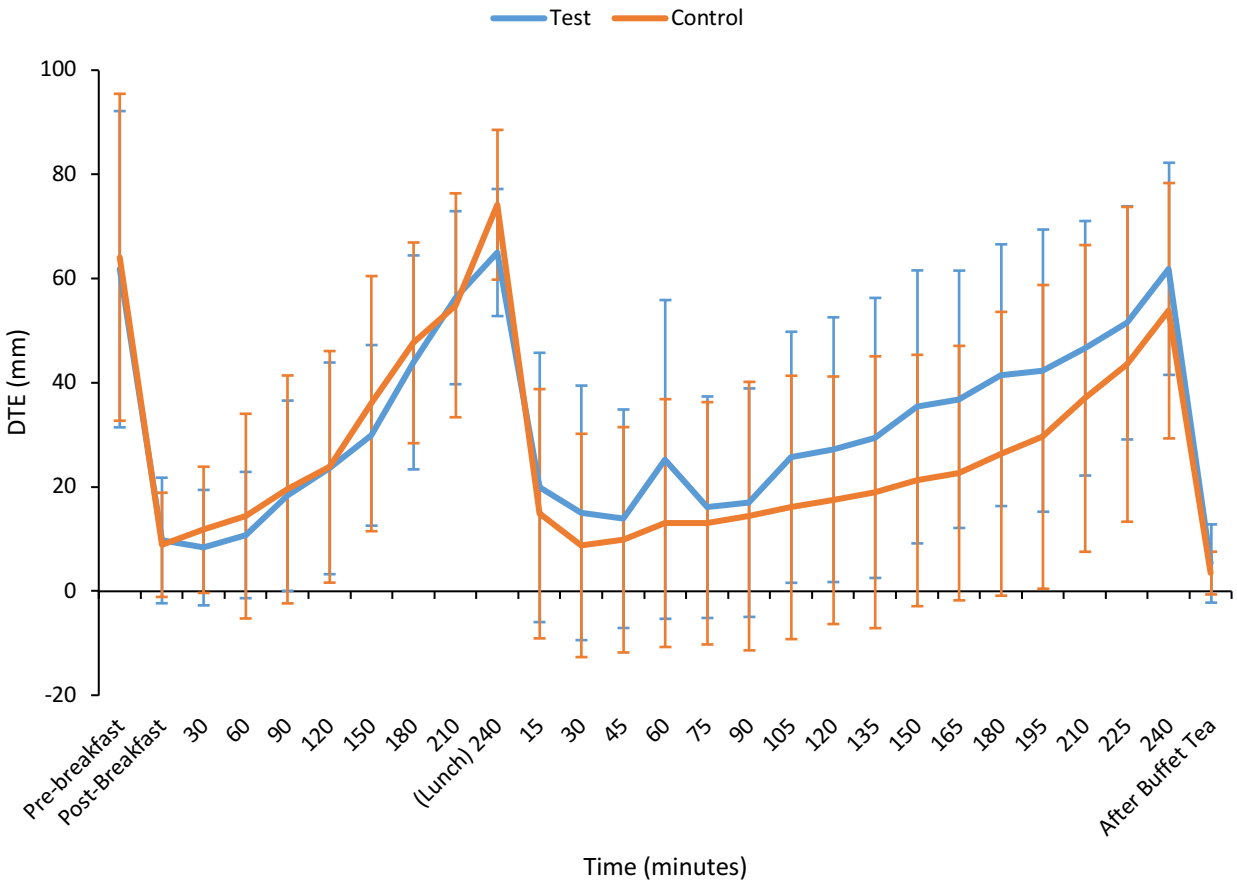

Figure 14: *Mean self-reported DTE ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

5.2.4 Prospective Consumption

Prospective consumption for the whole day was significantly different between the two ready meals ($F_{1,21}$ = 4.46, p=0.02), with the participants indicating they thought they could consume more food after the test meal compared to the control meal. There was also significance between lunch and the buffet tea ($F_{1,21}$ = 7.51, p<0.01; Figure 15).

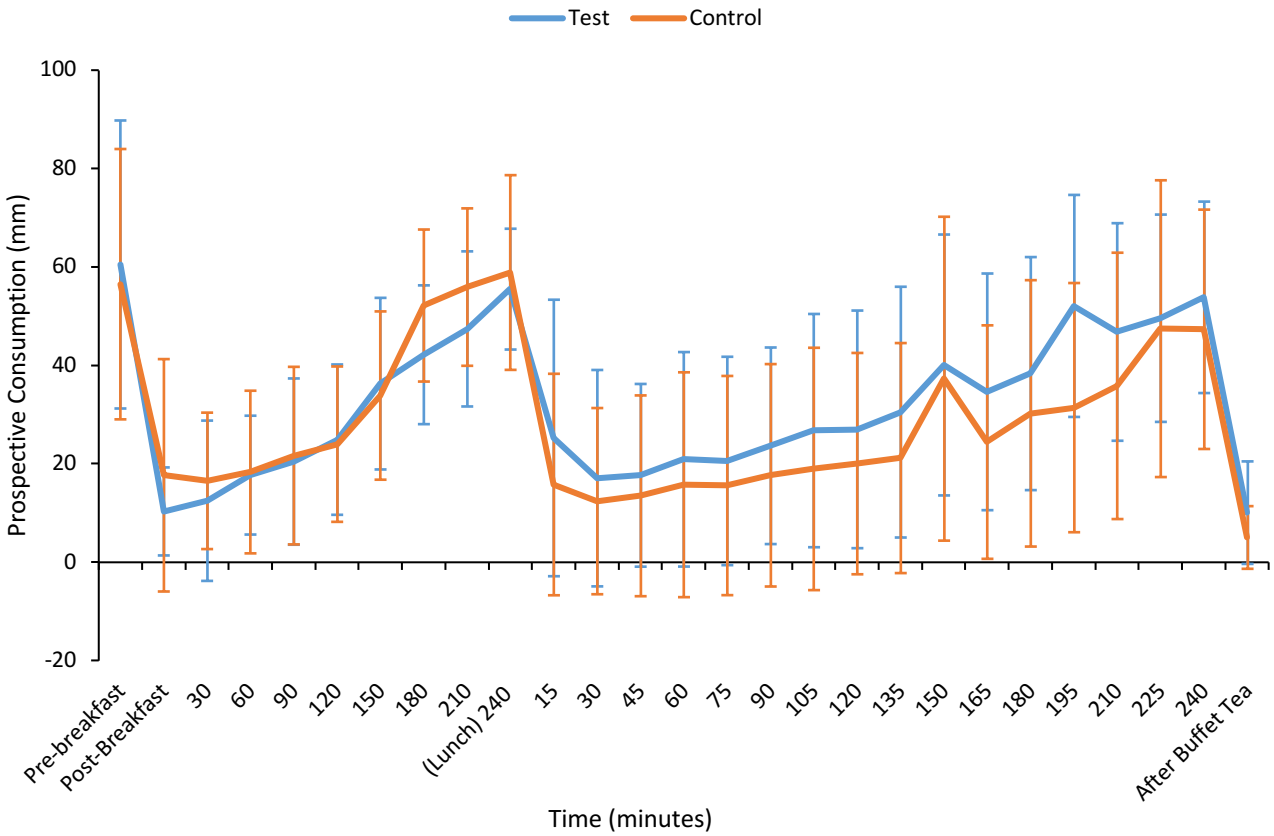

Figure 15: *Mean self-reported prospective consumption ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

5.2.5 Thirst

Whole day thirst was not significant between test and control (p=0.16). Lunch to buffet tea analysis indicated that thirst was significantly greater for the test than control ready meal ($F_{1,21}$ = 64.05, p<0.01; Figure 16).

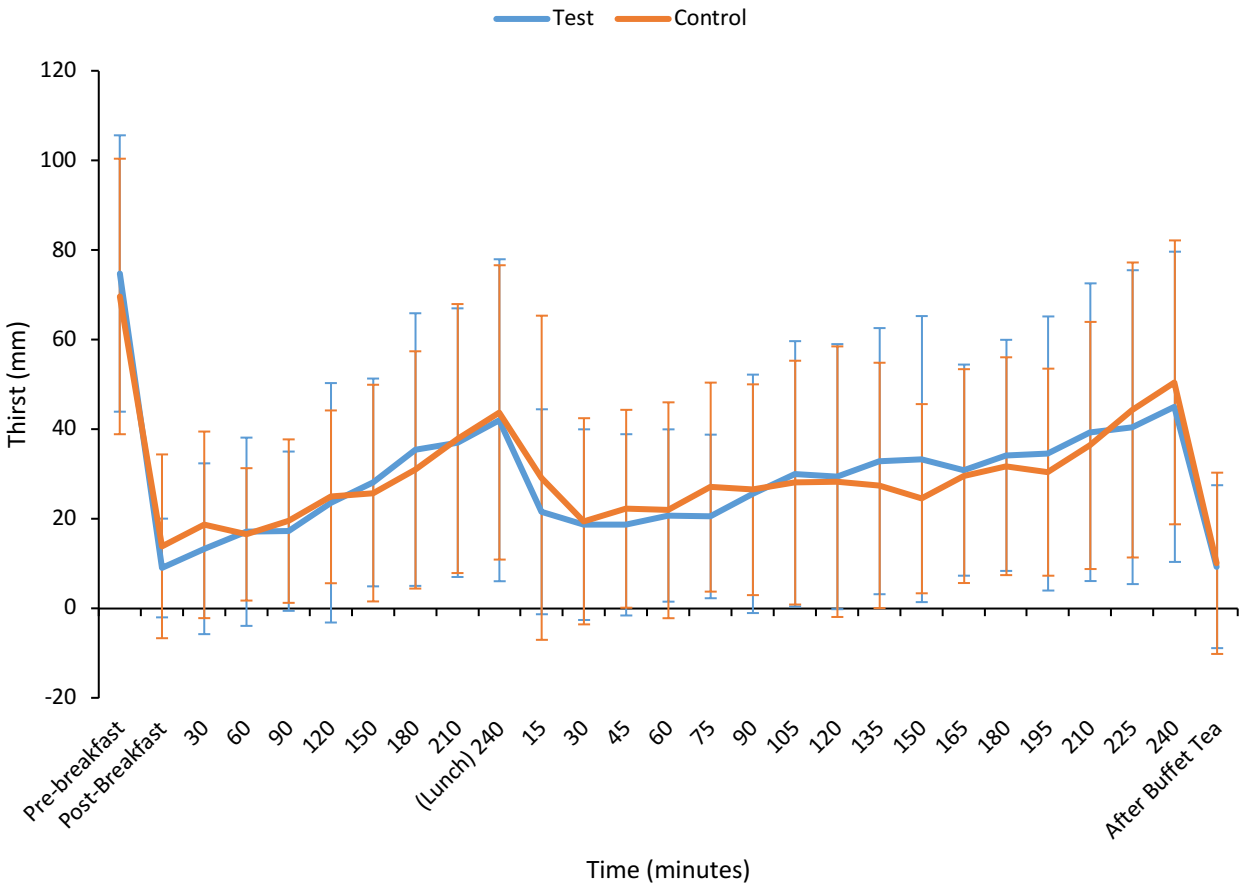

Figure 16: *Mean self-reported thirst ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

5.2.6 Nausea

Whole day nausea was greater for the control day ($F_{1,21}$ = 15.03, p<0.01) compared to the test day. AUC from lunch to buffet tea analysis indicated nausea was significantly greater after consuming the control ready meal ($F_{1,21}$ = 20.0, p<0.01; Figure 17).

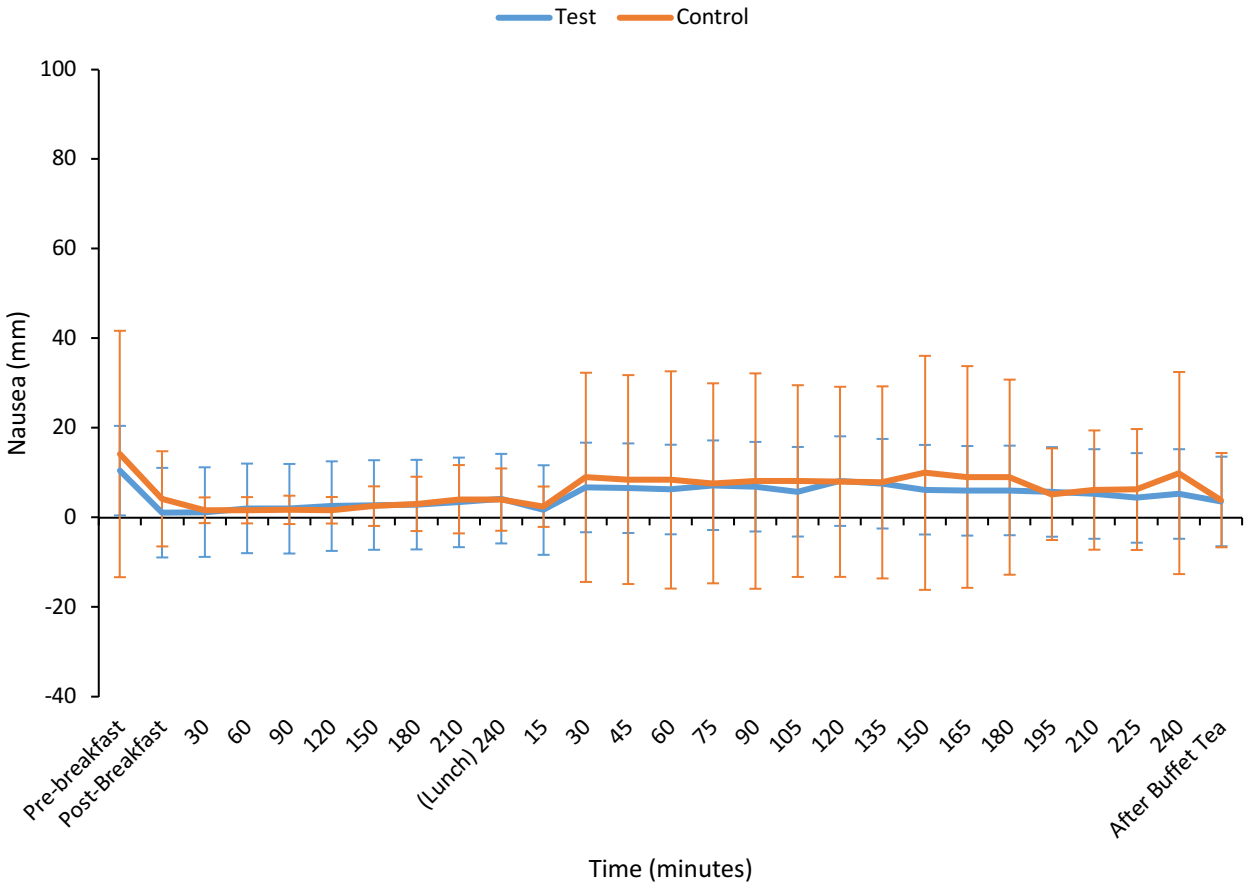

Figure 17: *Mean self-reported nausea ratings from visual analogue scales. Ratings were measured before breakfast, every 30 minutes until lunch, then every 15 minutes until the buffet tea with the final rating being recorded after finishing the buffet tea.*

5.3 Sensory Analysis

Attractiveness (p=0.02) and taste (p=0.01) were significantly greater for the control ready meal compared to the test ready meal (Figure 18). There was no significant difference in any other five sensory characteristics between the two testing days (p>0.05 for all pairwise comparisons) (Figure 18).

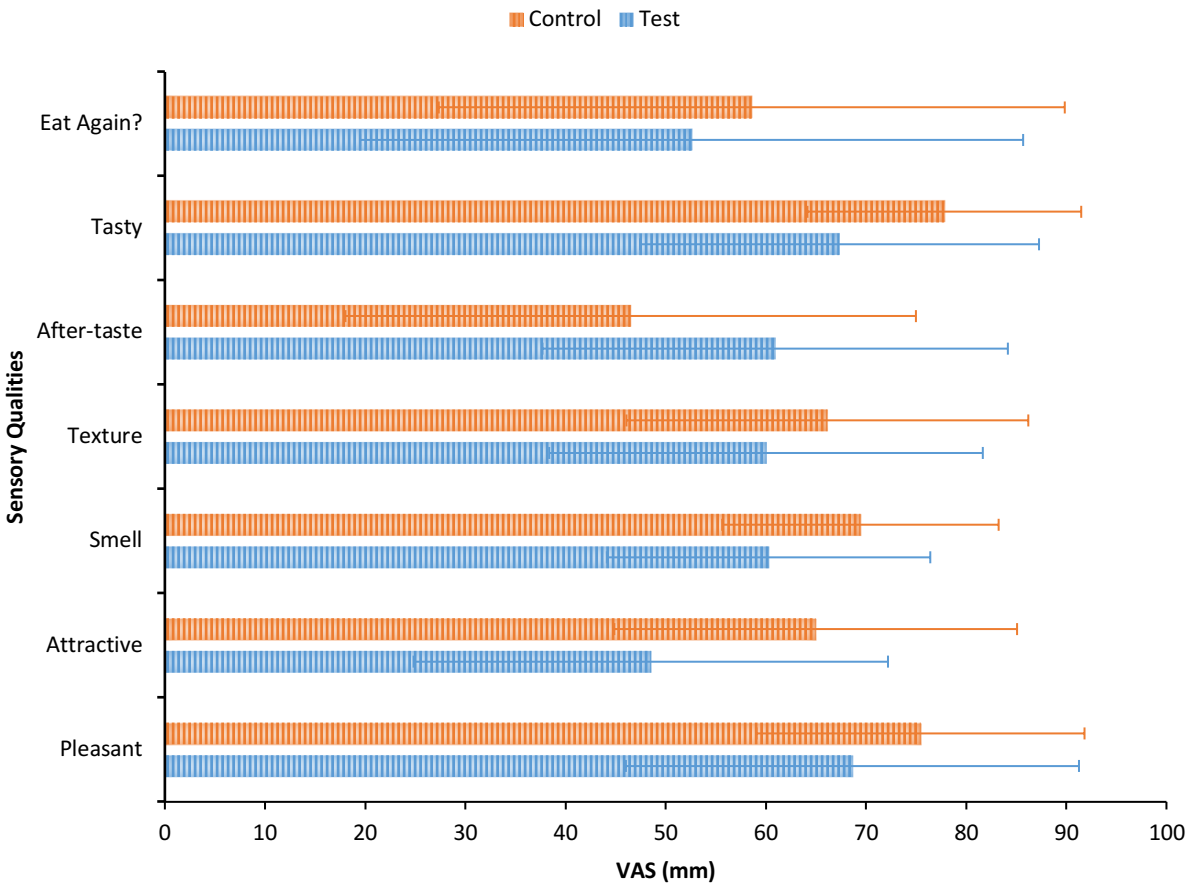

Figure 18: *Mean sensory product VAS evaluation scores between the two test meals*

5.4 Energy Intake

There was no significant difference between either the control or test buffet teas (p=0.23; Figure 19). Self-recorded weighed food diaries suggested that participants had no significant difference in EI (p=0.90) (Figure 19). TDEI for the whole testing day (breakfast, lunch, buffet tea & weighed food diary) was significantly higher (p=0.05) for the control day (~2042 kcal) compared to the test day (~1875 kcal) (total difference = 167; Table 10). There was no order effect during the buffet tea between either of the testing days (p>0.05).

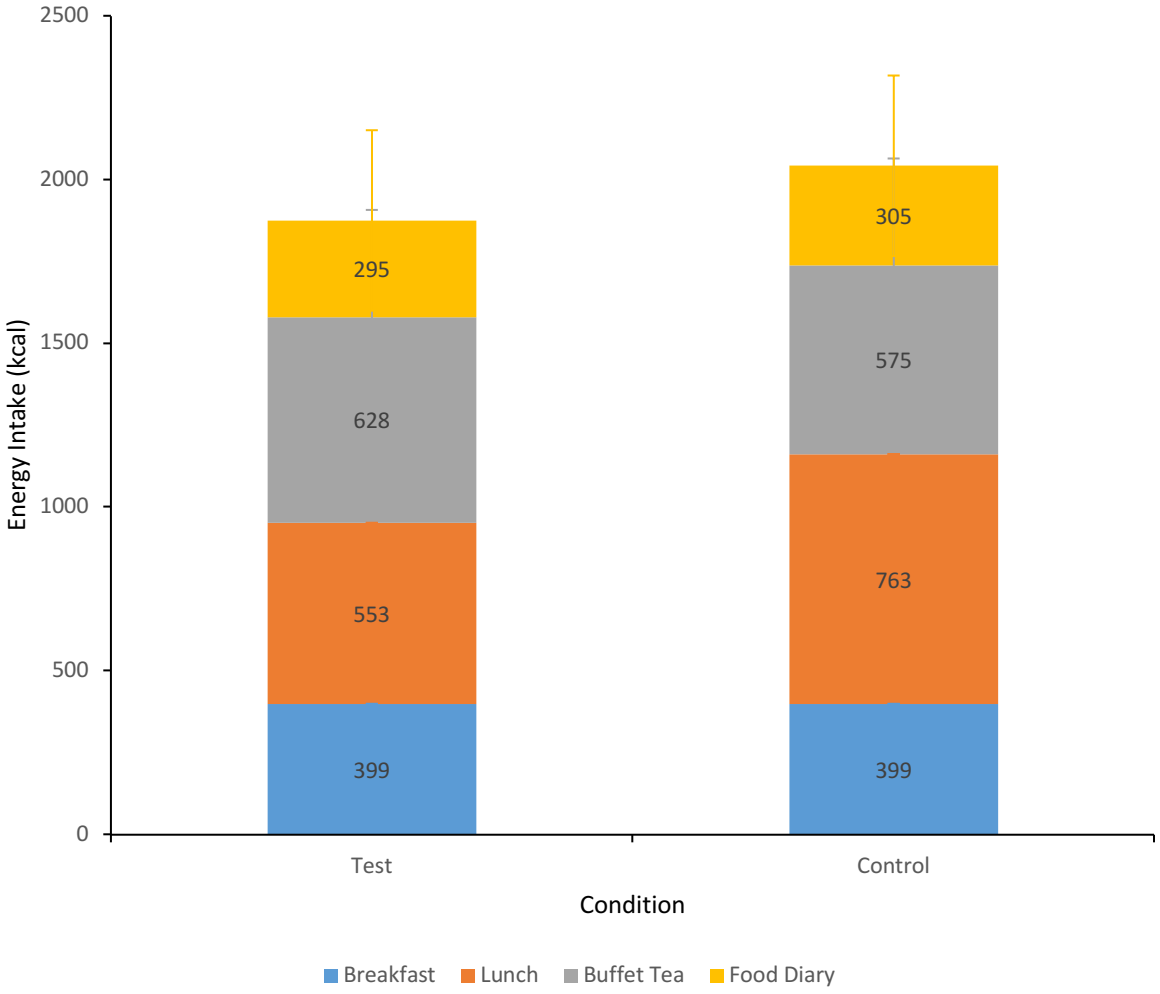

Figure 19: *Mean energy intake (kcal) during the two test days*

5.5 Macronutrient Intake

Participants consumed significantly less fat and saturated fat during the test day compared to the control day ($p<0.001$ for both comparisons). Carbohydrate, sugars, fibre, protein and salt intake between the two test days was not significantly different ($p>0.05$ for all comparisons; Table 10).

Table 10: *Nutrient composition of dietary intake during test days (breakfast, lunch, buffet tea and weight food diary combined).*

	Test Buffet Tea	Control Buffet Tea	Test Whole Day	Control Whole Day
Energy (kJ)	2641 ± 1598	2418 ± 1377	7695 ± 1802	8568 ± 1939†
Energy (kcal)	627.7 ± 380	575 ± 327	1872 ± 429	2040 ± 462†
Fat (g)	15.3 ± 9.6	14. 7 ± 8.2	49.5 ± 13.5	68.3 ± 14.3†
Saturates (g)	3.8 ± 2.3	3.6 ± 1.8	16.6 ± 5.0	26.4 ± 5.6†
CHO (g)	73.0 ± 47.6	63.0 ± 48.6	225.1 ± 55.7	231.3 ± 59.2
Sugars (g)	35.3 ± 24.1	33.1 ± 26.7	93.5 ± 37.9	88.4 ± 37.6
Fibre (g)	13.0 ± 8.9	11.8 ± 9.4	31.3 ± 115.5	27.9 ± 9.7
Protein (g)	41.0 ± 23.1	39.7 ± 17.8	115.5 ± 20.6	120.6 ± 31.1
Salt (g)	2.0 ± 1.1	1.8 ± 1.1	5.3 ± 0.9	5.8 ± 1.5

CHO = carbohydrate
† indicates significance ($P<0.05$)

Chapter Six: Discussion

The following section will discuss the results of each study independently within the context of their relevant literature. Subsequently, moving onto examine limitations collectively within this research in addition to potential future research.

6.1 Study One: Energy Matched Ready Meals

The purpose of the present study was to investigate the effects of energy-matched ready meals (beef lasagnes) on self-reported appetite ratings and subsequent dietary intake. It was hypothesised that after consuming the test ready meal subjective ratings for hunger, DTE and prospective consumption would decrease, whilst ratings of fullness would increase compared to after the control ready meal. Additionally, consuming the test ready meal would also reduce EI compared to the control ready meal. The main findings supported the proposed hypothesis with regards to the subjective appetite sensations – fullness increased whilst hunger, DTE and prospective consumption decreased after the test ready meal. However, there was no significant difference in EI between the two ready meals. These results indicate that the test ready meal may aid in subjective appetite regulation but that this might not translate, at least short-term, to reduced EI.

The results of the current study indicated that the test ready meal (Slimming World, lower ED) causes a reduction in mean subjective hunger ratings compared to the higher ED control ready meal, which is supported by findings from Buckland et al. (2018). Buckland and colleagues (2018) found that females with overweight or obesity reduced hunger, DTE and prospective consumption, whilst increasing fullness when they consumed LED meals compared to HED meals. These subjective appetite ratings were established throughout the whole day of testing, unlike in the current study, with differences in appetite ratings only being found between lunch and buffet tea. It could be suggested that this occurred due to the breakfast in the current study being identical (unlike LED and HED breakfasts provided in the Buckland study) and so no differences in appetite ratings were expected during the breakfast and lunch time point in the current study.

Despite the appetite ratings of the current study mirroring the appetite results from Buckland et al. (2018), there was no similarity in EI between the current study and the Buckland Study. *Ad libitum* evening EI and TDEI was significantly reduced on the LED day versus the HED day in the Buckland (2018) study, whereas there was no difference in buffet tea EI and TDEI between the lower ED ready meal and higher ED ready meal in the current study. Considering the current study was conducted on ready meals, and although the difference in ED was minor (0.32 kcal/g), it could be suggested that in order to achieve any impact on TDEI, a greater disparity is required in the difference between low and high ED meals consumed (1.7kcal/g difference in Buckland Study). Furthermore, it may be necessary for all meals to constitute LED throughout the day – not simply just one meal (at lunch), in order for there to be an effect on EI which could subsequently impact on weight loss. It should also be noted that the women in the Buckland et al. (2018) research were actively trying to lose weight, whereas this was not correct for all participants in the current study. Thus, it appears possible that active weight loss is not necessarily required for the impact of lower ED foods to be seen in terms of enhancing acute appetite ratings, however, it may be a factor in establishing a difference in calorie intake and potentially weight loss over time.

Results from a longitudinal analysis of a weight loss trial found that individuals with the greatest reduction in ED during an 18-month period, had the greatest reduction in EI and BMI, without changing the weight of food consumed (Flood et al., 2009). Further, the quartile of individuals that consumed more calories and had the highest mean ED at baseline reduced ED and EI most drastically after 18 months. Thus, long-term control of ED can beneficially impact BMI, in individuals aiming to lose weight. Perhaps further research warrants investigation into the implication of long-term ready meal consumption and the impact this may have on energy balance and weight, whilst also considering ED of participant's diets prior to conducting the research.

While the researcher aimed to maintain similar calories in the ready meals used in Study One, this was difficult to achieve because the study was investigating ready meals that were commercially available on supermarket shelves and as such were the best calorie-matched ready meals at the time of research (difference of 23 kcal/portion). There was more protein and fibre (44% and 69%, respectively) in the test ready meals compared to the control. As

previously mentioned, protein and fibre have enhancing satiating effects, therefore, contributed to favoured satiety outcomes for the test ready meal. Further portion size might impact satiety via influencing the cognitive phase of the satiety cascade (Figure 1) through visual cues (Benton, 2015). The participants in this study were provided with standard 'shop-bought' portion sizes for the ready meals, which differed in weight (difference of 150 g). It is credible that the packaging of the two ready meals might have influenced satiety responses, as the test ready meal was provided in foil container whereas the control ready meal was in a plastic container and visibly smaller in size. This may have caused individuals to modify subjective perceptions of satiety signals when consuming each ready meal (Ello-Martin et al., 2005). A study conducted by Rolls et al. (2002) served participants varying portion sizes of macaroni cheese, finding participants consumed 30% more energy when offered the largest portion than when given the smaller portion. Despite these differences in visible portion size, subsequent subjective ratings of hunger and fullness did not differ. Conversely, another study conducted by Rolls et al. (2004) in which portion size of a snack of crisps was increased, fullness ratings increased with the increased crisp portion size. It is possible this was affected by a visual indication but also highlights the issues with comparing varying study designs within appetite research. In the current study it is important to note that the two ready meals were provided on separate days. The test ready meal was visibly larger, but participants may have forgotten this if comparing the first ready meal and when consuming the second ready meal. Ultimately, this would benefit the outcome measurements by minimising the influence on size comparison.

Visual indications in conjunction with previous memories of eating experiences (specifically of lasagne) may have impacted pre-ingestive appetite signals, possibly impacting internal physiological satiety sensations and influencing appetite responses (Chambers et al., 2015). Hypothetically if the participants have had a previous experience consuming lasagne but did not feel satiated after, the participants may not anticipate sensations of feeling satiated - irrespective of nutrient load, which may consequently influence subjective appetite ratings (Chambers et al., 2015). Indeed, research has indicated that food delivered directly into the gut, omitting sensory pre-ingestive signalling via nasogastric tube feeding, reduces satiety responses to nutrients (Cecil et al. 1998). Rolls and Roe (2002) found that when preloads were put directly into the stomach, the volume of food infused was more significant to augmenting

satiety and reducing subsequent EI than the energy content of the preload. Thus, supporting findings from the current study in that the bigger volume of food consumed from the test meal caused reduced hunger, however, this did not translate into any significant change in EI.

Differences in satiety responses did not impact subsequent EI which may suggest that people may override signals when provided with a large proportion of food i.e. during the buffet tea. Data from the American Institute of Cancer Research (2004) found 69% of adults (n= 1000) would finish their meals when dining out, of which 30% stated that they would have been satisfied with a smaller portion. Thus, in the current study food intake may have been affected by the appeal of free food, including potential novel products not usually consumed (Benelam, 2009). Thus, participants may have consumed food in the absence of hunger or ignored satiety signals which could impact the relationship between appetite ratings and EI between the testing days. However, this is difficult to elucidate due to the required controlled nature of the research.

In addition to external factors i.e. vision potentially affecting satiety responses, it is possible that internal signals impacted responses. As the weight of the test ready meal was greater than the control ready meal (+150 g), gastric distension would have affected vagal afferents (Wang et al., 2007) i.e. the signalling along the vagus nerve of the gut-brain axis to liaise to the brain that the individual is full, to a greater extent. Wang et al. (2007), used a technique to mimic gastric distension from food intake using a balloon and pump inserted into the stomach. Findings revealed that fullness was significantly greater when the stomach was distended, however, there was no significant difference when the balloon was fully distended and deflated for hunger ratings. This suggests that gastric distension is more important in ratings of fullness compared to hunger. The current study supports this research regarding fullness feelings being impacted by greater distension (there was no difference in fullness at the point of eating the ready meals). This is probable because the test ready meal was bigger in mass hence likely causing greater gastric distension compared to the control, consequently increasing feelings of fullness. However, unlike hunger being unaffected in the Wang et al. (2007) study, the current study indicated a reduction in hunger ratings.

It should also be mentioned that attractiveness from the sensory evaluation of the two lunch meals was significantly greater for the control compared to the test ready meal. Considering sight is encompassed within the sensory aspect of the satiety cascade it could be suggested that this would contribute to satiety (Blundell et al., 2010). However, in the current study this did not appear to influence appetite ratings or food intake, as the control meal had reduced satiety outcomes. Though, it is important to note that these meals were evaluated on different days and as such attention should be given when interpreting these results as this may have influenced sensory evaluation due to not being evaluated on the same days as a result of the study design (Morten et al., 2006).

In summary, it appears that gastric distension may have been an important factor contributing to differences in appetite ratings between the two meals, as sensory analysis, ED and macronutrient content were all minor in their contribution to distinguishing each meal. It could also be suggested that although there appeared to be no significant difference in calorie intake between the days and thus there is no indication of altering energy balance (and weight loss), participants macronutrient intake was more favourable on the test day compared to the control day from a health perspective. This is due to the test ready meal day being lower in total fat and saturated fat, and higher in fibre and protein.

6.2 Study Two: Portion Sized Matched Ready Meals

The purpose of this study was to explore the effects of portion size matched ready meals on subjective appetite ratings and subsequent food intake. It was hypothesized that after consuming the test ready meal, self-reported hunger, DTE and prospective VAS ratings would be reduced, whilst fullness would be increased. Additionally, it was hypothesised that EI would be reduced to a greater extent after consuming the test ready meal compared to the control ready meal. The justification behind this hypothesis was that the test ready meal provided a smaller proportion of fat than the control meal, which is regarded as the least satiating macronutrient.

Analysis of appetite ratings between lunch and buffet tea indicated no difference between the two ready meals for hunger but that fullness ratings were significantly greater after

consuming the control ready meal. DTE and prospective consumption were significantly greater after consuming the test ready meal. Whole day food intake analysis showed a significant reduction (168 kcal) in EI for the test day. Fat and saturated fat were significantly reduced for the test day but there were no differences between test and control days regarding carbohydrate, sugars, fibre, protein and salt consumption. Considering that the portion sizes were identical in the current study (both 550 g) and any differences in important satiating macronutrients, such as fibre and protein were trivial, the effect on fullness may plausibly have been predominately driven by energy (kcal), as the control ready meal contained 210 kcal more than the test ready meal. Specifically, the proportion of fat was the biggest factor in terms of contributing to the calorie difference between the ready meals, with a 19.3 g disparity. Fat in the control ready meal contributed an extra 174 kcal compared to the test ready meal.

The presence of fat in the intestine stimulates the release of CCK (increases satiation, delays gastric emptying) and subsequently stimulates the release of PYY (known to enhance satiety) and suppresses ghrelin which would reduce hunger (Brennan et al., 2012). It is thus conceivable that due to enhanced fullness, participants would consume less food. However, the participants in the current study consumed more energy on the control day despite fullness ratings being significantly higher. The difference in TDEI was predominately caused by the differences in ready meal EI being greater for the control meal yet participants did not appear to adjust for this greater EI during the subsequent buffet tea. The control ready meal contained more fat compared with the test ready meal. As previously mentioned, it could be suggested that these results occurred due fat being the least satiating macronutrient in addition to those with overweight potentially having reduced sensitivity to the perception of fat (Moran et al., 2005; Brennan et al., 2012). This may have possibly skewed the release of hormones involved with appetite, yet as this was not measured this cannot be concluded. Evidently, increased energy was partially due to the fat present in the ready meal as fat is the most energy dense macronutrient and the control ready meal contained a greater quantity of fat (19 g more fat), but it is still reasonable to question why participants had a greater TDEI. Participants may have consumed a smaller weight of food but just consumed more energy dense foods, thus contributing to a greater calorie intake, sometimes referred to a ‘passive overconsumption’ (Blundell and MacDiarmid, 1997). It may also be reasonable to suggest that

the offer of a buffet tea contributed further to participants passively consuming food past the point of fullness. Another possible suggestion is that postprandial ghrelin suppression may be reduced in individuals with obesity (Yang et al., 2009). Hence, perhaps those with overweight or obesity are less sensitive to their internal hunger cues and respond more to external cues, specifically in this case sensory prompts (buffet tea) despite being told to eat until comfortably full.

Despite being higher in calories it could be suggested that the control ready meal palatability caused participants to consume more throughout the testing day without realising internal feedback cues (Blundell and MacDiarmid, 1997; Yeomans et al., 2004). Participants rated the sensory characteristics of the control meal as more desirable, being significantly better for taste and attractiveness than the test ready meal. Palatability plays an important role in appetite as greater palatability can increase food consumption (Erlanson-Albertonsson, 2005; McCrickerd and Forde, 2016). Thus, it could be suggested that the control ready meal caused enhanced fullness and reduced DTE and prospective consumption as it was rated as more palatable (Berthoud, 2007).

To conclude, the results indicate that when two ready meals are matched for portion size, the higher calorie ready meal (control) at lunch enhanced fullness rating's but appeared to cause a significant elevation in TDEI compared to the ready meal with fewer calories (test). However, results need to be interpreted with the knowledge that the current study was underpowered.

6.3 Limitations & Further Research

There are limitations within both studies that should be acknowledged and points for further research exploration. Firstly, the effect of ready meal consumption on appetite and satiety was only explored within the context of females, due to females partaking in weight loss to a greater extent than men (Crane et al., 2017). Thus, results intrinsically have an all-female bias. Considering only females were included in these studies, their menstrual cycle was not accounted for. This was due to the restricted timeframe for the studies to be completed and

so accounting for the menstrual cycle would have meant participants only coming into the lab monthly, further placing pressure on the limited timeframe. It would be beneficial in the future to consider the menstrual cycle of the participants and how hormones may potentially impact satiety ratings and EI during different phasing of the cycle (Bryant et al., 2006; Brennan et al., 2009; Campolier et al., 2016). A study by Brennan et al. (2009) found stunted gastric emptying rates, reduced subjective hunger ratings, which may have influenced the reduced EI, depress plasma insulin, glucose and GLP-1 concentrations during the follicular phase of the cycle relative to the luteal phase. Thus, suggesting females are tested during the same stage of their menstrual cycle in order to minimise any hormonal impact on satiety ratings or EI.

It may also be beneficial to continue this study on females who rely heavily on ready meals habitually and determine how outcomes may be impacted over a more prolonged timeframe. For individuals wanting to lose weight, ready meal consumption may not be the best choice when trying to achieve a calorie deficit. However, with the projected increased consumption and reliance on ready meals due to reduced time spent cooking and reduced cooking skills it is pertinent to assess ready meal consumption in those who habitually consume them (Monsivais et al., 2014; Mintel Group Ltd., 2019). It would be relevant to explore the long-term impact ready meal consumption may potentially have on satiety ratings and perhaps of greater interest to PHE, how lower energy dense ready meals may affect weight management.

Despite these studies investigating short-term effects on satiety and EI, long-term studies are beneficial to explore as they may portray, with more relevance, how long-term results may translate more appropriately to real life settings compared to acute studies. For example, Flood et al. (2009) found that decreased ED resulted in reduced BMI over an 18-month study period. This relationship was particularly strong during the first six months, when the greatest contrast in ED change coincided with the greatest weight loss. However, in Study One despite the ready meals differing in ED, the study was too short-term for the results to be interpreted for long-term implications, especially regarding any weight loss that may be incurred. Therefore, any future research in this area should research long-term effects, making results more pertinent to the real world.

It is also important to acknowledge that Study Two was underpowered which may have had an impact on results, one being why there was no significant difference for hunger but there was for fullness. Outcomes may have been bias, either falsely positive (rejecting true null hypothesis) or falsely negative. The fact the study was underpowered and if indeed there were false positives in the outcomes, this causes inconsistencies between comparing studies with those showing significant findings and those concluding null outcomes.

Any conclusions drawn from these studies are only relevant within the context of consuming lasagne as no other ready meals were used. This limits any conclusions that can be drawn in the wider context of ready meals generally, as differing ready meals will have differing macronutrient contents that might implicate the outcomes. As such, further research warrants exploration into the potential effects of ready meals on appetite and satiety.

A buffet is the most effective way of evaluating food intake but may not necessarily represent what individuals would choose themselves outside the study environment. Therefore, participants response may have been constrained by the lab setting and the novelty of consuming food in excess, limiting external validity (Blundell et al., 2010). Additionally, meal timings were chosen due to the restraints of the studies being lab-based, but this may not reflect times of when the participants would choose to eat their meals and so it is difficult to extrapolate these results to a real-world scenario (Benelam, 2009). Conducting lab-based research enables regulation regarding various confounding variables e.g. environmental factors or social relations that could potentially impact subjective appetite ratings or food intake. While a laboratory environment may not characterise a 'real-life' setting, it enables greater control of variables that may influence the outcome (Benelam, 2009). However, there are also variables that were not controlled for e.g. cortisol levels. Cortisol levels are generally higher in the morning, which may have been further increased in the lab setting due to stress (Lindholm et al., 2012). Nonetheless, it is essential for studies to be conducted under free-living conditions in order to be more ecologically valid. Future research could explore the possibility of letting participants decide when they want to consume their meals, making it more life-like to the consumption habits of each participants and being slightly more applicable to a real-world setting (Benelam, 2009).

Both sensory factors of the foods provided during the buffet teas and the actual choice of foods provided may have impacted food intake (Benelam, 2009). Thus, further research may warrant asking participants to rate foods offered on a Likert scale therefore enabling investigation of any relationships between preferred food choices and EI during the buffet tea. Additionally, participants may benefit from trial familiarisation prior to the first testing day as the second testing day may have caused participants to be more conversant with the testing procedures, which may have impacted outcomes.

Another drawback was the possibility that participants developed measurement fatigue in the period between lunch and the buffet tea, as VAS measurements were taken every 15 minutes. Measurement fatigue occurs when participants become disengaged with the task they are required to complete – in this case the VAS of subjective satiety ratings. As participants attention and motivation drops while the time continues their responses may have become more perfunctory. Thus, the quality of the data can begin to diminish – perhaps not being reflective of how their subjective satiety ratings truly were at the time measured (Lavrakas, 2008).

While participants were fasted prior to beginning both studies, there was no standardisation for the time in which they woke and began the studies. Consequently, it could be implied that appetite ratings may have differed depending on the length of time individuals were awake prior to commencing. Moreover, sleep deprivation can contribute to developing obesity and may impact appetite hormones such as leptin and ghrelin (Magee et al., 2008). It may be reasonable for participants to rate their sleep before commencing or alternatively monitoring the sleep of participants may deserve thought. A study by Taheri et al. (2004) found increased ghrelin and reduced leptin levels after limited sleep. Additionally, the time participants went to sleep was not recorded but participants who went to bed later may have consumed more energy (Cespedes Feliciano et al., 2019).

Another limit was not recording how much water each participant drank in between each meal. There is evidence to suggest that ingesting water prior to consuming a meal may reduce EI in that meal (Jeong, 2018). Although the researcher articulated avoiding large quantities of water immediately before each meal to the participants, this was difficult to regulate

Considering participants were able to leave the laboratory during the time between each meal, it would have been problematic to ask them to measure the quantify of water they consumed. Further, eating rate may have determined whether more water was ingested with the meal, potentially impacting appetite responses (Andrade et al., 2012). It is possible that this may have augmented gastric distension, hence inducing satiety but evidence regarding eating rate and water ingestion is conflicting (Rolls et al., 1999; de Graaf, et al., 2004). Perhaps in future research each participant should be designated a set proportion of water to consume throughout the day, in addition to allocating a certain amount of time for each participant to ingest the ready meal.

Chapter Seven: Conclusion

Both of these studies highlight the complexity of appetite research as factors such as portion size and macronutrient content, may influence outcomes. Hence, challenges occur with regards to translating these findings into health and/or weight management outcomes. The current research suggests that although a lower energy dense, calorie-matched ready meal may be favourable for subjective appetite ratings and aid in appetite control, there is no impact on EI within the testing day. However, results also indicated that when portion-matched ready meals were consumed, a higher calorie ready meal enhanced fullness but also caused increased EI.

It is important to further investigate the consumption of lower energy dense ready meals to improve consumer macronutrient consumption to better align with PHE nutritional guidelines (within the context of ready meals), especially if the forecast increase in ready meal consumption does occur. It may be beneficial for weight management organisations to continue to promote consumption of 'satiety-enhancing' ready meals over standard ready meals in order to lower fat, potentially impacting long-term energy balance and overall health but longitudinal studies would need to be conducted. Further, longitudinal studies can investigate if the enhanced satiety benefits of the test ready meal in these acute appetite studies accumulate and translate into a change in EI.

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Appendices

Appendix A: Recruitment Poster

OXFORD BROOKES UNIVERSITY

Participants Needed for Appetite Study

Love food?

Then, participate in a study exploring the effects of ready meals consumption on appetite, hunger and satiety!

FREE breakfast, lunch, tea & £15 Amazon Voucher

at

Oxford Brookes Centre for Nutrition and Health at Oxford Brookes University, Gypsy Lane site.

Who can participate?

Calling for female participants (18-65 years, Body Mass Index * ≥25 kg/m^2) who have no known allergies or intolerance to test foods, no significant health problems, not pregnant or breastfeeding and not on any supplements that affect appetite.

*Calculate BMI = weight (kg) ÷ height (m) squared.

What would be expected of participants?

Three sessions would be included in this study.

1. Screening: measurement of body composition and health questionnaire
2. Consumption of breakfast, test meal, and *ad libitum* buffet meal
3. Consumption of breakfast, control meal, and *ad libitum* buffet meal

Participants would also be required to complete visual analogue scales (VAS) rating hunger, satiety and satiation before and after breakfast, lunch and the buffet tea. You will also be asked to complete VAS in-between meals. Dietary intake for the rest of the day (until bedtime) using a weighed food diary would be recorded.

How long will it take?

Total contact time required: 3hr 40mins (1 screening: 20mins & 2 sessions: 20mins breakfast, 40mins lunch, 40mins buffet).

For more information contact:

Postgraduate Researcher
Sophie Hannon
18100097@brookes.ac.uk

Sophie: 18100097@brookes.ac.uk

Sophie: 18100097@brookes.ac.uk
Sophie: 18100097@brookes.ac.uk
Sophie: 18100097@brookes.ac.uk
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Sophie: 18100097@brookes.ac.uk
Sophie: 18100097@brookes.ac.uk
Sophie: 18100097@brookes.ac.uk
Sophie: 18100097@brookes.ac.uk

Appendix B: Participant Information Sheet Study One

Participant Information Sheet

Study: The Effect of Energy-Matched Ready Meals on Appetite, Satiety and Subsequent Energy Intake

Research Team		
TITLE & NAME	*POST*	*DEPT & FACULTY*
Dr Sarah Hillier	Senior Lecturer in Nutrition DoS	Health & Life Sciences/Sport & Health Sciences/ OxBCNH
Ms Sophie Hannon	MSc by Research Student	Health & Life Sciences/Sport & Health Sciences/ OxBCNH
Dr Sangeetha Thondre	Senior Lecturer in Nutrition & Subject Coordinator BSc Nutrition	Health & Life Sciences/Sport & Health Sciences/ OxBCNH
Dr Miriam Clegg	Senior Lecturer in Nutrition	Dept. Food and Nutritional Sciences

Invitation

You are being invited to take part in a research study that seeks to investigate the effects of commercial weight management prepared ready meals on appetite, satiety and subsequent food intake. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

What is the Purpose of the study?

The purpose of this study is to investigate the effects of energy (calories) matched ready meals on appetite, satiety, and subsequent energy intake in females.

Why have I been invited to participate?

This project is being run at Oxford Brookes University, as part of research by the Department of Health & Sport Sciences. A group of 30 female participants are needed, and you have been invited as you fulfil the inclusion criteria (see below).

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason. For students of Oxford Brookes University, choosing to either take part or not take part in the study will have no impact on your marks, assessment or future studies.

What are the inclusion and exclusion criteria?

Exclusion criteria:

Body Mass Index (BMI) below 25 kg/m^2

Males

Those who follow a vegetarian, vegan or halal diet.

Significant health problems (e.g. high cholesterol, diabetes, gastrointestinal disorders, other metabolic or non-metabolic diseases that may affect taste or digestion).

Taking any medication or supplements known to affect appetite or weight within the past month and/or during the study

Pregnant, planning to become pregnant or breastfeeding

History of anaphylaxis to food or known allergies or intolerance to foods and/or to the study materials (or closely related compounds) or any of their stated ingredients: wheat, egg, milk, barley, celery, mustard, soya

Smokers and those who have recently (i.e. for <9 months) ceased smoking

Participants who have significantly changed their physical activity in the past 2-4 weeks or who intend to change them during the study

Participants receiving systemic or local treatment likely to interfere with the evaluation of the study parameters

Participants who work in appetite or feeding related areas

Inclusion criteria:

Aged 18 years to 65 years

BMI above 25 kg/m^2

Understands and is willing, able and likely to comply with all study procedures and restriction

Able to eat most everyday foods

Habitually consumes three standard meals a day (i.e. breakfast, lunch and dinner)

Written informed consent to be given

What will happen to me if I take part?

The study will involve 3 visits (one screening session and 2 test sessions) to the Oxford Brookes Centre for Nutrition and Health (OxBCNH) at Oxford Brookes University.

Screening session

During the screening session, you will:

Be asked to sign a consent form and fill in a questionnaire.

have your height, weight and body composition measured

Test sessions

For each of the 2 test sessions, you will need to visit the Oxford Brookes Centre for Nutrition and Health following a 12 hour overnight fast. Each test session will begin between 8am to 9am on weekdays, with further test sessions throughout the day, at lunchtime (12-1pm), and a buffet tea (4-5pm). The three sessions will make up a full test day and include:

A standardised breakfast (breakfast cereals, toast, margarine, jam, tea/coffee), all of which

must be consumed.
A lunch meal (either a test or control beef lasagne ready meal and a green salad), again all of which must be consumed.
A buffet tea (sandwiches with a selection of snack bars, fruit and yogurts).
You will be asked to complete Visual Analogue Scales (VAS) rating hunger, satiety and satiation before and after breakfast, lunch and the buffet tea. You will also be asked to complete VAS every 30 minutes in between breakfast and lunch and then every 15 minutes in between lunch and dinner (you will receive a reminder).
You will be asked to record dietary intake for the rest of the day (until bedtime) using a weighed food diary.
You must refrain from consuming food, chewing gum or calorific beverages (unless water in moderation) in between the test meals.

The total contact time required from you will be 3 hours and 40 minutes approximately (20 minutes for the screening, 20 minutes for breakfast, 40 minutes for lunch, 40 minutes for buffet meal). Note you do not have to stay for this whole time, once you have finished the meal you are free to leave and come back in time for the next meal.

How to prepare for each test session

You need to fast overnight (approximately 12 hours) – this means **no food or drink**, although you are allowed to drink water in moderation.

Avoid strenuous exercise and alcohol.

For example, if you start your test session at 8.30 am, you need to stop eating/drinking (apart from water) at 8.30 pm the previous evening.

What are the possible benefits or risks of taking part?

Personal benefits include two days of a free breakfast, lunch and buffet.

You will receive a £15 Amazon voucher upon completion of all sessions.

The study will provide valuable information that will be used to help people manage their weight through portion size control and increased satiety (feeling of fullness).

You will be helping to inform valuable research on weight management and contribute to the development of new ready meals.

You will receive information about your body composition measurements.

Possible risks include having to eat foods you don't like.

What will happen to the information/results collected in the project?

Data will remain confidential and you will not be named within the results. Data will remain with the researcher in a password protected file, only accessible to the researcher and the project supervisor. However, due to small sample size, it may have implications for privacy/anonymity

All records will be coded and will only be available to the researchers involved in the study; your name will never appear in any published work.

All data will be securely stored at the University for a minimum of 10 years in accordance with the University's policy on academic integrity.

You are free to withdraw from the study at any time, without giving a reason, and to withdraw any unprocessed data previously supplied.

What happens if I do not want to take part in the project?

Participation is completely voluntary, and no details will be recorded for monitoring purposes. All data will remain confidential

What happens if I do want to take part?

If you want to take part in this study, please contact either:

Sophie Hannon: 18100097@brookes.ac.uk

Dr Sarah Hillier: sarahhillier@brookes.ac.uk

Who is organising and funding the research?

This study is organised by staff and an MSc by Research Student of the Oxford Brookes Centre for Nutrition and Health (OxBCNH) in the Department of Sport, Health Sciences and Social Work at Oxford Brookes University.

This study has been funded by Slimming World through an MSc by Research Studentship in 2019-2020.

Ethical Approval and funding

This study has been approved by the Oxford Brookes University Faculty Research Ethics Officer, Dr Anne Delextract. If you have any concerns about how this study has been conducted you can contact the Chair of the Faculty University Research Ethics Committee on frec@brookes.ac.uk.

Thank you for your help

Appendix C: Participant Information Sheet Study Two

Participant Information Sheet

Study: The Effect of Portion-Matched Ready Meals on Appetite, Satiety and Subsequent Energy Intake

Research Team		
TITLE & NAME	*POST*	*DEPT & FACULTY*
Dr Sarah Hillier	Senior Lecturer in Nutrition DoS	Health & Life Sciences/Sport & Health Sciences/ OxBCNH
Ms Sophie Hannon	MSc by Research Student	Health & Life Sciences/Sport & Health Sciences/ OxBCNH
Dr Sangeetha Thondre	Senior Lecturer in Nutrition & Subject Coordinator BSc Nutrition	Health & Life Sciences/Sport & Health Sciences/ OxBCNH
Dr Miriam Clegg	Senior Lecturer in Nutrition	Dept. Food and Nutritional Sciences

Invitation

You are being invited to take part in a research study that seeks to investigate the effects of commercial weight management prepared ready meals on appetite, satiety and subsequent food intake. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

What is the Purpose of the study?

The purpose of this study is to investigate the effects of portion-matched ready meals on appetite, satiety, and subsequent energy intake in females.

Why have I been invited to participate?

This project is being run at Oxford Brookes University, as part of research by the Department of Health & Sport Sciences. A group of 30 female participants are needed, and you have been invited as you fulfil the inclusion criteria (see below).

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason. For students of Oxford Brookes University, choosing to either take part or not take part in the study will have no impact on your marks, assessment or future studies.

What are the inclusion and exclusion criteria?

Exclusion criteria:

Body Mass Index (BMI) below 25 kg/m^2

Males

Those who follow a vegetarian, vegan or halal diet.

Significant health problems (e.g. high cholesterol, diabetes, gastrointestinal disorders, other metabolic or non-metabolic diseases that may affect taste or digestion).

Taking any medication or supplements known to affect appetite or weight within the past month and/or during the study

Pregnant, planning to become pregnant or breastfeeding

History of anaphylaxis to food or known allergies or intolerance to foods and/or to the study materials (or closely related compounds) or any of their stated ingredients: wheat, egg, milk, barley, celery, mustard, soya

Smokers and those who have recently (i.e. for <9 months) ceased smoking

Participants who have significantly changed their physical activity in the past 2-4 weeks or who intend to change them during the study

Participants receiving systemic or local treatment likely to interfere with the evaluation of the study parameters

Participants who work in appetite or feeding related areas

Inclusion criteria:

Aged 18 years to 65 years

BMI above 25kg/m^2

Understands and is willing, able and likely to comply with all study procedures and restriction

Able to eat most everyday foods

Habitually consumes three standard meals a day (i.e. breakfast, lunch and dinner)

Written informed consent to be given

What will happen to me if I take part?

The study will involve 3 visits (one screening session and 2 test sessions) over a period of 2 weeks to the Oxford Brookes Centre for Nutrition and Health (OxBCNH) at Oxford Brookes University.

Screening session

During the screening session, you will:

Be asked to sign a consent form and fill in a questionnaire.

have your height, weight and body composition measured

Test sessions

For each of the 2 test sessions, you will need to visit the Oxford Brookes Centre for Nutrition and Health following a 12 hour overnight fast. Each test session will begin between 8am to 9am on weekdays, with further test sessions throughout the day, at lunchtime (12-1pm), and a buffet tea (4-5pm). The three sessions will make up a full test day and include:

A standardised breakfast (breakfast cereals, toast, margarine, jam, tea/coffee), all of which must be consumed.
A lunch meal (either a test or control beef lasagne ready meal and a green salad), again all of which must be consumed.
A buffet tea (sandwiches with a selection of snack bars, fruit and yogurts).
You will be asked to complete Visual Analogue Scales (VAS) rating hunger, satiety and satiation before and after breakfast, lunch and the buffet tea. You will also be asked to complete VAS every 30 minutes in between breakfast and lunch and then every 15 minutes in between lunch and dinner (you will receive a reminder).
You will be asked to record dietary intake for the rest of the day (until bedtime) using a weighed food diary.
You must refrain from consuming food, chewing gum or calorific beverages (unless water in moderation) in between the test meals.

The total contact time required from you will be 3 hours and 40 minutes approximately (20 minutes for the screening, 20 minutes for breakfast, 40 minutes for lunch, 40 minutes for buffet meal). Note you do not have to stay for this whole time, once you have finished the meal you are free to leave and come back in time for the next meal.

How to prepare for each test session

You need to fast overnight (approximately 12 hours) – this means **no food or drink**, although you are allowed to drink water in moderation.

Avoid strenuous exercise and alcohol.

For example, if you start your test session at 8.30 am, you need to stop eating/drinking (apart from water) at 8.30 pm the previous evening.

What are the possible benefits or risks of taking part?

Personal benefits include two days of a free breakfast, lunch and buffet.

You will receive a £15 Amazon voucher upon completion of all sessions.

The study will provide valuable information that will be used to help people manage their weight through portion size control and increased satiety (feeling of fullness).

You will be helping to inform valuable research on weight management and contribute to the development of new ready meals.

You will receive information about your body composition measurements.

Possible risks include having to eat foods you don't like.

What will happen to the information/results collected in the project?

Data will remain confidential and you will not be named within the results. Data will remain with the researcher in a password protected file, only accessible to the researcher and the project supervisor. However, due to small sample size, it may have implications for privacy/anonymity

All records will be coded and will only be available to the researchers involved in the study; your name will never appear in any published work.

All data will be securely stored at the University for a minimum of 10 years in accordance with the University's policy on academic integrity.

You are free to withdraw from the study at any time, without giving a reason, and to withdraw any unprocessed data previously supplied.

What happens if I do not want to take part in the project?

Participation is completely voluntary, and no details will be recorded for monitoring purposes. All data will remain confidential

What happens if I do want to take part?

If you want to take part in this study, please contact either:

Sophie Hannon: 18100097@brookes.ac.uk

Dr Sarah Hillier: sarahhillier@brookes.ac.uk

Who is organising and funding the research?

This study is organised by staff and an MSc by Research Student of the Oxford Brookes Centre for Nutrition and Health (OxBCNH) in the Department of Sport, Health Sciences and Social Work at Oxford Brookes University.

This study has been funded by Slimming World through an MSc by Research Studentship in 2019-2020.

Ethical Approval and funding

This study has been approved by the Oxford Brookes University Faculty Research Ethics Officer, Dr Anne Delextract. If you have any concerns about how this study has been conducted you can contact the Chair of the Faculty University Research Ethics Committee on frec@brookes.ac.uk.

Thank you for your help

Appendix D: Ethical Approval from Oxford Brookes University Faculty of Health and Life Sciences Departmental Research Ethics Officer

E3/FH&LS

Oxford Brookes University

Faculty of Health and Life Sciences

Decision on application for ethics approval

The Departmental Research Ethics Officer (DREO) has considered the application for ethics approval for the following project:

Project Title: The effects of ready meal consumption on appetite, satiety and subsequent food intake

DREC Reference: 0119_44

Name of Applicant/s: Sophie Hannon

Name of Supervisor/s: Sarah Hillier

Please tick one box

1. The Departmental Research Ethics Officer / Faculty Research Ethics Committee gives ethical approval for the research project. ☑

Please note that the research protocol as laid down in the application and hereby approved must not be changed without the approval of the DREO / FREC

2. The Departmental Research Ethics Officer / Faculty Research Ethics Committee gives ethical approval for the research project, subject to the following: ☐

3. The Departmental Research Officer / Faculty Research Ethics Committee cannot give ethical approval for the research project. The reasons for this and the action required are as follows: ☐

Signed: .....
Approval Date: ...07/02/2019.....

Designation: Departmental Research Ethics Officer

(Signed on behalf of the Faculty Research Ethics Committee)

Date when application reviewed (*office use only*):.....22/01/2019.....

H&LS/FRec/E3 August 2011

Appendix E: Three Factor Eating Questionnaire

Three-Factor Eating Questionnaire

Please read all questions carefully and answer by circling the option that applies to you. There are no right or wrong answers and all records will be kept anonymous.

True – T

False – F

				Office use only
1	When I have eaten my quotas of calories, I am usually good about not eating any more.	**T**	**F**	
2	I deliberately take small helpings as a mean of controlling my weight.	**T**	**F**	
3	Life is too short to worry about dieting.	**T**	**F**	
4	I have a pretty good idea of the number of calories in common food.	**T**	**F**	
5	While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	**T**	**F**	
6	I enjoy eating too much to spoil it by counting calories or watching my weight.	**T**	**F**	
7	I often stop eating when I am not really full as a conscious mean of limiting the amount that I eat.	**T**	**F**	
8	I consciously hold back at meals in order not to gain weight.	**T**	**F**	
9	I eat anything I want, anytime I want	**T**	**F**	
10	I count calories as a conscious mean of controlling my weight.	**T**	**F**	
11	I do not eat some foods because they make me fat.	**T**	**F**	
12	I pay a great deal of attention to changes in my figure.	**T**	**F**	

13	How often are you dieting in a conscious effort to control your weight?				
	1	2	3	4	
	rarely	sometimes	usually	Always	
14	Would a weight fluctuation of 5lbs (~ 2kg) affect the way you live your life?				
	1	2	3	4	
	Not at all	slightly	moderately	Very much	
15	Do your feelings of guilt about overeating help you control your food intake?				
	1	2	3	4	
	never	rarely	often	Always	
16	How conscious are you of what you eat?				
	1	2	3	4	
	Not at all	slightly	moderately	Extremely	
17	How frequently do you avoid ‘stocking up’ on tempting foods?				
	1	2	3	4	
	Almost never	seldom	usually	Almost always	

18 How likely are you to shop for low-calorie foods?

1	2	3	4	
unlikely	Slightly unlikely	Moderately likely	Very likely	

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

1	2	3	4	
unlikely	Slightly likely	Moderately likely	Very likely	

Reference

Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. J Psychosom Res 1985; 29:71-83

20 How likely are you to consciously eat less than you want?

1	2	3	4	
unlikely	Slightly likely	Moderately likely	Very likely	

21 On a scale of 0 to 5, where 0 means no restraints in eating (eating whatever you want, whenever you want it) and 5 means total restraints (constantly limiting food intake and never 'giving in'), what number would you give yourself?

0
Eat whatever you want, whenever you want it

1
Usually eat whatever you want, whenever you want it

2
Often eat whatever you want, whenever you want it

3
Often limit food intake, but often 'give in'

4
Usually limit food intake, rarely 'give in'

5
Constantly limiting food intake, never 'giving in'

Office Use Only

TFEQ FI score:_____

Appendix F: Dutch Eating Behaviour Questionnaire

Dutch Eating Behaviour Questionnaire

Please the questions carefully and answer by circling one of the five options. Some questions have a non-relevant option (NR), if it applies to you please use this column. The last column is for office-use ONLY.

								Office Use only
1	If you have put on weight, do you eat less than you usually do?	Never	Seldom	Sometimes	Often	Always	NR	
2	Do you try to eat less at mealtimes than you would like to eat?	Never	Seldom	Sometimes	Often	Always		
3	How often do you refuse food or drink because you are concerned about your weight?	Never	Seldom	Sometimes	Often	Always		
4	Do you watch exactly what you eat?	Never	Seldom	Sometimes	Often	Always		
5	Do you deliberately eat foods that are slimming?	Never	Seldom	Sometimes	Often	Always		
6	When you have eaten too much, do you eat less than usual the following days?	Never	Seldom	Sometimes	Often	Always	NR	
7	Do you deliberately eat less in order not to become heavier?	Never	Seldom	Sometimes	Often	Always		
8	How often do you try not to eat between meals because you are watching your weight?	Never	Seldom	Sometimes	Often	Always		
9	How often in the evening do you try not to eat because you are watching your weight?	Never	Seldom	Sometimes	Often	Always		
10	Do you take into account your weight with what you eat?	Never	Seldom	Sometimes	Often	Always		

References
1. van Strien T, Frijters JER, Bergers GPA, Defares PB. The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. International Journal of Eating Disorders 1986;5:295-315.

For office-use only:

DEBQ final score:_____

Appendix G: Health Screening Questionnaire

Health Screening Questionnaire

Please circle as appropriate

Do you have an intolerance or allergy (including a history of anaphylaxis) to any foods? **YES NO**
If yes which one(s)? _____

Are there any foods you dislike?
YES NO
If yes which one(s)? _____

Do you habitually eat three standard meals per day (i.e. breakfast, lunch & dinner)?
YES NO

Are you following a special diet?
YES NO
If yes, which one(s)? _____

Have you lost more than 5% of your body weight in the previous year? **YES NO**
For example, if you are 80 kg, 5% would be 4 kg.

Do you suffer from any health conditions (i.e. hypercholesterolemia, diabetes, gastrointestinal disorder, or hypo/hyperthyroidism)?
YES NO

Are you taking any medication?
YES NO
If yes, which one(s)? _____

Do you take any supplements (i.e. vitamins, minerals or pre/probiotics)? **YES NO**

Have you undergone any major medical/ surgical event in the last 3 months?
YES NO

Are you a smoker?
YES NO
If yes, cigarettes/day: _____

Have you recently (within the last 9 months) ceased smoking? **YES NO**

Do you exercise or participate in any sports?
YES NO
How often a week? _____ Duration: _____ Intensity: _____

Have you significantly changed your physical activity in the last 2-4 weeks or do you intend to change your physical activity in the next 2 months?
YES NO
If yes, how have you/do you intend to do so? _____

Are you pregnant, planning to become pregnant or breastfeeding?
YES NO

Do you work in an appetite or feeding related research/industry? **YES** **NO**

Appendix H: Informed Consent Study One

OXFORD BROOKES UNIVERSITY

CONSENT FORM

Title:
The effects of ready meal consumption on appetite, satiety and subsequent food intake

Researchers and contact details:
Sophie Hannon
Oxford Brookes Centre for Nutrition and Health (OxBCNH)
Email: 18100097@brookes.ac.uk

Chief Supervisor:
Dr Sarah Hillier
Department of Sport and Health Sciences
Faculty of Health and Life Sciences
Oxford Brookes University
Oxford OX3 0BP
Email: sarahhillier@brookes.ac.uk

	Please initial box
I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.	☐
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.	☐
I agree to take part in the above study.	☐
I agree that I have completed the screening test regarding allergies.	☐

	Please tick box	
	Yes	No
I agree that my data gathered anonymously in this study may be stored, in a specialist data centre and may be used for future research.	☐	☐
I agree to be contacted regarding future research studies within OxBCNH.	☐	☐

Name of Participant	Date	Signature

Phone number:

Email address:

Name of Researcher	Date	Signature

Appendix I: Informed Consent Study Two

OXFORD BROOKES UNIVERSITY

CONSENT FORM

Title:
The effects of ready meal consumption on appetite, satiety and subsequent food intake

Researchers and contact details:
Sophie Hannon
Oxford Brookes Centre for Nutrition and Health (OxBCNH)
Email: 18100097@brookes.ac.uk

Chief Supervisor:
Dr Sarah Hillier
Department of Sport and Health Sciences
Faculty of Health and Life Sciences
Oxford Brookes University
Oxford OX3 0BP
Email: sarahhillier@brookes.ac.uk

	Please initial box
I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.	☐
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.	☐
I agree to take part in the above study.	☐
I agree that I have completed the screening test regarding allergies.	☐

	Please tick box	
	Yes	No
I agree that my data gathered anonymously in this study may be stored, in a specialist data centre and may be used for future research.	☐	☐

Name of Participant	Date	Signature

Phone number:

Email address:

Name of Researcher	Date	Signature

Appendix J: Sandwich Choices

Sandwich	Per Sandwich	Per Half Sandwich
Chicken Sandwich		
Ingredients	**Weight (g)**	**Weight (g)**
Tesco's Roast Sliced Chicken	60	30
Tesco's Little Gem	10	5
Hellman's Lighter than Light Mayo	15	7.5
Tesco's Cucumber	40	20
Warburton's Wholemeal Medium Sliced	2 slices = 88g	44
Houmous Sandwich		
Tesco Reduced Fat Caramelised Onion Houmous	40	20
Spinach Leaves	10	5
Warburton's Wholemeal Medium Sliced	2 slices = 88g	44
Egg Mayo		
Tesco Large Free-Range Eggs	60	30
Hellman's Lighter than Light Mayo	15	7.5
Warburton's Wholemeal Medium Sliced	2 slices = 88g	44
Tuna Mayo		
John West No Drain Tuna Steak Brine	60	30
Hellman's Lighter than Light Mayo	15	7.5
Warburton's Wholemeal Medium Sliced	2 slices = 88g	44
Ham Salad		
Tesco British Cooked Ham	50/2 slices	25
Tesco's Little Gem	10	5
Hellman's Lighter than Light Mayo	15	7.5
Tomatoes	60	30
Warburton's Wholemeal Medium Sliced	2 slices = 88g	44
Roast Beef & Tomato		
Tesco 4 Roast Beef Slices	25/1 slice	12.5
Tesco's Little Gem	10	5
Hellman's Lighter than Light Mayo	15	7.5
Tesco Wholegrain Mustard	10	5
Tomatoes	60	30
Warburton's Wholemeal Medium Sliced	2 slices = 88g	44

Appendix K: Weighed Food Diary

Food Diary record

OXFORD BROOKES UNIVERSITY

Thank you for participating in this study. Please return your sheet and scales to the researcher the next day.

This sheet is a way of recording your food intake. It is important that you record every single item that you have consumed otherwise the record and the results will not be reliable.

Principles and useful tips for making a perfect Food Diary record

- ✓ Record **EVERYTHING** you have eaten, might it be those two-three jelly beans you have been offered by your child or food supplements such as vitamins, minerals, cod liver oil, etc.
- ✓ Record the food items and their amounts **in a real time**, do not wait, otherwise you will forget items and the record and the analysis will be unreliable.
- ✓ Note down the **brand** and **name** of the product if you didn't make it yourself.
- ✓ Make sure you have noted down the **correct portion size**. For example, the crisps packets exist in at least three sizes. The volume of fluids is also written on their bottle or carton. Bread slices can be of different thickness and sizes, too. We have provided scales for you to weigh everything, however, if it's not possible to weigh items (e.g. you are out for dinner), then specify the product in as much detail as you can.
- ✓ The nature of the preparation/cooking method of food or snack is also important: fried or baked crisps? Deep pan Margherita pizza or a stone baked style? Do not forget to specify the size of pizza, even if only approximately. Fresh, frozen, dried or canned fruit?
- ✓ If you are cooking something don't forget to include seasoning (salt, black pepper, spices, etc.) and oil if used to cook the food in.

• **Important**:
The main rule is to record your food intake in as much detail as possible and to record everything you consumed in as precise amounts as possible. It is better to provide rather more detail than too little.

On the next page is an example of a Food diary records.
Happy recording and if you have any questions, please send an e-mail: 18100097@brookes.ac.uk

Time	Food and Drink	Amount	Brand	Leftovers
3 pm	Tea, decaffeinated Milk (fresh, whole) Jaffa cake – mini	300ml 10ml 6 (50g)	Twinings Tesco's own McVities	/
6.30 pm	Gin Lager Salted peanuts	Single measure 1 pint 1 handful	Gordon's Draught KP	/
8 pm	Spaghetti, wholemeal, cooked Bolognese sauce (see recipe) Courgettes (fried in butter) Tinned peaches in juice (juice drained) Single cream UHT Orange squash No Added Sugar	100gm 6 tablespoons (45g) 4 tablespoons (40g) 3 halves 15gm 1 tablespoon (7g) 200ml glass, 1 part squash, 3 parts tap water	Tesco's own Prince's Sainsbury's own	 / 30ml
9 pm	Grapes, green, seedless Chocolates, chocolate creams Potato crisps, Prawn Cocktail	15 (60g) 29g 25g bag from multipack	 Bendicks Walkers	 5g
1(**Example:**	Camomile tea (no milk or sugar)	300ml	Twinings	/

Post Test Dietary Record

Participant No.: Date: Treatment:

Time	Food and Drink	Amount	Brand	Leftovers

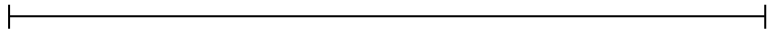
Appendix L: Visual Analogue Scales

Before breakfast meal VAS

How hungry do you feel?

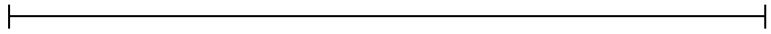
Not at all hungry — Extremely hungry

How full do you feel?



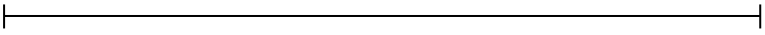
Not at all full — Extremely full

How strong is your desire to eat?



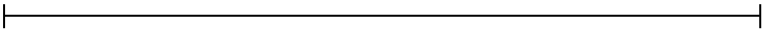
Not at all strong — Extremely strong

How much food do you think you can eat?



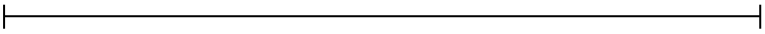
A large amount — Nothing at all

How thirsty do you feel right now?



Not thirsty — Very thirsty

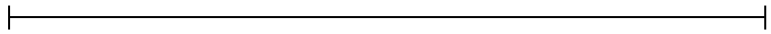
How nauseous do you feel right now?



Not at all nauseous — Extremely nauseous

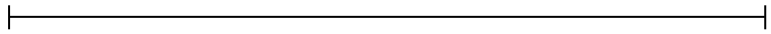
After breakfast meal VAS

How hungry do you feel?



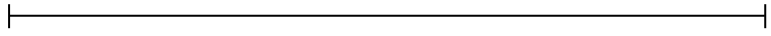
Not at all hungry Extremely hungry

How full do you feel?



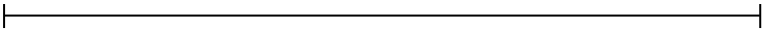
Not at all full Extremely full

How strong is your desire to eat?



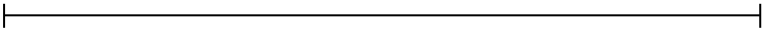
Not at all strong Extremely strong

How much food do you think you can eat?



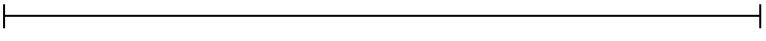
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

How nauseous do you feel right now?



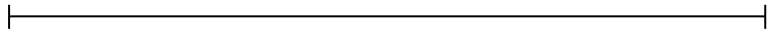
Not at all nauseous Extremely nauseous

30 minutes after starting breakfast VAS

How hungry do you feel?

Not at all hungry Extremely hungry

How full do you feel?

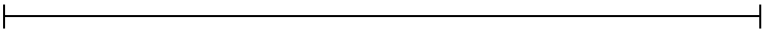


Not at all full Extremely full

How strong is your desire to eat?

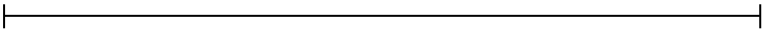
Not at all strong Extremely strong

How much food do you think you can eat?



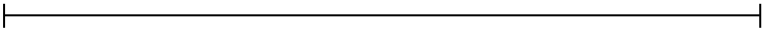
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

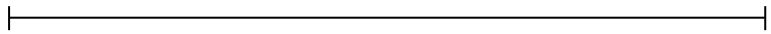
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

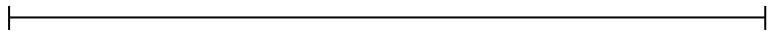
60 minutes after starting breakfast VAS

How hungry do you feel?



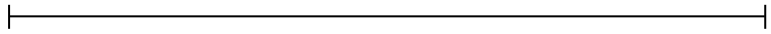
Not at all hungry Extremely hungry

How full do you feel?



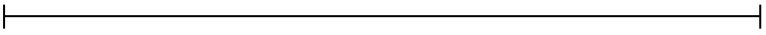
Not at all full Extremely full

How strong is your desire to eat?



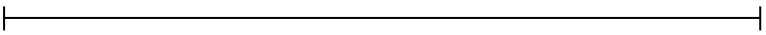
Not at all strong Extremely strong

How much food do you think you can eat?



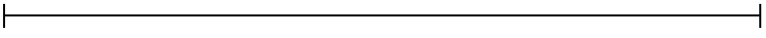
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

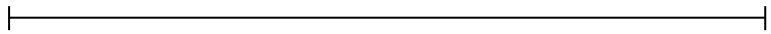
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

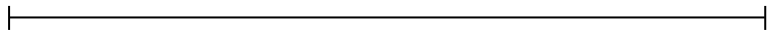
90 minutes after starting breakfast VAS

How hungry do you feel?



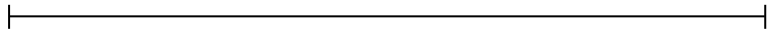
Not at all hungry Extremely hungry

How full do you feel?



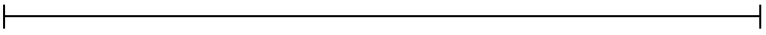
Not at all full Extremely full

How strong is your desire to eat?



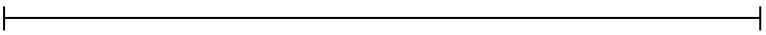
Not at all strong Extremely strong

How much food do you think you can eat?



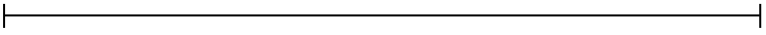
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

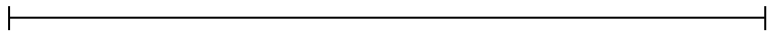
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

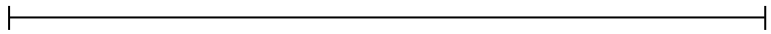
120 minutes after starting breakfast VAS

How hungry do you feel?



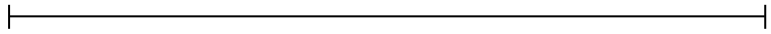
Not at all hungry Extremely hungry

How full do you feel?



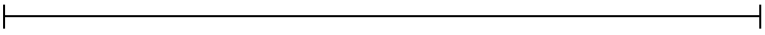
Not at all full Extremely full

How strong is your desire to eat?



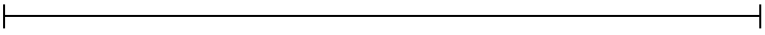
Not at all strong Extremely strong

How much food do you think you can eat?



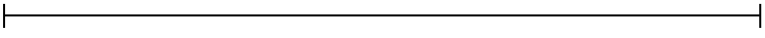
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

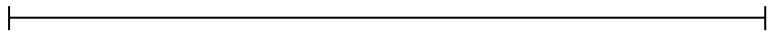
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

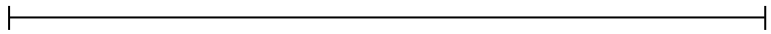
150 minutes after starting breakfast VAS

How hungry do you feel?



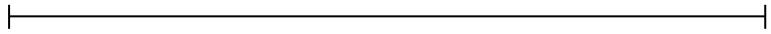
Not at all hungry Extremely hungry

How full do you feel?



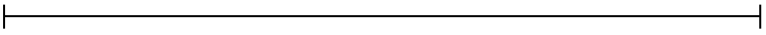
Not at all full Extremely full

How strong is your desire to eat?



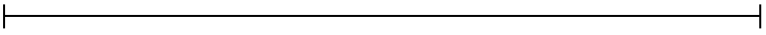
Not at all strong Extremely strong

How much food do you think you can eat?



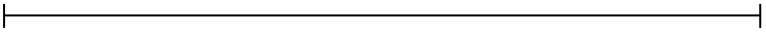
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

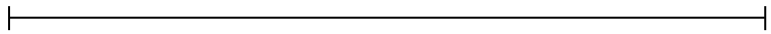
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

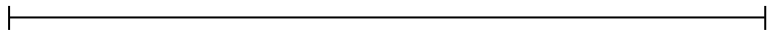
180 minutes after starting breakfast VAS

How hungry do you feel?



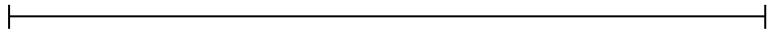
Not at all hungry Extremely hungry

How full do you feel?



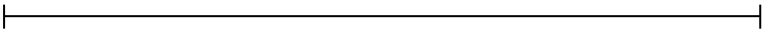
Not at all full Extremely full

How strong is your desire to eat?



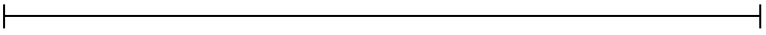
Not at all strong Extremely strong

How much food do you think you can eat?



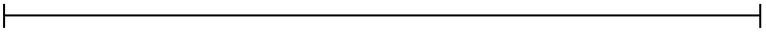
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

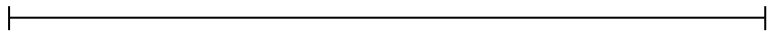
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

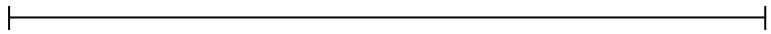
210 minutes after starting breakfast VAS

How hungry do you feel?



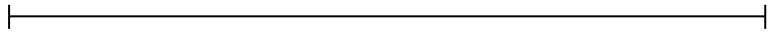
Not at all hungry Extremely hungry

How full do you feel?



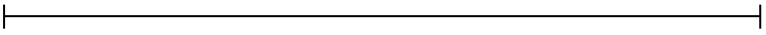
Not at all full Extremely full

How strong is your desire to eat?



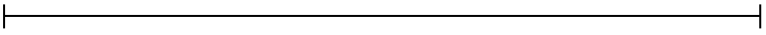
Not at all strong Extremely strong

How much food do you think you can eat?



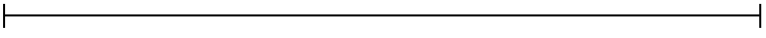
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

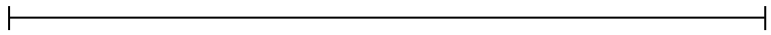
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

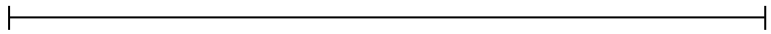
(240mins) Before Lunch VAS

How hungry do you feel?



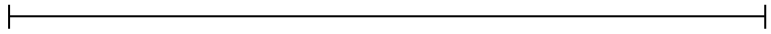
Not at all hungry Extremely hungry

How full do you feel?



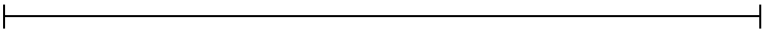
Not at all full Extremely full

How strong is your desire to eat?



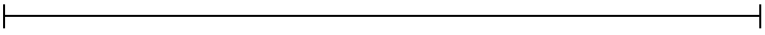
Not at all strong Extremely strong

How much food do you think you can eat?



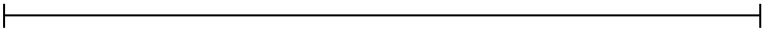
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

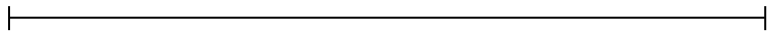
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

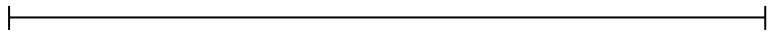
15 minutes after starting lunch VAS

How hungry do you feel?



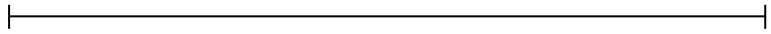
Not at all hungry Extremely hungry

How full do you feel?



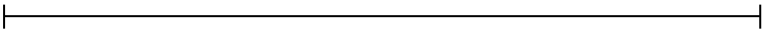
Not at all full Extremely full

How strong is your desire to eat?



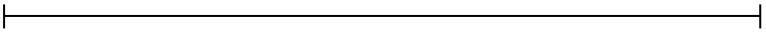
Not at all strong Extremely strong

How much food do you think you can eat?



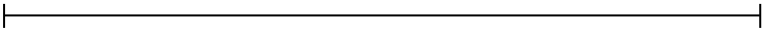
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

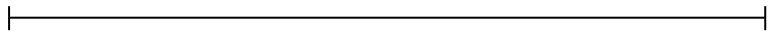
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

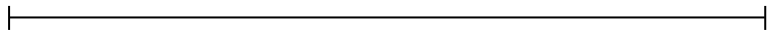
After lunch VAS (Please also record time you finish lunch)

How hungry do you feel?



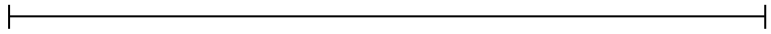
Not at all hungry Extremely hungry

How full do you feel?



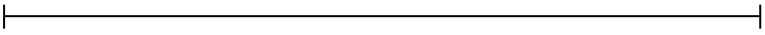
Not at all full Extremely full

How strong is your desire to eat?



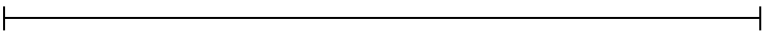
Not at all strong Extremely strong

How much food do you think you can eat?



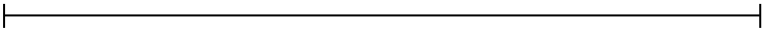
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

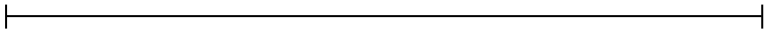
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

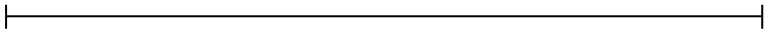
After Lunch Meal VAS (continued)

How pleasant was the product?



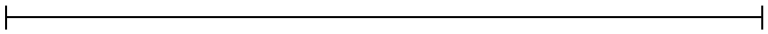
Not at all pleasant Extremely pleasant

How visually attractive was the product?



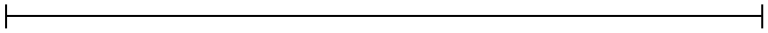
Not very attractive Extremely attractive

How much did the product's smell appeal to you?



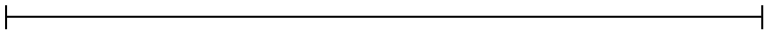
Not very appealing Extremely appealing

How much did the texture appeal to you?



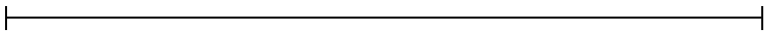
Not very appealing Extremely appealing

How much of an aftertaste did the product leave?



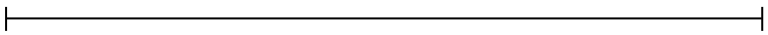
Not very much aftertaste Had an extreme aftertaste

How tasty was the product?



Not very tasty Extremely tasty

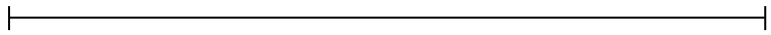
How likely would you be to eat this product again?



Not very likely Extremely likely

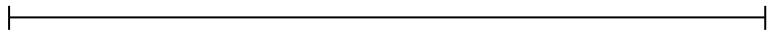
30 minutes after starting lunch VAS

How hungry do you feel?



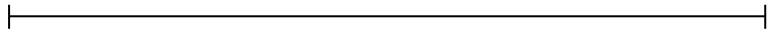
Not at all hungry Extremely hungry

How full do you feel?



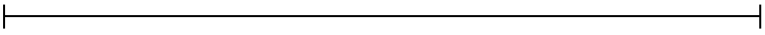
Not at all full Extremely full

How strong is your desire to eat?



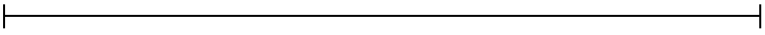
Not at all strong Extremely strong

How much food do you think you can eat?



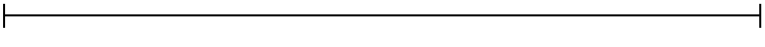
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

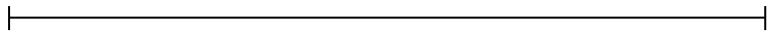
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

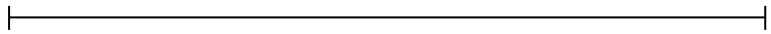
45 minutes after starting lunch VAS

How hungry do you feel?



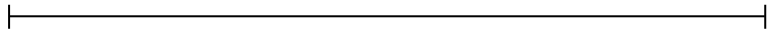
Not at all hungry Extremely hungry

How full do you feel?



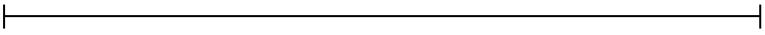
Not at all full Extremely full

How strong is your desire to eat?



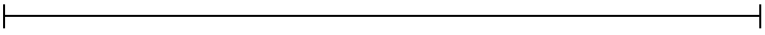
Not at all strong Extremely strong

How much food do you think you can eat?



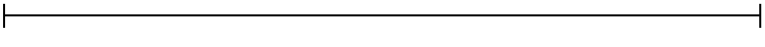
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

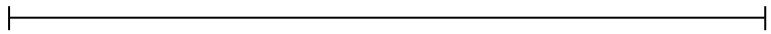
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

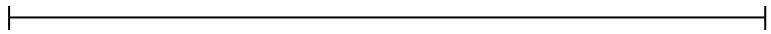
60 minutes after starting lunch VAS

How hungry do you feel?



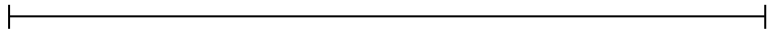
Not at all hungry Extremely hungry

How full do you feel?



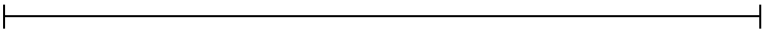
Not at all full Extremely full

How strong is your desire to eat?



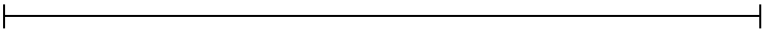
Not at all strong Extremely strong

How much food do you think you can eat?



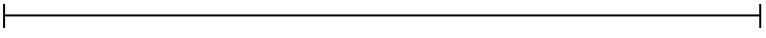
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

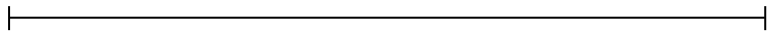
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

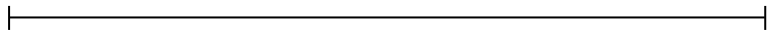
75 minutes after starting lunch VAS

How hungry do you feel?



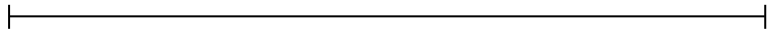
Not at all hungry Extremely hungry

How full do you feel?



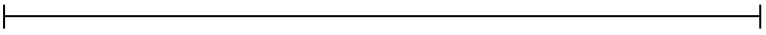
Not at all full Extremely full

How strong is your desire to eat?



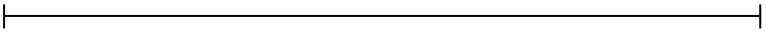
Not at all strong Extremely strong

How much food do you think you can eat?



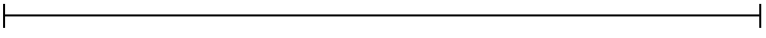
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

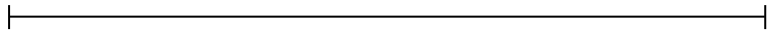
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

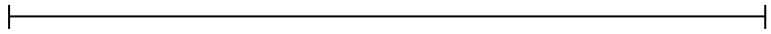
90 minutes after starting lunch VAS

How hungry do you feel?



Not at all hungry Extremely hungry

How full do you feel?

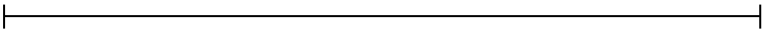


Not at all full Extremely full

How strong is your desire to eat?

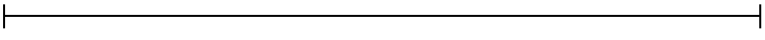
Not at all strong Extremely strong

How much food do you think you can eat?



A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

How nauseous do you feel right now?

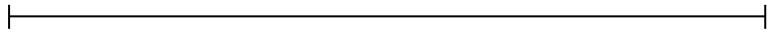
Not at all nauseous Extremely nauseous

105 minutes after starting lunch VAS

How hungry do you feel?

Not at all hungry Extremely hungry

How full do you feel?

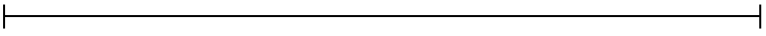


Not at all full Extremely full

How strong is your desire to eat?

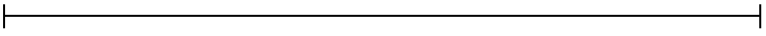
Not at all strong Extremely strong

How much food do you think you can eat?



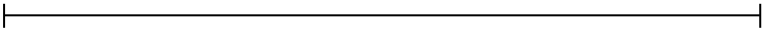
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

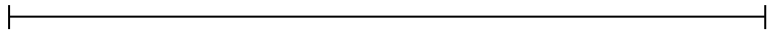
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

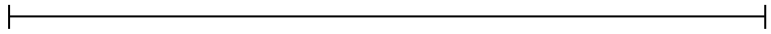
120 minutes after starting lunch VAS

How hungry do you feel?



Not at all hungry Extremely hungry

How full do you feel?

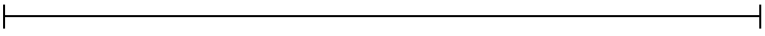


Not at all full Extremely full

How strong is your desire to eat?

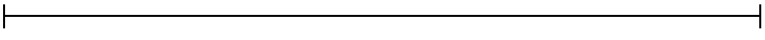
Not at all strong Extremely strong

How much food do you think you can eat?



A large amount Nothing at all

How thirsty do you feel right now?



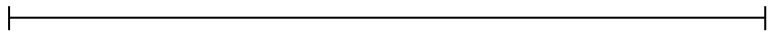
Not thirsty Very thirsty

How nauseous do you feel right now?

Not at all nauseous Extremely nauseous

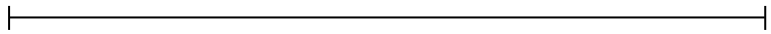
135 minutes after starting lunch VAS

How hungry do you feel?



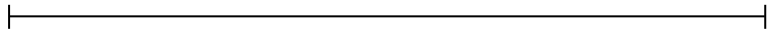
Not at all hungry Extremely hungry

How full do you feel?



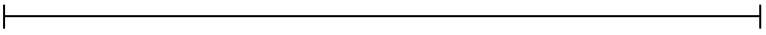
Not at all full Extremely full

How strong is your desire to eat?



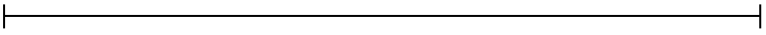
Not at all strong Extremely strong

How much food do you think you can eat?



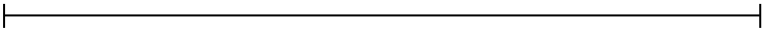
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

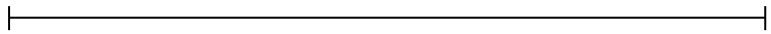
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

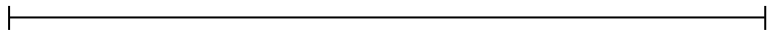
150 minutes after starting lunch VAS

How hungry do you feel?



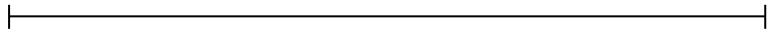
Not at all hungry Extremely hungry

How full do you feel?



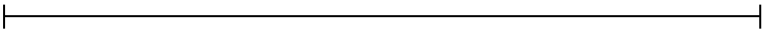
Not at all full Extremely full

How strong is your desire to eat?



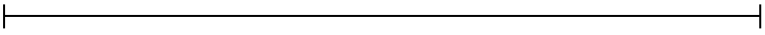
Not at all strong Extremely strong

How much food do you think you can eat?



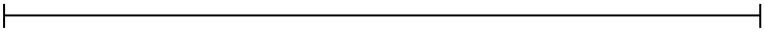
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

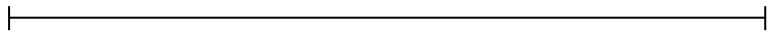
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

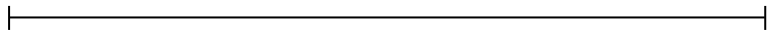
165 minutes after starting lunch VAS

How hungry do you feel?



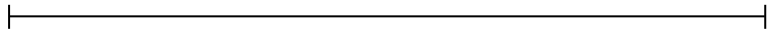
Not at all hungry Extremely hungry

How full do you feel?



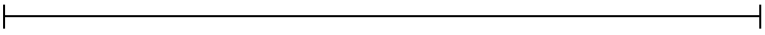
Not at all full Extremely full

How strong is your desire to eat?



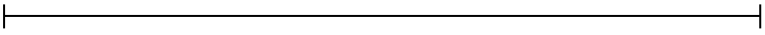
Not at all strong Extremely strong

How much food do you think you can eat?



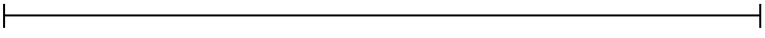
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

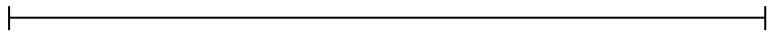
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

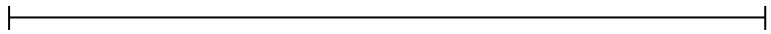
180 minutes after starting lunch VAS

How hungry do you feel?



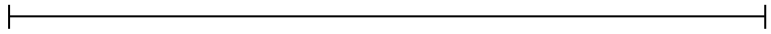
Not at all hungry Extremely hungry

How full do you feel?



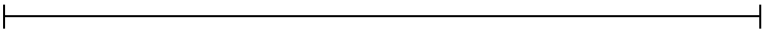
Not at all full Extremely full

How strong is your desire to eat?



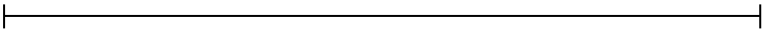
Not at all strong Extremely strong

How much food do you think you can eat?



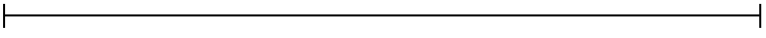
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

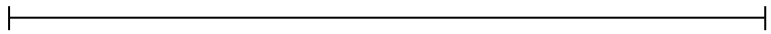
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

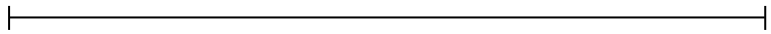
195 minutes after starting lunch VAS

How hungry do you feel?



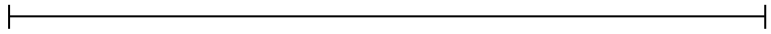
Not at all hungry Extremely hungry

How full do you feel?



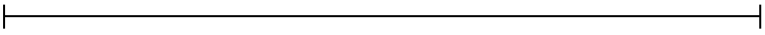
Not at all full Extremely full

How strong is your desire to eat?



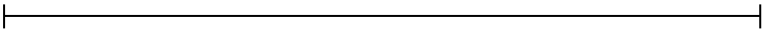
Not at all strong Extremely strong

How much food do you think you can eat?



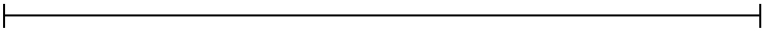
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

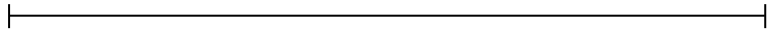
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

210 minutes after starting lunch VAS

How hungry do you feel?



Not at all hungry Extremely hungry

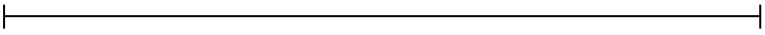
How full do you feel?

Not at all full Extremely full

How strong is your desire to eat?

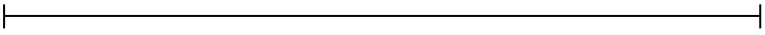
Not at all strong Extremely strong

How much food do you think you can eat?



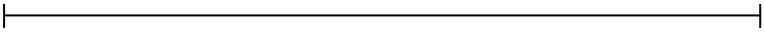
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

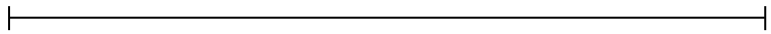
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

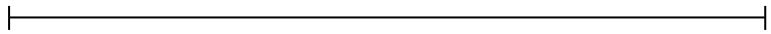
225 minutes after starting lunch VAS

How hungry do you feel?



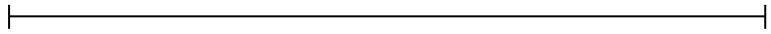
Not at all hungry Extremely hungry

How full do you feel?



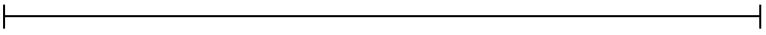
Not at all full Extremely full

How strong is your desire to eat?



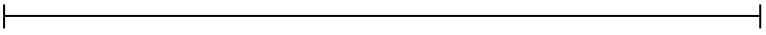
Not at all strong Extremely strong

How much food do you think you can eat?



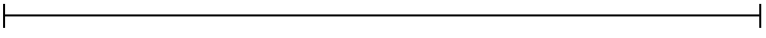
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

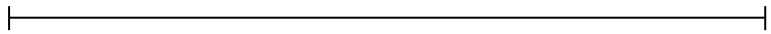
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

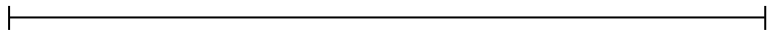
(240mins) Before Buffet Tea VAS

How hungry do you feel?



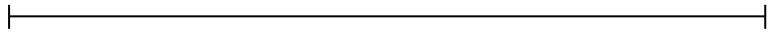
Not at all hungry Extremely hungry

How full do you feel?



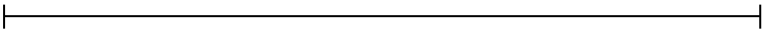
Not at all full Extremely full

How strong is your desire to eat?



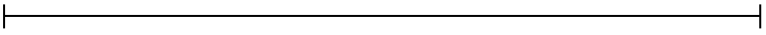
Not at all strong Extremely strong

How much food do you think you can eat?



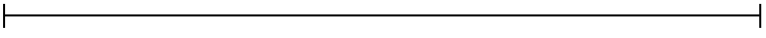
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

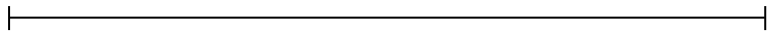
How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

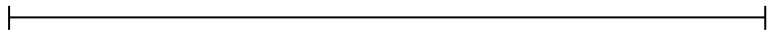
After Buffet Tea VAS

How hungry do you feel?



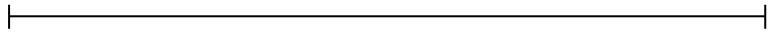
Not at all hungry Extremely hungry

How full do you feel?



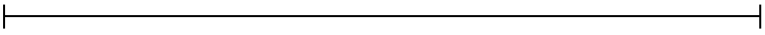
Not at all full Extremely full

How strong is your desire to eat?



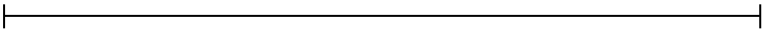
Not at all strong Extremely strong

How much food do you think you can eat?



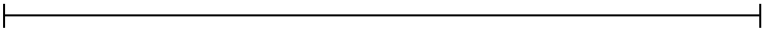
A large amount Nothing at all

How thirsty do you feel right now?



Not thirsty Very thirsty

How nauseous do you feel right now?



Not at all nauseous Extremely nauseous

Thank you for completing the Visual Analogue Scales.

Please return this booklet to the researcher.

We hope you enjoyed your day with us.

Appendix M: Area Under Curve Values

Study One

Hunger

	Test Mean	Test SD	Control Mean	Control SD
B-L	7611	4641	7279	4245
L-T	6586	4920	6715	4982
Whole Day	14197	8965	13994	8833

Fullness

	Test Mean	Test SD	Control Mean	Control SD
B-L	15698	5652	15865	5517
L-T	15773	5220	15334	5020
Whole Day	31470	9862	31199	10211

Desire to Eat

	Test Mean	Test SD	Control Mean	Control SD
B-L	4357	2423	4388	2326
L-T	7142	4916	7370	4791
Whole Day	15204	8599	15543	8532

Prospective Consumption

	Test Mean	Test SD	Control Mean	Control SD
B-L	9191	5658	9203	4903
L-T	7316	4877	7404	4380
Whole Day	16507	10005	16607	8574

Thirst

	Test Mean	Test SD	Control Mean	Control SD
B-L	8101	4889	7380	5177
L-T	7360	4638	6011	5328
Whole Day	15461	8736	13391	10184

Nausea

	Test Mean	Test SD	Control Mean	Control SD
B-L	1051	2380	1313	2610
L-T	726	1752	905	2222
Whole Day	1776	4028	2218	4701

Study Two

Hunger

	Test Mean	Test SD	Control Mean	Control SD
B-L	7188	2488	8281	3526
L-T	7725	5042	5486	5432
Whole Day	14912	6300	13767	8099

Fullness

	Test Mean	Test SD	Control Mean	Control SD
B-L	15231	6133	14289	6136
L-T	15082	5751	16993	6316
Whole Day	30313	11653	31282	11961

Desire to Eat

	Test Mean	Test SD	Control Mean	Control SD
B-L	7932	2926	8594	3898
L-T	7607	5040	5566	5337
Whole Day	15539	6806	14160	7966

Prospective Consumption

	Test Mean	Test SD	Control Mean	Control SD
B-L	8094	2627	8936	2925
L-T	7884	4548	6160	4966
Whole Day	15978	6190	15095	7069

Thirst

	Test Mean	Test SD	Control Mean	Control SD
B-L	7179	4741	7343	4653
L-T	7116	5598	7113	5439
Whole Day	14295	9101	14456	9716

Nausea

	Test Mean	Test SD	Control Mean	Control SD
B-L	768	1282	869	1390
L-T	1434	3287	1816	4499
Whole Day	2202	4067	2713	5723