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Original Article

Appetite perceptions and total peptide YY concentrations following 10 days consumption of vegetarian diets

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Abstract

The effects of ten days consumption of vegetarian diet on total peptide YY (PYY) and appetite perceptions were investigated in fifteen males. The experiment was a randomized cross-over design with two main trials including normal and vegetarian diets. Total PYY, glucose, and lipid profiles were assessed on day one and day eleven. Additionally, appetite perceptions were measured. The data were analyzed using two way repeated measures ANOVA and paired t-tests. There were no changes in fasting total PYY, glucose, high density lipoprotein, or subjective feelings of fullness following consumption of a vegetarian diet. However, cholesterol, and low density lipoprotein decreased significantly while the areas under the curve of subjective feelings of hunger in the vegetarian diet was higher than in the control trials. It is concluded that the consumption of a vegetarian diet induces increased subjective feelings of hunger but with no impact on total PYY or subjective feelings of fullness.

Keywords: total PYY, vegetarian diets, short term diet, hunger, fullness

1. Introduction

A vegetarian diet includes non-meat, vegetables, and soy products (Craig & Mangels, 2009). Consumption of a vegetarian diet results in decreased high-sensitivity C-reactive protein, insulin, oxidative stress, white blood cell, cholesterol, body weight, body mass index, disordered eating, and risk of cardiovascular diseases (Chen *et al.*, 2008; Kim, Cho, & Park, 2012; Mattes, Hollis, Hayes, & Stunkard, 2005; Pongstaporn & Bunyaratavej, 1999; Shridhar *et al.*, 2014; Timko, Hormes, & Chubski, 2012). In addition, vegetarians are leaner and have a higher resting metabolic rate than non-vegetarians (Janelle & Barr, 1995; Montalcini *et al.*, 2015). It has been demonstrated that there is a relationship between fat free mass and meal size as well as daily energy intake (Blundell *et al.*, 2012).

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Energy intake is associated with hunger and satiety (Mattes *et al.*, 2005). Hunger is influenced by several hormones such as neuropeptide Y, orexin A, and ghrelin (Huda, Wilding, & Pinkney, 2006). On the other hand, satiety or fullness is influenced by many hormones including leptin, pancreatic polypeptide, cholecystokinin, glucagon like peptide, and peptide YY (Huda *et al.*, 2006). Several potential mechanisms have been suggested to explain the association between appetite hormones and energy intake (Huda *et al.*, 2006). For example, intravenous ghrelin infusion leads to increased energy intake of approximately 30% and increased subjective feelings of hunger (Wren *et al.*, 2001). Circulating leptin concentrations were related to consumption of dietary fiber (Nakamura *et al.*, 2012). A previous study showed that concentrations of a satiety hormone like leptin were higher in non-vegetarians than in vegetarians (Ambroszkiewicz *et al.*, 2011). For this reason, it is possible that a short-term consumption of vegetarian diet might impact on other appetite hormones and it might be associated with appetite perceptions.

Peptide YY (PYY) is one of the satiety hormones (Huda *et al.*, 2006). PYY is released mainly from the ileum, colon, and rectum (Wynne, Stanley, McGowan, & Bloom, 2005). There is evidence that the level of PYY increase following a meal and remains elevated for up to six hours (Stanley, Wynne, McGowan, & Bloom, 2005). Administration of PYY results in suppressed energy intake (Batterham *et al.*, 2003). Circulating total PYY concentrations were increased after short term overfeeding and after consuming high proteins (Cahill, Shea, Randell, Vasdev, & Sun, 2011; Diepvens, Haberer, & Westerterp-Plantenga, 2008; Leidy, Armstrong, Tang, Mattes, & Campbell, 2010). It appears that the circulating total PYY concentration is responsive to food composition and related to appetite.

Interestingly, postprandial total PYY concentrations following consumption of a high protein vegetarian diet for two weeks were greater than those following a high protein meat diet in obese men (Neacsu, Fyfe, Horgan, & Johnstone, 2014). One study showed there was a difference in postprandial total PYY concentrations after consuming vegan meals in type 2 diabetes and healthy population (Belinova *et al.*, 2014). As a consequence of this, short-term consumption of a vegetarian diets might alter circulating fasting total PYY concentrations. It would be of interest to explore whether short-term consumption of a vegetarian diets has an effect on appetite perceptions in healthy men. A better understanding of how vegetarian diet affects appetite will be a powerful tool in developing more successful strategies for weight management. The ten days vegetarian diet festival is popular in Thailand. Therefore, the objective of this research was to investigate the effect of ten days consumption of a vegetarian diet on fasting total PYY concentrations and appetite perceptions in healthy men.

2. Materials and Methods

2.1 Participants

Fifteen healthy men between 19 and 21 years of age participated in this study, which was approved by the Research Ethics Committee of Srinakharinwirot University, Thailand. In order to assess eligibility, participants completed a health history questionnaire and a Physical Activity Readiness Questionnaire (PAR-Q). All participants were non-vegetarians, non-smokers, their body weight had not changed more than five kg in the last six months, and they were not taking any regular or prescribed medications. Participant characteristics are shown in Table 1.

2.2 Preliminary tests

Height (Wildcat Mettler Toledo, United States), body weight (Tanita, Japan), resting heart rate (Omron, Japan), blood pressure (Omron, Japan), body fat (Maltron, United Kingdom), and maximal oxygen consumption were measured seven days before the main trial. Maximal oxygen consumption was determined by using an incremental running test (h/p/ Cosmos Merry, Germany) where the gradient was increased by 2.5% every three minutes from an initial 3.5% until fatigue. Expired gas samples (COSMED; Quark PFT Ergo, Italy), heart rate (Polar, Finland), and rating of perceived exertion (Borg, 1982) were collected in each stage.

2.3 Research design

This experiment was a randomized cross-over design with two main trials including control and vegetarian diet trials. Each trial was separated by at least 14 days which is longer than recommended by previous study (Neacsu *et al.*, 2014). Participants were asked to eat either a normal or vegetarian diet over the following ten days. Participants also asked to record their food intake. According to food recorded, energy intake in both trials were equivalent. The composition of diet in control and vegetarian diet included 50% carbohydrate, 25% fat, and 25% protein. Fasting total PYY, glucose, lipid profiles, body weight, and body fat (Maltron, United Kingdom) were measured on day one and day eleven in both trials. In addition, the rate of perceived exertion (Borg, 1982) and appetite perceptions (Flint, Raben, Blundell, & Astrup, 2000) were measured over a period of time. Participants were asked to control their daily energy expenditure, energy intake, and not consume either alcohol or caffeine before sampling in both trials.

2.4 Blood sampling

Fasting blood samples (10 ml) were taken from an antecubital vein on day one and day eleven in both trials. Venous blood samples were collected into serum clot activator vacuette tubes (Greiner bio-one, Austria), anti-coagulant ethylenediaminetetra acetate (EDTA) vacuette tubes (Greiner bio-one, Austria), and sodium fluoride vacuette tubes (with

Table 1. Participant characteristics. Values are means ±SE (n=15). Total percent body fat and percent fat free mass were assessed by using BioScan (Maltron, United Kingdom).

	Mean ±SE
Age (years)	20 ± 0
Body mass (kg)	68 ± 2
Height (cm)	173 ± 1
Body mass index (kg/m^2)	23 ± 0
Waist (cm)	75 ± 1
Hip (cm)	94 ± 1
Waist/Hip ratio	0.8 ± 0
Total percent body fat (%)	12 ± 1
Total percent fat free mass (%)	88 ± 1
Blood pressure: systolic / diastolic (mmHg)	122 ± 2 / 68 ± 2
Resting heart rate (beats /min)	62 ± 3
Maximum oxygen consumption (ml/kg/min)	58 ± 2

EDTA K3, Greiner bio-one, Austria). The vacuette tubes were spun at 5,000 rpm at 5°C for ten minutes (NF400R, Austria). Serum and plasma were removed and the sample were stored at -20°C for analysis.

2.5 Blood biochemistry

Plasma total PYY concentrations were measured using Enzyme-linked immunosorbent assay (Millipore, United States). Serum cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), and glucose concentrations were measured using the enzymatic colorimetric method (Cobas 6000 analyzer series, Switzerland).

2.6 Appetite perceptions

Appetite perceptions were assessed at 7.00 a.m. from day one until day eleven in both trials. Appetite perceptions were assessed using 100 mm visual analogue scales (Flint *et al.*, 2000) which compose of two questionnaires including subjective feelings of hunger (not hungry at all to as hungry as I ever have) and subjective feelings of fullness (not full at all to very full). Participants indicated their appetite perceptions by marking on the line. Visual analogue scales scores were determined by the distance from the beginning of the line.

2.7 Statistical analysis

All data were analyzed using statistical software (SPSS 14.0, United States). Two-way repeated measures ANOVA and paired *t*-tests were used to analyze differences for total PYY, glucose, lipid profiles, body weight, body fat, and appetite perceptions between two trials. Areas under the curve for subjective feelings of hunger were calculated from day one until day eleven using the trapezoid rule as previously described (Neacsu *et al.*, 2014). Paired *t*-tests were used to evaluate the difference between control and vegetarian trials. Statistical significance was accepted at the 5% level ($p<0.05$). Data are presented as means ±SE.

3. Results

3.1 Total PYY concentrations

Circulating fasting total PYY concentrations were not significantly different between trials at the baseline (Figure 1). No significant effect of vegetarian diets on fasting plasma total PYY concentrations were observed.

3.2 Lipid profiles and glucose concentrations

There were no significant differences in cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), or glucose concentrations at the baseline. Two-way ANOVA revealed a trial and time interaction ($p<0.01$) for

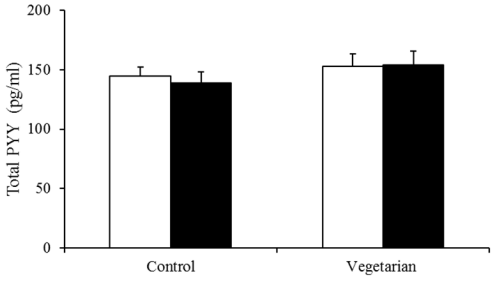

Figure 1. Total PYY concentrations either before (□) or after (■) in control and vegetarian trials. Values are means ± SE (n=15).

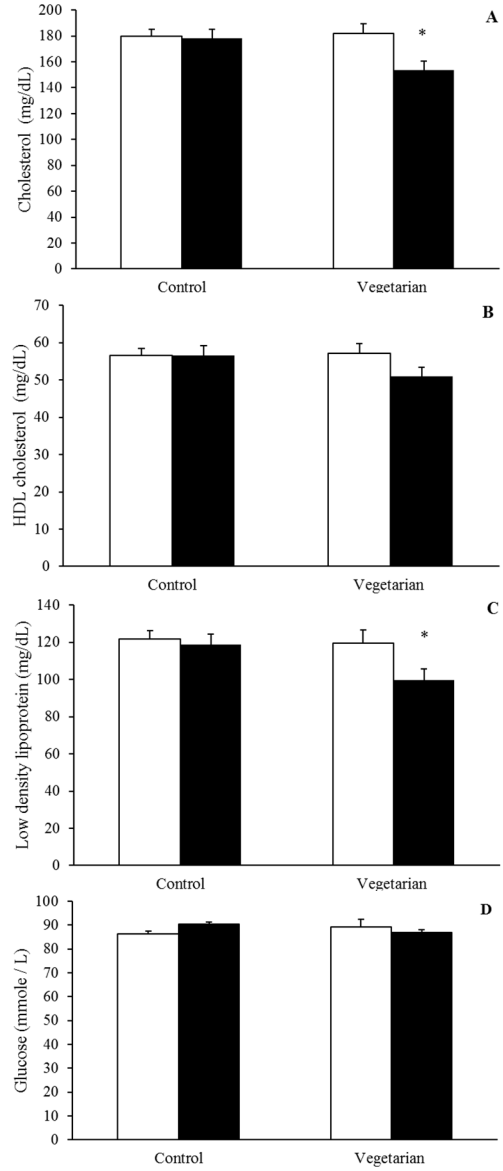

Figure 2. Cholesterol (A), HDL cholesterol (B), low density lipoprotein (C), and glucose (D) concentrations either before (□) or after (■) in control and vegetarian trials. Values are means ± SE (n=15). *Significantly different between control and vegetarian trials ($p<0.05$).

serum cholesterol and low density lipoprotein concentrations between trials. *Post hoc* analysis indicated that consumption of a vegetarian diet caused a decrease in fasting cholesterol (p=0.04) and low density lipoprotein (p=0.02). However, there was no change in circulating high density lipoprotein or in glucose concentrations following consumption of a vegetarian diets.

3.3 Appetite perceptions and rate of perceived exertion

Subjective feelings of hunger, fullness, and rate of perceived exertion did not differ at baseline. There were no changes in rate of perceived exertion or subjective feelings of fullness following consumption of a vegetarian diet for ten days. Two-way ANOVA revealed there was a trial effect for subjective feelings of hunger (p=0.01) but there was no trial and time interaction (p=0.07). Conversely, there was a significant increase in the area under the curve of subjective feelings of hunger following the vegetarian diet (vegetarian, 519; control, 389, p=0.01).

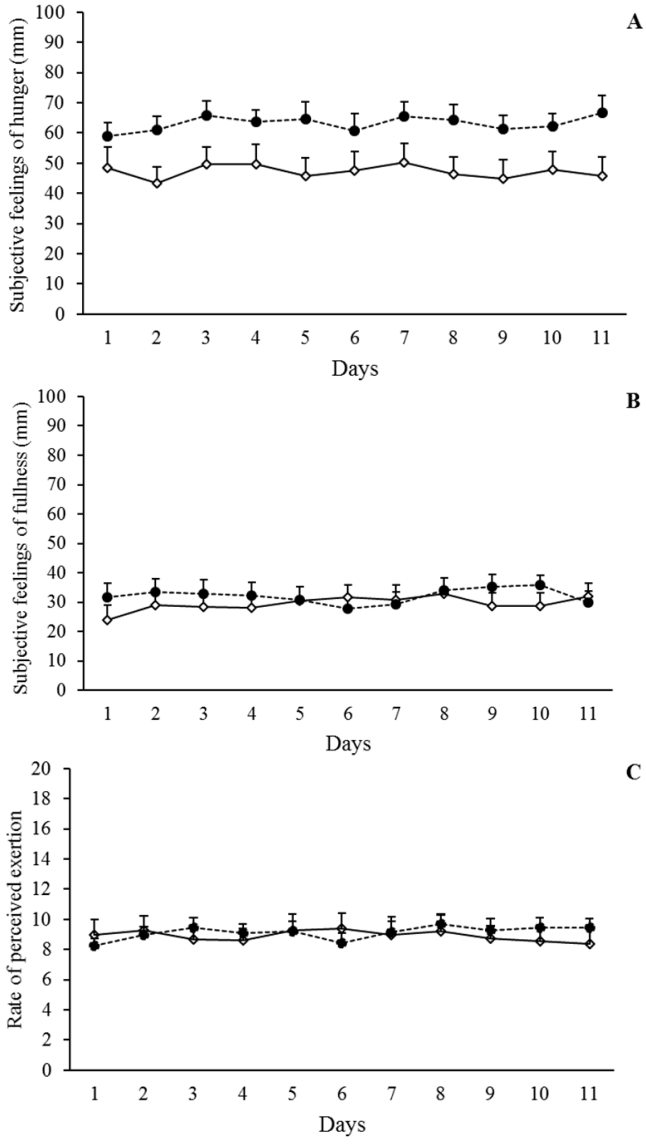

Figure 3. Subjective feelings of hunger (A), subjective feelings of fullness (B), and rate of perceived exertion (C) in control (◇) and vegetarian diet (●) trials. Values are means ± SE (n=15).

3.4 Body weight and body fat

Body weight and body fat did not differ significantly between trials at the baseline. There was no statistical difference in body weight between control and vegetarian trials, although body weight following the vegetarian diet (68.36±1.62 kg) tended to be lower than before a vegetarian diet (67.63±1.54 kg). Two-way repeated measures ANOVA did not reveal any trial effects for body weight (two-way ANOVA: trial X time interaction, p=0.05; trial, 0.64; time, p<0.04). In addition, body fat following a vegetarian trial tended to be lower than the control trial (two-way ANOVA: trial X time interaction, p=0.07; time, p<0.05; vegetarian, 7.89±0.76 kg; control, 8.86±1.08 kg).

4. Discussion

The purpose of this study was to investigate the effects of ten days consumption of a vegetarian diet on fasting total PYY concentrations and appetite perceptions in healthy men. This study demonstrated that short-term consumption of a vegetarian diet results in decreased circulating fasting cholesterol and LDL concentrations. Additionally, the area under the curve for subjective feelings of hunger was increased during a vegetarian diet. However, there were no changes in fasting total PYY concentrations or subjective feelings of fullness.

In the present study, there was no changes in fasting total PYY concentrations following consumption of a vegetarian diet. To our knowledge, there has not been a study to investigate the impact of short-term consumption of a vegetarian diet on fasting total PYY concentrations in healthy men. The vegetarian diets of this study comprised rice, noodles, vegetables, and soy products. It has been reported that fasting total PYY concentrations after consumption of a vegetarian high protein diet for two weeks were higher than those after a meat high protein diet in obese men (Neacsu *et al.*, 2014). One study showed fasting total PYY concentrations were elevated after consumption of soy isoflavones supplement for eight weeks in healthy postmenopausal women (Weickert *et al.*, 2006). The effect of a vegetarian diet on fasting total PYY concentrations might correlate with the composition of the vegetarian food and participant characteristics. It appears that long-term consumption of a vegetarian diet shows a higher response than short-term consumption. Therefore, the impact of a vegetarian diet on satiety hormones is still unclear and needs to be investigated further.

PYY is one of the satiety hormones which is released after food consumption. A previous study demonstrated that postprandial total PYY concentrations after consuming a vegetarian high protein diet for two weeks were greater than those after a meat high protein diet in obese men (Neacsu *et al.*, 2014). Postprandial total PYY concentrations after consuming vegan meals were higher than those after meat meals in type 2 diabetes (Belinova *et al.*, 2014). However, it has been reported that there were no differences in postprandial total PYY concentrations following consumption of soy protein and beef in healthy adults (Douglas, Lasley, & Leidy, 2015). One study showed that postprandial total PYY concentrations following ingestion of vegan meals were lower than those after meat meals in healthy males and females (Belinova *et al.*, 2014). It appears that a single meal and a short-term consumption of vegetarian diet induced a change in postprandial total PYY concentrations. One of the limitations of this study is that postprandial total PYY concentrations were not examined. Therefore, it would be interesting to observe the response to the meal of total PYY concentrations following a short-term consumption of a vegetarian diet in healthy men.

There were no differences in subjective feelings of fullness between the two trials in the present study. This result is consistent with the recent finding that there was no difference in fullness scores between vegetarian and meat-based diets for two weeks in obese men (Neacsu *et al.*, 2014). Several studies have investigated the impact of a single meal on subjective feelings of fullness. A previous study reported that fullness scores were elevated following consumption of dietary fibers (Freeland, Anderson, & Wolever, 2009). On the other hand, there was no effect of soy protein on subjective feelings of fullness (Williamson *et al.*, 2006). The finding that there was no impact of ten days consumption of a vegetarian diet on subjective feelings of fullness in the present study may be explained by the failure to observe any change in fasting total PYY and glucose concentrations.

Interestingly, the area under the curve of subjective feelings of hunger in the vegetarian trial was higher than those in the control trial. One possible explanation is that, as the participants in this study were non-vegetarians and were not familiar with vegetarian diet, they might feel hunger after consumption of a vegetarian diet. Previous study showed there was no effect of soy protein on subjective feelings of hunger (Williamson *et al.*, 2006). In contrast, one study reported subjective feelings of hunger were suppressed after consuming soy proteins (Leidy *et al.*, 2015). It should be noted that mixed meals of vegetarian diets were given in the present study, and therefore it might not have a similar effect to the previous studies. It has been demonstrated that there was no difference in hunger scores between vegetarian and meat-based diets for 14 days in obese men (Neacsu *et al.*, 2014). One possibility is that the response to a vegetarian diet might correlate with the characteristics of participants. It appears that the healthy men in this study showed a higher response to subjective feelings of hunger more than the obese men.

Circulating glucose concentrations might be associated with subjective feelings of hunger and hunger hormones. Although there was no trial effect of glucose concentrations in the present study, circulating glucose concentrations tended to be lower in the vegetarian diet trial. Glucose concentrations in vegetarians were lower than those in non-vegetarians (Mattes *et al.*, 2005). It would be interesting to assess the changes in glucose concentrations during consumption of vegetarian diet. Additionally, postprandial ghrelin concentrations following consumption of vegetarian diet were greater than those following a meat diet (Belinova *et al.*, 2014). It is possible that the increasing subjective feelings of hunger might be correlated with glucose and hunger hormones such as ghrelin. One of the limitations in the present study was that the hunger hormones were not measured, therefore, the relationship between the areas under the curve of subjective feelings of hunger and hunger hormones remain unclear and need to be investigated further.

Consumption of a vegetarian diet resulted in reduced circulating fasting cholesterol and low density lipoprotein concentrations in the current study. This is consistent with previous studies showing that cholesterol and low density lipoprotein were decreased following consumption of vegetarian diets (Chen *et al.*, 2008; Jian *et al.*, 2015; Kim *et al.*, 2012; Neacsu *et al.*, 2014; Shridhar *et al.*, 2014). It appears that short-term consumption of a vegetarian diet induced decreases in fasting cholesterol and low density lipoprotein concentrations. Body fat and body weight also tended to decrease in the present study. Although the area under the curve of subjective feelings of hunger was increased, the body weight tended to decrease. One possible explanation is that the energy intake in both trials were equivalent. It has been demonstrated that ethical and health consideration as well as weight control were the top three reasons for those who choose to be vegetarians (Timko *et al.*, 2012). Our findings suggest that this short term vegetarian diet induced health benefits by decreases in body fat, body weight, and blood lipid profiles related to heart disease.

5. Conclusions

In summary, consumption of the vegetarian diet resulted in decreased fasting cholesterol, low density lipoprotein, and increased subjective feelings of hunger. However, there were no alterations in fasting total PYY concentrations or subjective feelings of fullness following ten days consumption of a vegetarian diet in healthy men. The results of the present study indicate that absence of any change in total PYY concentrations might be associated with absence of changes in subjective feelings of fullness and glucose concentrations. The effect of long-term consumption of vegetarian diet on fasting and postprandial appetite hormones need to be investigated further.

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References

Ambroszkiewicz, J., Klemarczyk, W., Gajewska, J., Chelchowska, M., Rowicka, G., Oltarzewski, M., & Laskowska-Klita, T. (2011). Serum concentration of adipocytokines in prepubertal vegetarian and omnivorous children. *Developmental Period Medicine, 15*(3), 326-334.

Batterham, R. L., Cohen, M. A., Ellis, S. M., Le Roux, C. W., Withers, D. J., Frost, G. S., . . . Bloom, S. R. (2003). Inhibition of food intake in obese subjects by peptide YY3-36. *The New England Journal of Medicine, 349* (10), 941-948.

Belinova, L., Kahleova, H., Malinska, H., Topolcan, O., Vrzalova, J., Oliyarnyk, O., . . . Pelikanova, T. (2014). Differential acute postprandial effects of processed meat and isocaloric vegan meals on the gastrointestinal hormone response in subjects suffering from type 2 diabetes and healthy controls: A randomized crossover study. *PLoS One, 9*(9), e107561.

Blundell, J. E., Caudwell, P., Gibbons, C., Hopkins, M., Naslund, E., King, N. A., & Finlayson, G. (2012). Body composition and appetite: Fat-free mass (but not fat mass or BMI) is positively associated with self-determined meal size and daily energy intake in humans. *British Journal of Nutrition, 107*(3), 445-449.

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise, 14*(5), 377-381.

Cahill, F., Shea, J. L., Randell, E., Vasdev, S., & Sun, G. (2011). Serum peptide YY in response to short-term over feeding in young men. *The American Journal of Clinical Nutrition, 93*(4), 741-747.

Chen, C. W., Lin, Y. L., Lin, T. K., Lin, C. T., Chen, B. C., & Lin, C. L. (2008). Total cardiovascular risk profile of Taiwanese vegetarians. *European Journal of Clinical Nutrition, 62*(1), 138-144.

Craig, W. J., & Mangels, A. R. (2009). Position of the American Dietetic Association: Vegetarian diets. *Journal of the American Dietetic Association, 109*(7), 1266-1282.

Diepvens, K., Haberer, D., & Westerterp-Plantenga, M. (2008). Different proteins and biopeptides differently affect satiety and anorexigenic/orexigenic hormones in healthy humans. *International Journal of Obesity, 32*(3), 510-518.

Douglas, S. M., Lasley, T. R., & Leidy, H. J. (2015). Consuming beef vs. soy protein has little effect on appetite, satiety, and food intake in healthy adults. *Journal of Nutrition, 145*(5), 1010-1016.

Flint, A., Raben, A., Blundell, J. E., & Astrup, A. (2000). Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. *International Journal of Obesity and Related Metabolic Disorders, 24*(1), 38-48.

Freeland, K. R., Anderson, G. H., & Wolever, T. M. (2009). Acute effects of dietary fibre and glycaemic carbohydrate on appetite and food intake in healthy males. *Appetite, 52*(1), 58-64.

Huda, M. S., Wilding, J. P., & Pinkney, J. H. (2006). Gut peptides and the regulation of appetite. *Obesity Reviews, 7*(2), 163-182.

Janelle, K. C., & Barr, S. I. (1995). Nutrient intakes and eating behavior scores of vegetarian and nonvegetarian women. *Journal of the American Dietetic Association, 95*(2), 180-186.

Jian, Z. H., Chiang, Y. C., Lung, C. C., Ho, C. C., Ko, P. C., Nfor, O. N., . . . Liaw, Y. P. (2015). Vegetarian diet and cholesterol and TAG levels by gender. *Public Health Nutrition, 18*(4), 721-726.

Kim, M. K., Cho, S. W., & Park, Y. K. (2012). Long-term vegetarians have low oxidative stress, body fat, and cholesterol levels. *Nutrition Research and Practice, 6*(2), 155-161.

Leidy, H. J., Armstrong, C. L., Tang, M., Mattes, R. D., & Campbell, W. W. (2010). The influence of higher protein intake and greater eating frequency on appetite control in overweight and obese men. *Obesity (Silver Spring), 18*(9), 1725-1732.

Leidy, H. J., Todd, C. B., Zino, A. Z., Immel, J. E., Mukherjea, R., Shafer, R. S., . . . Braun, M. (2015). Consuming high-protein soy snacks affects appetite control, satiety, and diet quality in young people and influences select aspects of mood and cognition. *Journal of Nutrition, 145*(7), 1614-1622.

Mattes, R. D., Hollis, J., Hayes, D., & Stunkard, A. J. (2005). Appetite: Measurement and manipulation misgivings. *Journal of the American Dietetic Association, 105* (5), S87-S97.

Montalcini, T., De Bonis, D., Ferro, Y., Care, I., Mazza, E., Accattato, F., . . . Pujia, A. (2015). High vegetable fats intake is associated with high resting energy expenditure in vegetarians. *Nutrients, 7*(7), 5933-5947.

Nakamura, Y., Ueshima, H., Okuda, N., Miura, K., Kita, Y., Okamura, T., . . . Stamler, J. (2012). Relation of dietary and lifestyle traits to difference in serum leptin of Japanese in Japan and Hawaii: the INTERLIPID study. *Nutrition, Metabolism, and Cardiovascular Diseases, 22*(1), 14-22.

Neacsu, M., Fyfe, C., Horgan, G., & Johnstone, A. M. (2014). Appetite control and biomarkers of satiety with vegetarian (soy) and meat-based high-protein diets for weight loss in obese men: A randomized crossover trial. *The American Journal of Clinical Nutrition, 100*(2), 548-558.

Pongstaporn, W., & Bunyaratavej, A. (1999). Hematological parameters, ferritin and vitamin B12 in vegetarians. *Journal of the Medical Association of Thailand, 82* (3), 304-311.

Shridhar, K., Dhillon, P. K., Bowen, L., Kinra, S., Bharathi, A. V., Prabhakaran, D., . . . Grp, I. M. S. (2014). The association between a vegetarian diet and cardiovascular disease (CVD) risk factors in india: The Indian migration study. *PLoS One, 9*(10), e110586.

Stanley, S., Wynne, K., McGowan, B., & Bloom, S. (2005). Hormonal regulation of food intake. *Physiological Reviews, 85*(4), 1131-1158.

Timko, C. A., Hormes, J. M., & Chubski, J. (2012). Will the real vegetarian please stand up? An investigation of dietary restraint and eating disorder symptoms in vegetarians versus non-vegetarians. *Appetite, 58*(3), 982-990.

Weickert, M. O., Reimann, M., Otto, B., Hall, W. L., Vafeiadou, K., Hallund, J., . . . Koebnick, C. (2006). Soy isoflavones increase preprandial peptide YY (PYY), but have no effect on ghrelin and body weight in healthy postmenopausal women. *Journal of Negative Results in Biomedicine, 5*, 11.

Williamson, D. A., Geiselman, P. J., Lovejoy, J., Greenway, F., Volaufova, J., Martin, C. K., . . . Ortego, L. (2006). Effects of consuming mycoprotein, tofu or chicken upon subsequent eating behaviour, hunger and safety. *Appetite, 46*(1), 41-48.

Wren, A. M., Seal, L. J., Cohen, M. A., Brynes, A. E., Frost, G. S., Murphy, K. G., . . . Bloom, S. R. (2001). Ghrelin enhances appetite and increases food intake in humans. *The Journal of Clinical Endocrinology and Metabolism, 86*(12), 5992.

Wynne, K., Stanley, S., McGowan, B., & Bloom, S. (2005). Appetite control. *The Journal of Endocrinology, 184* (2), 291-318.