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Comparisons of 6-n-Propylthiouracil (PROP) Sensitivity, Food Liking and Food Intake between Vegetarian and Non-Vegetarian Women

Sung Eun Choi*

Department of Family, Nutrition and Exercise Sciences, Queens College, the City University of New York (CUNY), Flushing NY, USA

***Corresponding author:** Sung Eun Choi, PhD, RD, Department of Family, Nutrition and Exercise Sciences, Queens College, CUNY Remsen Hall 305 A, 65-30 Kissena Boulevard, Flushing NY, 11367-1597, USA, Tel: 1-718-997-4169; Fax: 1-718-997-4163; E-mail: sungeun.choi@qc.cuny.edu

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Abstract

Background: Previous studies have suggested that vegetarians have a lower risk of overweight and obesity than do non-vegetarians. However, little is known about how meat consumption interacts with taste perception, thereby influencing food intake and body weight.

Objective: The objective of this study was to examine the relationship of meat consumption with 6-n-propylthiouracil (PROP) sensitivity, food liking, food intake and body mass index in female long term vegetarians and non-vegetarians.

Methods: A cross-sectional design with a total of 94 racially diverse female subjects (mean age 23 years, 42 vegetarians, 52 non-vegetarians) living in the New York City area was used in this study. Body Mass Index (BMI) was calculated using the measured weight and height and PROP sensitivity was assessed using a PROP filter paper disk method and a general Labeled Magnitude Scale (gLMS). The subjects also completed a questionnaire to report the food liking/disliking for 19 food items using a hedonic version of the gLMS. Dietary intake was assessed using a food frequency questionnaire.

Results: The PROP sensitivity of vegetarians was significantly higher than that of non-vegetarians. Vegetarians showed significantly less liking of fat foods than did non-vegetarians, whereas there was no significant difference in sweet foods liking. The BMI, energy, protein, fat, saturated fat, cholesterol, B vitamins, iron, zinc, sodium, potassium, and alcohol intake values of the vegetarians were significantly lower than those of the non-vegetarians. Multiple regression results revealed that only vegetarian status significantly contributed to the predictions of all the dependent variables, energy intake, fat intake and BMI.

Conclusion: The study findings suggest that a difference in taste perception between vegetarians and non-vegetarians may play a role in determining energy intake and weight status. Further studies are needed to examine the mechanisms by which habitual meat consumption affect taste perception and thus food intake.

Keywords: Vegetarian; Body mass index; Food liking, 6-n-propylthiouracil (PROP), Food intake

Introduction

A vegetarian diet has been suggested as an approach for weight management by scientific literature. The scientific literature suggests that a plant-based diet is inversely related to Body Mass Index (BMI), and to the incidence of overweight, and obesity [1-3]. Although the studies in the reviews varied in their design and adjustment for potential confounders in the analyses, most studies found that vegetarians have a lower BMI on average [1-6]. Several studies observed that vegans have a lower mean BMI than that of other types of vegetarians [1,7-9]. A possible explanation for the obesity preventive effect of meatless eating patterns includes the consumption of lean protein foods, reduced-fat dairy products, dietary fiber and whole grains [2,10-13].

For weight-loss seekers to receive such potential benefits from a vegetarian diet, the subjects must strictly commit to a vegetarian diet for a significant period of time. However, studies showed that many vegetarians fail to strictly adhere to meat abstention [14-20]. Several large-scale surveys using a representative American sample also revealed that more than half of self-identified vegetarians admitted that they had eaten animal flesh [21-24]. In a study examining possible reasons for the discrepancy between self-definition and admitted behavior among vegetarians, Rothgerber suggested the weaker disgust for meat of non-strict vegetarians than that of strict vegetarians can be a cause or consequence of their occasional consumption of animal flesh [25]. Disgust is a negative emotion characterized by a primitive revulsion at the prospect of bodily contamination and a symbolic element rejecting immoral or polluting objects, behaviors, or individuals [26]. A study by Fessler identified disgust as a multifaceted emotional state that is potentially measurable as a mental state, contamination potency, nausea, ideational rejection, and facial expression [26]. Once a philosophical opposition to meat has formed, a dislike for the sensory and inherent qualities of meat occurred in vegetarians as a way of supporting and internalizing meat avoidance [14]. These components of disgust were thought to motivate further avoidance of meat. Thus, it is expected that a complete hedonic shift from liking to disliking or being disgusted at meat is required to maintain strict vegetarian practices. The most frequent reasons given for red meat abstinence were also dislike of the taste and the high-fat content of red meat [27]. The response of current vegetarians to the flavor of meat differed from those of former vegetarians and non-vegetarians [16]. These results suggest that a taste factor can act on meat consumption as a cause or a consequence.

Although food choices are influenced by a broad range of economic, social and behavioral variables (e.g., food availability), taste and other sensory properties of foods have been deemed a major determinant of the selection of one food over another [28]. Thus, it was expected in the present study that a sensory hedonic shift regarding meat among vegetarians would influence other food choices and ultimately affect weight status. The motivations for and the nutritional outcomes of meat avoidance have been studied extensively. However, little is known about how meat consumption behavior affects total food intake and body weight by interacting with taste perceptions.

Therefore, the present study investigated the interplay among meat consumption behavior, energy intake, and weight status in female long term vegetarians and non-vegetarians, with a focus on the role of taste perception. Sensitivity to the bitter compound 6-n-propylthiouracil (PROP) and self-reported food liking/disliking were assessed as measures of taste perception for the following reasons. First, the ability to taste a low concentration of PROP has been linked to a newly discovered taste receptor gene, TAS2R38, thus providing a phenotypic marker for genetic variation in oral sensation and food preference [29,30]. A number of studies have shown that PROP non-tasters experience less oral sensation from a variety of sensory qualities than PROP tasters [31-35], and the weaker oral perception in non-tasters has been associated with increased food preferences for high-fat and strong-tasting versions of foods [36-41]. Second, self-reported food liking is strongly suggested as a valuable measure to connect chemosensation with health outcomes [42,43]. This research will provide valuable insight into how meat consumption behavior influences food intake and weight status and will provide explanations for the food selection and resulting nutritional outcomes of vegetarians.

Methods

Subjects

Healthy non-smoking female adult subjects were recruited via flyers posted on a college campus in the New York City area between January and November 2012. They had no chronic diseases and were not taking any medications that interfered with taste or olfactory perception. Subjects with high levels of dietary restraint were excluded because high dietary restraint may cause people to under-report a preference for sweet foods [44]. Of the 106 subjects who were recruited, 12 participants were excluded due to a reported score >15 on the Restrained Eating Scale [45] and/or a reported energy intakes <500 kcal or >5,000 kcal per day [46]. A total of 94 female subjects were included in the final analyses. The "vegetarians" were defined as subjects who had not consumed any portion of red meat or poultry for at least the past year. Fish and dairy consumption were acceptable for the "vegetarians" classification. Among 42 non-meat eaters, 19 subjects were pesco vegetarians who consume fish and seafood, 10 subjects were lacto-ovo vegetarians who consume dairy and egg products, 6 were lacto vegetarians, and 7 subjects were vegans who consume neither meat nor any other animal products. All procedures were approved by the Institutional Review Board at the City University of New York and all subjects provided informed written consent and received monetary compensation for participation.

PROP paper test and classification

The subjects were classified by PROP taster status using the paper disk method developed by Zhao and colleagues [47]. The subjects were instructed to rinse their mouths with distilled water before they began tasting and between each sample. The order of tasting was as follows: subjects first tasted a blank disk (control), then tasted a disk impregnated with 1.0 mol/l NaCl (Sigma-Aldrich, St. Louis, MO) and finally a disk impregnated with 50 mmol/l PROP (6-n-propyl-2-thiouracil, Sigma-Aldrich, St. Louis, MO). The subjects placed each disk on the tip of the tongue for 30s or until the disk was moistened with saliva before discarding the disk. The paper disk test was administered twice with a 5 min break between tests at room temperature.

The subjects rated the intensity of the taste using the general Labeled Magnitude Scale (gLMS), which is a generalization of the adjective-labeled, ratio scale devised by Green and colleagues [48]. Unlike conventional scales, the gLMS can provide valid comparisons across individual and groups [49]. The gLMS ranges from 0, which is "no sensation", to 100, which is the "strongest imaginable sensation of any kind", with intermediate levels at 1.4 (barely detectable), 6 (weak), 16.5 (moderate), 35 (strong), and 51 (very strong). Before using the scale, the subjects were provided with an orientation to the gLMS to understand the use of the scale. The subjects were asked to rate the intensity of a range of imagined sensations, such as the light in the room, the light in a dimly lit restaurant, and the brightest light they had ever seen.

The mean of the two replicates was calculated for each subject. The test-retest reliability for the two PROP tasting replicates was high (r=0.88), which was a similar result from other studies [33,38,50]. Initially, those who rated the intensity of the PROP disk as moderate or less (≤16.5 on the gLMS) were classified as non-tasters, whereas, those who indicated ratings of very strong or greater (≥51 on the gLMS) were classified as supertasters. The sodium chloride ratings were used to help classify taster classification when subjects gave a borderline rating to PROP [47]. Cut-off scores based on the group means (±95% confidence) for PROP taste intensity were determined. Based on the characteristics of the study subjects, the cut-off score for non-tasters was <12.2 on the gLMS, the cut-off score for super-tasters was >60.3, and medium tasters fell between those the limits (≥12.2 and ≤60.3). The kappa statistic measuring the agreement between PROP categories from the first and the second classifications was good (κ=0.63). Most (80%) participants were classified into the same category the second time. The PROP status of the remaining subjects (20%) differed by only one category. For the final statistical analysis, the medium and supertaster groups were combined to form a taster group because of the small sample size, particularly the low number of supertasters.

Food liking/disliking rating using a questionnaire

Subjects were asked to use the hedonic version of the gLMS to rate their liking/disliking of 19 items that were used in a study performed by Duffy et al. [51]: cheddar cheese, salt, mayonnaise, sugar, beef steak or prime rib, whipped cream, whole milk, cooked broccoli without condiments, black coffee, beer, sour cream, salted pretzels, fried chicken, sweets, sausage, milk chocolate, butter, gravy, and grapefruit juice. For the analysis, a fat food group and a sweet food group were formed using the same food items in each group as those used in a study performed by Duffy et al. [51]. The 12 fat foods (cheddar cheese, mayonnaise, beef steak or prime rib, whipped cream, whole milk, sour cream, fried chicken, sweets, sausage, milk chocolate, butter, and gravy) formed a statistically reliable group (Cronbach's α=.72) and the 4 sweet foods (sugar, whipped cream, sweets, and milk chocolate) formed a grouping that was also statistically reliable (Cronbach's α=. 73). These food items were listed with a scale and not tasted. Each direction of this bi-directional gLMS is 100 points with adjective spaced at roughly logarithmic points: ±1.4 (barely), ±6 (weak), ±16.5 (moderate), ±35(strong), ±51(very strong), and ±100 (strongest imaginable liking/disliking) and "neither like nor dislike (neutral) is positioned at the mid-point and equal to zero [51].

Assessment of energy and fat intake

The subjects were asked to report their food intake during the previous year using a semi-quantitative food frequency questionnaire (FFQ) created by reorganizing the Block FFQ [52]. The FFQ includes >135 food items that all relate to the diet during the previous year in ten categories: fruits and juices; vegetables and grains; meat, poultry, eggs and fish; mixed dishes; breads, salty snacks, spreads; breakfast cereals; sweets; dairy products; beverages; and foods to be added. The FFQ has been validated against 24-hour recall data [53,54]. Upon completion of the FFQ, a registered dietitian individually reviewed the FFQ, and any discrepancies/questions were addressed. The daily intake per item was entered into the Food Processor software program (version 10.12, 2012, ESHA, Salem, OR) to analyze the daily energy intake and fat intake of each subject.

Anthropometric measures

Height and weight were measured on a physician's scale (Cardinal Scale Mfg. Co., Webb City, MO), and then BMI was calculated as kg/m^2. All measurements were taken with the participants in lightweight clothing, without shoes.

Statistical analysis

An independent samples t-test was used to test the effect of vegetarian status on continuous variables, and a χ^2 test was used for categorical variables, as appropriate. To predict energy intake and fat intake, multiple linear regression models were fit with covariates, vegetarian status, PROP intensity, fat foods liking and sweet foods liking. To test the normality and multicollinearity of variables, a normal plot of the residuals were examined and collinearity statistics were calculated in the regression models. Residuals and expected values were linearly plotted, which suggests agreement with normality. Additionally, according to the result of collinearity analysis, because all of the variance inflation factors for independent variables were less than 10 (range 1.096-2.953), there was no multicollinearity among the independent variables in the regression models [55]. Data were analyzed using SPSS (version 20.0, 2011, IBM Inc., Armonk, NY). Statistical significance was set at P<0.05.

Results and Discussion

The subject characteristics by vegetarian status are summarized in Table 1. The median age of all subjects was 22 years with a range 18-38 years and there was no significant difference in the mean age between vegetarians and non-vegetarians (Table 1). The largest ethnic group of subjects in this study was Asians (44.7%), followed by Caucasians (23.4%), African Americans (20.2%), and Hispanics (11.7%), but no significant difference was observed in the distribution of vegetarian status among the four ethnic groups (P=0.450).

	Total (n=94)	Vegetarians (n=42)	Non-vegetarians (n=52)	P value[1]
Age (year), Mean (SE[2])	23.1(0.4)	23.2(0.8)	23.1(0.5)	0.919
Ethnicity, N (%[3])				0.45
Caucasians	22(23.4)	10(23.8)	12(23.1)	
African Americans	19(20.2)	6(14.3)	13(25.0)	
Asians	42(44.7)	22(52.4)	20(38.4)	
Hispanics	11(11.7)	4(9.5)	7(13.5)	
PROP[4] taste intensity,[5] Mean (SE[2])	31.6(2.3)	38.1(3.8)	26.3(2.6)	0.012
PROP[4] taster status				0.526
Non-tasters	16(17.0)	6(14.3)	10(19.2)	
Tasters	78(83.0)	36(85.7)	42(80.8)	
BMI (kg/m^2), Mean (SE[2])	22.6(0.4)	21.4(0.4)	23.6(0.7)	0.006
BMI, N (%[3])				0.012
Underweight (<18.5)/Normal (18.5-24.9)	74(78.7)	38(90.5)	36(69.2)	

Overweight (25.0-29.9)/Obese (≥30.0)	20(21.3)	4(9.5)	16(30.8)	

[1]P values were determined using independent t-test for continuous variables and χ^2 test for categorical variables, as appropriate; [2]SE: Standard Error; [3]Column percentage; [4]6-n-propylthiouracil; [5]Intensity scores were rated using the general Labeled Magnitude Scale (gLMS). The gLMS ranges from where 0 is 'no sensation' and 100 is the 'strongest imaginable sensation of any kind' with intermediate levels at 1.4(barely detectable); 6(weak); 16.5(moderate); 35(strong); 51(very strong); The level of significance was set at P<0.05

Table 1: Descriptive characteristics of 94 female subjects by vegetarian status.

The median PROP intensity was 26.0 with a range 1.7-98.0 and an inspection of the means of the two group indicated that the mean PROP intensity for vegetarians was significantly higher than that for non-vegetarians (P=0.012, Table 1). However, the Pearson chi-squared result from testing whether the statistical assumptions were met indicated that there was no significant difference in PROP taster distribution between vegetarians and non-vegetarians (P=0.526). The proportion of PROP non-tasters out of the total number of subjects was 17% (=16/94), which is lower than the proportion in other reports. The proportions of the non-taster group in the studies that used the same method of PROP group classification in both genders (42-48% males, age range 25-65 years) as the present study, were 22 and 27% [47,50,56]. The frequency of non-tasters in the United States is estimated to be approximately 20-25% of the population [57], and the estimated proportions of non-tasters in the Caucasian population is approximately 30% [58]. The previous studies suggested that female subjects were significantly more likely to be tasters possibly due to their increased number of fungiform papillae and taste buds compared with those of male subjects [57,59,60]. Therefore, having only the female subjects in the current study is thought to cause the lower proportion of non-tasters.

The median BMI was 22.6 with a range of 15.4-43.3 and the mean BMI of the vegetarians was significantly lower than that of the non-vegetarians (P=0.006, Table 1). This finding supports the results of previous observational studies that a plant-based diet is inversely related to BMI and the incidence of overweight, and obesity [1-3]. The cross-sectional study conducted by Newby and colleagues using 55,450 healthy women also found that self-identified semivegetarian, lactovegetarian, and vegan women have a lower risk of overweight and obesity than do omnivorous women [2]. The difference of mean BMI between vegetarians (=21.4) and non-vegetarians (=23.6) was 2.2, which is larger than the differences found in previous studies [1,4-6,61,62]. The previous studies showed that vegetarians had BMIs approximately 1 unit lower than that of the omnivores (non-vegetarians) [1,4-6,62] and the difference was even greater between non-vegetarians and vegans. The BMI difference between vegetarians and non-vegetarians in women was also greater than that in men [1,4-6,62]. Farmer and colleagues reported that BMI can differ as much as 1.9 for vegetarian men and 2.1 for vegetarian women compared to non-vegetarians [62]. However, no significant difference was observed in the distribution of vegetarians among the two BMI groups (Table 1) in the current study.

The comparison data on energy, macronutrients, fiber, cholesterol, micronutrients, water, alcohol, and caffeine intakes are presented in Table 2. These data delineated the outline of different characters between vegetarians and non-vegetarians. The energy, protein, total carbohydrate, total fat, saturated fat, cholesterol, thiamine, riboflavin, niacin, Vitamin B6, B12, iron, zinc, sodium, potassium, and alcohol intakes of vegetarians were significantly lower than those of non-vegetarians (Table 1). These results are consistent with the findings of previous vegetarian studies reporting a significantly lower intake of energy, protein, fat, saturated fat [61-66], cholesterol [61-64], niacin, vitamin B12, zinc [61,62], sodium [62], and alcohol [61,64] and a significantly higher intake of fiber [61-64] by vegetarians. Contrary to the result from the present study, some studies of vegetarians reported a significantly higher intake of carbohydrate, thiamine, riboflavin, folate, and iron [61,62] by vegetarians than by non-vegetarians. Unlike previous studies, there was no significant difference in fiber intake between vegetarians non-vegetarians in the present study. A study conducted among 553 adolescents (312 females, mean age 15 years with a range of 12 to 18) by Burkholder and colleagues found that vegetarians consumed significantly less soda/sweetened drinks, pastries, coffee/tea, but they ate significantly more fruits than did their non-vegetarian counterparts [67]. These results suggest the possibility that the reduced risk of overweight or obesity in vegetarians might be related to the difference in the types of carbohydrates that are consumed.

	Total (n=94)	Vegetarians (n=42)	Non-vegetarians (n=52)	P value[1]
Energy intake (kcal)	2195.6(98.9)	1807.5(99.9)	2509.1(146.5)	<0.001
Fat intake (kcal)	611.0(35.0)	465.1(27.7)	728.8(54.1)	<0.001
Protein (g)	92.4(5.5)	69.4(4.4)	110.9(8.5)	<0.001
Carbohydrate (g)	305.3(13.3)	272.5(17.6)	331.8(18.7)	0.026
Fiber (g)	27.6(1.4)	27.9(2.1)	27.3(1.8)	0.832
Total fat (g)	68.0(3.9)	51.8(3.1)	81.0(6.0)	<0.001
Saturated fat (g)	22.2(1.4)	16.8(1.1)	26.6(2.2)	<0.001
Cholesterol (mg)	282.0(21.2)	195.2(21.5)	352.2(31.1)	<0.001

Vitamin A (IU)	12439.7(847.9)	12742.1(1333.4)	12195.5(1101.2)	0.75
Vitamin C (mg)	134.8(7.9)	133.1(11.1)	136.2(11.2)	0.843
Vitamin E (mg, α-Tocopherol)	10.4(0.9)	9.2(1.2)	11.4(1.3)	0.229
Thiamin (mg)	1.9(0.1)	1.6(0.2)	2.2(0.2)	0.023
Riboflavin (mg)	2.4(0.2)	1.9(0.2)	2.8(0.3)	0.013
Niacin (mg)	31.7(2.5)	22.2(2.5)	39.3(3.8)	<0.001
Vitamin B6 (mg)	2.7(0.2)	2.0(0.2)	3.3(0.4)	0.003
Vitamin B12 (mg)	6.9(0.8)	5.1(1.3)	8.3(1.0)	0.05
Folate (mcg)	494.2(33.5)	430.0(47.6)	546.1(45.9)	0.085
Calcium (mg)	1168.8(79.9)	1040.6(111.5)	1272.3(111.8)	0.15
Magnesium (mg)	333.4(16.0)	307.1(23.7)	354.7(21.5)	0.14
Iron (mg)	23.8(1.7)	19.7(2.3)	27.2(2.4)	0.029
Zinc (mg)	14.5(1.1)	10.9(1.4)	17.4(1.6)	0.003
Sodium (mg)	3290.1(181.6)	2656.3(173.9)	3802.0(278.6)	0.001
Potassium (mg)	2929.6(126.5)	2652.3(155.5)	3153.5(186.7)	0.048
Water (g)	2851.9(134.0)	2715.6(186.9)	2961.9(190.0)	0.364
Alcohol (g)	3.0(0.5)	1.5(0.4)	4.2(0.8)	0.002
Caffeine (mg)	116.0(12.9)	100.5(17.3)	128.5(18.7)	0.284
Mean (Standard Error); The level of significance was set at P<0.05				

Table 2: Daily intakes of energy, macronutrients, micronutrients, water, alcohol and caffeine for 94 female subjects by vegetarian status.

A study conducted by Spencer and colleagues in the UK assessed differences in BMI among 38,000 meat-eaters, fish-eaters, vegetarians and vegans and evaluated the contribution of major dietary and lifestyle factors to these differences [8]. They reported the differences in BMI are largely attributable to dietary factors rather than nondietary lifestyle factors such as smoking and exercise and among the dietary factors, high protein and low fiber intakes were the factors most strongly associated with increasing BMI [8]. The potential mechanism for important effect of protein on BMI includes high protein intakes causing hormonal changes in the body which alter metabolic systems to favor abdominal adiposity deposition [68,69]. The effect of fiber intake on BMI has been also explained by the association with the level of adiposity [70]. Fiber has been proposed to promote maintenance of lean weight via effects on satiety [70-72], insulin control [73] or by reducing fat absorption [74]. One extensive review study about nutraceuticals and dyslipidemia suggests that nutraceuticals and functional food ingredients that are more likely to be ingested by vegetarians may reduce the overall cardiovascular risk induced by dyslipidemia by reducing 7α-hydroxylase, increasing fecal excretion of cholesterol, decreasing 3-hydroxy-3-methylglutaryl-CoA reductase mRNA levels or reducing the secretion of VLDL [75]. As this connection of nutraceuticals to lipid metabolism may be used to explain the lower risk of obesity in vegetarians.

Among the nutraceuticals preventing negative effects of dyslipidemia on the cardiovascular system, zinc merits special attention when evaluating nutritional benefit of vegetarian due to the following reasons. First, more than half of the zinc in US diets is derived from animal foods, and one quarter of the zinc comes from beef [76]. The bioavailability of zinc from vegetarian diets is also likely to be less than that of non-vegetarian diets because the bioavailability of zinc is enhanced by dietary protein, but plant sources of protein are also generally high in phytic acid, an inhibitor of zinc bioavailability [77]. As commented above, most vegetarian studies including the present study reported that vegetarians had the significantly lower zinc intake than non-vegetarians. Another reason to pay attention to zinc is that one of the functions of zinc is to provide integrity of taste perception in healthy persons [78]. Therefore, it is plausible that insufficient zinc intake in vegetarians changes their taste preference and food selection, which ultimately affects their body weight.

The comparisons of food liking/disliking between vegetarians and non-vegetarians are presented in Table 3. The food that was most disliked foods (the largest negative value) by all subjects was black coffee, and the most liked food (the largest positive value) was sweets. There were significant differences in the liking of fat foods, beef steak or prime rib, whole milk, beer, and sausage between the vegetarians and the non-vegetarians. An interesting result is that no significant difference was observed in the likings of bitter vegetable/fruit (cooked broccoli, grapefruit juice) and sweet foods (sugar, whipped cream, sweets, and milk chocolate). Even for the likings of some fatty dairy products such as cheese, whipped cream, butter, and sour cream, no significant difference was found between vegetarians and non-vegetarians.

	Total (n=94)	Vegetarians (n=42)	Non-vegetarians (n=52)	P value[1]
Food liking/disliking score[2], Mean (SE[3])				
Fat foods liking	13.4(2.2)	1.9(3.2)	22.7 (2.3)	<0.001
Sweet foods liking	32.4(2.4)	30.1(4.0)	34.2 (3.0)	0.4
Cheddar cheese	24.1(3.3)	26.7 (5.4)	22.1 (4.0)	0.491
Salt	19.4(2.6)	19.2(4.5)	19.6 (3.0)	0.935
Mayonnaise	-0.4(3.7)	-1.7(6.1)	0.6 (4.7)	0.766
Sugar	33.6(3.0)	30.0(4.7)	36.5 (3.8)	0.281
Beef steak or prime rib	3.8(5.4)	-39.6(5.7)	38.8 (4.5)	<0.001
Whipped cream	23.4(3.3)	26.4(4.6)	21.1 (4.7)	0.428
Whole milk	6.9 (4.5)	-4.8(6.7)	16.4 (5.7)	0.018
Cooked broccoli without condiments	23.4(3.5)	22.3(4.9)	24.2 (4.9)	0.789
Black coffee	-32.5(4.5)	-36.2(6.3)	-29.5(6.4)	0.468
Beer	-23.1(5.2)	-35.2(7.8)	-13.3 (6.8)	0.037
Sour cream	2.9 (3.9)	2.6(6.3)	3.1(4.9)	0.942
Salted pretzels	16.9 (2.7)	14.1(4.9)	19.1 (2.9)	0.363
Fried chicken	5.6 (4.8)	-30.7(6.6)	34.9(3.4)	<0.001
Sweets	39.9 (3.0)	36.2(4.4)	42.9 (4.2)	0.281
Sausage	-4.5(5.1)	-37.8(6.1)	22.3(5.4)	<0.001
Milk chocolate	32.6 (3.9)	27.7(6.8)	36.5 (4.4)	0.261
Butter	17.0 (3.5)	16.1(5.4)	17.7(4.7)	0.821
Gravy	9.6(3.6)	1.9(6.2)	15.8(3.9)	0.062
Grapefruit juice	7.9(4.2)	0.4(5.8)	13.8(5.9)	0.111

[1]P values were determined using independent t-test; [2]The hedonic version of bi-directional gLMS: ±1.4 (barely); ±6 (weak); ±16.5 (moderate); ±35 (strong); ±51 (very strong); and ±100 (strongest imaginable) liking/disliking (+/–) and 'neither like nor dislike (neutral)' is positioned at the mid-point and equal to zero; [3]SE: Standard Error; The level of significance was set at P<0.05

Table 3: Food liking/disliking results for 19 food items using a hedonic version of generalized Labeled Magnitude Scale (gLMS) by vegetarian status.

Table 4 presents the multiple regression results for the independent variables that were used to predict energy intake, fat intake and BMI. This combination of independent variables significantly predicted energy intake, fat intake, and BMI (P<0.001, P<0.001, and P=0.031, respectively, Table 3). Only vegetarian status significantly contributed to the predictions of all the dependent variables (energy intake, fat intake and BMI). The positive beta weights of vegetarian status, as presented in Table 3, suggest that non-vegetarian subjects would have a higher energy intake, a higher fat intake, and a higher BMI score.

Dependent Variable: Energy intake (kcal/day)				
Variables	Unstandardized Coefficients	Standardized Coefficients	*t*	P value
	B ± SE[1]	ß		
Vegetarian status	593.09 ± 229.01	0.31	2.59	0.011
PROP taste intensity	4.98 ± 4.19	0.12	1.19	0.237

Fat foods liking	6.33 ± 7.19	0.14	0.88	0.381
Sweet foods liking	8.61 ± 5.67	0.21	1.52	0.132
Constant	1346.53 ± 274.68			
R^2=0.238 (Adjusted R^2=0.204), F (4,89)=6.955, P<0.001				
Dependent Variable: Fat intake (kcal/day)				
Variables	Unstandardized Coefficients	Standardized Coefficients	*t*	P value
	B ± SE[1]	ß		
Vegetarian status	191.28 ± 80.89	0.28	2.37	0.02
PROP taste intensity	0.31 ± 1.48	0.02	0.21	0.833
Fat foods liking	3.25 ± 2.54	0.2	1.28	0.204
Sweet foods liking	2.04 ± 2.00	0.14	1.02	0.312
Constant	385.68 ± 97.02			
R^2=0.240 (Adjusted R^2=0.205), F (4,89)=7.008, P<0.001				
Dependent Variable: Body mass index (kg/m^2)				
Variables	Unstandardized Coefficients	Standardized Coefficients	*t*	P value
	B ± SE[1]	ß		
Vegetarian status	1.88 ± 0.93	0.23	0.76	0.045
PROP taste intensity	-0.04 ± 0.02	-0.2	-1.82	0.066
Energy intake	0.001 ± 0.001	0.24	1.64	0.347
Fat intake	-0.003 ± 0.003	-0.25	-1.15	0.32
Constant	23.55 ± 1.27			
R^2=0.111 (Adjusted R^2=0.072), F (4,89)=2.791, P=0.031; [1]Standard Error; Independent variables included: Vegetarian status (0: vegetarian, 1: non-vegetarian); The level of significance was set at P<0.05.				

Table 4: Simultaneous multiple regression analysis summary for vegetarian status, 6-n-propylthiouracil (PROP) taste intensity, fat foods liking, and sweet foods liking predicting energy intake, fat intake and body mass index.

The strengths of the current research include the homogeneous sample with respect to gender and age and the elimination of extraneous variables (e.g., smoking, degree of dietary restraint) that affect taste perception and food intake for a clear interpretation of the results. In addition, the meat consumption status was confirmed not by relying on self-report but through a food frequency questionnaire. The present study is also the first study to examine the difference in PROP sensitivity and food liking/disliking between vegetarians and non-vegetarians using a validated field assessment of PROP status and a generalized scale.

Study Limitations

Despite the strengths, this study was limited by a relatively small sample size. As a result of post-hoc power analysis from the present study using 94 total subjects (42 and 52 in each group), the effect size for the independent t-test on PROP sensitivity is 0.734, which is, according to Cohen [68], a medium to large sized effect. However, as compared with other studies examining the dietary pattern of vegetarians, the smaller sample size of subjects in this study may have been insufficient to generalize the results. Additionally, PROP medium tasters and supertasters were combined due to the low number of supertasters. Another limitation of this study is that PROP intensity was the only measurement of genetic taste sensitivity. PROP is known to be a single type of bitter taste, and its perception has been linked to variations in the TAS2R38 gene [38], which is one of more than two-dozen known bitter taste receptor genes. A final limitation to this study is that the present study didn't include the examination of physical activity and dietary supplement intake, which can significantly affect energy metabolism. Additional validation studies including those factors would provide insight into ways that taste perceptions and food preference that can characterize vegetarian modes may affect body weight status.

Conclusion

The present study demonstrated that vegetarians are significantly different from non-vegetarians in terms of PROP sensitivity, fat foods liking, fat intake, energy intake and BMI. The results suggest that meat consumption itself plays a role in taste perception, food intake, and ultimately BMI. The regression results indicated that compared with PROP sensitivity, meat eating status is thought to contribute more to the prediction of fat intake, energy intake and BMI. Thus, an interpretation of the cause and consequence of meat avoidance on food intake is of considerable interest for identifying the relationship between meat consumption and health outcomes. The findings from this study warrant additional investigation of the effects of habitual meat consumption on food acceptance and food intake. In particular, identifying the mechanisms and the degree to which cultural food experiences regarding meat consumption interact with taste perception such as PROP sensitivity can provide deeper insight into the underlying causes of food selection.

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