Association between food liking and the dietary quality in Australian young adults

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ABSTRACT

Background and Objectives: An individual's liking for food maybe associated with food consumption. This study investigates the association between food liking and dietary quality in Australian young adults. **Methods and Study Design:** Food liking and food frequency data were collected via an online Food Liking Questionnaire (FLQ) and Food Frequency Questionnaire (FFQ). Food liking scores were calculated for groupings of foods. FFQ Food intake data was used to calculate diet quality using a 13 item Dietary Guideline Index (DGI). The relationship between food liking and DGI was assessed using linear regression models and the difference was assessed using an independent sample t-test and One-way ANOVA. **Results:** Data were available from n=2,535 participants (BMI=24 (SD 3.74), age=21.9 (SD 5.05) years, female=77.1%). Liking for grains, vegetables, fruits, dairy, plant-based protein, was weakly positively associated with diet quality. Liking for animal-based protein, fat and oil, sweet food, and salty food, was weakly negatively associated with diet quality. Liking for grains, vegetables, fruits, dairy, plant-based protein and healthy foods increased across increasing DGI tertiles, and liking for animal-based protein, fat and oil, sweet food, salty food and discretionary foods decreased across increasing DGI tertiles. **Conclusions:** The results were logical with increased liking for healthy or discretionary foods linked with increased consumption of those foods. The results reinforce the strategy to introduce a variety of healthy food groups early in life to initiate flavour-nutrient learning and increase liking for healthy foods.

Key Words: food liking, dietary quality, young adult

INTRODUCTION

Food liking is the perceptual outcome which combines the flavour of a food, previous experiences with the food, health state all of which make an individual's response to food is multi-dimensional and dynamic.[1] These factors may influence liking decisions at any point in time.[2] The liking of a food's flavour is an important driver of short-term food consumption and energy intake, as those who enjoy the flavour of the food they are consuming tend to eat more of it.[2-7]

Flavour is a psychological construct with the flavour we experience from a food being a combination of inputs from the five classic senses: taste, smell, touch, sight and hearing. There is large inter-individual variation in each of the senses and as they each have inputs into the perceived flavour of a food, each individual experience flavour from a food that are

unique to that individual.[8-11] Food flavour is also indicative of the nutrients found in the food consumed and has an important influence on food choice.[4,7,12-15] For example, sweet taste may indicate energy and carbohydrate content, umami and salty tastes may indicate protein and sodium content respectively and all three qualities are appetitive and encourage consumption.[12, 13] Energy imbalances due to overconsumption of food is common, especially given discretionary foods high in palatable fat, sugar and salt.[16-20] Food liking has been observed to be a driver of food consumption and may in part be responsible for determining diet quality and excessive energy intakes.

Obesity represents the largest preventable disease worldwide and is a contributor to ill-health outcomes including cardiovascular disease, stroke, type 2 diabetes, hypertension, arthritis, respiratory disorders and certain cancers.[21] Whilst the causes of obesity are multi-factorial and complex, they are embedded within energy imbalances brought about by psychological, cultural, personal, environmental, lifestyle, and dietary factors which favour excessive energy intake coupled with sedentary behaviour.[22]

Given that an improvement in dietary quality may lead to an improved quality of life.[23-25] it is useful to explore the relationship between food liking and diet quality. The association between food liking and dietary quality was reported by Zoghbi et al. and Sharafi et al.[26,27] and the study found that the healthy dietary quality correlated with liking and intake of a healthy foods. A study by Duffy et al.[28] demonstrated that the liking of fatty foods was positively correlated with fat intake. Further, a positive relationship between the liking for fatty foods, body weight and systolic blood pressure was found. This relationship between food liking and dietary intake was also observed in a large study by Mejean et al. which found that those with a higher liking for fatty foods had an increased intake of total energy, fat and certain foods (high in fat) such as meat, butter, desserts and pastries, and a positive relationship between the liking for fatty foods and obesity risk was observed.[29]

The aim of this study was to determine the relationship between food liking and dietary quality in Australian young adults. The Dietary Guideline Index (DGI) measures how well an individual achieves the recommended number of servings for each of the recommendations within the Australian Dietary Guidelines. It was hypothesised that the liking of a food will be a factor influencing the dietary quality in Australian young adults.

MATERIALS AND METHODS

Participants and Procedures

Participants were undergraduate students enrolled in a first-year food and nutrition subject at Deakin University. Data collection occurred during 2015-2018. Participants completed the questionnaires as part of their assessment tasks for the subject, and after completion of their assignments they were invited to provide consent to allow the data to be used for research purposes. Ethics approval was obtained from the Human Research Ethics Committee at Deakin University (HEAG-H 163_2009) and all participants who agreed to participate in the study provided written informed consent.

Food liking questionnaire

The FLQ and subsequent Food Liking Score has been previously described.[30] In brief, the FLQ used was a modified version of a FLQ from Duffy et al.[28] which was adapted for culturally relevant Australian foods. The questionnaire contained 73 food items and measured liking using a nine-point hedonic scale. This scale consists of a series of nine verbal categories representing degrees of liking from 'dislike extremely' to 'like extremely'. For subsequent quantitative and statistical analysis, and all verbal categories were converted to numerical values: 'like extremely' was coded as '9', 'dislike extremely' as '1'. FLQ contained the instruction "*if you have never eaten a particular food, or never experienced one of the listed items, please rate the item as 'neither like or dislike*". Food items within the FLQ were classified into 10 main categories based on the Australian Guide to Health Eating: grains, vegetables, fruits, dairy, animal-base protein, plant-base protein, fat and oil, sweet food, salty food, and alcohol Food liking scores were generated for each food grouping and the groups grains, vegetable, fruit, dairy, animal-base protein, plant-based protein, fat and oil groups were further combined to generate a healthy group and sweet food, salty food, and alcohol groups were combined in a discretionary group.[23]

Food frequency questionnaire

An adapted version of the 1995 Australian National Nutrition Survey FFQ.[31] was used to measure each participant's habitual pattern of food intake. Participants were required to indicate, on average, how many times in the previous month they consumed a number of food and beverages and vitamin and mineral supplements (118 items; bread and cereal foods, dairy foods, meat, fish, eggs, sweets, baked goods, and snacks, dressings, non-dairy beverages, vegetables, fruits). Participants were instructed to select the most appropriate answer on a

nine-point scale with response options ranging from "Never, or less than once a month", "1-3 times per month", "once per week", "2-4 times per week", "5-6 times per week", "once per day", "2-3 per day", "4-5 times per day" and "6+ times per day"

Diet quality assessment

The Diet quality of participants was assessed using data from FFQ and a previously developed Dietary Guideline Index (DGI).32 Dietary information collected from the FFQ was used to assess the diet quality using a 130-point diet quality index for each participant. The DGI is comprised of thirteen components with each component having a maximum possible score of 10 points, a higher DGI score reflects a better diet quality.[32] The thirteen components of the DGI are set to assess a participant's intake of key nutrients from core food groups, the proportion of key nutrient intakes from healthy food types (e.g., lean meats or wholegrain cereals), variety of foods in the diet and intakes of unhealthy foods. Those that reported to be in between the criteria for minimum and maximum had scores proportionately adjusted; for example, if a participant reporting consuming one serve of fruit (half the recommended amount as per day in the 2013 Food for Health Guidelines within the Australian Dietary Guidelines)[23] they received a score of 5 for that component—half of the maximum possible score. This method of diet quality assessment has been previously validated; a higher DGI score has shown to be inversely related with poor health outcomes in previous research.[32]

Statistical analysis

Statistical analyses were carried out using SPSS version 25.0 (IBM Corporation, Armonk, NY, USA). Cronbach's Alpha was used to determine internal consistency of the liking score for each food group. The Cronbach's alpha values were interpreted as unacceptable (<0.50), poor (0.51-0.60), questionable (0.61-0.70), acceptable (0.71-0.80), good (0.81-0.90), and excellent (0.91-1).[33] Relationships between food liking and DGI was assessed using linear regression models accounting for BMI and gender. Regression beta coefficient (β) and 95% confidence interval (CI) were reported. Eta-square effect size (η^2) was calculated for multiple regression to determine magnitude of the associations. η^2 was interpreted as small (<0.02), medium (0.02-0.13), and large (>0.26).[34] Independent sample t-test was used to compare the food liking groups between genders. Chi square test was used to compare BMI categories across gender. A value of $p<0.05$ was considered statistically significant. One-way ANOVA was performed to compare food linking with BMI categories follow by Post-Hoc comparison, Bonferroni method was used to account multiple comparison.

RESULTS

Participant characteristics

From the n=2,657 participants that were initially available, n=122 participants were excluded as they did not answer the self-reported weight and height questions, or provided unusual data (BMI lower than 14 and over than 50) or had incomplete data (Incomplete FLQ – defined as missing any liking rating for any food or beverage item), leaving the total number of participants as n=2,535. The mean age was 21.9 (±5.05) years. The majority (77.1%) of the participants in this study were female. The average of Body Mass Index (BMI) was 24 (±3.74). Thirty-three percent (n=848) were overweight. See Table 1 for the complete demographics.

Linear regression analysis was used to investigate the association between food liking groups and diet quality as measured by the DGI. The effect size estimates for multiple regression for the association between food liking groups and DGI were small for all of food groups (<0.02) (Table 3).

The liking score for grain, vegetable, fruit, dairy, plant-based protein, and healthy groups showed statistically significant positive associations with DGI score. Thus, an increased liking of grain (β = 2.45, CI [1.90, 3.00]), vegetable (β=1.17, CI [0.62, 1.72]), fruit (β=0.92, CI [0.28, 1.55]), dairy (β=0.48, CI [0.17, 0.79]), plant-based protein (β = 0.99, CI [0.61, 1.37]), and healthy groups (β=1.06, CI [0.32, 1.80], was associated with an increase in DGI score. For animal-based protein (β=-0.42, CI [-0.73, -0.11]), fat and oil (β=-0.88, CI [-1.28, -0.47]), sweet food (β=-1.01, CI [-1.43, -0.60]), salty food (β=-0.86, CI [-1.30, -0.43]), and discretionary groups (β=-1.17, CI [-1.67, 0.68]), an increase liking was associated with a decreased DGI score (Table 3).

Linear association was used to examine food liking and DGI scores separately for males and females. For males, the liking score for grain had a positive statistically significant association with a higher DGI score (β=2.56, CI [1.28, 3.85]). An increased liking for fat and oil (β=-1.34), CI [-2.42, -0.26]), sweet food (β=-2.39, CI [-3.45, -1.32]), salty food (β=-1.68, CI [-2.85, -0.50]) and Discretionary food (β=-0.60, CI [-1.40, 0.20]), were statistically significantly associated with a decrease DGI score. For females, an increase in liking for grains (β=2.44, CI [1.82, 3.05]), vegetables (β=1.33, CI [0.70, 1.96]), fruits (β=1.34, CI [0.61, 2.06]), dairy (β=0.49, CI [0.16, 0.83]), plant-based protein (β=0.96, CI [0.55, 1.38], and healthy food (β=1.14, CI [0.31, 1.98]) were significantly associated with an increase in DGI score. The liking score for animal-based protein (β=-0.43, CI [-0.76, -0.10]), fat and oil (β=-0.82, CI [-1.26, -0.39]), Sweet food (β=-0.70, CI [-1.16, -0.24]), salty food (β=-0.70, CI [-1.17,

-0.22]), and discretionary food (β=-0.89, CI [-0.43, -0.34]) had a significant negative association with a higher DGI score.

Independent sample t-tests were used to compare the mean differences of food liking between genders (Table 3). Statistically significant mean differences between genders (p<0.001) were observed in all food groups except for healthy good liking.

The mean differences of food liking scores between genders was statistically significant (p<0.001) for all food groups except heathy food (all Mean Differences are male-female, respectively): grain (MD=-0.39 , CI [-0.49, -0.28]), vegetables (MD -0.71, CI [-0.82, -0.60]), fruits (MD=-0.22, CI [-0.31, -0.13]), dairy (MD=0.65, CI [0.50, 0.81]), animal-based protein (MD=1.12, CI [0.98, 1.27]), plant-based protein (MD=-0.52, CI [-0.66, -0.38]), fat and oil (MD=0.32, CI [0.19, 0.45]), sweet food (MD=0.35, CI [0.22, 0.48]), salty food (MD=0.33, CI [0.21, 0.45]), alcohol (MD=0.56, CI [0.38, 0.76]), discretionary food (MD=0.37, CI [0.27, 0.48]), and DGI score (MD=-2.95, CI [-4.32, -1.60]).

Comparing food liking between DGI categories

One-way ANOVA were used to compare the mean differences of food liking between DGI tertiles (Table 4). Bonferroni method was used for accounting in Post-Hoc comparisons. Significant differences (Bonferroni adjusted alpha=0.01) were observed for Post-Hoc comparison across DGI tertiles for all food groups.

The mean difference of food liking between DGI tertiles was statistically significant for all of food groups: grains, vegetables, fruits, dairy, animal-based protein, plant-based protein, fat and oil, sweet food, salty food, healthy food, and discretionary food (p<0.01) except alcohol. There was a significant increase in liking of grain (p<0.01), vegetable (p<0.01), fruit (p<0.01), diary (p<0.01), plant-based protein (p<0.01), and healthy food (p<0.01) across DGI tertiles, participants with a high DGI score participants rating liking higher for these food groups than participants with a lower DGI score. Conversely liking for animal-based protein (p<0.01), fat and oil (p<0.01), sweet food (p<0.01), salty food (p<0.01) and discretionary food groups was higher for participants with a low DGI score compared to participants with a high DGI score.

Comparing food liking and DGI score between BMI categories

One-way ANOVA were used to compare the mean differences of food liking between BMI categories (Table 5). The Bonferroni method was used for accounting for multiple comparisons in Post-Hoc comparisons. Significant mean difference (p≤0.008) were observed for Post-Hoc comparison across BMI categories for all food groups.

The mean difference of food liking between BMI categories for all participants was statistically significant in six food groups: animal-based protein, plant-based protein, fat and oil, sweet food, salty food and discretionary food group. There was a difference between participants of a healthy weight and those overweight, in the liking of plant-based protein (p<0.001) with healthy weight participants rating their liking of that food higher than those overweight participants. There was a significant difference of liking of animal-based protein (p<0.001), fat and oil (p<0.001), sweet food (p<0.001), salty food (p<0.001), and discretionary food (p<0.001) groups with overweight participants rating liking higher than healthy weight participants.

The mean difference of food liking between BMI categories in female participants was statistically significant in seven food groups: animal-based, plant-based protein, fat and oil, sweet food, salty food, alcohol and discretionary food groups. There was a difference between participants of a healthy weight and those overweight, in the liking of plant-based protein (p<0.006) with healthy weight participants rating their liking of that food higher than those overweight participants. There was significant a difference in liking of animal-based protein (p<0.002), fat and oil (p<0.001), sweet food (p<0.001), salty food (p<0.001), and discretionary food (p<0.001) groups with overweight participants rating their liking higher than healthy weight participants. There was no difference of food liking and BMI categories in male participants for all of food groups.

DISCUSSION

The association between food liking and dietary quality intake in Australian young adults was explored in the present study. As hypothesised, a higher liking for healthy foods (as indicated by a higher food liking score) was associated with higher diet quality, and a higher liking for discretionary foods was associated with lower dietary quality. These associations were observed in both males and females.

One of our primary findings was a significant difference in food liking between DGI tertiles for all of food groups. The participants who had a higher liking for grains, vegetables, dairy, plant-based protein, healthy food groups had higher DGI scores than those in the low DGI and average DGI tertiles. In simple terms, the more an individual liked a food, the more of that food they consumed. As consumption of fruits, vegetables and wholegrains are below levels suggested for optimum health, developing strategies to increase consumption are important for public health. One strategy that is likely to be successful is flavour-nutrient learning through repeated exposure during childhood. For example, a study by Lakkakula et

al and Havermans & Jansen reported on the repeated exposure of vegetable flavours during childhood at school in the USA and the Netherlands.[36,37] The results showed that children improved the liking of vegetables after repeated exposure to the flavour of vegetables. If this increased liking is transferred through to adulthood the results from this study indicate increased consumption of vegetables. Furthermore, combined studies on healthy food liking and dietary quality by Zoghbi et al and Sharafi et al[26,27] examined that those who had a high liking of healthy food including grains, vegetables and fruit had a higher dietary quality and a lower BMI.

Liking of salty and sweet flavours can result in health issues through the overconsumption of food high in sugar and salt – often foods high in sugar and salt may be high in fat and energy.[2,23-25,28] Our studied found that participants who had a low DGI score had a higher liking for animal-based protein, fat and oil, sweet food, salty food, and discretionary food groups. Supporting this hypothesis, Mela, Frehlich et al, and Maskarinec et al[38-40] have observed that individuals who have a higher liking of high energy foods such as animal-based protein, fat and oil, sweet food, salty food, and discretionary food groups consumed more of those foods. This higher intake of high energy foods is at least in part likely to be driven by increased liking of this food group and linked to a poor dietary quality.

Gender differences in food liking and dietary quality were observed in the current study. Females reported a higher liking of healthy food groups and higher DGI score compared with males. Female participants were found to have a higher food liking score than the male participants in the following food groups: grains, vegetables, fruits, and plant-based protein. In contrast, the males had a significantly higher liking for dairy, animal- based protein, fat and oil, sweet food, salty food, alcohol and discretionary food. This observation is consistent with previous publications. A study of Cooke and Wardle reported that young UK female participants had significantly higher liking for fruit and vegetables in comparison to young male participants who had significantly higher liking preference for fatty and sugary foods, meats, processed meat products, and eggs.[41] It is potentially unsurprising as females have also been found to be more likely to have concerns about health than men and this may drive an increased liking for foods associated with health.[42] The current results, combined with those of Ward et al, Alan et al, Arganini et al, Hiza et al, and Guenther et al.[43-47] indicate that females report a greater liking for healthy food, experience high diet quality and have a higher health attitude than male.

Post hoc analysis revealed differences in liking of food groups between BMI categories. Overall a higher liking for animal-based protein, fat and oil, sweet food, salty food and

discretionary food groups was associated with a higher BMI. This is an intuitive finding supporting the large French study by Deglaire et al and Lampure et al[29,48] who reported a positive association between weight status and liking of salt and fat in adult cohort, individuals who have a high liking for salt and fat have a higher BMI. A study by Pallister et al[49] reported on the trends of food preference patterns and BMI in a UK twin cohort with higher liking for an animal-based protein pattern associated with a higher BMI. Appleton noted that frequency of consumption of animal-based protein was also associated with the liking of animal-based protein and a higher BMI in a cohort from the UK.[50] Multiple research studies of taste and nutrients in food have found that taste of food indicates the nutrient profile of the food, for example sweet indicates a carbohydrate rich food and salty and savoury indicate a protein rich food. Both sweet and salt tastes are appetitive and drive consumption of food, this can lead to higher intake of food and may increase the risk of further weight gain especially if those foods have high energy.[5,12,13,51-57]

The results of the present study add to the existing literature indicting that food liking is an important driver of food choice and consumption,[2-7,58] and can influence BMI.[16-20] Several studies have observed that participants who are focused on the flavour of food and are less motivated by health concerns will make unhealthy food choices.[59-61]

The present study has limitations that should be noted. Results for Grains, plant-base protein, fat and oil is presented for exploratory purpose due to poor internal consistency. The study populations are restricted to young adults attending university and may not be representative of the broader young adult Australian population. The participants were students who studied in health science may have had a greater overall interest in and awareness of the relationship between food intake and health.[62] However, the large sample size and the consistency with the observations from the current study and those available within the literature provide confidence in the outcomes from this study. It is also important to note that while increased liking of food was associated with increase in consumption of foods within the food groups, the magnitude was small and large numbers of participants are needed to find the effects.

Conclusions

Our findings demonstrate that food liking influences diet quality and BMI in Australian young adults. As the liking of food can be taught by repeated exposure especially during childhood, it is important to continue to explore strategies that increase the exposure and consumption of foods associated with health, and reduce exposure to foods associated with

increased BMI and poorer dietary quality. Strategies should also be explored to help those participants who are considered overweight or obese, in changing their flavour preference from unhealthy food groups to healthy food groups.

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AUTHOR DISCLOSURE

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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Table 1. Characteristics of study participants[†]

Characteristic	Total Participants (n=2,535) M(SD)	Males (n=582)[§] M(SD)	Female (n=1951) M(SD)
Age	21.9 (5.05)	21.9 (4.10)	21.9 (5.30)
Height (m)[*]	169.2 (9.26)	179.8 (7.50)	166.0 (7.13)
Weight (kg)[*]	65.5 (12.70)	77.4 (11.86)	62.0 (10.62)
BMI (kg/m^2)[*]	24.0 (3.74)	25.1 (3.19)	23.7 (3.82)
BMI categories, % (n)[*]			
Underweight	2.5 (64)	0.2 (1)	3
Healthy weight	64.0 (1,623)	52.7 (307)	67.4 (1,315)
Overweight	27.0 (684)	40.7 (237)	22.9 (446)
Obese	6.5 (164)	6.4 (37)	6.5 (127)

[†]Australian weight status; underweight ≤18.5; healthy weight BMI 18.5-24.9 (kg/m^2); overweight BMI 25-29.9 (kg/m^2); obese BMI ≥30(kg/m^2).[35]
[§]Two participants did not identify gender detail.
[*]Significant at 0.05 level.

Table 2. Internal consistency of conceptual groups generated from the FLQ (n=2,535)

Groups (58 items)	Cronbach's alpha	M (SD)
Grains - plain porridge, wholegrain bread, spaghetti, rice, grains	0.551	6.75 (1.31)
Vegetables – tomato, greens, broccoli, carrot, cabbage, mushrooms, potato (not deep-fried chips), vegetable soup	0.75	6.96 (1.31)
Fruits – apple, pineapple, melon, berries, banana, orange, grapes	0.71	7.57 (1.12)
Dairy - milk, yoghurt, cheese	0.78	6.66 (1.14)
Animal-base Protein - beef steak, lamb, pork products, chicken, duck, white fish, pink fish, eggs	0.89	6.30 (1.46)
Plant-based protein - beans and beans products (not include beverage), tofu, nuts	0.56[§]	6.19 (1.41)
Fat and oil – butter, margarine, olive oil	0.51[§]	5.77 (1.39)
Sweet foods - ice cream, sweet biscuits, chocolate, lollies, cake, cola soft drinks, citrus soft drinks, fruit juice	0.84	6.44 (1.50)
Salty foods – cornflakes, white bread, potato chips (crisps), corn chips, savoury biscuits, hamburgers, hot chips, Asian takeaway, pizza, toasted sandwich, KFC/Red Rooster/rotisserie chicken	0.88	6.40 (1.35)
Alcohol- red wine, white wine, beer e.g. lager/bitter	0.73	4.22 (1.17)

[†]Classification of Cronbach's alpha value: <0.50 = unacceptable; 0.51-0.60 = poor; 0.61-0.70 = questionable; 0.71-0.80 = acceptable; 0.81-0.90 = good; 0.91-1 = excellent.[33]
[§]Cronbach's alpha value 0.51-0.60 indicated poor internal consistency and results should be interpret with caution.

Table 3. Bivariate Linear Regression Analysis Investigating the association between food group liking and DGI and comparison mean difference between gender of food liking and DGI score

Variable	Association between food liking and DGI					
	All Participant (n=2535)			Male (N=582)		
	Liking score, M (SD)	β (95% CI)	η^2	Liking score M (SD)	β1 (95% CI)	η^2
Grains	6.8 (1.09)	2.45 (1.90, 3.00)***	0.036	6.5 (1.15)	2.56 (1.28, 3.85)***	0.038
Vegetables	7.0 (1.14)	1.17 (0.62, 1.72)***	0.008	6.4 (1.21)	0.69 (-0.58, 1.95)	0.003
Fruits	7.6 (0.94)	0.92 (0.28, 1.55)**	0.004	7.4 (1.00)	-0.27 (-1.73, 1.20)	0.000
Dairy	6.7 (1.91)	0.48 (0.17, 0.79)**	0.004	7.2 (1.54)	-0.17 (-1.17, 0.84)	0.000
Animal-based protein	6.3 (1.95)	-0.42 (-0.73, -0.11)**	0.003	7.2 (1.38)	-0.43 (-1.56, 0.69)	0.001
Plant-based protein	6.2 (1.58)	0.99 (0.61, 1.37)***	0.012	5.8 (1.51)	0.95, (-0.04, 1.93)	0.009
Fat and oil	5.8 (1.47)	-0.88 (-1.28, -0.47)***	0.009	6.0 (1.35)	-1.34 (-2.42, -0.26)*	0.015
Sweet food	6.5 (1.42)	-1.01 (-1.43, -0.60)***	0.011	6.7 (1.36)	-2.39 (-3.45, -1.32)***	0.048
Salty food	6.5 (1.35)	-0.86 (-1.30, -0.43)***	0.007	6.7 (1.28)	-1.68 (-2.85, -0.50)**	0.020
Alcohol	4.2 (2.14)	-0.18 (-0.46, 0.10)	0.001	4.7 (2.00)	-0.60 (-1.40, 0.20)	0.006
Healthy food	6.7 (0.80)	1.06 (0.32, 1.80)**	0.004	6.8 (0.83)	0.55 (-1.24, 2.33)	0.001
Discretionary food	6.2 (1.19)	-1.17 (-1.67, -0.68)***	0.010	6.4 (1.12)	-2.61 (-3.92, -1.30)***	0.038
DGI score	91.4 (13.98)			89.1 (14.98)		

Variable	Association between food liking and DGI			Comparison between gender	
	Female (n=1951)				
	Liking score M (SD)	β1 (95% CI)	η^2	Mean difference	95% CI of the difference
Grains	6.9 (1.06)	2.44 (1.82, 3.05)***	0.036	-0.39	-0.49, -0.28***
Vegetables	7.1 (1.06)	1.33 (0.70, 1.96)***	0.011	-0.71	-0.82, -0.60 ***
Fruits	7.6 (0.92)	1.34 (0.61, 2.06)***	0.008	-0.22	-0.31, -0.13***
Dairy	6.5 (1.98)	0.49 (0.16, 0.83)**	0.005	0.65	0.50, 0.81***
Animal-based protein	6.1 (2.02)	-0.43(-0.76, -0.10)**	0.004	1.12	0.98, 1.27***
Plant-based protein	6.3 (1.58)	0.96, (0.55, 1.38)***	0.013	-0.52	-0.66, -0.38***
Fat and oil	5.7 (1.50)	-0.82 (-1.26, -0.39)***	0.009	0.32	0.19, 0.45***
Sweet food	6.4 (1.43)	-0.70 (-1.16, -0.24)**	0.006	0.35	0.22, 0.48***
Salty food	6.4 (1.36)	-0.70 (-1.17, -0.22)**	0.005	0.33	0.21, 0.45***
Alcohol	4.1 (2.17)	-0.15 (-0.46, 0.16)	0.001	0.56	0.38, 0.76***
Healthy food	6.7 (0.80)	1.14 (0.31, 1.98)**	0.004	0.03	-0.04, 0.10
Discretionary food	6.1 (1.20)	-0.89 (-0.43, -0.34)**	0.006	0.37	0.27, 0.48***
DGI score	92.1 (13.54)			-2.95	-4.32, -1.60***

M: mean; SD: standard deviation; n: number of participants in each group; CI: confidence interval; β: standardised beta coefficient (gender and BMI), β [1] = Standardised beta coefficient (BMI): Significance indicated the ** p<0.01, *** p<0.001: η^2 = Eta-square effect size estimates for multiple regression small (<0.02), medium (0.02-0.13), and large (>0.26). [34] Results for Grains, plant-base protein, fat and oil is presented for exploratory purpose due to poor internal consistency.

Table 4. Comparing mean difference of food liking between DGI score tertiles

		Liking score				
Variable	All participants	Low DGI (41.39-85.28) (n=825)	Average DGI (85.29-97.68) (n=854)	High DGI (97.69-126.42) (n=856)	F (df1, df2)	*p*-value
Grains	6.8 (1.09)	6.5 (1.17)	6.8 (1.04)	7.0 (1.00)	49.77 (2, 2532)*	<0.0001
Vegetables	7.0 (1.14)	6.8 (1.21)	7.0 (1.10)	7.1 (1.08)	15.44 (2, 2532)*	<0.0001
Fruits	7.6 (0.94)	4.5 (0.97)	7.7 (0.88)	7.6 (0.97)	8.76 (2, 2532)*	<0.0001
Dairy	6.7 (1.91)	6.7 (1.82)	6.5(2.04)	6.9 (1.84)	11.15 (2, 2532)*	<0.0001
Animal-based protein	6.3 (1.95)	6.6 (1.77)	6.2 (2.05)	6.2 (1.99)	10.28 (2, 2532)*	<0.0001
Plant-based protein	6.2 (1.58)	5.9(1.58)	6.3 (1.54)	6.3 (1.56)	24.52 (2, 2532)*	<0.0001
Fat and oil	5.8 (1.48)	6.0 (1.40)	5.7 (1.51)	5.7 (1.49)	11.94 (2, 2532)*	<0.0001
Sweet food	6.5 (1.42)	6.7 (1.39)	6.4 (1.43)	6.3 (1.42)	14.63 (2, 2532)*	<0.0001
Salty food	6.5 (1.35)	6.7 (1.32)	6.4 (1.40)	6.4 (1.32)	9.07 (2, 2532)*	<0.0001
Alcohol	4.2 (2.14)	4.4 (2.17)	4.2 (2.14)	4.2 (2.12)	1.83 (2, 2532)	0.161
Healthy food	6.7 (0.80)	6.7 (0.83)	6.7 (0.78)	6.8 (0.79)	5.35 (2, 2532)*	0.005
Discretionary food	6.2 (1.19)	6.3 (1.17)	6.1 (1.20)	6.1 (1.18)	13.85 (2, 2532)*	<0.0001
Overall	6.6 (0.80)	6.7 (0.82)	6.6 (0.78)	6.6 (0.79)	1.60 (2, 2532)	0.202

M: mean; SD: standard deviation; n: number of participants in each group values are for the comparison food liking rating between DGI categories were determined using One- way ANOVA: * Bonferroni adjusted significance level = 0.01. Results for Grains, plant-base protein, fat and oil is presented for exploratory purpose due to poor internal consistency.

Table 5. Comparing food liking between BMI categories

Variable	Liking score, M(SD)													
	All participants (n=2,535)				F	Male (n=582)				F	Female (n=1,951)				F
	UWt	Healthy	OWt	Obese	(df1, df2)	UWt	Healthy	OWt	Obese	(df1, df2)	UWt	Healthy	OWt	Obese	(df1, df2)
Grains	6.6	6.8	6.7	6.7	1.73	4.6	6.5	6.5	6.2	1.84	6.7	6.9	6.8	6.8	0.74
	(1.28)	(1.07)	(1.12)	(1.08)	(3, 2531)	(0.00)	(1.10)	(1.17)	(1.33)	(3, 578)	(1.26)	(1.05)	(1.07)	(0.96)	(3, 1947)
Vegetables	7.0	7.0	6.9	6.9	1.54	5.6	6.4	6.4	6.1	1.04	7.0	7.1	7.1	7.1	0.455
	(1.24)	(1.13)	(1.15)	(1.10)	(3, 2531)	(0.00)	(1.22)	(1.19)	(1.22)	(3, 578)	(1.24)	(1.06)	(1.06)	(0.95)	(3, 1947)
Fruits	7.4	7.6	7.6	7.6	1.06	7.4	7.4	7.4	7.5	0.20	7.4	7.6	7.6	7.6	1.51
	(0.90)	(0.95)	(0.95)	(0.86)	(3, 2531)	(0.00)	(1.06)	(0.94)	(0.83)	(3, 578)	(0.91)	(0.91)	(0.94)	(0.88)	(3, 1947)
Dairy	6.3	6.6	6.8	6.8	2.51	8.0	7.2	7.1	7.1	0.24	6.3	6.5	6.6	6.8	1.42
	(1.87)	(1.95)	(1.88)	(1.63)	(3, 2531)	(0.00)	(1.52)	(1.59)	(1.38)	(3, 578)	(1.88)	(2.01)	(1.99)	(1.69)	(3, 1947)
Animal-based protein	5.6	6.2	6.6	6.5	12.93*	5.3	7.1	7.4	7.0	2.79	5.6	6.0	6.3	6.4	4.90*
	(2.29)	(2.02)	(1.76)	(1.57)	(3, 2531)	(0.00)	(1.49)	(1.20)	(1.48)	(3, 578)	(2.31)	(2.07)	(1.89)	(1.58)	(3, 1947)
Plant-based protein	6.0	6.3	6.1	5.7	6.05*	5.0	5.8	5.8	5.2	1.93	6.0	6.4	6.3	5.9	4.16*
	(1.65)	(1.58)	(1.53)	(1.62)	(3, 2531)	(0.00)	(1.56)	(1.43)	(1.51)	(3, 578)	(1.65)	(1.57)	(1.55)	(1.63)	(3, 1947)
Fat and oil	5.7	5.7	5.9	6.0	5.96*	5.7	6.0	6.0	6.1	0.12	5.7	5.6	5.9	6.0	5.68*
	(1.50)	(1.51)	(1.40)	(1.35)	(3, 2531)	(0.00)	(1.33)	(1.37)	(1.43)	(3, 578)	(1.51)	(1.54)	(1.41)	(1.33)	(3, 1947)
Sweet food	6.2	6.4	6.5	6.9	7.27*	7.9	6.7	6.7	7.0	0.64	6.2	6.3	6.5	6.8	6.19*
	(1.58)	(1.48)	(1.32)	(1.09)	(3, 2531)	(0.00)	(1.44)	(1.26)	(1.27)	(3, 578)	(1.58)	(1.47)	(1.34)	(1.03)	(3, 1947)
Salty food	6.3	6.4	6.6	6.9	8.00*	6.6	6.7	6.8	6.8	0.92	6.3	6.3	6.5	6.9	7.40*
	(1.36)	(1.40)	(1.28)	(1.05)	(3, 2531)	(0.00)	(1.34)	(1.18)	(1.41)	(3, 578)	(1.37)	(1.40)	(1.32)	(0.93)	(3, 1947)
Alcohol	3.6	4.2	4.3	4.5	3.44	1.0	4.6	4.8	4.7	1.59	3.7	4.1	4.1	4.4	1.80*
	(2.36)	(2.12)	(2.18)	(2.11)	(3, 2531)	(0.00)	(2.01)	(2.01)	(1.92)	(3, 578)	(2.35)	(2.13)	(2.23)	(2.16)	(3, 1947)
Healthy food	6.5	6.7	6.8	6.7	3.87	5.9	6.7	6.8	6.6	1.04	6.5	6.7	6.8	6.8	3.66
	(0.93)	(0.80)	(0.79)	(0.77)	(3, 2531)	(0.00)	(0.84)	(0.81)	(0.87)	(3, 578)	(0.93)	(0.80)	(0.78)	(0.74)	(3, 1947)
Discretionary food	6.5	6.7	6.8	6.7	10.02*	6.3	6.4	6.5	6.6	0.25	5.9	6.0	6.1	6.5	8.38*
	(1.28)	(1.23)	(1.11)	(0.90)	(3, 2531)	(0.00)	(1.18)	(1.05)	(1.10)	(3, 578)	(1.29)	(1.23)	(1.13)	(0.83)	(3, 1947)
Over all	6.4	6.6	6.7	6.8	6.95*	6.1	6.7	6.8	6.7	0.41	6.4	6.6	6.7	6.8	6.34*
	(0.93)	(0.81)	(0.78)	(0.70)	(3, 2531)	(0.00)	(0.81)	(0.78)	(0.83)	(3, 578)	(0.93)	(0.80)	(0.77)	(0.67)	(3, 1947)
DGI score	87.0	91.5	91.7	90.8	2.33	71.4	88.0	90.4	90.3	1.67	87.3	92.3	92.5	91.0	3.18
	(15.34)	(14.13)	(13.57)	(13.48)	(3, 2531)	(15.13)	(14.85)	(14.10)	(14.98)	(3, 578)	(15.34)	(13.70)	(12.74)	(13.54)	(3, 1947)

UWt: underweight; OWt: overweight; M: mean; SD: standard deviation; n: number of participants in each group: p values are for the comparison food liking rating between Australian and Thai samples were determined using One- way ANOVA: * Bonferroni adjusted significance level = 0.008: Australian weight status, underweight ≤18.5, healthy weight BMI 18.5-24.9 (kg/m^2), overweight BMI 25-29.9 (kg/m^2), obese BMI ≥30 (kg/m^2): [35] Results for Grains, plant-base protein, fat and oil is presented for exploratory purpose due to poor internal consistency.