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The share of ultra-processed foods determines the overall nutritional quality of diet in British vegetarians

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Abstract

The aim of this study was to describe the dietary intake of British vegetarians according to the Nova classification and to evaluate the association between the consumption of ultra-processed foods and the nutritional quality of the diet. We used data from the UK national survey (2008/2019). Food collected through a 4-d record were classified according to the Nova system. In all tertiles of the energy contribution of ultra-processed foods, differences in the average nutrient intake, as well as in the prevalence of inadequate intake, were analysed, considering the values recommended by international authorities. Ultra-processed foods had the highest dietary contribution (56·3 % of energy intake), followed by fresh or minimally processed foods (29·2 %), processed foods (9·4 %) and culinary ingredients (5 %). A positive linear trend was found between the contribution tertiles of ultra-processed foods and the content of free sugars (β 0·25, $P < 0·001$), while an inverse relationship was observed for dietary fibre (β –0·26, $P = 0·002$), potassium (β –0·38, $P < 0·001$), Mg (β –0·31, $P < 0·001$), Cu (β –0·22, $P < 0·003$), vitamin A (β –0·37, $P < 0·001$) and vitamin C (β –0·22, $P < 0·001$). As the contribution of ultra-processed foods to total energy intake increased (from the first to the last tertile of consumption), the prevalence of inadequate intake of free sugars increased (from 32·9 % to 60·7 %, respectively), as well as the prevalence of inadequate fibre intake (from 26·1 % to 47·5 %). The influence of ultra-processed foods on the vegetarian diet in the UK is of considerable magnitude, and the consumption of this food was associated with poorer diet quality.

Keywords: **Vegetarians: Dietary quality: Food processing: UK**

In recent years, vegetarianism has emerged as increasingly adopted dietary choice among people worldwide[1–3]. This dietary pattern is based on excluding or substantially reducing the consumption of animal products, focusing instead on plant-based foods[4]. In addition to its positive impact on reducing animal suffering and mitigating the effects of livestock on the environment[5,6], the vegetarian diet has been linked to several health benefits, including a lower risk of chronic diseases such as CVD, type 2 diabetes and certain types of cancer, as well as promoting a healthy body weight and better control of cholesterol levels and blood pressure[7–9].

Despite that, it is relevant to emphasise that not all plant-based diets may be equally beneficial to health[10–14]. This becomes even more significant in light of the transformations in food production and supply over the last decades, which have promoted an increase in the consumption of ready-to-eat or pre-made products conveniently labelled as vegetarian[15].

Ultra-processed foods are composed of substances derived from foods, including many that are exclusively used by the food industry, along with cosmetic additives that provide sensory attributes to these products. In addition, they lack whole foods in their composition and are high in sugar and fats and low in fibre and essential nutrients. These products are formulated to be highly attractive, convenient and widely available[16]. Several studies have shown an association between the consumption of these foods and lower overall nutritional diet quality[17] and an increased risk of obesity and other chronic diseases, as well as mortality[18,19].

Considering the increase in these foods, which are commonly sold in sophisticated packaging with claims related to nutrition,

Abbreviation: NDNS, National Diet and Nutrition Survey.

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health and even environmental issues, alongside aggressive marketing, it is necessary to evaluate the quality of vegetarian food by considering the degree and purpose of industrial food processing. Therefore, this article aims to describe the consumption of foods according to the groups of the Nova classification among British vegetarians and to evaluate the association between the consumption of ultra-processed foods and the intake of nutrients recommended in international guidelines for this group.

Methodology

Sampling, data collection and food consumption

Data from the National Diet and Nutrition Survey (NDNS) were utilised, encompassing the years 2008–2019. Detailed descriptions of the survey's methodology have been previously published[20,21]. Briefly, survey samples were randomly selected from the UK Postcode Address Archive, which contains a comprehensive list of all addresses in the four constituent countries (England, Wales, Scotland and Northern Ireland). From each randomly selected address, one child (aged 1·5–18 years) or one child along with an adult (aged 19 years or older) was selected. Data collection involved an interview with a researcher to obtain sociodemographic and food consumption information, as well as a visit from a nurse. Food consumption was assessed using a food diary completed by participants over four consecutive days. Participants who completed the diary for 3 or 4 d were included in the survey, resulting in a sample size of 15 643 individuals. In our study, we analysed data from individuals who identified as vegetarians, representing 2·3 % of the population (with 0·17 % identifying as vegan).

Food consumption was assessed using 4-d food diaries that included workdays and weekends, thus covering all days of the week. Individuals were instructed to record all food and beverages consumed on the day, inside and outside the home. It is important to note that children under 10 years of age had the help of their parents or caregivers for guidance when filling in the food record (and the 'self-declaration' of being vegetarian) with the help of the child. Portion sizes were estimated using homemade measurements or portions from labels. Once completed, the diaries were verified by interviewers with respondents, and missing details were added to enhance completeness. Diary days were randomly selected to ensure a balanced representation of all days of the week. Food consumption data from the complete registries were coded and edited using the DINO (Diet In, Nutrients Out) Program[22], and nutrient intake was estimated using the NDNS (Nutrient Databank) food nutrition composition table[23].

To identify participant groups, we used data from a questionnaire where participants self-declared as either vegetarians or vegans, collectively referred to as vegetarians. Initially, participants were asked, 'Can I check whether you would describe yourself as vegetarian or vegan?' with response options 'vegetarian', 'vegan' or 'neither'. If participants identified as vegetarian, an additional question served as a data quality control: 'Can I check if you eat meat, fish, poultry, or dishes containing these foods?' They responded with 'yes' or 'no'. For those identifying as vegan, another data quality control question followed: 'Can I check if you consume any food of animal origin, such as meat, fish, poultry, milk, dairy products, eggs, or dishes containing these foods?' Again, they responded with 'yes' or 'no'. We compared responses to the initial question with these follow-up questions and found no discrepancies. All foods reported by participants who identified themselves as vegetarians were included in the analyses, regardless of whether they included meat in their diet.

Our outcomes were based on the values recommended by the WHO for nutrient intake for the prevention of chronic non-communicable diseases: proteins, carbohydrates, free sugars, total fats, saturated fats and dietary fibre[24–27] and the European Food Safety Authority (EFSA) for micronutrients and vitamins A, B_6, B_{12}, C and E, Na, potassium, Ca, Mg, phosphorus, Fe, Cu, Zn, iodine and Se[28]. Protein content, carbohydrates, free sugars, total fats and saturated fats were expressed as a percentage of total energy intake, while fibre and micronutrients were expressed per 1000 kcal (g, mg or μg per 1000 kcal). We used the following cut-offs specified by the WHO for free sugars ≥ 10 % of total energy, saturated fats ≥ 10 % of total energy and dietary fibre < 12·5 g/1000 kcal. The recommended values for each micronutrient, based on EFSA guidelines and stratified by sex and age group, are presented in online Supplementary Table 1. Both the average requirements of the EFSA reference values and, in the absence of these, the adequate intakes were considered. Due to the scarcity of information about postmenopausal women, the recommended amount of Fe for this phase (6 mg/d) was adopted for individuals over 40 years of age. As for Zn, average requirements recommendations vary according to the amount of phytate present in the overall diet. Since these data are not included in the NDNS database, the intermediate Zn recommendations for moderate phytate levels (7·6 mg/d for women and 9·3 mg/d for men) were used.

Food classification according to industrial processing

All foods present in the food records were classified according to Nova, a food classification system based on the nature, extent and purpose of the industrial processing to which the food was subjected prior to its consumption[16]. The foods were classified exclusively into one of the four groups of Nova: fresh or minimally processed foods; processed culinary ingredients; processed foods; and ultra-processed foods; as well as their respective subgroups.

All foods in the NDNS database are coded as food numbers and grouped into subsidiary food groups (n 155). For the subsidiary food groups that include foods belonging to different Nova groups (n 52), the codes were classified individually. By doing so, it was possible to classify each ingredient of homemade preparations into its corresponding Nova group and subgroup. Further details regarding food categorisation methods can be found in previous publications[29,30].

Socio-economic and demographic characteristics

The socio-economic and demographic variables of interest were sex, age (continuous), region (England, Wales, Scotland and Northern Ireland), ethnicity (White, mixed groups such as White

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and Black Caribbean, White and Black African, White and Asian, or other origins, Black, Asian, and other ethnicities) and occupational social class (management positions and higher specialists, lower management and specialist positions, intermediate occupations (clerk, sales and service) and self-employed, manual and routine service occupations, technicians and unemployed). A missing category was created for the 'occupational social class' variable due to 2·8 % of the sample having missing data for this variable.

Data analysis

For the analyses, we used the average of all available food record days for each person, with more than 96 % completing all four food diary days.

First, we estimated the distribution of the total energy consumed by the individuals according to the groups and subgroups of Nova (% of the total energy of self-declared vegetarians). Next, we examined how the energy share of each Nova food group and subgroup varied in the tertiles of the energy share provided by ultra-processed foods in all groups. We also estimated nutritional indicators of the overall diet and within all tertiles of the dietary share of ultra-processed foods. Linear regression models were used to test trends in tertiles of the dietary contribution of ultra-processed foods. Standardised regression coefficients (β) were estimated to allow for comparisons across variables with different units.

Finally, we evaluated the prevalence of inadequate nutrient intake per tertile of the dietary share of ultra-processed foods. Prevalence ratios were estimated using Poisson regression. The models were adjusted for sex, age, ethnicity, occupational social class, region and year of research. We adopted a significance level of 5 % and for all analyses, the sample design of the research and its weighting factors were considered. Data were analysed using Stata version 16.0.

Results

Sociodemographic characteristics of the UK vegetarian population

A total of 359 participants who self-declared as vegetarians were eligible for the analyses, equivalent to 2·3 % of the general population in cycles 1–11 of the national survey. The majority of self-declared vegetarians were women (66·4 %), aged between 19 and 64 (73·6 %), of White ethnicity (70·5 %), held lower management or specialist positions (26·2 %) and lived in central England (55·7 %) (Table 1).

Table 1. Sociodemographic characteristics of the UK self-declared vegetarian population, NDNS 2008–2019 (percentages and 95 % confidence intervals)

	Self-declared vegetarians	
	%	CI
Sex		
Female	66·4	58·8, 73·3
Male	33·5	26·6, 41·1
Age group (years)		
1·5–10	7·1	5·3, 9·6
11–18	9·1	6·8, 12·1
19–64	73·6	67·4, 79·1
≥ 65	10·0	6·0, 15·9
Ethnicity		
White	70·5	61·3, 78·2
Mixed group	0·9	0·3, 2·5
Black	1·4	0·3, 6·1
Asian	26	18·4, 35·4
Other ethnicities†	0·9	0·1, 6·9
Occupational social class		
Higher management and specialist positions	26·1	20·0, 33·3
Lower management and specialist positions	26·2	20·3, 33·2
Intermediate (clerk, sales and service) and self-employed occupations	18·0	13·1, 24·2
Manual and routine service occupations, technicians and unemployed	24·0	17·6, 31·8
Region		
England (South)	19·4	13·9, 26·4
England (North)	15·1	10·4, 21·3
England (Centre)	55·7	47·6, 63·4
Scotland	5·1	3·0, 8·3
Wales	3·8	2·4, 5·9
Northern Ireland	0·7	0·4, 1·4

† Other ethnicities: Included in this variable are 'White and black Caribbean, white and black African, white and Asian or other origin'.

Distribution of the total energy consumed according to the groups of the Nova classification

The percentage of total energy consumed from fresh or minimally processed foods was 29·2 %, with the highest contributions coming from milk (4·6 %), fruits (4·4 %), grains (4·3 %) and roots and tubers (2·5 %). The percentage of total energy consumed from culinary ingredients was 5 %, with emphasis on animal fat (1·8 %), vegetable oil (1·5 %) and sugar (1·3 %). Processed foods contributed 9·4 % of the total energy consumed, with the highest consumption observed in cheeses (4 %), beers and wines (2·3 %), pickled vegetables (1·3 %) and processed breads (1 %). Ultra-processed foods contributed more than half of the total energy consumed, accounting for 56·3 %. The most consumed foods in this category were industrialised packaged breads (14 %), meatless ready-to-eat dishes (8 %), sweets and desserts (7·3 %), breakfast cereals (5 %), cookies (4 %) and 'vegetarian' meats (3·5 %) (Table 2).

Distribution of groups and subgroups of the Nova classification according to tertiles of consumption of ultra-processed foods in the vegetarian population

The dietary share of ultra-processed foods ranged from 37·5 % of total energy content (first tertile) to 74 % (third tertile). Across the groups of fresh or minimally processed foods, culinary ingredients and processed foods, the dietary contribution of most subgroups decreased from the first to the last tertile of ultra-processed food consumption. Notably, reductions were observed in nuts and seeds, grains, and vegetables (fresh or minimally processed foods), vegetable oils (culinary ingredients), and beers and wines and processed breads (processed foods).

For the ultra-processed food group, the dietary share of most subgroups increased from the first to the last tertile of the

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Table 2. Distribution of average energy consumed according to Nova classification groups in the UK self-declared vegetarian population, NDNS 2008–2019 (Average and 95 % confidence intervals)

	Percentage of total energy consumed	
	Self-declared vegetarians	
Nova groups and subgroups	Average	CI
1) Fresh or minimally processed foods	29·2	26·8, 31·6
Milk	4·6	3·9, 5·2
Fruits	4·4	3·7, 5·0
Grain	4·4	3·5, 5·2
Roots and tubers	2·5	1·9, 2·9
Legumes	2·4	1·8, 2·9
Vegetables	2·4	2·0, 2·8
Pasta	2·2	1·6, 2·7
Nuts and seeds	1·9	1·1, 2·5
Other minimally processed foods[a]	1.6	1·1, 2·0
Eggs	1·4	1·1, 1·7
100 % fruit juice[b]	1·2	0·7, 1·5
Fish	0·1	0·9, 6·3
2) Cooking ingredients	5·0	4·2, 5·7
Animal fats	1·8	1·2, 2·2
Vegetable oil	1·5	1·2, 1·8
Sugar	1·3	0·9, 1·6
Other cooking ingredients	0·4	0·0, 0·6
3) Processed foods	9·4	8·2, 10·2
Cheeses	4·0	3·4, 4·6
Beers and wines	2·3	1·6, 3·0
Pickled vegetables[c]	1·3	0·8, 1·7
Processed breads	1·0	0·2, 1·5
Other processed foods[d]	0·7	0·4, 0·9
4) Ultra-processed foods	56·3	53·7, 58·9
Industrialised packed breads	14·0	12·4, 15·7
Ready-to-eat dishes (meat-free)[e]	8·0	6·6, 9·3
Sweets and desserts[f]	7·3	6·1, 8·3
Breakfast cereals	5·0	4·1, 5·7
Cookies	4·0	3·3, 4·5
Vegetarian meats[g]	3·5	2·7, 4·2
Packet snacks	2·5	2·0, 2·9
Soft drinks	2·0	1·3, 2·6
Sauces	1·8	1·5, 2·1
Margarine	1·8	1·4, 2·1
French fries	1·7	1·2, 2·2
Milk-based beverages	1·3	0·9, 1·5
Other sugary drinks[h]	1·3	0·8, 1·7
Canned vegetables in sauce	0·8	0·5, 0·9
Other ultra-processed foods[i]	0·7	0·3, 1·0
Ready-to-eat dishes (with meats)[j]	0·5	0·1, 0·7
Reconstituted meats	0·2	0·0, 0·3
Ultra-processed cheeses	0·1	0·0, 0·1

[a] Coffee, tea, mushroom, mixed dishes; [b] Fresh fruit smoothie and fruit smoothie; [c] vegetables preserved in brine and fruit in syrup; [d] condensed milk, salted chestnuts; [e] pizza, instant soups, meat-free ready-to-eat dishes; [f] pies and cakes, ice cream, popsicles, desserts, stuffed sweets; [g] refer to imitation processed 'meats' (e.g. 'sausages', 'hams' or vegetarian 'hamburgers'). [h] soya-based beverages and other milk 'substitute' beverages; [i] distilled alcohol, artificial sweeteners; [j] burgers, sandwiches and ready-to-eat dishes that contain meats (such as bacon, sausage, beef, chicken or fish).

contribution of ultra-processed foods and was statistically significant for ready-to-eat dishes (meat-free), sweets and desserts, cookies, vegetarian meats, packet snacks, soft drinks, crisp, margarine, other sugary drinks, canned vegetables in sauce, ultra-processed cheeses and reconstituted meats. It is noteworthy that French fries (433·3 % increase), vegetarian meats (280 %), meatless ready-to-eat dishes (269·4 %), sweets and desserts (167·6 %) and packaged snacks (126·6 %) were the subgroups that showed the highest increases along the tertiles of the dietary participation of ultra-processed foods (Table 3).

Nutritional indicators of the diet according to the contribution of ultra-processed foods

The average energy intake of the participants was 1758·5 kcal/d, being distributed in the total diet in 12·3 % protein, 53 % carbohydrate, 10·9 % free sugar, 32·2 % fat and 11·4 % saturated fat.

As the tertiles of the contribution of ultra-processed foods to total energy intake increased, the content of free sugars increased significantly (from 8·9 % in the first tertile to 13 % in the last tertile), while the dietary content of fibre (from 15·7 % to 13·4 %), potassium (from 1742·3 mg to 1443·5 mg), Mg (from 178·6 mg to 154·2 mg), Cu (from 0·8 mg to 0·7 g), vitamin A (from 712·4 µg to 443·3 µg) and vitamin C (from 68 mg to 47·7 mg) decreased.

In the analysis using the continuous variable, we observed that for each 10 % increase in the dietary contribution of ultra-processed foods, the free sugar content (β –0·25) increased, while the density of fibre (β –0·26), potassium (β –0·38), Cu (β –0·22), Mg (β –0·31), Zn (β –0·15), iodine (β –0·25), vitamin A (β –0·37) and vitamin C (β –0·22) decreased (Table 4).

Prevalence of inadequate intake according to dietary contribution of ultra-processed foods

More than half of vegetarians did not meet the recommended values for saturated fat (65·3 %) and dietary fibre (42·9 %). Regarding micronutrients, 95 % of the participants had inadequate potassium intake and more than half had inadequate intake of Mg, Cu, Zn, iodine, vitamin B_{12} and E. As the contribution of ultra-processed foods to total energy intake increased (from the first to the last tertile of consumption), the prevalence of inadequate intake of free sugars increased significantly (from 32·9 % to 60·7 %, respectively), as well as the prevalence of inadequate fibre intake (from 26·1 % to 47·5 %).

In the analysis using the continuous variable, we observed that for every 10 % of the dietary contribution of ultra-processed foods, the prevalence of inadequate intake of free sugar (prevalence ratio = 1·12), dietary fibre (prevalence ratio = 1·12) and potassium (prevalence ratio = 1·01) increased (Table 5).

Discussion

Ultra-processed foods contributed more than half of the energy consumed by the UK's vegetarian population, with emphasis on packaged breads, meat-free ready-to-eat dishes and sweets and desserts. As the dietary share of ultra-processed foods increased, there was a decrease in the share of fresh and minimally processed foods, culinary ingredients, and processed foods, particularly in subgroups that are considered markers of healthy eating, such as grains and cereals, fruits, nuts, and seeds, and vegetables.

The higher consumption of ultra-processed foods was associated with poorer nutritional quality of the diet, with higher free sugar content and lower amounts of fibre, potassium, Mg,

Table 3. Distribution of the groups and subgroups of the Nova classification according to the tertiles of consumption of ultra-processed foods (UPF) in the self-declared vegetarian population of the UK, NDNS 2008–2019

% of total energy consumed				
	Tertiles of the contribution of UPF consumption to total energy intake among vegetarians			$P_{for\ trend}$
Nova groups and subgroups	T1	T2	T3	
1) Fresh or minimally processed foods	43·6	27	16·8	< 0·001
Milk	5·7	53·2	31·5	0·003
Fruits	6·5	3·7	2·9	< 0·001
Grains	8·5	3·2	1·5	< 0·00
Roots and tubers	2·7	2·3	2·4	0·706
Legumes	3·7	2·3	1·4	< 0·001
Vegetables	4·4	1·9	0·9	< 0·001
Pasta	2·7	2·6	1·3	0·051
Other minimally processed foods[a]	2·3	1·6	0·6	0·009
Eggs	1·7	1·6	1·1	0·157
Fruit juice 100 %[b]	1·2	1·5	0·8	0·254
Fish	0·3	0·3	0·5	0·45
2) Culinary ingredients	7·1	4·8	2·9	< 0·001
Animal fats	2·1	2·1	1	0·007
Vegetable oil	2·7	1·2	0·7	< 0·001
Sugar	1·7	1	1·1	0·211
Other culinary ingredients	0·6	0·5	0·1	0·029
3) Processed foods	11·7	10·3	6·2	0·001
Cheeses	4	4·9	3·4	0·549
Beers and wines	3·2	2·9	0·9	0·007
Pickled vegetables[c]	2·1	1	0·9	0·058
Processed breads	1·5	0·6	0·6	0·304
Other processed foods[d]	0·8	0·8	0·3	0·145
4) UPF	37·5	57·9	74	< 0·001
Industrialised packaged breads	13·9	14·3	14·2	0·89
Ready-to-eat dishes (meat-free)[e]	3·6	7·1	13·3	< 0·001
Sweets and desserts[f]	3·4	9·4	9·1	< 0·001
Breakfast cereals	4·6	5·4	4·9	0·798
Cookies	2·5	4·3	5	0·001
Vegetarian meats[g]	1·5	3·3	5·7	< 0·001
Packet snacks	1·5	2·5	3·4	0·002
Soft drinks	0·8	1·5	3·8	0·002
Sauces	1·5	2·4	1·6	0·785
Margarine	1	2	2·3	0·002
French fries	0·6	1·5	3·2	< 0·001
Milk-based beverages	1	1	1·8	0·065
Other sugary drinks[h]	0·6	1·1	2	0·022
Canned vegetables in sauce	0·5	0·6	1·1	0·029
Other UPF[i]	0·3	0·6	1·1	0·067
Ready-to-eat dishes (with meats)[j]	0	0·5	0·9	0·053
Reconstituted meats	0	0	0·5	0·029
Ultra-processed cheeses	0	0·1	0·2	0·003

[a] Coffee, tea, mushroom, mixed dishes; [b] fresh fruit juices and fruit smoothie; [c] vegetables preserved in brine and fruit in syrup; [d] ham, meat and fish, smoked, salted or canned; [e] pizza, instant soups, meat-free ready-to-eat dishes; [f] pies and cakes, ice cream, popsicles, desserts, filled sweets; [g] refer to imitation processed 'meats' (for example, 'sausages', 'hams' or vegetarian 'hamburgers'), [h] soya-based beverages and other milk 'substitute' beverages; [i] distilled spirits, artificial sweeteners; [j] hamburgers, sandwiches, and ready-to-eat dishes that contain meats (such as bacon, sausage, beef, chicken or fish).

Cu, iodine, vitamin A and vitamin C. These results provide new insights the dietary contribution of ultra-processed foods and their impact on the overall diet quality of vegetarians, since few studies have evaluated the diet of this population considering the different levels of processing. The lack of statistically significant findings regarding Na levels across the tertiles of ultra-processed foods may be attributed to the high prevalence of elevated Na intake among self-declared vegetarians, as all participants have an excessive intake of this nutrient (see Table 5). Another salient observation pertains to specific micronutrients, notably Fe, for which we did not discern a pattern akin to those commonly observed in analogous studies. This discrepancy may arise from the consumption of ultra-processed foods fortified with said micronutrients, or from inherent disparities in nutritional composition among distinct subcategories of ultra-processed foods.

The significant dietary contribution of ultra-processed foods to the total energy intake of British vegetarians observed in this study aligns with findings in studies conducted in high-income countries. Similar trends have been reported in the general populations of the USA (57·5 %), the UK (56·8 %), Canada (47·7 %), Australia (42 %) and France (24·1 %)[29,31–34]. Regarding vegetarian populations, a French cohort study showed that the energy contribution of ultra-processed foods was higher for vegetarians (37 %) and vegans (39·5 %) than for meat eaters (33 %) and that this high intake was driven by the consumption of vegetarian meats and plant-based beverages[13].

The negative impact of the greater dietary contribution of these foods on the nutritional quality of the diet observed in our study is consistent with studies conducted with representative samples of the general population from several countries[32,34–36]. In the UK, analysis of general population consumption data showed that as the consumption of ultra-processed foods increased, the dietary content of carbohydrates, free sugars, total fats, saturated fats and Na increased, while the protein, fibre and potassium content decreased[29].

The possible reasons for the high consumption of ultra-processed foods among British vegetarians may be due to social and economic issues, given that most of this population is in management and specialist positions[37]. Along with this, most of it is in the centre of England, where you can have more access to ultra-processed foods. The idea that vegetarian eating is inherently healthy due to its superior nutritional quality has been widespread due to the potential benefits associated with health[9,10,12,38–40]. However, the findings of our research offer a critical view of this assumption by revealing that the vegetarian population has experienced a high consumption of ultra-processed foods and an unfavourable nutritional profile, specifically, indicating an increase in sugar content. This can be explained by the high amount of sugars present in plant-based products. Excessive consumption of these foods by vegetarians raises concerns about potential negative impacts on health[14].

The lower content of fibre, potassium, Mg, Cu and vitamins A and C associated with the higher consumption of ultra-processed foods may result from the substitution of fresh and minimally processed foods with ultra-processed alternatives. A study conducted on the French NutriNet-Santé cohort demonstrated that most vegetarians have a preference for unhealthy products over healthier options, as assessed through a plant-based diet index[13]. This may explain, in part, the unfavourable nutritional profile of the diet observed in our analysis.

Finally, considering the energy contribution of some meat-containing dishes, we can observe that self-reported vegetarian

Table 4. Nutritional indicators of the diet according to consumption of ultra-processed foods in the self-declared vegetarian population of the UK, NDNS 2008–2019

		Ultra-processed foods (% of total energy)					
		Tertile of consumption*				Continuous (10 % increase in consumption)	
Indicator	Total diet	T1	T2	T3	$P_{for\ linear\ trend}$	β*	$P_{for\ linear\ trend}$
Energy consumed (kcal/d)	1758·5	1623·8	1881·4	1771·5	0·197	0·12	0·136
Protein (% of total energy)	12·3	12·5	11·9	12·4	0·777	–0·05	0·510
Carbohydrate (% of total energy)	53·0	52·5	51·5	54·9	0·109	0·13	0·116
Free sugar (% of total energy)	10·9	8·9	10·8	13·0	0·002	0·25	0·001
Fats (% of total energy)	32·2	31·3	33·9	31·5	0·872	0·04	0·619
Saturated fats (% of total energy)	11·4	11·1	12·4	10·8	0·689	0·01	0·912
Dietary fibre density (g/1000 kcal)	14·1	15·7	13·1	13·5	0·012	–0·26	0·002
Na density (mg/1000 kcal)	1110·9	1070·2	1093·4	1170·3	0·071	0·14	0·116
Potassium density (mg/1000 kcal)	1563·2	1742·3	1500·5	1443·5	< 0·001	–0·38	< 0·001
Ca density (mg/1000 kcal)	508·8	508·9	521·9	495·4	0·647	–0·01	0·933
Mg density (mg/1000 kcal)	163·5	178·6	157·4	154·2	0·004	–0·31	< 0·001
Phosphorus density (mg/1000 kcal)	658·7	682·0	648·1	645·5	0·116	–0·14	0·057
Fe density (mg/1000 kcal)	6·6	6·9	6·3	6·6	0·378	–0·09	0·240
Cu density (mg/1000 kcal)	0·8	0·8	0·7	0·7	0·027	–0·22	0·003
Zn density (mg/1000 kcal)	4·6	4·9	4·3	4·5	0·095	–0·15	0·044
Iodine density (μg/1000 kcal)	73·9	83·7	75·4	62·4	0·013	–0·25	0·005
Se density (μg/1000 kcal)	20·6	21·8	19·8	20·3	0·408	–0·03	0·668
Vitamin A density (μg/1000 kcal)	558·8	712·4	517·7	443·3	< 0·001	–0·37	< 0·001
Vitamin B_6 density (mg/1000 kcal)	0·9	0·9	0·8	0·8	0·259	–0·09	0·350
Vitamin B_{12} density (μg/1000 kcal)	1·7	1·7	1·9	1·5	0·262	–0·04	0·665
Vitamin C density (mg/1000 kcal)	58·1	68·0	58·5	47·7	0·005	–0·22	0·001
Vitamin E density (mg/1000 kcal)	6·2	6·2	6·2	6·3	0·763	0·01	0·875

* Standardised regression coefficient: adjusted for sex, age, ethnicity, occupational social class, region and year of survey.

Table 5. Prevalence of inadequate intake according to consumption of ultra-processed (UPF) foods in the self-declared vegetarian population of the UK, NDNS 2008–2019

		UPF (% of total energy)					
		Consumption tertile				Continuous (10 % increase in consumption)	
Indicator	Total diet	T1	T2	T3	$P_{for\ linear\ trend}$	PR*	$P_{for\ linear\ trend}$
Free sugar (> 10 % of total energy)	46·9	32·9	45·9	60·7	0·009	1·12	0·042
Saturated fat (> 10 % of total energy)	65·3	55·2	77·7	61·9	0·597	1·04	0·226
Dietary fibre density (< 12·5 g/1000 kcal)	42·9	26·1	52·4	47·5	0·009	1·12	0·048
Na density (mg)†,‡	100						
Potassium (mg)‡	95·5	92·0	96·6	98·1	0·062	1·01	0·033
Ca (mg)‡	42·8	47·0	28·0	54·7	0·465	1·01	0·727
Mg (mg)‡	63·8	62·2	58·6	70·9	0·359	1·05	0·182
Phosphorus (mg)‡	3·3	3·0	1·1	17·7	0·274	2·08	0·213
Fe (mg)‡	10·2	12·2	6·5	12·8	0·813	1·02	0·884
Cu (mg)‡	60·3	54·2	61·1	65·5	0·263	1·06	0·146
Zn (mg)‡	56·5	59·9	49·4	60·4	0·984	1·00	0·963
Iodine (μg)‡	64·5	66·0	56·1	72·1	0·564	1·04	0·314
Se (μg)‡	7·1	5·3	8·7	6·5	0·884	0·94	0·741
Vitamin A (μg)‡	22·6	21·4	14·2	33·6	0·258	1·10	0·324
Vitamin B_6 (mg)‡	35·4	39·5	24·9	43·1	0·789	1·05	0·426
Vitamin B_{12} (μg)‡	69·2	73·5	57·5	77·5	0·717	1·00	0·792
Vitamin C (mg)‡	45·0	41·4	40·0	53·0	0·248	1·07	0·222
Vitamin E (mg)‡	66·0	71·8	63·5	62·8	0·301	0·94	0·078

PR, prevalence ratio.
* PR: adjusted for sex, age, ethnicity, occupational social class, region and year of survey.
† The tertile analyses were not performed because 100 % of the participants exceeded the maximum recommended Na intake.
‡ The recommended values for each micronutrient, by sex and age group, are presented in online Supplementary Table 1.

diets and vegetarian diet status based on dietary data may not be consistent. This discrepancy may arise because vegetarians have their own individual definitions of vegetarianism, a term that can be interpreted broadly.

In recent years, there has been a rise in plant-based meat and dairy substitutes, with various companies capitalising on the growing consumer preference for vegetarian options. These products are prominently displayed in supermarkets and often

marketed alongside traditional meat and dairy products. While vegetarian or plant-based diets are generally associated with health benefits, not all plant-based diets offer the same advantages. Our study focuses on how ultra-processed foods affect the energy intake of self-declared vegetarians in the UK and the nutritional quality of their diets. This research suggests the need for policies that encourage informed food choices among vegetarian consumers. We used data from the NDNS, which employs a high-quality dietary assessment method providing a detailed analysis of the foods consumed. This method considers variations in consumption between different days of the week and seasons. Additionally, we utilised the Nova food classification system, which is widely recognised as a valid tool for nutrition research, public health and policy.

Some potential limitations also need to be considered. The data that were used are self-reported and therefore susceptible to social desirability bias; in essence, it constitutes a systematic research bias wherein participants tend to provide responses that align more closely with socially desirable norms rather than accurately reflecting their genuine opinions or behaviours. Regarding the methods, although food records are already recognised as one of the most comprehensive methodologies for assessing food consumption, one limitation is the possibility of abstaining from reporting some foods, especially ultra-processed foods. This may be due to the wide dissemination of the findings that the consumption of these foods causes in health. However, the data that NDNS provides are validated and accurate, where reviews are made by trained professionals to minimise the possibility of incorrect records[21]. Even though the data in the NDNS database do not consider the degree of food processing, the standardisation methods minimise possible errors and biases. Lastly, we acknowledge that the cut-off values in UK guidelines differ slightly from those of the WHO and EFSA, which may lead to minor variations in prevalence rates of nutrient inadequacy.

Conclusion

In this cross-sectional study, it was possible to analyse food consumption in detail, considering the different levels of industrial processing among British vegetarians, and to evaluate the impact of the dietary contribution of ultra-processed foods on the intake of nutrients recommended in the international guidelines for the prevention of chronic non-communicable diseases.

Our findings highlight that the impact of ultra-processed foods on the diet of the vegetarian population in the UK constitutes more than half of the energy consumed. Therefore, a higher consumption of ultra-processed foods is associated with a poorer nutritional quality of the diet.

We reinforce the need for public policies that include fiscal and regulatory measures on these foods in order to reduce their consumption and thus increase the consumption of healthy preparations from minimally processed foods.

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The authors have no conflict of interest to declare.

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Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114524001909

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