Is the modern vegetarian diet as healthy as it used to be?

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Summary

Recently there has been an increase in people choosing a vegetarian diet, due to a variety of reasons, including the availability of plant-based meat alternatives. This modern vegetarian diet is marketed as being just as healthy as what is traditionally considered to be a vegetarian diet, despite the fact that its effects on health are not entirely understood. The aim of this thesis is to elucidate the health outcomes of both, by comparing the nutritional composition of these variants and the standard diet (which includes meat).

Generally, a vegetarian diet leads to less intake of protein, total and saturated fats and vitamin B12 than a meat diet. It also encompasses a higher consumption of fiber, carbohydrates and sodium. When comparing vegetarian diets, a few patterns emerge. A traditional diet is defined by a high intake of whole foods, such as fruits, vegetables, legumes, nuts and whole grains, whereas the modern one relies more on takeout, snacks and ultra-processed foods that are meant to replace meat. The findings reveal clear differences between the two vegetarian diets. The traditional one has been shown to have positive health benefits, including lower risks for metabolic syndrome, neurodegenerative diseases and certain cancers. Conversely, the modern diet relying on ultra-processed foods can lead to nutritional deficiencies and adverse health effects due to higher intake of saturated fats, sodium and industrial additives.

Ultimately, the modern vegetarian diet is not as healthy as the traditional one. To maintain health, it is important to eat a variety of whole foods and avoid relying on convenient ultra-processed foods and to pay extra attention to the claims made on labels, which exaggerate the healthfulness of products.

Terms and Abbreviations

acellular nutrients = nutrients found outside of cells, such as in milk or fruit juices
bioavailability = fraction of a given compound or its metabolite that reaches the systemic circulation
FFQ = food frequency questionnaire
PDI = plant derived index, a value to compare the healthfulness of plant-based foods
UPF = ultra-processed food

Introduction

Vegetarianism is usually defined by the absence of meat in the diet. Most often, this category is divided into lacto-ovo-vegetarianism (consumption of milk and eggs), pescetarianism (consumption of fish) and veganism (avoidance of all animal products). However, these are general labels and, when taking a closer look, different patterns emerge based on the individual foods that comprise the diet. The motivation behind choosing vegetarianism can differ, and it has an impact on the precise composition of the diet, and therefore its health outcomes. According to a survey by Wunsch (2024), 40% of respondents in 2023 chose to participate in Veganuary (annual challenge promoting veganism) for animal welfare. The other top reasons being personal health (21%) and the environment (18%). In another study, these reasons are divided into two categories: moral (for animal and environmental preservation) and health (physical wellness and weight control) (Dai & Leung, 2024). Personal motivations are not the only reasons to become vegetarian, and as it will be explained, the increased availability of plant-based meat alternatives also plays a role.

In recent years, vegetarianism has seen a decrease in "emerging economies" such as India, but it is overall on the rise, like in Europe and the United States (Buchholz, 2022). For example, in the UK veganism quadrupled between 2014 and 2019 (Gallagher et al., 2021). Furthermore, there is a rise in the consumption of plant-based meat alternatives, with yet unclear health consequences (McClements & McClements, 2023). This increase can be attributed to multiple factors that also play a role as the motivation for choosing such a diet. Traditionally, the key factors were mainly just animal welfare, the environment and personal health. Recently, due to the convenience and accessibility of plant-based meat alternatives, people that wouldn't have chosen a vegetarian diet are more likely to do so.

	2009-2010	2018-2020
India	450M (35%)	276M (29.5%)
Brazil	8%*	29.3M (14%)
USA	12M (4%)	14M (4.2%)
UK	5.4M (9%)	6.2M (10%)
Netherlands	0.7M (4%)	0.85M (5%)

Table 1. Total number of vegetarians (and proportion of population) across 10 years (World Population Review, n.d.)

*percentage is given as fraction of respondents to a survey (Statista Research Department, 2024)

When vegetarianism saw its first spike in popularity (at least in the western world), it attracted a niche group of people, motivated to follow this diet for the reasons stated above. It wasn't an easy feat, so it is likely that some people that tried it consequently gave up. Only the long-term vegetarians (which studies pay attention to) were the ones willing to put in the effort. However, nowadays with the increased availability of plant-based meat replacements, it is a lot easier to adhere to such a diet, therefore the demographic composition of this group has changed. Currently, vegetarians tend to be younger people (millennials), with 37% stating that vegetarianism is a healthier option and 22% choosing a vegetarian diet at least for some time (Phoenix, 2023). To better illustrate this group, 67% of vegans are females, a vegan household tends to spend 8% less on groceries. On average they earn less than $30,000 a year and 44% of vegans choose plant-based meat alternatives (Joshi, 2023). Since vegetarians are a niche group different from the general population, there could be confounding factors that have an impact on their health. These include their age, the overrepresentation of women, lower body mass index and higher level of physical activity (Gehring et al., 2020).

With the now changing composition of vegetarian diets and increase of people choosing this diet, it is uncertain how this new-age vegetarianism compares with the traditional version, based mainly on unprocessed foods. Even just ten years ago it was shown that a well balanced vegetarian or vegan diet can prevent metabolic syndrome and neurodegenerative diseases, mainly attributed to the consumption of whole grains, pulses, fruits and vegetables (Pistollato & Battino, 2014). It is therefore important to understand if these effects are still present nowadays, or if ultra-processed foods (UPFs) negate the benefits of a vegetarian diet. The filters through which the information will be analyzed are nutritional contents (particularly protein, saturated fats, fiber and vitamin B12), general health outcomes and the effects on the microbiome.

This thesis therefore aims to illuminate how the diet has changed and what the health impacts of that change are. With the information provided, readers can make more informed decisions and answer the question: Are vegetarian diets nowadays still as healthy as they used to be?

Standard diet vs vegetarianism

As humans differ massively in their routines, choices and lifestyles, analyzing their diets is a challenging task. However, with a sufficiently large sample, patterns emerge. Firstly, a large study from 2014 will be discussed. A Food Frequency Questionnaire (FFQ) was used to analyze the food patterns of 89 000 US vegetarians and non-vegetarians. As standard procedure, vegetarians were defined by avoidance of meat, but from the analysis additional patterns surfaced. Across all vegetarian groups, a higher consumption of fruits, vegetables, grains and nuts, but a lower consumption of dairy products, eggs, added fats, sweets, and non-water beverages was observed. An expectation that was contradicted by this data, was that lacto-ovo vegetarians would consume more dairy products and eggs to make up for the lack of meat. However, that was not the case. Instead they observed that vegetarians access a variety of food-sources, which can be helpful to mitigate the lack of (micro)nutrients that would normally originate from animal products. Furthermore, since vegetarians eat more plant-based foods, they are ingesting a larger amount of fiber and a variety of phytochemicals (plant chemicals), with positive effects on health (Orlich et al., 2014).

This data is in line with the expectation of a traditional vegetarian diet being generally healthy. When compared to a standard diet (an average diet of people who include meat and fish), vegetarians have half the risk of developing type 2 diabetes, 24-32% lower mortality from ischaemic heart disease, but no difference in the risk of stroke (Appleby & Key, 2015). Moreover, the standard diet has been seen as less healthy due to the heightened risk for developing hypertension, heart failure and risk of type 2 diabetes, especially for processed meat products (Geiker et al., 2021).

However, when looking at newer models, where processed plant-based meat alternatives are included, some more differences between the diets become clear. For example, a study modeled the effects of switching from a standard diet to a vegetarian one, using data from the UK National Diet and Nutrition Survey rolling program. The partial replacement model investigated replacement of meat with alternatives, by either 25, 50, 75 or 100%. The alternative model replaced the total amount of meat with either vegetable, myco-, bean and pea, tofu, nut-based and soy protein. The modeled nutritional intakes were compared with the data from the FFQ, where vegetarians were excluded as to portray only the standard diet (Farsi et al., 2021). Representative results can be seen in the following tables:

	Standard	Partial Replacement Model	Alternative Model
Protein. g/d	86.67	-8.982	-12.572
Saturated fat, g/d	30.96	-2.407	-4.005
Fiber, g/d	21.86	+4.947	+7.308
B12, μg/d	7.47	-1.047	-1.766

Table 2. Average changes in nutrient intake based on the study by Farsi et al. (2021). In the partial replacement model the average is taken from 25, 50, 75 and 100% replacement and in the alternative model the average nutritional values of different plant-based alternatives are calculated. Standard value was calculated from the FFQ responses.

	Standard	Vegetarian
Protein, %	15.372	5.739
Saturated fat, %	5.75	4.254
Fiber, %	0	2.683
B12, %(μg)	1.833	0.983

Table 3. Average nutritional intake when comparing chicken nuggets, salmon, eggs, milk and cheese with their plant-based counterparts. % is g of nutrient per 100g of food, or 100 ml for milk. Vitamin B12 is given in μg per 100g (McClements & McClements, 2023).

Based on these studies, there is a tendency of vegetarian foods to contain less protein, fat and vitamin B12 than standard animal-derived foods, but more fiber. The decrease in protein does not pose a threat to health, since keeping track and eating more food easily mitigates its possible deficiency. As the World Health Organization recommends that no more than 10% of calories come from saturated fats, and the fact that they have detrimental effects on cardiovascular health, make the decline in saturated fat favorable. Vitamin B12 deficiency should be actively prevented, due to its physiological importance and possible negative effects of supplementation. The positive effects of increased fiber consumption will be discussed in the following chapters.

Traditional vegetarian vs modern vegetarian

As explained in the previous chapter, there are some significant differences between a plant-based and animal-based diet. However there are also differences between the vegetarian diets themselves, which we will now explore.

From cluster and factor analyses done by Gallagher et al. (2021), four clusters of vegetarians emerged: **convenience** (most identifiable pattern, with a higher consumption of sweets, crisps, fats and oils, convenience meals & snacks and dairy alternatives), **health conscious** (indicated by cooking from scratch and using protein alternatives to meat and fish), **unhealthy** (high alcohol, take-aways and salt) and **traditional** (potatoes, vegetables, fruit and grains). To validate these patterns, cluster analysis was conducted. Results show that all but two respondents belong to one of three clusters: convenience, traditional and health conscious. The largest number of participants (51.2%) fit in the last cluster, as opposed to the results from the factor analysis, where the largest group was following the convenience pattern (22%).

These findings are corroborated by McClements and McClements (2023), who identified two categories of vegetarian diets, traditional and new. The *traditional* category is comparable to the health conscious and traditional groups found by Gallagher et al. (2021). The *new* category, which is defined by a higher consumption of ultra-processed “Next-Generation Plant Based” food, is comparable to the convenience and unhealthy groups from the Gallagher et al. (2021) study.

Consequently, the contemporary vegetarian diet can be primarily divided into two categories. There is the traditional version, which is most similar to the classic vegetarian diet. It is characterized by high consumption of whole foods, such as fresh fruits and vegetables, nuts, whole grains and potatoes (Gallagher et al., 2021). This diet still encompasses all the health benefits discovered by studies investigating classical vegetarianism. Contrastingly, the modern vegetarian diet is one characterized by convenience (a higher consumption of sweets, crisps, fats and oils, convenience meals & snacks and dairy alternatives), consumption of UPFs and a tendency to not plan meals adequately, which can lead to deficiencies.

The traditional vegetarian diet

A well balanced vegetarian diet, such as the traditional one, has been shown to have positive health effects. A summary of cross-sectional and prospective cohort studies by Appleby and Key (2015) found vegetarians to have lower risks for diabetes, diverticular disease, eye cataract, degenerative arthritis, hyperthyroidism, metabolic syndrome, obesity and ischaemic heart disease. They indicate that vegetarians might have a lower risk of developing cancers, particularly stomach, lymphatic and hematopoietic. However, these findings were not confirmed by all studies they analyzed.

Another study investigated the role of vegetarianism in preventing metabolic syndrome and neurodegenerative diseases. Metabolic syndrome is a cluster of risk factors for cardiovascular disease and is mainly characterized by abdominal obesity, high blood pressure, dyslipidemia and inflammation. The authors lay out how a traditional vegetarian diet (composed of mainly fruits, vegetables, legumes and whole grains) can prevent and even reverse metabolic syndrome.

For example, plant antioxidants can reduce oxidative stress, likely reducing inflammation. Mono- and poly- unsaturated fatty acids have been shown to decrease hypertension, insulin resistance and triglyceride levels. Furthermore, fiber has a wide array of positive health benefits such as reducing diabetes risk, blood pressure, fasting blood glucose and lipid profile and increasing insulin sensitivity.

This analysis takes into account the fact that traditional vegetarian food is less calorically dense, which helps to avoid overeating. Then, the authors explain how vitamins (Bs, C, D, K and E) and minerals (Fe, Li, Mg, Cu, I, Mn), which are often found in plant foods, have a neuroprotective effect. A big part of this effect is also the reduction of inflammation. The rest is attributed to phytochemicals (polyphenols, nicotinamide, creatine, melatonin, resveratrol and flavonoids) with a variety of pharmaceutical effects, such as epigenetic regulation (downregulation of disease-promoting genes but upregulation of brain-derived neurotrophic factor) or stimulation of mitochondrial biogenesis. They conclude that a well-balanced vegetarian diet can lower the risk of metabolic syndrome and neurodegeneration, as opposed to a diet rich in red-meat. However, an unbalanced vegan diet can lead to deficiencies, and supplementation is only advised if dietary changes cannot be made (Pistollato & Battino, 2014).

The modern vegetarian diet

Once again, a varied and balanced diet is the key to its health benefits, but a modern vegetarian diet that relies on ultra-processed foods cannot provide the variety and nutrients necessary. Therefore, the studies presented previously might not be applicable to the modern diet. In the next section, the effects of a more realistic vegetarian diet based on convenience are discussed.

Contrary to expectations, the health conscious group tends to have lower wellbeing. A study by Dai and Leung (2024) found that health motivation was indirectly leading to poorer psychological health. Moreover, due to dietary restraint and orthorexia, health conscious vegetarians might not be eating a wide variety of foods, thus having nutritional deficiencies which affect both physical and mental health. Gallagher et al. (2021) also found that health conscious vegetarians consume less dairy and its alternatives, which combined with overall lower food intake, can lead to deficiencies in vitamin B12 and calcium.

Comparison

The study by Gallagher et al. (2021) does not go into detail about the health benefits of any of these dietary variants, but they generalize the “convenience” and “unhealthy” patterns to be less healthy than the “health conscious” and “traditional” ones. An expressed concern is the possible n-3 (omega-3 fatty acids) deficiency across all groups. Other factors such as (ultra)processing and supplementation were also mentioned, but will be discussed later.

The study by McClements and McClements (2023) used data from Tso & Forde (2021) to compare (micro)nutrient intake in the traditional (whole food) diets and the modern (ultra-processed) diets (Fig 1).

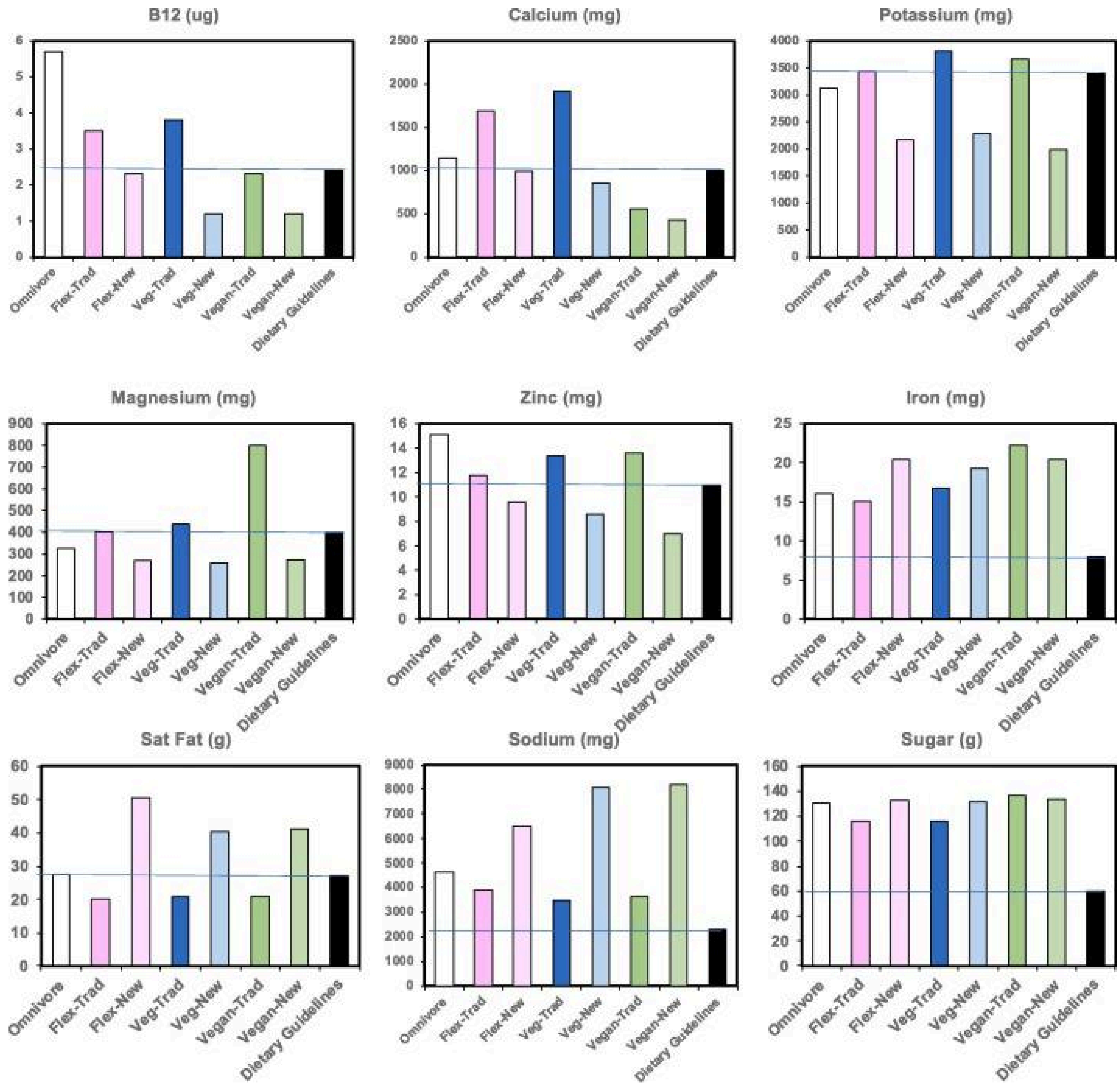

Fig 1. Comparison of micronutrient, saturated fat, salt (sodium) and sugar intakes for omnivore, flexitarian, vegetarian, and vegan diets. The plant-based diets replaced animal-based products with “new” plant-based foods (like meat, fish, egg, or dairy analogs) or “traditional” ones (like nuts, fruits, and vegetables). Image adapted from McClements and McClements (2023). Data from Tso and Forde (2021).

The important conclusion to draw from these findings is that, with a few exceptions, the traditional vegetarian diets do not have any deficiencies, while the modern ones do. The exceptions being the intake of calcium of traditional vegans and the amount of saturated fat in all the traditional diets. However, as previously mentioned, the consensus is that saturated fats should contribute to less than 10% of the caloric intake (World Health Organisation, 2023).

To further compare the traditional vegetarian diet with the modern version, a study looking at just vegetarian consumption patterns will now be presented. Gehring et al. (2020) used data from the NutriNet-Santé cohort (n = 21,212, with a subsample of n = 1,400 following a type of vegetarian diet) to study the relation between the level of food processing and what determines vegetarians to eat what they do. To assess the level of processing, the food and beverages were assessed by a committee consisting of three dieticians and five researchers. The items were placed into one of four NOVA categories: **ultra-processed** (defined by industrial processes such as adding chemical additives, texturing, extrusion, made from food-derived ingredients, for example packaged bread and vegetarian burger patties), **unprocessed + minimally processed** (processes such as pasteurization, fermentation, freezing, e.g. dried fruit, milk), **processed ingredients** (salt, sugar, butter) and finally **processed food** (canned food, cheese, bread, foods with added salt).

One positive correlation found, is between meat avoidance and percentage of calories originating from UPFs (33.0%, 32.5%, 37.0%, and 39.5% of energy intakes for meat eaters, pescatarians, vegetarians, and vegans). This is explained by the replacement of meat with ultra-processed meat alternatives. The authors also found that participants who avoid meat are more likely to eat larger quantities of fruit, vegetables, legumes, whole starchy food, potatoes and other unprocessed plant-based foods.

Moreover, a separate classification was made, using healthy and unhealthy plant-based diet indices (PDIs), with the higher the 'healthy PDI', the healthier the food, but the higher the 'unhealthy PDI', the less healthy it is. This classification results in three categories: plant-based healthy, plant-based unhealthy and animal-based.

The PDI analysis revealed that the degree of meat avoidance and both healthy and unhealthy PDIs were linearly correlated. Vegans had the highest number for unhealthy PDI, but also for healthy PDI. This can be explained by the larger quantity of plant-based food that is needed to achieve the same caloric intake. Pearson correlation between the proportion of energy from UPFs and the PDI scores was conducted. UPFs are negatively correlated with the healthy PDI and positively correlated with unhealthy PDIs. This further provides information on the unhealthiness of ultra-processed foods. Lastly, the study found that people who started a vegetarian diet more recently are more likely to rely on UPFs than those who started longer ago. This is probably due to the recently increased availability of UPFs and lack of experience with cooking vegetarian meals as well as the convenience of using familiar items such as meat replacements.

	Traditional vegetarian	Modern vegetarian
Level of processing	Less processed food	More processed food
Consumption of whole foods	Increased consumption of whole foods	Moderately increased consumption of whole foods
Nutrient deficiencies	Minimal risk	Increased chance

Table 4. Summary of the differences between the prevalent vegetarian diets nowadays

To conclude this chapter, there are clear differences between what has traditionally been considered a vegetarian diet and what modern vegetarians eat. Following a well planned traditional vegetarian diet mitigates the risk of deficiencies and brings health benefits. On the contrary, the new diets characterized by convenience and “unhealthiness” can lead to nutritional deficiencies and increased consumption of saturated fats and salt, (partially) due to improperly formulated ultra-processed foods. To further highlight the consequences of processing, the next chapter will discuss the food matrix, nutrient availability and the interplay with the microbiome.

The nutrition of processed food

As food items vastly differ from one another, so to their nutritional contents and processes they undergo. This chapter illustrates the interactions between industrial processes and their impact on health, mainly through the perspective of the microbiome. Further, the link between the labels and actual nutrition and level of processing will be discussed.

On processing and the food matrix

Food is a complex amalgamation of many organic and inorganic compounds that interact in intricate ways. Mainly, food is understood to be made up of carbohydrates, fats and protein, and sometimes there is focus on vitamins and minerals as well. An important piece of the puzzle is how all these components are organized. In a report by Aguilera (2018) it is stated that this term is used vaguely, referring to food itself or its microstructure. A more concrete understanding of this concept is important, since the food matrix has an influence on the nutritional availability, the subjective experience (flavor, texture) and the industrial processing of food. As such, several types of matrices were defined: liquid, emulsion, gel, (exo-, extra-) cellular and more, including artificial matrices. All these interact with each other and different properties emerge.

For example, when eating a piece of fruit the nutrients are mainly inside of cells. A fraction of them are broken by mechanical processes of digestion, making their nutrients available. What remains whole will end up in the colon, where the microorganisms can process the fruit further, breaking down cell walls and releasing both fruit nutrients and their own metabolites (such as short chain fatty acids). In opposition, drinking fruit juice makes the nutrients immediately available to the human (which can spike blood glucose levels) and changes what is available for the microbiome (i.e. less fiber, but more carbohydrates).
Furthermore, the texture of foods given by the matrix changes not only the mouthfeel, but also satiation (end of eating) and satiety (period of feeling full). Gel and gum matrices increase stomach volume and in turn upregulate these signals. Artificial matrices can be used in food such as plant-based meat alternatives to shelter micronutrients and release them slower, in a way that mimics meat. Microorganisms have also been entrapped in artificial matrices to have a probiotic effect.

As it was briefly explained above, the industrial procedures that food undergoes have repercussions on how it is digested, and therefore the gut microbiome. This is not necessarily unhealthy, as processing can make nutrients more bioavailable (bioavailability = fraction of a given compound or its metabolite that reaches the systemic circulation (Aguilera, 2018)). The study by McClements and McClements (2023) argues that foods which are mechanically, chemically, or thermally processed release more nutrients, increasing their bioavailability, since the plant cell walls are disrupted. However, they also have a section in which the effects of diet on the microbiome are explained, illustrating the complexity of nutrition. The authors illustrate that vegetarian diets have been associated with increased microbial diversity in the gut, mainly due to the intake of fibers. Diversity improves the reliability of the microbiome, since it is more resilient against environmental variation (some species can compensate for the loss of others).

The gut microbiome plays a crucial role in human metabolism, immune system function and mental health. Literature has mainly attributed these effects to the production of short-chain fatty acids, which improve the integrity of the intestinal barrier, mucus production and protection against inflammation. Moreover, a varied microbial population produces many metabolites other than short-chain fatty acids, which can play different roles in the gut homeostasis.

In contrast, according to Zinöcker and Lindseth (2018), UPFs are the drivers of diet-related diseases. They explain how acellular nutrients (nutrients found outside of cells), which were usually found rarely in human diets, have become a staple in our daily lives. This not only increases nutrient availability in the small intestine (sometimes surpassing its absorption capabilities), but also in the colon. As a consequence, the microbial diversity decreases and several species become dominant. This further leads to inflammation and associated pathologies (such as the metabolic syndrome). Then, they explain how industrial additives can have undesirable effects, such as emulsifiers that increase the virulence factors of the microbiome or artificial sweeteners which can impair glucose tolerance and also increase inflammation. These factors play a role in the modern vegetarian diet as it is largely based on UPFs.

To dive a little deeper, UPFs differ amongst themselves. A study by de las Heras-Delgado et al. (2023) compared plant-based meat alternatives with unprocessed and processed animal-based foods. NOVA classifications for level of processing and the NutriScore provided on food labels were analyzed. The authors found dairy, fish, and meat alternatives to be relatively healthier, but cheese alternatives to be less healthy than processed animal-based foods. However, unprocessed fish and meat are healthier than their plant-based counterparts. For the NOVA classification they found 36.5% of plant-based food and 71.7% of animal-based products to be ultra-processed. Out of all the plant-based alternatives, 75.8% were placed in NutriScore categories A and B (most healthy), however in the ultra-processed subdivision there was large variability for the NutriScores. Moreover, although most plant-based products investigated were in categories A and B, they were also mainly classified as processed and ultra-processed. As such, even if a product has a “healthy” nutrient profile, it could be less healthy due to additives (for example emulsifiers) and high contents of salt.

Conclusion

As it was hopefully made clear, nutrition is a complex landscape with many factors interacting. With vegetarianism on the rise and the increased availability of ultra-processed plant-based alternatives to animal products, it is unclear what health effects choosing such a diet has. To answer the question if contemporary vegetarianism is as healthy as it used to be, several factors were considered. Overall, the average vegetarian (regardless of classification) eats more carbohydrates, fiber and sodium, while having a lower intake of protein, fats (including saturated) and sweets (such as candy or cookies). Some of the vegetarian groups, such as the convenience pattern or vegans, have a higher risk of being vitamin B12 or iron deficient. Furthermore, it was explained that there are different patterns of vegetarianism, influenced by (but not limited to) motivation, and that the new vegetarian diet based on UPFs has an undesirable profile. The relationship between the food matrix and the gut microbiome was illustrated, showing that more nutrients available for the host do not necessarily mean better food. It was also mentioned that ultra-processed plant-based foods might be healthier than ultra-processed meat products.

It is therefore reasonable to conclude that a modern vegetarian diet is not as healthy as the traditional one. The recommendation is then to eat a variety of whole foods, covering all nutritional demands, and to critically evaluate the labels, as the NutriScore is not a reliable indicator for a food's healthfulness. Additionally, policy changes need to limit the claims food manufacturers can make over the health of their products and guidelines need to be put in place to clarify the level of processing an item has been through.

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