# Green Food Report: On the Nutritional Adequacy of a Vegan Diet

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# Introduction

Over the past few years, veganism has become ever more popular among countries with access to internet. The diet is now regularly mentioned on social media, it is heard of in conversation and it has become part of regular offers in restaurants and cafés. Kamiński, Skonieczna-Żydecka, Nowak and Stachowska (2020) looked into Google-trend data to investigate the popularity of multiple diets. It soon became clear that the sheer number of searches for veganism on the search-engine have made a great growth spurt over the last couple of years (as can be observed in Figure 1), positioning veganism as one of the most popular diets today along with gluten-free diets and vegetarianism.

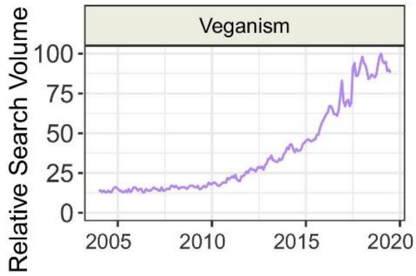

*Figure 1: Relative Search Volume of 'veganism' on Google (Kamiński, Skonieczna-Żydecka, Nowak & Stachowska (2020).*

When someone chooses to adhere to a vegan diet, one deliberately eliminates all products coming from animal sources from their menu, including meat, milk and milk-products, eggs and honey (Larsson & Johansson, 2002). This decision can be based on ethical reasons or concerns for one's health or the environment (Radnitz, Beezhold, & DiMatteo, 2015). Although the total number of individuals consuming a plant-based diet is on the rise – as is for example reflected in the growing market of dairy- and meat-alternatives (Grant & Hicks, 2018; van der Weele et al., 2019) – it continues to be disputed whether a vegan diet is nutritionally adequate (e.g. Larsson & Johansson, 2002; Flores-Guerrero, Minović, Groothof & Gruppen, 2020).

It is hypothesized that although vegans often consume a large variety of foods, a truly balanced vegan diet needs careful planning in order to meet the recommended daily amounts of all nutrients. This hypothesis will be tested by investigating the nutritional adequacy of a vegan diet through reviewing several nutrients often highlighted for their prevalence in animal-products, including iron, zinc, calcium, selenium, iodine, vitamins-$B_2$, -$B_{12}$, -D, protein and omega-3 fatty acids, and how these may (or may not) be obtained through consumption of vegan products. Moreover, this essay will contain a case-study of vegans and non-vegans with the aim to discern differences in consumption within these groups. Through this assessment and the review, this essay aims to give the reader a more thorough understanding on whether a vegan diet can sustain human needs.

## Method

For the literature-review, the search-engines GoogleScholar and PubMed were utilized. Key words used included, amongst others: “Plant-based diets nutritional adequacy”, “Vegan diets and health”, and specific searches (e.g. “iodine vegan diet” & “calcium veganism”). The titles and abstracts of seemingly relevant sources were scanned to decide whether these could be included. A preference was given to primary, peer reviewed studies which included an omnivorous or vegetarian control-group for comparison. In another document provided with this essay, all Recommended Daily Allowances (RDAs) and Upper Tolerable Intake Levels (ULs) of every nutrient included in this essay will be given, along with several sources where each specific nutrient can be obtained. Additionally, a sample-menu retrieved from David and Melina (2014) will be provided.

Separate from the review, a case study was conducted through the means of a survey distributed on the 24th of March 2020 amongst students of University College Roosevelt (UCR), and further though snowballing, targeting vegans and non-vegans willing to complete the survey. The aim of the survey was to assess the difference in eating-behaviour of vegans and non-vegans. After enough replies were received and it was time for interpretation, all participants were given a participant-number. Text-replies were converted to numerical variables (e.g. ‘never’ became 0), and all replies that could not be interpreted were coloured orange and were consequently not included in further analysis. This was the case for when answers were estimations (e.g. estimating weight led to orange for BMI), when no answers were given, and when answers did not make sense compared to previous answers (e.g. first saying not to be vegan and thereafter answering questions specifically for vegan participants, which were not interpreted). For replies where the answer was an estimation, the average was taken (e.g. ‘1-3 days per week’ would become 2), whereas other answers were directly interpretable (e.g. ‘daily’ became 7). These numbers were thereafter used for data-analysis and tested for significance with the use of a T-test. Questions with binary answers (e.g. ‘Do you take any supplements’ ‘Yes/No’) were interpreted using chi-squared.

## Literature

### Nutritional adequacy of a vegan diet

#### Iron.

Females of childbearing-age are advised to consume 18 mg iron a day, while males and postmenopausal females are advised to consume 8 mg a day (Davis & Melina, 2014). Iron is an important component of haemoglobin, which plays a vital role in oxygen-transfer from the lungs to the rest of the body (National Institutes of Health, 2019). Moreover, this trace mineral is associated with muscle metabolism, support of connective tissue, physical growth and hormone synthesis. These examples show the importance of proper iron consumption, as deficiencies can lead to fatigue, inflammations and pale skin (National Health Service, 2018).

Iron can be divided into haem- and non-haem iron. Haem-iron can only be found in animal-products, while non-haem iron is primarily found in plant-based foods (National Institutes of Health, 2019). Vegans, with their abstinence of animal products, will therefore not consume haem-iron. Unfortunately, the absorption-rate of non-haem iron is significantly lower compared to haem-iron (Craig, 2009), which could theoretically cause problems for vegans to meet their daily iron-requirements (Sanders, 1999). Whereas no specific requirements have been set for vegans, the Institute of Medicine (IOM) advises them to aim at consuming 1,8 times more iron than omnivores due to the difference in bioavailability of haem- versus non-haem iron (Davis & Melina, 2014).

The absorption-rate of non-haem iron can be compromised further by consumption of beverages containing polyphenol, including coffee, tea and cocoa, leading to a decrease in the absorption-rate ranging from 47 to 94% depending on the beverage concerned (Hurrell, Reddy & Cook, 1999). Additionally, phytate, present in whole grains, legumes and seeds, has been found to inhibit iron absorption as well by binding to the iron, therefore hindering its retention (Hallberg, Rossander & Skånberg, 1987; Cook & Reddy, 2001; Schlemmer, Frølich, Prieto & Grases, 2009).

Though these studies suggest that iron requirements might be difficult to meet with non-haem iron alone, no significant difference of iron-deficiency levels was found when vegans were compared to omnivores (Larsson & Johansson, 2002). Zimmermann and Hurrell (2007) noted that as iron is present in a large quantity and variety of foods, those whose energy requirements are met are likely to have an adequate intake. This statement seems to apply in this situation as well. A comparison of the dietary intake of 30 vegans and 30 omnivores showed that of the vegan group, 20% had low iron status, while this was similarly the case for 23% of the non-vegans (Larsson & Johansson, 2002). While iron consumption was similar with male vegans and male omnivores, it appeared that vegan females had a higher iron-intake than their meat-consuming counterparts (vegan: 14 ± 4.5 mg per day compared to omnivores: 11 ± 3.0 mg per day). When iron supplements were considered, both groups consumed similar quantities of iron. A more recent study by Clarys et al. (2014) also resulted in the conclusion that vegans consume more iron than other diets.

These results can be valid – even though non-haem iron is less absorbable than haem-iron – as there are several ways to improve the absorption rate of iron. Consumption of vitamin A and β-carotene can increase iron absorption up to three-fold through countering the inhibitory effects of phytate and polyphenols (García-Casal et al, 1998). Moreover, consumption of vitamin C along with iron can improve absorption as well ("IJzer", 2018; Hallberg, Brune & Rossander, 1989). Lastly, according to Finch and Cook (1984), the human body can compensate for low iron stores by increasing the iron-absorption from food, making non-haem iron more iron worthy.

**Zinc.**

The RDA of zinc is 8 mg for females and a bit higher for males, being 11 mg per day (Davis & Melina, 2014). Most of the element zinc consumed by Americans is derived from animal-products (Anderson & Zlotkin, 2000). As the bioavailability of zinc, like that of iron, is compromised by phytate-containing foods, consuming adequate amounts of zinc could be an issue for vegans as they often increase the consumption of phytate containing foods, including legumes and whole grains, to replace animal products (Gibson, 1994; Hunt, 2003). Dietary protein enhances the bioavailability of zinc, although sources of plant-based protein generally contain high doses of phytic acid as well (Sandström, Arvidsson, Cederblad & Björn-Rasmussen, 1980). Hunt (2003) formulated the advice for vegetarians to increase their zinc-intake by approximately 50% in order to surpass the inhibitory effects of phytic acid. It is hypothesized that the same principle applies to vegans, although it is currently not advised due to lack of evidence.

The consequences of inadequate zinc-consumption are yet to be fully understood. A more in-depth analysis of the effects of a zinc-deficiency is also complicated by the fact that the human body is able to change the amount of zinc absorbed through homeostatic regulation, similar to iron (Polberger et al, 1996; Lönnerdal, Jayawickrama, & Lien, 1999). This process ensures that when there is a consistent lack of zinc, the absorption-rate will be increased. The idea that the human body can adapt to zinc deficiency is supported by the fact that no negative effects of the lowered bioavailability of zinc have been found within vegetarian participants (Hunt, 2003). Although vegans generally consume larger quantities of phytate-containing foods compared to vegetarians, it is plausible that homeostatic regulation also limits the onset of zinc-deficiency in vegans. Larsson and Johansson (2002) indeed observed that while zinc was found in lower quantities within the vegan group, it was within the recommended range.

**Calcium.**

Calcium is present in several food products, including milk, cereals, eggs, meat, fish and vegetables (Theobald, 2005). Adults are advised to consume 1000mg/day while females above 50 and males above 70 should consume 1200mg/day (Davis & Melina, 2014). In order to increase calcium absorption, it is advised to consume adequate amounts of vitamin D and protein (Theobald, 2005). Moreover, for maintaining a proper calcium-status it is recommended to lower one’s intake of caffeine and alcohol (Theobald, 2005), while considering that consumption of phytic acid decreases retention of calcium (Fredlund et al., 2006).

As calcium is predominantly present in products from animal sources, the average vegan consumes less calcium than omnivores (Clarys et al., 2014; Castañé & Antón, 2017; Larsson & Johansson, 2002). This finding led some to recommend consuming calcium fortified foods in order to reach the recommended intake (Castañé & Antón, 2017). However, the World Cancer Research Fund (2007) advices male vegans to limit the amount of calcium retrieved from fortified foods, as diets too high in this type of calcium might lead to prostate cancer. Moreover, consumption of foods fortified with calcium can lower absorption of iron and zinc (Cook, Dassenko & Whittaker, 1991; Hallberg et al., 1991; World Health Organization, 1996). Even though calcium intake was lower with vegans in a study conducted by Kohlenberg-Mueller and Raschka (2003), it remained within the recommended range with those consuming a balanced diet. Lastly, again in line with both iron and zinc, when less calcium was ingested, the absorption rate appears to increase (Kohlenberg-Mueller & Raschka, 2003).

**Selenium.**

The RDA for selenium has been set at 55mcg a day (Davis & Melina, 2014). Selenium is low in European soils and is supplemented to farm-animals in order to assure their health, ensuring presence of selenium in milk-products and meat. Selenium can also be derived from fish, shrimp and oysters. With this in mind, Hoeflich, et al. (2010) investigated the selenium status of vegetarians and vegans as a deficiency in selenium could potentially lead to less selenoproteins, that in turn serve oxidoreductase functions (Labunskyy, Hatfield & Gladyshev, 2014). A selenium deficiency was also linked to cancer (Jackson & Combs, 2012) and heart disease (Flores-Mateo, Navas-Acien, Pastor-Barriuso & Guallar, 2006), amongst others. However, the results were inconclusive as the vegan and vegetarian participants had either a deficiency or not depending on the investigated biomarker (Hoeflich, et al., 2010). An earlier study confirmed that vegan selenium-status does not significantly differ from the control groups, which consisted of elderly, blood donors, laboratory personnel and lactovegetarians (Åkesson & Öckerman, 1985).

The intake of selenium with vegetarians and vegans can vary significantly across countries as the selenium-content of the ground differs per region (Rauma & Mykkänen, 2000). Even though Rauma, Törrönen, Hänninen, & Mykkänen (1995) reported a significant lower consumption of selenium with vegans, the activity of erythrocyte glutathione peroxidase – an enzyme protecting against oxidative stress of which selenium is a necessary component – was similar in vegans and omnivores (Necheles, Steinberg & Cameron, 1970). Another recent study found that long-term vegans had lower intakes of selenium when compared to non-vegans (Elorinne et al., 2016). These values matched concentrations within individuals who reside in an area where the soil is not fertilized with this nutrient. However, the selenium-levels remained within the recommended range.

**Iodine.**

One has an iodine deficiency when the excretion of this element is lower than 100 micrograms per litre urine. This is in line with a lower consumption of 150mcg iodine a day (Davis & Melina. 2014). Iodine deficiency is present in 80% of vegans and 25% of vegetarians included in a study conducted by Krajčovičová-Kudláčková, Bučková, Klimeš and Šeboková (2003). Iodine is primarily found in fish and other animal-products, as well as sea salt. Products of a plant-origin have a lower iodine-content compared to animal-products as there is only a low concentration of this element present in soil, similar to selenium (Krajčovičová-Kudláčková, et al., 2003). As vegans consume less (sea) salt than omnivores, an iodine deficiency might occur more frequently, as has also been shown by Krajčovičová-Kudláčková et al. (2003). It is necessary that the daily recommended intake is met for healthy hormone-production and prevention of an enlarged thyroid and other growth-abnormalities (Delange, 1994). Elorinne et al. (2016) observed that within a Finnish group of participants, all vegans and 91% of the control group excreted iodine indicating a mild iodine deficiency. These studies call for caution when one consumes a vegan diet, and advise to consciously include sea-salt, salt fortified with iodine or iodine-supplements in one’s diet in order to prevent the aforementioned issues.

### Vitamin $B_2$ (Riboflavin).

Riboflavin was found to be deficient in 33.3% of included vegans (n = 42) and in approximately 12.5% of omnivores (n = 40) and 10% of the vegetarians (n = 36), who therefore consumed less than the RDA of 1.1mg (females) or 1.3mg (Males) $B_2$ (Majchrzak et al., 2006; Davis & Melina, 2014). A lowered $B_2$ intake was only found in male vegans by Larsson and Johansson (2002). A deficiency in vitamin $B_2$ can affect the metabolism of other B-vitamins, in particular $B_6$. The lowered riboflavin intake of vegans was attributed the fact that vegans do not consume cow's milk, a primary source of vitamin $B_2$ for omnivores and vegetarians (Majchrzak et al., 2006).

### Vitamin $B_{12}$ (Cobalamin).

Vitamin $B_{12}$ is solely derived from microbes and is present in meat and oily fish (Sanders, 1999). The RDA has been set at 2.4 mcg a day (Davis & Melina, 2014). As vegans do not consume meat nor fish, they need to be aware of the need for consuming of $B_{12}$ fortified foods or supplements in order to meet their daily $B_{12}$ requirement. $B_{12}$ is present in some vegan foods, including spirulina and nori, which have been argued to be able to satisfy the cobalamin needs of vegans, however, these foods contain $B_{12}$ that is very unlikely to be biologically active (Dagnelie, van Staveren & van den Berg, 1991). Moreover, these foods might contain cobalamin analogues, potentially inhibiting enzymes which need $B_{12}$ to function properly (Stabler, Brass, Marcell & Allen, 1991).

Several studies have investigated whether vegans are able to uphold the recommended serum level of $B_{12}$, with differing but overall negative results. Haddad et al. (1999) found that of their vegan participants (N = 25), 40% had lower serum levels while of the 131 participants in a study conducted by Waldmann, Koschizke, Leitzmann and Hahn (2004), 28,2% showed signs of $B_{12}$ deficiency. A suboptimal level of $B_{12}$ could lead to megaloblastic anaemia, where red blood cells are fewer and larger than normal (Allen, 2008). This issue can also be caused by a folate deficiency, although $B_{12}$ is more of concern for vegans. On average, those switching from an omnivorous- to a vegan diet developed symptoms of a vitamin $B_{12}$ deficiency after 6 years of adhering to a vegan diet (Allen, 2008). Herbert (1988) averaged the onset of megaloblastic anaemia to occur between 5 to 10 years after having a $B_{12}$ deficiency. These results show that vegans should take utmost care in maintaining proper $B_{12}$ levels in order to prevent this blood disorder in the long term.

When 22 vegans were compared on the nutritional adequacy of their diet, it appeared that even though 91% of vegan participants took supplements of $B_{12}$, they had lower $B_{12}$ concentrations compared to the non-vegetarian control group (Elorinne et al., 2016). However, even though the concentration of $B_{12}$ was lower, a mere 5% of the vegans had a serum level of $B_{12}$ below the recommended intake, suggesting that supplements are a useful addition to the vegan menu.

**Vitamin D.**

Vitamin $D_2$ (ergocalciferol) can be found in several plant- and fungi sources whereas vitamin $D_3$ (cholecalciferol) can be produced 7-dehydrocholesterol in the skin when exposed to ultraviolet light from the sun, and can be obtained through consumption of meat, oily fish and eggs (Wilson, Tripkovic, Hart & Lanham-New, 2017). An adequate consumption of vitamin D is important for bone health (Prentice et al., 2006) and for absorption of calcium (Theobald, 2005).

The daily recommended intake of this vitamin is 15 µg (600 IU) for adults under 70 years old, whereafter 20 µg is advised (Davis & Melina, 2014). The sun is argued to easily provide one with 250 µg (10.000 IU) after full-body exposure to the sun. While this vitamin can be produced by the human body when it is exposed to the sun, vegans generally have a higher frequency of vitamin-D deficiency due to a decreased consumption of the vitamin though their diet, primarily when sun-exposure in these individuals is limited (Dunn-Emke et al., 2005). Lowered levels of vitamin D in vegans was also found by Larsson and Johansson (2002) within females. Regular exposure to the sun could help prevent negative consequences from a vitamin D deficiency.

**Protein.**

In order to have a balanced diet, one is advised to consume 0.83 grams of protein per kilogram weight per day (Davis & Melina, 2014). This would entail that an 80 kg person would have to consume 66,4 grams of protein a day. The WHO advises vegans to consume a little more (0,90 g/kg/day) due to the lowered digestibility of plant-based protein (Davis & Melina, 2014). Protein requirements of vegans can be easily met when one consumes a diet with a variety of plant-based foods – including legumes, nuts, seeds and grains – that meet one's energy requirements (Marsh, Munn, & Baines, 2013). Moreover, the quality of plant-based protein does not appear to differ significantly from the quality of meat-based protein as the amino acids present in plant proteins complement each other (Sanders, 1999). Even though vegans have a lowered intake of protein compared to omnivores, they do reside within the recommended range (Larsson & Johansson, 2002). This lowered intake has been speculated to improve retention of calcium as diets high in protein tend to promote the excretion of calcium in urine (Heaney, 2007). Moreover, a lowered consumption (and in vegans the complete exclusion) of animal protein has been associated with a lowered risk of pancreatic cancer (Chan, Wang & Holly, 2007). Furthermore, within the Adventist Health Study, researchers found that a higher consumption of legume-based protein can lead to a lowered risk of colon cancer (Fraser, 1999).

**Omega-3 Fatty Acids.**

While males are recommended to consume 1.6 grams a day, the limit for females has been set at 1.1 grams of omega-3 fatty acids daily (Davis & Melina, 2014). These levels are based on a diet of 2000 calories. As vegans do not consume animal products, their intake of both eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) is severely limited, with EPA merely existing in kelp oil awhile DHA can be found in microalgae (Craig, 2009). DHA is important for functioning of the retina and the central nervous system, while both EPA and DHA are very important for cardiovascular health (Sanders, 1999). Intakes of another fatty acid - α-linolenic acid (ALA) – are similar to non-vegans, and the most important source of omega-3 for vegans (Saunders, Davis & Garg, 2013).

In a large study where diets of 196 omnivores, 231 vegetarians and 232 vegans were compared, it was reported that even though vegans had lower intakes of DHA and EPA, the status of the polyunsaturated fatty acids remained similar over time (Rosell et al., 2005). This proportion was not affected by the duration one was adhering to a vegan diet, suggesting that the body is able to adequately convert ALA to both DHA and EPA when it is not part of one's diet.

## Results

In the end, the sample size of 16 vegans and 19 non-vegans was reached (N = 35). The vegan group consisted of 15 females and one male, with an average age of 21 years old ranging from 18 to 25. There are varying reasons why an individual would decide to adhere to a vegan diet. Within the sample, a majority noted that they eat vegan due to ethical reasons (n = 15) and some mentioned health (n = 5), while the environment also was a major contributing factor (n = 14). With regards to strictness, answers were varied. Only four respondents do not deviate from their diet. All other respondents either deviate once a year (n

= 5), once a month (n = 5) or once a week (n = 2). Lastly, participants have been eating a vegan diet for varying lengths as measured in months, with a mean of 40,5 and a range of 1 to 204 (figure 2). The non-vegans contained both omnivores and vegetarians. Of this group, there were 15 females, three males and one preferred not to specify their gender. Their average age was 20,94 ranging from 18 to 28 with one participant not disclosing their age.

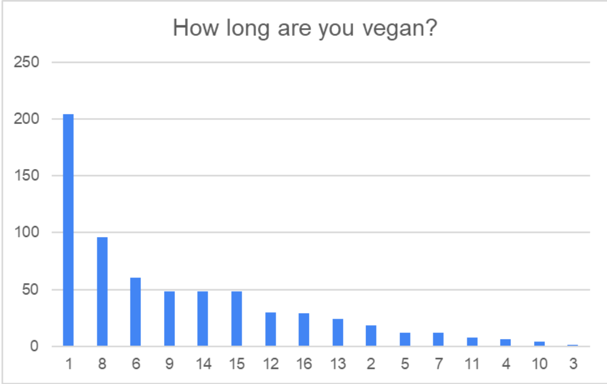


*Figure 2: Distribution of adherence to a vegan diet of all 16 vegan participants*

With regards to BMI, there were four missing values for participants that either guessed their weight or did not specify. It appeared that the vegans ($M$ = 21,04) had a significantly lower BMI compared to the non-vegans ($M$ = 22,85; $p$ < 0,05; figure 3). These findings are consistent with the conclusions of larger-scale studies. One example is a study by Spencer, Appleby, Davey and Key (2003) including 37.875 participants of varying diets with ages between 20 and 97. They concluded that there was a significant difference between the BMI of meat-eaters and vegans with the first having an average BMI of 24.41 (men) and 23.52 (women) while vegans had an average BMI of 22.49 (men) and 21.98 (women). While no table was given with the specific BMI of young adults, an included graph showed a meat-eater BMI of approximately 23.40 (men) and 22.70 (women) while the vegan BMI was near 21.80 for males and 21.40 for females (See Figure 1 in Spencer, Appleby, Davey & Key, 2003). It was not specified whether the deviation in BMI between the two diets in this age-group was significant or not. Differences between

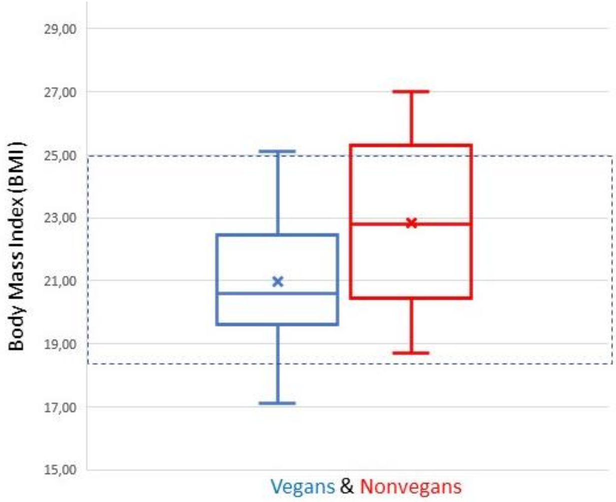


*Figure 3: BMI distribution of the participants. The dotted line represents the healthy weight-range of BMI 18.5 to 24,9.*

omnivore- and vegan BMI were mostly attributed to different fibre- and macronutrient-content of the diets opposed to lifestyle-differences between the groups.

Another finding was that vegans significantly consume more supplements ($p < 0{,}001$) than non-vegans, even with the Yates correction taken into account ($p < 0{,}05$; figure 4). This finding is supported by Larsson and Johansson (2002). Of the 11 vegans taking supplements, most were taking $B_{12}$ (n = 8).

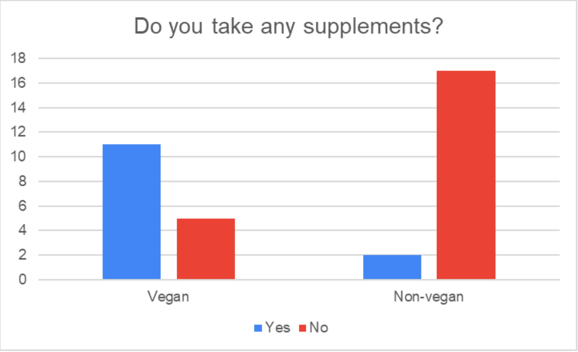


*Figure 4: Supplement-consumption in vegan and non-vegan participants.*

Participant number 13 mentioned taking "all vitamins". Due to the anonymous nature of the survey, it is currently not possible to trace which vitamins were taken exactly in which dose. Other common supplements were iron (n = 5), omega-3 (n = 3), and vitamin D (n = 4). Participant number 7 mentioned consuming 200% of both iron and $B_{12}$ on a daily basis. The Tolerable Upper Intake Level (UL) has been defined in order to give a limit whereafter consumption of a nutrient may become hazardous (Institute of Medicine, 2001). For iron it has been specified as 45 mg. Assuming the 200% is based on the minimal requirements of female participant 7 (18 mg/day), this would entail having a supplement of 36 mg every day. On itself this amount of iron would not be unhealthy per se, however, as the 200% only constitutes a supplement and her daily diet is not included, the participant might easily surpass the Ul on a daily basis. With regards to her $B_{12}$ consumption, a recent study in the Netherlands contested the prior consensus that there was no danger in consuming more $B_{12}$ as excess would be excreted through urine (Callaghan et al, 2014). Flores-Guerrero, Minović, Groothof & Gruppen (2020) found that elevated plasma concentrations of vitamin $B_{12}$ correlated with increased all-cause mortality. The explicit ways in which this process works was outside of the scope for this study. Even though no UL has been set to date, consistent consumption of excessive $B_{12}$ is unwise.

From the answers given to the remaining questions of the survey, it appeared that vegans consume more legumes and pulses, dried fruit, plant-based milk, dark leafy greens and coffee ($p < 0{,}05$), as well as seeds ($p < 0{,}10$), compared to non-vegans (please consult the appendix for all related graphs). Larsson and Johansson (2002) also found that vegans consume more legumes and seeds compared to omnivores. No sources on dried fruit and coffee could be found. However, vegans are often advised to consume dried fruit as it contains approximately six times more iron than servings of non-dried fruits due to density-differences between the two (Venti & Johnston, 2002). For all other questions on food-products and additives (nuts, fruit, vegetables, salt, bouillon and soy sauce, potatoes, rice, pasta, bread, pizza, meat replacements, fries, chips, salted nuts, salted popcorn, wine, beer, water and tea), no significant difference between vegans and non-vegans was observed.

## Conclusion

It has been found that a vegan diet could potentially be nutritionally adequate, however, for this to be possible, one should take care to carefully plan their diet to make sure that the recommended amounts are reached of each nutrient. For some that might be easier than for others. While it has been discussed that one is able to receive adequate amounts of iron through a varied diet with enough calories, this is a different story for iodine and vitamin $B_{12}$. However, someone who is prepared to do some planning and willing to take some supplements can be healthy while consuming a vegan diet, even in the long run.

## Discussion

As no full food-reports were requested from the participants, it was not possible to perform a full analysis of the number of calories consumed by each participant and therefore each group (vegans and non-vegans). This might have made for a more complete analysis of the nutritional adequacy of a vegan diet as then also specific nutrients and their amounts consumed by the participants could have been addressed. However, it should be considered that there are inherent problems with food-reports. Larsson and Johansson (2002) note that after comparison of one's reported energy-consumption with one's energy expenditure, it was discovered that both vegans and omnivores underreported their energy-consumption (VG by 14% and O by 12%). Another limitation might be the relatively small sample-size of the study, hindering the generalizability of the results. As UCR is a small university with an intensive program, it was to be expected that the sample-size would be small. For future research into this topic it is recommended to gain more participants and device a more inclusive way of sampling the participants' diets, therefore giving a more comprehensive idea of the nutritional adequacy of a vegan diet.

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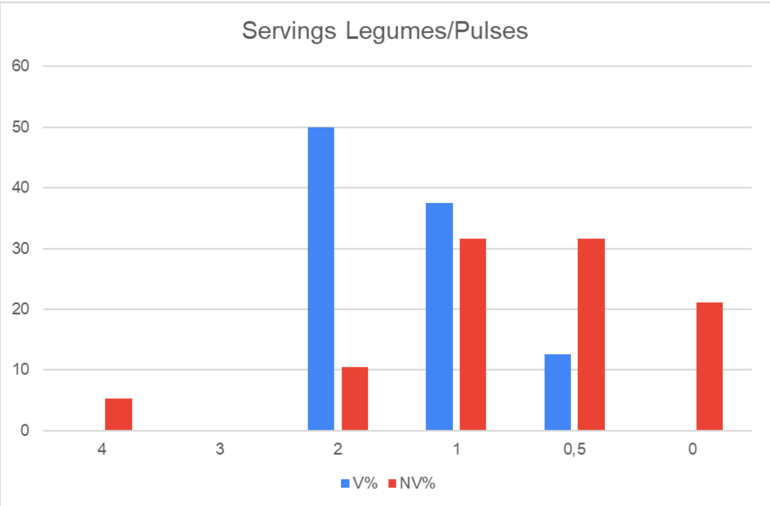
# Appendix

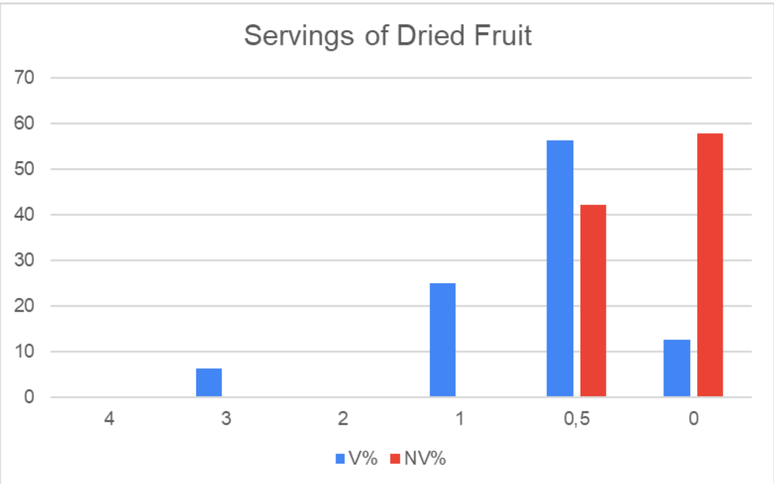
As the total number of participants in both groups is inequal, the following graphs have been plotted according to the fraction of each group that consumes a given product a x amount of times, rather than based on the sheer number of responses. This ensures that direct comparison of the two groups is possible. Next to the graphs, the meaning of the numbers on the x-axis is specified.

*Graph 1: Servings of Legumes/Pulses*



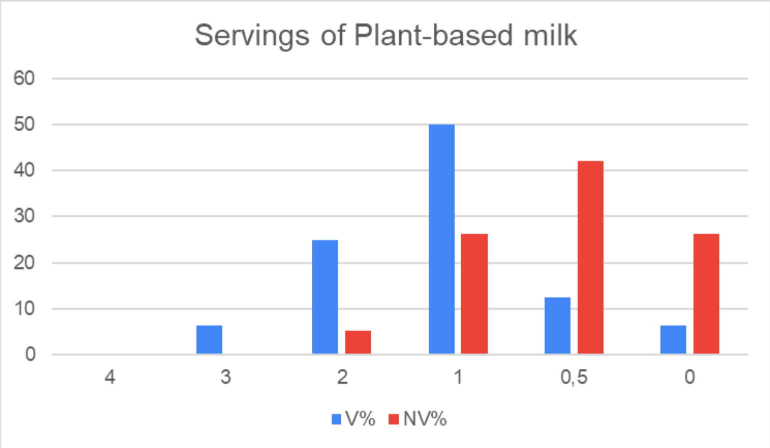

4 = >3 servings per day
3 = 3 servings per day
2 = 2 servings per day
1 = 1 serving per day
0.5 = <1 serving per day

*Graph 2: Servings of Dried Fruit*



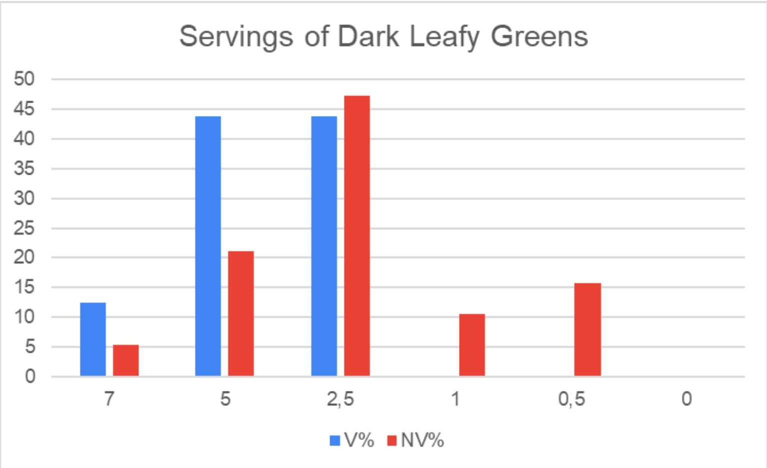

4 = >3 servings per day
3 = 3 servings per day
2 = 2 servings per day
1 = 1 serving per day
0.5 = <1 serving per day

*Graph 3: Servings of Plant-based Milk*



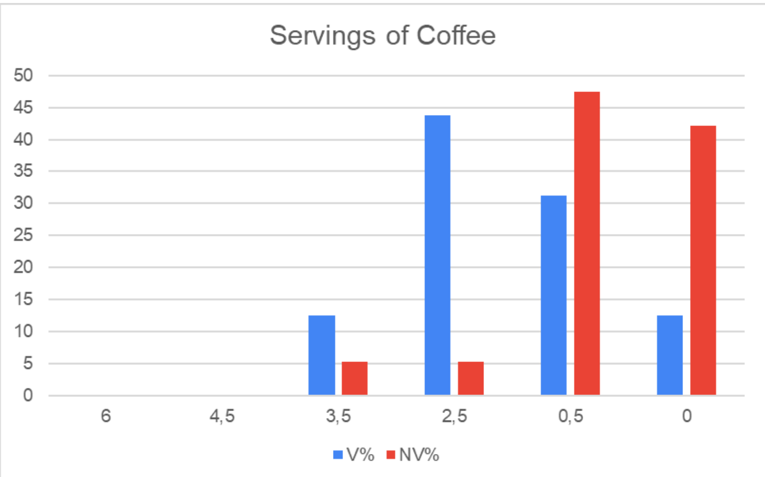

4 = >3 servings per day
3 = 3 servings per day
2 = 2 servings per day
1 = 1 serving per day
0.5 = <1 serving per day

*Graph 4: Servings of Dark Leafy Greens*



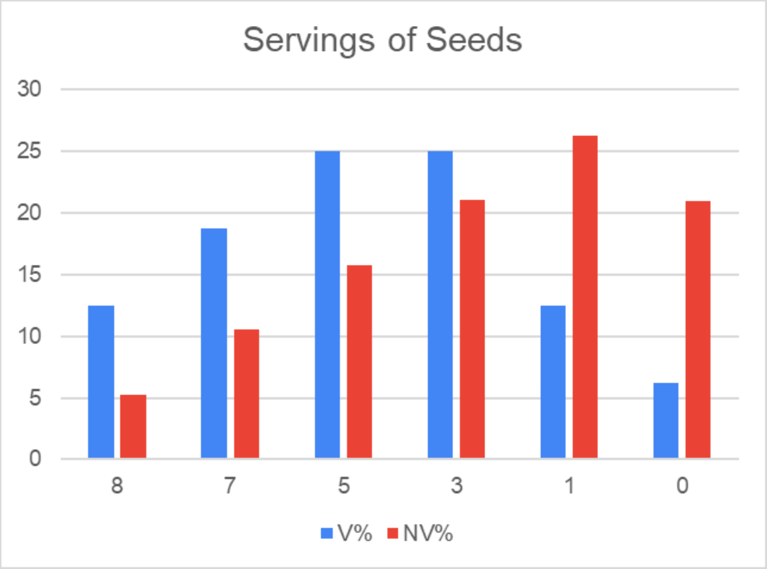

7 = every day
5 = 4-6 a day
2.5 = 2-3 a day
1 = 1 a day
0.5 = <1 a day
0 = never

*Graph 5: Servings of Coffee*




6 = >5 cups a day
4.5 = 4-5 cups a day
3.5 = 3-4 cups a day
2.5 = 2-3 cups a day
0.5 = 1 or less than 1 a day
0 = never

*Graph 6: Servings of Seeds*




8 = >1 per day
7 = 1 per day
5 = regularly
3 = sometimes
1 = seldom
0 = never