

Vegan diet: utilization of dietary supplements and fortified foods

An internet-based survey

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Abstract

The number of people following a vegan diet in Germany has been growing for several years. In this context, the question arises as to whether this group is guaranteed an adequate supply of nutrients. Vitamin B₁₂ is a particularly critical nutrient for vegans. Studies to date have enabled us to draw only insufficient conclusions on the use of dietary supplements by people following a vegan diet. The objective of this study was therefore to survey the use of dietary supplements, and the use of vitamin B₁₂ in particular, among vegans by means of an online questionnaire (chance sample, n = 1,924). Of those surveyed, 83.9% stated that they consumed vitamin supplements and 37.2% (of 1,924) consumed foods fortified with vitamins. This most frequently concerned vitamin B₁₂ (81.5% and 27.3% respectively) and vitamin D (41.4% and 13.1% respectively). Further analysis showed that the proportion of vitamin B₁₂ users rose in accordance with the level of education. Dietary supplements containing minerals and foods fortified with minerals were consumed by 20.3% and 19.9% of respondents respectively. Magnesium (9.9%) and iron (8.9%) were most frequently mentioned in connection with dietary supplements and calcium (16.7%) and iodine (4.2%) in connection with fortified foods.

Keywords: vegan diet, micronutrients, vitamins, minerals, dietary supplements, fortified foods, supplementation, vitamin B₁₂

ical/animal rights reasons [5]. But health and environmental motives are also determining factors for the adoption of a vegan diet [6–8].

Some epidemiological studies show that vegans are less likely to suffer from diabetes mellitus type 2, hypertension, cardiovascular diseases and, in part, cancer, in comparison to omnivores [9–13]. Vegans are more likely to achieve the recommended levels of many micronutrients than omnivores thanks to an increased consumption of plant foods. Including vitamins B₁, B₆, C, E, folate and niacin, as well as the minerals calcium and magnesium [14–17].

However, the question as to whether vegans receive an adequate supply of various micronutrients (vitamin B₂, B₁₂, iron, calcium, zinc, iodine), which are primarily contained within animal products, is repeatedly the subject of controversial debate [14–18]. The supply of vitamin B₁₂ is a major focal point. This vitamin is present exclusively in animal foods and is therefore a particularly critical nutrient in a vegan diet. Numerous studies have shown that a large proportion of vegans are not sufficiently supplied with this nutrient [19–22]. An insufficient supply of vitamin B₁₂ can lead to haematological, psychiatric and cardiovascular conditions, as well as to severe irreversible neurological disorders [21].

It is therefore crucial that a vegan diet is well-planned and adequate dietary supplements are incorporated, to ensure an adequate supply of

Introduction

There has been a clear trend towards the adoption of vegetarian/vegan diets in recent years. Estimates reveal that between 3.7 and 10.0% of the population in Germany were vegetarian and between 0.7 and 1.1% were vegan in the years 2014/15 [1–3]. Current data points to 1.6% (corresponds to 1.3 million) vegans in Germany [4].

The motivation behind the adoption of a vegan diet is often multifaceted. Many people become vegan for eth-

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Overview 1: Contents of questionnaire

Questions on exclusion criteria

- diet (vegan yes/no)
- supplements due to illness

Diet

- motive
- diet before switch to vegan
- duration of vegan diet
- upkeep of diet

Dietary supplements and fortified foods

- Use of fortified foods yes/no
- type of micronutrient
 - frequency
 - duration
 - dose
 - prescribed by doctor yes/no

Use of fortified foods yes/no

- type of micronutrient
- estimated dose
- product category
- supplementation of other nutrients (e.g. DHA, EPA)

Health and eating behaviour

- question on vitamin B₁₂ blood parameter testing
- question on testing of other blood parameters
- assessment of state of health
- consumption of organic foods
- assessment of eating behaviour
- cigarette consumption
- alcohol consumption
- physical activity

Sociodemographic data

- gender
- pregnant/breastfeeding
- age
- postcode
- weight and height
- living situation (e.g. living alone)
- other vegans in household yes/no

Socioeconomic Data

- school-leaving qualification
- professional training/further education
- employment
- occupational status
- income

DHA = docosahexaenoic acid; EPA = Eicosapentaenoic acid

nutrients. Nutritional advice and dietary supplements therefore become particularly important [17].

The use of dietary supplements by people following a vegan diet has hardly been studied to date. Globally there have been only a few studies, most based on relatively small collectives, which have been able to make statements about the type, quantity and frequency of dietary supplements taken by vegans [14, 15, 19]. Therefore, the objective of this study was to survey the use of dietary supplements and fortified foods among people following a vegan diet (>12 years) in Germany and to obtain data on the intake of vitamin B₁₂ in particular. A comparison with data from the *Nationale Verzehrstudie II (NVS II)* (National Consumption Study) was carried out in order to classify the results.

Methodology

The use of dietary supplements by people following a vegan diet (aged 12–80) in Germany was surveyed in September and October 2016 by means of a free-to-access online questionnaire. The study participants in this chance sample were acquired through personal environments, social networks such as Facebook, and through various organisations and foundations¹, institutions (universities in Fulda and Karlsruhe), online vegan shops¹ and blogs¹.

As a result of the questions addressed by this study, only persons who stated that they followed a vegan diet and did not take vitamin or mineral supplements because of a chronic disease were included.

Participants who terminated the survey early (before answering the

questions on supplements) were not taken into account in the analysis. Multiple participations were excluded by means of the questionnaire programme.

The questionnaire developed for the survey comprised five sets of themes (♦ overview 1) and was implemented by means of web application QuestBack Enterprise Feedback Suite® (EFS). The questionnaire was checked for accuracy and consistency with the help of an automated test (consistency check and filter test) as well as a subsequent standard pre-test (n = 6).

The determination of body mass index (BMI) was based on data provided by the respondents. Classification was based on the WHO clas-

¹ Detailed data is available from the authors.

sification [23]. Implausible data on BMI was categorised as invalid and excluded from the analysis.

The division of age groups was analogous to the NVS II. However, the age categories of 12–17 and 65–80 were adopted, in line with the options available for selection in the online survey (12–80 years).

The determination of level of education followed the basis for calculating education of socioeconomic status (SES) [24] in the *Studie der Gesundheit Erwachsener in Deutschland* (Study on the Health of Adults in Germany) (DEGS1). To this end, data on the education and professional qualifications of study participants were allocated point values between 1 and 7 and an education score was determined. The study participants were divided into three status groups for statistical analysis. A scale value of 1.0–3.0 was classified as low SES, 3.1–6.0 as medium SES and a value between 6.1 and 7.0 as high SES. Income was not taken into consideration in the calculation [24]. Personal eating habits were assessed by the respondents on a scale of 1 (= unhealthy) to 6 (= healthy). Due to a lack of data on general characteristics – these questions were not mandatory – information on this was not available for all of the people in the study collective.

Data analysis was carried out using the software SPSS® 23. Parameters such as number of cases, mean values, medians, standard deviations and 5% and 95% percentiles were analysed in part broken down by gender or stratified according to age group. A study of group differences was carried out by means of the chi-square test, which determined a 5% significance level. The data from the

^a educational status: education and professional qualifications (score values: 6.1–7 high SES; 3.1–6 medium SES; 1–3 low SES)
^b excluding the 12–17 age group
 BMI = Body Mass Index;
 SD = standard deviation

Variables	n	Mean ± SD	Median	%
Gender	1,336			
female	978			73.2
Age (year)				
average age total	1,327	46.1 ± 13	50	
male	356	44.6 ± 13	47	
female	971	46.7 ± 13	50	
12–17 Age	20			1.5
18–24 Age	64			4.9
25–34 Age	190			14.4
35–50 Age	417			31.6
51–64 Age	606			46
65–80 Age	21			1.6
BMI	1,288	22.9 ± 4.3	22.0	
underweight	76			5.9
normal weight	940			73.9
overweight	202			15.7
obese	70			5.4
Educational status ^a	767			
high	540			51.1
medium	461			43.7
low	55			5.2
Cigarette consumption	1,344			
non-smoker	1,146			85.3
Alcohol consumption ^b	1,344			
never	445			33.1
once per month	328			24.4
several times per month	214			15.9
once/several times per week	344			25.5
Physical activity (days per week)	1,344			
no physical activity	97			7.2
1 day	192			14.3
2 days	275			20.5
3 days	306			22.8
4 days	165			12.3
> 5 days	309			23
Assessment of eating behaviour	1,347			
1 unhealthy	10			0.7
2	80			5.9
3	64			4.8
4	266			19.7
5	704			52.3
6 healthy	223			16.6
Assessment of state of health	1,348			
very good	648			48.1
good	629			46.7
moderate/poor/very poor	71			5.3

Tab. 1: **General characteristics of the study collective**
 Mean, median and percentage relate to the sample size stated for the respective variable.

online questionnaire was compared with data from the NVS II from the years 2005–2007, representing the general population of Germany.

Results

2,282 people took part in the online questionnaire, of which 125 were excluded based on illness and associated intake of dietary supplements. A further 233 participants terminated the survey early (question on supplements) and were also not taken into account in the analysis. Consequently, 1,924 people remained in the overall collective for statistical analysis, having at least provided data on their use of vitamin supplements; it should be noted that not all questions were answered by all participants³. The respective sample size numbers are detailed in ♦ table 1, which presents the general characteristics of the study collective. Of those who provided data on gender, 73.2% were female, and the available data on age produced an average age of 46. Around half of participants who answered the corresponding question had a high educational status, 5.2% a low educational status. The BMI determined from the available data provided on weight and height was 22.9 ± 4.3 kg/m² on average. 73.9% had a BMI in the normal weight field (♦ table 2).

Motive for adopting a vegan diet and duration

The 3 (of a possible 6) main reasons cited for adopting a vegan diet were: ethical/animal rights reasons (75.9%), health (10.3%) and environmental reasons (8%). 19.4% of respondents stated that they had been vegan for more than 5 years, more than 42.0% for more than 2 years, and 19.0%

for more than 1 year. 70.4% of respondents were vegetarian before they switched to a vegan diet.

Consumption of dietary supplements

Vitamins in general

83.9% of the 1,924 study participants stated that they took vitamin supplements (♦ table 2). The most frequently cited vitamin supplement was vitamin B₁₂ (81.5%), followed by vitamin D (41.4%). Mention of the use of supplements for the other 11 vitamins was made by fewer than 10% in each case (♦ Figure 1).

In response to the question on how often the vitamins were taken, more than half (55.3%) selected the response category of “daily”. A further 19% stated that they took supplements several times per week and 12.2% once per week. 6.3% of respondents stated that vitamin supplements were prescribed to them by a doctor.

Consumption of fortified foods

Vitamins in general

37.2% of the 1,924 study participants stated that they consumed foods fortified with vitamins. The number of participants who con-

	%	n
Vitamins		
study collective	83.9	1,615
female	81	792
male	85.5	306
12–17 age	50	10
18–24 age	84.4	54
25–34 age	83.2	158
35–50 age	84.9	354
51–64 age	81.5	494
65–80 age	57.1	12
Mineral		
study collective	20.3	390
female	24.9	244
male	19.8	71
12–17 age	15	3
18–24 age	29.7	19
25–34 age	22.6	43
35–50 age	25.9	108
51–64 age	22.1	134
65–80 age	14.3	3

Tab. 2: Use of dietary supplements

The figures on gender and age distribution relate to the data respectively available.

sumed foods fortified with vitamins increased with age.

As with vitamin supplements, the vitamin most frequently cited in re-

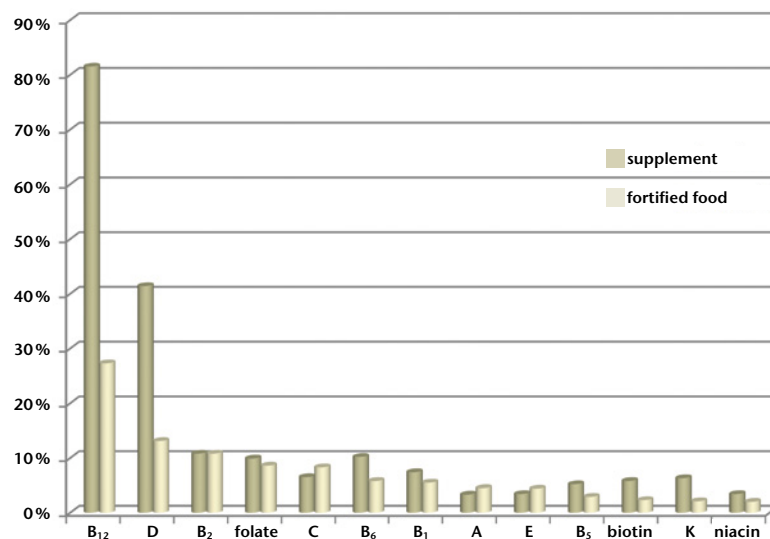


Fig. 1: Consumption of vitamins by means of supplements and fortified foods
 frequency of citation in % (with regard to the study collective, n = 1,924)

³ Further data on the sample size for each question is available from the authors.

Question Item	Response	n	%
Manner of intake	supplements	1,079	94.5
	fortified foods/toothpaste	390	34.2
	combination of both	327	28.6
	fortified foods only	63	5.5
Frequency of intake	taglich	513	39.1
	mehrmals wochentlich	441	33.6
	1-mal pro Woche	145	11
Duration of intake	more than 2 years	499	38
	more than 1 year	330	25.2
	several months	343	26.1
Prescribed by doctor	yes	119	9.1

Tab. 3: Response frequencies on the use of vitamin B₁₂ by those who stated that they used vitamin B₁₂ (n = 1,142) multiple responses possible

lation to fortified foods was vitamin B₁₂. Around a third (27.3%) stated that they purchased foods fortified with vitamin B₁₂. The second and third most frequently cited were vitamin D (13.1%) and vitamin B₂ (10.8%). The consumption of food fortified with folate was cited by 8.6% of participants (♦ Figure 1). The most commonly cited fortified food products were plant-based milk alternatives (55.6%), followed by juices (37.7%). Fortified salt, sweets, bread and baked goods, as well as cereals and protein shakes, were rarely mentioned.

Vitamin B₁₂

Almost all vitamin B₁₂ users (94.5%) consumed vitamin preparations, only 5.5% stated that they obtained the vitamin exclusively through fortified foods and/or fortified toothpaste. 28.6% of respondents stated that they consumed vitamin B₁₂ both as a preparation and in fortified foods/fortified toothpaste (♦ table 3).

Most users (39.1%) stated that they consumed a vitamin B₁₂ supplement on a daily basis. 38% responded to the question on how long they had taken supplements with “more than 2 years” and 25.2% with “more than 1 year” (♦ table 3). It is worth mentioning here that the duration of vitamin B₁₂ intake correlated with

the duration of the vegan diet (p ≤ 0.05). Almost half of those who stated that they took vitamin B₁₂ supplements had done so for more than one year, and had followed a vegan diet for just as long. This correlation applied to 55.5% of those in the field of “more than 2 years”. According to the data provided, vitamin B₁₂ was largely taken on the initiative of the participants and not prescribed by a doctor (♦ table 3). Those who consumed vitamin B₁₂ via fortified foods frequently did so through the consumption of fortified milk alternatives (80.1%).

In response to the question on vitamin B₁₂ blood analysis, 44.2% of vitamin B₁₂ users stated that they had not (to date) had any vitamin

B₁₂ blood parameters tested; a further 26.2% could provide no data on tested blood parameters. Of those who had investigated their vitamin B₁₂ blood parameters and who provided data on this, 21.4% mentioned the holotranscobalamin value; this was the most frequently tested vitamin B₁₂ blood parameter (other possible blood parameters which could have been mentioned were serum vitamin B₁₂, methylmalonic acid and homocysteine).

In a group comparison between vitamin B₁₂ users and non-users, differences were primarily apparent in the general use of dietary supplements and fortified foods. The vitamin B₁₂ group also consumed other vitamins more frequently than non-users of vitamin B₁₂ through dietary supplements (16 times more often) or fortified foods (3 times more often). Mineral supplements and mineral-fortified foods were respectively 3 and 4 times more frequently cited by the vitamin B₁₂ group in comparison to the non-users of vitamin B₁₂ (♦ Figure 2).

Differences between vitamin B₁₂ users and non-users also emerged in regard to educational status. The vitamin B₁₂ users, on whom data on educational status was available, had on average a statistically significantly higher educational status (p ≤ 0.05). The duration of the vegan diet

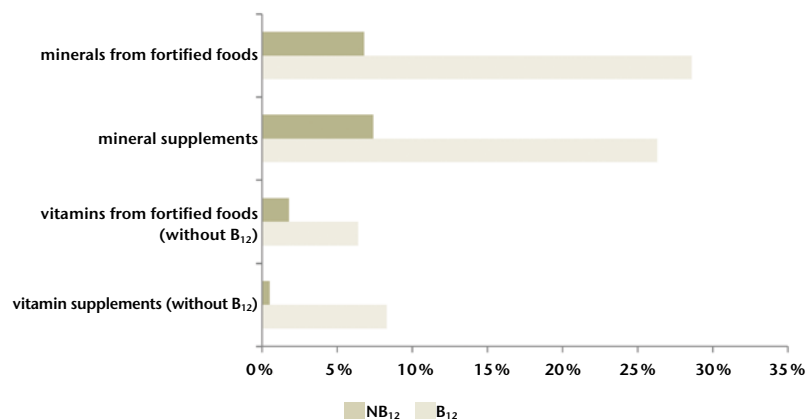


Fig. 2: Use of other micronutrient supplements (excluding vitamin B₁₂) in comparison Vitamin B₁₂ users (n = 1,142 [B₁₂]) vs. non-users (n = 190 [NB₁₂])

also differed between both comparative groups. Vitamin B₁₂ users had followed a vegan diet for longer than the non-users of vitamin B₁₂. Other differences were revealed in living situation. Vitamin B₁₂ users were more likely to live in a household with several people following vegan diets than non-users of vitamin B₁₂.

Consumption of dietary supplements

Minerals

20.3% of the entire collective stated that they took dietary supplements containing minerals (♦ table 2), of which magnesium was the most frequently cited at 9.9%, followed by iron and calcium. All other minerals were cited by only 10% or less (♦ Figure 3). On average, 43.5% of study participants stated that they took mineral supplements on a daily basis. 15.9% of respondents took mineral preparations several times per week. The question on whether the mineral supplement was prescribed by a doctor was answered in the negative by 88.9%.

Consumption of fortified foods

Minerals

The survey also revealed that 19.9% consumed minerals through fortified foods. The most frequently cited mineral in mineral-fortified foods was calcium (16.7%), followed by iodine (4.2%) and iron (3.6%) (♦ Figure 3).

In contrast to vitamins, where no difference was found between genders in the consumption of fortified products, the survey revealed differences between genders in the frequency of mineral consumption for iodine, iron, magnesium, fluoride and zinc. Men consumed iodine through fortified foods almost twice as often as women. However, women consumed foods fortified with iron, magnesium, fluoride and zinc more often than men.

Mineral-enriched milk alternatives (29.7%) were the most frequently cited product category, with the exception of the “other” category, followed by juices (18.9%).

Comparison with the general population (NVS II)

A comparison between the vegans in this study and the participants in the NVS II revealed that the proportion of normal weight persons who are vegan was higher than in the NVS II (73.9% vs. 44.2%) [25]. The vegans in this study were also more likely to assess their own state of health as very good in comparison to the participants in the NVS II (48.1% vs. 17.5%). The relative proportion of non-smokers (85.3% vs. 52% in the NVS II) was comparatively high among vegans; the proportion of those physically inactive was significantly lower than in the NVS II (“physically inactive” 7.2% vs. 28.6%). The proportion of vegans who took vitamin supplements in this study is more than 5 times higher than the general population [25]. 83.9% of vegans stated that they consumed vitamin prepa-

rations, compared to 15.7% of the NVS II participants. However, if we exclude vitamin B₁₂, only 5.8% of vegans took vitamin preparations. The difference was slight for mineral preparations; 20.3% of vegans and 19.4% of NVS II participants stated that they took these.

Only dietary supplements of vitamin B₁₂ (81.5% vs. 19.3%) and vitamin D (41.4% vs. 16.2%) were more frequently cited by vegans in this study.

Discussion

This survey on the supplementation behaviour of vegans in Germany was based on a chance sample of online-generated data from 1,924 people. Of which 83.9% stated that they consumed vitamins by way of nutritional supplements. This value initially seems very high, but relates primarily to vitamin B₁₂, which is recommended for a vegan diet [25]. A total of 81.5% of surveyed vegans stated that they consumed vitamin B₁₂ as a supplement. Of which 34.2% stated that they

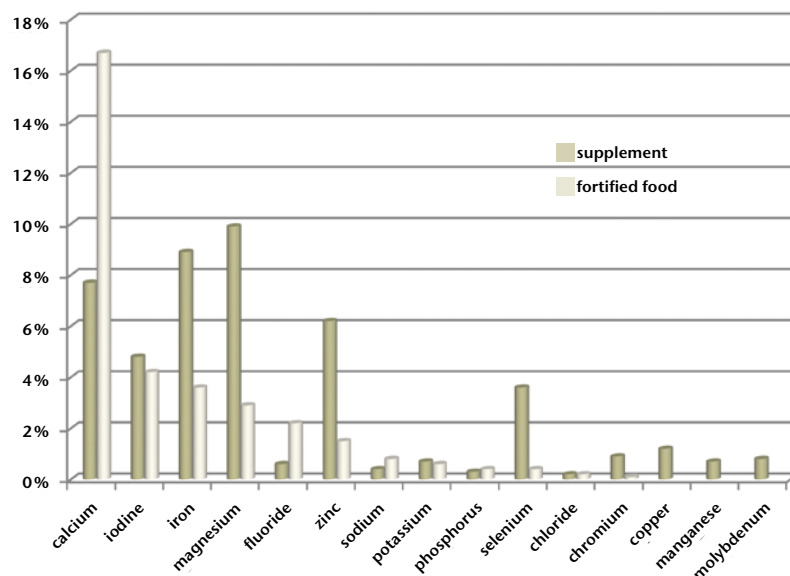


Fig. 3: Consumption of minerals by means of supplements and fortified foods
 frequency of citation in % (with regard to study collective, n = 1,924)

additionally or exclusively used foods fortified with vitamin B₁₂ and/or other preparations.

However, this (pleasingly) high frequency of vitamin B₁₂ intake cannot be applied to all vegans in Germany due to the non-representative nature of this survey (▣▣▣ paragraph on “limitations”). This is because, on the one hand, the approach to the study participants named supplementation behaviour as the research objective of the survey. The possibility therefore exists that people who did not take supplements were less likely to take part. On the other hand, the parent population from which the sample was taken is unknown, as it is unclear from which people with which characteristics the group of vegans in Germany is composed. An estimate on the prevalence of vitamin B₁₂ supplementation is therefore not possible on the basis of this data.

In the *Deutsche Vegan Studie* (German Vegan Study) (n = 154; 1994–1995) only around 20% of participants stated that they supplemented their diet with vitamin B₁₂ (46.1% regularly took dietary supplements) [15]. At that time, more than half of participants were motivated by health reasons to adopt a vegan diet. However, given the predominant motivation of vegans today (mainly ethical/animal rights reasons) and thus accordingly their potentially more open attitude to the use of supplements, it is conceivable that a higher proportion of vegans are prepared to use the recommended supplements today than 20 years ago. The correlation found in this survey between vitamin B₁₂ supplementation and the duration of the vegan diet, as well as a potentially greater willingness to take supplements than in the past, could correlate with the increase in educational work in recent years. Above all, information from associations and foundations, such as ProVeg (formerly *Vegetarierbund Deutschland* [VEBU]) or the *Albert Schweizer Stiftung für unsere*

Mitwelt (Albert Schweizer Foundation for Our Contemporaries), may have contributed and may continue to contribute to this. As the theme is also widely discussed in the general press, we can assume that many vegans today are informed on this matter.

In this survey, educational status is the main differentiating factor between those who stated that they supplement their diet with vitamin B₁₂ and those who stated that they did not. Thus we can assume that vegans with a higher educational status are more informed about nutritional issues or corresponding recommendations. Due to a lack of data on educational status in this survey, this analysis should however be treated with caution.

The necessity of vitamin B₁₂ supplementation among vegans due to an insufficient supply has been documented in many studies [16, 26–28]. For example, in the British EPIC Oxford Study, 52% of examined vegans had a serum vitamin B₁₂ concentration below the normal range [29]. However, in contrast, a current study from Switzerland showed a vitamin B₁₂ status below the reference value for only 7.5% of examined vegans [30]. The vitamin B₁₂ toothpaste study carried out in Germany determined that, despite awareness and acceptance among most vegans in regard to vitamin B₁₂ supplementation, it is often not consistently and reliably carried out; this is reflected in the high prevalence of a lack of vitamin B₁₂ (lowered holotranscobalamin value: 59.2%; raised methylmalonic acid value: 50.0%) [22]. No conclusion can be made on the status of the vitamin B₁₂ supply of vegans in Germany based on this data. Analysis of vitamin B₁₂ status based on blood parameters was only specified by a small number of respondents; data was not requested about these test results.

Vitamin D was the second most common vitamin consumed as a supplement by respondents to this survey. All other vitamin supplements were each consumed by fewer than 10% of participants, even though vitamin B₂, in addition to vitamins B₁₂ and D, is a critical nutrient in a vegan diet.

In contrast to vitamins, only 20.3% of participants stated that they supplemented their diet with minerals (most commonly magnesium, iron and calcium). Zinc and iodine were also cited, but each by fewer than 7% of respondents. Except for magnesium, these named minerals are critical in a vegan diet which is not well-planned. The comparatively high frequency of magnesium intake is surprising, as a sufficient quantity of this mineral is typically consumed as part of a well-planned vegan diet [14, 15]. Magnesium was also the most frequently consumed mineral supplement in the general population [25]. Thus magnesium appears to be a frequently supplemented mineral irrespective of diet.

The vitamin and mineral intake determined in this study demonstrates that the micronutrients regarded as critical for vegans (as well as the “uncritical” magnesium) exhibit a high prevalence of intake. Accordingly, significant differences in supplementation behaviour were determined between this sample and the general population. A comparison with data from the NVS II showed that, as to be expected, vitamin B₁₂ and vitamin D were less frequently taken as supplements by the general population. However, it should be taken into account in this data comparison that the compositions of the samples vary significantly, e.g. in regard to educational status, and that the data from the NVS II is potentially no longer current. However, another current representative consumer study recorded similar data on supplementation behaviour among the general population [31].

The primary preventive nature of supplementation was demonstrated by the fact that only a few stated that they had been prescribed vitamin and/or mineral supplements by a doctor. This could imply that supplements are taken on the initiative of users and possibly upon commencement of a vegan diet. Hence, as shown by this data, the duration of the vegan diet went hand in hand with the duration of the intake of dietary supplements such as vitamin B₁₂.

Only half as many vegans in this study stated that they consumed vitamin-fortified foods in comparison to vitamin supplements. The reason for this could be that vitamin B₁₂ and vitamin D are largely not present in sufficient quantities in fortified foods to cover the necessary supply through the standard consumed quantities. In addition, consumers must contend with the precise contents of the foods. Another reason for a lower use of fortified foods could be that special attention must be paid as to whether the foods are fortified with nutrients and they are not necessarily purchased for this reason. And lastly, the consumption of less processed products and more fresh ingredients by vegans could suggest that fortified foods find less use than dietary supplements. As it is important to ensure a secure supply, primarily of vitamin B₁₂, the respondents probably, in accordance with recommendations, preferred to use dietary supplements.

As was the case for dietary supplements, foods fortified with vitamin B₁₂ were also the most frequently cited in the context of fortified foods. Second place was taken by foods fortified with vitamin D. This again illustrates the value of both vitamins from a “vegan perspective”. In regard to minerals, around 20% of participants stated that they consumed these additionally by way of fortified foods. In contrast to dietary supplements, it was not magnesium

which was the most commonly consumed, but calcium, followed by iodine. This could be due to the fact that plant-based milk alternatives are predominantly enriched with calcium and this product category was the most frequently cited by the participants who consumed fortified foods. There are very few products fortified with magnesium.

Limitations

The way in which the sample was selected most likely resulted in a non-representative sample. The results cannot therefore be applied generally to the entire population of vegans in Germany. It is also possible that, due to the complexity and length of the questionnaire, all of the data on supplementation behaviour was not provided (e.g. due to insufficient knowledge to respond to some questions, unknown and/or temporary consumption of some products and difficulties understanding packaging information). A lack of data on some questions can presumably be traced back to the complexity and length of the questionnaire. Hence, data on mineral consumption is missing for 23.4% of participants and data on the use of food fortified with vitamins and minerals by 16.3% and 26.7% respectively. 16.2% provided no data on the intake of vitamin B₁₂. In this context, prevalence estimates must be regarded as conservative, as those who provided no data on questioned vitamins or minerals were regarded as non-users.

In the comparison of data obtained from this survey with that from the NVS II, it must be taken into account that the NVS II data comes from a significantly older survey and from another study collective. This could lead to under- or overestimation of the described differences. It should also be taken into account that the survey exclusively consists of data provided by the respondents,

which always involves a risk of misinformation and often exhibits a tendency to report socially-desired behaviour [32].

Conclusion

The survey on supplementation behaviour by vegans in Germany carried out on the basis of a chance sample suggests that there is a strong compliance with recommendations on nutrient supplementation by this target group. Due to a lack of knowledge on the entire population of vegans and a lack of comparative data from other studies, no general statement in regard to the actual supplementation behaviour of vegans in Germany can be made. Yet the data obtained points to the frequent use of nutritional supplements, particularly in the case of vitamin B₁₂ which is regarded as critical. However, this data does not establish whether the type and quantity of supplements used ensure sufficient supply and the possibility of overdose cannot also be excluded. Therefore, further surveys, which also include biological markers of supply status, are necessary.

Professor Keller has received fees for reports and lectures from Alpro and for a scientific study on vitamin B₁₂ fortified toothpaste from Logocos. He is a member of the scientific committee of the Vegetarierbund Deutschland and the *Albert Schweitzer Stiftung für unsere Mitwelt*.

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Conflict of Interest

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The other authors declare that there is no conflict of interests.

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