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The Nitrate Content of Commonly Consumed Agricultural Products Including Vegetables, Cereals, and Legumes in Iran

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KEYWORDS

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ABSTRACT: The excessive presence of nitrate in foodstuff can be potentially toxic and carcinogenic to humans. This is because about 80% of the nitrate that enters the human body comes from vegetables. Therefore, the present study determined the nitrate content in agricultural products commonly consumed by Iranians. A total of 222 samples of 19 different varieties of these products, including vegetables (171 samples), cereals (42 samples), and legumes (9 samples), were randomly collected from major grocery stores in different cities in Iran between September 22 and December 15, 2020. The methods of HPLC-UV were used to evaluate the nitrate content. The detection limits (L.O.D.) and limit of quantification (L.O.Q.) were 0.071 and 0.22 mg kg^{-1}, respectively. As a result, the mean nitrate levels in the different samples varied from 1042.50 mg kg^{-1} in lettuce to 49.90 mg kg^{-1} in wheat. Potato also had a higher mean nitrate concentration than the standard level. In addition, products such as tomatoes, eggplant, spinach, herbs, and lettuce had significantly lower average nitrate concentrations than the typical values. Moreover, the average nitrate concentration was highest in the central region (492.7 mg kg^{-1}). In contrast, the lowest average nitrate concentration was in the northern region (121.7 mg kg^{-1}) ($P < 0.05$). Moreover, the highest average nitrate concentration (468.52 mg kg^{-1}) was found in the vegetable group and the lowest in the cereal group (50.40 mg kg-1) ($P < 0.05$). Taken together, this information could allow the establishment of a database for the quantification of nitrate exposure and its risk-benefit determination in the Iranian population.

INTRODUCTION

Nitrate (NO_3^-) is the major form of nitrogen that plays a unique role in the photosynthesis process of plants. It is also approved as a food additive under the European codes E249-E252 [1, 2]. Nitrate is naturally derived from soil,

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either as a component of mineral fertilizers or through soil microorganisms' decomposition of organic matter [3]. Most of the nitrogen is taken up by plant roots and serves as a precursor for synthesizing proteins and other nitrogen compounds [4]. Under certain circumstances, plants tend to accumulate more nitrates than they need, for example, when nitrate uptake exceeds assimilation by the plant; as a result, nitrate pollution of plants occurs [3]. Among the plants, vegetables contain large amounts of this element. About 80% of nitrate intake in the human diet comes from vegetables, while 5% comes from food additives and 15% from water [1, 5, 6]. Some plant species are good nitrate accumulators, especially the leafy vegetables (spinach, lettuce, cabbage, beetroot, etc.), containing a significant amount of nitrate. On the other hand, vegetables such as tomatoes, potatoes, carrots, beans, peas, and cauliflower hardly accumulate nitrate. The nitrate value of plants can vary from 1 to 10,000 mg kg^{-1} [2, 8]. Accordingly, this accumulation is correlated with various factors such as agricultural factors (e.g., soil composition, plant genotype, a particular part of the plant, type and amount of fertilizer, degree of atmospheric nitrogen fixation by plant symbiotic bacteria, and root nitrate reduction activity) and environmental situations (e.g., temperature, season, light conditions, humidity, carbon dioxide concentration, distribution of plants in the field, pH, and postharvest conditions) [1, 7-9]. Vegetables have played an important role in human nutrition for many years, as they are an excellent source of minerals, vitamins, fiber, and antioxidants (polyphenols).

In addition, numerous scientific studies have established the beneficial effects of dietary nitrate on various aspects of general health. For example, a similar protective effect on the cardiovascular system as that of nitric oxide (NO) has been noted by various scientists [6, 11, and 12]. To date, the World Health Organization (WHO) [10] advises everyone to eat at least 400 g of vegetables (excluding tubers) and fruits daily. Despite all these beneficial effects associated with vegetable consumption, some potential risk factors such as nitrates [3, 8]. Nitrate has been shown to have a negligible level of toxicity naturally, but when converted to nitrite ($NO2^-$), it acts as a reactant to convert amines and/or amides into carcinogenic compounds (i.e., N-nitrosamines) that may pose potential health problems, which gives nitrate special attention.

Consequently, the International Agency for Research on Cancer (I.A.R.C.) classifies nitrate as "probably carcinogenic to humans" (Group 2A) under certain conditions [13]. Several studies link excessive nitrate intake to increased incidence of various cancers (thyroid, mammary, renal, esophageal, gastric, colorectal) [5, 14-16] and methemoglobinemia in children [8, 9]. However, epidemiological studies lack strong evidence, as it is inherently difficult to link nitrate consumption to health or disease outcomes [5]. For this reason, the European Commission (E.C. No. 1881) [17] has set the maximum permissible limit (M.P.L.) for nitrate in various vegetables. Since vegetables are constantly present in people's diet and also play an important role in providing minerals, vitamins, and antioxidants, it is necessary to measure nitrate as excessive intake of nitrate from food is very harmful. So, the main objective of this study was to evaluate the nitrate content of different agricultural plants such as vegetables (spinach, lettuce, cabbage, onion, potato, tomato, carrot, watermelon, melon, sugar beet, beetroot, eggplant, mushroom), herbs (basil, mint, dill, coriander, chives, and parsley), cereals (rice and wheat) and legumes (pinto beans, lentils, and soybeans) grown in different cities of Iran to determine if they exceed the standard allowable value.

MATERIALS AND METHODS

Sample collection

In this study, a total of 222 samples of 19 types of more frequently consumed agricultural products, including vegetables (n = 171), cereals (n = 42), and legumes (n = 9) from the main municipal markets in various cities of Iran (Tabriz, Sarvelat, Amol, Fereydunkenar, Behshahr, Golestan, Gorgan, Jiroft, Varamin, Karaj, Mashhad, Sarakhs, Sabzevar, Fariman, Neyshabur, Kashmar, Ghochan, Taybad, Torbat-e Heydarieh, Torbat-e Jam, Birjand, Jolge Majan, Bojnord, Mane and Samalghan, Shirvan, Esfarayen, Tabas, Esfahan, Kashan, Kermanshah, Hamedan, Yazd, Ahvaz, Dezful, Shiraz, Bushehr, Bandar

Abbas), were randomly collected during autumn 2020 (September 22 until December 15, 2020). The sampling procedure was planned according to the criteria authorized by the Institute of Standards and Industrial Research of Iran (I.S.I.R.I.) No. 1532. All samples were put into paper bags and promptly (< 1 hour of purchase) transferred to the cooperator laboratory of the Food and Drug Organization, and then stored at 4 ℃until analyzed in an accredited public laboratory. The minimum weight of the sample was 1 kg.

Sample preparation

The extraction of nitrate, preparation of filtrate, and determination were carried out according to the method No. 16721-2 (2015) of the Iranian National Standardization Organization (I.N.S.O.). The basis of the method is based on the extraction of nitrate from food with hot water and removal of interfering substances by treatment with Carrez 1 and 2 reagents.

Reagent and standard solutions

Carrez 1 and 2, sodium nitrate (purity 99%), borax, and dibasic sodium phosphate were purchased from Merck (Darmstadt, Germany). C18 cartridges for solid-phase extraction (6 ml, 500 mg) were supplied by Waters (Massachusetts, U.S.A.). Milli-Q water was prepared using a Millipore purification system (Millipore, Bedford, MA, U.S.A.). Calibration standard nitrate solutions were purchased from certified commercial standards (Sigma-Aldrich, Steinheim, Germany), diluted in water, and stored in vials at 4°C. The concentrations of the calibration standards ranged from 0.5 to 100 mg ml^{-1}.

Nitrate extraction

All nitrate extraction procedures were performed rapidly (< 24 hours). First, the samples were checked, and any impurities were removed with a damp paper towel, and the inedible or rotten outer parts were separated. For small vegetables, the entire sample was cut. In contrast to the voluminous samples, e.g., cabbage, cut vertically into quarters, only one quarter was used for analysis. Then the edible parts were washed one by one in distilled water and dried in a manually operated spin dryer. After drying, the samples were homogenized (10 g of the sample plus 400 ml of water (> 80°C) were placed in a 500 ml volumetric flask and homogenized with the magnetic stirrer). Finally, the samples were frozen and stored in a freezer at -20°C. The maximum storage time before analysis is about six weeks.

Preparation of filtrate

Briefly, 1-10g of homogenized samples, plus 5 mL of sodium tetraborate and 100mL of hot water (70 to 80°C), was placed in the boiling water bath for about 5 min. In contrast, Carrez I (2mL), Carrez II (2mL), and also double distilled water (up to 200mL) were added and then passed through a 0.45-mm paper filter. Finally, the filtered solution was injected at HPLC-UV.

Nitrate determination

The nitrate value was identified and quantified by high-performance liquid chromatography (Agilent Technologies Inc., Palo Alto, CA, U.S.A.) using a U.V. light detector. Separation was performed on a 4.6×250mm 5-10µm Agilent Alltech-C18 column thermostatted at 30 °C and equipped with a 1200 series quaternary pump. A mobile phase of 10 g/1000 ml potassium dihydrogen phosphate (K2HPO4) and 50 ml acetonitrile was used. Samples were passed through a 0.45µm membrane filter (Merck Millipore, Darmstadt, Germany). The injection volume was 20µl, and the isocratic flow rate was set to 1.0ml min^{-1}, with a total run time of 20 min. Absorbance was measured at 205 nm. The typical retention time for nitrate was 9.8 min. The coefficient of determination (R2) was more than 0.9999, and the recovery was 98%. The limit of detection (L.O.D.) was 0.071mg l^{-1}, and the limit of quantification (L.O.Q.) was 0.22mg l^{-1}.

The result was expressed in mg kg^{-1} based on the formula: mg kg^{-1}= a (mg kg^{-1}) × b (ml) / weight (g), where a = concentration read from chromatogram, b = dilution (Chou et al., 2003).

Statistical analysis

The T-test in S.P.S.S. software (version 16) (S.P.S.S. Inc., Chicago, IL, U.S.A.) was used to compare the average nitrate concentrations of plant agricultural samples with their standard Iranian limits. One-way analysis of variance (ANOVA) was used to compare the mean value of nitrate in different groups of samples and five regions of Iran. The results were expressed as mean ± S.E.M. Statistical significance was set at $p < 0.05$.

RESULTS

The nitrate contents of commonly consumed vegetables, cereals, and legumes and the minimum and maximum nitrate levels were presented in Table 1. According to Table 1, the mean nitrate levels in agricultural samples varied from 1042.50 mg kg^{-1} in lettuce to 49.90 mg kg^{-1} in wheat. The nitrate concentrations in some of these samples were significantly or not significantly higher than the Iranian national nitrate standard for agricultural products (I.N.S.O., 16596) (E.C. No 1881: 2006) [17] (Table 1). Our analysis revealed that tomato (75.52 mg kg^{-1}), eggplant (97.66 mg kg^{-1}), spinach (129.75 mg kg^{-1}), herbs (841.60 mg kg^{-1}), and lettuce (1042.50 mg kg^{-1}) had significantly lower mean nitrate concentrations than the Iranian standard values (Table 1). At the same time, potatoes (216.24 mg kg^{-1}) had a higher mean nitrate concentration than the normal control value. From the results presented in Table 1, it can be concluded that the average nitrate concentration in some of these products (i.e., kale, watermelon, rice, pinto beans, soybean) was numerically but not significantly ($p > 0.05$) higher than the Iranian standard maximum values. On the other hand, in other products (i.e., onion, carrot, melon, sugar beet, beetroot, mushroom, wheat, and lentil), the nitrate level was not significantly lower than the standard level; thus, they were close to the maximum permissible levels of the standard.

By comparing the groups of different crops (vegetable, cereals, and legumes), the highest average concentration of nitrate (468.52 mg kg^{-1}) was for the vegetable group, and the lowest level was for the cereal group (50.40 mg kg^{-1}) ($P < 0.05$) (Table 2).

By comparing the regions of the samples, the highest average concentration of nitrate was for the central region (492.7 mg kg^{-1}). While the lowest average level of nitrate was for the northern region (121.7 mg kg^{-1}).

The concentration of nitrate in crops collected from northern region (121.7 mg kg^{-1}) was significantly lower than central region (492.7 mg kg^{-1}), southern region (427.9 mg kg^{-1}), and eastern region (389.7 mg kg^{-1}) ($P < 0.05$). But there was no significant difference between the average nitrate level of the northern region (121.7 mg kg^{-1}) and the western region (215.4 mg kg^{-1}) ($P > 0.05$) (Table 3).

Table 1. Nitrite (mg kg^{-1}) concentration in different types of fresh vegetables, cereals and beans supplied from various cities of Iran in comparison with Iranian standard level.

Type of samples		Number of samples	Minimum (Mg kg^{-1})	Maximum (Mg kg^{-1})	Average (Mg kg^{-1})	Standard error	Iranian standard level (Mg kg^{-1})	Significance level (P < 0.05)
Vegetables	Spinach	13	703	1580	129.75	64.02	2000	0.001 (S)
	Lettuce	21	922	1253	1042.50	17.46	1500	0.001 (S)
	Cabbage	5	418	626	544.00	46.54	500	0.398 (NS)
	Onion	21	59	138	84.09	3.44	90	0.102 (NS)
	Potato	21	144	571	216.24	20.04	170	0.032 (S)
	Tomato	19	43	111	75.52	3.42	120	0.001 (S)
	Carrot	15	184	302	248.33	9.29	250	0.860 (NS)
	Watermelon	3	51	82	66.66	8.95	60	0.534 (NS)
	Melon	2	67	73	70.00	3.00	90	0.095 (NS)
	Sugar beet	10	192	770	415.50	60.92	500	0.199 (NS)
	Beetroot	11	334	767	442.91	34.05	500	0.125 (NS)
	Eggplant	6	74	113	97.66	5.84		
	Mushroom	4	58	107	84.75	10.11	100	0.229 (NS)
	herbs	20	610	1132	841.60	29.90	1000	0.001 (S)
Cereals	Rice	21	44	73	50.90	1.64	50	0.588 (NS)
	Wheat	21	37	81	49.90	1.93	50	0.961 (NS)
Legumes	Pinto bean	1	110	110	110.00		100	
	lentil	5	70	133	91.20	11.20	100	0.476 (NS)
	Soybean	3	80	184	117.67	33.26	100	0.648 (NS)

S: the relationship between the mean concentration level of nitrate and the standard level was significant; NS: the relationship between the mean concentration level of nitrate and the standard level was significant.

Table 2. Comparison the nitrite (mg kg^{-1}) concentrations between different groups of crops, significant level was $P < 0.05$.

Groups	Number of samples	Average (Mg kg^{-1})	Standard error	Minimum (Mg kg^{-1})	Maximum (Mg kg^{-1})
Vegetables	171	468.52^{a}	32.56	43	1580
Cereals	42	$50.40b^{c}$	1.258	37	81
Legumes	9	102.11^{c}	12.09	70	184
total	222	374.35	27.61	37	1580

^{abc} Different superscript letters show the significant difference ($P < 0.05$)

Table 3. Comparison the nitrite (mg kg^{-1}) concentrations between different regions, significant level was $P < 0.05$.

Regions	Number of samples	Average (Mg kg^{-1})	Standard error	Minimum (Mg kg^{-1})	Maximum (Mg kg^{-1})
North	24	121.7a	49.67	44	1129
East	115	389.7^{bcde}	40.75	37	1580
South	34	427.7^{cd}	64.59	43	1121
Center	37	492.7^{cd}	72.14	44	1390
West	12	215.4^{acde}	38.22	67	571
Total	222	374.3	27.61	37	1580

^{abcde} Different superscript letters show the significant difference ($P < 0.05$

DISCUSSION

Nitrate is neither toxic nor carcinogenic below the maximum levels (ML) (Table 1). However, it increases the potential risk and makes nitrate an important regulatory factor when it is converted into its proven harmful metabolites such as nitrite, nitrous acids, and nitrosamines [18]. After ingestion, nitrate is converted to nitrite via the entero-salivary circulation with the help of endogenous nitrate reductases. Subsequently, nitrite is partially reduced to NO in the acidic pH of the stomach, and the remainder of the nitrite is absorbed into the bloodstream and serves as the end product of the L-arginine- NO synthesis pathway [5]. NO is a relatively short-lived molecule, but under oxidative conditions (i.e., in the presence of reactive oxygen species (R.O.S.)), it can form nitrosyl peroxide, which enhances oxidative/nitrosative damage. Alternatively, nitrous acid may react with an amine under acidic conditions (i.e., in the stomach, pH 2.5-3.0) and consequently increase the rate of N-nitrosation [19]. Excessive consumption of nitrate-containing foods has been associated with certain health consequences in humans, such as bladder cancer, stomach cancer, and methemoglobinemia syndrome [20-22]. Although several recent studies have attempted to prove the association between nitrate consumption and carcinogenesis, the findings obtained are still not convincing [22, 24-27].

This study found the highest average nitrate content in lettuce and the lowest in wheat, with the highest and lowest nitrate content being 1042.50 mg kg^{-1} and 49.90 mg kg^{-1}, respectively. Generally, it should be noted that nitrate content in plants follows the following order: Leaf > Stem > Root > Inflorescence > Gland > Fruit > Grain [9]. Thus, higher levels of nitrates tend to accumulate in leaves, while lower levels are found in seeds or tubers. Consequently, leafy vegetables (i.e., herbs, spinach, and lettuce) are considered dominant nitrate-enriching species [1, 22, and 28]. Similarly, it was claimed that nitrate concentrations in leafy vegetables (lettuce, basil, parsley) were higher than those in root vegetables (onion, carrot), and concentrations in root vegetables were higher than those in fruiting vegetables (tomato) [9]. This is also confirmed by other researchers [1, 29]. Nitrate levels in vegetables vary widely. Accordingly, plants can also be classified into three groups based on nitrate concentration: (1) high nitrate plants (> 1000mg kg^{-1}), including arugula, spinach, lettuce, beetroot, celery, cabbage, and herbs; (2) medium nitrate plants, most typical vegetables are in the medium range

(100-1000 mg kg^{-1}), including carrots and potatoes at the lower limit and green beans, cabbage at the upper limit; (3) Plants with low nitrate content (< 100 mg kg^{-1}), including tomatoes and onions, berries, fruits, cereals, legumes [7, 28, 30]. These data agreed well with our results, except for spinach, which was lower in the current study (129.75 mg kg^{-1}). In contrast to our results, spinach has been found to accumulate high levels of nitrate [31-33]. In addition, another study has shown that spinach and herbs, including cilantro, dill, and parsley, have been described as high accumulators of nitrate [21]. In addition, the data collected showed that the highest nitrate content was detected in spinach and parsley, and the lowest nitrate content was detected in tomatoes [34]. The evidence presented also explained that spinach had the highest nitrate value (1266.5 mg kg^{-1}), followed by lettuce (646 mg kg^{-1}) and potatoes (173.5 mg kg^{-1}), while carrots had the lowest nitrate average value (40 mg kg^{-1}) [22]. However, consistent with our result, several studies have not found nitrate contamination in spinach [40, 41]. Moreover, the EFSA Panel on Contaminants in the Food Chain (CONTAM) [35] reported a mean value for nitrate in lettuce (844 mg kg^{-1}), spinach (1066 mg kg^{-1}), herbs (1240 mg kg^{-1}), mushrooms (61 mg kg^{-1}), tomatoes (43 mg kg^{-1}), onions (164 mg kg^{-1}), cabbage (311 mg kg^{-1}), beetroot (1379 mg kg^{-1}), carrots (296 mg kg^{-1}), potatoes (168 mg kg^{-1}) and others. Some of these vegetables, such as lettuce, spinach, herbs, onions, beetroot, and carrots, had higher nitrate concentrations than those described in our study. Moreover, the results of another researcher [36] reported average nitrate levels in iceberg lettuce (928.1 mg kg-1) and spinach (949.6 mg kg-1), which were higher than our results [36]. In numerical contradiction with our results, the average nitrate value in vegetable samples, including lettuce (51.36 mg kg^{-1}), onion (42.54 mg kg^{-1}), carrot (35.17 mg kg^{-1}), and tomato (33.32 mg kg^{-1}) was found to be lower than the standard value [9]. However, the fact that the lowest nitrate content was found in tomatoes agrees with our results. Moreover, in another study in Isfahan, nitrate levels in onions, tomatoes, cucumbers, spinach, and lettuce were lower than the Iranian standard limit [18]. In the case of lettuce, the data of this study were in agreement with the results of other researchers [1, 35], who insisted that lettuce is considered a nitrate-enriching species. On the other hand, in the studies of Kyriacou et al. (2019) [21] and Croitoru et al. (2015) [37], the nitrate content of lettuce was among the lowest. According to our results, the nitrate concentration in potatoes was higher than the standard limit. Another researcher [18] concluded in a review article that potato samples were mostly contaminated by nitrate higher than the standard limits in various studies in Iran. Tomatoes, on the other hand, were less contaminated. This agrees well with our study. In another study on the level of contamination of potatoes and tomatoes in Khorasan Razavi, it was described that the level of nitrate in potatoes was below the standard. On the other hand, the contamination level of tomatoes was much higher than the standard limit [38]. Studies of eggplant in the Iranian cities of Ahvaz and Tehran revealed that the nitrate contamination of this product was 864.5 and 279.76 mg kg^{-1}, respectively, which was higher than our results [39, 40]. On the other hand, the eggplant contamination in a Shiraz study was 66.9 mg kg^{-1}, which was lower than our results [41]. Limited data are available on the nitrate content of cereal products (rice and wheat); the nitrate content of wheat flour ranged from 10 to 19.8 mg kg^{-1}, which was lower than our results [42, 43]. Moreover, a recent study in two Iranian cities, Varzaghan and Parsabad, found average nitrate levels in cereals and bread to be 336 and 420 mg kg^{-1}, respectively [44]. The nitrate level of rice in our study (50.90 mg kg-1) was comparable to the average nitrate concentration of rice in Japan (21 mg kg^{-1}) [45] and in Nigeria (170-940 mg kg^{-1}) [46]. The average nitrate levels of commonly consumed cereals, legumes, fruits and vegetables were also determined in Tehran, Iran, during 2014-2016 [47]. The nitrate levels of rice, watermelon, and melon were 240, 110, and 220 mg kg^{-1}, respectively, which were significantly higher than our results. Among legumes, soybean had the lowest nitrate levels (100 mg kg^{-1}), followed by lentil (110 mg kg^{-1}), similar to our results. Among vegetables, the lowest mean nitrate values were found for tomato (170 mg kg^{-1}), potato (380 mg kg^{-1}) and carrot (500 mg kg^{-1}). And the highest nitrate levels were for beetroot (4900 mg kg^{-1}), lettuce (3600 mg kg^{-1}), mint (2800 mg kg^{-1}), followed by coriander (2400 mg kg^{-1}), basil (2400 mg kg^{-1}), spinach (1800 mg kg^{-1}), dill (1800 mg kg^{-1}) and parsley (1700 mg kg^{-1}). Derived results in Estonia also showed that the highest mean nitrate concentrations were documented in lettuce (2167 mg kg^{-1}), spinach (2508 mg kg^{-1}) and beetroot (1447 mg kg^{-1}) [28]. In addition, the lowest mean concentrations of nitrates were found in onion (55 mg kg^{-1}), tomato (41 mg kg^{-1}) and potato (94 mg kg^{-1}). Moreover, the mean concentrations of carrot (148 mg kg^{-1}) and watermelon (95 mg kg^{-1}) were comparable to ours. Moreover, the nitrate concentration in potato of Japanese [48] and Korean [49] origin was 713 and 452 mg kg^{-1}, respectively.

Several surveys have documented that the nitrate level in plants varied from < 1 mg kg^{-1} to > 1000 mg kg^{-1}, based on different factors; such as plant conditions (i.e., species, genotype, and age), cultivation practices (i.e., soil composition, nitrogen supply, plant density), climate condition (i.e., season, light intensity, temperature, moisture, carbon dioxide concentration), sampling, storage conditions, and cooking method [9, 18, 21, 23]. Different scientists defined that the nitrate content in plants during autumn and winter was higher than during spring and summer [9, 50]. Taken together, increased use of nitrogen-containing fertilizers due to the harvesting time, which was in autumn, might be an explanation for higher nitrate contents in our findings, which were so close to the maximum permissible levels. Regarding the above, it is recommended to apply controlling strategies to reduce nitrogen compounds in plants, including 1) carefully monitoring the cultivation conditions, 2) using low nitrate accumulator genotypes, 3) reducing the usage of nitrogen fertilizer, 4) partial substitution of nitrate-based fertilizers with other nitrogen forms like chlorides, 5) applying organic and biological fertilizers, 6) constant and careful supervision of the importing and maintenance of plants by experienced experts [1, 18].

CONCLUSIONS

Consequently, access to a reputable database on nitrate concentrations in food is critical to address this complicated issue. However, unlike other nutrients and food components, there is no valid, acceptable, and all-inclusive database such as the Food Composition Table (F.C.T.) of the United States Department of Agriculture (U.S.D.A.) for nitrate in Iran. Given the lack of such data, the main objective of the current study was to investigate the amount of nitrate in commonly used agricultural products among Iranians. The Iranian Food Authority could use our results to evaluate the factors affecting nitrate concentration and dietary nitrate intake and estimate the risk-benefit analysis of dietary nitrate exposure. Among the 200 agricultural products analyzed in the present study, 16 samples (8%) exceeded the Iranian national standard nitrate value applicable to potato samples. It can be concluded that the nitrate level in some of the samples (i.e., onion, carrot, melon, sugar beet, beetroot, mushroom, wheat, and lentil) was overall lower than the standard value. Still, the differences were not significant and again so close to the maximum permissible values of the standard. Therefore, more attention should be paid to H.A.C.C.P. (hazard analysis and critical control points), and G.M.P. (good manufacturing process) of these products should be focused.

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Conflicts of interest

The authors declared no conflict of interest.

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