Original Article

Evaluation of the Effect of Different Methods of Cooking on Nitrate and Nitrite Residues in Potatoes on Human Health

Ehsan Shamloo[1], Zohreh Abdimoghadam[1], Mojtaba Yousefi[2], Nasim Khorshidian[2], Ramin Radfar[1], Karim Parastouei[3]* and Ruhollah Ferdowsi[4]*

[1]Student Research Committee, Department of Food Science and Technology, Faculty of Nutrition Sciences and Food Technology/National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran; [2]Food Safety Research Center (Salt), School of Nutrition and Food Sciences, Semnan University of Medical Sciences, Semnan, Iran; [3]Health Research Center, Life Style Institute, Baqiyatallah University of Medical Sciences, Tehran, Iran; [4]Department of Food Technology Research, National Nutrition and Food Technology, Research Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Corresponding author:
Karim Parastouei,
Health Research Center,
Life Style Institute,
Baqiyatallah University of Medical Sciences,
Tehran, Iran,
Tel: 982182483586
E-mail: parastouei@gmail.com
Ruhollah Ferdowsi,
Department of Food Technology Research,
National Nutrition and Food Technology,
Research Institute,
Faculty of nutrition Sciences and Food Technology,
Shahid Beheshti University of Medical Sciences,
Tehran, Iran
Tel: 9821223764 26
E-mail: r.ferdosi@gmail.com

Abstract

Introduction: Potato is one of the foods with high nutritional value. High content of nitrate and nitrite in potato is one of the most challenging issues in its consumption and health of individuals. One of the ways to increase the potato quality index is to use cooking processes, and thus, reducing nitrate and nitrite content in the diet, in order to improve the health of the community. Thus, the objective of this research was to evaluate the effect of different cooking method on nitrite and nitrate in potato on human health. **Methods and materials:** In this descriptive research, 60 potato samples were randomly selected from fruit and vegetable square of Tehran, and the mentioned samples were measured in terms of nitrite and nitrate contents by Greece- Ilosoay method. Then, the considered baking methods were applied and the nitrite and nitrate contents were re-measured. **Results:** Nitrate and nitrite in the tested samples were 162.3 to 378.7 and 1.7 to 4.9 mg/kg, respectively. The peeling, washing and rinsing of potatoes reduced the nitrate and nitrite contents. Boiling, steaming and frying had a significant effect on reducing nitrate and nitrite contents. **Conclusion:** The use of boiling, steaming and frying methods can have a significant effect on nitrate and nitrite in potatoes and thus human health.

Keywords: Nitrate; Nitrite; Cooking method; Potato; Human health

Introduction

Nitrate of vegetables is one of the most important quality characteristics of them. Nitrate is naturally found in water, air, soil and food, especially vegetables. [1] Vegetables have high importance in diet due to having vitamins, minerals and fiber. The consumption of vegetables at adequate level prevents cardiovascular disease, diabetes and obesity, but vegetables usually contain high contents of nitrate and nitrite. Nitrate and nitrite consumption through food can be harmful to health. Nitrate itself is not toxic, but its metabolism in the body can produce toxic substances. High intake of nitrate and nitrite leads to methemoglobinemia, leading to shortage of oxygen in the body. [2] Nitrate can be reduced to nitrite in the oral cavity and stomach. This compound in the stomach can react with amines and amides and create carcinogenic groups called n-nitrosamine compounds. [3] Researchers argue that N-nitrosamine compounds in stomach are associated with an increased risk of stomach, esophagus and gallbladder cancer. [4] For example, they have reported that high contents of nitrate in the diet were associated with stomach cancer in the United Kingdom, Colombia, Chile, Japan, Denmark, Hungary and Italy. [5] Potato is one of the crops with favorable nutritional value containing high contents of carbohydrates, protein, fat, and vitamins. It is the fourth most important source of human nutrition after the wheat, rice and corn. Nearly 75-87 percent of nitrate and 16 to 43 percent of nitrite received by humans enter the body through vegetables. [6] It is estimated that about 65 to 75 percent of the nitrate received through potatoes enters the body. [7] Nitrate is also used as a preservative and antimicrobial agent in various foods such as cheese, meat, fish and beverages. [8] Given the increasing population growth, demand for foods has grown increasingly. For this reason, the excessive and uncontrolled use of organic fertilizers has become common in many parts of world for more production of this crop. In this regard, it was found that increasing nitrogen content increased the potato nitrate content. [9,10] In fresh vegetables, the content of nitrite is usually very low, but its content increases due to inappropriate harvesting and the presence of bacteria. Reduced consumption of nitrogen fertilizers as well as blanching, peeling, freezing and cooking can reduce the content of nitrate in them. [11] Skubina et al. reported that peeling of beet leads to 20 and 6.6% reduction in nitrate and nitrite contents, respectively. Moreover, cooking with boiling water and steaming caused 66.48 and 8% reduction in nitrite content and 69.55% and 15% reduction in nitrate content, respectively. In addition cooking with microwave increased nitrite and nitrate contents by 23 and 19%, respectively. [12] Thus, the objective of this research was to evaluate the effect of cooking process on three methods of boiling, steaming and frying on the nitrate and nitrite contents in potatoes.

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Table 1: Content of nitrates (mg NO • kg) and nitrites (mg NO • kg) in potato tubers without processing.

Sample number 1		Sample number 2		Sample number 3	
Nitrates x ± SEM	Nitrites x ± SEM	Nitrates x ± SEM	Nitrites x ± SEM	Nitrates x ± SEM	Nitrites x ± SEM
216.5 ± 7.29	1.7 ± 0.03	162.3 ± 8.77	4.9 ± 0.3	378.7 ± 9.22	2.49 ± 0.4

Table 2: Effect of culinary processing on content of nitrates (mg NO • kg) in potato tubers.

Cooking method	Sample number 1 x ± SEM	Sample number 2 x ± SEM	Sample number 3 x ± SEM
Preliminary processing	174 ± 3	131.3 ± 3.5	295.7 ± 9.22
Boiling	119.1 ± 3.2	94.2 ± 4.2	231 ± 5.5
Steaming	154.2 ± 3.2	110.3 ± 1.8	265.3 ± 7.4
Frying	93.7 ± 1.7	83.3 ± 2.3	216.3 ± 6.2

Table 3: Effect of culinary processing on content of nitrites (mg NO • kg) in potato tubers after processing.

Cooking method	Sample number 1 x ± SEM	Sample number 2 x ± SEM	Sample number 3 x ± SEM
Preliminary processing	1.45 ± 0.1	3.83 ± 0.2	1.7 ± 0.1
Boiling	0.55 ± 0.01	1.13 ± 0.3	0.45 ± 0.09
Steaming	0.84 ± 0.02	2.21 ± 0.3	1 ± 0.1
Frying	0.97 ± 0.03	2.6 ± 0.4	1.13 ± 0.2

Materials and Methods

Sampling was performed at four seasons as nitrate and nitrite contents of potato at different seasons are variable. In each sampling, 10 potatoes were selected and t3 of them were randomly selected each time to measure their nitrate and nitrite contents. Each sample was divided into four equal 10-gram parts and experiments were performed on them. Finally, the sample that had higher nitrate and nitrite content was used for boiling, frying and steaming. For each of these samples, the measurement was repeated three times and the mean of them was considered as the nitrite or nitrate content in that sample. In order to determine the nitrite and nitrate content in each of the samples, the extraction step was first performed using the chemical reagents and solutions. Then, the absorbance rate of the samples was measured at 538 nm using a spectrophotometer, and finally, the nitrite and nitrite content in the sample was obtained after plotting the absorbance-concentration chart. Samples were first measured without nitrate and nitrite reagent, and then, they were measured after adding the reagent. Then, the difference between these two obtained numbers was included in the equation obtained from the standard curve of passing the light from sodium nitrate solution at different concentrations, and accordingly, the nitrate and nitrite contents of each sample were determined. [13] Then, different methods of cooking (boiling, steaming, frying) were performed and the nitrite and nitrate samples were re-measured.

Cooking techniques were used as follows:

Boiling: Cooking the potatoes in boiling water for 25 minutes to be softened

Steaming: Cooking the potatoes at 99% moisture at 100°C for 20 minutes

Fry: Frying potatoes at 150°C for 4 minutes

Results

Nitrate and nitrite contents were measured before applying different cooking methods. The nitrate content was obtained 216.5 ± 7.29, 162.3 ± 8.77, 378.7 ± 9.22 (mg NO • kg) in the first, second, and third samples, respectively, and the nitrite content was obtained 1.7 ± 0.03, 4.9 ± 0.3, and 2.49 ± 0.4 (mg NO • kg) in the first, second, and third samples, respectively [Table 1]. Then, nitrite and nitrate contents were re-measured after applying the three cooking methods in this study. The results revealed that the nitrate content in the first sample was 119.1 ± 3.2 using boiling method, 154.2 ± 3.2 using steaming method, and 93.7 ± 1.7 (mg NO • kg) using the frying method. In the second sample, it was found 94.2 ± 4.2 using frying method, 110.3 ± 1.8 steaming method, and 83.3 ± 2.3 (mg NO • kg) using boiling method. In the third sample, it was found 231 ± 5.5 using boiling method, 265.3 ± 7.4 using steaming method, and 216.3 ± 6.2 (mg NO • kg) using frying method [Table 2]. The results of comparison of Tables 1 and 2 revealed a significant difference in nitrate reduction after application of different cooking methods compared to that before applying these methods. Finally, in the first sample, the nitrite content was obtained 0.55 ± 0.01 using boiling method, and 0.84 ± 0.02 using the steaming method, and 0.97 ± 0.03 (mg NO • kg) using the frying method. In the second sample, it was found 1.13 ± 0.3 using the boiling method, and 2.21 ± 0.3 using the steaming method and 2.6 ± 0.4 (mg NO • kg) using frying method. In the third sample, it was found 0.45 ± 0.09 using the boiling method, 1 ± 0.1 using a steaming method, and 1.13 ± 0.2 (mg NO • kg) using a frying method [Table 3].

The results of Tables 1-3 comparison showed a significant difference in the reduction of nitrite content after applying different cooking method compared to that before applying these methods.

Discussion

Excessive consumption of nitrate and nitrite by using various foods, including potatoes, is very harmful to human health. Nitrate alone is not toxic, but its metabolism in the human body produces various toxic substances, which threat human health. Excessive consumption of nitrate and nitrite can cause various diseases, including methemoglobinemia in the human body. Vegetables and plants, including potatoes, are beneficial foods, which are important for the health of the human body due to the presence of nutrients such as vitamins preventing many diseases in humans. However, it should be noted that they usually contain high contents of nitrate and nitrite (2 and 3). Hence, the objective of this research was to evaluate the nitrite and nitrate contents before and after applying different methods of cooking in potatoes. The results of this research revealed that the nitrate and nitrite content in the samples is very high and variable. The maximum and minimum nitrate contents were 378.7 and 162.3 mg/kg, respectively, and nitrite content varied between minimum of 1.7 and maximum of 4.9.

As nitrate content in the potato skin is more than that in its center, washing, peeling and rinsing of potatoes reduce the nitrate and nitrite contents, but the effect of different cooking methods was observed in nitrate and nitrite reduction. Frying, compared to other two methods, has two more effects in reducing the nitrate content. The lowest reduction in nitrate belonged to steaming method. The results of this research are in line with those of studies conducted by Waclaw Mozolewski and Czarniecka-Skubina. [12,14] In the case of nitrite, the greatest reduction was found in the boiling process, which is similar to that of the study by Marin et al. [15] Probably the reason for high nitrite and nitrate in samples is due to factors such as amount and type of fertilizer, type of potato varieties, soil quality and weather conditions of that area. With regard to nitrite, the highest reduction was obtained in boiling method, which is in line with the result of the study conducted by Marin et al. [15] The high content of nitrite and nitrate in samples might depend on factors such as amount and type of fertilizer used, variety type of potato, soil quality, and weather conditions of the region.

Given high content of nitrate, we should account treat with caution in its consumption, since nitrates in the body may be combined with secondary organic amines and form nitrosamines. Its carcinogenicity property has been proven in studies on animals. [16,17] Based on clinical and epidemiological studies, high content of nitrite and nitrate in the diet has been found to cause stomach cancer. [18,19] As an example, high content of nitrate in the diet is associated with stomach cancer in the United Kingdom, Colombia, Chile, Japan, Denmark, Hungary and Italy. [9] A case-control study conducted in Canada with regard to human contact with nitrite and nitrate consumed to preserve meat products significantly increased the risk of stomach cancer. [20] Malakuti and Tabatabaei concluded that h high consumption of nitrogen fertilizers (more than 400 kg of urea per hectare) leads to excessive accumulation of nitrate in potatoes (290 mg/kg of nitrate based on dry weight).

The accumulation of nitrate in the consumable organs of vegetables and crops is closely associated with content nitrogen fertilizers and they of their consumption, so that if we increase the nitrogen fertilizer content in potato and carrot fields from 90 to 120 kg/ha, the content of nitrate would increase by 5 times in potatoes and 1.5 times in carrot compared to allowed content. Excessive nitrogen fertilization increases the content of nitrate in vegetables. Some researchers, such as Malakuti et al. have announced that the critical allowed limit of nitrate is 290 mg/kg based on dry weight and 60 mg/kg based on fresh weight). [21] In Italy, potato nitrate content was reported less than 200 ppm and it was shown that the variety, type and content of nitrogen fertilizer and harvest time affect the content of this compound. [22] As nitrate is soluble in water, washing, peeling and rinsing have a great impact on reducing the contents of nitrate and nitrite. Boiling, steaming and frying also reduce nitrate contents. It was observed that, as other studies, frying has the highest impact on nitrate reduction in potatoes compared to other two methods. The maximum nitrite reduction was obtained in the boiling method.

Conclusion

Given the results of this study and other studies, it can be expected that the nitrate and nitrite contents to be significantly reduced using simple methods such as peeling, rinsing and various methods of cooking such as boiling, steaming and frying, and prevent their harmful effects on human health.

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Conflict of Interest

The authors disclose that they have no conflicts of interest.

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