

The Studies on Nitrate-Nitrite Accumulation and Health Concerns

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Abstract

Currently, the rapid increase in population has become a driven force of the increase in yield and quality of plant production. Recently, excessive application of nitrogen fertilizers is main way to increase plant production, but leads to the accumulation of nitrate-nitrite in plants.

The plants, especially leafy vegetables, can accumulate high levels of nitrate and, upon being consumed by living beings, pose serious health hazards.

The nitrate intake from vegetables or other food items is reduced to nitrite which cause toxicity known as methemoglobinemia especially in children and carcinogenic (tumors in liver, lung, kidney, stomach cancer), as result of the formation of nitrosamines. High level of nitrate when converted to nitrite cause blue baby syndrome".

Key Words: Nitrate, nitrite, accumulation, human health

1. Introduction

Currently, the rapid increase in population has become a driven force of the increase in yield and quality of plant production. Recently, excessive application of nitrogen fertilizers has been the main way to increase plant production and consequently the use of fertilizers has been increased.

Excessive application of nitrogen fertilizers and pesticide create a danger to human and environment. In Turkey, human population increases by \square 2.5% per year. This leads a necessity of an increase yield per area due to decreasing agricultural production field[1].

Increasing population has become higher priority to security and environmental pollution in the countries with limited sources and thus excessive application of nitrogen fertilizers and pesticide has occurred.

Excessive application of nitrogen fertilizers leads to the accumulation of nitrate-nitrite in plants. The plants, especially leafy vegetables, can accumulate high levels of nitrate and, upon being consumed by living beings, pose serious health hazards. Application of nitrogen fertilizers also causes greenhouse effect when volatilized to nitrogen toxics in atmosphere and leads to water pollution when washed to ground water.

Direct consumed leafy vegetables such as spinach, lettuce, cabbage accumulate nitrate by 10% or more of total dry weight. The consumption of these vegetables if applied excessive of nitrogen fertilizers is unhealthy[2].

High nitrate levels in vegetables is not acceptable. Nitrate levels rising to 15 mg/kg and over causes disintegration of intestinal membrane.

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The nitrate intake from vegetables or other food items is reduced to nitrite which causes toxicity known as methemoglobinemia especially in children. Symptoms of methemoglobinemia include shortness of breath, fatigue, dark brown blood color and vomiting. Nitrites in strongly acidic conditions such as that of the human stomach may end up with nitrosamines which are carcinogenic in liver, lung, kidney, stomach[3-4-5].

If nitrate which is got by various nutrients is not fragmented in mouth and stomach reaches to small intestine and absorbed in variable rates depending the sort of eaten nutrition. While nitrate normally causes toxic effect in higher dose (LD50=8-15 g), nitrite could be toxic in low dose. It's known that high dose usage of nitrate effects thyroid gland negatively. Essentially composed of nitrite nitrate is mainly toxic and occurs as a result of the microbial issues on human organism [6].

Besides, it's stated that nitrate causes shortage of Vitamin A in human body. It was announced that two babies (two-months and three and half months) were died of intoxication eating spinach pulp in Federal Republic of Germany in 1964 and nitrite concentration was around 2180 ppm in fresh spinach. 15-70 mg nitrate nitrogen or 20 mg nitrite nitrogen for each kilogram of human body is considered to be intoxicating. It's accepted that an adult have daily 75 mg of nitrate on average in the USA (ca. 0.2-0.3 ppm nitrate nitrogen kg/day), 75 % of this rate is acquired via vegetables[7].

To minimize nitrogen fertilizers to merge into underground water by washing in irrigated farming fields, less and frequent watering should be preferred instead washing more at once. In other words, irrigation-fertilizing relationship particularly should be managed properly. Sole remedy to fertilize on time and properly is to do soil analysis. Using fertilizers before soil analysis prevents the economic usage of soil, increases fertilizing costs, decreases crop quality and quantity, damage the soil and environment[5].

Intaken nitrate changes to nitrit in the digestive system and penetrates the blood circulation which causes cyanosis especially in infants.

Daily amount of nitrate for human is 50-120 mg; amount of nitrite is 2-5 mg. Reasonable amount of nitrate and nitrite content for plants is standardized in many countries nowadays. Some countries, moreover, want to know nitrate content besides pesticide and hormonal management for import plants. Before putting on the market nitrate content of the plants are determined, plants contain nitrate over the specified limit is prohibited to sell in some countries such Holland and Germany. Critical specified nitrate limit for winter lettuce is 4500 mg, for summer lettuce is 2500 mg NO_3^-/kg [8-9]

Maximum permissible nitrate limit for fresh and canned vegetables for children up to four years of age is respectively 900 and 450 mg NO_3^-/kg and for adults respectively 1200 and 900 mg NO_3^-/kg in Germany. Likewise, more than 200 mg/kg nitrate in spinach is not allowed[10].

According to data of WHO and FAO, 219 mg. nitrate for a 60 kg human daily seems to be tolerable. Yet, this rate is inappropriate for infants who are more sensitive than adults. In many countries, nitrate content of consuming plants are determined and crops include more than the specified limit are not allowed to put on the market. According to FAO sources, amount of daily nitrate shouldn't be more than 5 mg for each kilogram of human body is

advised[6]. 70 % of incoming nitrate is originated from vegetables, 20 % of nitrate is originated from nitrate added nutrition, 10 % of nitrate is originated from milk products and fruit[11-12].

2. Studies About Nitrate and Nitrite Accumulation in Turkey

In a study that was carried out in İstanbul, found the amount of nitrate in lettuce, parsley, spinach in order; 842 , 810.4 and 920.3 mg/kg which were over the references determined by World Health Organization (WHO)[13].

Founded the amount of nitrate in spinach and lettuce in order 303.5 and 307.2 mg/kg in Eskişehir[14]

Aimed to determine the amount of nitrate in Konya in lettuce, spinach and green bean, and it was found in order 833.43, 786.97 and 636.71 ppm[15].

In around Samsun, were examined the nitrate amount of some fresh vegetables like red cabbage, cucumber, tomato, carrot, pepper, white radish, parsley, roquette and pepperweed. The amount of nitrate based on dry matter in red cabbage, cucumber, tomato, carrot, pepper, white radish, parsley, roquette and pepperweed were found in order 129.77, 229.65, 334.80, 438.47, 757.42, 3169.26, 5342.01, 6581.97, 7426.40 and 8738.87 mg/kg[16]

It was examined the amount of nitrate and nitrite in spinach in around İzmir. According to the analysis, the amount of nitrate and nitrite in soil and plant example were found at normal level (spinach 245 ppm). Nitrate concentration in scapus was found higher than leaves[17].

In a study that was carried out in Bursa, found nitrate concentration in broccoli, spinach, lettuce, white cabbage, leek and roquette as 13.50 ,61.07,70.57, 10.81, 3.25, 104.0 ppm. According to the research results, nitrate and nitrite concentrations in these vegetables weren't found harmful for human and animal health[18].

In a study that was carried out with enzymatic method to determine nitrate level in some vegetables and fruits in around Ankara, it was found high in celery (3667.40 mg/kg), roquette (3019.41 mg/kg), chard (2621.79 mg/kg), and it was found low in melon (0.00-47.93 mg/kg), water melon (47.21-126.19 mg/kg), carrot (0.00-47.71 mg/kg), tomato (0.00-71.10 mg/kg)[19].

In around Ödemiş, was founded NO_3^- (1832 ppm) that was low level in lettuce from the soil and leaf examples[20].

It was examined on 96 examples of some vegetables and fruits in Tekirdağ to find out the amount of nitrate and nitrite. The average amount of nitrate based on fresh weight in spinach, lettuce, green bean, potato, apple and grape (mg/kg) were found in order 362.5, 685.6, 168.6, 777.9, 18.1, 16.6[21]

In a study that was carried out with nitrate content in 28 species of vegetables and 5 species of fruits gathered from Samsun vegetable bazaar and it was determined 780 mg/kg NO_3 in cress, 375 in roquette, 377 in squash, , 48 in spinach, 216 in mint, 275 in lettuce, 33 in tomato, 222 in strawberry, 0.7 in kiwi, and 2 mg/kg NO_3 in apple[22].

It was examined amount of nitrate and nitrite in 7 kind of vegetables in Ankara wholesales market, and it was found in tomato, carrot, lettuce, parsley, spinach in order; ; 11.0, 190.0, 914.2, 1042.8, 623.3, 1513.3, 1456.0 ppm nitrate and 0.36, 0.65, 0.84, 0.98, 0.92, 1.78, 2.31 ppm nitrite. Also vegetables were analyzed in different 6 months and it was found that amount of nitrite and nitrate were higher in winter than other seasons of a year[23].

3. Examining the Matter in Terms of Environment and Health

In terms of nitrate content, leafy vegetables have the most nitrate level, and this is followed by tuber vegetables and fruits[19-22].

Also the amount of nitrate and nitrite found are different in the different parts of a plant. The Leafstalk and plant stem contain the most, leaf and root contain medium, and fruit and flower contain very lowest nitrate amount[24-25].

nitrate fertilizers causes more nitrate amounts in leaf edible vegetables, comparing to other fertilizers, [2-20-25-26].

Airless storage increases nitrate cumulation. Freezing and cooking decrease nitrate concentration[27-28].

After cooking green leafy vegetables shouldnt be left at room temperature. It is recommended to preserve them in the refrigerators. And they could be consumed within maximum 1 or 2 days. Frozen vegetables shouldn't de-frost in room temperature, and it is possible to decrease nitrate content in vegetables with favorable washing methods[28].

Conclusions;

Today in many countries in the World as well as, EU and Turkey, high amount of nitrate in water, vegetables and foods has become a serious issue for human health. It's crucial to take some precautions to prevent harmful effects of nitrate to human health. Especially, it is important to prevent excessive usage of nitrate fertilizer in cultivated areas. Favorable storage circumstances should be provided in whole process long that is from farm to consumers. It is necessary to apply monitoring policies in foods, drinking water, vegetables and fruits, and carrying out regular measurement.

Referances

- [1] Atılğan, A., Coşkan, A., Saltuk, B. ve Erkan, M., 2007. Antalya Yöresindeki Seralarda Kimyasal Ve Organik Gübre Kullanım Düzeyleri Ve Olası Çevre Etkileri. *Ekoloji Dergisi* 15, 62, 37-47
- [2] Turan, M., 2002. Farklı Azotlu Gübrelerin Erzurum Yöresinde Yetiştirilen Beyaz Lahana (*Brassica Oleracea* var. *Capitate*)’Nın Verim, Nitrat Birikimi, Toprak ve Bitkisel Özelliklerine Etkisi . Atatürk Üniversitesi Fen Bilimleri Enstitüsü Doktora Tezi.183s., Erzurum.33
- [3] Bolin, B. Ve Arrhenius, E.,1977. An Essential Life Factor And A Growing Enverimental Hazard. *Ambio* 6, 96-105.
- [4] Fritsch, Q. ve De Saint Blanquat,G., 1989. Nitrates- Nitrites Nitrosamines.Dans:Toxicologie et Securite des Aliment. Edit, R. Derache) Tech. Doc. Lavosier, Paris, 281-298.
- [5] Gök, M., Özbek, H. ve Çolak, .A.K.,1991. İçel Bölgesi Sera Koşullarında Yapılan Aşırı Nitrat Gübrelemesinin Hıyarda Nitrat Birikimi Üzerine Etkisi. *Ü.Z.F. Dergisi*,6(3), 47-58.
- [6] Szwonek, E. 1986 Nitrates Concentration in Lettuce And Spinach as Dependent on Nitrate Doses. *Acta Horticulturae*, 176:93-97.
- [7] Oruç, H. ve Ceylan, H., S 2001. Bursa’da Tüketilen Bazı Sebzelerde Nitrat ve Nitrit. *Uludağ Üniversitesi, Veteriner Fakültesi Dergisi*, 20 (3): 17-21.
- [8] Anonymus. 1982. 15 Sept.1982.Vastelling Maximal Toelbaar Gehalte Nitrat in Bladgronten. *Nederlandse Staatscourant*.
- [9] Anonymus. 1985. 15 Oct. 1985. Wijziging Nitrat-Gehaten in Bladgrnten. *Nederlandse Staatscourant*.
- [10] Fidan F, Sürmeli N. ve Genç Ç. 1993. Ispanaklarda Nitrat Birikimi Üzerinde Çeşitli Azot Dozu ve Ekim Zamanının Etkisinin Araştırılması. *Atatürk Bahçe Kül. Merk. Araş. Ens. Yalova*.
- [11] Šebecic B. ve Vedrina-Dragojevic I .,(1999) Nitrate and Nitrite in Vegetables from Areas Affected by Wartime Operations in Croatia. *Nahrung*, 43, 4, 284-287.
- [12] Ximenes MIN, Rath S. ve Reyes F.G.R. (2000) Polarographic Determination of Nitrate in Vegetables. *Talanta*, 51, 49-56.
- [13] Erkmén, G., Orak, H., Şatıroğlu, S., 1990. Nitrate And Nitrite Content of Fresh Vegetables of Turkish Origin. *Doğa Tr-J. Of Chemistry* 14(3):196-200.
- [14] Malkoçoğlu, B., 1993. Eskişehir’de Porsuk Çayı İle Sulanan Bazı Sebzelerde Meydana Gelen Mikrobiyal Nitrit Miktarının Belirlenmesi. *Anadolu Üniversitesi Fen Bilimleri Enstitüsü. Yüksek Lisans Tezi. 67 S. Eskişehir*.
- [15] Gür , K., Zengin, M., Uyanöz, H. Ve Gülderen, M.Ş., 1995. Konya Ve Çevresinden Toplanan Bazı Sebze Örneklerinde Nitrat- Nitrit Kirliliği. *Çevre Sempozyumu*.18-20 Eylül 1995. Erzurum. 41-54s.
- [16] Ustun, N.Ş. ve Tosun İ., 1998. A Research On Nitrate Content Of Some Raw Consumed Vegetables. *Ondokuzmayıs Üniversitesi Ziraat Fakültesi Dergisi* 13 (2) : 13-19.
- [17] Mordoğan, N. ve Yaşar, M., 1999. İzmir Ve Civarında Ispanak Yetiştirilen Toprakların ve Ispanak (*Spinacia Oleracea* L.) Bitkisinin Nitrat- Nitrit İçerikleri. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, 36(1-2-3):9-15.
- [18] Oruç, H. ve Ceylan, H., S 2001. Bursa’da Tüketilen Bazı Sebzelerde Nitrat ve Nitrit. *Uludağ Üniversitesi, Veteriner Fakültesi Dergisi*, 20 (3): 17-21.

- [19] Artık, N., Poyrazođlu, E.S., ŐimŐek, A., Kadakal, . ve Karkacier, M., 2002. Enzimatik Yöntemle Bazı Sebze ve Meyvelerde Nitrat Düzeyinin Belirlenmesi. *Gıda*, 27(1):5-13.
- [20] Ceylan, Ő., Mordođan, N. ve akıcı, H., 2002. Ödemiş ve Civarındaki Bazı Marul (*Lactuca sativa L.*) Alanlarının Nitrat ve Nitrit Miktarları. , S:213-219.
- [21] Dıraman, H., Gündüz, H. ve Demirci, M., 2005. Tekirdađ İlinde YetiŐtirilen Bazı Sebze ve Meyvelerde Nitrat ve Nitrit Miktarları Üzerinde AraŐtırmalar. *Gıda*, 30(1):37-42.
- [22] EkŐi, 2005. Samsun Sebze Pazarlarından Toplanan Bazı Sebze ve Gıda Örnekleriyle Bazı İme Suyu Ve Taban Suyu Örneklerinin Nitrat İeriđine İliŐkin Bir AraŐtırma. Ondokuz Mayıs Üniversitesi Fen Bilimleri Enstitüsü. Yüksek Lisans Tezi. 45s. Samsun.
- [23] Ayaz, A., Topu, A., Yurttagöl, M., 2007. Survey Of Nitrate And Nitrite Levels of Fresh Vegetables in Turkey. *Journal of Food Technology* 5(2):177-179.
- [24] Zengin, M. Ve Gür, K., 1998. Farklı Mevsim ve Topraklarda YetiŐtirilen Ispanak Bitkisinde Nitrat Birikimi Üzerinde Bazı Gübrelere Etkileri.. Seluk Üniversitesi Ziraat Fakültesi Dergisi, 12(16)111-121.
- [25] Yüksel, B., 2002. Demir ve DeđiŐik Kaynaklardan Uygulanan Azotun, Ispanak Bitkisi (*Spinacia Oleracea L.*)’nin GeliŐimi İle Oksalik Asit, Nitrat Ve Klorofil İeriđine Etkisi. Ankara Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi.199 s. Ankara
- [26] Őensoy, S., Abak K.ve DaŐgan H.Y., 1996.EŐdeđer Miktarda Mineral ve Organik Gübre Uygulamalarının Marulda Nitrat Birikimi, Verim Ve Kaliteye Etkileri. I. Sebze Tarım Sempozyumu. Őanlıurfa, 249-255.
- [27] akırođlu, P.F., 1995. Ankara Toptancı Haline Gelen Sera Domates ve arliston Biberlerinin Nitrat Kapsamları ve eŐitli Yöntemlerle PiŐirmenin Nitrat Kapsamlarına Etkisi. Ankara Üniversitesi Fen Bilimleri Enstitüsü, Doktora Tezi, 73 s.
- [28] Topu, A., 2003. Bazı Sebzelerin Nitrat ve Nitrit Miktarları ve Ispanakta Bekletme, PiŐirme ve Dondurmanın Nitrat ve Nitrit İeriđine Etkisi Üzerine Bir AraŐtırma. Hacettepe Üniversitesi Sađlık Bilimleri Enstitüsü, Doktora Tezi, 145 s.