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Indian J Dermatol. 2013 May-Jun; 58(3): 240. PMCID: PMC3667300
doi: 10.4103/0019-5154.110846

# Low Nickel Diet in Dermatology

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Received 2011 Jan; Accepted 2012 Feb.



## Abstract

Nickel is a ubiquitous trace element and the commonest cause of metal allergy among the people. Nickel allergy is a chronic, recurring problem; females are affected more commonly than males. Nickel allergy may develop at any age. Once developed, it tends to persist life-long. Nickel is present in most of the dietary items and food is considered to be a major source of nickel exposure for the general population. Nickel in the diet of a nickel-sensitive person can provoke dermatitis. Careful selection of food with relatively low nickel concentration can bring a reduction in the total dietary intake of nickel per day. This can influence the outcome of the disease and can benefit the nickel sensitive patient.

**Keywords:** *Allergy, diet, iron, nickel*

## Introduction

**What was known?**

Nickel is the commonest cause of metal allergy among the people. Once sensitized, the sensitization tends to persist life-long. Studies have confirmed the benefit of low nickel diet in the management of nickel eczema. Careful selection of food with relatively low nickel concentration can help to control nickel dermatitis.

Nickel is a ubiquitous trace element and it occurs in soil, water, air and of the biosphere. Nickel was first isolated by the Swedish chemist Cronstedt in 1751. It is the twenty-second most abundant element and the seventh most abundant transitional metal with an atomic number of 28 in the periodic table with an atomic weight of 58.71. It has five naturally occurring isotopes. It is a tough, silvery-white heavy metal and is highly resistant to attack by air and water. It occurs in igneous rocks, as a free metal and together with iron; it is also a component of the earth core. Nickel also occurs in living organisms, mainly in plants. Nickel; forms numerous alloys with other metals. Its alloy with iron, nickel steel, is extremely tough and corrosion resistant. Most of the nickel produced world-wide is used for the manufacture of stainless steel, which is mostly used to produce food processing equipment and containers. It is also used to manufacture fashion jewelry, machinery parts, coins; finely-divided nickel is used as hydrogenation catalyst.

## The problem of nickel allergy

Nickel is one of the commonest sensitizers all over the world. Once sensitized, the sensitization tends to persist life-long. Nickel sensitivity is more common in females than males. The prevalence of nickel sensitivity varies from 4-13.1% in different countries.[1,2] All age groups are affected; prevalence may be high in some occupational groups, for example, hairdressers, in whom the prevalence rate may be as high as 27-38%.[3] Women are more commonly sensitized by non-occupational contacts such as ear piercing with ordinary needle and use of fashion jewelry that contains free nickel, while males are mostly sensitized by occupational exposure. The degree and pattern of nickel allergy varies: (a) Some individual develop skin allergy from even brief contact with nickel-containing items, while others develop allergy only after many years of skin contact with nickel. A “secondary rash” due to spread of dermatitis.[4] to distant regions is rarely observed at present. (b) Some individual develop hand eczema, often many years after primary sensitization. It may be due to the chronic contact with nickel containing articles like detergent, coins, and fashion jewelry. (c) Few patients develop vesicular type of hand eczema following the ingestion of nickel in diet.[5] Such hand eczema flares up when such patients are treated with oral nickel sulfate. (d) Rarely, patient with nickel sensitivity may present with baboon syndrome.[6] a generalized rash with particular involvement of buttock, anogenital area, flexures and eyelids. Baboon syndrome is thought to be a pattern of systemic contact dermatitis. Cases of erythema multiforme and vasculitis have been reported following nickel ingestion.[7,8] (e) Chronic urticaria, a type 1 hypersensitivity response, has been attributed to dietary nickel; but this is rare.[9]

## Distribution of nickel

Nickel; forms approximately 0.008% of the Earth’s crust and 0.01% of the igneous rock.[10] It occurs in soil, water, air and in the biosphere. The concentration of nickel normally encountered is as follows:[11] Soil: 5-500 μg/gram (may be higher locally) Plant tissue: 0.5-5 μg/gram (may be higher locally) Animal tissue: 0.1-5 μg/g Fresh water: 5-100 μg/litre

## Nicakel-human cycle

The plant acquires its total quota of Nickel from the soils. Animal acquires nickel mostly from plants and from other animals. Human acquires nickel both from Plants and Animals. Most of the human food that comprises both plants and animals acquire their nutrition from soil; therefore, the nickel content of food is strongly influenced by the concentration of nickel in the soil.[12] The concentration of nickel in the soil varies from place to place. Some of the important factors that influence the concentration of nickel in soil are:[13,14]

1. Type of soil: Serpentine soils often contain very high level of nickel.
2. Use of modern agricultural practices such as the use of synthetic fertilizers and pesticides
3. Contamination of soil with industrial effluents and urban wastes
4. Distance of the soil from the nickel smelters

Land plant tissue contains four times more nickel than that of animal tissues.[12]

## Role of diet in nickel allergy

Nickel is present in most of the dietary items of humans and an average diet supplies 300-600 μg of nickel to the human body per day.[12] The presence of sufficient amounts of nickel in the diet of a nickel-sensitive person can provoke dermatitis. It has been observed that nickel sulfate when orally administered in the range of 600-5,600 mg as a single dose may provoke hand eczema.[15] The hands are the most commonly affected sites for systemic nickel dermatitis. However, other body areas may be affected as well. There are

reports of serious reactions such as erythema multiforme and vasculitis following oral challenge.[7,8] The evidence for the role of dietary nickel in provoking/aggravating eczema is as follows:

1. Flare of eczema and/or patch test sites upon oral nickel challenge.[5]
2. Improvement of dermatitis on a low nickel diet.[16]
3. Improvement of dermatitis by oral disulfiram, which chelates nickel and increases its excretion.[17]
4. Improvement of dermatitis by oral disulfiram and low nickel diet.[18]
5. It has been noted that children with orthodontic braces, who are therefore exposed to low continuous levels of ingested nickel, may have less subsequent nickel allergy.[19]

## Nickel in foods

Nickel; constitutes approximately 0.008% of the Earth's crust, and the soil contains 40 ppm of nickel on average.[12] It is present in most of the dietary items. Food is the major source of nickel exposure for the general population. Major dietary source of nickel is plant food. Plant tissues contain more nickel than animal tissues. Therefore, the total dietary intake of nickel per day varies depending on the amount of consumption of plant and animal foods. The amount of nickel in foods may vary considerably from place to place. This is due to the nickel content of the soil that varies from place to place. In a study conducted in UK, it was found that nickel (the mean concentration of nickel as mg/kg fresh weight) was present in the following amounts in various foods: In cereals (0.17); carcass meat (0.04); poultry (0.04); fish 0.08; eggs (0.03); green vegetables (0.11); other vegetables (0.09); potatoes (0.10); milk (<0.02); dairy products (0.02); nuts (2.5); fresh fruits (0.03); oils and fats (0.03), etc.,[20] In another UK-based study of selected snack and convenience foods, the nickel content was found to be as follows (mg/kg): Instant tea (7.8-12); instant coffee (0.62-1.3), roasted, salted cashews (4.1-4.7), custard (0.02-0.03), lentils (1.6-2.3), mixed nuts (0.99-5.29), dried peas (0.39-0.76), haricot beans (0.65-2.3), varieties of crisps (0.06-0.61).[21]

A Korean study found significant nickel content in the following (mg/kg): A green tea bag contained 235.57; a black tea bag, 62.79; chocolate, 27.87; crisps, 12.70; wheat flour, 12.15; Welsh onion, 0.02; garlic, 0.016, milk, 0.004; egg, 0.002 and salt, 0.0.[22] However, certain foods are routinely high in nickel content such as cocoa and chocolate, soya beans, oatmeal, nuts and almonds, fresh and dried legumes.[15] The following list shows some common foods with higher nickel content.[23]

## Food with high nickel content irrespective of the soil content

Whole wheat, whole grain, rye, oat, millet, buckwheat, cocoa, chocolate, tea, gelatin, baking powder, soy products, red kidney beans, legumes: Peas, lentils, peanut, soya beans and chickpeas, dried fruits, canned foods, beverages, strong licorice, and certain vitamin supplements.

## Other foods containing considerable amount of nickel

Beer, red wine, mackerel, tuna, herring and shellfish, sunflower seeds, linseeds, hazelnuts, marzipan, walnuts, tomatoes, onion, raw carrots The mean total dietary intake of nickel has been reported to be between 0.12-0.21 mg in UK,[20] 0.13 mg in Finland,[24] 0.17 mg in US.[25] and between 0.207-0.406 mg in Canada.[26] The dietary intake of nickel in Denmark is comparatively higher and could reach over 900 μg/day, and this was due to the high intake of oatmeal and legumes, including soybean, nuts, cocoa and chocolate.[27] Indian diets are rich in plant food in comparison to Western diet, which is rich in animal food, and therefore, it contains considerable amount of nickel. Cereals, pulses and vegetables constitute the main bulk of the Indian diet. Pulses comprise varieties of gram, lentils, beans and peas, which have high nickel content. Vegetables used in Indian diets include green leaves, roots and tubers and other vegetables. Vegetables such as spinach, onion and garlic are very popular and are found to contain moderately high amounts of nickel. Tea is consumed throughout India; dried tea leaves used for beverage making have been

found to contain high nickel concentration which is about 3.9-8.2 mg/kg.[28] Similarly, Coffee, which is very popular in South India, is found to contain high nickel concentration of 43 mg per 100 g of coffee beans (roasted, ground).[29] Cocoa beans, from which cocoa and chocolate are made may contain up to 10 mg/kg of nickel and are common constituents of fast-foods in India.[30]

Cows' milk, which is an essential part of majority of Indians' diet, is fortunately has relatively low concentration of nickel; it is about 0.03 ppm of nickel.[12] Similarly Jaggery (*Gurr* or Indian sugar), which is commonly eaten in rural India, is found to have low nickel concentration of 0.011 mg/g of jaggery.[31]

High concentration of nickel is sometimes found in processed foods. This is free nickel, picked up from the stainless steel used in the manufacture of equipment and containers. In general, cooking in stainless utensils releases negligible amount of nickel; however, cooking acidic food in these utensils may increase the nickel content.

A daily dietary requirement of 25-35 μg of nickel has been suggested.[30] However, the role of nickel in biochemical functions is not clear.

### The concept of low nickel diet

Nickel is a ubiquitous trace metal, and it is a fact that nickel cannot be completely avoided from diet; however, the careful selection of food with relatively low nickel concentration can bring a reduction in the total dietary intake of nickel per day and thereby can minimize the risk for endogenous activation of immunocompetent cells in nickel sensitive individuals. This can influence the outcome of nickel dermatitis. Studies have confirmed the benefit of low nickel diet in the management of nickel eczema.

### However, there are some practical problems while preparing low nickel diet

These are

1. Nickel content of the same foods varies from place to place and even in different batches of the same food.[13]
2. Even seasons can influence the concentration of nickel in human food derived from plants. Plant tissue contains more nickel in spring and autum but low in midsummer.[32]
3. There are differences in the concentration of nickel in different parts of same plant. Leaves contain mote nickel than stem and root; Old leave contain more nickel than young leaves.[33]

Therefore the benefit received by a patient from a particular Low ND may not be uniform in all the seasons and in every patient. Similarly, benefit received from one type of LND by one group in one place may not be observed by other group in a different place.

### Following points must be taken into consideration while drafting a low nickel diet

1. Avoid all foods that are routinely high in nickel content such as cocoa, chocolate, soya beans, oatmeal, nuts, almonds and fresh and dried legumes.
2. Avoid all drinks and vitamin supplements with nickel and canned food. Nickel dissociates from the alloy of the can and thus increases the total nickel content of the canned food.
3. Animal tissues generally contain less nickel in comparison to plant tissues. Meat, poultry and eggs are suitable for low nickel diet. Except for a few varieties of fishes that show high concentration of nickel such as tuna, herring, shellfish, salmon and mackerel, other fishes can be used for low nickel diet.
4. Nickel content of milk is low; therefore, milk and its products such as butter, cheese, curd and cottage cheese (paneer) can be consumed.

5. Nickel content of cereals is low. Foods prepared from rice (polished), refined wheat or corn (corn flakes, macaroni, etc.,) are allowed.
6. Vegetables such as potatoes, cabbage and cucumber can be used. However, vegetables such as onion and garlic, which are very popular in our country, should be used in moderation.
7. Green leafy vegetables are an inseparable part of Indian food; if desired, they may be taken sparingly due to the possibility of high concentration of nickel. Young leaves are preferred than older leaves as they contain relatively lower concentration of nickel. Mushroom can be used.
8. Among the fruits, one may partake bananas (in moderation), apples (up to 3-4 times a week) and citrus fruits (up to 3-4 times a week).
9. Tea and coffee are very popular in India; in weaker concentration, these beverages can be taken in moderation (up to 2 cups a day).
10. While cooking, nickel-plated utensils should not be used and should be replaced. Acidic food should not be cooked in stainless steel utensils as the acids may lead to the dissociation nickel from the utensils and it may increase the nickel content of the food. The initial water flow from the tap in the morning should not be drunk or used for cooking as nickel may be released from the tap during night.

However, it should be understood that the dermatitis will not clear completely during the diet period; however, it is likely to lead to fewer and milder flare-ups. While planning a low nickel diet, the dietary habits of the patients should be considered to encourage the acceptability of the diet.

### Other substances/physical states that interfere with nickel absorption from diet

1. Vitamin C, orange juice, tea, coffee, milk inhibit nickel absorption in human[34]
2. Iron deficiency Anemia, Pregnancy and Lactation can enhance nickel absorption in human body[35]
3. Adequate iron intake and status can reduce nickel absorption from diet in human.[36]

Gastrointestinal absorption of nickel is variable and depends on the composition of the diet. It is reported that nickel absorption may be suppressed by binding or chelating substances, competitive inhibitors, or redox reagents; on the other hand, absorption is often enhanced by substances that increase pH, solubility, or oxidation, or by chelating agents that are actively absorbed. Such compounds include: Ascorbic acid, citric acid, pectin (from orange juice), which affect trace mineral absorption; tannins (in tea and coffee), which inhibit absorption of iron and zinc; ascorbic acid which suppresses nickel absorption; and complexing agents, such as EDTA, wich depress plasma-nickel levels.

It is seen that absorption of nickel in the human body can be enhanced by iron deficiency and thus, an individual with iron deficiency anemia (IDA) tends to retain more nickel from the diet. This is due to the up regulation of divalent metal transporter (DMT) protein in intestinal the mucosa of the individual with IDA.[37,38] DMT protein is present on the luminal surfaces of enterocytes of the intestinal epithelium, whose function is to transport iron ($Fe^{++}$) from the diet into the enterocyte of the intestinal mucosa. In the absence or paucity of iron in the diet, the DMT protein tends to immediately bind and transport other available divalent cation(s), including nickel across the membrane. This is important for those suffering from nickel allergy because nickel is a ubiquitous trace element and is present in most of the human foods. In other words, individuals with IDA are at a higher risk to accumulate nickel in their body. Conversely, it has also been found that adequate iron intake and status can limit nickel absorption due to the down regulation of DMT protein on the luminal surfaces of enterocytes.[39]

## Conclusion

Nickel produces more cases of allergic contact dermatitis than all other metals together. Once sensitized,

the sensitization tends to persist life-long. The result of presently available treatment of such nickel eczema is mostly unsatisfactory as the relapse rate is high. This is due to the fact that nickel is present in most of the dietary items of humans. Unless this continuous supply of nickel is reduced, nickel eczema will continue to relapse, particularly the vesicular type of hand eczema. The careful selection of food with relatively low nickel concentration can result in the reduction in the total dietary intake of nickel per day. This can help to control nickel dermatitis. Therefore, a good knowledge of the presence of nickel in food is helpful for the management of nickel allergy.

**What is new?**

In practice, the benefit of Low nickel diet is not uniformly seen in all patients receiving it for nickel dermatitis. This is due to the fact that there are factors which can interfare with Nickel absorption from the diet in human body. In addition, there are some factors which can influence the level of nickel concentration in the food. If these factors are not taken into consideration while drafting a low nickel diet, benefit will be poor.

## Footnotes

**Source of Support:** Nil

**Conflict of Interest:** Nil.

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