Nitrate in vegetables
Scientific Opinion of the Panel on Contaminants in the Food chain\textsuperscript{1}

Question N° EFSA-Q-2006-071

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**SCIENTIFIC PANEL MEMBERS**

**SUMMARY**
Nitrate is a naturally occurring compound that is part of the nitrogen cycle, as well as an approved food additive. It plays an important role in the nutrition and function of plants. Nitrate is an important component of vegetables due to its potential for accumulation; this can be affected by a number of biotic and abiotic factors. Higher levels of nitrate tend to be found in leaves whereas lower levels occur in seeds or tubers. Thus leaf crops such as lettuce and spinach generally have higher nitrate concentrations. Human exposure to nitrate is mainly exogenous through the consumption of vegetables, and to a lesser extent water and other foods. Nitrate is also formed endogenously. In contrast exposure to its metabolite nitrite is mainly from endogenous nitrate conversion.

Nitrate per se is relatively non-toxic, but its metabolites and reaction products e.g., nitrite, nitric oxide and N-nitroso compounds, have raised concern because of implications for adverse health effects such as methaemoglobinemia and carcinogenesis. On the other hand recent research indicates that nitrite participates in host defence having antimicrobial activity, and other nitrate metabolites e.g. nitric oxide, have important physiological roles such as vasoregulation. Despite being a major source of nitrate, increased consumption of vegetables is widely recommended because of their generally agreed beneficial effects for health.

In order to provide a strategy to manage any risks to human health from dietary nitrate exposure resulting from vegetable consumption an updated risk assessment was requested from the Panel on Contaminants in the Food Chain (CONTAM) of the European Food Safety Authority (EFSA) by the European Commission. The opinion was to take into account the amounts of nitrate found in vegetables as consumed and any relevant considerations on the possible balance between risks and benefits.

As a response to a call for data on nitrate levels in vegetables, EFSA received 41,969 analytical results from 20 Member States and Norway. There was a large variation in median concentrations of nitrate in different vegetables from a low of 1 mg/kg (peas and Brussels sprouts) to a high of 4,800 mg/kg (rucola). Less than 5% of all samples were reported as being below the limit of detection (LOD) for nitrate. A reasonable approximation of European vegetable consumption was estimated from the GEMS/Food Consumption Cluster Diets database and consumption data submitted by EU Member States. In consequence, a base case of vegetable and fruit intake of 400 g/person/day, as recommended by the World Health Organization (WHO), was used, but considered to be all in the form of vegetables. In addition, from the data collected, different scenarios combining a range of consumption patterns with concentration of nitrates in the relevant food category were estimated. The scenarios demonstrated that the critical driver for a high dietary exposure to nitrate is not the absolute amount of vegetables consumed but the type of vegetable (e.g. leafy vegetables) and the concentration of nitrate related to the conditions of production.

An Acceptable Daily Intake (ADI) for nitrate of 3.7 mg/kg b.w./day, equivalent to 222 mg nitrate per day for a 60 kg adult was established by the former Scientific Committee on Food (SCF) and was reconfirmed by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) in 2002. The CONTAM Panel noted that no new data were identified that would require a revision of the ADI.

To assess any potential health impacts from the different vegetable intake scenarios the CONTAM Panel compared the nitrate exposure estimates with the ADI for nitrate of 222 mg/day for a 60 kg human. Additionally, to place these findings in context, exposures from other nitrate sources such as drinking water and cured meat, at an average of 35-44 mg/person per day, were also taken into account. As a conservative
base case, a person eating 400 g of mixed vegetables at typical median nitrate concentration levels would on average receive a dietary exposure to nitrate of 157 mg/day. This is within the ADI even when the exposure to nitrate from other dietary sources is considered. Considering that for most people, fruit, which has low nitrate levels in the order of 10 mg/kg, comprises up to one half of the total recommended daily intake of 400 g of vegetables and fruit, actual nitrate intakes would be reduced to between 81-106 mg/day for the majority of the EU population. Further mitigation of nitrate intake may result from processing e.g. washing, peeling and/or cooking.

A small part of the population (2.5%) in some Member States eats only leafy vegetables and in high amounts, which can lead to the ADI being exceeded. Should the vegetables be produced under unfavourable growing conditions the ADI could be exceeded by approximately two fold. The Panel also noted that consumption of more than 47 g of rucola at the median nitrate concentration would lead to an excursion above the ADI without taking into account any other source of nitrate exposure.

Epidemiological studies do not suggest that nitrate intake from diet or drinking water is associated with increased cancer risk. Evidence that high intake of nitrite might be associated with increased cancer risk is equivocal.

The Panel compared the risk and benefits of exposure to nitrate from vegetables. Overall, the estimated exposures to nitrate from vegetables are unlikely to result in appreciable health risks, therefore the recognised beneficial effects of consumption of vegetables prevail. The Panel recognised that there are occasional circumstances e.g. unfavourable local/home production conditions for vegetables which constitute a large part of the diet, or individuals with a diet high in vegetables such as rucola which need to be assessed on a case by case basis.

**KEY WORDS**

Nitrate, nitrite, vegetables, ADI, risk assessment, risk benefit analysis, human health