National Research Programme NRP 69
Healthy Nutrition and Sustainable Food Prodution

Nanostructured minerals for human nutrition

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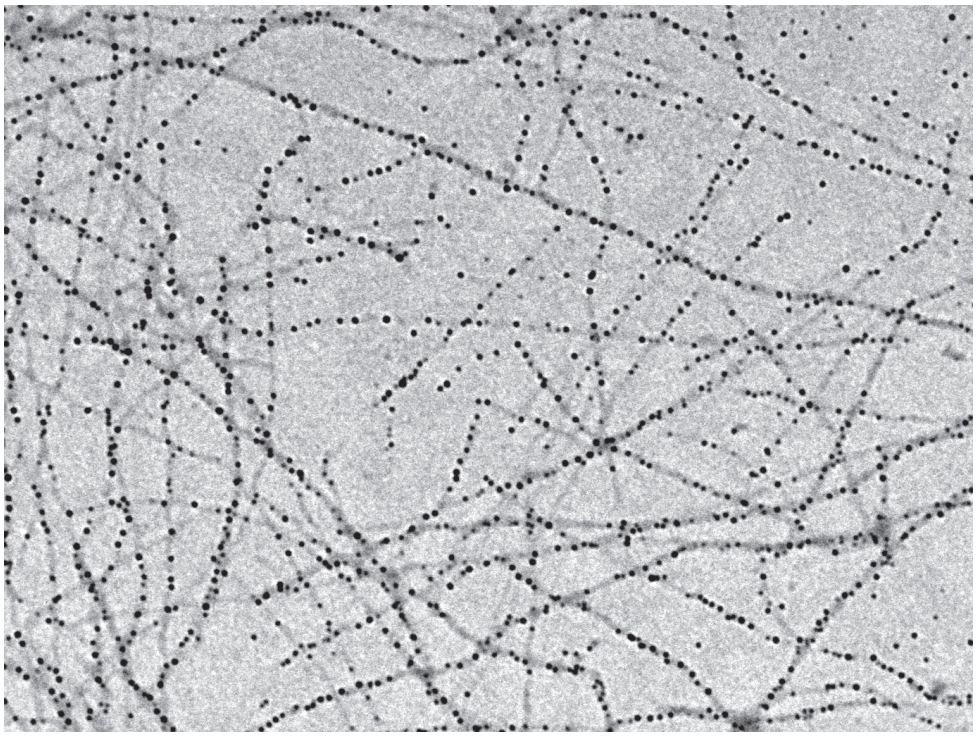
Nanotechnology-based innovation provides efficient way of combating iron deficiency

Researchers at ETH Zurich developed a new method for supplementing food with the trace element iron using nanofibres made from milk protein as carriers for the iron nanoparticles. Tests showed that the hybrid material is easy to digest and effective in combating iron deficiency, which is widespread in the human population. Unlike conventional iron preparations, the new method does not impair the taste and colour of food. The results of the project, which was carried out as part of NRP 69, show that the technology has significant potential for real-world applications in nutrition and medicine.

Over two billion people worldwide suffer from iron deficiency. Women and children are particularly affected in both industrialised and developing countries. Deficiency causes a variety of problems, especially certain types of anaemia, worsen the state of health of the population. Preparations that are ingested with food can remediate such deficiencies. As yet, however, such food supplements have a limited practical use, either because the body has difficulty digesting iron-enriched foodstuffs or because the iron taints the taste, odour and colour of food.

A nanotechnology-based process for adding the trace element to food holds out greater promise of success because nanoparticles have a good bioavailability and do not affect taste. However, the tiny particles have the disadvantage of being inherently unstable, which prevents them from achieving the intended effect. As part of NRP 69,



The transmission electron microscope shows that iron nanoparticles have accumulated on the milk protein nanofibres. The nanoparticles appear as black dots.
Source: TEM image, ETH Zurich

researchers at the Federal Institute of Technology in Zurich have developed an innovative method for stabilising iron nanoparticles so that the body can utilise them effectively.

Fibres as carriers for iron nanoparticles

The researchers developed a novel hybrid material consisting of protein nanofibres (known as amyloid fibres) and nanoparticles of the essential mineral iron. The amyloid fibres are obtained from beta-lactoglobulin (BLG), a common edible milk protein. When amyloid fibres are mixed with an iron salt in an acid, nanoparticles of iron are deposited on the surface of the nanofibres. By providing a carrier for the iron, the amyloid fibres stabilise the nanoparticles and prevent them from oxidising.

Further information: *www.nrp69.ch*

The scientists tested the efficacy of the method by simulating conditions in the human stomach in a test tube. The compound proved to be highly digestible. When they come into contact with acid, the iron nanoparticles dissolve into iron ions, which can be rapidly absobed. The new hybrid material also proved to be both digestible and effective against iron deficiency in a series of tests with rats. Furthermore, the researchers were unable to detect any undesirable side effects. They found no signs of nanofibre deposition in the internal organs of the animals that were given the dietary supplement. There is a strong body of evidence to suggest that the combination of amyloid fibres and iron nanoparticles is a safe, efficient and also taste-neutral method of combating iron deficiency (see box).

Application

Strong potential for the elimination of iron deficiency

The innovative method has considerable potential as a technique for supplementing food with iron. By virtue of their excellent solubility, the amyloid fibres make a first-class carrier for the trace element. The hybrid material is suitable for supplementing food in both liquid and solid form, and does not impair either the taste or colour of foodstuffs. Moreover, the starting materials are simple and cheap to produce. BLG fibres are a by-product of cheese manufacturing and iron salts are easy to obtain. The low costs associated with this method of iron supplementation make it particularly appealing for less developed countries, where iron deficiency is a particularly widespread issue.

The researchers have patented their method and are interested in working with industry partners to further develop it. They want to put their innovative technique for administering nanostructured minerals through comprehensive safety testing, after which they will contemplate clinical trials.

More information in the article in Nature Nanotechnology:

"Amyloid fibril systems reduce, stabilize and deliver bioavailable nanosized iron", Yi Shen, Lidija Posavec, Sreenath Bolisetty, Florentine M. Hilty, Gustav Nyström, Joachim Kohlbrecher, Monika Hilbe, Antonella Rossi, Jeannine Baumgartner, Michael B. Zimmermann & Raffaele Mezzenga, **Nature Nanotechnology** volume 12, pages 642–647 (2017)

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