German Federal Institute for Risk Assessment

FAQ

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Copper intake: Essential in trace amounts, but risky in larger amounts

Copper is a heavy metal and occurs naturally in the soil in varying concentrations depending on geological conditions. Agricultural practices can lead to correspondingly higher natural concentrations in certain regions, such as wine-growing or fruit-growing areas, if copper-based plant protection products or fertilisers are applied there, or if copper-impregnated wood – for example, in the form of stakes – is used. Locally elevated copper levels in the soil may also occur in the vicinity of copper-processing industries.

As a trace element, copper is essential in small amounts as a component of certain proteins and cofactors for humans, animals and plants. As the body cannot produce it itself, it must be taken up through the diet. However, excessive intake of copper can lead to adverse health effects, particularly in the long term. Furthermore, as a heavy metal, it is not biodegradable and therefore tends to accumulate when used, for example, in soil.

The German Federal Institute for Risk Assessment (BfR) has compiled a list of questions and answers on copper intake from a health perspective.

What is copper?

As a heavy metal, copper is a component of the Earth's crust and is therefore also present in agricultural soils. In agriculture, for example in fruit growing and viticulture, copper compounds are also used as plant protection products (PPPs), including in organic farming. Furthermore, it is used for wood preservation, for example in the posts used in agricultural production. It generally remains in the soil after use. Copper salts can be taken up by plants from the soil, but can also enter drinking water drawn from wells in copper-bearing soils. The heavy metal enters the food chain via plants used as raw materials for food and feed production, as well as via drinking water. Another route by which copper enters the food chain is via copper-containing additives in feed used for livestock intended for food production.

How does copper act in the body?

The body requires copper in trace amounts, as it is a component of many enzymes and proteins. The metal plays a particularly important role in oxidation and reduction processes. As the body cannot produce it as an element, copper must be obtained from the diet and is classified as an essential trace element. The German Nutrition Society (DGE) specifies daily intake reference values for copper for adolescents over 15 years of age and adults of between 1.0 and 1.5 milligrams (mg). For infants and children, the intake should be lower, in line with their body weight. An adequate intake for infants up to 12 months is considered to be between 0.2 mg and 0.7 mg per day; for children aged one to six years, a daily intake of between 0.5 and 1 mg and for older children aged seven and over between 1 and 1.5 mg of copper is considered as adequate.

What are the sources of copper intake?

The population in Germany takes up copper through food, including drinking water. Foods of animal origin that are particularly rich in copper include, above all, offal such as liver or kidneys, but also some types of cheese. Plant-based foods with relatively high copper content include, for example, cocoa, nuts, oilseeds, wheat germ and wheat bran, as well as pulses. Another important source of intake is drinking water, which, according to the Drinking Water Ordinance, may contain up to 2 mg per litre. However, the values determined in the study 'Meals for Exposure Assessment and Food Analysis' (MEAL) by the German Federal Institute for Risk Assessment were well below the limit value. Copper-containing food supplements may also be a source.

How much copper do people living in Germany take up through food?

According to the German Nutrition Society, the population living in Germany has an nutritionally adequate copper intake from food across all age groups.

This is confirmed by an analysis conducted using data from the MEAL study by the German Federal Institute for Risk Assessment (BfR) that focused specifically on copper intake. According to this, the copper intake of children aged between 0.5 and under 6 years in Germany ranges between 0.04 and 0.08 mg/kg body weight per day (median). The high exposure groups (95th percentile) among children in this age group range from 0.07 to 0.11 mg/kg body weight per day. Exposure among adults in Germany ranges from 0.02 (median) to 0.04 (95th percentile) mg/kg body weight per day. Median copper intake was approximately 10 per cent higher in a scenario where consumers primarily chose organically produced versions of the foods. Grains and grain products make the largest contribution to copper intake due to their high consumption. The medium and high levels of exposure among children exceeded the Acceptable Daily Intake (ADI) of 0.07 mg/kg body weight per day, which was derived by the European Food Safety Authority (EFSA) in 2022. It is, however, important to note that children have a higher copper requirement for growth, so that, according to the EFSA's assessment, there is no cause for concern even at these levels. With a typical German diet, the Tolerable Upper Intake Level (UL) for copper is utilised up to 85 per cent in children, whilst in adolescents and adults, over 50 per cent of the UL is reached.

What are the consequences of insufficient copper intake over a prolonged period?

Generally speaking, the population in Germany has an adequate supply of copper. However, if copper is not taken up in sufficient quantities over a long period, a copper deficiency may occur. This, in turn, can lead to a deficiency in certain types of white blood cells. There is also a risk of a disorder in bone metabolism, resulting in progressive bone loss (osteoporosis).

What are the consequences of excessive copper intake?

A key factor in the adverse health effects of excessive copper intake is what is known as copper homeostasis. This refers to the maintenance of copper levels in the body that ensure the proper functioning of normal (vital) physiological processes without causing any unfavourable health effects. Copper homeostasis is based on the regulated and coordinated functioning of various processes, such as the intake of copper, its distribution within the organism, its storage and its excretion.

Following short-term intake of a higher dose of copper (over 10 mg), gastrointestinal disorders such as vomiting or heartburn have been observed in adults. Such health disorders are often reversible, provided that copper is not continued to be ingested in higher doses.

The development of chronic copper toxicity depends on the capacity of the copper homeostasis system. Long-term health effects are to be expected if the mechanisms that counteract the build-up of toxic copper levels in the body become overburdened, particularly when the body's capacity to excrete copper is exceeded. With long-term excessive intake, copper accumulates in humans primarily in the liver, which can lead to impairment of liver function (hepatotoxicity).

Infants and young children are particularly sensitive to copper. Long-term intake of high amounts of copper can lead to the occurrence of severe, irreversible liver damage.

Is the additional intake of copper via copper-containing food supplements advisable given the typical dietary habits in Germany?

Given that people in Germany have a more than adequate supply of the trace element copper, additional intake via food supplements is not advisable. Indeed, it may lead to the Tolerable Upper Intake Level for copper intake being exceeded and, as a result, to an increased risk of adverse health effects.

Are there maximum levels for copper in food supplements?

The regulator has not set any maximum levels for copper in food supplements. According to the proposals put forward by the German Federal Institute for Risk Assessment for maximum levels for vitamins and minerals in food supplements, the recommended daily dose of a food supplement should contain no more than 1 mg of copper in order to avoid excessive additional copper intake. This recommendation does not apply to children and adolescents, as these population groups already take up relatively high amounts of this trace element through their food alone.

Is copper used in animal feed?

Copper is also an essential trace element for animals and, as an authorised feed additive, is used in animal feed to ensure that animals' needs are met. It is important to note that the specified maximum levels of copper in feed must not be exceeded. This ensures that excessive copper does not enter animal food products and the environment, for example through the excretion of copper in animal faeces. In particular, when rearing piglets, copper fed in quantities exceeding their requirements can play a significant role, as it can have a positive effect on gut health and thus improve the piglets' feed intake. To reduce the amount of copper released into the environment, the maximum permitted levels in pig feed were last reduced by the European Commission in 2018.

Can copper cookware contribute to increased copper intake?

Copper vessels are traditionally used for preparing a wide range of foods, such as chocolate, cheese and jam, as well as in breweries and distilleries. The vessels are usually made of elemental copper, but are often (e.g. cooking pots) coated on the inside with tin or stainless steel. Copper is also used in alloys such as brass or bronze.

There are no specific EU-wide regulations governing the release of elements into food from metal materials intended to come into contact with food. However, in 2013 the Council of Europe published a Technical Guide on metals and alloys for materials and articles intended to come into contact with food, in which a specific migration limit – i.e. the maximum amount that may migrate from a metal food contact material into food – of 4 mg per kg of food is derived for copper.

Under certain circumstances, copper may migrate in significant amounts into the food being prepared in cookware such as uncoated copper pans or pots. The same applies to uncoated copper drinking vessels. The amounts leached from the copper wall of the vessel depend on the food and its acidity, as well as other parameters such as the duration of contact and the temperature of the food. For example, a study from 2020 showed that, over a period of three hours, approximately 80 times as much copper was released into a 3 per cent citric acid solution at 60 °C as into water at 4 °C. To replace increased copper leaching, uncoated copper (cooking) utensils should therefore not be used with acidic foods such as mulled wine, sauerkraut, fruit juices or fruit salads, particularly at higher temperatures and over a prolonged period.

Do copper drinking water pipes in the home pose a health risk?

The Drinking Water Ordinance sets a limit value of 2 milligrams per litre for copper. Provided this limit value is not exceeded, no health effects are to be expected, even for young children and infants, who are the most vulnerable groups. Due to its high corrosion resistance, smooth surface and effective joining techniques, copper is a commonly used material in drinking water installations. When copper pipes come into contact with drinking water, a protective layer forms on their surface, consisting of corrosion products; once this layer has formed, the release of further metal into the drinking water may be reduced.

The risk of increased copper intake via drinking water depends largely on the pH value of the water flowing through the copper pipes. The pH value indicates how acidic or alkaline a

solution is. According to the Drinking Water Ordinance, the pH value of drinking water must be between 6.5 and 9.5. However, water with a pH value of 7 or below is acidic and, depending on the acidity and hardness of the drinking water, leaches increased amounts of copper ions from the copper pipe. In the case of hard, acidic drinking water (pH value below 7) with a high TOC (total organic carbon) content, the solubility of copper is permanently increased.

Copper pipes can be used without hesitation in drinking water with a pH value of 7.4 or higher. In the pH domain between 7.0 and 7.4, the TOC must not exceed 1.5 mg/l. The use of copper pipes is not permitted in drinking water with a pH value below 7.0.

In the case of centralised water supply via water treatment plants – and indeed in decentralised water supply systems as well – there are hardly any drinking water systems in which copper pipes may not be used. The pH of drinking water from these supplies is usually between 7 and 8, which is in the neutral to slightly alkaline range, meaning that no copper is leached from the drinking water pipes. However, the pH is often higher, particularly when the drinking water is treated to adjust the calcium-carbonate balance.

Residential buildings with copper drinking water pipes and an individual domestic water supply – i.e. private water supply systems – pose a potential risk if the pH value of the self-supplied drinking water is not monitored by the operators through appropriate measures and maintained at 7–8 or higher.

In Germany, the Federal Ministry of Health is responsible for setting limit values for copper and other substances in drinking water. The Federal Environment Agency develops the scientific basis for this.

Can significant amounts of copper enter the body via fruit, vegetables, grapes or wine?

In fruit, vegetables and grape cultivation, residues can enter food through the use of authorised copper-containing plant protection products (PPPs). Copper-impregnated wooden stakes used in the field also represent a source of contamination. Residues may therefore remain on food up to the maximum permitted levels. This also applies to products from organic farming, as copper is authorised as a PPP in this sector.

The permitted residues resulting from the correct use of PPPs contribute only to a small extent to reaching the tolerable upper limits for copper intake.

Further information on copper at the BfR websites

Information platform microco.info on copper
https://www.microco.info/minerals/copper/

Proposed maximum levels for the addition of copper to foods including food supplements
https://www.microco.info/cm/349/proposed-maximum-levels-for-the-addition-of-copper-to-foods-including-food-supplements.pdf

About the BfR

The German Federal Institute for Risk Assessment (BfR) is a scientifically independent institution within the portfolio of the Federal Ministry of Food and Agriculture (BMEL) in Germany. The BfR advises the Federal Government and the States ('Laender') on questions of food, chemicals and product safety.
The BfR conducts independent research on topics that are closely linked to its assessment tasks.

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