German Federal Institute for Risk Assessment

Opinion 003/2024

23 January 2025

Lectins in plant-based foods: Is there a health risk?

Many plant foods contain so-called lectins. They fulfil important functions in the plant by protecting it from diseases and pests. When consumed in moderation, most lectins are not expected to have any adverse effects on human health. However, ingesting certain lectins, which are mainly found in raw pulses, can lead to health impairments, including symptoms such as nausea, vomiting and diarrhoea. Children are particularly at risk due to their low body weight.

To avoid the undesirable effects, it is usually sufficient to follow the recommended preparation methods for pulses. Since the lectin activity is destroyed by high heat, the following applies: cook fresh beans in boiling water for at least 30 minutes. Dried pulses should be soaked for at least five hours and then boiled in fresh water, after pouring away the soaking water. Gentle cooking methods such as steaming or stewing are not suitable for most pulses. Sugar snap peas and peas are an exception, as they contain only low amounts of lectins. They can even be eaten raw in moderation. This also applies to many other foods that contain lectins, including tomatoes, mushrooms and bananas.

Under no circumstances should plant-based foods be avoided in favour of a low-lectin diet. A diet with a varied selection of fruits and vegetables (including pulses in a sufficiently cooked form) provides, among other things, valuable vitamins, minerals and dietary fibre.

As the adverse effects of lectins are mainly due to improper preparation of pulses, the Federal Institute for Risk Assessment (BfR) recommends to intensify risk communication: Packaged foods such as dried pulses or fresh green beans can be labelled to indicate that they should only be consumed if they are sufficiently cooked.

In view of the expected increase in plant-based diets and the possible toxic and, in some cases, allergenic potential of certain lectins, the BfR also considers the further development of efficient and standardised detection methods for lectins in food to be desirable.

Intake of active lectins via food

Affected are	General population				
B Probability of health impairment when legumes are prepared properly	Very low	**Low**	Medium	High	Very high
C Severity of health impairment from eating raw pulses	No impairment	Slight impairment	**Moderate impairment [reversible]**	Severe impairment	
D Informative value of the available data	High: The most important data is available and consistent	**Medium: Some important data are missing or contradictory**	Low: Numerous important data are missing or contradictory		
D Controllability by consumers	Control not necessary	**Controllable through precautionary measures**	Controllable through renunciation	Not controllable	

Fields with a dark grey background indicate the properties of the risk assessed in this opinion (for more details, see the text of Opinion 03/2025 from the BfR dated 23 January 2025).

Explanations
The risk profiles are intended to visualise the risk outlined in the Opinion. The profile is not intended to be used to compare risks. The risk profiles should be read only in conjunction with the Opinion.

Line B - Probability of health impairment
The undesirable effects of lectins are mainly due to improper preparation of pulses and are therefore avoidable. However, with moderate consumption, most lectins are not expected to have adverse effects on health.
Line C - Severity of the health impairment:
The severity of the impairment can vary. Whether symptoms occur and how pronounced they are varies greatly from person to person. Children are particularly at risk due to their low body weight.
Line D - Significance of the available data
There are no detailed findings on the dose-effect relationship of lectins in humans. Information on this comes mainly from observations of cases of poisoning. The critical dose is currently unknown.
Line E - Controllability by consumers
The health risk can be minimised or eliminated by preparing pulses correctly. Boiling certain foods that contain lectins for a sufficient length of time protects against possible adverse health effects.

1 Subject of the assessment

The German Federal Institute for Risk Assessment (BfR) was asked by the German Federal Ministry of Food and Agriculture (BMEL) to elaborate an opinion on the topic of lectins in food. The aim of the assessment was to investigate the occurrence of lectins in food, the effects on human health and possible precautionary measures to reduce the content of lectins in food. In addition, the BfR was asked to examine whether it might consider it

appropriate to carry out regulatory follow-up of lectins in food at the EU level. This could include, for example, a request to the European Food Safety Authority (EFSA) for an assessment of the risks to human health associated with the presence of lectins in food or a request to the European Reference Laboratory (EURL) for mycotoxins and plant toxins to investigate analytical aspects for the determination/quantification of lectins in food.

2 Results

Lectins are found in various plant-based foods. Based on current knowledge, it can be assumed that most lectins do not have any negative effects on human health when consumed in moderate amounts. However, the intake of certain lectins, which are mainly found in raw pulses, can lead to health impairments (e.g., in the upper and lower gastrointestinal tract). The health risk can be minimised or eliminated by proper preparation. Scientific studies have shown that heating to 100 °C for about 10 to 15 minutes destroys the heat-stable lectins. To ensure that the entire legume is heated to a sufficiently high temperature, it is often recommended that fresh beans be cooked for about 30 minutes. Dried pulses should also be soaked in water for at least five hours before being boiled in fresh water for 30 minutes.

Epidemiological studies indicate that the consumption of plant-based foods containing lectins - including cooked pulses, wholemeal products and nuts - is associated with health benefits (lower rates of obesity, type 2 diabetes and cardiovascular disease). As the occurrence of adverse health effects of lectins are mainly due to improper food preparation, the BfR recommends that consumers should be better informed about the potential risks associated with eating raw or undercooked pulses. Another possible measure would be to label packaged foods such as dried pulses or packaged fresh green beans with instructions that they should only be consumed when sufficiently cooked.

Furthermore, the development of standardised analytical methods for the simple and efficient detection of lectins in food is considered desirable, not only with regard to the toxic and possible allergenic potential of certain lectins, but also with regard to the assessment of the lectin content of *novel foods.*

3 Rationale

3.1 Risk assessment

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3.1.1 Hazard identification

Lectins are widely occurring glycoproteins (macromolecules consisting of a protein and one or more covalently bound carbohydrate groups) that fulfil a variety of biological functions in microorganisms, plants, animals and humans. However, some of them can also have a toxic effect. Lectins can bind to carbohydrate structures of cells in the human intestine or blood and thereby induce cell division, cause agglutination ("clumping") of red blood cells (so-called haemagglutination), affect the immune system, alter the permeability of the intestinal barrier and generally disrupt cell metabolism (Banwell et al, 1988; Dalla Pellegrina et al,

2009; King et al, 1980; Kumar et al, 2013; Peumans and Van Damme, 1996). As this can reduce the absorption of nutrients in the intestines, lectins are also classified as antinutritional substances. In plants, lectins have a protective function against diseases and pests such as herbivorous insects and other animals.

The consumption of lectins can cause extreme nausea and vomiting, as well as diarrhoea and abdominal pain, within one to three hours of ingestion (Noah et al., 1980). Recovery is usually rapid, with undesirable effects typically resolving within three to four hours of the onset of symptoms. Hospitalisation was only necessary in some cases. There are only a few scientific reports of lectin-related poisoning. In the United Kingdom, for example, a total of 50 health incidents related to the consumption of red kidney beans were recorded between 1976 and 1989 (Rodhouse et al., 1990). In the Czech Republic, between 1996 and 2001, garden and runner beans were listed among the plant species that most frequently caused hospitalisation in children, with a total of 13 cases. While most affected children were discharged after one day, there were only four cases that required hospitalisation for more than two days. There were no recorded deaths (Vichova and Jahodar, 2003). Between 1995 and 2009, 42,193 cases of plant exposure in humans and 255 acute moderate to fatal poisonings were registered in Switzerland. These included eight cases of accidental consumption of raw beans, which were not fatal (Fuchs et al., 2011). In Japan, lectin poisoning occurred in 2006 after a television programme promoted the consumption of staple foods containing powdered, roasted white kidney beans. One thousand viewers suffered from acute intestinal problems and 100 had to be hospitalised. The adverse effects were later attributed to lectins, which were still active due to insufficient heat treatment of the beans (Ogawa and Date, 2014). Between 2004 and 2013, there were 124 health incidents in China (40 % of national poisoning cases) involving 7,526 people (64 % of people poisoned nationwide) that were linked to fresh kidney beans. Most of these cases of poisoning occurred in communal canteens (Sun et al., 2019).

The BfR poisoning database also contains a few individual cases of poisoning between 1996 and today that are linked to the consumption of plant-based foods containing lectins. While there's a high probability that only one of the cases of poisoning (the consumption of undercooked green beans) was caused by lectins, it is unclear what exactly caused the harmful effects in the remaining cases (drinking soymilk and consuming products made from sweet lupins). In 2020, the poison centres received an increasing number of enquiries about garden beans and faba beans. It was not reported whether the enquiries were related to accidental ingestion of plant parts or beans as food. Only a few cases of moderate symptoms were documented. The majority of exposures were asymptomatic or resulted in mild symptoms. It should be noted that cases of poisoning and suspected cases of food poisoning are exempt from the reporting requirement under Section 16e of the Chemicals Act. However, the BfR includes such reports in the database as voluntary reports. The cases registered in the BfR poisoning database are therefore not representative of the overall incidence of poisoning in Germany. In order to obtain a more comprehensive overview of cases of poisoning in Germany in the future, the Federal Government has passed a law to establish a national poisoning registry at the BfR. The poisoning registry will commence its work on 1 January 2026.

Lectins are found in various foods. While pulses (e.g., green beans, red kidney beans, jack beans) and wheat germ contain comparatively high amounts, nightshade plants (e.g.,

potatoes, tomatoes) and certain fruits (e.g., bananas) contain only small amounts of lectins. Known examples of plant-based foods that contain lectins are listed in Table 1.

Table 1 Examples of plant-based foods containing lectins by food group

Food group	Food*
Pulses	Red kidney beans (*phytohaemagglutinin*), green beans (*phasin*), jack beans (*concanavalin A*), soybeans, field beans, chickpeas, lentils, peas, peanuts
Solanaceae	Potatoes, tomatoes, aubergines (eggplants), peppers
Cereals	Wheat (*wheat germ agglutinin*), rice, maize, quinoa
Mushrooms	Oyster mushrooms, white button mushrooms
Leek family	Garlic, onions
Fruits	Bananas (*BanLec*), elderberries

*Lectins of selected foods are listed in brackets

3.1.2 Hazard characterisation

If lectins are consumed raw, they cannot be digested in the gastrointestinal tract. After binding to cellular structures in the gastrointestinal tract, some lectins can cause the adverse effects already described (see 3.1.1). If these lectins enter the bloodstream in their active form, severe systemic effects may also occur. As lectins in pulses are thermolabile (not heat-resistant), their structure can be destroyed by heat. Raw pulses such as beans, lentils and chickpeas, which contain large amounts of lectins, must therefore be cooked sufficiently before consumption. It is recommended that fresh beans be cooked at 100 °C for 30 minutes. Bender and Reaidi analysed the residual amounts of toxic lectin in samples of red beans after different heating times (2 to 45 minutes) at temperatures of 70, 80, 90 or 100 °C. In this study, the lectins in some samples were largely destroyed after just 2 minutes at 100 °C, while it took almost eight times as long at 90 °C. At a heating temperature of 80 °C, there was a considerable increase in the agglutination force (clumping force), which reached a maximum after 15 minutes that was seven times higher than the initial value. Even after 45 minutes of heating, there was still five times as much agglutinin present as in the raw beans. At 70 °C, the effect was similar, but to a lesser extent (Bender and Reaidi, 1982). Gentle cooking methods such as steaming or stewing are therefore not recommended for pulses, as the temperatures achieved are not high enough to destroy the lectin structures. Dried pulses should also be soaked in water for at least five hours, then the soaking water should be poured away and the pulses boiled in fresh water for 30 minutes. As sugar snap peas and peas contain only a small amount of lectins, they are excluded from this preparation recommendation and, according to the German Nutrition Society (DGE), can also be eaten raw in small quantities (DGE, 2016; BZfE, 2020). This also applies to many other foods containing lectins, such as tomatoes, mushrooms and bananas. If consumed in moderation, most lectins are not expected to have any negative health effects on human health.

The effects of lectin consumption have so far mainly been investigated in animal experiments. Both beneficial (Gupta et al., 2018) and toxic (Bender and Reaidi, 1982; Jayne-Williams and Burgess, 1974; McPherson, 1990; Sun et al., 2019) effects have been observed.

Detailed findings on the dose-effect relationship of lectins in humans do not exist, as experiments with potentially harmful lectins have not been carried out in humans for obvious ethical reasons. Information on the acute toxicity of lectins in humans therefore mainly stems from observations of cases of poisoning. According to these, the consumption of just four to five raw beans can lead to adverse health effects, particularly in children due to their low body weight (Noah et al., 1980). However, as the concentration of natural plant ingredients can vary greatly and depends on the variety, growing conditions and time of harvest, it is not possible to specify an exact quantity. It is assumed that there are large individual differences. The critical dose is currently unknown.

3.1.3 Exposure estimation and assessment

The amount of active lectins that we ingest with our food is largely unknown. However, as lectins are found in almost all foods, it can be assumed that the majority of the population regularly consumes certain amounts of lectins. It should be noted that the consumption of foods with high concentrations of active lectins is rare. Lectins are most efficacious in their raw state. Foods such as pulses, which contain these active lectins, are not typically consumed raw.

3.1.4 Risk characterisation

Lectins are glycoproteins found in various plant-based foods. Depending on the quantity and the specific lectin, they can damage the microvilli (protrusions) of the intestinal mucosa and disrupt the absorption of nutrients, as well as cause red blood cells to clump. The BfR assumes that the acute toxicity (in particular the temporary damage to the upper and lower gastrointestinal tract) of lectins in pulses is mainly due to improper preparation. The fact that most people do not show any lectin-related damage in the intestinal tract, despite regularly consuming lectins with their food, could be due to the small amounts ingested, the protective layer of the intestinal epithelium, which consists of carbohydrate-protein compounds (glycoconjugates) and the ratio of intestinal surface area to the amount of lectins from food.

3.2 Framework for action, recommendation of measures

Lectins can have a wide range of effects. While most lectins do not cause any health problems in healthy people, some people may react more sensitively. In addition to cooking certain foods containing lectins, moderate consumption of these foods as part of a varied and balanced diet helps to protect against possible adverse health effects. In addition, eating a wide variety of vegetables contributes to a high intake of fibre, which reduces the risk of obesity and diabetes and has a positive effect on the human intestinal flora and the risk of colon cancer (Bouchenak and Lamri-Senhadji, 2013; Liu et al., 1999). The BfR does not recommend a general reduction of plant-based foods in order to reduce the intake of lectins.

As it is not clear to what extent the population is (still) aware of the correct preparation of pulses, one possible measure to prevent future cases of poisoning with lectins would be to provide targeted consumer information. In addition to the recommendations for preparation, instructions could be added on packaged foods such as dried pulses or fresh green beans, indicating that these should only be consumed if they are sufficiently cooked.

With regard to prioritising possible further measures, the BfR is of the opinion that a request to EFSA for the assessment of risks to human health associated with the presence of lectins in food is less urgent for the time being, provided that consumers are adequately informed about the correct preparation of lectin-containing foods, such as pulses. On the other hand, a risk assessment by EFSA could also serve as an important basis for the refinement of risk communication, e.g., for the development of recommendations for consumers.

Whether a request to the EURL for mycotoxins and plant toxins to work on analytical aspects for the determination/quantification of lectins in food is appropriate is difficult for the BfR to judge. In view of the possible toxic and, in some cases, allergenic (see 3.3) potential of lectins in combination with the expected increase in plant-based diets, the further development of analytical methods for the simple and efficient detection of lectins in food would be fundamentally desirable. Various approaches for the detection and quantification of lectins in food are already being investigated (Mamone et al., 2009; Nasi et al., 2009; Wang et al., 2021).

Knowledge on the occurrence of certain lectins and their concentration would also be important for novel plant-based foods, in order to assess health risks that could arise from the intake of potentially harmful lectins.

3.3 Other aspects

In addition to their possible toxic properties, some lectins also appear to have allergenic potential (Barre et al., 2020). For example, lectins in the following six foods are classified as potential food allergens by the WHO/IUIS (World Health Organisation/International Union of Immunological Societies) Subcommittee on Allergen Nomenclature (the allergen and associated lectin are given in brackets): Banana (Mus a 2, class I chitinase), wheat (Tri a 18, wheat germ agglutinin), maize (Zea m 8, class IV chitinase), beetroot (Bra r 2, chitin-binding protein), chestnut (Cas s 5, chitinase) and avocado (Pers a 1, class I chitinase) (Pomés et al., 2018). The underlying mechanisms of action, the exact extent of the possible allergenic potential and clarification of whether other lectins from other types of fruit and vegetables are also potential food allergens requires further scientific investigation.

Further information on the BfR website on the topic of lectins in food

Press release “Only enjoy cooked beans”
https://www.bfr.bund.de/en/press_information/2021/32/only_enjoy_cooked_beans-278526.html

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About the BfR

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

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Responsible according to the German Press Law: Dr Suzan Fiack

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