German Federal Institute for Risk Assessment

DOI https://doi.org/10.17590/20230202-075856

Spelt can also trigger allergies - low level of public knowledge about spelt being a type of wheat

BfR Opinion No 001/2023 issued 13 January 2023 (assessment as of 30 November 2020)

In the case of prepacked food, the 14 most common triggers for allergies and food intolerances must always be included in the list of ingredients. These triggers include gluten-rich cereals such as wheat, rye, barley and oat. Spelt is also a type of wheat and must be labelled as 'wheat' in accordance with the Food Information Implementing Regulation (LMIDV). Merely including spelt in the list of ingredients is not enough.

The German Federal Institute for Risk Assessment (BfR) has assessed the relevance of labelling spelt as a type of wheat in the list of ingredients in terms of protecting public health. There is also the question of whether commercially available spelt has the same level of allergenicity as commercially available wheat and, if so, whether consumers are aware of this fact. Secondly, there is the question of whether the public knows that spelt is a type of wheat.

The BfR has concluded that there are no meaningful clinical data published to date that would substantiate any claim for a lower allergenic potential for spelt compared with commercially available wheat. Furthermore, spelt and common wheat share a relatively high level of correspondence in terms of potentially allergenic components (protein molecules), so one may assume a similar degree of allergenicity.

The BfR conducted a representative telephone survey in order to obtain data on the extent of public knowledge about spelt and wheat. Only half of the respondents stated that they knew spelt was a member of the wheat family. Compared with wheat, only roughly one in five respondents assumed that spelt would have a comparable level of allergenicity.

Since there have been reports in the media that spelt is allegedly less allergenic than wheat, one may therefore assume that some wheat allergy sufferers may turn to spelt products without first seeking medical advice. Regardless of the allergenicity of these products, individuals wishing to avoid wheat products for other reasons should certainly be aware of the fact that spelt is a type of wheat.

From a health risk assessment perspective and to keep the general public properly informed, the BfR recommends including a clear indication that spelt is a type of wheat as part of applicable allergy labelling regulations.

1 Subject of the assessment

In accordance with article 21(1) letter a of *Regulation (EU) No 1169/2011 on the provision of food information to consumers* (FICR), substances or products causing allergies or intolerances must always be indicated in the list of ingredients for prepacked food, and namely "with a clear reference to the name of the substance or product as listed in Annex II".

The enactment of the FICR has harmonised food labelling law across the EU. With *Commission Delegated Regulation (EU) No 78/2014 of 22 November 2013 amending Annexes II and III to Regulation (EU) No 1169/2011*, the EU Commission corrected the originally misleading

wording of annex II(1) of the FICR, clarifying that spelt is indeed a member of the wheat family. The amendment reads as follows: “1. Cereals containing gluten, namely: wheat (such as spelt and khorasan wheat), rye, barley, oat or their hybridised strains, and products thereof (…)”[1].

On its website, the German Allergy and Asthma Association states that spelt is not a general substitute for wheat, since these allergenic cereals are virtually identical.[2]

In light of the above, the BfR had to address the following questions:

1. Has it been scientifically proven that commercially available spelt has the same level of allergenicity as commercially available wheat - or is a distinction between spelt and wheat to be tolerated or even necessary in terms of food labelling?

2. If it is scientifically proven that commercially available spelt has the same level of allergenicity as commercially available wheat, are consumers aware of this fact? From a scientific perspective, are those individuals who suffer from allergic reactions to wheat protein the only group whose level of knowledge needs to be assessed?

3. Are consumers aware that spelt is a member of the wheat family?

2 Results

Since spelt and common wheat are both members of the *Triticum* genus, there is a high degree of homology between the proteins found in spelt and those found in common wheat.

As of this writing, the BfR is aware of no meaningful clinical data that would clearly substantiate a lower level of allergenic potential in the case of spelt as opposed to common wheat (also known as ‘bread wheat’). Since commercially available spelt can therefore exhibit a level of allergenicity similar to that of commercially available wheat, the BfR recommends including a clear indication that spelt is a type of wheat as part of applicable allergy labelling.

In November 2020, a representative consumer phone survey conducted on behalf of the BfR demonstrated a low level of knowledge in relation to cereal classification within the general population in Germany, also showing that only roughly one in five respondents (22%) assumed that commercially available spelt exhibits a level of allergenicity comparable to that of commercially available wheat. In addition, of those respondents who correctly assigned spelt to the same cereal family as wheat, only roughly a third (32%) also assumed that both types of cereal would have the same level of allergenicity. Knowledge that spelt is a member of the wheat family is therefore not necessarily associated with the knowledge that both species of cereal are likely to exhibit a comparable level of allergenicity.

The study in question did not distinguish between those individuals who are allergic to wheat protein and those who are not allergic to wheat protein. Accordingly, this survey cannot be

[1] https://eur-lex.europa.eu/legal-content/En/TXT/PDF/?uri=CELEX:32014R0078&rid=1, accessed on 21 November 2020

[2] https://www.daab.de/ernaehrung/nahrungsmittel-allergien/ausloeser/uebersicht/weizen/, accessed on 21 November 2020

used to derive statements about the knowledge held specifically by allergy sufferers. In light of this fact, it must be assumed that some wheat allergy sufferers may possibly choose to purchase spelt-based products as a result of reading or viewing occasional reports in the media that spelt is allegedly less allergenic than wheat. Regardless of this fact, spelt should also be clearly labelled as a member of the wheat family for consumers who wish to avoid wheat products for other reasons.

Accordingly, the BfR believes clearly stating that spelt is a type of wheat to be an important and advisable part of applicable labelling. In consideration of the 2019 recommendation issued by the ALS (Working Group of Food Chemistry Appraisers for the Länder and the Federal Office of Consumer Protection and Food Safety), the BfR recommends labelling spelt flour in the future as 'spelt flour (type of wheat)', with the term 'spelt flour' possibly being replaced by the more general term 'spelt'. Accordingly, the recommendation would therefore be 'spelt (type of wheat)' or 'spelt flour (type of wheat)'.

3 Rationale

3.1 Wheat genus (*Triticum* L.)

The wheat genus (*Triticum* L.) is a member of the grasses family (Poaceae). Species of wheat include common wheat (*Triticum aestivum* L.), durum wheat (*Triticum turgidum* subsp*. durum*), spelt (*Triticum aestivum L.* subsp. *spelta*), einkorn wheat (*Triticum monococcum*) and emmer wheat (*Triticum dicoccum*).
Spelt (*Triticum aestivum* L. subsp*. spelta*) and common wheat (or bread wheat) (*Triticum aestivum* L. subsp*. aestivum*) constitute subspecies of common wheat (*Triticum aestivum* L.) (Münzing, 2008).

The wheat genus is subdivided into three lineages, which relate to the degree of polyploidy[3] exhibited by the respective species. The einkorn series is diploid, having two sets of chromosomes (*T. monococcum,* 2n=14, genome AA), while the emmer series is tetraploid, with four sets (*T. dicoccum,* 4n=28, genome AABB), with the final, spelt series being hexaploid, with six sets of chromosomes (6n=42, genome AABBDD). This last series includes spelt and common wheat (Steinmüller, 2017).

It is supposed that the hexaploid forms have resulted from natural hybridisation, targeted cultivation and selection. European spelt and common wheat probably came about as a result of the hybridisation of a tetraploid wheat (*T. dicoccum*, AABB) with a diploid wild grass (*Aegilops tauschii,* DD) roughly 10,000 years ago. This brought about the integration of the DD genome, and would explain the complexity of the wheat genome and therefore its complex protein composition (Appels et al., 2018; Dubcovsky and Dvorak, 2007; Steinmüller, 2017; Vasil, 2007).

Accordingly, spelt and common wheat are very closely related and can be hybridised together (Steinmüller, 2017).

[3] Polyploidy = inheritable increase in the number of copies of the genome

3.2 Wheat sensitivity

In the western world, roughly 0.5 percent of children and adolescents, and roughly 1 percent of adults are affected by an immunoglobulin E (IgE)-mediated wheat food allergy (Inomata, 2009; Sievers et al., 2020; Venter and Arshad, 2011; Zuidmeer et al., 2008). Augmentation factors can strengthen the allergic response and are in some cases even necessary for triggering symptoms, such as in the case of wheat-dependent exercise-induced anaphylaxis (WDEIA). Some of the best-known augmentation factors include physical effort and the use of non-steroidal anti-inflammatory drugs (NSAIDs), although alcohol, fever, acute infection and allergic complaints during the pollen season have also been described as augmentation factors (Worm et al., 2015).

IgE-mediated wheat allergy is distinct from coeliac disease, which is a T cell-mediated, chronic inflammatory bowel condition affecting individuals with a genetic predisposition to the disease (Sievers et al., 2020). In addition, wheat protein can also cause respiratory allergies ('Baker's asthma') and skin allergies (contact urticaria) (Czaja-Bulsa and Bulsa, 2017). More recently, there have also been reports of non-coeliac gluten/wheat sensitivity (NCGWS, Ludvigsson et al., 2013) - a condition not requiring the involvement of IgE. Most allergy specialists have questioned NCGWS, however, as a result of an absence of clear diagnostic criteria as well as a lack of clinical validation (Reese et al., 2018). Another condition that has been associated with wheat protein is irritable bowel syndrome (IBS), although no clear serological markers are available here either, with symptoms being similar to those of NCGWS and the circumstances still being the subject of discussion (Catassi et al., 2017).

3.2.1 Proteins contained in wheat

Conventionally, wheat proteins are subdivided into four fractions, namely water-soluble albumins and salt-soluble globulins (soluble in 0.5 mol/l NaCl), plus gliadins and glutenins, with both of these last two proteins also being glutens (Scherf et al., 2015).

The gluten concentration is 9.4 to 10.6 percent. Using a classification system based on repetitive amino acid sequences, gliadins can be grouped into α-, β-, γ- and ω types. Based on their electrophoretic motility in the presence of an acidic pH, glutenins can be categorised into high-molecular-weight (HMW) and low-molecular-weight (LMW) types (Burkhardt et al., 2018).

Non-gluten proteins (from the albumin or globulin fractions) include lipid transfer proteins (LTPs), puroindolines, β-amylases and α-amylase trypsin inhibitors (ATIs) (Burkhardt et al., 2018).

3.2.2 Wheat allergies

The epitopes that are responsible for the allergenicity can be found in both wheat gluten proteins and soluble wheat proteins (non-gluten proteins) (Juhász et al., 2012). Clinical trials on the allergenic potential of wheat have shown that wheat-specific IgE binds to both non-gluten and gluten protein fractions. In terms of gluten proteins, IgE antibodies taken from sera from wheat allergy sufferers may target both gliadin as well as gluten fractions (Scherf et al., 2015). In this study, Battais et al. (2003) show that 60 percent of wheat allergy patients exhibit IgE against α/β-gliadins and low-molecular-weight (LMW) glutenins, 55 percent against γ-gliadins,

48 percent against ω-gliadins and 28 percent against high-molecular-weight glutenin subunits (HMW-GS) (Battais et al., 2003).

The allergen database maintained by the *International Union of Immunological Societies* (IUIS) and the World Health Organisation is the official reference for allergen names, and publishes the systematic nomenclature for allergenic proteins on the *www.allergen.org* website (Radauer, 2017).

For wheat, 28 allergens (Tri a 12 to Tri a 45) have currently been classified, which differ from one another in relation to their sensitisation pathway, exposure and clinical manifestation (Matsuo et al., 2015; Tordesillas et al., 2017).[4]

Immune responses to many of these proven allergens can also lead to cross-reactivity with other species of cereals (Baar et al., 2012; Sievers et al., 2020).

3.3 Studies on the allergenicity of spelt and wheat

Spelt is considered to be a 'traditional' type of cereal by some consumers[5], while common wheat (bread wheat, i.e. the subspecies *Triticum aestivum* subsp. *aestivum*) is regarded instead as a 'modern' type of cereal[6]. At the same time, 'traditional' types of cereal are considered to be more easily digested[7].
Wheat-related illnesses and the potential health benefits of types of cereal considered to be 'traditional' instead of 'modern' have been investigated in many studies, while also giving rise to controversies in scientific circles (Dubois et al., 2016; Gianfrani et al., 2015; Gianfrani et al., 2012; Iacomino et al., 2016; Prandi et al., 2017; Ribeiro et al., 2016; Valerii et al., 2015).
For its part, BfR has identified the following studies, which have investigated spelt (*Triticum aestivum* subsp. *spelta*) in comparison with bread wheat (*Triticum aestivum* subsp. *aestivum*) in relation to an IgE-mediated wheat allergy (non-systematic literature search conducted up until 13 November 2020).

3.3.1 Oral provocation tests

During the literature search, only one study was identified in which an oral provocation test had been conducted with spelt in comparison to wheat. In this study (Armentia, 2012), an oral provocation test with the common wheat variety 'Astral' and spelt was conducted in 66 test subjects (45 men and 21 women) recruited using a wheat allergy database and for whom wheat-specific IgE had been detected using the *Immuno CAP* system (Phadia, Uppsala, Sweden). Oral provocation with wheat was positive in 22 (33%) patients, while only 6 (27.3%) of

[4] http://www.allergen.org/viewallergen.php?aid=618, accessed on 10 November 2020

[5] https://www.alnatura.de/de-de/magazin/warenkunde/warenkunde-alte-getreidesorten/, accessed on 10 November 2020

[6] https://www.brigitte.de/gesund/ernaehrung/gesund-essen---weizenwampe----gefahr-aus-der-aehre--10160108.html, accessed on 10 November 2020

[7] https://www.sueddeutsche.de/gesundheit/mythos-des-monats-ist-urgetreide-bekoemmlicher-als-weizen-1.3141157, accessed on 10 November 2020

these 22 patients had an immune response to spelt. Overall, however, this article has significant shortcomings. The performance of the test, including details of the quantities of extracts used and the severity of symptoms, is not described, nor are the type of symptoms triggered. Nor are any patient data presented. Accordingly, this severely limits the relevance of this study.

3.3.2 Studies with wheat-specific IgE

A study conducted by Sievers et al. (2020) investigated the binding capacity of wheat-specific IgE sera to water- and salt-soluble protein fractions (albumins and globulins), and water-insoluble protein fractions (gliadins and glutenins), of selected diploid, tetraploid and hexaploid cultivars of the *Triticum* (wheat) genus.

The cultivars selected were as follows: spelt (*Triticum aestivum* L. subsp. *spelta*, variety: *Oberkulmer Rotkorn* and *Franckenkorn*, a wheat-spelt hybrid); einkorn wheat (*Triticum monococcum*, variety *Terzino* and *Tifi*); emmer wheat (*Triticum dicoccum*, variety *Osiris* and *Ramses*); winter durum wheat ((*Triticum durum*, variety *Wintergold*, as well as two other varieties that were not further specified); tritordeum (cross between durum wheat and wild barley); and winter common wheat (*Triticum aestivum L. subsp. aestivum* (bread wheat), variety *Akteur*). The extracted protein components of the cultivars were separated using gel electrophoresis and were investigated using immunoblots to test their reactivity to wheat-specific IgE in serum. To perform the immunoblot, a pool serum was used from six wheat-sensitised children (1 to 11 years of age), in which wheat-specific IgE had been detected. As a control, IgE pool sera that tested negative for wheat-specific IgE from five children (3 to 13 years of age) with an atopic condition and from six children without an atopic condition (3 months to 5 years of age) were used in the study.

In terms of the separated protein bands from albumins and globulins, there was a high level of similarity between the varieties, with the exception of einkorn wheat. The IgE detection pattern in the immunoblot was also characterised by a high degree of similarity between the cultivars, again with the exception of einkorn wheat. Overall, all cultivars of the tested varieties were positive in the immunoblot and exhibited IgE binding to a large set of protein bands. The protein banding patterns achieved with gel electrophoresis for the α-/β-, γ- and ω-gliadins differed between the varieties, as they also did for the glutenins and residual proteins. Spelt and common wheat also differed in terms of their binding patterns. Here too, however, all cultivars were positive in the immunoblot and exhibited IgE binding to a large set of protein bands, despite the individual protein patterns.

The authors also used an identical method to investigate other cultivars of einkorn wheat, emmer wheat, common wheat, spelt, oat and rye, only in terms of the water- and salt-soluble protein components albumins and globulins. In this further analysis, the protein samples were also very similar between common/bread wheat (variety *Akteur*, *Graziro* and *Goldblume*) and spelt (variety *Bauländer Spelz*, *Schwabenkorn*, *Oberkulmer Rotkorn*), and very few differences were discovered in the IgE binding pattern. In terms of the IgE binding pattern, rye and oat differed to wheat and spelt, but also exhibited positive signals for wheat-specific IgE. It should be noted, however, that this study only used sera with wheat-specific IgE from children (n = 6).

A study conducted by Baar et al. (2012) screened a wheat seed cDNA expression library with pooled sera from patients for whom a wheat allergy had been confirmed. A low-molecular-weight glutenin subunit (LMW-GS) Glu-B3 (allergen name: Tri a 36) was identified as an IgE-

reactive cDNA *clone*. Recombinant Tri a 36 was expressed in *Escherichia coli* and then isolated as a soluble protein. A RAST-based dot blot assay was then used to test IgE reactivity to Tri a 36 (for this, pooled sera from 26 confirmed wheat allergy sufferers were utilised). Tri a 36 reacted with IgE from sera from roughly 80 percent of the wheat allergy sufferers. An amino acid sequence comparison of homologous proteins in other cereal species revealed a sequence identity of 76 percent for LMW-GS in rye, 64 percent for B-hordein in barley, 48 percent for avenin in oat, 46 percent for γ-gliadin in spelt and 40 percent for supposed prolamin in rice. The study demonstrated that IgE from sera from wheat allergy sufferers exhibited cross-reactions with protein fractions from wheat, rye, barley, oat, spelt and rice.

An experimental study conducted by Pahr et al. (2012) established a cDNA library from wheat (*Triticum aestivum*), and compared this with serum IgE antibodies from patients with wheat-induced inhalation allergies and food allergies. The aim here was to identify new wheat allergens. The recombinant proteins were produced using *E. coli* bacteria. The IgE reactivity of the five wheat allergens identified using mass spectrometry methods (1-Cys-peroxiredoxin, thioredoxin-h-isoform, glutathion transferase, profilin and dehydrin) was analysed in RAST-based dot blot experiments and using ELISA with patient IgE sera. The study findings demonstrated cross-reactions from the IgE targeting the five wheat allergens to proteins of other cereal species. Accordingly, the allergen 1-Cys-peroxiredoxin (Tri a 32) exhibited IgE cross-reactivity with seed proteins from barley, rye, rice, maize, soy, oat and spelt. An IgE-mediated cross-reactivity relating to the wheat allergen thioredoxin h (Tri a 25) was also demonstrated in the study for rice, maize, sunflower and spelt (Pahr et al., 2012).

Furthermore, cross-reactions were also demonstrated for dehydrin (Tri a 35) in rice, maize, soy, oat, rye and spelt, and for glutathione transferase in oat and spelt (Pahr et al., 2012). In the case of wheat profilin (Tri a 12), which has been detected by means of specific IgE antibodies in patients with baker's asthma, wheat-induced food allergies and in patients with grass pollen (hay fever) allergies (Constantin et al., 2009), no cross-reactivity with spelt was found, but was indeed discovered in the case of maize, rice, oat and rye.

For the allergenic wheat protein α-purothionin (Tri a 37), cross-reactions to homologous proteins in rye and barley were also identified, but not in the case of oat, soy, rice and spelt (Pahr et al., 2014).

An older study dating from 2001 (Klockenbring et al., 2001) investigated the binding of IgA, IgE, IgG1 and IgG4 to water- and salt-soluble albumins and globulins from five samples of the *Triticum* (wheat) genus, using ELISA and immunoblot assays. The samples investigated were taken from winter wheat (variety *Astron*), two wheat-spelt hybrids (*Franckenkorn* and *Hubel*) and two spelt cultivars (*Bauländer Spelz* and *Oberkulmer Rotkorn*). The following discussion focuses only on the IgE results, since an IgE test is recommended in particular as an antibody test for diagnosing a food allergy, with experts advising against an IgG assay (Kleine-Tebbe et al., 2009; Worm and Reese, 2016).

Six sera from individuals with specific IgE against wheat flour and grass pollen (determined using RAST-analysis, age and sex not specified) were pooled. Pooled sera from six non-responders were therefore also used as a control in this study. To distinguish between conformational (discontinuous) and continuous (linear) epitopes, the ELISA analysis was conducted with native and denatured protein samples. While the degree of IgE binding to native proteins was roughly the same in all five cultivars (only slightly less in the case of *Hubel*), IgE binding in

the case of the denatured proteins was, in contrast, less strong and more varied with the various cultivars, except for common wheat, where IgE binding strength remained roughly at the same level. On the other hand, the immunoblot with specific IgE, also conducted under denatured conditions, exhibited a relatively similar binding pattern between all cultivars. In this study, however, only five cultivars were investigated, together with only six sera from individuals with wheat-specific IgE, whose age and sex were not specified.

3.3.3 Studies on the prevalence of allergenic proteins in spelt and wheat

Ribeiro et al. (2016) investigated the gliadin concentrations and distribution of individual gliadin fractions (ω5, ω1,2, α/β and γ) in bread wheat (*Triticum aestivum* L. subsp. *aestivum*), spelt (*Triticum aestivum* L. subsp. *spelta*) and durum wheat (*Triticum turgidum* subsp. *durum*) (Ribeiro et al., 2016). While gliadins were detected in all wheat species analysed, the specific concentrations varied from one species to another.

This finding has also been confirmed by the results of a more recent investigation (Geisslitz et al., 2019). Concentrations of gluten proteins (gliadins and glutenins) in spelt, durum wheat, emmer wheat and einkorn wheat were analysed in over 300 samples, which included 15 varieties each of common wheat (*Triticum aestivum* L.), spelt, durum wheat, emmer wheat and einkorn wheat, all grown in the same year at four sites in Germany. Total protein concentrations were influenced both by the site location and the wheat species. At all four sites, einkorn wheat, emmer wheat and spelt exhibited higher concentrations of protein and glutens than common wheat. The gliadin proportion of gluten was higher in spelt than in common wheat, while the glutenin concentration was roughly the same in both cases.

A quantitative mass spectrometry analysis of amylase trypsin inhibitor (ATI) concentrations showed that the spelt and emmer wheat cultivars investigated exhibited higher concentrations of ATI than the durum and common wheat cultivars (Geisslitz et al., 2018).

3.3.4 Proteomics study

A study conducted by Afzal et al. (2020) had the aim of analysing potential differences in the proteome of spelt and bread wheat using mass spectrometry (nano LC-ESI-MS/MS), comparing proteome variation between and within these subspecies, and characterising potential environmental influences on protein expression. To this end, 15 representative varieties from current spelt and bread wheat production in Germany were used, which had been cultivated at three separate test sites. Roughly two thirds of the proteins detected were expressed both in spelt and bread wheat (Afzal et al., 2020).

3.4 Questions

Question 1: Has it been scientifically proven that commercially available spelt has the same level of allergenicity as commercially available wheat - or is a distinction between spelt and wheat to be tolerated or even necessary in terms of food labelling?

Overall, the studies looking at wheat-specific IgE show that individuals with a sensitisation to wheat exhibit an IgE response to both common wheat proteins and spelt proteins (Baar et al., 2012; Klockenbring et al., 2001; Pahr et al., 2012; Pahr et al., 2013; Sievers et al., 2020). When comparing spelt and common wheat, the IgE binding patterns on the separated protein

fractions of the albumin/globulin fraction were very similar (Sievers et al., 2020). Accordingly, one may assume that spelt contains allergens similar to those of common wheat in terms of water- and salt-soluble albumins and globulins. However, differences were observed in the IgE binding pattern for gliadins and glutenins (Sievers et al., 2020). This means that, in terms of this protein fraction, spelt and common wheat can presumably also express different allergens, to which individuals may also respond (react) differently. However, these data cannot be used to conclude that spelt exhibits a lower allergenic potential. Furthermore, a monosensitisation to individual wheat proteins is less common in the case of an IgE-mediated wheat allergy (Sander et al., 2011; Sievers et al., 2016). While detection of wheat-specific IgE does provide evidence of sensitisation, this does not necessarily correlate to a clinical response in the individual. On the other hand, IgEs are a precondition for the development of allergic symptoms (Sievers et al., 2016; Sievers et al., 2020).

Data are unclear as regards the effect on allergenicity resulting from the processing of the cereal, the site location and cultivation conditions, together with differences in protein expression between individual cultivars within a subspecies (Geisslitz et al., 2020; Geisslitz et al., 2019; Sievers et al., 2020; Verhoeckx et al., 2015).

The allergenic potential of any one food can be graded in terms of the severity of the allergic reactions triggered, the threshold value for triggering an allergic reaction and the allergy's frequency of occurrence (Richter et al., 2008). Since there has been a lack of systematic investigations to date in the form of double-blind, placebo-controlled oral food provocation tests, the allergenic potential of spelt cannot be reliably estimated. To date, the BfR is aware of only one case study, and furthermore one only published as a conference article abstract (German Allergy Congress, Dresden, 27 to 29 September 2018)[8], which has demonstrated spelt tolerance in a child suffering from a wheat allergy. Evidence for this tolerance was secured by means of an open food provocation test using spelt under medical supervision. The authors also note, however, that experience shows the likelihood of a cross-reaction with spelt to be very high in the case of wheat allergy sufferers.

The rationale for this cross-reactivity is based on the close phylogenetic relationship between the two wheat subspecies (spelt and other common wheat subspecies).

Accordingly, no meaningful clinical data are yet available that would effectively substantiate any claim for a lower allergenic potential for spelt compared with other common wheat subspecies.

Since commercially available spelt can therefore exhibit a level of allergenicity similar to that of commercially available wheat, the BfR recommends including a clear indication that spelt is a type of wheat as part of applicable allergy labelling.

Question 2: If it is scientifically proven that commercially available spelt has the same level of allergenicity as commercially available wheat, are consumers aware of this

[8] https://link.springer.com/article/10.1007/s15007-018-1693-9, accessed on 12 November 2020

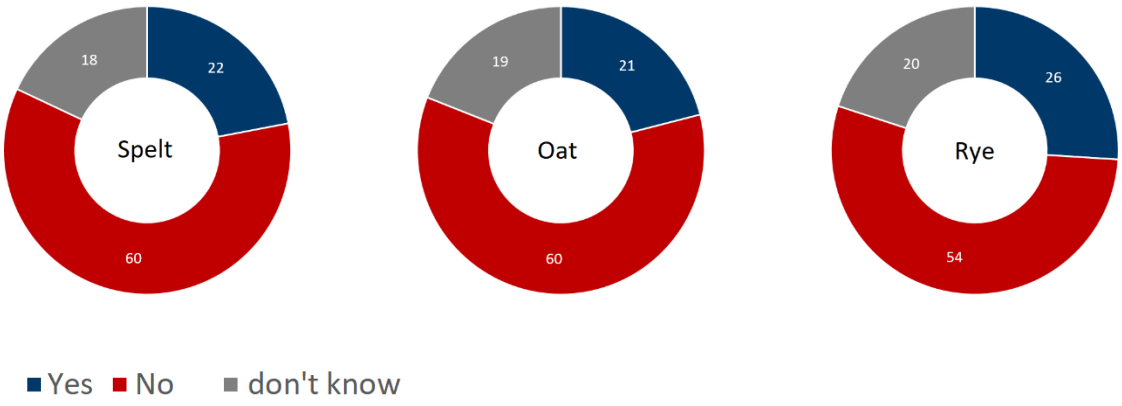
fact? From a scientific perspective, are those individuals who suffer from allergic reactions to wheat protein the only group whose level of knowledge needs to be assessed?

A representative survey of the population was commissioned in order to answer questions relating to the level of knowledge and perception on the part of consumers in relation to spelt. The survey was conducted from 11 to 12 November 2020, and included 1,014 individuals aged 14 and over in private households in the Federal Republic of Germany. The survey was embedded into a phone-based multi-topic survey (CATI omnibus survey) and conducted by a market research company. To recruit participants, a dual-frame approach was used, which involved taking a random sample of landline and mobile phone numbers, also including telephone numbers not listed in telephone directories (in line with Working Group of German Market Research Institutes (ADM) guidelines). To ensure survey data were representative, data were weighted according to gender, education, age, employment status, town/city size and German federal state ('Land').

To obtain answers to the above question 2, survey participants were asked to respond as follows: "Do you think that people who are allergic to commercially available wheat products would always be allergic to the following types of cereals as well?" Alongside spelt, rye and oat were also offered as other types of cereals.

While common wheat (*Triticum aestivum* L. subsp. *aestivum*) and spelt (*Triticum aestivum L.* subsp. *spelta*) are closely related and therefore could exhibit similar levels of allergenicity, only 22 percent of consumers surveyed stated that they thought individuals who are allergic to commercially available wheat would always be allergic to spelt as well. A similar percentage of responses was also found for rye (26%) and oat (21%), however (figure 1).

Figure 1 - responses to the question "Do you think that people who are allergic to commercially available wheat products would always be allergic to the following types of cereals as well?"



Basis: 1,014 respondents, responses as percentage

Of those respondents stating that spelt is a member of the wheat family (*n* = 521; see question 3), only roughly a third (32%) stated that spelt would have the same level of allergenicity as commercially available wheat. In contrast, more than half of respondents (60%) answered the

question as to whether individuals who are allergic to commercially available wheat would be allergic to spelt in the negative: 18 percent left the question unanswered or specified 'Don't know'. This means that a majority of consumers are unaware that commercially available spelt could have the same level of allergenicity as commercially available wheat.

It can be assumed that individuals diagnosed as wheat allergy sufferers and individuals diagnosed as coeliac patients have been generally informed by their attending doctor - and most likely also by means of their own research (conducted with the corresponding professional organisations[9, 10]) - that they should avoid spelt as an allergenic and gluten-rich cereal, independently of any specific knowledge on their part that spelt is indeed a member of the wheat family. The survey in question did not distinguish between those individuals who are allergic to wheat protein and those who are not allergic to wheat protein. Accordingly, the survey cannot be used to derive statements about the knowledge held specifically by allergy sufferers.

Since some online media sources have reported that spelt could offer an alternative to wheat for wheat allergy sufferers [11,12,13,14], some wheat allergy sufferers could potentially resort to spelt products without having had a personal tolerance confirmed by a medical practitioner, and therefore could expose themselves to the risk of an allergic reaction, which could - depending on individual circumstances - have serious consequences.

Alongside wheat allergy and coeliac disease, wheat sensitivity (non-coeliac gluten sensitivity (NCGS) or non-coeliac wheat sensitivity) is now frequently cited as another clinical syndrome in this context (Reese et al., 2018). The pathological mechanism is unclear, however, and there is a lack of meaningful diagnostic parameters. There has been heated debate for many years now as to whether this is a separate, discrete condition and also regarding the constituent in wheat that is the relevant trigger. Among other things, undiagnosed coeliac disease is also postulated as the cause of these symptoms (Reese et al., 2018).

An analysis of serum samples from participants in a study on the health of children and adolescents in Germany (KiGGS), which was conducted by the RKI from 2003 to 2006, has shown that coeliac disease is likely to be severely underdiagnosed in Germany (Laass et al., 2015). The data expand the pool of nine children with confirmed coeliac disease by a potential 97 new cases. Accordingly, the prevalence of coeliac disease in children and adolescents in Germany is comparable with the prevalence in the general population in other European countries and North America of roughly 1 percent. It can be assumed that individuals with undiagnosed coeliac disease, who wish to avoid wheat on account of symptoms arising from a presumed wheat sensitivity, are not aware of the fact that they should also avoid spelt products. From the perspective of health benefits, it would be useful for these individuals, until a final diagnosis has been made, if spelt were clearly identified as a type of wheat. As a general point,

[9] https://www.daab.de/ernaehrung/nahrungsmittel-allergien/ausloeser/uebersicht/weizen/, accessed on 17 November 2020

[10] https://www.dzg-online.de/glutenfrei-leben---diaet.213.0.html, accessed on 17 November 2020

[11] http://www.ernaehrung.de/tipps/nahrungsmittelallergien/allergie16.php, accessed on 17 November 2020

[12] https://praxistipps.chip.de/dinkel-unvertraeglichkeit-was-sie-darueber-wissen-sollten_114354, accessed on 17 November 2020

[13] https://www.dinkelbäck-mobil.de/dinkel/19-weizenallergie, accessed on 17 November 2020

[14] https://www.proplanta.de/agrar-nachrichten/verbraucher/welche-mehlsorten-sind-besonders-gesund_article1466425212.html, accessed on 17 November 2020

individuals who suspect that they suffer from wheat sensitivity should have a differential diagnosis performed to clarify the matter. Without a medically confirmed diagnosis, voluntary avoidance of gluten (except in the case of unconfirmed coeliac disease) does not automatically equate to a healthy diet (Reese et al., 2018; DGE, 2018).

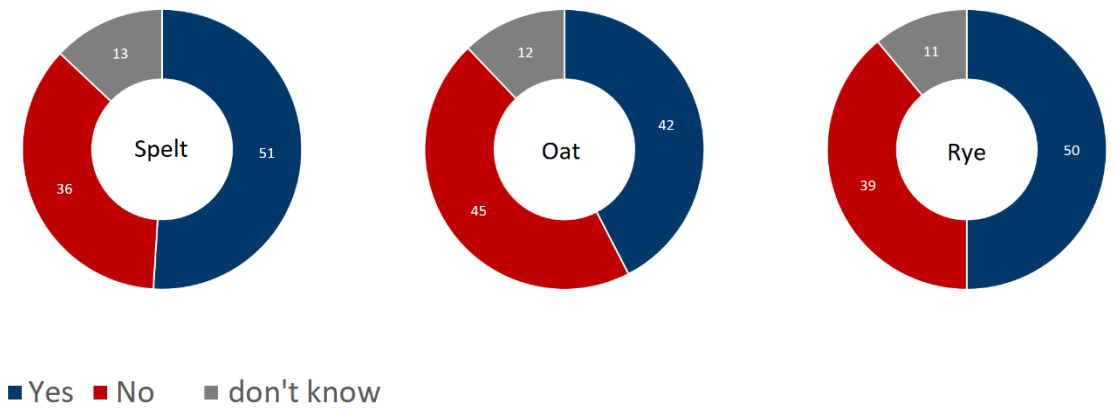
From a scientific perspective, the level of knowledge needs to be assessed for a wider group of individuals than those who explicitly suffer from allergic reactions to wheat protein. This is because individuals with undiagnosed coeliac disease, wishing to avoid wheat on account of a suspected wheat sensitivity, would benefit from the knowledge that spelt is a type of wheat.

For reasons of transparency, consumers who may wish to avoid wheat products for other reasons should also be informed that spelt is a member of the wheat family.

Question 3: Are consumers aware that spelt is a member of the wheat family?

The representative survey shows that only roughly half of all consumers surveyed assumed that spelt is a wheat family cereal. However, this result was then also repeated for rye (50%) and, to a lesser degree, for oat (42%). Of those surveyed, 36 percent stated that spelt is not a wheat species. For all cereals, slightly more than 10 percent of respondents replied with 'Don't know' or gave no answer in each case (figure 2).

Figure 2: Response to the question "Do you think that the following cereals are members of the wheat cereal family?"



Basis: 1,014 respondents, responses as percentage

These findings lead one to conclude that there is a low level of public knowledge in Germany in relation to the genetic classification of cereals. While half of respondents correctly stated that spelt is a member of the wheat family, this statistic should be seen in the context of the fact that many respondents also said the same about rye and oat, which are not members of this genus.

3.5 Other aspects

Alongside health protection, a further aim of food labelling is to guard against misinformation and therefore achieve greater clarity for the labels provided on food packaging.
The representative phone survey conducted by the BfR has shown that only roughly half of all consumers surveyed assumed that spelt is a member of the wheat family. In light of this fact, a clear formulation in labelling, stating that spelt is a wheat cereal, is also advisable for consumers for reasons of transparency, since these individuals may wish to avoid wheat products for many different reasons.

The BfR believes there are good arguments for considering terms such as 'spelt wheat flour' as being likely to result in confusion among consumers, as consumer surveys on the portal 'lebensmittelklarheit.de' have indeed already shown.[15,16,17] In this case, consumers tended to assume that 'spelt wheat flour' probably refers to mixtures of spelt flour and wheat flour, with 'wheat' also being overlooked as part of the term.

Accordingly, the BfR recommends following the recommendation of the Working Group of Food Chemistry Appraisers for the Länder and the Federal Office of Consumer Protection and Food Safety (ALS), which proposed the following two sets of wording in a statement on the clarification and improved intelligibility of spelt labelling adopted in their 113th session (2019): 'spelt flour (type of wheat)' or 'spelt flour (spelt wheat)' (ALS, 2019).
The BfR considers the first new wording proposed by the ALS - 'spelt flour (type of wheat)' - as likely to be better understood by consumers, with the term 'spelt flour' possibly being replaced by the more general term 'spelt'. Accordingly, the recommendation would therefore be 'spelt (type of wheat)' or 'spelt flour (type of wheat)'.
In the opinion of the BfR, the second wording proposed by the ALS - 'spelt flour (spelt wheat)' - is less suitable for the purposes of improving intelligibility, since it cannot be assumed that consumers are actually aware of what 'spelt wheat' is referring to.

The BfR also considers a clear statement that spelt is a wheat to be crucial for spelt labelling because adults may experience severe anaphylactic reactions with respiratory and/or cardiovascular symptoms as a result of consuming products containing wheat cereals (Dölle et al., 2012).

Further information on the topic of allergies is available from the BfR website:

Overview page on the topic of allergies:
https://www.bfr.bund.de/en/a-z_index/allergies-129835.html

[15] https://www.lebensmittelklarheit.de/produkte/allergenkennzeichnung-wie-weizen-dinkel-oder-dinkelweizen-bei-lebensmitteln-mit-dinkel, accessed on 16 November 2020

[16] https://www.lebensmittelklarheit.de/forum/kennzeichnung-dinkel-weizen, accessed on 16 November 2020

[17] https://www.lebensmittelklarheit.de/forum/weizenmehl-dinkelmehl, accessed on 16 November 2020

4 References

Afzal M, Pfannstiel J, Zimmermann J, Bischoff SC, Würschum T, Longin CFH (2020). High-resolution proteomics reveals differences in the proteome of spelt and bread wheat flour representing targets for research on wheat sensitivities. Sci Rep. 10: 14677.

ALS (2019). Arbeitskreis Lebensmittelchemischer Sachverständiger der Länder und des Bundesamtes für Verbraucherschutz und Lebensmittelsicherheit (ALS). 113. ALS-Sitzung. Journal of Consumer Protection and Food Safety 14: 429-457.

Appels R, Eversole K, Stein N, Feuillet C, Keller B, Rogers J, Pozniak CJ, Choulet F, Distelfeld A, Poland J, Ronen G, Sharpe AG, Barad O, Baruch K, Keeble-Gagnère G, Mascher M, Ben-Zvi G, Josselin A-A, Himmelbach A, Balfourier F, Gutierrez-Gonzalez J, Hayden M, Koh C, Muehlbauer G, Pasam RK, Paux E, Rigault P, Tibbits J, Tiwari V, Spannagl M, Lang D, Gundlach H, Haberer G, Mayer KFX, Ormanbekova D, Prade V, Šimková H, Wicker T, Swarbreck D, Rimbert H, Felder M, Guilhot N, Kaithakottil G, Keilwagen J, Leroy P, Lux T, Twardziok S, Venturini L, Juhász A, Abrouk M, Fischer I, Uauy C, Borrill P, Ramirez-Gonzalez RH, Arnaud D, Chalabi S, Chalhoub B, Cory A, Datla R, Davey MW, Jacobs J, Robinson SJ, Steuernagel B, van Ex F, Wulff BBH, Benhamed M, Bendahmane A, Concia L, Latrasse D, Bartoš J, Bellec A, Berges H, Doležel J, Frenkel Z, Gill B, Korol A, Letellier T, Olsen O-A, Singh K, Valárik M, van der Vossen E, Vautrin S, Weining S, Fahima T, Glikson V, Raats D, Číhalíková J, Toegelová H, Vrána J, Sourdille P, Darrier B, Barabaschi D, Cattivelli L, Hernandez P, Galvez S, Budak H, Jones JDG, Witek K, Yu G, Small I, Melonek J, Zhou R, Belova T, Kanyuka K, King R, Nilsen K, Walkowiak S, Cuthbert R, Knox R, Wiebe K, Xiang D, Rohde A, Golds T, Čížková J, Akpinar BA, Biyiklioglu S, Gao L, N'Daiye A, Kubaláková M, Šafář J, Alfama F, Adam-Blondon A-F, Flores R, Guerche C, Loaec M, Quesneville H, Condie J, Ens J, Maclachlan R, Tan Y, Alberti A, Aury J-M, Barbe V, Couloux A, Cruaud C, Labadie K, Mangenot S, Wincker P, Kaur G, Luo M, Sehgal S, Chhuneja P, Gupta OP, Jindal S, Kaur P, Malik P, Sharma P, Yadav B, Singh NK, Khurana JP, Chaudhary C, Khurana P, Kumar V, Mahato A, Mathur S, Sevanthi A, Sharma N, Tomar RS, Holušová K, Plíhal O, Clark MD, Heavens D, Kettleborough G, Wright J, Balcárková B, Hu Y, Salina E, Ravin N, Skryabin K, Beletsky A, Kadnikov V, Mardanov A, Nesterov M, Rakitin A, Sergeeva E, Handa H, Kanamori H, Katagiri S, Kobayashi F, Nasuda S, Tanaka T, Wu J, Cattonaro F, Jiumeng M, Kugler K, Pfeifer M, Sandve S, Xun X, Zhan B, Batley J, Bayer PE, Edwards D, Hayashi S, Tulpová Z, Visendi P, Cui L, Du X, Feng K, Nie X, Tong W, Wang L (2018). Shifting the limits in wheat research and breeding using a fully annotated reference genome. Science 361: eaar7191.

Baar A, Pahr S, Constantin C, Scheiblhofer S, Thalhamer J, Giavi S, Papadopoulos N G, Ebner C, Mari A, Vrtala S and Valenta R (2012). Molecular and Immunological Characterization of Tri a 36, a Low Molecular Weight Glutenin, as a Novel Major Wheat Food Allergen. J Immunol 189: 3018-3025.

Battais F, Pineau F, Popineau Y, Aparicio C, Kanny G, Guerin L, Moneret-Vautrin DA, Denery-Papini S (2003). Food allergy to wheat: identification of immunogloglin E and immunoglobulin G-binding proteins with sequential extracts and purified proteins from wheat flour. Clin Exp Allergy 33: 962-970.

Burkhardt JG, Chapa-Rodriguez A, Bahna SL (2018). Gluten sensitivities and the allergist: Threshing the grain from the husks. Allergy 73: 1359-1368.

Catassi C, Alaedini A, Bojarski C, Bonaz B, Bouma G, Carroccio A, Castillejo G, De Magistris L, Dieterich W, Di Liberto D, Elli L, Fasano A, Hadjivassiliou M, Kurien M, Lionetti E, Mulder CJ, Rostami K, Sapone A, Scherf K, Schuppan D, Trott N, Volta U, Zevallos V, Zopf Y, Sanders DS (2017). The Overlapping Area of Non-Celiac Gluten Sensitivity (NCGS) and Wheat-Sensitive Irritable Bowel Syndrome (IBS): An Update. Nutrients 9: 1268.

Constantin C, Quirce S, Poorafshar M, Touraev A, Niggemann B, Mari A, Ebner C, Akerström H, Heberle-Bors E, Nystrand M, Valenta R (2009). Micro-arrayed wheat seed and grass pollen allergens for component-resolved diagnosis. Allergy 64: 1030-1037.

Czaja-Bulsa G, Bulsa M (2017). What Do We Know Now about IgE-Mediated Wheat Allergy in Children? Nutrients 9: 1268.

DGE (2018). Selbstdiagnose Unverträglichkeit. „frei von“-Lebensmittel nur bei bestimmten Lebensmittelunverträglichkeiten sinnvoll. Presseinformation: DGE aktuell, Presse 01/2018 vom 10.01.2018. https://www.dge.de/presse/pm/selbstdiagnose-unvertraeglichkeit/ Abgerufen am 16.11.2020

Dölle S, Hompes S, Grünhagen J, Worm M (2012). Nahrungsmittelassoziierte Anaphylaxie. Der Hautarzt 63: 294-298.

Dubcovsky J, Dvorak J (2007). Genome plasticity a key factor in the success of polyploid wheat under domestication. Science 316: 1862-1866.

Dubois B, Bertin P, Mingeot D (2016). Molecular diversity of α-gliadin expressed genes in genetically contrasted spelt (Triticum aestivum ssp. spelta) accessions and comparison with bread wheat (T. aestivum ssp. aestivum) and related diploid Triticum and Aegilops species. Mol Breed. 36: 152.

Geisslitz S, America AHP, Scherf KA (2020). Mass spectrometry of in-gel digests reveals differences in amino acid sequences of high-molecular-weight glutenin subunits in spelt and emmer compared to common wheat. Anal Bioanal Chem. 412: 1277-1289.

Geisslitz S, Longin CFH, Scherf KA, Koehler P (2019). Comparative Study on Gluten Protein Composition of Ancient (Einkorn, Emmer and Spelt) and Modern Wheat Species (Durum and Common Wheat). Foods 8: 409.

Geisslitz S, Ludwig C, Scherf KA, Koehler P (2018). Targeted LC-MS/MS Reveals Similar Contents of α-Amylase/Trypsin-Inhibitors as Putative Triggers of Nonceliac Gluten Sensitivity in All Wheat Species except Einkorn. J Agric Food Chem. 66: 12395-12403.

Gianfrani C, Camarca A, Mazzarella G, Di Stasio L, Giardullo N, Ferranti P, Picariello G, Rotondi Aufiero V, Picascia S, Troncone R, Pogna N, Auricchio S, Mamone G (2015). Extensive in vitro gastrointestinal digestion markedly reduces the immune-toxicity of Triticum monococcum wheat: implication for celiac disease. Mol Nutr Food Res. 59: 1844-1854.

Gianfrani C, Maglio M, Rotondi Aufiero V, Camarca A, Vocca I, Iaquinto G, Giardullo N, Pogna N, Troncone R, Auricchio S, Mazzarella G (2012). Immunogenicity of monococcum wheat in celiac patients. Am J Clin Nutr. 96: 1339-1345.

Iacomino G, Di Stasio L, Fierro O, Picariello G, Venezia A, Gazza L, Ferranti P, Mamone G (2016). Protective effects of ID331 Triticum monococcum gliadin on in vitro models of the intestinal epithelium. Food Chem. 212: 537-542.

Inomata N (2009). Wheat allergy. Curr Opin Allergy Clin Immunol. 9: 238-243.

Juhász A, Gell G, Békés F, Balázs E (2012). The epitopes in wheat proteins for defining toxic units relevant to human health. Funct Integr Genomics. 12: 585-598.

Kleine-Tebbe J, Reese I, Ballmer-Weber B, Beyer K, Erdmann S, Fuchs T, Henzgen M, Heratizadeh A, Huttegger I, Jäger L, Jappe U, Lepp U, Niggemann B, Raithel M, Saloga J, Szépfalusi Z, Zuberbier T, Werfel T, Vieths S, Worm M (2009). Keine Empfehlung für IgG- und IgG4-Bestimmungen gegen Nahrungsmittel. Allergo Journal 18: 267-268.

Klockenbring T, Boese A, Bauer R, Goerlich R (2001). Comparative Investigations of Wheat and Spelt Cultivars: IgA, IgE, IgG1 and IgG4 Binding Characteristics. Food and Agricultural Immunology 13: 171-181.

Laass MW, Schmitz R, Uhlig HH, Zimmer KP, Thamm M, Koletzko S (2015). Zöliakieprävalenz bei Kindern und Jugendlichen in Deutschland. Ärzteblatt 112: 553-60.

Ludvigsson JF, Leffler DA, Bai JC, Biagi F, Fasano A, Green PH, Hadjivassiliou M, Kaukinen K, Kelly CP, Leonard JN, Lundin KE, Murray JA, Sanders DS, Walker MM, Zingone F, Ciacci C (2013). The Oslo definitions for coeliac disease and related terms. Gut 62: 43-52.

Matsuo H, Yokooji T, Taogoshi T (2015). Common food allergens and their IgE-binding epitopes. Allergology International 64: 332-343.

Münzing KRK (2008). Qualität und Verarbeitungswert von heimischem Öko-Dinkelweizen. 314: 79-97. Verfügbar unter: https://www.openagrar.de/receive/import_mods_00004566. Abgerufen am 16.11.2020.

Pahr S, Constantin C, Mari A, Scheiblhofer S, Thalhamer J, Ebner C, Vrtala S, Mittermann I, Valenta R (2012). Molecular characterization of wheat allergens specifically recognized by patients suffering from wheat-induced respiratory allergy. Clin Exp Allergy. 42: 597-609.

Pahr S, Constantin C, Papadopoulos NG, Giavi S, Mäkelä M, Pelkonen A, Ebner C, Mari A, Scheiblhofer S, Thalhamer J, Kundi M, Vrtala S, Mittermann I, Valenta R (2013). alpha-Purothionin, a new wheat allergen associated with severe allergy. Journal of Allergy and Clinical Immunology 132: 1000-1003.e1004.

Pahr S, Selb R, Weber M, Focke-Tejkl M, Hofer G, Dordić A, Keller W, Papadopoulos NG, Giavi S, Mäkelä M, Pelkonen A, Niederberger V, Vrtala S, Valenta R (2014). Biochemical, biophysical and IgE-epitope characterization of the wheat food allergen, Tri a 37. PLoS One 9: e111483.

Prandi B, Tedeschi T, Folloni S, Galaverna G, Sforza S (2017). Peptides from gluten digestion: A comparison between old and modern wheat varieties. Food Res Int. 91: 92-102.

Radauer C (2017). Wegweiser durch den Allergendschungel: Allergendatenbanken, ihre Merkmale und Anwendungsgebiete. Karger Kompass Pneumologie 5: 138-148.

Reese I, Schäfer C, Kleine-Tebbe J, Ahrens B, Bachmann O, Ballmer-Weber B, Beyer K, Bischoff SC, Blümchen K, Dölle S, Enck P, Enninger A, Huttegger I, Lämmel S, Lange L, Lepp U, Mahler V, Mönnikes H, Ockenga J, Otto B, Schnadt S, Szepfalusi Z, Treudler R, Wassmann-Otto A, Zuberbier T, Werfel T, Worm M (2018b). Non-celiac gluten/wheat sensitivity (NCGS)-a currently undefined disorder without validated diagnostic criteria and of unknown prevalence: Position statement of the task force on food allergy of the German Society of Allergology and Clinical Immunology (DGAKI). Allergo J Int. 27: 147-151.

Ribeiro M, Rodriguez-Quijano M, Nunes FM, Carrillo JM, Branlard G, Igrejas G (2016). New insights into wheat toxicity: Breeding did not seem to contribute to a prevalence of potential celiac disease's immunostimulatory epitopes. Food Chem. 213: 8-18.

Richter K, Kramarz S, Niemann B, Grossklaus R, Lampen A (2008). Schwellenwerte zur Allergenkennzeichnung von Lebensmitteln. Tagungsband Herausgegeben vom Bundesinstitut für Risikobewertung (Tagungsband Herausgegeben vom Bundesinstitut für Risikobewertung). https://www.bfr.bund.de/cm/350/schwellenwerte_zur_allergenkennzeichnung_von_lebensmitteln_tagungsband.pdf Abgerufen am 16.11.2020.

Sander I, Rozynek P, Rihs HP, van Kampen V, Chew FT, Lee WS, Kotschy-Lang N, Merget R, Brüning T, Raulf-Heimsoth M (2011). Multiple wheat flour allergens and cross-reactive carbohydrate determinants bind IgE in baker's asthma. Allergy 66: 1208-1215.

Scherf K, Koehler P, Wieser H (2015). Gluten and Wheat Sensitivities - an Overview. Journal of Cereal Science 67: 2-11.

Sievers S, Rawel HM, Ringel KP, Niggemann B, Beyer K (2016). Wheat protein recognition pattern in tolerant and allergic children. Pediatr Allergy Immunol. 27: 147-155.

Sievers S, Rohrbach A, Beyer K (2020). Wheat-induced food allergy in childhood: ancient grains seem no way out. Eur J Nutr. 59: 2693-2707.

Steinmüller R (2017). Lebensmittelallergene - Teil 5: Weizen und verwandte Getreide als Krankheitsursache - botanische Grundlagen; Teil 6: Allergien und Intoleranzen auf Weizen und verwandte Getreide. Ernaehrungs Umschau 3: s9-e24.

Tordesillas L, Berin MC, Sampson HA (2017). Immunology of Food Allergy. Immunity 47: 32-50.

Valerii MC, Ricci C, Spisni E, Di Silvestro R, De Fazio L, Cavazza E, Lanzini A, Campieri M, Dalpiaz A, Pavan B, Volta U, Dinelli G (2015). Responses of peripheral blood mononucleated cells from non-celiac gluten sensitive patients to various cereal sources. Food Chem. 176: 167-174.

Vasil IK (2007). Molecular genetic improvement of cereals: transgenic wheat (Triticum aestivum L.). Plant Cell Rep. 26: 1133-1154.

Venter C, Arshad SH (2011). Epidemiology of food allergy. Pediatr Clin North Am. 58: 327-349, ix.

Verhoeckx KCM, Vissers YM, Baumert JL, Faludi R, Feys M, Flanagan S, Herouet-Guicheney C, Holzhauser T, Shimojo R, van der Bolt N, Wichers H, Kimber I (2015). Food processing and allergenicity. Food Chem Toxicol. 80: 223-240.

Worm M, Reese I (2016). Nahrungsmittelallergie - die neue Leitlinie. Haut 2: 87-92.

Worm M, Reese I, Ballmer-Weber B, Beyer K, Bischoff S, Claßen M, Fischer P, Fuchs T, Huttegger I, Jappe U, Klimek L, Koletzko B, Lange L, Lepp U, Mahler V, Nast A, Niggemann B, Rabe U, Raithel M, Saloga J, Schäfer C, Schnadt S, Schreiber J, Szépfalusi Z, Treudler R, Wagenmann M, Watzl B, Werfel T, Zuberbier T, Kleine-Tebbe J (2015). Leitlinie zum Management IgE-vermittelter Nahrungsmittelallergien. S2k-Leitlinie der Deutschen Gesellschaft für Allergologie und klinische Immunologie (DGAKI) in Zusammenarbeit mit dem Ärzteverband Deutscher Allergologen (AeDA), dem Berufsverband der Kinder- und Jugendärzte (BVKJ), dem Deutschen Allergie- und Asthmabund (DAAB), der Deutschen Dermatologischen Gesellschaft (DDG), der Deutschen Gesellschaft für Ernährung (DGE), der Deutschen Gesellschaft für Gastroenterologie, Verdauungs- und Stoffwechselkrankheiten (DGVS), der Deutschen Gesellschaft für Hals-Nasen-Ohren-Heilkunde, Kopf- und Hals-Chirurgie, der Deutschen Gesellschaft für Kinder- und Jugendmedizin (DGKJ), der Gesellschaft für Pädiatrische Allergologie und Umweltmedizin (GPA), der Deutschen Gesellschaft für Pneumologie und Beatmungsmedizin (DGP), der Gesellschaft für Pädiatrische Gastroenterologie und Ernährung (GPGE), der Deutschen Kontaktallergie-Gruppe (DKG), der Österreichischen Gesellschaft für Allergologie und Immunologie (ÖGAI), dem BerufsVerband Oecotrophologie e.V. (VDOE) und der Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften (AWMF). Allergo J Int. 24.

Zuidmeer L, Goldhahn K, Rona RJ, Gislason D, Madsen C, Summers C, Sodergren E, Dahlstrom J, Lindner T, Sigurdardottir ST, McBride D, Keil T (2008). The prevalence of plant food allergies: a systematic review. J Allergy Clin Immunol. 121: 1210-1218 e1214.

About the BfR

The German Federal Institute for Risk Assessment (BfR) is a scientifically independent institution within the portfolio of the German Federal Ministry of Food and Agriculture (BMEL). 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.

This text version is a translation of the original German text which is the only legally binding version.