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2024-25 HONEY TESTING

ANNUAL REPORT

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Intertek Food Services GmbH
Bremen, Germany

intertek.com/food/honey-solutions/

Contents

HONEY MARKET AND HONEYTRACE

In 2024, the honey market once again experienced significant turbulence – whether due to new regulatory requirements or high-profile media campaigns that sparked uncertainty and debate.

EU Breakfast Directives

In May 2024, the European Union published the so-called Breakfast Directive (EU) 2024/1438 amending, amongst others, Directive 2001/110/EC relating to honey and, as expected, significantly tightened the labelling requirements for honey regarding its geographical origins. As previously known, all countries that make up a blend must be listed in descending order in the future. In addition, it is now required that at least the four main origins be specified with their respective percentage shares, with a tolerance of ± 5%. This percentage value is to be understood as "relative", meaning that for example, a share of 20% allows for a range from 19% to 21%. Such precise requirements, however, cannot be determined analytically in any reliable way. The EU Breakfast Directive has to be transposed into national laws by 14th December 2025 and these shall then apply from 14th June 2026. Furthermore, the legal act may later be adjusted or amended through delegated acts, (without changing the essential elements of the law), or supplemented through implementing acts regarding the requirements for analytical methods to be applied to verify whether honey is compliant with this directive.

EU Honey Platform

For this purpose, an expert panel called "Honey Platform" was established, in which Intertek is also involved. The Honey Platform met for the first time in November 2024 and is intended, among other things, to discuss and gather data for methods to improve authenticity controls of honey. It is worth mentioning that the European Joint Research Centre had already launched the "HarmHoney" project the previous year, following the "From the Hives" campaign, to harmonise analytical methods for honey authenticity testing. Here, too, Intertek is actively contributing with its experts.

HoneyTrace

Another discussion point of the Honey Platform will be to provide recommendations for a European Union traceability system. As previously mentioned, the required conditions for origin labelling cannot be verified in the laboratory. To address this, in 2024 Intertek launched "HoneyTrace", a traceability system specifically designed for the international honey trade. The principle is based on blockchain technology, where relevant data, such as honey batch quantities and laboratory test reports, are recorded. This ensures full transparency of the entire supply chain of a honey blend, provided that all involved parties, from the beekeeper to the packer, contribute data to the system. With HoneyTrace, the requirements for country labelling can be met, but the system also serves as an additional tool for detecting honey adulteration. For example, if artificial sugar syrups are added, the mass balances of a batch no longer match, triggering an alert.

DNA metagenomic analysis

In Autumn 2024, a media campaign was launched in which honey samples were subjected to DNA metagenomic analysis by a laboratory in Estonia, with the majority of the tested samples being classified as "non-authentic" or "adulterated". The message conveyed was that established analytical methods, such as ^{1}H-NMR, $^{13}C/^{12}C$-EA/LC-IRMS, and LC-HRMS, according to the Estonian laboratory, are unable to detect certain foreign sugar additives in honey, but this can supposedly be achieved using the DNA method.

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However, due to the lack of transparency and the relatively limited scope of the underlying database, which clearly does not account for many origins, as well as numerous other technical questions that the laboratory has either not answered or only inadequately addressed, doubts have been raised regarding the plausibility of the results.

Nevertheless, the fundamental approach of detecting species present in honey through DNA sequences and making inferences about origins and adulteration is intriguing. As a result, our laboratory in Bremen is in close contact with an Intertek laboratory in Manchester (UK), which specialises in this technique. A collaboration is now underway to explore how DNA analytics can provide added value.

The present annual report contains evaluations of our test results for honey samples regarding authenticity, residues and contaminants.

All data was generated at Intertek Food Services in Bremen using the latest analysis techniques. All data are for internal use only. The submitted data are not imperatively representative for the respective countries as they are based on customers' samples (not randomly selected) and customer declaration of the country of origin (origin not verified). All information has been established according to the best of our knowledge. However, correctness and validity of the data are not guaranteed.

We thank all customers and partners for their trust and cooperation with us.

Your Intertek Food Services Team in Bremen

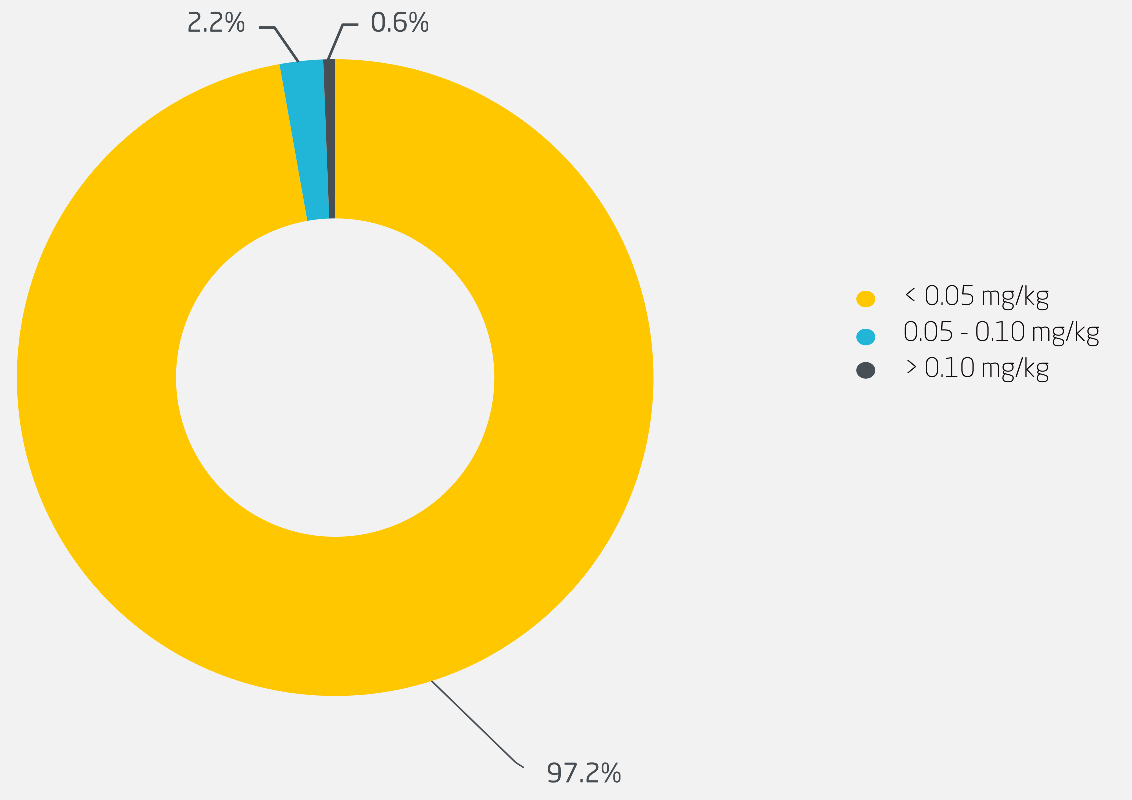
1. ELEMENTAL ANALYSIS

In the European Union, only a few legal limits are established for toxic heavy metals in honey. Legal limits have been established only for lead (Regulation (EU) 2023/915) and for mercury (Regulation (EC) No 396/2005). For lead, it is 0.1 mg/kg and for mercury, it is 0.01 mg/kg.

The honey samples which have been analysed during the relevant period show that arsenic, chromium, nickel, and mercury were not observed in toxicologically significant amounts.

Compared to 2023, the total number of honey samples tested for lead slightly decreased but the percentage of results higher than 0.05 mg/kg has doubled. As the last years, samples from India as the country of origin showed the highest number of lead findings in honey. But in 2024, samples from Vietnam as the country of origin showed also a significant number of results higher than 0.05 mg/kg.

Figure E-1. Lead testing of 3,930 honey samples in 2024.



2. AUTHENTICITY

2.1 Introduction

In the field of honey authenticity, we are dealing with many different origins and varieties. For some rare honeys, the general evaluation criteria do not always apply. Intertek has been working with honey for decades and has obtained a lot of experience in even rare varieties. This also includes a very large number of data sets from different analytical methods and years that can be evaluated retrospectively. Geographical and botanical origins play an important role in these statistical evaluations. This enables us to subsequently establish special rules for certain origins and varieties. We therefore strongly recommend always providing this information when placing the order.

We have summarised all varieties and origins for which there are currently exceptions to the stable isotope analysis in Table AU-1.

Table AU-1. List of origins with specific IRMS assessment.

Botanical origin
Alfalfa
Aloe
Balsamie *(Impatiens)*
Borage
Bracatinga honeydew
Citrus spp.
Lavender
Leatherwood
Manuka
Menzies banksia
Pine
Red gum
Rhododendron
Robinia/false acacia
Sorghum honeydew

Geographical Origin

The country from which the sample is sent is not always identical with the country of origin of honey. Please note that we can therefore only apply special criteria if the botanical and/or geographical origins are explicitly stated in the sample name, in order forms or directly on the sample container.

Over the years, we also recorded a large number of data sets with NMR area that can be filtered according to their botanical and geographical origins and reviewed in context. Intertek has been able to derive exceptions and special evaluations from this data and will continue to do so in future. Due to the diversity of the honey market, these cases will continue to appear and based on our many years of experience in NMR profiling, Intertek Bremen's NMR experts are also able to identify and evaluate uncommon honeys.

In 2024, all samples for NMR profiling were processed with version 3.1.3. As soon as Bruker announces an update, our customers will be informed by email. The Bruker report serves as the basis of our evaluation and is always attached to the Intertek analysis report, but only the latter represents our final assessment of authenticity.

As already described, not all geographical and botanical origins are covered by the Bruker database and therefore, our expert assessment is mandatory to avoid false-positive and -negative results. For those wanting to perform the assessment on its own, we also offer NMR profiling without expert assessment. For samples pre-destined as baker's honey, we offer an assessment neglecting the quality parameters HMF and ethanol.

In the following section, we present the honey authenticity testing results for 2024. Only the countries that contributed more than 1% of the total number of samples are considered in the evaluation. Results for Germany, France, Poland, Belgium, Netherlands, Spain, Italy, UK, Canada, Australia, and USA are likely influenced by imported honeys and therefore, have been excluded for most of the evaluations. Please note that low shares are highly influenced by the main contributors and could be statistically not significant for the respective country.

2.2 $^{13}C/^{12}C$-EA-IRMS (Isotope ratio analysis, detection of C_4 sugar)

In 2024, we tested approximately 1,300 honey samples with the AOAC 998.12 method. In combination with LC-IRMS, we evaluated a total of nearly 22,000 samples by EA-IRMS. Across all countries, 2.0% of total samples were found to contain added foreign sugars according to AOAC 998.12. 40% of the samples received had no stated origin or came from the above-mentioned countries that are not considered in the evaluation. Regarding the main countries of origin, the proportion of positive samples from India is higher than the average (Table AU-2).

Table AU-2. Evaluation of AOAC 998.12 results for honey samples tested in 2024 by country.

Country	Share 2024 (%)	Positive Rate (%)
Average AOAC 998.12	100.0	2.0
Argentina	21.3	**0.7**
Hungary	7.2	**1.1**
Brazil	6.0	1.3
Mexico	5.3	0.0
Vietnam	5.0	0.0
Ukraine	4.6	1.7
Uruguay	4.0	0.0
India	2.3	3.3
China	1.2	0.0
Cuba	1.2	0.0

2.3 $^{13}C/^{12}C$-EA/LC-IRMS (Isotope ratio analysis coupled with LC detection of C_3 /C_4 sugars)

In 2024, approximately 20,400 honey samples were examined for addition of foreign $C_3$and C_4 sugars using the combination of EA and LC-IRMS. 12.1% of all honey samples were found to have added foreign sugars. The largest proportion of samples were sent from India (20.0%), while 29% of all honeys were received without origin or came from Germany, France, Poland, Belgium, Netherlands, Spain, Italy, UK, Canada, Australia or USA.

In 2024, Argentina, India, Mexico and Turkey had a higher-than-average percentage of adulterated samples (Table AU-3). Please note that the results for Argentina and Mexico were still influenced by levels of C_4 plant-based authentic sorghum honeydew honey. Due to the expanding aphid population, we have expanded the sorghum evaluation to include honeys from all over Central and South America starting from December 16th, 2024. The positive testing results could be neglected in 2024 by a negative NMR profiling or LC-HRMS result. Our recommendation for these origins would still be to perform NMR profiling and/or LC-HRMS in combination with EA-IRMS, as no false positive results have yet been observed by using this combination.

Please note that all shares are highly influenced by the main contributors and are not statistically representative for the country of origin.

Table AU-3. Evaluation of combined EA/LC-IRMS results in honey samples tested in 2024 by country.

Country	Share 2024 (%)	Positive Rate (%)
Average C_3/C_4 sugar	100.0	12.1
India	20.0	25.0
China	11.6	1.6
Argentina	8.6	30.0*
Brazil	7.1	6.2
Ukraine	5.5	0.7
Bulgaria	3.5	2.4
Mexico	3.3	13.3*
Hungary	2.7	5.6
Vietnam	2.6	3.9
Turkey	1.2	12.6
Romania	1.2	5.6

* Several samples from Mexico and Argentina had a false positive result due to a share of authentic honeydew honey from Sorghum.

2.4 LC-ELSD (honey-foreign oligosaccharides & psicose)

The LC-ELSD method is focused on honey-foreign maltooligosaccharides (hf-os) and is used for detecting starch-based sugar syrups like corn, rice, or wheat in honey. In total, approximately 1,200 honey samples were tested in the observation period. Of all samples, approximately 7.3% were found to be adulterated on average. The largest number of samples was sent from India like the previous years, while 31% of honeys were received without origin or came from Germany, France, Poland, Belgium, Netherlands, Spain, Italy, UK, Canada, Australia or USA.

Only the shares of adulterated samples for India were higher than the mean (Table AU-4). In all other countries, adulterated samples were either absent or very low in abundance.

Table AU-4. Evaluation of LC-ELSD results in honey samples tested in 2024 by country.

Country	Share 2024 (%)	Positive Rate (%)
Average hf - os	100.0	7.3
India	32.8	13.8
China	8.8	0.5
Hungary	7.2	0.0
Ukraine	7.1	0.0
Romania	3.4	10.8
Mexico	2.2	0.0
Bulgaria	1.8	0.0
Vietman	1.5	0.0
Argentina	1.1	0.0

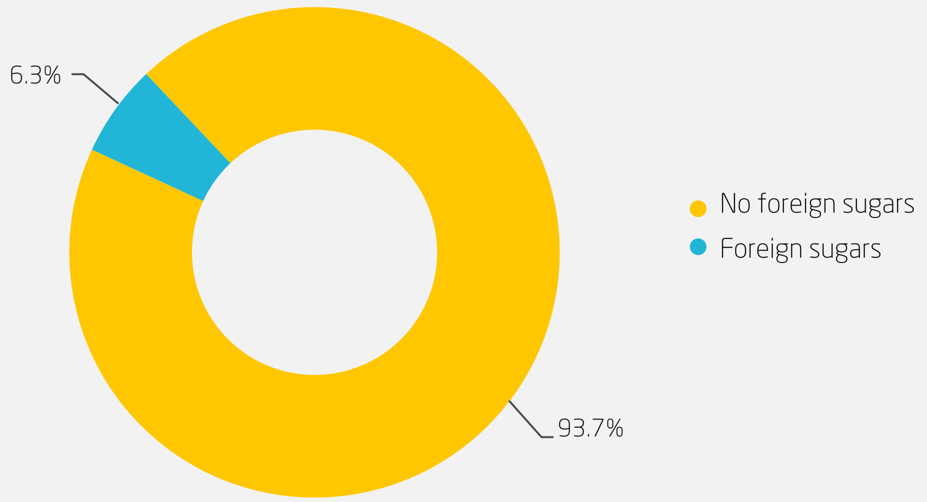
The sugar psicose is known as a marker for honey adulteration with high fructose corn syrup (HFCS).

Approximately 19.2% of 125 samples tested for psicose in 2024 were found to have added foreign sugars. The largest shares of samples have been sent from China and Bulgaria. For China, we determined a falsification rate of 8.8% and for Bulgaria 0%. 46.4% have an unknow origin or were received from the countries mentioned above. In comparison to all other authenticity methods, the number of psicose tests was quite low, therefore, we have not published an overview by country for 2024.

2.5 NMR Honey Profiling

In 2024, approximately 7,800 honey samples were analysed via NMR Honey Profiling. The overall positive rate of all analysed samples was 6.3%, whereas in 93.7% no sufficient indications for foreign sugars could be found (Figure AU-1). It is worth noting that the average rate of non-authentic samples determined by NMR analyses is influenced by major contributors and may not be representative for the overall market. Also, an overall decline in adulteration findings could be detected over the last three years.

Figure AU-1: Rates of foreign sugar detection via NMR Profiling and expert assessment in 2024.



Bruker NMR Honey Profiling™ 3.1 puts a strong emphasis on the involvement of the geographical and botanical origin, meaning that results can vary depending on the client's information provided along with the sample. Therefore, for the sake of completeness, correctness, and comparability, we strongly recommend submitting information about the geographical origin, as well as botanical variety in case it is known.

Despite the Bruker database containing almost 30,000 samples, not all specific features and origins are always adequately covered. This is why an expert assessment is very important. The automated analysis may produce false positives for uncommon honey origins and varieties. Many years of experience, critical data analysis and additional verification of the NMR Bruker Honey Profiling have enabled our team to recognise and correctly assess many false positive results produced by the automated Bruker analysis report. Intertek is participating in monthly technical discussions with Bruker Biospin and other major laboratories regarding the state of the profiling analysis. Considerable amounts of valuable technical feedback from our NMR experts have been officially incorporated into updates of the Bruker analysis in the past. However, there is still room for improvement especially regarding a wider representation of honeys in some origin models. A good coverage of different types of honeys in model-based analytical methods is crucial for its performance.

The NMR adulteration rates by country are shown in Table AU-5. Around 19% of all honey samples have been sent without any information regarding botanical and/or geographical origin. This shows a steady improvement of providing crucial meta information, which enables a more accurate evaluation.

The rate for the detection of foreign sugars for these unspecified samples was 11.7%. Particularly the botanical origin has the most influence on the composition and consequently the NMR signal spectrum of the sample. Therefore, a considerable number of samples may not have been assessed to the analysis' full potential. Specifying the supposed botanical origin as well as the geographical origin of honey samples is therefore highly recommended if known. With NMR profiling, variety and origin can be confirmed, provided respective database models are available.

Table AU-5: Adulteration rates and shares for the most contributing known origins (> 1% of total sample volume). Only samples with a known geographical origin are considered overall. For a significant fraction of samples, no geographical origin was stated by the client (≈ 19%).

Country	Share 2024 (%)	Positive Rate (%)
Unknown/Unstated/Mixtures	18.6	11.7
India	18.5	13.9
China	15.2	4.0
Argentina	14.7	1.1
Ukraine	6.5	0.0
Brazil	4.5	1.4
Mexico	3.7	0.7
Bulgaria	3.7	0.4
Romania	2.2	0.6
Hungary	2.1	1.2
Spain	1.5	1.8
Chile	1.5	3.5
Vietman	1.1	1.1

2.6 Mannose

At Intertek, the sugar mannose has been used as a marker for adulteration testing in honey for years. Two analytical techniques namely ion exchange chromatography (IC) and NMR Honey Profiling are able to quantify this sugar with similar limit of quantification, although other techniques like liquid chromatography coupled with mass spectrometry might also be viable.

Recently the European Joint Research Centre (JRC) investigated the appearance of mannose in honey in their EU coordinated action "From the Hives". According to this report, the quantification of mannose was achieved by using Nuclear Magnetic Resonance (NMR) Bruker Honey Profiling™, an analytical service provided by Bruker Biospin GmbH. Due to its increasing awareness and importance in testing schemes also used by authorities, we decided to dedicate an extra segment for this parameter in this report, briefly pointing out its advantages and disadvantages as a parameter regarding the detection of honey adulteration.

While it is true that in most blossom honeys mannose is not observed naturally, this is not the case for some variety honeys and honeydew honey. Most honey samples analysed in our facility are lacking detailed information about their botanical and geographical origin. Currently no available adulteration analysis is capable of reliably inferring meta information such as geographical origin and botanical variety based on the measured data, except for Bruker NMR Honey Profiling™. This is because Honey Profiling utilises databases, which enables the access to statistical classification data.

At the time of the measurement, no further information about the honey is available in most cases, preventing therefore an assessment of this sugar in context of botanical influences. In fact, mannose, as a single parameter, rarely can be used to determine foreign sugars in honey but should always be evaluated in the context of the honey's botanical influences to avoid false-positive findings.

Currently, the Bruker NMR Honey Profiling™ is designed in such a way that the presence of mannose alone will not lead to a failure of one of the integrated tests for foreign sugars but leaves the detected concentration up to the interpretation of the expert ("Interpretation required", indicated by a yellow traffic light in the Bruker analysis report).

For some countries, mannose is rarely observed in unadulterated honeys. Some nations mostly export blossom honeys, e.g. Ukraine. Hence, the appearance of mannose in authentic Ukrainian honey is very unlikely and should raise immediate suspicion if detected. In other countries, mannose is observed more regularly because the exported honey does more often contain honeydew honey or varieties which are known to naturally contain mannose.

Overall, mannose is still found in many sugar syrups used to adulterate honey. However the fraudsters' race against the development of modern methods leads to more sophisticated syrup production methods, which omit the formation of mannose, therefore its occurrence in adulterated samples is slowly declining. To avoid false-positive assessments, mannose should not be used as a standalone parameter for the detection of foreign sugars in honey.

2.7 Honey-Foreign Enzymes

Foreign enzymes, which are usually used to produce sugar syrups, play still a significant role in adulteration testing for honey.

The enzymatic activity of β- and γ-amylases, especially the terminal breakdown of starch to maltose and glucose, facilitates the use of these corresponding enzymes in synthesis of starch-base sugar syrups. Unlike α-amylases, β- and γ-amylases are considered foreign enzymes in honey.

The detection of foreign-amylase activity in honey is hence regarded as unnatural and associated with adulteration by enzymatically treated sugar syrups. In addition, certain materials applied in bee feeding are under suspicion to increase the foreign-amylase activity in honey. Presumably, it is observed in such cases, where the honey harvest is impacted by a preceded bee feeding practice (which is not in line with Directive 2001/110/EC). Nevertheless, findings of β- and γ-amylases can also have natural reasons: Our evaluations have shown that high activities of the natural enzyme invertase can induce higher levels of β- and γ-amylases, too. For this reason, the reports of analyses have been supplemented by an appropriate statement in such cases.

Approximately 2,100 honey samples were tested for β- and γ-amylase activity in 2024, and 4.9% of them were assessed as "positive", showing activities larger than the defined authenticity limit of 5.0 U/kg. The number of positives is much lower compared to the previous year. The country with the highest percentages of positives was Bulgaria. Chinese honeys, which represent a considerable number of tested samples, showed to be almost fully inconspicuous.

Heat-stable (or thermo-stable) α-amylase can be used to hydrolyse starch to produce sugar syrups.

The proportion of conspicuous findings for this parameter was 0.6% (of 670 samples in total), which is significantly lower than the rate of 2023. The only positive honey samples originated from China and India.

The foreign α-amylase profiling (FAmyP) is used to distinguish between authentic honey α-amylase (diastase) and foreign α-amylase. Equivalent to the heat-stable α-amylase, in 2024 the rate of positives was again lower compared to the year before (4.2% of 930 samples in total). Honeys from China were quite unsuspicious, whereas samples from Turkey showed an elevated number of positives. In some rare cases there are still false-positive findings for honeydew honeys from the Iberian Peninsula. Such results are excluded from the interpretation when the geographical origin is known.

β-fructofuranosidase is different from the previously mentioned enzymes, as it is used for producing inverted sugar syrups from sucrose-based material such as sugar cane or sugar beet syrup, not from starch-based plants.
β-fructofuranosidase catalyses the breakdown of the disaccharide sucrose to the monosaccharides named glucose and fructose. As this enzyme does not occur naturally in honey, the detection of its specific enzymatic activity is associated with an adulteration. As described for β- and γ-amylases, the detection of elevated β-fructofuranosidase activity may also be associated with bee feeding. In 2024, approximately 2,700 honey samples were tested for β-fructofuranosidase activity, and 3.5% of total samples were found to be adulterated. All tested honeys from India were assessed as "positive" in terms of β-fructofuranosidase activity.

2.8 LC-HRMS

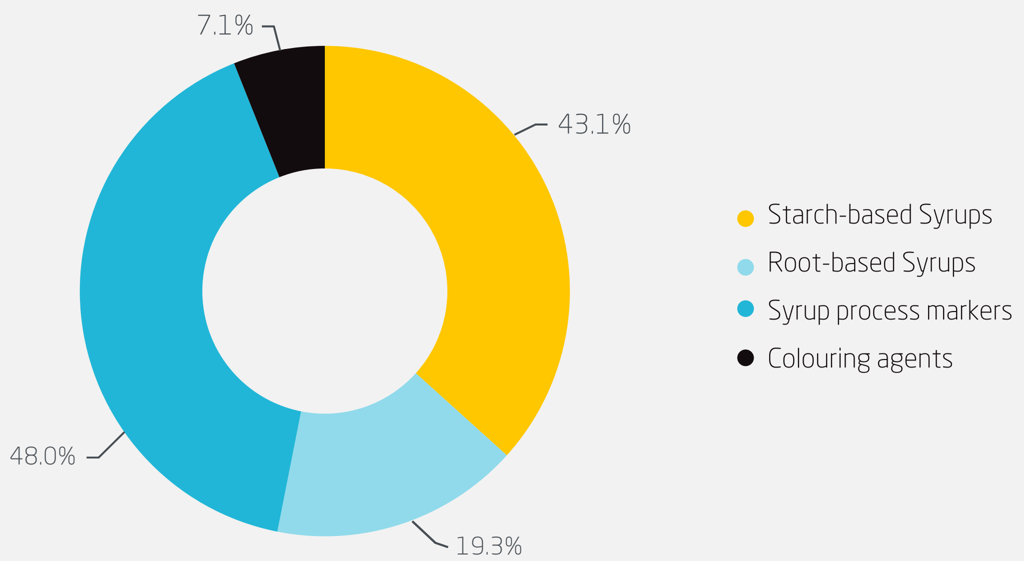
Liquid chromatography-high resolution mass spectrometry (LC-HRMS) stands alongside the ^{13}C isotope analysis (EA/LC-IRMS) and NMR profiling already described. Knowledge in this field is constantly increasing and new markers that indicate the presence of foreign sugars are regularly added. The principle of this technique is characterised by the identification of specific and statistically represented multiclass marker signals, which are assigned to one or more syrup or dye types. These indicators are supplemented by markers from technical process treatments that are not authorised for honey packaging (e.g. degradation products of sulphonic acids). Such technically unavoidable residues and the colouring agents mentioned are more likely to be found in syrups and indirectly indicate the presence of a corresponding additive. Furthermore, the three methods mentioned are to be regarded as complementary methods. The most reliable authenticity test is still achieved with a combination of several methods.

Our current set of adulteration markers in LC-HRMS analyses covers the following honey fraud sources:

- Syrups of starch-based origin such as rice, (high-fructose) corn, tapioca, or wheat
- Syrups of root-based origin such as sugar beet
- Syrups of inulin-based origin
- Addition of colouring agents
- Additional syrup markers that cannot be related to a specific syrup type

Of 9,250 honeys analysed in 2024, 6.2% tested positive for one or more of the associated markers. Of these, 18% were positive for more than one marker group. The most common indicators of foreign sugars are the non-specific markers, which include the molecular products of syrup processing. These were detected in 3.0% of all samples analysed and in 48% of positive samples. Other markers were less frequent (Figure AU-2).

Figure AU-2: Allocation of LC-HRMS marker types 2024.



The samples sent in by our customers show the region-dependent situation given in Table AU-5. In addition, foreign sugars from Brazil, Greece, Italy, Romania, Spain, Thailand, Turkey, the USA and Vietnam were detected in a small number of samples. Please note that only samples with a known geographical origin are considered. For a significant proportion of samples (10.4%), no geographical origin was specified.

Table AU-5: LC-HRMS adulteration rates and shares for the most contributing known origins (> 0.5%).

Country	Share 2024 (%)	Positive Rate (%)
Average LC-HRMS	100.0	6.2
India	26.4	11.1
China	13.4	4.6
Argentina	24.2	7.1
Uruguay	0.5	1.9
Mexico	1.4	2.5
Ukraine	0.5	1.0
Bulgaria	5.9	1.2

2.9 SM-R, SM-B, 4-MEI, TM-R, and Caramel Colouring (E 150d)

Analyses for complementary markers are still available, and these parameters represent a subset of the markers that can be determined by LC-HRMS. Apart from the specific rice syrup marker (SM-R), these markers can also be quantified, which means a more far-reaching approach. Nevertheless, it should be noted that the reliable detection of one of these markers alone would also indicate illegal sugar addition.

The most frequently tested syrup marker, SM-R, was analysed using the single substance LC-MS/MS method or in combination with the specific marker for sugar beet (SM-B) and the dye indicator 4-methylimidazole (4-MEI). Only the results of these specific marker tests are considered in this chapter.

In the case of SM-R, approximately 1,470 honey samples were sent in for analysis in 2024, with the largest contingents of assignable samples also being of Chinese and Indian origin at 46% and 33% respectively, followed by a smaller proportion of Vietnamese honeys at 4.5%. Honey from Slovakia no longer plays a role, presumably due to changes in government requirements. SM-R was detected in a relatively increasing proportion of 7.6% of the total samples (2023: 3.9%, 2022: 2.0%), and with two exceptions of Chinese origin, these positives were Indian goods, i.e. 22.8% of the Indian honey samples analysed tested positive. This means that the proportion of positive samples has doubled for the second time in a row.

In recent years, positive findings for the two markers SM-B and 4-MEI were also limited to a few origins. SM-B was positive in only 8% of the honey samples analysed; of these, Bulgarian, Chinese or Turkish origins could be reliably assigned during this period. Other positive results could not be reliably assigned to a specific origin. In the case of Mexican or Cuban honey, a detected SM-B does not necessarily indicate the presence of sugar beet syrup if no other analyses provide corresponding positive results. Based on the knowledge gained in recent years, a natural source of SM-B cannot be ruled out. However, there were no orders from Central or South America for this specific analysis during the observation period. Regarding 4-MEI, samples of Eastern European, Chinese or Turkish origin were analysed; only few samples from Bulgaria yielded positive results.

The detection of a caramel colouring in honey may indicate an adjustment of the honey colour after the addition of clear sugar syrups or ultrafiltered honey. Specific marker molecules of the food colouring (E 150d) can be detected by LC-MS/MS. In 2024, around 490 independent analyses were carried out for E 150d, which now yielded 1.8% positive results (i.e. > 2 mg/kg). Individual samples with positive results were sent in from India and the Czech Republic, China, Mexico or Bulgaria.

For TM-R (trace marker rice syrup; analysed by ICP-MS), results above the limit of 15 ppbw clearly indicate the presence of rice syrup and is usually combined regarding findings of SM-R. The total number of honey samples tested for TM-R in 2024 was 986, whereas 23.3 % of all samples showed results higher than 15 ppbw, which is a huge increase compared to the previous year. For samples from India, which represented most honeys tested for TM-R, the percentage of findings above the limit was 47.0 %, so the reason for the total increase of positives are honeys originating from India. For Chinese honey samples none was found positive. Only an isolated number of conspicuous samples came from other regions.

3. PESTICIDES

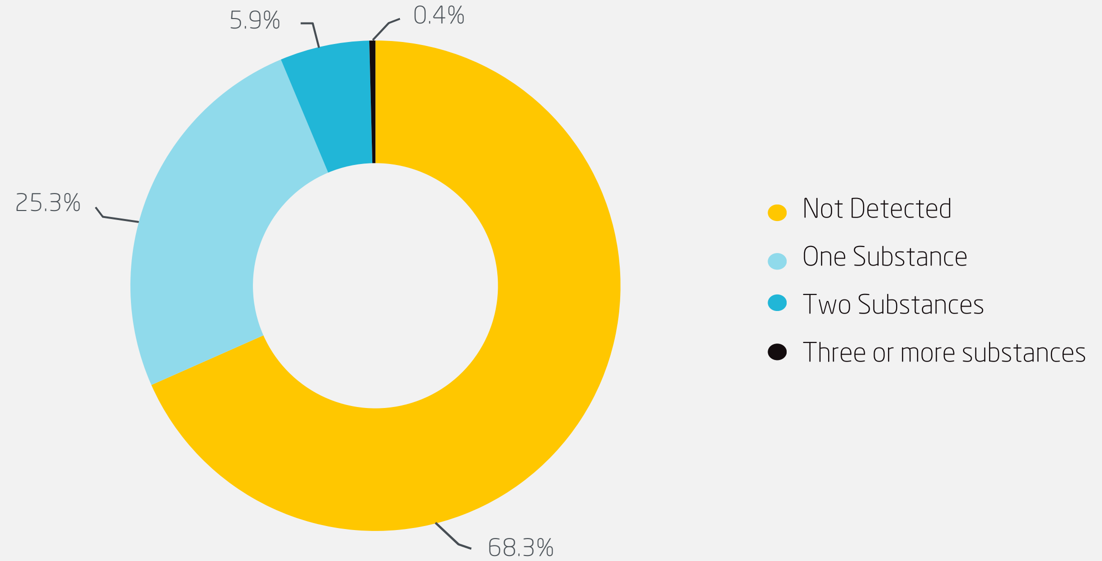
Intertek offers various approaches regarding the analysis of pesticides residues including bee treatment agents such as coumaphos, amitraz (including metabolites) and tau-fluvalinate in honey. These are presented and discussed in the following chapters, beginning with the multi-residue method by GC-MS/MS and LC-MS/MS. For relevant bee treatment agents, repellents, and single residue methods (such as glyphosate) results are pointed out in separate evaluations.

3.1 Pesticide Residues (Multi-Residue Method by GC and LC)

In 2024, approximately 6,500 honey samples were tested for the scope of active substances by the pesticide multi-residue method by GC-MS/MS and LC-MS/MS. The scope comprises known relevant substances and is continually adapted to new requirements.

31.6% of these analysed samples contained pesticide residues ≥ LOQ (limit of quantification), of which 6.3% were positive for more than one active substance (Figure Pe-1). These results are comparable to those of previous years. In case of organic honey, 6.0% of all samples labelled as organic showed positive results for pesticide residues.

Figure Pe-1: Raw honey samples containing pesticides in 2024.



2.4% of the honey samples with positive results (0.9% of the total samples analysed) did not comply with the maximum residue levels (MRLs) of the EU Regulation on pesticide residues (i. e. Regulation (EC) No 396/2005). This percentage is significantly lower compared to the three previous years. In the last evaluation for 2023, a high percentage of 8.2% was determined. We found two main reasons for this decrease.

Firstly, acetamiprid, the second most frequently identified neonicotinoid compound after the active substance amitraz, exceeded the respective maximum residue level in significantly fewer cases than in the previous year, although the absolute number of positive findings increased to 650.

Secondly, the number of positive findings for matrine and oxymatrine in the submitted honey samples decreased. Matrine and oxymatrine are alkaloids extracted from plants of the genus *Sophora* . These substances are also used as pesticides in several Asian countries (e.g. Bangladesh, China, Mongolia, Myanmar, Vietnam). In the EU, both substances have been classified as pesticides, which means that with the standard maximum residue level of 0.01 mg/kg applies in accordance Regulation (EC) No 396/2005.

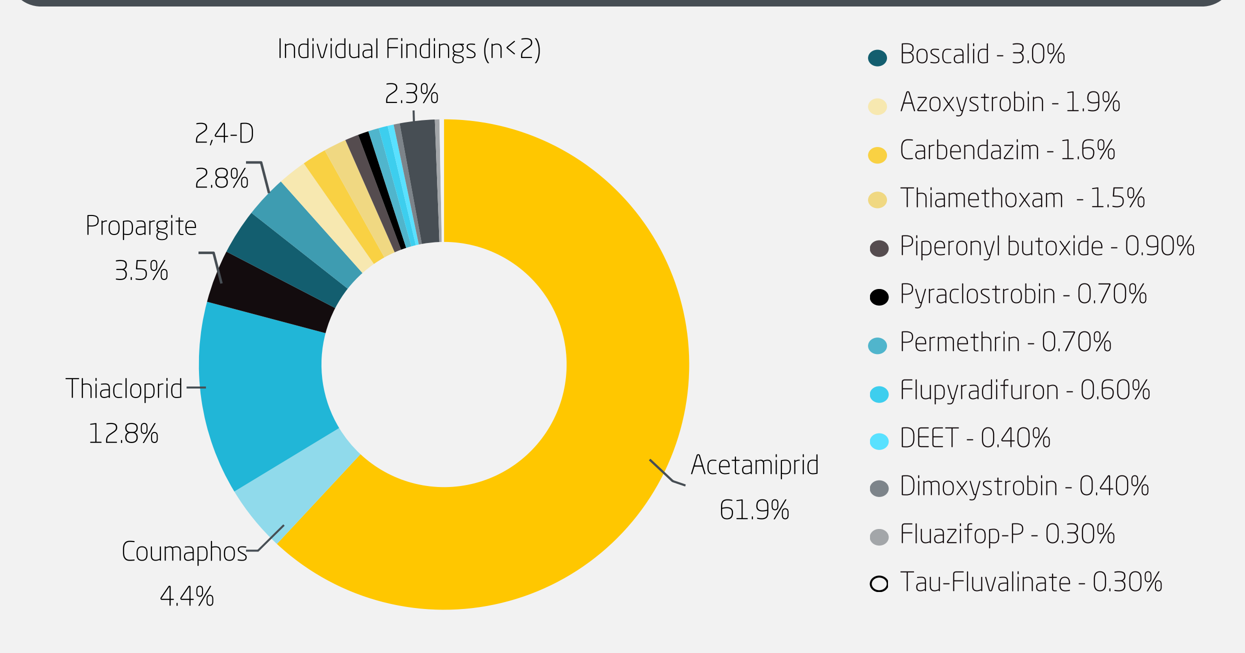
Matrine and oxymatrine are still detected in honey samples from China, especially in acacia honey, although the percentage of positive samples has decreased significantly since the implementation of the analysis. The scientific debate as to whether the presence of matrine and/or oxymatrine in honey is due to contamination of honey by a natural source or due to their use as a pesticide is still ongoing.

Residues of matrine and/or oxymatrine could originate from the nectar of *Sophora vicifoliai* , a plant that blooms as acacia trees in China at this time. The first publications supporting the hypothesis that the presence of these substances could be due to a natural source were already published in 2022.

Both matrine and oxymatrine were included in the multi-residue pesticide spectrum. These substances are also analysed with an available and offered single residue method, which is usually also used for confirmation. In the evaluation of the specific analysis, the proportion of positive results is around 2.3%, whereas it was an order of magnitude higher at the start of this analysis in 2021. Both compounds are comparable in terms of the number of positive results and the concentration. Detection is still almost exclusively in samples of Chinese origin.

Figure Pe-2 shows the overall distribution of the individual active substances that were positively detected in the multi-residue analysis for pesticides in honey. The most frequently detected substance amitraz is not included (results are described in chapter 3.2). In addition to the compounds listed, other residues were detected in only one or two honey samples (e.g. acephate, chlorpyrifos, cypermethrin, deltamethrin, fluopyram, etofenprox, fenazaquin, malathion, quinclorac, tetramethrin).

Figure Pe-2: Pesticides residues detected in positive honey samples in 2024 (excluding amitraz).

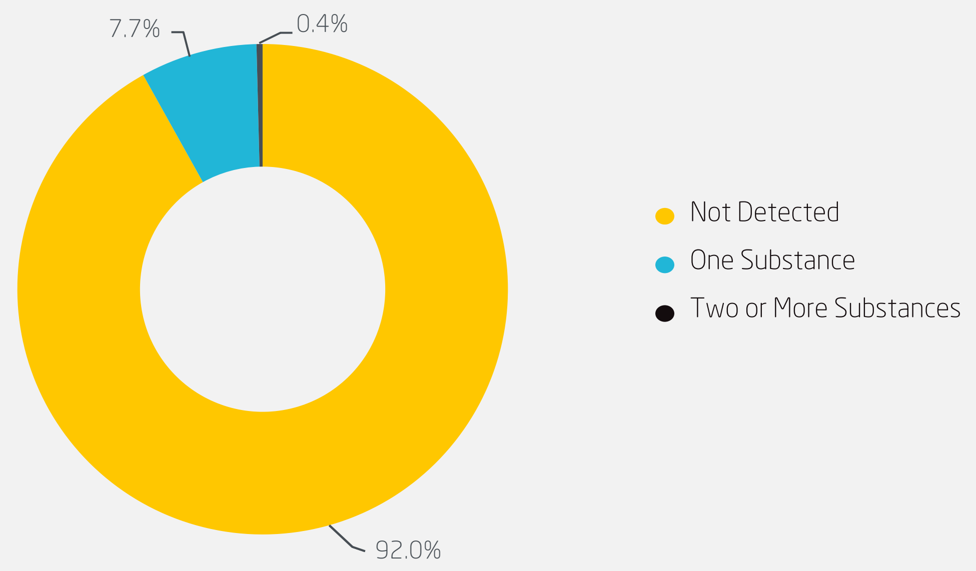


In terms of the number of positive findings, the most important residues are the neonicotinoids acetamiprid and thiacloprid. While the approval for thiacloprid was not renewed in 2020, acetamiprid has gained in importance. Nevertheless, the proportion of samples in which the maximum residue level of 0.05 mg/kg was exceeded has fallen significantly from 19% in 2023 to 3.4% now. It is also noteworthy that most of the acetamiprid findings were recorded in samples from both Eastern Europe and China.

For other frequently detected substances, propargite is found almost exclusively in Vietnamese samples, 2,4-D in Indian or South American samples, while boscalid is not further assigned to a specific origin.

Of 6,500 total samples analysed in 2024, 1,570 samples were labelled as organic honey. About 8% of the samples (i. e. 2% more than in the previous reporting period), had residues above or equal to the LOQ of 0.01 mg/kg (Figure Pe-3). The most frequently detected pesticides in these samples were amitraz, acetamiprid, coumaphos and thiacloprid. Eight samples did not meet the legal requirements (Regulation (EC) No 396/2005) due to positive findings of matrine, oxymatrine, permethrin or tetramethrin.

Figure Pe-3: Raw organic honey samples containing pesticides in 2024.



3.2 Amitraz

Amitraz is regularly the most frequently detected pesticide in honey. It has been proven that amitraz residues are widespread in many honey-producing countries. Further data on amitraz for different origins are presented in the following chapter.

In 2024, about 12,200 honey samples were analysed for amitraz (including metabolites) by GC-MS/MS or LC-MS/MS (considering single-residue and multi-residue methods). Approximately 29.3% of these samples contained residues of amitraz ≥ 0.01 mg/kg. This proportion is 4% higher than in the previous year. Of these, 0.9% of the total samples (or 3.2% of the amitraz-positive samples) exceeded the maximum residue level of 0.2 mg/kg in accordance with Regulation (EU) No 37/2010 and Regulation (EC) No 396/2005. The highest amitraz levels were found in samples from Spain and the USA with amitraz concentrations > 0.5 mg/kg. The comprehensive results of the amitraz analyses for each country are listed in Table Pe-1.

Table Pe-1: Allocation of amitraz in raw honeys by country in 2024.

Country	Share of samples [%] with amitraz residue levels of			
	< 0.010 mg/kg	0.010 - 0.050 mg/kg	0.051 - 0.200 mg/kg	> 0.200 mg/kg
Argentina	26.4	72.4	1.2	-
Bulgaria	88.3	10.4	1.1	0.2
Brazil	98.1	1.9	-	-
Canada	74.8	24.3	0.9	-
Chile	1.8	98.1	0.2	-
China	24.2	75.6	0.2	-
Hungary	72.3	26.8	-	-
India	100.0	-	-	-
Mexico	90.6	8.1	1.3	-
Romania	60.4	37.5	2.1	-
Spain	3.8	38.0	54.8	3.4
Ukraine	96.1	2.6	1.3	-
Uruguay	79.7	14.6	4.7	1.0
USA	9.5	39.6	44.2	6.7
Vietnam	4.9	94.4	0.6	-

Please note: Samples from Spain or from the USA could correspond to imports of unknown origin.

The data confirms the statistical picture of the distribution of amitraz in recent years. Most of the samples contained amitraz concentrations well below the maximum residue level of 0.2 mg/kg. Only a few samples from Spain, the USA, Uruguay or Bulgaria showed residues above the MRL.

The use of amitraz in beekeeping and inputs from the use of recycled beeswax are to be regarded as the main sources of these residues. Inputs from plant cultivation are unlikely, as the use of amitraz is prohibited and amitraz has not been detected in foodstuffs other than bee products.

3.3 Coumaphos and Tau-Fluvalinate

During the monitoring period, many honey samples were analysed for bee treatment products using specific methods, including amitraz, coumaphos, tau-fluvalinate, DEET and chlorfenvinphos. The results for the most common compound, amitraz, are listed in section 3.2.

Approximately 9,900 honey samples were analysed for coumaphos in 2024 using multi-residue methods or corresponding specific reduced-spectrum methods, with a total of 0.8% of all samples containing coumaphos residues ≥ LOQ 0.01 mg/kg. The proportion in the single-residue methods was 2.4%. This is a lower value compared to the two previous years (4%).

The average amount of coumaphos detected in positive samples was 0.0153 mg/kg. The highest levels of 0.066 mg/kg and 0.094 mg/kg coumaphos were found in samples from Bulgaria. Apart from Hungary, however, the percentage of coumaphos-positive samples is lower than before. In Hungary, the percentage of positive samples (14.8%) doubled compared to the previous year (7.1%). None of the samples exceeded the legal maximum residue limit (MRL) of 0.1 mg/kg in accordance with Regulation (EU) No 37/2010.

Table Pe-2 lists the relevant countries of origin for positive coumaphos results. Further positive results were found in samples from a customer in Slovenia, but the number of samples did not allow any statistical information to be obtained.

Table Pe-2: Shares of coumaphos-positive samples by country in 2024.

Country	Share of samples [%] with coumaphos residue levels ≥ 0.010 mg/kg
Mexico	13.2
Hungary	14.8
Bulgaria	3.0
Romania	8.3

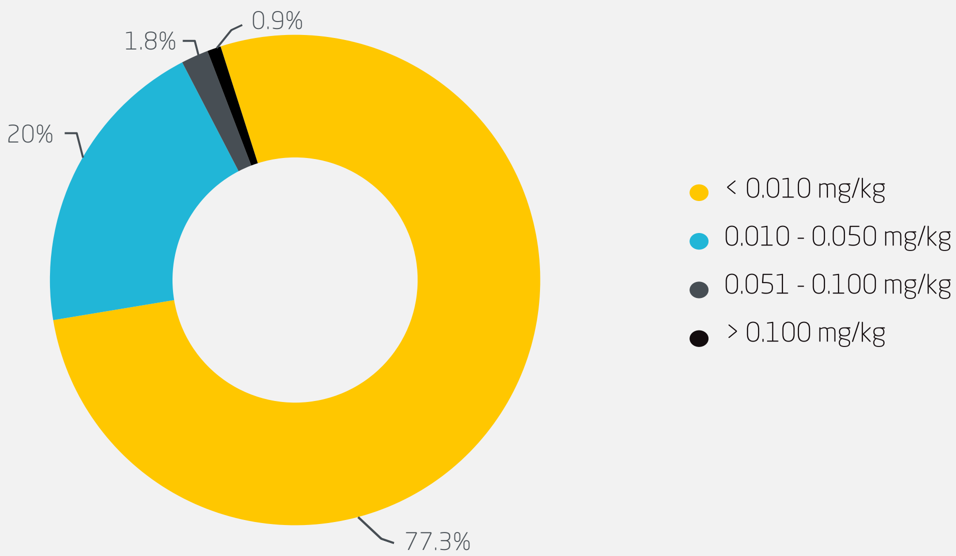
Around 1,840 samples were analysed for bee treatment products regarding the other active substances mentioned. Tau-fluvalinate (LOQ = 0.01 mg/kg) was not detected during this period, which indicates that it is not a significant residue. As in previous years, chlorfenvinphos was also not detected, while DEET was determined in seven samples from Bulgaria, Argentina and Romania.

3.4 Glyphosate

In 2024, a total of 6,360 honey samples were analysed for glyphosate residues using LC-MS/MS. Figure Pe-4 shows the overall distribution of glyphosate for the samples of raw honey analysed. 77.3% of total samples analysed contained residue levels below the limit of quantification (LOQ) of 0.01 mg/kg, which means that the proportion of positive samples decreased by about 2% compared to the previous year.

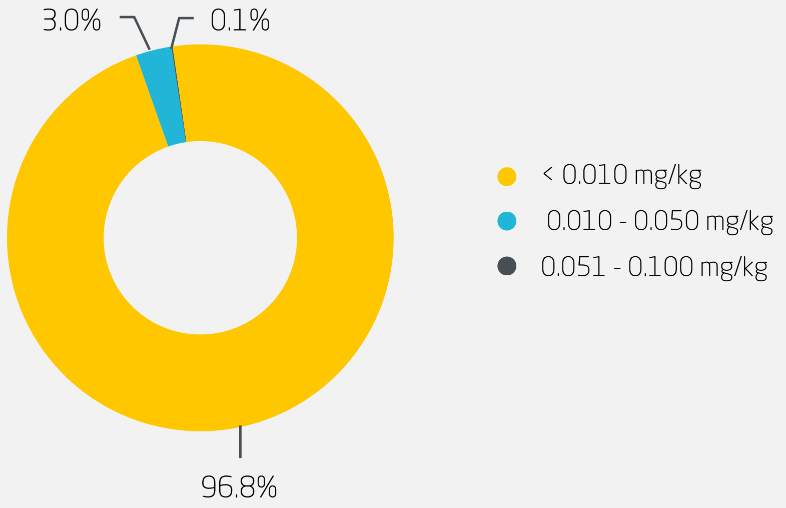
20% of the samples showed concentrations below the EU maximum residue level (MRL) of 0.05 mg/kg in accordance with Regulation (EC) No 396/2005. 2.7% of the samples contained more than 0.05 mg/kg glyphosate and therefore did not comply with Regulation (EC) No 396/2005. With a few exceptions, only the active substance was detectable; the AMPA concentrations of the metabolite were almost always below 0.01 mg/kg. AMPA was only detected in a few samples from South America and in one sample from Mexico with an average concentration of 0.027 mg/kg.

Figure Pe-4: Evaluation of glyphosate residues in 6,360 honey samples in 2024.



Approximately 790 organic honey samples were analysed for glyphosate residues using LC-MS/MS. Figure Pe-5 shows the glyphosate residues in organic honey samples. In 3.1% of these samples, the glyphosate content was above the guideline value of 0.01 mg/kg for organic products set by the Bundesverband Naturkost Naturwaren e. V. (BNN). The maximum residue level for glyphosate of 0.05 mg/kg in honey was only exceeded in one organic sample from Bulgaria.

Figure Pe-5: Evaluation of glyphosate residues in 790 organic honey samples in 2024.



A high proportion of 89% of the honey samples could be assigned to a specific origin. Table Pe-3 summarises the available data on glyphosate residues for these origins. It is known that the number of samples containing glyphosate, and the individual concentrations are relatively high for origins with extensive authorisations for the use of genetically modified plants. This is the case for South American countries, while a smaller number of samples from European countries were tested positive for this herbicide. Raw honeys from Argentina, Brazil or Uruguay were repeatedly conspicuous, with 14.2% to 88.8% testing positive. However, the proportion of positive samples from Uruguay has now fallen again following the increase recorded last season.

Table Pe-3: Distribution of glyphosate residue levels by country in 2024.

Country	Share of samples [%] with glyphosate residue levels of			
	< 0.010 mg/kg	0.010 - 0.050 mg/kg	0.051 - 0.100 mg/kg	> 0.100 mg/kg
Argentina	11.2	81.7	5.0	2.1
Brazil	79.7	16.7	2.1	1.5
Chile	92.1	7.9	-	-
Uruguay	85.7	8.4	5.0	0.8
Cuba	100	-	-	-
Mexico	94.7	3.5	0.3	1.5
Bulgaria	97.6	1.9	0.3	0.1
Ukraine	93.4	5.3	1.1	0.3
Romania	94.8	3.7	0.7	0.7
Greece	95.5	4.5	-	-
Spain	92.7	7.3	-	-
China	100	-	-	-
India	100	-	-	-

3.5 Bee Repellents

Four compounds (benzaldehyde, phenylacetaldehyde, phenol and para-dichlorobenzene) from the spectrum of bee preservatives analysed using GC-MS were subjected to closer examination. Naphthalene and nitrobenzene, on the other hand, played a subordinate role in the residue situation in honey. Some strikingly similar findings were obtained for thymol compared to previous years, which make further future monitoring appear advisable.

Apart from para-dichlorobenzene, which is used in products against wax moths *(Galleria mellonella)*, all the other substances mentioned above are occasionally used as bee repellents. For many years, thymol has only rarely been detected in honey above the reporting limit of 0.1 mg/kg, but it is still present in beeswax samples. Nitrobenzene is practically no longer relevant today.

Please note that important honey importers such as Germany, Spain, Italy, France, USA, Canada or Great Britain were not analysed. Only results for reliably defined origins obtained with our GC-MS method are included.

3.5.1 Benzaldehyde and Phenylacetaldehyde

It should be considered that both benzaldehyde and phenylacetaldehyde are typical natural flavour components of honey, but they can also be residues after the use of repellents during harvesting. Therefore, in case of unusual amounts of aldehydes in honey, a sensory test is required to determine the natural or unnatural origin. The following should be noted about the natural formation of phenylacetaldehyde: According to a scientific study, the biosynthesis of phenylacetaldehyde depends on the available amount of amino acid phenylalanine. In this context, it could be concluded that levels of 1 mg/kg to 2.5 mg/kg phenylacetaldehyde cannot be safely regarded as a residue if the phenylalanine content is not considered.

In 2024, 53% of total samples were tested positive for phenylacetaldehyde > 0.1 mg/kg and 20% were tested positive for benzaldehyde > 0.1 mg/kg, which are slightly lower figures than those for 2023. The actual proportions of samples by country for the detected concentrations > 0.1 mg/kg and > 1.0 mg/kg, the latter only for phenylacetaldehyde, are summarised in Table Pe-4.

Table Pe-4: Shares of aldehyde-positive samples by country 2024.

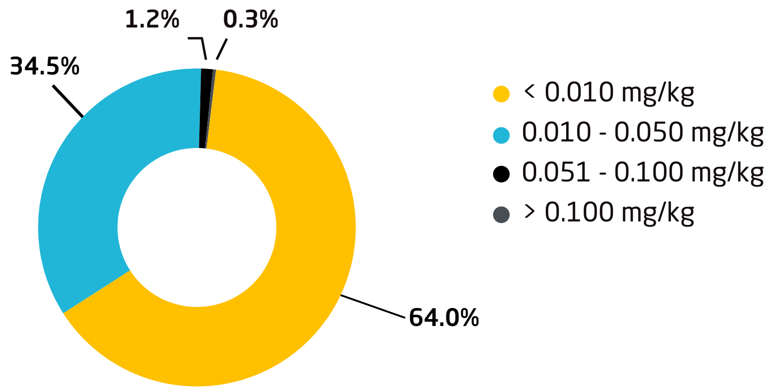
Country	Share of samples [%] with concentration of			
	Benzaldehyde	Phenylacetaldehyde		
	> 0.10 mg/kg	> 0.10 - 0.50 mg/kg	> 0.51 - 1 mg/kg	> 1 mg/kg
Argentina	11.1	80.6	2.8	-
Brazil	17.5	61.4	10.5	12.3
Chile	12.0	81.3	12.5	-
Cuba	50.0	80.0	20.0	-
Mexico	51.3	9.9	23.8	64.4
Nicaragua	41.3	60.9	10.9	21.7
Greece	1.8	26.8	7.1	10.7
Bulgaria	8.7	30.1	0.3	-
Ukraine	8.6	12.5	3.1	-

It is immediately apparent that higher levels of both aldehydes are found in honeys from Brazil, Central America and Greece, with benzaldehyde playing a smaller role for the latter origin. In contrast, benzaldehyde contents >1mg/kg were determined in two samples from Mexico only. Highest phenylacetaldehyde amounts of >5mg/kg were present in four honeys from Greece.

3.5.2 Phenol, Thymol and Naphthalene

Figure Pe-6 shows the overall distribution of phenol concentrations for the raw honey samples analysed in 2024. 64% of the samples showed no residues above the LOQ of 0.01 mg/kg. The majority of the samples contained phenol in concentrations between 0.01 mg/kg and 0.05 mg/kg. Only about 1.5% of all analysed samples showed concentrations above 0.05 mg/kg. The current rate of negative samples, i.e. < 0.01 mg/kg, corresponds to the trend of the last five years, in which the number of positive findings among the analysed samples decreased overall.

Figure Pe-6: Allocation of phenol concentrations in raw honey samples in 2024.



The percentage of positive findings for phenol > 0.01 mg/kg by country is given in Table Pe-5.

Table Pe-5: Shares of phenol positive samples by country in 2024.

Country	Share of samples [%] with phenol	
	≥ 0.010 mg/kg - 0.050 mg/kg	> 0.050 mg/kg
Argentina	77.0	1.1
Brazil	89.7	-
Bulgaria	4.4	0.6
China	2.5	-
Mexico	89.8	8.2
Nicaragua	63.0	4.3
Greece	16.1	-
Romania	13.5	-

Somewhat differently to previous years, thymol was determined in some honey samples with maximum concentrations of up to 5 mg/kg. This corresponds to 2.7% of the honeys analysed; the reporting limit is 0.1 mg/kg. None of these honeys is labelled as thyme honey. Some of these samples with a defined origin come from Bulgaria or Chile, including some organic blossom honeys. One probable entry pathway is migration during the reuse of waxes from beekeeping. Analyses of these waxes revealed high thymol concentrations of up to 50 mg/kg in a large proportion of the wax samples examined. Continuous monitoring is recommended.

There are still no positive results for naphthalene above the LOQ of 0.01 mg/kg.

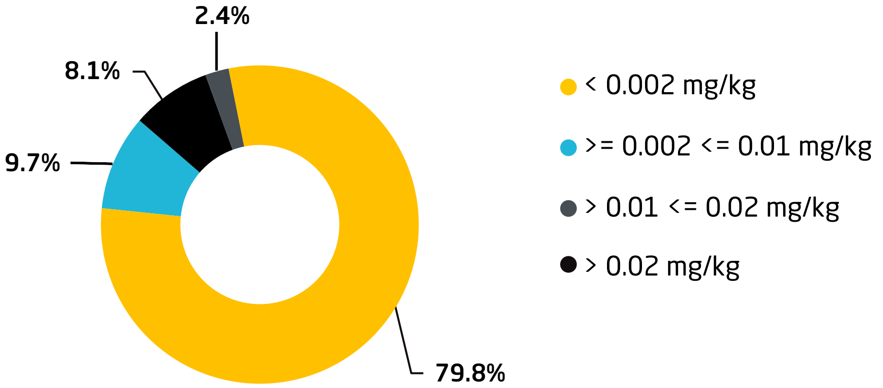
3.5.3 Para-Dichlorobenzene

The substance para-dichlorobenzene is used in products against wax moths. According to Regulation (EU) No 37/2010, para-dichlorobenzene is not listed as a bee treatment product. Furthermore, Regulation (EC) No 396/2005 does not specify a maximum residue limit (MRL). Therefore, the default MRL of 0.01 mg/kg according to Article 18 of Regulation (EC) No 396/2005 applies.

A total of 1,110 honey samples were analysed in 2024 for para-dichlorobenzene using GC-MS. Almost all samples tested positive above the LOQ of 0.002 mg/kg could be assigned to a country of origin, and with one exception for Chile, these were Mexican honeys.

Figure Pe-7 shows the proportion of positive samples for these Mexican honeys in 2024. The proportion of positive samples has increased significantly over the last four years. In 2020, only three samples from Mexico showed residues > 0.005 mg/kg. In 2021, 6.3% of all Mexican honey samples had residues above the MRL of 0.01 mg/kg, while this segment accounted for 8.3% in 2023. In 2024, this proportion increased to 10.5%, while the proportion of honeys without para-dichlorobenzene residues (< 0.002 mg/kg) remained comparable.

Figure Pe-7: Shares of para-dichlorobenzene in Mexican honeys in 2024.



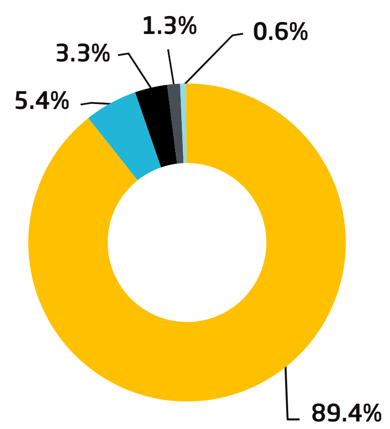
3.6 Chlorate and Perchlorate

For chlorate, Regulation (EC) No 396/2005 sets a maximum residue level of 0.05 mg/kg for honey. Maximum levels for perchlorate have been set for various foodstuffs in Regulation (EU) 2023/915. However, honey or other beekeeping products are not listed in this regulation. Nevertheless, the orientation value of 0.05 mg/kg is still commonly used for assessment.

Further analyses of these parameters were commissioned after these decisions came into force. In 2024, around 690 honey samples were analysed for chlorate and perchlorate residues. The overall results for chlorate and perchlorate are shown in Figure Pe-8.

In contrast to previous years, chlorate was present more frequently than perchlorate in the analysed samples. The maximum residue level of 0.05 mg/kg was exceeded in 1.9% of all samples, with the highest levels of > 1.0 to 3.8 mg/kg being found in five honeys from Greece. The only other exceedances of the maximum residue level were found in Ukraine. Table Pe-6 shows the concentration distribution for the respective countries of origin. In addition, chlorate was determined in two samples from Bulgaria.

Figure Pe-8: Allocation of chlorate and perchlorate levels in raw honey samples in 2024.



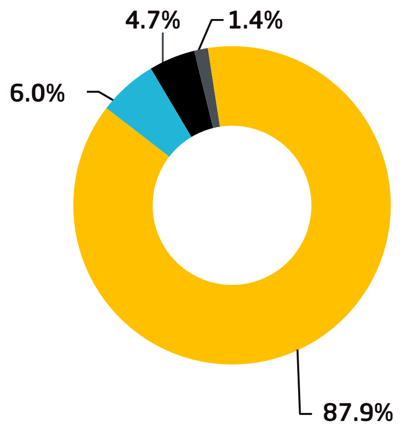


Table Pe-6: Shares of chlorate-positive honey samples by country 2024.

Country	Share of samples [%] with chlorate levels of				
	< 0.010 mg/kg	0.010 - 0.020 mg/kg	0.021 - 0.050 mg/kg	0.051 - 0.10 mg/kg	> 0.10 mg/kg
Romania	95.8	2.8	1.4	-	-
Greece	68.9	10.1	12.8	2.0	6.1
Hungary	90.8	9.2	-	-	-
Ukraine	89.2	8.4	1.2	1.2	-
China	92.2	6.5	1.3	-	-
Vietnam	95.8	4.2	-	-	-

Of the samples exceeding the benchmark value of 0.05 mg/kg perchlorate, only those from China can be assigned to a specific country of origin. The positive results from the other known countries of origin - Argentina, Greece, Vietnam - are in the range of 0.01 - 0.02 mg/kg.

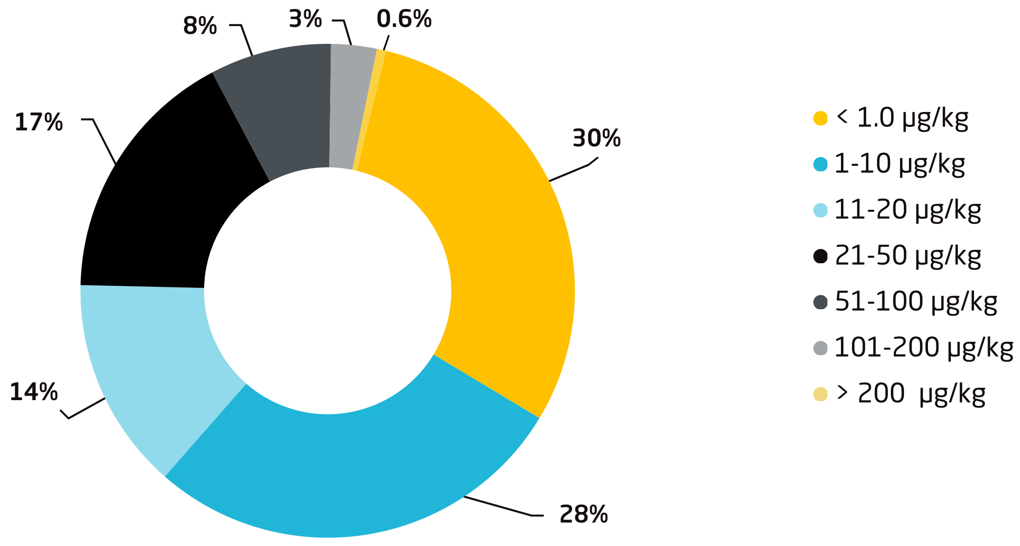
4. PYRROLIZIDINE ALKALOIDS

The evaluation of the pyrrolizidine alkaloid (PA) concentrations in the majority of the samples is based on 28 individual compounds, which include both tertiary PAs and their N-oxides. Further isomers are only included if they correspond to the analytical parameters of selected compounds and cannot be separated using standard chromatographic methods.

For 6.5% of the samples, the newer scope of 21 pyrrolizidine alkaloids and additional 14 co-eluting compounds according to Regulation (EU) 2023/915 is included. Intertek has been offering this test scope since summer 2022 and it has gained in importance since then. Regarding the N-oxide forms, it is known that high quantities are only present in fresh raw honey, while these substances are detectable in significantly lower proportions after longer storage.. Even though Regulation (EU) 2023/915 still does not set a maximum level for honey, the situation has been well described in recent years.

Approximately 79% of all raw honeys analysed in 2024 were labelled with indications of origin. Figure PA-1 below shows the overall distribution of the sum of PAs analysed for the raw honey samples received during this period.

Figure PA-1: Allocation of PA-concentrations in raw honey samples 2024.



The proportion of samples with total concentrations below the limit of quantification of 1 µg/kg ('PA-free') fell slightly from 33% in 2023 to 30%. Overall, more highly contaminated samples with concentrations above 50 µg/kg were observed in 2024. However, this seasonal up and down is known from previous analyses.

Some other aspects have also been known since the start of these investigations and have been confirmed once again: Samples from Central and South America are mostly contaminated with PA. In particular, samples from Argentina or Brazil showed higher PA concentrations > 20 µg/kg. The same applies to Uruguay, although the number of samples was too small for a meaningful assessment. Samples with high PA concentrations were submitted from most regions, whereby the samples from the Iberian Peninsula were again conspicuous, while honeys from Eastern Europe continued to show only low concentrations. High PA concentrations in German honey are often associated with the presence of Senecio jacobeae (maximum value 800 µg/kg). As in previous years, Chinese honeys were mostly free of PA.

Table PA-1: Allocation of PA in raw honeys by country in 2024.

Country	Share of samples [%] with PA concentrations of						
	< 1 µg/kg	1 - 10 µg/kg	11 - 20 µg/kg	21 - 50 µg/kg	51 - 100 µg/kg	101 - 200 µg/kg	> 200 µg/kg
Argentina	17.0	31.3	21.3	25.4	4.4	0.6	-
Brazil	11.6	14.5	11.6	27.5	21.7	10.5	2.9
Chile	22.9	25.7	20.0	25.7	5.7	-	-
Cuba	-	30.8	19.2	30.8	7.7	11.5	-
Mexico	4.7	54.1	25.9	11.8	2.4	1.2	-
Nicaragua	27.3	36.4	30.3	6.1	-	-	-
Greece	39.4	33.3	8.1	8.1	4.0	5.1	2.0
Bulgaria	82.8	17.2	-	-	-	-	-
Hungary	82.0	16.2	1.8	-	-	-	-
Romania	75.0	25.0	-	-	-	-	-
Ukraine	59.8	39.2	-	1.0	-	-	-
Turkey	-	17.4	17.4	47.8	13.0	4.3	-
Spain	8.5	14.6	18.4	32.1	18.9	7.1	0.5
China	95.5	4.5	-	-	-	-	-
Vietnam	-	57.6	33.3	9.1	-	-	-

5. ANTIBIOTICS

5.1 Important information about the evaluation used

Table An-1 shows the results of the antibiotic residue tests carried out for honey samples and, in individual cases where the information can be a useful supplement, for other bee products from the exporting countries (EU and non-EU) in 2024. Detected residues of generally prohibited pharmacologically active substances for which reference points for action (RPA) have been established, as well as those of prohibited nitroimidazoles, have been evaluated in rows highlighted in colour. Residue levels below the RPA values led to entries in the column 'Number of positives < RPA' in Table An-1. The categorisation was based on the RPA values of 0.15 µg/kg for chloramphenicol and 0.5 µg/kg for nitrofuran metabolites. Colchicine, chlorpromazine and beta-lactam antibiotics have not yet tested positive in honey and have therefore not been included in the list. The lowest LOQ currently offered by Intertek for honey (ultra methods) is indicated in the list. Confirmed residue levels below the ordered reporting limit were also considered. In such cases, 'additional information' was issued to the customer.

As the actual countries of origin cannot be reliably assigned, honey-importing countries such as Belgium, Germany, Italy, France, Poland, the USA or the UK were not assessed. Exceptions were made for Canada and, in particular, for Spain. The results for these countries were considered if the origin could be reliably specified. All cases with more than 20 samples were documented, as was the overall percentage of positive results. For other countries of origin not included in the list, there is currently not enough specific data available (in 2024, e.g. Israel, Croatia, Czech Republic, Lithuania, Malaysia, Myanmar and New Zealand). However, some countries with little data (< 10 analyses) were nevertheless included due to significant positive results (Australia, Turkey and Slovakia). Further individual results are listed at the end of this chapter (see below). In some cases (e.g. China, Spain, Ukraine and Turkey), data for other bee products such as royal jelly, pollen and propolis were also included in the analysis in addition to honey. All residues of interest were documented. Further individual findings are noted at the end of this chapter (see below).

5.2 Further information regarding the assessments

For chloramphenicol, we generally recommend testing by LC-MS/MS, especially for high risk, as the ELISA method is only designed for screening purposes (according to Decision 2002/657/EC) with known false-positive and false-negative results (up to 5% isomers other than the RR-para-CAP isomer are not detected by ELISA or comparable tests).

As the substance trimethoprim is often used in combination with certain sulfonamides, the number and quantity of positive detections of trimethoprim are in most cases already included in the number of detected sulfonamides residues and are not analysed further (indicated by a '+').

In 2024, new residues were also detected in honey in various countries of origin for the first time after a longer period, such as nitrofuran metabolites in individual samples from Argentina or Uruguay, amphenicols also in Argentine and Brazilian samples, tylosin in a Spanish sample and dapsone in a sample from Vietnam.

In addition to the data listed in the following table An-1, there were positive findings in individual samples for streptomycin or dihydrostreptomycin in honeys from Rwanda and Serbia or for semicarbazide (SEM) in honeys from Cameroon.

Information on the column "Number of positives"
< RPA: samples with positive findings below the respective RPA for non-allowed pharmacologically active substances (chloramphenicol and nitrofuran metabolites)
≥ limit: samples with positive findings above the respective RPA for non-allowed pharmacologically active substances and above the LOQ for other antibiotics

Key	
HO: Honey RJ: Royal jelly PO: Pollen PR: Propolis	Black: No positive findings Red: Positive findings were observed in 2024 Green: No positive findings were observed in 2024, but positive findings were observed in previous years

Table An-1: Detected antibiotics. Timeframe of residue evaluation: 1st January to 31st December 2024.

Sample country of origin (Matrix)	Group of residue	Active substances - positive findings (> lowest LOQ)	Lowest LOQ (µg/kg)	Total number tested	Number of positives		% positive (> lowest LOQ)	Comment
					< RPA	≥ limit		
Argentina (HO)	Sulfonamides + Trimethoprim	Sulfadimethoxine, Sulfamethazine, Sulfamonomethoxine	0.5	627		5	0.8	
	Tetracyclines	Oxytetracycline, Tetracycline	0.5	649		62	9.6	
	Aminoglycosides	Streptomycin	0.5	464		0	0.0	Positive in 2022
	Macrolides	Tylosin	0.5	443		4	0.9	
	Fluoroquinolones		0.5	4444		0	0.0	
	Fumagillin		5	< 10		0	-	Positive in 2023
	Nitrofuran metab.	AOZ	0.2	1186	0	1	0.1	New residue
	Amphenicols	Florfenicol	0.05	911	0	2	0.2	New residue, no RPA in place
	Nitroimidazoles		0.1	180	-	0	0.0	
Australia (HO)	Sulfonamides + Trimethoprim		0.5	< 20		0	0.0	
	Tetracyclines	Oxytetracycline	0.5	16		4	25.0	
	Amphenicols	Chloramphenicol	0.05	< 20		1	Not calc.	New residue
	Other classes of antibiotics or prohibited substances not counted					0		No positives
Brazil (HO)	Sulfonamides + Trimethoprim	Sulfamethoxazole, Trimethoprim	0.5	89		0	0.0	Positive in previous years
	Tetracyclines	Oxytetracycline	0.5	90		1	1.1	
	Aminoglycosides		0.5	97		0	0.0	
	Macrolides		0.5	68		0	0.0	
	Fluoroquinolones		0.5	183		0	0.0	
	Nitrofuran metab.	SEM	0.2	218	0	2	1.0	New residue
	Amphenicols		0.05	173	0	0	0.0	
	Nitroimidazoles		0.1	34	-	0	0.0	
Bulgaria (HO, PO)	Sulfonamides + Trimethoprim	Sulfathiazole, Sulfamethoxazole, Trimethoprim, Sulfamethazine	0.5	625		91	14.6	
	Tetracyclines	Oxytetracycline, Tetracycline, Doxycycline	0.5	572		34	5.9	
	Aminoglycosides	Streptomycin, Dihydrostreptomycin	0.5	513		14	2.7	
	Macrolides	Tylosin, Erythromycin, Lincomycin	0.5	535		24	4.5	
	Fluoroquinolones	Flumequin, Enrofloxacin, Ofloxacin	0.5	512		28	5.5	
	Nitrofuran metab.	AMOZ, SEM, AOZ	0.2	473	0	7	1.5	SEM: Pollen, Positive in previous years
	Amphenicols	Chloramphenicol	0.05	462	0	1	0.2	
	Nitroimidazoles	Metronidazole	0.1	569	-	21	3.7	
Canada (HO)	Sulfonamides + Trimethoprim		0.5	< 20		0	0.0	
	Tetracyclines	Oxytetracycline	0.5	< 20		1	Not calc.	Positive in previous years
	Aminoglycosides		0.5	< 20		0	0.0	
	Macrolides	Tylosin, Lincomycin	0.5	< 20		1	Not calc.	Positive in previous years

Sample country of origin (Matrix)	Group of residue	Active substances - positive findings (> lowest LOQ)	Lowest LOQ (µg/kg)	Total number tested	Number of positives		% positive (> lowest LOQ)	Comment
					< RPA	≥ limit		
	Fluoroquinolones	Ciprofloxacin	0.5	113		0	0.0	Positive in previous years
	Fumagillin		5	< 20		0	-	Positive in previous years
	Prohibited substances not counted						No positives	
Chile (HO)	Sulfonamides + Trimethoprim	Sulfamethazine, Trimethoprim	0.5	51		0	0.0	Positive in previous years
	Tetracyclines	Oxytetracycline, Tetracycline	0.5	60		4	6.7	
	Aminoglycosides		0.5	53		0	0.0	
	Macrolides		0.5	50		0	0.0	
	Fluoroquinolones	Ciprofloxacin, Enrofloxacin	0.5	49		9	18.4	
	Fumagillin		5	< 20		0	0.0	Positive in previous years
	Nitrofuran metab.		0.2	33	0	0	0.0	
	Amphenicols		0.05	30	0	0	0.0	
	Nitroimidazoles	Metronidazole	0.1	30	-	0	0.0	Positive in 2022
China (HO, RJ)	Sulfonamides + Trimethoprim	Sulfaclozine, Sulfadiazine, Sulfamethoxazole, Trimethoprim	0.5	488		30	2.7	
	Tetracyclines	Oxytetracycline	0.5	573		2	0.3	Royal Jelly, Honey: Positive in previous years
	Aminoglycosides	Streptomycin	0.5	723		15	2.1	
	Macrolides	Lincomycin	0.5	505		1	0.2	
	Fluoroquinolones	Ciprofloxacin, Norfloxacin	0.5	600		3	0.5	
	Dapsone		0.5	120		0	0.0	
	Nitrofuran metab.	SEM	0.2	767	0	4	0.5	
	Amphenicols	Chloramphenicol	0.05	691	0	5	0.7	
	Nitroimidazoles	Metronidazole	0.1	682	-	0	0.0	Positive in previous years
Cuba (HO)	Sulfonamides + Trimethoprim	Sulfamethoxazole, Trimethoprim	0.5	86		0	0.0	
	Tetracyclines		0.5	77		0	0.0	
	Aminoglycosides		0.5	38		0	0.0	
	Macrolides		0.5	30		0	0.0	
	Fluoroquinolones		0.5	22		0	0.0	
	Nitrofuran metab.		0.2	27	0	0	0.0	
	Amphenicols		0.05	22	0	0	0.0	
	Nitroimidazoles		0.1	20	-	0	0.0	
Greece (HO, PR)	Sulfonamides + Trimethoprim	Sulfaclozine, Sulfathiazole, Sulfamethazine, Sulfamonomethoxine	0.5	114		9	7.9	
	Tetracyclines	Oxytetracycline, Tetracycline	0.5	110		16	14.5	
	Aminoglycosides	Streptomycin, Dihydrostreptomycin	0.5	110		6	5.5	
	Macrolides	Tylosin	0.5	35		0	0.0	Positive in previous years
	Fluoroquinolones	Ciprofloxacin, Flumequin	0.5	35		0	0.0	Positive in previous years

Sample country of origin (Matrix)	Group of residue	Active substances - positive findings (> lowest LOQ)	Lowest LOQ (µg/kg)	Total number tested	Number of positives		% positive (> lowest LOQ)	Comment
					< RPA	> limit		
	Fumagillin		5	40		0	0.0	Positive in previous years
	Nitrofuran metab.		0.2	78	0	0	0.0	
	Amphenicols		0.05	50	0	0	0.0	
	Nitroimidazoles	Metronidazole	0.1	76	-	0	0.0	Positive in previous years
Guate-mala (HO)	Sulfonamides + Trimethoprim		0.5	24		0	0.0	
	Tetracyclines	Tetracycline	0.5	21		0	0.0	Positive in previous years
	Aminoglycosides		0.5	20		0	0.0	
	Macrolides		0.5	< 20		0	-	
	Fluoroquinolones		0.5	< 20		0	-	
	Prohibited substances not counted							No positives
Hungary (HO)	Sulfonamides + Trimethoprim	Sulfadiazine, Sulfame-thazine, Sulfathiazole, Trimethoprim	0.5	528		7	1.3	
	Tetracyclines	Oxytetracycline, Tetracycline, Doxycycline	0.5	527		9	1.7	
	Aminoglycosides	Streptomycin, Dihydrostreptomycin	0.5	308		0	0.0	Positive in previous years
	Macrolides	Tylosin	0.5	259		1	0.4	
	Fluoroquinolones	Enrofloxacin	0.5	169		0	0.0	Positive in previous years
	Fumagillin		5	21		0	-	
	Nitrofuran metab.	AOZ	0.2	274	0	1	0.4	
	Amphenicols	Chloramphenicol	0.05	262	0	2	0.8	
	Nitroimidazoles	Metronidazole	0.1	340	-	4	1.2	
India (HO)	Sulfonamides + Trimethoprim	Sulfamethoxazole, Sulfa-diazine, Trimethoprim,	0.5	2286		105	4.6	
	Tetracyclines	Tetracycline, Oxytetracycline, Doxycycline	0.5	1672		610	36.5	
	Aminoglycosides	Streptomycin	0.5	1009		5	0.5	
	Macrolides	Erythromycin	0.5	330		1	0.3	
	Fluoroquinolones	Ciprofloxacin, Enrofloxacin, Norfloxacin, Ofloxacin	0.5	2926		700	23.9	
	Nitrofuran metab.	SEM	0.2	1077	0	5	0.5	
	Amphenicols	Chloramphenicol	0.05	2183	9	27	1.2	
	Nitroimidazoles	Metronidazole	0.1	2182	-	44	2.0	
Mexico (HO)	Sulfonamides + Trimethoprim	Sulfamonomethoxine, Sulfathiazole, Sulfisoxa-zole, Trimethoprim	0.5	559		41	7.3	
	Tetracyclines	Oxytetracycline, Tetracycline, Doxycycline	0.5	511		15	2.9	Positive in previous years
	Aminoglycosides	Streptomycin	0.5	524		13	2.5	
	Macrolides		0.5	201		0	0.0	
	Fluoroquinolones	Enrofloxacin, Norfloxacin	0.5	303		4	1.3	Positive in previous years
	Nitrofuran metab.		0.2	278	0	0	0.0	
	Amphenicols	Florfenicol	0.05	321	0	0	0.0	Positive in 2023
	Nitroimidazoles		0.1	148	-	0	0.0	

Sample country of origin (Matrix)	Group of residue	Active substances - positive findings (> lowest LOQ)	Lowest LOQ (µg/kg)	Total number tested	Number of positives < RPA	Number of positives ≥ limit	% positive (> lowest LOQ)	Comment
Nicaragua (HO)	Sulfonamides + Trimethoprim		0.5	38		0	0.0	
	Tetracyclines		0.5	38		0	0.0	
	Aminoglycosides		0.5	38		0	0.0	
	Macrolides		0.5	40		0	0.0	
	Fluoroquinolones		0.5	40		0	0.0	
	Nitrofuran metab.		0.2	33	0	0	0.0	
	Amphenicols		0.05	32	0	0	0.0	
	Nitroimidazoles		0.1	20	-	0	0.0	
Romania (HO)	Sulfonamides + Trimethoprim	Sulfathiazole	0.5	125		2	1.6	
	Tetracyclines	Oxytetracycline, Tetracycline,	0.5	164		20	12.2	
	Aminoglycosides	Streptomycin, Dihydrostreptomycin	0.5	157		18	11.5	
	Macrolides	Tylosin	0.5	110		4	3.6	
	Fluoroquinolones	Enrofloxacin, Flumequin	0.5	107		0	0.0	Positive in previous years
	Nitrofuran metab.		0.2	49	0	0	0.0	
	Amphenicols	Chloramphenicol	0.05	98	2	0	0.0	Positive in previous years
	Nitroimidazoles	Metronidazole	0.1	80	-	0	0.0	Positive in previous years
El Salvador (HO)	Sulfonamides + Trimethoprim		0.5	28		0	0.0	
	Tetracyclines		0.5	28		0	0.0	
	Aminoglycosides		0.5	28		0	0.0	
	Macrolides		0.5	< 20		0	-	
	Fluoroquinolones		0.5	< 20		0	-	
	Prohibited substances not counted						No positives	
Slovakia (HO)	Sulfonamides + Trimethoprim		0.5	28		0	0.0	
	Tetracyclines	Tetracycline	0.5	28		0	0.0	Positive in previous years
	Aminoglycosides		0.5	< 20		0	0.0	
	Macrolides		0.5	< 20		0	-	
	Fluoroquinolones	Ciprofloxacin	0.5	< 20		0	-	Positive in previous years
	Prohibited substances not counted						No positives	
Slovenia (HO)	Sulfonamides + Trimethoprim	Sulfaclozine, Sulfamethazine	0.5	23		2	8.7	Positive in previous years
	Tetracyclines		0.5	27		0	0.0	
	Aminoglycosides		0.5	23		0	0.0	
	Other classes of antibiotics or prohibited substances not counted					0	-	No positives
Spain (HO, PO)	Sulfonamides + Trimethoprim		0.5	206		0	0.0	
	Tetracyclines	Tetracycline	0.5	155		4	2.6	
	Aminoglycosides	Streptomycin	0.5	223		2	0.9	
	Macrolides	Tylosin A, Lincomycin	0.5	44		1	2.3	New residue, pos. in 2023
	Fluoroquinolones		0.5	49		0	0.0	
	Nitrofuran metab.		0.2	50	0	0	0.0	
	Amphenicols		0.05	40	0	0	0.0	
	Nitroimidazoles		0.1	28	-	0	0.0	

Sample country of origin (Matrix)	Group of residue	Active substances - positive findings (> lowest LOQ)	Lowest LOQ (µg/kg)	Total number tested	Number of positives		% positive (> lowest LOQ)	Comment
					< RPA	≥ limit		
Turkey (HO, PO, PR)	Sulfonamides + Trimethoprim	Sulfamethazine, Sulfadiazine	0.5	< 20		3	Not. Calc.	
	Tetracyclines	Oxytetracycline, Tetracycline	0.5	17		2	11.8	Positive in previous years
	Aminoglycosides	Dihydrostreptomycin, Streptomycin	0.5	18		1	5.6	Positive in previous years
	Macrolides	Erythromycin	0.5	< 20		0	-	Positive in previous years
	Fluoroquinolones	Enrofloxacin	0.5	< 20		0	-	Positive in previous years
	Nitrofuran metab.		0.2	< 20	0	-	0.0	
	Amphenicols		0.05	< 20	0	-	0.0	
	Nitroimidazoles		0.1	< 20	-	0	0.0	
Ukraine (HO, PR)	Sulfonamides + Trimethoprim	Sulfadiazine, Sulfamethazine, Trimethoprim	0.5	473		2	0.4	
	Tetracyclines	Oxytetracycline, Tetracycline	0.5	453		3	0.7	Positive in previous years
	Aminoglycosides	Streptomycin, Dihydrostreptomycin	0.5	502		15	3.0	Positive in previous years
	Macrolides	Tylosin A, Erythromycin	0.5	400		2	0.5	Positive in previous years
	Fluoroquinolones	Ciprofloxacin, Enrofloxacin	0.5	323		5	1.2	Positive in previous years
	Nitrofuran metab.	AOZ, SEM,	0.2	513	2	17	3.3	
	Amphenicols	Chloramphenicol	0.05	474	1	2	0.4	
	Nitroimidazoles	Metronidazole	0.1	825	-	3	0.4	
Uruguay (HO)	Sulfonamides + Trimethoprim		0.5	68		0	0.0	
	Tetracyclines		0.5	67		0	0.0	
	Aminoglycosides		0.5	61		0	0.0	
	Macrolides		0.5	57		0	0.0	
	Fluoroquinolones		0.5	67		0	0.0	
	Nitrofuran metab.	SEM	0.2	123	0	1	0.8	New residue
	Amphenicols		0.05	68	0	0	0.0	
	Nitroimidazoles		0.1	< 20	-	0	-	
Vietnam (HO, RJ)	Sulfonamides + Trimethoprim	Sulfamethoxazole, Trimethoprim, Sulfamethazine,	0.5	381		1	0.3	Positive in previous years
	Tetracyclines	Oxytetracycline, Tetracycline	0.5	357		16	4.5	
	Aminoglycosides	Streptomycin, Dihydrostreptomycin	0.5	432		1	0.2	Positive in previous years
	Macrolides	Tylosin, Erythromycin, Lincomycin	0.5	90		2	2.2	
	Fluoroquinolones	Ciprofloxacin, Enrofloxacin, Norfloxacin	0.5	467		0	0.6	
	Dapsone		0.5	61		1	not calc.	New residue
	Nitrofuran metab.	SEM	0.2	165	0	5	3.0	
	Amphenicols	Chloramphenicol, Thiamphenicol, Florfenicol	0.05	464	0	4	0.9	Positive in previous years; Thiamphenicol: no RPA in place
	Nitroimidazoles		0.1	35	-	0	0.0	

CONCLUSION

The global honey market is and remains very dynamic and continually presents challenges for all actors in the supply chain. We have not registered a significant reduction in adulterated honey samples yet. Contaminants and residues are also still regularly detected in honey from all over the world. Last year we saw an increase in media coverage of these issues. Various projects have been initiated to specifically address the problem of adulteration. We at Intertek are actively committed to shaping the future of the honey market by taking part in these projects.

The results as always highlight the continued importance of rigorous quality control measures and the need for comprehensive industry standards for adulteration testing to ensure the purity and integrity of honey products available on the market.

HOW INTERTEK CAN HELP

We are one of the world-leading experts in the analysis of honey and hive products and offer a comprehensive service solution to the food industry, providing customers with a tailored service, with practical advice and fast, reliable test results. Each year we test approximately 60,000 honey samples for quality parameters, veterinary drugs and authenticity. This information is added to a comprehensive database which is used for providing specific analytical recommendations to our customers.

Intertek is a leading Total Quality Assurance provider to industries worldwide. Our network of more than 1,000 laboratories and offices in more than 100 countries, delivers innovative and bespoke Assurance, Testing, Inspection and Certification solutions for our customers' operations and supply chains. Intertek Total Quality Assurance expertise, delivered consistently with precision, pace and passion, enabling our customers to power ahead safely.

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