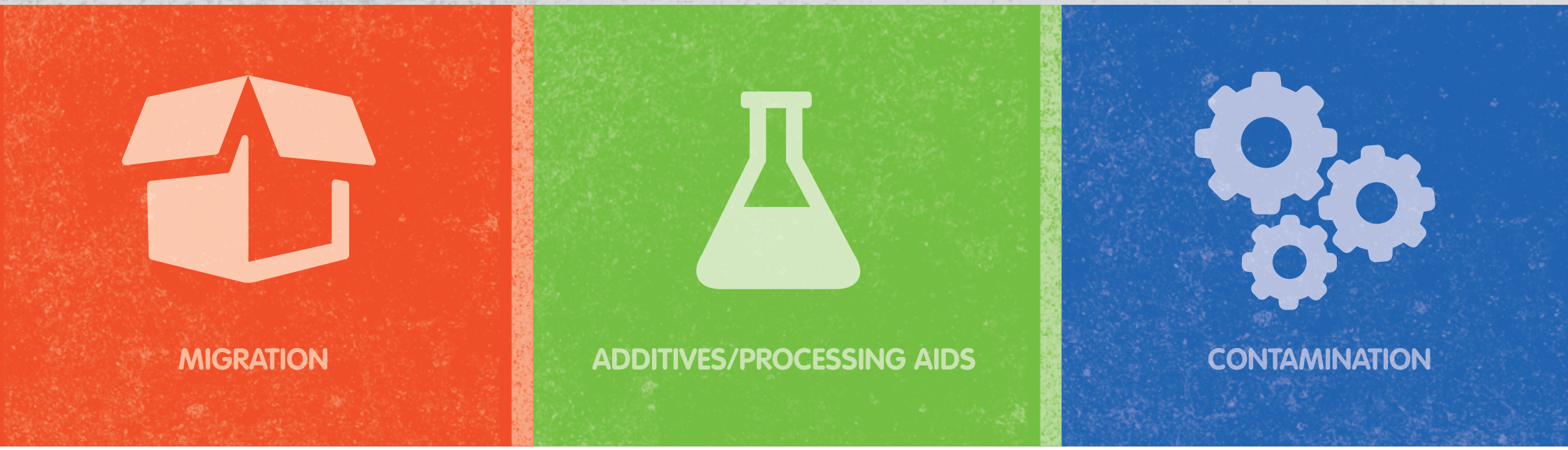
TOOLBOX FOR

PREVENTING THE TRANSFER OF
Undesired Mineral Oil Hydrocarbons into Food



FOODDRINK EUROPE
Enjoy food, today and tomorrow

BLL
Bund für Lebensmittelrecht und Lebensmittelkunde e.V.

SEPTEMBER 2018

CONTENTS

PREFACE

The presence of mineral hydrocarbons has caused concern in almost all sectors of the food industry – including laboratories and suppliers – for a number of years. The abbreviation "MOSH/MOAH" has been established as a (generic) term for all substances derived from mineral oil – including chemical analogues from non-mineral oil sources. Today, the complexity of the issue is well known and consideration of this topic has been expanded beyond "recycled fibre" as the source of contamination; it now includes all possible routes of entry along the entire value chain for food, and food packaging.

The industry is committed to reducing the transfer and the occurrence of undesired mineral oil hydrocarbons in food. As evidenced from several product tests and examinations, measures applied have so far yielded tangible results.

The prerequisites for an effective prevention are process analyses, the scale-up of findings and their strict application at industrial level.

This toolbox intends to summarise background information and provide practical support in decision-making. The *"Toolbox for preventing the transfer of undesired mineral oil hydrocarbons into food"* presented here by BLL, provides an overview of the routes of entry of mineral oil hydrocarbons – both those currently known and thought of as potential routes of entry (as per 2017). Based on this information, every individual company can then review its own processes and devise appropriate product-related measures for the reduction of contamination.

It is the intention of the "BLL Toolbox" to reduce preventable contamination with mineral oil as much as possible and to identify approaches that aim at reducing the amount of mineral oil contaminants (present in food). This procedure focuses on controllable sources along the entire value chain. Contaminations that are beyond any control, for example because of ubiquitous environmental pollution and indispensable substances, will be discussed. However, prevention or reduction does not mean that there are target values provided for analytical measurements across the board or that a general "zero tolerance" for mineral oil hydrocarbons is in place.

Rather, the point is to enable (food) companies to review appropriate and feasible problem-solving approaches while exercising their due diligence. This concept aims at shared responsibilities for all levels of the entire value chain, and promotes the ALARA principle, wherein the presence of a contaminant is reduced to "as low as reasonably achievable".

The BLL Toolbox is intended for the food industry, and we hope to make it accessible to all interested stakeholders. BLL, in producing this document, will also contribute to increased objectivity in resolving related issues and to strengthening the discourse within the supply chain, with official authorities as well as in political and public domains. The BLL Toolbox is not a final document, but will rather evolve and develop in light of future findings.

The BLL is grateful to the Association of the German Confectionery Industry (BDSI) and the Food Chemical Institute (LCI) for providing the BDSI Toolbox as a template. The BLL also wishes to thank the group of experts amongst its members for their active support.

Berlin, December 2017

FoodDrinkEurope, representing Europe's food and drink industry, would like to commend BLL for their hard work in preparing this toolbox, and offer its full endorsement.

Brussels, September 2018

INTRODUCTION

A 2013 study on the "Scope of migration of undesirable substances from packaging materials made from waste paper into food" showed the possible pollution of packaging made from recycled fibres and the migration of mineral oil hydrocarbons, in particular. According to this study, which was performed on dry food in folding boxes made with recycled fibres, there is a high number of potentially migrating substances that may be introduced from the waste paper into the packaging material, which renders it impossible to perform a risk assessment of the individual substances. Therefore, "functional barriers" have clearly been recommended as protection of foods in such packaging[1].

As the industry – including suppliers of paper-packaging materials, plastics, and printing inks – becomes more aware of the issue of mineral oils, there are more findings available today on possible routes of entry and sources of contamination, on avoidable and unavoidable ubiquitous loads and on analytical problems.

Preventative approaches in practice and within individual companies are varied and may apply to all or almost all of the stages of different processing chains. The complexity of food and packaging materials can present a challenge, because it can be difficult to identify one single potential entry source in the production process, or because several sources and/or routes can play a role. Apart from recycled fibres contaminated with mineral oil residues from printing inks used in paper and cardboard packaging materials, there are also sources of contamination that stem from the use of certain substances.

Moreover, all refined mineral oil products including paraffin, microcrystalline wax and plastics are composed of hydrocarbons of mineral origin and thus belong to the group of MOSH when considered in terms of composition. For the purpose of differentiation, the material groups that are directly derived from fossil mineral oil are grouped in the Toolbox under the term "MOSH analogues".

However, the impossibility of analytical separation may lead to misinterpretation of results, e.g. with mineral oils from food additives or processing aids based on mineral oil. Often "humps" where the data is misinterpreted as MOSH in food and exclusively considered as "mineral oil contamination" will occur. Without scrutinising potential MOSH analogues specific to the product and process, this may lead to unjustified and wrong conclusions.

1 Project to support decision-making, German Federal Ministry of Food, Agriculture and Consumer Protection, from 2010 to 2012, publication in 2013.

RELEVANT DEFINITIONS

The following terms are used for mineral oil hydrocarbons (MOH = Mineral Oil Hydrocarbon):

- **MOSH** = Mineral Oil Saturated Hydrocarbons: paraffin-like, open-chained, commonly branched hydrocarbons (e.g. alkanes) and naphthene-like cyclic hydrocarbons (cycloalkanes) [2,3]
- **MOAH** = Mineral Oil Aromatic Hydrocarbons: hydrocarbons mainly consisting of highly alkylated mono- and/or poly-aromatic rings [2,3]

A large variety of possible compounds may be summarised under these terms that can be detected as complex mixtures of saturated (aliphatic) or aromatic hydrocarbons in food.

The following groups of materials play a role as so-called **MOSH analogues**:

- **MORE** = Mineral Oil Refined Products: certain MOSH that may be introduced into food through the use of additives and processing aids that are approved refined mineral oil products, such as paraffin-like waxes
- **PAO** = Poly-alpha olefins: components in synthetic lubricants and hot melt adhesives that may migrate into food. Difficult to differentiate analytically from MOSH
- **POSH** = Polymer Oligomeric Saturated Hydrocarbons: oligomers of the plastics polyethylene or polypropylene. Chemically similar to MOSH and cannot be separated analytically

MOSH analogues result in elevated analytical MOSH values and thus in a shift in the MOSH:MOAH ratio (approx. 4:1) which is common in mineral oil and which may be considered as indicating a migration of mineral oil from recycled fibres. A deviating ratio is considered as indicating a false MOSH level and the presence of MOSH analogues. However, it is not possible to distinguish analytically between MOSH, POSH, PAO and MORE with the established methods.

OCCURRENCE MOSH/MOAH AND MOSH ANALOGUES

Inadvertent and unintentional presence

such as:

- packaging materials and transport materials for raw materials, intermediate products and final products, in particular through the use of paper waste from printed materials such as newspapers made with mineral-oil containing printing inks
- improper use of machine oils or lubricants or oil-containing compressed air throughout the entire raw materials and processing chain
- upstream treatment of packaging materials, process and transport materials with mineral oil products (e.g. mould oils or batching oils)

Targeted and necessary application of substances

such as:

- "food-grade" lubricants and technical lubricants
- oils for moulds and rollers, anti-friction agents for food contact materials
- white oils as food additives and processing aids
- waxes and paraffins as food additives, such as anti-caking or release agents, coating agents, brighteners
- waxes and paraffins as technical processing aids such as anti-foaming agents, anti-caking or release agents
- food contact materials made from plastics such as plastics packaging or processing materials
- adhesives, "hot melts", sealing agents
- components from animal drugs
- additives (carrier substances), adhesives or active agents in pesticides such as paraffin oil
- anti-freezing agents

Substances from these applications can be detectable in food or packaging tests due to the similarity in their structure with MOSH. These substances cannot be analytically separated with the current commonly applied measuring methods. It is therefore important that further information related to their relevance and the route of entry is shared and discussed in this Toolbox. These substances are often used for process or food technology reasons and are difficult to replace, thus making it impossible to prevent transfer or migration. However, such substances should only be used in technically required amounts ("as little as possible, as much as necessary" or quantum satis).

However, process analyses shall deal with all imaginable incident and improper use at the different stages.

Natural occurrence and biogenic substances

such as:

- natural waxes in vegetable food including fruits and vegetables
- biogenic waxes, terpenes, n-alkanes, olefins, e.g. from vegetable raw materials, which may be a concomitant substance in vegetable oils in flavours or in pectin (from apple or citrus pomace)

Hydrocarbons, innate to natural raw materials, may also be analytically relevant MOSH analogues. Thus their presence in certain vegetable-based foods (tea, herbal infusions, herbs, spices) is inevitable, even if no mineral oil based processing aids or additives are used.

Furthermore, natural hydrocarbons such as olefins, terpenes and carotenoids may increase the analytically detected MOAH value.

Ubiquitous loads and environmental impacts

such as:

- emissions
- oil vapours
- combustion gases
- particulate airborne matter
- soot

Mineral oil hydrocarbons that are ubiquitously present in the environment may migrate into food raw materials, e.g. through agricultural measures, transport and handling, storage or processing. This migration is unavoidable.

ROUTES OF ENTRY INTO FOODS

From the described sources, MOSH, MOSH analogues and MOAH can migrate along the entire process chain into foods using different routes.

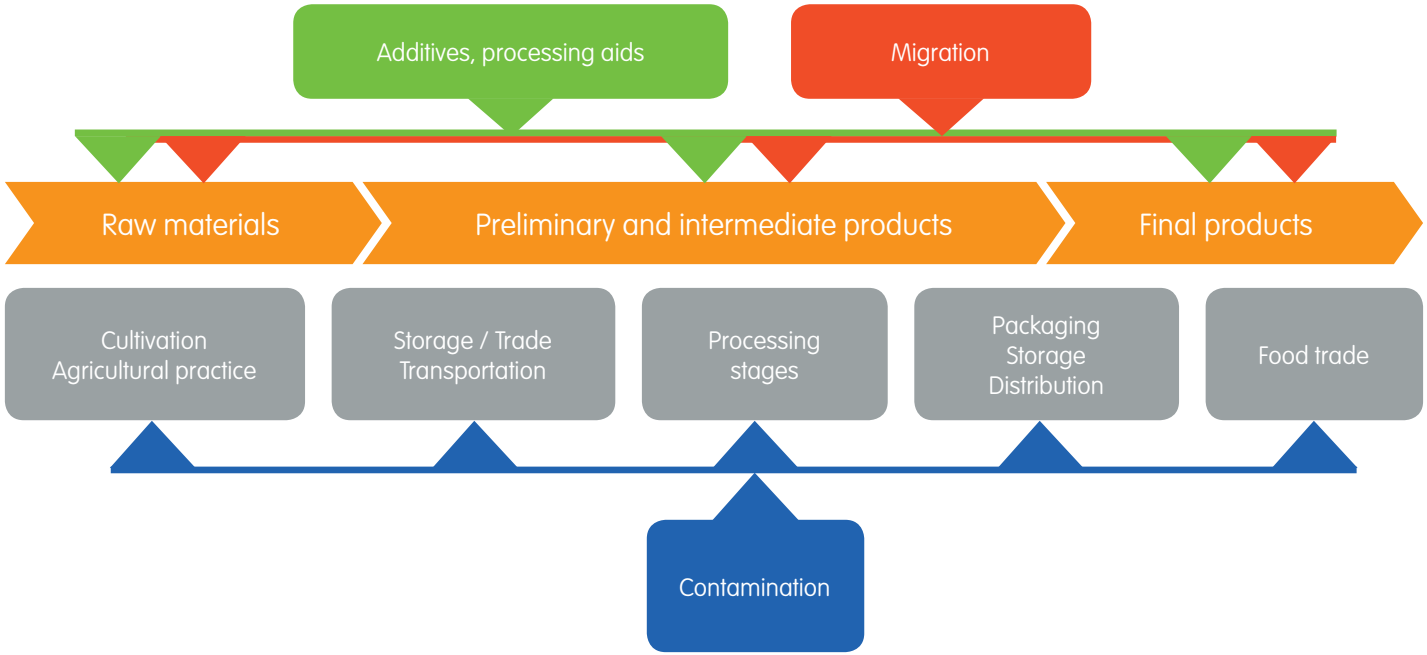


Figure 1: Systematic illustration of the routes of entry of MOSH/MOSH analogues and MOAH into food (according to [4])

Possible and relevant routes of entry include:

Mineral oils may **transfer or migrate** to products packed in packaging materials that contain recycled fibre and/or from packaging with printing inks containing mineral oils. Transfer does not necessarily require direct contact between food and the material that contains the migrating mineral oil hydrocarbons such as the recycling material; it can also be gas-borne, which can make it harder to identify the source.

It has been possible to minimise, to a large extent, contamination caused by printed food packaging by changing to non-mineral oil or low-mineral oil inks [5, 6].

Potentially, transfer through migration from upstream packaging of food raw materials and semi-finished products is possible during transport and storage.

Migration into food is temperature-dependent and occurs in general via evaporation, transportation in the gas phase and re-condensation in the food. At ambient temperatures, it is the mineral oil hydrocarbons with a chain length of up to C25 that migrate; the migration of MOH with a chain length over C25 requires direct contact [1] or elevated temperatures.

Unintentional **contaminations** are possible along the processing chain. The reasons for this are numerous: the general environment may lead to unavoidable contamination of food raw materials with mineral oil hydrocarbons, for example from combustion processes (amongst others, exhaust gases from combustion engines, emissions from the energy supply and industrial plants, wildfires etc.) and through particulate matter from paved roads. Alternatively, it is possible that oiled machine parts can be the source of contamination when they come into contact with the raw materials or foods during harvesting or production.

Moreover, the use of **certain approved food additives and processing aids**, which are applied in many food processing areas and stages, may be the source of transfer of mineral oil compounds into food. These are permissible and often technologically necessary applications. In these cases, it is only the MOSH analogues that are transferred because the substances are usually purified products such as approved paraffin-like waxes that are derived from refined mineral oils or white oils [9].

GENERAL INFORMATION ON ANALYSIS AND ISSUES OF MOSH ANALOGUES

The determination of mineral hydrocarbons in food is a highly challenging analytical task because they are present as a complex mixture that needs to be quantified as a sum of all components. Due to the extremely high number of individual chemical compounds, it is not possible to analyse individual components.

This is the reason why an analysis of complex mineral oil mixtures by gas chromatography does not deliver distinct peaks, but rather broad signals. Such phenomena are referred to as chromatographic "humps" or "unresolved complex mixtures" (UCM) by analytical chemists.

The Scientific Opinion on Mineral Oil Hydrocarbons in Food published by EFSA [2] recommends that for quantification, a system consisting of liquid chromatography (LC) online coupled with gas chromatography with flame ionisation detection (online LC-GC-FID) be applied.

In July 2017, for the first time a standardised European method for the quantification of MOSH/MOAH in certain foods was published:

> — DIN EN 16955: 2017-08 "Foodstuffs – Vegetable oils and foodstuffs on the basis of vegetable oils – Determination of mineral oil saturated hydrocarbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH) with online HPLC-GC-FID analysis".

This European standard is essential in comparing the levels determined in different laboratories. The reference method has been confirmed in ring tests; it is suitable for MOSH and MOAH concentrations above 10 mg/kg each in food based on vegetable fats. According to the standard's recommendation, the fossil origin of the MOSH and MOAH fractions shall be verified by mass spectrometry (GC-MS) [10].

The performance achieved in MOSH/MOAH analysis via LC-GC-FID is dependent on the matrix of the food sample and on fat content in particular. Detection limits and the uncertainty of measurement increase with the fat level in the sample matrix.

Currently the sample preparation methods in the labs are usually performed based on the joint mineral oil analysis compendium of the Federal Institute for Risk Assessment (BfR) and the Cantonal Laboratory of Zurich (KLZH): "Determination of mineral oil hydrocarbons in food and packaging material" [11].

The MOSH/MOAH Ratio/Clarification and interpretation of MOH values

It is known that the targeted use of processing aids and approved food additives in the form of refined mineral oil products (MORE) such as paraffin-like waxes increases the MOSH level and results in a shift of the MOSH:MOAH ratio characteristic for mineral oils. Since it is not possible to distinguish MOSH, POSH, PAO and MORE analytically in online coupled LC-GC-FID, a mass spectrometric method such as two-dimensional gas chromatography mass spectrometry (GCxGC-TOF-MS) may be helpful for further characterisation of the substance classes present. The European standard DIN EN 16955 as well as some newer publications refer to this method [12, 13].

There is no possibility of differentiating directly between the introduced MOSH, MOSH analogues (from mineral oil products such as paraffin) or POSH from plastics or adhesive applications or partially detected native saturated hydrocarbons with the currently commonly applied LC-GC-FID analysis method.

Other MOSH-like structures, so called Polyolefin Oligomeric Saturated Hydrocarbons (POSH) from polyethylene (PE) or polypropylene (PP) films or polyalphaolefins (PAO), which are components in synthetic lubricants and hot melt adhesives, further complicate the analysis. The respective substances may migrate into food; they are difficult to distinguish analytically from MOSH introduced from mineral oil [14].

Fossil mineral oil typically has a MOSH:MOAH ratio of 4:1; technical mineral oil products such as lubricants or printing ink oils still show this characteristic MOSH:MOAH ratio (15-35% MOAH in the MOH concentration) [2]. This is why such a finding can be taken as an indicator for a direct transfer of mineral oil and for recycled fibres with printing ink oils as sources. In purified, refined mineral oils (white oils) the percentage of MOAH is lower. Therefore, contaminations stemming from the use of products that are based on such refined mineral oil products, such as paraffin-like waxes, will increase the percentage of saturated hydrocarbons as MORE. Because these contaminations are in almost all cases free from MOAH, the MOSH:MOAH ratio varies depending on the MOAH analogues detected with this method [14] (**see figure 2**).

In order to correctly interpret MOSH values detected in food with common analysis methods (LC-GC-FID), differentiating questions and information must be evaluated, including:

- Does the MOSH:MOAH ratio indicate the presence of fossil MOSH from crude oil?
- Do other substances such as diisopropylnapthalene (diPN) indicate a migration from recycled fibres?
- Are there indicators for plastic-specific oligomers (POSH)?
- Which packaging materials, processing aids and additives are known to have been used along all different process stages?

In the case that information indicates sources other than recycled fibres or MOSH/MOAH of fossil origin, further verification is recommended. However, this does not guarantee that the actual source of contamination can be unequivocally determined.

The comparison of so called "fingerprints", e.g. of mineral oil based lubricants could in individual cases lead to their identification as sources.

The commonly used unspecific summarising statement "MOSH/POSH" per kilogram of food for MOSH findings and presumed MOSH analogues may be taken as a general indicator for several sources but will still require clarification. If for example the MOSH:MOAH ratio or other product information gives rise to the suspicion that possible sources other than mineral oil from recycled fibres play a role, confirmatory analysis with mass spectrometric methods such as GCxGC-TOF-MS is required; however these are not suitable for routine analyses. The comparison of so called "fingerprints", e.g. of mineral oil based lubricants could in individual cases lead to their identification as sources.

Even if it is not possible to clearly identify the source, misinterpretations based on "false-positive results" and the resulting consequences within the supply chain will be avoided.

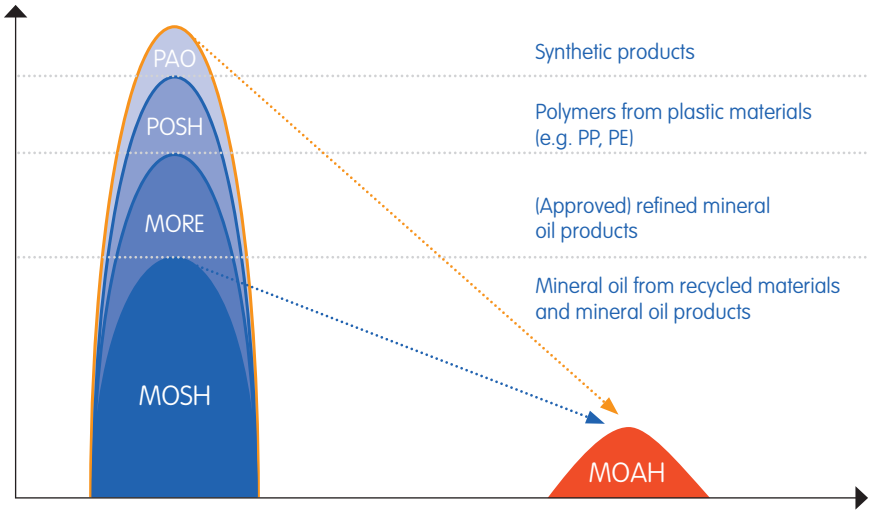


Figure 2: Shifting of the MOSH:MOAH ratio commonly found in mineral oil by MORE, POSH and PAO as MOSH analogues *[according to 14 and 15] (for abbreviations see definitions and text)*

Other interferences in the LC-GC-FID chromatogram may be caused by natural hydrocarbons, which co-elute in the MOAH fraction in the hump. For example, olefins, terpenes and carotenoids that are naturally present in the food may by detected together with the MOAH fraction and thus increase the apparent MOAH concentration. According to the latest findings, extractable substances from wood such as abietic acid derivatives as well as resin compounds that are naturally present in papers or are used as binding agents in printing inks will also play a role. It is not clear whether these can be excluded by epoxidation.

Employing epoxidation (e.g. with meta-chloroperbenzoic acid, m-CPBA) for purification allows the separation of these biogenic hydrocarbons analytically from the MOAH compounds. It should be noted that with this purification step, aromatic components might also be removed, depending on the amount of epoxidation reagent, thus resulting in possible false low readings for MOAH. Some substances with a natural origin (not POSH) might be present in the MOSH hump. A possibility to remove them is to apply a second LC clean-up with aluminium oxide. This clean-up can remove up to 40% of the MOSH, however, and is consequently difficult to justify application.

FOOD SAFETY INFORMATION

In its opinion of 2012, the EFSA identifies human exposure to mineral oil hydrocarbons from different sources between 0.03 and 0.3 mg MOH / kg body weight; in children the recording is higher. It is assumed that about 20% of this intake is from MOAH [2].

Saturated hydrocarbons may accumulate in human fatty tissues. MOSH with a carbon chain up to C45 was detected and quantified in rats' organs (liver, spleen). MOSH with a carbon chain below C16 does not accumulate in the human body [2, 16].

The Federal Institute for Risk Assessment (BfR) has defined a value of 12 mg/kg food for MOSH with a carbon chain length of C_{10} to C_{16} as a reference value for a tolerable migration from papers, cartons or cardboards made with recycled fibres. For a chain length of $>C_{16}$ to C_{20}, a tolerable migration level of 4 mg/kg food was established [17, 18].

Due to missing toxicological data, no tolerable migration has thus far been defined for the other fractions. Since 2014, studies with newer data have been performed on the accumulation of MOSH with different molecular weights within the scope of an EFSA project aimed at further assessment of the toxicity of MOSH. The EFSA has not yet published a new Opinion (as of December 2017) [19].

Because the MOAH fraction mainly consists of highly alkylated aromatic hydrocarbons, which may also include some potentially carcinogenic compounds, no tolerable intake levels for MOAH have been defined.

RECOMMENDED PRACTICE

European Monitoring

In 2017, the European Commission (EC) adopted Recommendation EU 2017/84 on the monitoring of MOHs in food and in Food Contact Materials.

The European Commission has requested that Member States with the active involvement of food business operators as well as manufacturers, processors and distributors of food contact materials and other interested parties, monitor the presence of MOH in food during 2017 and 2018. The monitoring should cover animal fat, bread and rolls, fine bakery ware, breakfast cereals, confectionery (including chocolate) and cocoa, fish meat, fish products (canned fish), grains for human consumption, ices and desserts, oilseeds, pasta, products derived from cereals, pulses, sausages, tree nuts, vegetable oils, as well as food contact materials used for those products. The monitoring process will create a database for a science-based assessment of exposure and risk evaluation by EFSA. For concrete implementation of monitoring, the European Joint Research Centre (EU-RL, Ispra) shall develop specific guidelines based on the methodology developed by BfR/KLZH. These have not yet been published (as of July 2018).

In view of EU Monitoring according to Commission Recommendation (EU) 2017/84 [22] introduced by the European Commission in January 2017, this Toolbox can also be viewed as a collection of potential sources of contamination and information about the products and process chain highlighted in the recommendation.

Germany

There is no binding regulation containing legal limits in place.

For findings in food or packaging materials, evaluation in principle uses as a basis the general food legislation (according to EU Basic Regulation 178/2004 and framework regulation (EC) No 1935/2004 on food contact materials).

For paper packaging materials, evaluations may use the BfR XXXVI Recommendations on papers, cartons and cardboards as food contact materials. Since paraffin-like hydrocarbon solvents are used as a formulation aid in paper production, they specify the migration level of hydrocarbons (up to C20) corresponding to toxicologically deduced limits (see above) [17] as follows:

- 12 mg/kg food for $C^{10} – C^{16}$
- 4 mg/kg food for $C^{17} – C^{20}$

According to the last (4th) draft of the German "Mineral Oil Regulation" (22th Ordinance amending the Consumer Goods Ordinance) of the Federal Ministry of Nutrition and Agriculture (BMEL) of March 2017 [20], no migration of MOAH into food shall be permitted from food contact materials that are produced with the use of recycling materials. The migration of <0.5 mg MOAH/kg food or food simulant is considered to be "not detectable". In order to achieve this, a legal ban is being considered on the production and marketing of MOAH-contaminated packaging materials made from recycled paper to be used as food contact material without a functional barrier. If migration can be excluded, the regulation will provide for certain exemptions from the obligatory barrier.

In the current (4th) draft, there is no intention to regulate MOSH in recycled fibre containing packaging material or to specify MOSH migration limits in food. According to the official reasoning in the draft, it is not necessary in terms of consumer health protection. Moreover, because of the issue of MOSH analogues, there is no valid measuring method available that specifically detects MOSH only.

The following limits from earlier BMEL drafts are obsolete and may at best only be considered for orientation:

- Recycled fibre material for food contact: 24 mg MOSH/kg paper and 6 mg MOAH/kg paper
- Migration limits for food in packaging containing recycled fibre : 2 mg MOSH/kg food and 0.5 mg MOAH/kg food

When using these values for product evaluation or in specifications, it should be noted that they are by definition migration limits, which have been proposed for the migration of MOSH/MOAH from one single source, which is packaging materials made with recycled fibres. Therefore, these values cannot be translated into generally applicable MOSH and MOAH limits in food as they are too restrictive.

Belgium

In Belgium, since November 2017, the recommendations of the Belgian Food Safety Authority FAVV have applied as assessment criteria for MOSH levels in food. The FAVV has derived "action limits" for MOSH (C_{16}-C_{35}) from the ADI values of EFSA and described for several food groups [21]:

- 5 mg MOSH/kg milk and milk products
- 15 mg MOSH/kg food for cereals
- 20 mg MOSH/kg food for vegetable products, snacks and desserts
- 30 mg MOSH/kg for products of animal origin, sugar and confectionery
- 60 mg MOSH/kg food for fish and fish products
- 70 mg MOSH/kg food for spices and herbs
- 100 mg MOSH/kg food for animal and vegetable oils
- 150 mg MOSH/kg food for vegetables, tree nuts and oil seeds as well as for egg products

INFORMATION ON THE SELECTION AND EVALUATION OF BARRIER MATERIALS

When using packaging materials with recycled fibres, the migration of mineral oil components is not only dependent on their level in the packaging materials but also on the type of food and the condition of its storage. For many packaging concepts, inclusion of an appropriate "functional barrier" is the method of choice. Functional barriers are defined as layers or coatings of the packaging material that ensure that – according to the respective length of time and application – no undesired substances will migrate. This means that no general statements can be made on the effect of barriers.

Paper liners or liners based on polyolefins will delay migration but do not stop it completely. They are not considered to be "barriers" for the migration of MOSH and MOAH. Polypropylene (PP) films have a limited barrier effect that depends on layer thickness as well as on the time and temperature profiles. Aluminium, polyethylene terephthalate (PET) or polyamide (PA) barriers as composite layers are considered to be migration-proof barriers that are able to almost completely prevent migration of MOSH and MOAH. However, the potential migration of plastic oligomers such as POSH must be taken into consideration.

Other functional barrier materials, e.g. for liners (Bag-in-box), besides PA and PET, include (among others) ethylene-vinyl alcohol copolymer (EVOH), polyvinylidene chloride (PVDC) or bi-axially oriented polypropylene (BOPP).

For the modification of recycled fibre containing paper and carton materials (such as folding boxes), various barrier materials have been developed, such as plastic coatings, coatings with other materials, adsorbing layers, etc.

The possibility of predicting the extent of mineral oil migration is essential for the selection of suitable packaging materials aimed at preventing it. Different concepts and measuring methods are available for functionality tests of barrier layers and adsorbing materials. MOSH and MOAH are mixtures of substances that make the prediction of permeation rather complex, and therefore individual case studies are required [23, 24].

The permeation of a substance through a functional barrier is influenced by, amongst others, concentration in the contaminated packaging material or in the gaseous phase, thickness and quality of the barrier layer, packaging design, and temperature. The diffusion coefficient in the barrier layer is the material constant that is decisive for the evaluation of mineral oil barriers. The characteristics of a functional barrier may be determined with the following methods [25]:

- Migration tests
- Permeation tests with static acceptor
- Permeation tests with dynamic acceptor
- Lag-time tests

Within the scope of a research project conducted by the Fraunhofer Institute for Process Engineering and Packaging (IVV), guidelines are being developed that can be used to assess migration behaviour and the interaction of the food matrix and the type/design of packaging. The results of this research project will eventually introduce guidelines on predictability, using mathematical modelling and will be shared with the industry (Research Association of the German Food Industry, research project "Minimisation of mineral oil migration", AiF research project no. 19016N, as of November 2017).

THE BLL TOOLBOX CONCEPT

Use and objectives of the Toolbox

The information in this BLL Toolbox will help to identify appropriate and constructive approaches for the prevention and reduction of MOSH and MOAH. This applies to the different stages of the sometimes highly complex processes and value-added chains in the food industry.

Use of one tool cannot aim for total treatment or elimination of an identified source. The Toolbox will contribute to a company's decision-making process in overall risk assessment and prevention of transfer.

Therefore, the objective is to enable individual companies to control the risk of transfer of mineral oil as much as possible by implementing practicable solutions. Within the scope of a risk-based procedure, the prevention of migration of MOAH is key.

In terms of MOSH and MOSH analogues, the Toolbox shall support the discussion on the limitations of technical avoidability in particular of ubiquitous or systemic transfer or migration from indispensable processing aids.

Analysis allows verification of whether a prevention measure is successful. Examinations shall be performed as stage controls and as close to the source as possible. In complex processes, there are several routes of entry for MOSH and MOSH analogues which renders final product control unfit for monitoring the performance of a measure aimed at reducing migration or contamination. Moreover, requests for complete "absence of MOSH" as a result of such implemented measures are neither feasible nor the goal of an appropriate prevention strategy based on the ALARA principle.

The collection of information in the BLL Toolbox does not claim to be complete and should not be considered as a "best practice" document. The procedures introduced here are simply examples; they are based on the state of knowledge and current research (as per December 2017).

Organisation of the tools and notes

The Toolbox is structured along the potential routes of entry (see also Figure 1):

The following tables with the tools are organised as follows:

Sequential number	To facilitate discussions
Source	Subject matter, substance or material that may result in the entry of MOSH, MOAH or MOSH analogues
Route of entry/cause	Possible path of transfer/migration of MOSH, MOAH or MOSH analogues or causes
Saturated and unsaturated mineral oil hydrocarbons/groups	Expected substances or substance groups in relation to the route of entry or cause, defined and differentiated here (see "relevant definitions" and Figure 2) — **MOSH/MOAH** — **PAO, POSH, MORE and other MOSH analogues**
Tool	Proposal of a possible action based on specific reduction or prevention measures for such entries
Notes and examples	Exemplary information which may facilitate understanding and decision making – no claim for completeness
Reference	Relevant literature is listed under References (see below); oral notes from experts are described as [Expert]

Recommendations in the Toolbox: Specification within the supply chain

Communication along the supply chain may be a decisive factor in the minimisation of risks and prevention of undesired entries. Experience shows that an example of suitable communication within the supply chain is coordinated specifications, containing product-related requirements agreed upon with suppliers and customers. Therefore, the use of "specifications" as a supporting tool will be recommended at different points throughout this Toolbox.

In this context, the BLL would like to refer to the information leaflet "Specifications in the food packaging chain" (2011): https://www.bll.de/de/lebensmittel/verpackung.

The symbol  indicates that respective specifications should be reviewed at this stage.

I. INFORMATION ABOUT THE TOOLS: MIGRATION

Migration predominately takes place via packaging materials made with recycled fibres. These materials can be used at all stages (production, storage and processing of raw materials, transport, refining and production, trade) of the food supply chain.

The points of entry are possible at all processing stages of a value chain.

TOOLS: Migration

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
1	Paper/ carton/board	Primary packaging	**MOSH/MOAH**	Where necessary, use **fresh fibre products**: Bags, folding boxes and corrugated board made from fresh fibres	• Consider recommendations (BfR or CoE) for the production and use of papers, cartons and cardboard that come into contact with food; GMP guidelines of the associations for folding boxes and prints. • Not all fresh fibres are free from MOSH/MOAH because entry through processing aids used in paper production is possible; fresh fibre fraction can absorb MOSH/MOAH during storage; fresh fibre is not a barrier. • Ex: Specified primary fibre cartons according to DIN, such as GC1, GC2, GN4 and others.	[6a] [6b] [17] [27] [26]
2	Paper/ carton/board	Primary packaging	**MOSH/MOAH**	Where necessary, use **functional barriers** for final product packaging: coatings, bag-in-box systems or liners (Kraft bags), corrugated boards Applies also to packaging of upstream products	• Use barrier materials suitable for raw materials/ upstream and intermediate products: • coatings: co-extruded plastics or surface finish of cartons, e.g. in cartons or paper bags • Ex: Barrier optimised products, e.g. for folding boxes or corrugated paper cartons. • EVOH, PVDC, PA, PET, BOPP for bag-in-box	[17] [24] [25]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
3	Paper/ carton/board	Primary packaging	**MOSH/MOAH**	When using **barrier materials**: ● Consider **permeation time** of barrier ● Adapt packaging design	● Depending on the nature and storage conditions of the food, permeation of MOSH/ MOAH is possible via the sponge effect. ● Within one packaging unit, the parts at the edges may be more contaminated than parts in the middle. There are different suppliers of barrier-optimised products on the market. ● Suitable barrier layers delay migration. When using recycled material, combination with barrier or absorber materials is possible. ● Trimmed edges should be reduced, and flap surfaces that are freely accessible in the packaging head space minimised.	[25] [24] [6b]
4	Paper/ carton/board	Primary packaging	**MOSH/MOAH**	When using **recycled materials**: ● Specify **quality** (define max. MOSH/MOAH level) ● Check for food-grade quality ● Choose **the storage and transport conditions** for making migration impossible	● When using recycled fibre in the production of food contact materials, the selection of the type of waste paper is relevant. ● There should be no use of recycled fibre material for large-surface primary packaging for dry, non-fatty food including flour, semolina, rice, sugar, etc., without suitable barriers. ● Migration is dependent on contact time and storage temperature. ● There is no relevant migration into frozen products and at short contact times. ● Therefore, transport cartons made from recycled fibres should be removed as soon as possible; transport cartons made from corrugated board should not be used to store produce.	[17] [27] [10] [1]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
5	Paper/ carton/board	Primary packaging	**MOSH analogues (MORE)**	Request information on the **materials** used in paper production and finishing: ● Request the use of **glue substances** that do not transfer any MOSH analogues ● Avoid **waxes** used for paper production ● Use non-paraffin anti-foaming agents	● Glues are used in paper production to keep the ink (in the pulp); they may give false positive results, Ex: Wax and paraffin dispersions, di-alkyl (C10-C22) diketene. ● Waxes make the papers easier to print (water-repelling action); introduction in coating; gives false positive results. ● Paraffin oils may be used as anti-foaming agents.	[17]
6	Paper/ carton/board	Secondary packaging	**MOSH/MOAH**	See tools: Primary packaging	● Migration in secondary packaging made from corrugated board is relevant only if the primary packaging has no barrier properties. ● In this case, use of cartons based on recycling materials and the type of barrier should be reviewed.	[Expert]
7	Paper/ carton/board	Transport packaging, tertiary packaging	**MOSH/MOAH**	See tools: Primary packaging	● Transport packaging includes several packaging materials for the purpose of transportation or storage. ● Transport packaging for the delivery of primary and secondary packaging or packaging components must be such as to exclude any influence. ● Where necessary, use barrier materials.	[Expert]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
8	Paper/ carton/board	Container linings/ liners	**MOSH/MOAH**	Use of low mineral oil linings (dressings), in particular for sea transport 	• Container dressings for the transport of bulk and bagged goods in containers or open bulk goods should be free from mineral oils and free from waste paper substances or equipped with functional barriers. • Concretise FCC guidelines.	[28] [29]
9	Paper/ carton/board	Container liners	**MOSH/MOAH**	Use alternative materials for the absorption of moisture/humidity in transport containers 	• Refrain from using carton dressings made from waste paper or based on recycling materials.	[28]
10	Paper/ carton/board	Secondary packaging	**MOSH/MOAH**	No heat treatment of raw materials (e.g. melting) or intermediate products inside the packaging (applies in particular to plastic or carton packaging). Remove packaging materials completely. Avoid open liners in closed cartons	• Heat makes MOSH/MOAH leak from secondary packaging such as corrugated board, e.g. by warming or melting of fats or decontamination of powders.	[Expert]
11	Printing ink	Primary packaging	**MOSH/MOAH**	Use low migration and mineral oil free inks 	• Apply FFI/ECMA and EuPIA recommendations with GMP guidelines.	[30] [6a] [6b]
12	Printing ink	Primary packaging	**MOSH/MOAH**	Prevent carry-over of mineral oil containing inks in the printing company	• Carry-over of mineral oil containing inks from other printing processes during machine re-configuration in the printing company. • "Good Manufacturing Practice", while considering GMP guidelines, should be applied.	[Expert] [6a]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
13	Printing ink	Primary packaging	**MOSH/MOAH**	Use functional barrier with packaging with inside print	• Use mineral oil free printing inks for inside printing as well. • Even mineral oil free printing inks may result in false-positive findings caused by concomitant substances with binding agents.	[Expert] [Expert]
14	Printing ink	Primary packaging	**MOSH/MOAH**	Avoid contact of printed surfaces with food contact material surfaces	• Apply FFI/ECMA and EuPIA recommendations. • Printing according to the stipulation of the GMP Regulation No 2023/2006 (Annex 1).	[13] [6a] [6b]
15	Adhesives	Primary packaging and secondary packaging	**MOSH/MOAH** **MOSH analogues (PAO, MORE)**	Request use of adhesives that release no or only minor amounts of low molecular hydrocarbons; use of seal/reseal adhesives that do not release any low molecular hydrocarbons	• Hot melts, pressure-sensitive adhesives, water-based adhesives, seal/reseal adhesives are sources of MOSH and MOSH analogues (PAO). • Adhesives may release low molecular hydrocarbons that migrate.	[31] [32]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
16	Plastics	Primary packaging	**MOSH analogues (POSH)**	When using plastic materials as functional barriers, make sure that they have sufficient barrier properties, e.g. suitable layer thickness or composite design 	• Migration of POSH from plastic layers is possible and likely • In particular PP/PE plastics may give false positive results through the migration of POSH. There is no way to separate MOSH and POSH analytically. Consider respective SML and total migration according to Regulation (EU) 10/2011. Multi-component materials or acryl lacquer may reduce migration of POSH. • This refers to foil and composite packaging, e.g. bags, big bags, PE liners, jerry cans, transport boxes, containers, sealing foil (foil on trays) and others. • Possible increase in POSH levels with heat treatment, e.g. melting of fats in bags. • Production oils (technical white oils) may be used in the production process and may be MOAH sources.	[33] [Expert]
17	Plastics	Secondary packaging	**MOSH analogues (POSH)**	Select materials with appropriate barrier properties 	• Barrier properties of the secondary packaging serve as protection against migration from transport and/or tertiary packaging, e.g. shrink foil, wrapping foil. • However, for materials with absolute barrier properties, no discharge through "gassing" is possible.	[Expert]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
18	Jute and sisal fibres	Bags	**MOSH/MOAH**	Request use of suitable jute bags according to IJP (food grade) and use of vegetable batching oils 	• Refers to e.g. transport of bulk goods such as cocoa beans, grains, spices in jute bags from countries of origin; no sufficient definition of "food grade quality". • Comply with IJO Standards, no quality standards as regards MOSH/MOAH levels.	[28] [34] [35]
19	Metal foil/ metal sheets (lacquered/ laminated)	Primary packaging	**MOSH analogues (MORE)**	Avoid surface lubricants on MOH or MORE basis, if possible Do not allow inevitable residues of rolling oils or rolling emulsions Both sides in the case of rolled or stacked products Use MOSH/MOAH-free coatings and lacquers 	• Rolling oils or rolling emulsions are used for the production of metal foils, in general paraffin oils which may introduce MOSH analogues. • In the case of lacquered or laminated applications, the foils/sheets must be annealed and the rolling oils used evaporated. • Consider lacquer and laminating components because they may contain MOSH analogues (MORE). • Consider printing ink specifications for printing and avoid contact with the inside of cans.	[Expert] [36] [44]
20	Composite materials Laminates	Primary packaging	**MOSH/MOAH**	Use suitable materials with appropriate layer thickness as barrier materials. For aluminium foil, a thickness of 6 µm is considered to be suitable depending on the other composite materials Review packaging tightness under consideration of the closing technology 	• Specify aluminium tightness (pin holes/defects) for aluminium foils and composite materials. • For beverage cartons, a common layer thickness is 6.25 µm. • Metal coatings other than metal or aluminium foils are in general not a barrier for MOSH/ MOAH.	[24] [Expert] [44]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Notes/examples	Reference
21	Laminated composite foils	Primary packaging	**MOSH/MOAH** **MOSH analogues (POSH)**	Use suitable carrier materials (plastics) with appropriate layer thickness 	• The requirements of Plastics Regulation No 10/2011 in combination with declarations of compliance apply. • E.g. composite bag as inside bags.	[Expert] [24]
22	Metal foils/ sheets with non-lacquered/ non-laminated metal surfaces	Primary packaging and preliminary stages of primary packaging	**MOSH/MOAH** **MOSH analogues (MORE)**	Avoid residues of roller and mould oils (surface lubricants) 	• Rolling oils based on MORE are used for the production of metal foils or sheets instead of rolling emulsions. Usually they comply with the FDA purity requirements. • In any case, a soft anneal process has to be applied prior to further processing in order to evaporate rolling oil residues from the roller process. • Ex: Foil for chocolate, uncoated food trays, cans.	[Expert] [6] [37]
23	Wood	Secondary packaging	**MOSH/MOAH**	Combine with suitable primary packaging with barrier effect	• Wooden boxes, e.g. used for decoration or transport, do not display barrier properties.	[Expert]

II. INFORMATION ABOUT THE TOOLS: CONTAMINATION

— Occasional contamination is possible at all processing stages, e.g. from lubricants, compressed air or use of processing aids (e.g. defoaming agents) or from the processing environment (e.g. dust control agents).

— Occasional contamination is possible in the case of damages/accidents, or inappropriate use of processing aids throughout the chain. Substances present may introduce MOSH/MOAH and/or MOSH analogues while analytical separation and unique identification of sources is not possible.

TOOLS: Contamination

No.	Source	Route of entry/cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Note	Reference
24	Lubricants in food processing (food grade incidental food contact)	Damage, contamination, continuous entry	**MOSH/MOAH** **MOSH analogues (PAO, MORE)**	Use specified and internationally certified NSF lubricants (NSF-H1) or synthetic lubricants. Minimise technically inevitable entry (instructions, staff training). Adhere to hygienic design of equipment (lubrication cup, motors etc.) by maintenance	● "Food grade" lubricants for machines and equipment, use in food production without intended food contact. ● Lubricants on mineral oil basis may contain MOSH as well as MOAH. MOAH-free products are available; according to FDA: maximum residue of 10 mg "mineral oils"/ kg food for H1 lubricants. PAO will deliver false positive results after damage. Synthetic lubricants are more homogeneous, not free from MOSH and PAO, free from MOAH.	[36] [37] [38] [39]
25	Lubricants - technical quality (no food contact)	Damage	**MOSH/MOAH** **MOSH analogues (PAO, MORE)**	No use of lubricants with technical quality (NFS-H2) in food production and if possible in the entire processing environment (e.g. drives) Maintenance measures with plans in case of damage. Provide for blockages	● Lubricants of technical quality are less purified and may contain MOAH.	[28]

No.	Source	Route of entry/cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Note	Reference
26	Lubricants - technical quality	Compressed air Pneumatic plants	**MOSH/MOAH** **MOSH analogues (PAO, MORE)**	Check compressed air for oil penetration on a regular basis Use oil-free compressors, and if possible, draw in zero-emission environmental air	● The quality of compressed air is stipulated in the Standards DIN ISO 8573 ff. According to ISO 8573-1 a maximum residue oil level of 0.01 mg/sqm was defined for compressed air with food contact. ● Ex: Use of compressed air for spray drying, pneumatic conveying plants for the transport of granulates or powders (e. g. filling and emptying of silos); contact of food with compressed air in filling/packaging lines.	[Expert] [40; 41]
27	Technical lubricants	Continuous entry through harvesters or damage	**MOSH/MOAH** **MOSH analogues (PAO)**	Avoid/reduce leaks that may result in the entry of lubricants Use suitable lubricants (NSG-H1/ NSF-H2) at all primary production levels, if possible	● Elaborate maintenance and damage action plans in case of leaks and accidents. ● Ex: Use of harvesters e.g. combines, and conveyors in harvesters.	[28]
28	Smoke, gases from drying/ combustion	Drying methods	**MOSH/MOAH**	Avoid direct drying of raw materials with combustion gases dependent on the energy source	● Concerns mainly entry of volatile hydrocarbons and PAH during drying processes, e.g. spices, grain products.	[Expert]
29	Transport container with direct contact	Transport containers contaminated with mineral oil	**MOSH/MOAH**	Check proper cleaning (if necessary certificate), exclude suspect previous cargos	● Concerns containers that are used for raw materials and food, e.g. liquid, pasty products (oils, fruit pulps) or powders (e.g. milled grain products).	[Expert]

No.	Source	Route of entry/cause	Saturated and unsaturated mineral oil hydrocarbons/groups	Tool	Note	Reference
30	Technical lubricants	Transport chain	**MOSH/MOAH** **MOSH analogues (PAO)**	Prevent/minimise entry of lubricants. All pneumatic and belt conveyors are concerned. Use H1 lubricants within the entire transport chain, if possible 	● Even when using H1 lubricants, MOSH and PAO may enter, e.g. conveyors, fork lifts, contaminated transport containers or carriers (e. g. returnable pallets).	[Expert] [28]
31	Technical lubricants	Damage or systematic contamination	**MOSH/MOAH** **MOSH analogues (PAO)**	Prevent contact between raw materials and storage areas/floors contaminated with lubricants No raw materials from contaminated cultivation areas	● Occurs during handling of raw materials in the country of production (e. g. drying) or during transportation (e. g. loading platforms).	[Expert]
32	Exhaust gases	Environmental air ventilation	**MOSH/MOAH**	Avoid contamination by exhaust gases. Check vehicle fleet, check external air inlets	● Prevent trucks from backing up to storage areas, turn off motors, etc.	[Expert] [27]

III. INFORMATION ON PRESENCE VIA ADDITIVES AND PROCESSING AIDS

The notes provided here within the scope of the Toolbox are not "tools" as defined previously. The information is provided in order to offer complete information on the potential route of entry in food products and to better explain possible findings.

However, this does not aim to replace or eliminate technologically required food additives or processing aids.

The same applies to all production processes for any type of packaging material or other food contact materials. The description of the required processing aids and additives that may potentially introduce MOSH analogues need to be considered in addition to the current scope of this Toolbox.

Food additives and technical processing aids are used as approved and are a necessary part of the conditioning of ingredients, raw materials, processing conditions, materials and for the proper functioning of equipment.

They are applied based on Good Manufacturing Practice (GMP).

In the final product there is no way currently to analytically separate mineral oil hydrocarbons and analogues with common analysis methods. Food additives which may give false positive results such as MOSH analogues and which are used in accordance with Regulation (EC) No 1333/2008 amongst others include anti-caking agents, edible glazing agents, anti-foaming agents or ingredients according to the "quantum satis" principle (q.s.) such as: [42]

Microcrystalline waxes/hard paraffins	E 905
Carnauba wax	E 903
Candelilla wax	E 902
Beeswax	E 901
Siloxane	E 900
Oxidised polyethylene wax	E 914
Hydrogenated poly-1-decene	E 907

Information on paraffin/paraffin oils/hard paraffin

Paraffins are crude oil products that consist of mixtures of alkanes (saturated hydrocarbons) and thus correspond to the definition of MOSH. Depending on the mixture and additives, paraffins can be liquid, viscous/pasty or solid.

White oils are paraffin oils; "technical" white oils may contain MOAH, whereas medical white oils are MOAH free [36]. For white oils with medium to high viscosity, EFSA has established an average daily intake (ADI) of 12mg/kg body weight/day in 2013. [43]

Paraffin-based processing aids or additives have a broad range of application in food processes at all stages: from growing/production to processing of raw materials and foods, as well as for the manufacture of food contact materials, e.g.:

- Lubricants (food grade and technical)
- Bases for technical protection and release/anti-caking agents
- Maintenance products for machines and equipment
- Maintenance products in animal husbandry
- Lubricants for movable equipment parts or food contact materials (e. g. artificial casings)
- Production oils, rollers, release and form oils for food contact materials, as food additives and others, glazing agents, release agents or coating agents
- Animal drug components (by-products in vaccines)
- Pesticides (as adhesives or active agents)
- Anti-freeze agents in crop cultivation

Hard paraffins, micro-crystalline waxes and their mixtures with beeswax, waxes, resins or plastics are used in the production of food contact materials such as adhesives, paper coatings and certain other coatings not intended for human consumption [45].

Surface lubricants, rolling oils and rolling emulsions are needed for the manufacture and processing of metallic materials. Their use is technically required. These products are generally based on paraffins; they must comply with the internationally acknowledged requirements of the US Code of Federal Regulation (CFR) 21 § 178.3570 *(Lubricants for incidental food contact),* § 178.3620 *(Mineral Oil),* and § 178.3910 *(Surface lubricants used in the manufacture of metallic articles),* in particular in terms of established purity criteria.

According to these specifications, rolling oils and surface lubricants contain MOH, which may be relevant analytically as MOSH analogues.

In the manufacturing process of aluminium foils, trays or tubes and similar products, which are intended to be used as food contact materials, the primary metal foils and sheets are subjected to a soft anneal process in order to evaporate the rolling oil from the rolling process.

Surface lubricants are also used in the manufacture of tinplate cans. If the lubricants remain on the surface, they must be approved for food contact (CFR 21 § 178.3570) or otherwise removed after mechanical processing for subsequent lacquering.

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/ groups	Notes/examples	Reference
a	Release agent	Microcrystalline waxes used as ● wrappers ● coatings ● glazing agents ● coatings	**MOSH analogues (MORE)**	● Used in e.g. waxed papers or coatings for meat products. ● Abrasion of microcrystalline waxes results in the migration of compounds predominantly from the MOSH fraction, which delivers false positive results as MOSH analogues. ● Consider SML according to Regulation (EC) No 10/2011 and conditions of use according to Regulation (EC) No 1333/2008. ● Where necessary, check process temperature for wrappers. ● Where necessary, review alternatives: — wrapper coatings based on vegetable esters — quantum satis (q.s.) use.	[33] [42]
b	Release agent	Hard paraffin or microcrystalline waxes	**MOSH analogues (PAO, MORE)**	● Used with e.g. confectionery, fruits. ● Is harmless when used as approved; however, relevant to analysis as MOSH analogues. ● Where necessary, use alternative waxes such as carnauba wax or beeswax, which are also relevant as MOSH analogues in analysis.	[Expert]
c	Glazing agents, release waxes, coating agents	Surface treatment MOSH analogues can be present via saturated hydrocarbons.	**MOSH analogues (PAO, MORE)**	● Used with e.g. confectionery, sausage casings or food contact materials. Where necessary review product formulation. Alternatively use suitable glazing agents based on vegetables, where necessary.	[Expert] [42]

No.	Source	Route of entry/ cause	Saturated and unsaturated mineral oil hydrocarbons/ groups	Notes/examples	Reference
d	Dust control agents	Spraying of mineral-oil based oils	**MOSH/MOAH**	● Used with dusting bulk goods that are food raw materials such as soya beans, grains, rape seeds and other oil seeds. ● Alternatively use mineral oil-free dust control agents based on vegetable oils. ● For dusting food with flours or powders, only use dust control agents on a vegetable oil basis or substances according to Regulation (EC) No 1333/2008.	[2]
e	Release agents Anti-sticking agents	Paraffin oils or white oils for machine maintenances or as release oils for bakery moulds and sheets	**MOSH/MOAH** **MOSH analogues (MORE)**	● Use of medicinal white oils; in the case of predictable food contact, only vegetable oils or substances according to Regulation (EC) No 1333/2008 are permitted.	
f	Parchment papers for baking or release	Processing aids, release agents with direct food contact	**MOSH analogues (PAO, MORE)**	● Used with baking and heating processes. Composition may result in the presence of MOSH analogues.	[17]
g	Defoaming agents	Silicone oils Paraffin oils	**MOSH/MOAH** **MOSH analogues (MORE)**	● Are often used in food processing: washing water, frying processes. Technical use in paper production, for paper recycling, in the production of adhesives. ● Where necessary, use of vegetable oils as components in defoaming agents.	[42]
h	Pesticide formulations	Use of pesticides based on paraffin oil	**MOSH/MOAH** **MOSH analogues (MORE)**	● Use and presence as MOSH analogue within the area of vegetable raw materials possible.	
i	Maintenance greases	Based on paraffin	**MOSH/MOAH** **MOSH analogues (MORE)**	● Used with food producing animals; quantum satis use, prevention of damages.	

REFERENCES

[1] Abschlussbericht (2012): Ausmaß der Migration unerwünschter Stoffe aus Verpackungs- materialien aus Altpapier in Lebensmitteln. Ein Entscheidungshilfeprojekt des Bundesministeriums für Ernährung, Landwirtschaft und Verbraucherschutz. Veröffentlicht durch die Bundesanstalt für Landwirtschaft und Ernährung (BLE) https://service.ble.de/ptdb/index2.php?detail_id=21002&site_key=145&stichw=Altpapier&zeilenzahl_zaehler=1&pId=21002&dId=116619

[2] EFSA Panel on Contaminants in the Food Chain (Contam) (2012, replaced in 2013): Scientific Opinion on Mineral Oil Hydrocarbons in Food. EFSA Journal 10 (6): 2704 http://www.efsa.europa.eu/de/efsajournal/pub/2704

[3] Matissek R, Baltes W (2015) Lebensmittelchemie. 8. Auflage. Springer Spektrum Verlag . Berlin: 361 ff

[4] Matissek R, Raters M, Dingel A, Schnapka J (2014) Masterplan zur Minimierung von MOSH/ MOAH in Lebensmitteln. Food Lab (3): 30-33

[5] Matissek R, Dingel A, Schnapka J (2016) Minimierung von Mineralölbestandteilen in Lebensmitteln - Forschungsprojekt zur Identifizierung von Eintragswegen und Minimierungsmaßnahmen. WPD Moderne Ernährung heute

[6a] European Printing Inks Association http://www.eupia.org/index.php?id=29&type=98

- Information Leaflet: Printing Inks for Foods Packaging (en, fr, de)
- Frequently Asked Questions on the Legal Status of Printing Inks, Coatings and Varnishes for the Non-food Contact Surface of Food Packaging (en, fr, de)
- EuPIA Guideline on Printing Inks Applied to the Non-Food Contact Surface of Food Packaging Materials and Articles (en, fr, de)
- Inventory List compromising Packaging Ink Raw Materials Applied to the Non-Food Contact Surface of Food Packaging (en)
- Good Manufacturing Practices (GMP): Printing Inks for Food Contact Materials (en, de)

[6b] European Carton Makers Association (ECMA) (2013):

- Food Safety Good Manufacturing Practice Guide https://www.ecma.org/uploads/Bestanden/Publications/GMP/UK%20GMP%20%20Version%201.1%20%2016%2012%202013%20%20-%20FINAL.pdf

[7] Neukom HP, Grob K, Biedermann M, Noti A (2002) Food Contamination by C20 - C50 mineral paraffins from atmosphere. Atomos Environ. 36 (30):4839-4847

[8] Richter L, Biedermann-Brem S, Simat T J, Grob K (2014): Internal bags with barrier layers for foods packed in recycled paperboard. Eur Food Res Technol 239 (2): 215–225

[9] Lommatzsch M, Richter L, Biedermann-Brem S, Biedermann M, Grob K, Simat T J (2016): Functional barriers or adsorbent to reduce the migration of mineral oil hydrocarbons from recycled cardboard into dry food. Eur Food Res Technol DOI

[10] DIN EN 16955 : 2017-8 „Lebensmittel – Pflanzliche Öle und Lebensmittel auf Basis pflanzlicher Öle – Bestimmung von gesättigten Mineralöl-Kohlenwasserstoffen (MOSH) und aromatischen Mineralöl-Kohlenwasserstoffen (MOAH) mit on-line HPLC-GC-FID"

[11] Bundesinstitut für Risikobewertung/Kantonales Labor Zürich-Kompendium „Messung von Mineralöl-Kohlenwasserstoffen in Lebensmitteln und Verpackungsmaterialien" http://www.bfr.bund.de/cm/343/messung-von-mineraloel-kohlenwasserstoffen-in-lebensmitteln-und-verpackungsmaterialien.pdf

[12] Spack L, Leszczyk G , Varela J, Simian H, Thomas, Gude T, Stadler R (2017): Understanding the Contamination of Food with Mineral Oil: The Need for a Confirmatory Analytical as well as Procedural Approach. Food Addit & Contam 34:1032-1071

[13] Biedermann M , McCombie G, Grob K, Kappenstein O, Hutzler C, Pfaff K, Luch A (2017) FID or MS for mineral oil analysis? Journal of Consumer Protection (online 16. September 2017)

[14] Schnapka J, Dingel A, Matissek R (2017): MOSH und MORE in Lebensmitteln - Was steckt unter dem MOSH-Hump? DLR (113): 442-448

[15] Matissek R (2017): „MOSH/MOAH Minimisation in Foods". Präsentation bei „Mineralölbestandteile in Lebensmitteln und Kosmetik. 9.-10.2.17 in Berlin

[16] Barp L, Kornauth C, Wuerger T, Rudas M, Biedermann M, Reiner A, Concin N, Grob K (2014): Mineral oil in human tissues, Part I: concentrations and molecular mass distributions. Food Chem Toxicol 72: 312–321

[17] Bundesinstitut für Risikobewertung (BfR) (2016): XXXVI. Papiere, Kartons und Pappen für den
Lebensmittelkontakt (Stand 1.7.2016) sowie XXXVI/2. Papiere für Backzwecke: https://bfr.ble.de/kse/faces/resources/pdf/360.pdf;jsessionid=F316D84321C5909FA0891666F1DD326C

[18] Bundesinstitut für Risikobewertung (BfR): Fragen und Antworten zu Mineralölbestandteilen Lebensmitteln – Aktualisierte FAQ des BfR vom 26. November 2015 http://www.bfr.bund.de/de/fragen_und_antworten_zu_mineraloelbestandteilen_in_schokolade_aus_adventskalendern_und_anderen_lebensmitteln-132213.html

[19] Kantonales Labor Zürich (2016): „EFSA-Projekt zur Toxizität von Mineralöl" Jahresbericht: 61 ff.

[20] Entwurf des Bundesministeriums für Ernährung und Landwirtschaft „Zweiundzwanzigste Verordnung zur Änderung der Bedarfsgegenständeverordnung" (BedGgstV). as of 07.03.2017 http://www.bmel.de/SharedDocs/Downloads/Service/Rechtsgrundlagen/Entwuerfe/Entwurf22VerordnungBedarfsgegnstaende.pdf?__blob=publicationFile

[21] SciCom, Wetenschppelijk Comite can het Federaal Agentschap voor de Veiligheid van de Voedselketen (FAVV): Advies 19-2017 „Actiedrempels voor minerale olie koolwaterstoffen in levensmiddelen" (SciCom 2016/15 vom 22.9.2017): http://www.favv.be/professionelen/levensmiddelen/mineraleolie/

[22] COMMISSION RECOMMENDATION (EU) 2017/84 of 16 January 2017 on the monitoring of mineral oil hydrocarbons in food and in materials and articles intended to come into contact with food (OJ L 12, 17.1.2017, p. 95–96)

[23] Schweizerisches Verpackungsinstitut SVI. SVI Guideline 2015.01 (2015): „Überprüfung und Bewertung der Barrierewirksamkeit von Innenbeuteln für Lebensmittelverpackungen in Recyclingkarton"

[24] Richter L, Simat T J (2015): Lebensmittelverpackungsfolien Schicht für Schicht – ein Überblick.
Dtsch Lebensmitt Rundsch 111: 59–64

[25] Ewender J, Fengler R, Franz R, Gruber L, Welle F (2016) Fraunhofer Institut für Verfahrenstechnik und Verpackung: „Funktionelle Barrieren gegen Mineralöl aus Papier- und Kartonverpackungen". DLG-Expertenwissen 10/2016

[26] DIN 19303 : 2011-3: Karton – Begriffe und Sorteneinteilungen

[27] COUNCIL OF EUROPE Resolution ResAP(2002)1 on paper and board materials and articles intended to come into contact with foodstuffs , (Adopted on 18 September 2002): https://wcd.coe.int/ViewDoc.jsp?p=&Ref=ResAP(2002)1&Language=lanEnglish&Ver=original&direct=true

[28] Dingel A (2017): „Mineralische Kohlenwasserstoffe in Kakao und Schokolade und Konzepte zur Minimierung", Dissertation TU Berlin (2017)

[29] Federation of Cocoa Commerce (FCC) (2013): Guidelines for shipment of cocoa beans in containers. 16. Dezember 2013. URL: http://www.cocoafederation.com/services/guidelines

[30] Commission Regulation (EC) No 2023/2006 of 22 December 2006 on good manufacturing practice for materials and articles intended to come into contact with food (OJ L 384, 29.12.2006, p. 75–78)

[31] Lommatzsch M, Biedermann M, Grob K, Simat T J (2016) Analysis of saturated and aromatic hydrocarbons migrating from a polyolefin-based hot-melt adhesive into food. Food Addit Contam A 33 (3): 473– 488

[32] Barp L, Suman M, Lambertini F, Moret S (2015): Migration of selected hydrocarbon contaminants into dry pasta packaged in direct contact with recycled paperboard. Food Addit Contam A 32 (2): 271–283

[33] Commission Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food Text with EEA relevance (OJ L 12, 15.1.2011, p. 1–89)

[34] International Jute Study Group (IJSG): IJO Standard 98/01 [Revised 2005]

[35] Grob K, Artho A, Biedermann M, Mikle H (1993): Verunreinigung von Haselnüssen und Schokolade durch Mineralöl aus Jute- und Sisalsäcken. Z Lebensm Unters Forsch (197): 370–374

[36] Verband Schmierstoff-Industrie e. V. (2016) Auswahl und Verwendung von Lebensmitteltechnischen Schmierstoffen [EGLi-Positionspapier]

[37] U.S. Goverment Publishing Office (GPO) Code of Federal Regulations. Title 21: Food and Drugs. PART 178—INDIRECT FOOD ADDITIVES: ADJUVANTS, PRODUCTION AIDS, AND SANITIZERS http://www.ecfr.gov/cgi-bin/text-dx?SID=5bc8309dcc97db05e9aca78ad1cd3ab3&mc%20=true&node=se21.3.178_13570&rgn=div8

[38] Schnapka J, Matissek R (2016): MOSH/MOAH in lebensmitteltechnischen Schmierstoffen. Lebensmittelchemie 70 (1): 6

[39] International NSF: White Book™ – Nonfood Compounds Listing Directory. Listing Category http://info.nsf.org/USDA/psnclistings.asp

[40] DIN ISO 8573-1 (2010-04): Druckluft - Teil 1: Verunreinigungen und Reinheitsklassen Ausgabedatum

[41] DIN ISO 8573-5 (2002-12): Druckluft - Teil 5: Methoden zur Messung von Öldampf und organischen Lösungsmitteln

[42] Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives (OJ L 354, 31.12.2008, p. 16–33)

[43] European Food Safety Authority (EFSA) (2013): Safety of medium viscosity white mineral oils as food additive. http://www.efsa.europa.eu/de/efsajournal/pub/3073

[44] FABES Forschungs-GmbH für Analytik und Bewertung von Stoffübergängen (2003): Investigation Report. Migration/permeation investigation on barrier properties of Aluminium foils against organic molecules. http://www.alufoil.org/files/alufoil/reference_library/FABES_for_EAFA_MAR_2004.pdf

[45] Bundesinstitut für Risikobewertung (BfR) (2005): Empfehlung XXV. Hartparaffine, mikrokristalline Wachse und deren Mischungen mit Wachsen, Harzen und Kunststoffen https://bfr.ble.de/kse/faces/resources/pdf/360.pdf;jsessionid=F316D84321C5909FA0891666F1DD326C

ACKNOWLEDGEMENTS

Fundamental work was performed at the Food Chemistry Institute (LCI) of the Association of the German Confectionery Industry (BDSI) within the scope of a comprehensive research project (20132016) on the issue of "Minimisation of 'MOSH/MOAH' in food" which delivered important findings. These were supplemented by expert knowledge from members of the BLL, namely producers and laboratories.

The BLL would like to thank the BDSI for providing their own toolbox as a basis for this Toolbox and in particular the colleagues from the LCI for their constructive and fruitful cooperation. The BLL also thanks the members of the working group for their contribution of time and expertise.

BLL WORKING GROUP TOOLBOX:

Erik Becker (Institut Kirchhoff Berlin GmbH)
Monika Daiber (HiPP-Werk Georg Hipp OHG)
Dr. Uwe Dirks (Dr. August Oetker Nahrungsmittel KG)
Dr. Anna Dinge (LCI Food Chemistry Institute of the BDSI)
Dr. Martin Einig (Association of the German Spice Industry and Kulinaria e.V.)
Dr. Torben Erbrath (Association of the German Confectionery Industry)
Dr. Stefan Hoth (Peter Kölln GmbH & Co. KGaA)
Prof. Dr. Reinhard Matissek (LCI Food Chemistry Institute of the BDSI)
Jens Christian Meyer (H. & J. Brüggen KG)
Dr. Ingo Mücke (Bahlsen GmbH)
Dr. Ulrich Nehring (Institut Nehring GmbH)
Dr. Gerhard Neuberger (Ferrero Deutschland GmbH)
Petra Schmanke (Nestlé Deutschland AG)
Dr. Julia Schnapka (LCI Food Chemistry Institute of the BDSI)
Wolfgang Tiaden (Wernsing Feinkost GmbH / Federal Association of the Fruit, Vegetable and Potato Processing Industries, BOGK)
Michael Warburg (REWE-Group)

Coordination:

Dr. Sieglinde Stähle (German Federation of Food Law and Food Science (BLL)

BLL
Bund für Lebensmittelrecht und Lebensmittelkunde e.V.

German Federation of Food Law and Food Science (Bll e.V)
Claire-Waldoff-Straße 7
10117 Berlin
Germany

Tel. +49 30 206143-0
Fax +49 30 206143-190

bll@bll.de
Twitter: @BLL_de
Facebook: @BLL.de

FOODDRINK EUROPE

Enjoy food, today and tomorrow

Avenue des Nerviens, 9-31
1040 Brussels
Belgium

Tel: +32 2 514 11 11
Email: info@fooddrinkeurope.eu
@FoodDrinkEU
www.facebook.com/fooddrinkeurope