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Migration of mineral oil hydrocarbons from carton made of recycled fibers into eggs

Egg cartons, both in box shape for the retailers as well as the larger, stackable pallets used by producers and the trade, commonly consist of recycled fiber material. The question arose whether the migration of mineral oil hydrocarbons from this carton into shelled eggs could reach problematic levels.

To obtain a generally valid answer, in collaboration with EiCO frigemo ag (Bern) a reasonable worst case was constructed.

Experimental

Experiments were performed with unsalable eggs with thin and damaged shell (provided by EiCO frigemo ag), i.e. eggs with shells of particularly weak barrier efficiency. Among several lots, the one with the lowest mineral oil content in the egg was selected.

As worst case storage conditions, 31 days at ambient temperature were selected for fresh eggs and 3 months at refrigerator temperature (4-5 °C) for processed eggs.

To reflect a worst case and considering that the migration proceeds through the gas phase (evaporation from the carton and recondensation on the egg shell), the carton should have a relatively high mineral oil content in the range of the volatile constituents (up to 24 carbon atoms, C_{24} [1]).

- For storage at ambient temperature, a carton box containing 260 mg/kg mineral oil saturated hydrocarbons (MOSH) up to n-C_{24} was used. This concentration was somewhat below the average of 340 mg/kg measured in 2009/2010 for recycled board to make folding boxes [2], which was taken into account in the final evaluation.
- As the MOSH concentrations was clearly lower in all pallets available, one containing 140 mg/kg MOSH up to n-C_{24} was spiked with additional 400 mg/kg MOSH (Gravex 913, Shell) to result in 540 mg/kg potentially migrating MOSH – which is unlikely to be exceeded in reality.

For storage at ambient temperature, the box containing the eggs was closed and wrapped into aluminum foil to simulate the situation of stacked boxes with negligible escape of vapors to the environment. The pallet was cut to two pieces with 4 positions for eggs each, the second one to cover the eggs. This arrangement was again wrapped into aluminum foil.

At the end of the storage period, for each of the two experiments two eggs were analyzed for MOSH. The egg content was homogenized; 5 g of this was suspended in 25 ml ethanol. After 1 h, the ethanol (containing the water) was decanted and the residue extracted with hexane overnight. The two extracts (ethanol/water and hexane) were combined and split into an ethanol/water and a hexane phase by addition of water. The hexane phase was analyzed by on-line coupled high performance liquid chromatography (HPLC) – gas chromatography (GC) – flame ionization detection (FID), as described in the literature [2,3].

The analysis was limited to the MOSH. In reality these are accompanied by 15-18 % mineral oil aromatic hydrocarbons (MOAH).

To ensure proper performance of the extraction and the quantitative determination, non-exposed eggs spiked with 1 mg/kg Gravex 913 (including 0.72 mg/kg MOSH) were analyzed.

The eggs used for the experiments contained 2.2 mg/kg MOSH to begin with, of which 1.5 mg/kg were in a molecular mass range above n-C_{24}, i.e. above that relevant for migration. This contamination is in the range frequently observed (probably environmental and transferred by the feed) and determined the detection limit for the analysis.

Results

In none of the eggs migrated MOSH were detectable, with a detection limit of about 0.3 mg/kg.

Evaluation

For the interpretation of the result, the selected conditions must be taken into consideration:

1. According to EiCO frigemo ag, the duration of storage corresponded to the realistic maximum on the market.
2. The eggs had shells worse than acceptable on the market.
3. The content of MOSH below n-C_{24} in the pallet was adjusted to the conceivable worst case. That in the box (260 mg/kg) was not: it could be almost double. It is assumed that the MOSH migration is proportional to the MOSH concentration in the carton and that with the given detection limit the migration could approach 0.6 mg/kg.
4. Evaporation into the environment was excluded.

This enables the general conclusion that the MOSH migration from recycled carton into shelled eggs is likely to remain below 0.6 mg/kg.

Presently there are no legal limits for MOSH or MOAH. For the compliance with the general rule that a danger to human health must be ruled out, the following references can be used:

- 0.6 mg/kg corresponds to the lowest value for migrating MOSH discussed in the context of the planned German mineral oil regulation. It is based on an evaluation by WHO/JECFA which was withdrawn in 2012 [4,5].
- The German Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung, BfR) specified a limit for MOSH in foods of 12 mg/kg for the molecular mass range up to C_{16} [6] and of 4 mg/kg for those between C_{17}-C_{20} [7]. This was based on the assumption that the MOSH of low molecular mass are little accumulated in human tissues. It follows that a limit for the MOSH above C_{20} would be clearly lower.
- In the opinion from 2012, EFSA did not specify a limit for MOSH and MOAH, but stated that the present human exposure to mineral oil hydrocarbons is „of potential concern“ [8].

It is concluded that on the basis of the present toxicological evaluation of mineral oil hydrocarbons there is no concern about the migration of mineral oil from recycled paperboard into fresh eggs.

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Literature

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