transfer of polycyclic aromatic hydrocarbons and their principle metabolites to milk after chronic exposure of dairy cows to contaminated soil

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Increasing attention is being paid to environmental pollution by polycyclic aromatic hydrocarbons (PAH) in developed countries. The carcinogenic risk of some of these compounds is well established, and ingestion is considered as the principal pathway of exposure in humans. The food chain can also be contaminated to a notable extent through ruminants grazing around anthropogenic PAH sources. Indeed, cows can absorb appreciable amounts of these pollutants if roughage or soil have previously been exposed to them. Because soil can be much more heavily contaminated than grass, it is necessary to study this source of PAH in cattle in order to determine whether transfer from soil intake to dairy products can be anticipated and therefore if there is a risk of PAH accumulation in milk. The intake of soil by dairy cows at pasture ranges from 4 to 8% of their dry matter intake (i.e. up to 1.5 kg of soil each day) depending on the season, grass density and herd size. Global levels of contamination of around 100 µg PAH/g of soil have commonly been reported for all 16 recorded PAH (EPA list), so that dairy cows could easily ingest 50 mg daily, and sometimes more. The aim of the study is to assess the transfer of soil-bound PAH into the milk of dairy cows during chronic exposure, as the levels of both native PAHs and their principal metabolites were determined simultaneously in both milk and faeces.

In order to assess the effect of a soil contaminated exposition, the excretion of PAH in milk and faeces by dairy cows was studied following a chronic supply of soil contaminated by fluorene, phenanthrene, pyrene and benzo[a]pyrene. These compounds were measured in their native form in milk and faeces using GC-MS. This technique was also used to determine their possible absorption and metabolism into their principal metabolites in milk. For a period of 28 days, 500 g of contaminated soil was inserted every morning after milking into three lactating multiparous dairy cows (Prim'Holstein) via a ruminal cannula. Control samples of milk and faeces were collected from each cow before the daily administration of contaminated soil. Milk and faeces test samples were then collected once a week during the experiment.

No significant differences in the levels of excreted PAH were observed in milk when they were supplied via the soil. These variations mainly reflected concentration or dilution effects as a function of the cows milk yield. During this study, neither Fluo nor B[a]P were found in milk, before or after supply. However, an increased appearance of metabolites in milk (up to 1.6% of the native PAH supplied) suggested the metabolism of these compounds after extraction from the soil. During our trial, the excretion of metabolites (2-OH fluorene, 3-OH phenanthrene and 1-OH pyrene) in milk during a supply of contaminated soil was clearly demonstrated. The appearance of PAH metabolites in milk soon after the beginning of supply was in line with the hypothesis of PAH extraction from the soil followed by its absorption in the body. The transfer of metabolites to milk, expressed as a proportion of the daily supply of PAH reached 0.09%, 0.03% and 1.62% respectively for 2-OH Fluo, 3-OH Phe and 1-OH Pyr at the peak level of excretion. In faeces, less than 4% of the PAH supplied daily were recovered, thus confirming their previous extraction during digestive transfer. It is therefore possible that the PAH and/or their metabolites could have been distributed throughout the body, for instance in organs such as the liver, lungs, intestine or adipose tissue, or have been excreted in the urine. The results of this study indicate that following a chronic supply of PAH-contaminated soil to dairy cattle, the initial levels of native pollutants in milk were not significantly affected. The marked increase in the levels of their principal metabolites in milk suggests the extraction of PAH from the soil and their absorption by the animals in the gastrointestinal tract. The levels of native PAH in milk did not change significantly during the supply period. The risk of human exposure to native PAH in milk is therefore small, as is their transfer from contaminated soil into milk. Nevertheless, the relative toxicity of the resulting metabolites is at present unknown in mammals, and more detailed work is necessary to determine the true risk to health.