

Chemistry, Formation and Occurrence of Genotoxic Heterocyclic Aromatic Amines in Fried Products

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Abstract

Heterocyclic aromatic amines (HCAs) are substances with a high mutagenic and cancerogenic potential. They occur in heated meat and fish when the cooking temperature exceeds 150 °C. This means that during boiling the HCAs are formed at a very low level but when the meat is heated more intensively as is done during frying grilling baking or roasting the formation of these substances is increased significantly.

The substances identified till today comprise two separate groups of HCAs namely the polar group the imidazoquinolines (e.g IQ) and imidazoquinoxalines (e.g. IQx) type substances and the non-polar group which are of pyridoindole and dipyridoimidazole type. The precursors which lead to the formation of the polar HCAs are amino acids, carbohydrates and creatinine.

Mutagenicity tests like the Ames test and mouse as well as rat models showed the mutagenic/cancerogenic potential of these substances. The IARC analysed the published work on HCAs and classified IQ as probable human carcinogen (group A2) and MeIQ, MeIQx and PhIP as possible human carcinogen (group 2B).

All known HCAs have a more or less planar structure. They bind to the DNA base guanosin, which leads to frameshift mutations that are more easily detected using the strain *Salmonella typhimurium* TA98. The other commonly used strain TA100 is more sensitive to base exchange mutations.

The comparison of the mutagenic activity of the HCAs shows that some of them have a significantly higher mutagenicity than other well known carcinogens like Aflatoxin B1 or benzo[a]pyrene.

Although the HCAs are found ubiquitary it is only the uptake of heated meat and fish products that contributes significantly to the exposure since the concentrations in other foods are extremely low. The analysis in meat and fish showed concentrations in the range of 0 to 10 ng/g. The concentration depends on the cooking method and type of meat. In tables 2 and 3 the values are summarized. It can be seen that the IQ and IQx type substance are formed in the low ppb range. In meat extracts and gravies the concentrations can be much higher. This is a result of the higher concentration of the precursors from the meat juice, the higher temperature and a concentration effect of the evaporating water. PhIP which is formed by a different mechanism occurs in substantial higher amounts. The non-polar HCAs - which are formed as pyrolysis products of amino acids can also be very high

In model systems many different substances can be tested that have the potential to reduce the content of HCAs. Using model systems the chemical reactions can be decoupled from the food matrix. If the model system has the same chemical composition as the meat - with respect to amino acid, creatinine, carbohydrates - the chemical reactions can be studied in detail. It was shown that MeIQx increases if oxidised fatty acids or iron are added. The presence of antioxidants results normally

in a reduced content of the HCAs. Oguri and co-workers showed that when catechines from green tea as well as isolated substances ((-)-epigallocatechingallat, luteolin, quercetin, caffeic acid) are added to the model systems the formation of HCAs is reduced.