HETEROCYCLIC AMINES IN CHICKEN IN RELATION TO DIFFERENT COOKING METHODS

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Background

Several epidemiological studies have shown a correlation between the intake of fried, broiled or roasted meat and the development of cancer, and it has been suggested that heterocyclic amines (HAs) play a role in the aetiology of human cancer (IARC 1993). HAs are formed during cooking of muscle food at ppb levels, and about twenty HAs have hitherto been identified (Sugimura 1997, Felton et al. 1997). The most common HAs in cooked foods are 2-amino-3,8-dimethylimidazo[4,5-*f*]quinoxaline (MeIQx) and 2-amino-1-methyl-6-phenylimidazo[4,5-*b*]pyridine (PhIP), see figure 1. The International Agency on Cancer Research (IARC) has recommended reduced human exposure to these compounds. Other common HAs e.g. Harman (1-methyl-9H-pyrido[3,4-*b*]-indol) and Norharman (9H-pyrido[3,4-*b*]-indole) have been discussed in relation to neurotoxins and enzyme inhibitors (de Meester 1995). Chicken is an eminent muscle food source, but high levels of HAs have been reported in cooked chicken (Skog 1993). The most important factors affecting the formation of HAs are cooking method, temperature and time. Since HAs may be produced under ordinary household cooking conditions, it is important to collect data on levels of HAs in normally cooked poultry to find means of minimizing the formation and thus exposure to HAs.

Objective

The objective of this study was to examine the formation of HAs in chicken cooked in various ways under well-controlled conditions.

Methods

Chicken fillets from the same batch were obtained from a local slaughterhouse. For each fillet, three thermocouples were used to measure the temperature during cooking: one thermocouple was inserted in the centre of the fillet and two were fixed just below each surface. For the pan frying experiments, a fourth thermocouple was placed between the fillet and the frying pan. The thermocouples were connected to a data logger and the temperature was recorded every 10 s. The cooking procedure lasted until the centre temperature reached 72°C.

In a first set of experiments, the chicken fillets were prepared using following cooking methods: boiling, oven roasting, oven roasting in a roasting bag or in a unglazed clay pot, roasting, deep frying and pan frying. The cooking temperatures used in the different methods varied from 150 to 220°C in the oven, 160 °C for deep-frying and 175°C for pan-frying

In the second set of experiments, the chicken fillets were fried at 175, 200 and 225°C in a frying pan. When the centre temperature reached 50°C, the fillets were turned and fried until the centre temperature reached 72°C. Three fillets were fried at each temperature, one at time. For each fillet, 10 g margarine was added, and frying was started when the temperature of the fat had reached the desired frying temperature. The fried fillets were weighed, and the weight loss was calculated

The outer layer of the fillets were extracted and analysed for HAs using reverse-phase HPLC. (Gross et al. 1992) with minor modifications (Borgen et al. 2001). Extraction recovery rates were determined by the addition of a known amount of synthetic HAs to one sample extracted in parallel with two unspiked samples. HAs were identified and quantified using retention times and spectra from synthetic standards of known concentration, run under the same conditions.

Results and discussion

HAs were detected in chicken fillets heated to a centre temperature of 72°C using different cooking methods. The weight loss was generally low and ranged from to 9% for cooking in a clay plot to 32% for pan-frying at 220°C.

Figure 2 shows the amounts of HAs formed during the various conditions. MeIQx and PhIP were detected in the pan-fried and deep-fried chicken. PhIP was also detected in the roasted chicken. Harman (H) was detected in all samples, and Norharman (NH) in all samples but the boiled chicken and the chicken cooked in the clay pot. The highest amounts of NH and H were found in the deep-fried and pan-fried samples. Extraordinary high levels of HAs have earlier been reported in chicken cooked at high temperatures (Sinha et al. 1995), however, our study shows that the amount of HAs in cooked chicken varies with cooking method and that only low amounts of HAs are formed if the chicken is boiled or prepared in the oven.

Figure 3a and b shows the temperature profile from one surface trough the centre to the other surface when the centre temperature had reached 72°C. The cooking methods, where the chicken fillets were exposed to a high surface temperature e.g. pan-frying and deep-frying yielded the highest levels of HAs.

Conclusions

The amounts of HAs in chicken highly depend on cooking method. The largest amounts of HAs are formed during pan-frying and deep-frying. When the fillets were pan-fried at different temperatures, the amount of HAs increased with the temperature.

Acknowledgements

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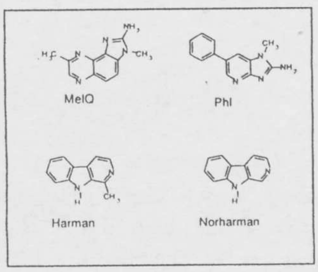

Figure 1. Chemical structure of four heterocyclic amines.

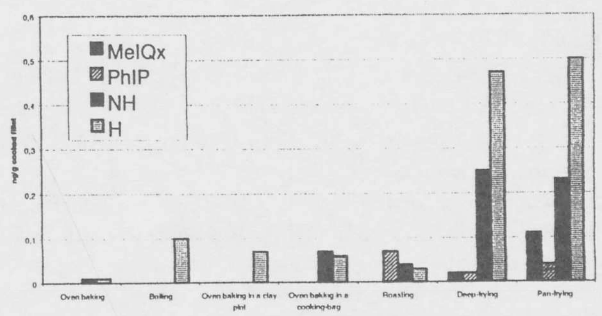

Figure 2. HAs in chicken at different cooking conditions

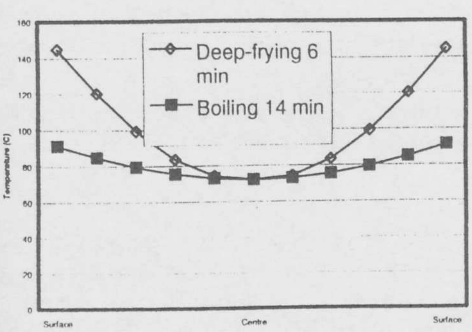

Figure 3a. Temperature profile in chicken breasts when the centre temperature had reached 72C.

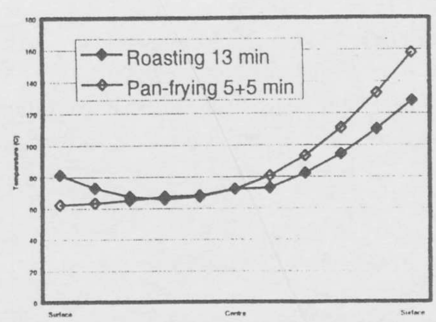

Figure 3b Temperature profile in chicken breasts cooked to 72C. The lower surface temperatures are at the surface exposed to air and the higher surface temperatures at the surface having contact with a heated source.