EFFECT OF DIFFERENT PAN-FRYING CONDITIONS ON THE FORMATION OF HETEROCYCLIC AROMATIC AMINES AND SENSORY QUATILY IN FRIED BACON

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Abstract – Heterocyclic Aromatic Amines (HAA) are formed during the Maillard reaction in the crust of heated meat samples. Most HAA have a high mutagenic potential and they are also carcinogenic in long-term animal studies. For this reason, health organizations recommended to reduce the daily intake of these substances. Besides precursors in the raw materials and preparation methods, important factors are physical parameters such as temperature and heating time. In this study, bacon slices were investigated for the concentrations of HAA after pan frying under different monitored heating conditions. The following HAAs MeIQx (2-Amino-3,8-dimethylimidazo [4,5-*f*]quinoxaline) (1.5 – 5.6 ng/g) and PhIP (2-amino-1-methyl-6-phenylimidazo [4,5-*b*]pyridine) (0.1 – 2.6 ng/g) were found in pan-fried bacon slices. The bacon contained clearly higher concentrations of HAA both with longer frying times and at higher temperatures of 200 - 220°C than 150 -170°C, respectively. Similar continuously increase of the concentrations was observed for Norharman (5.0-19.9 ng/g) and Harman (0.3-1.7 ng/g). The sensory evaluation using a hedonic test design for color, and flavor of the pan fried bacon slices resulted in a preferred frying time of 5 min at 150-175°C. However, some testers preferred clearly crispy and darker bacon slices fried at higher temperatures.

Key Words –β-carbolines, MeIQx, PhIP, Processed meat

• INTRODUCTION

Several epidemiological studies have shown that a relationship between nutrient diet and the risk for the incidence of cancer exists. In particular, red and processed meat focused to risks to contract colorectal cancer [1]. Scientific report of the World Cancer Research Fund and the American Institute for Cancer Research in 2007 (WCRF/AICR) described these relationships. Heterocyclic Aromatic Amines (HAA) are process contaminates which are formed in the Maillard reaction in the crust of meat products at heating treatments. Besides precursors of the raw material and chemical interactions with antioxidants [2], the most influencing factors of each preparation method are the heating temperature and time [3]. Although meats and patties have been widely investigated with regard to their HAA contents for processed meat, such as bacon, only low data exists about the concentrations of HAA after pan frying [4-6].

The objective in this study was the analysis of bacon slices after different monitored heating treatments. As a working hypothesis, the concentration of HAA may be affected by pan frying time and temperature. The sensory quality of the bacon slices according to color and flavor after pan frying, as well as consumer preference, was determined using a hedonic test with a trained sensory panel.

• MATERIALS AND METHODS

Preparation of bacon:

Belly with rind and without gristles, 40 g/kg curing salt (0.9 % sodium nitrite), 5 g/kg bacon seasoning, 3 g/kg Schinkin Cum Spezial, 0.25 g/kg starter cultures (Bitec-SM 96, Frutarom,

Ditzingen, Germany). The preparation of the bacon was a dry-curing process for 4 days. After removal of the excess curing salt and a ripping time of 5 days (+2°C, 75-80% rel. humidity), the bacons were dried for 4 h and 5 min cold smoked. They were dried again at 28°C for 5 min process was repeated up to 85% weight loss. Each bacon was sliced in 2 mm thick slices.

Heating conditions:

The bacon slices were pan fried for 3, 4, 5, and 6 min at 150-170°C as well as 2 and 3 min at 200-220°C in a Teflon pan which were rubbed with sun flower oil. The temperature was monitored with a data logger (Therm 3280-8M, Ahlborn, Holzkirchen, Germany).

The bacon slices were continuously turned around after 1 min. The total pan frying time for each side of every slice was equal.

Determination of HAA:

The method includes the determination of polar and apolar HAA. The used method of HPLC analysis [7] with some modifications was based on the method described by Gross and Grüter [8]. The peaks of HAA, as well as Norharman and Harman, in samples were identified by comparing the retention times and UV-spectra with standards. The quantification was carried out with the method of standard addition.

Determination of principal components:

The main components of the prepared bacon were determined according to the instructions of the official collection of methods of analysis [9].

Determination of weight loss:

For the determination of weight loss, the bacon slices (n=8) were weighted before and 1 h after pan frying.

Sensory evaluation:

Sensory panelists were trained for the sensory evaluation of bacon slices. The testers evaluated the heated slices after pan frying. Sensory scores were rated using a continuous 10-cm scale for color (0 to 10, very light to very dark, 5 = optimal), and for flavor (0 to 10, under-fried to over-fried (burnt), 5 = optimal). The panelists (n = 12) ranked the samples by a mark on the scale. In addition, they had to mark the preferred sample.

- RESULTS AND DISCUSSION

For the standardization of the pan frying conditions, similar weight losses in both temperature ranges were chosen (Fig. 1). The weight loss of the bacon slices significantly increased with rising frying time ($p<0.05$). The weight loss increased at 150-170°C from 39 to 53% if the frying time is heightened from 3 to 6 min. At 200-220°C, an increase from 42 to 52% was found. Higher heating times of 4 min resulted in all burnt products with weight losses at about 64%. For further tests, only bacon slices in the defined range of 39-53% weight loss were used.

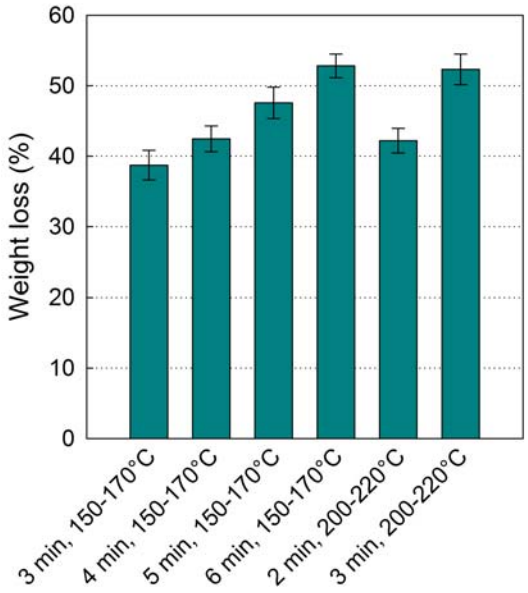

Figure 1. Weight loss (%) of the bacon slices after pan frying using different temperatures and times

The results of our analysis showed that the raw material of the bacon generally consisted of the principal compounds with little variation in their concentrations including proteins, fats, minerals (ashes), moisture, and sodium nitrite and potassium nitrate (Table 1).

Table 1 Main composition of the used bacon

Analysis	Mean	Standard deviation
Moisture (%)	49.6	0.1
Protein (%)	19.5	0.12
Fat (%)	26.0	0.2
Minerals (ashes) (%)	4.45	0.01
Sum of main compounds (%)	99.6	0.42
Collagen (%)	1.92	0.01
Nitrite (calculated as sodium nitrite) (mg/kg)	50	6.7
Nitrate (calculated as potassium nitrate) (mg/kg)	140	35

In all bacon samples, MeIQx, PhIP, Norharman, and Harman were found (Fig. 2A and B). High contents of MeIQx were quantified after a pan frying time of 6 min at 150-170°C and after a frying time of 3 min at 200-220°C. Both batches had a similar weight loss of 52% and 53%, respectively. The concentration of PhIP was relative low in all batches; However with higher frying times, the contents of PhIP increased (Fig. 2A). The concentrations of Norharman and Harman continuously enlarged both with extension of the frying time and increase of frying temperature (Fig.2 B).

In an earlier HAA study, which was also performed after pan frying of bacon, comparable levels of 0.4-4.3 ng/g MeIQx and 0-4.8 ng/g PhIP were determined [6]. In an article done by

Alaejos and Afonso [10], a review was given about HAA concentrations in different meats and processed meats. Bacon slices which were pan fried, both HAA compounds MeIQx, PhIP, and the β-carbolines Norharman and Harman were found in comparable concentrations as in our study according to the temperature and frying time conditions. In very well done products additionally often 4,8-DiMeIQx were quantified [11].

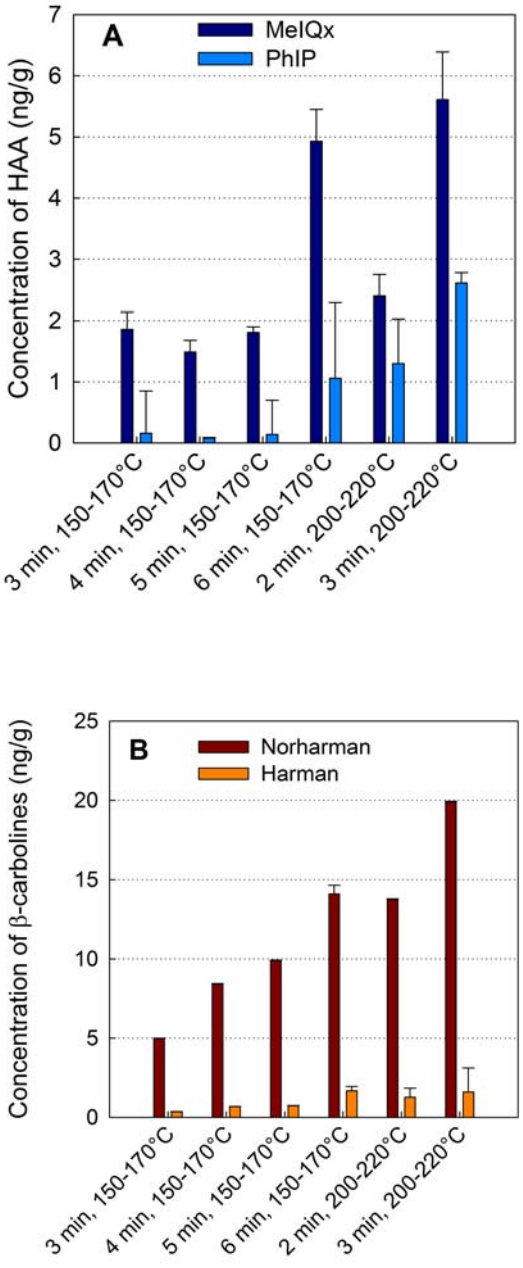

Figure 2. Concentration of (A) MeIQx and PhIP and (B) of Norharman and Harman (ng/g) after pan frying of bacon slices

The sensory evaluation of the bacon slices resulted in an optimal evaluation regarding the bacon slices after pan frying of 5 min for both color and flavor (Fig. 3). The preferred sample of the testers was overall the pan fried slices which were heated for 5 min at 150-170°C. Similar results in the sensory evaluation got the slices fried for 2 min at 200-220°C. Between these both batches, no significant differences in regard to color and flavor were found.

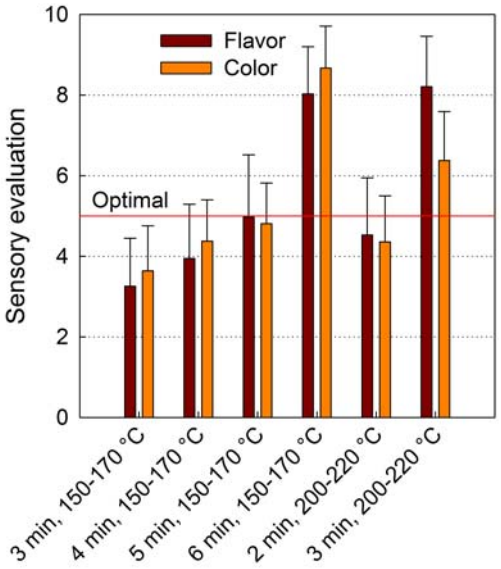

Figure 3. Sensory evaluation of bacon slices after pan frying (0 to 10, very light to very dark) and for flavor (0 to 10, under-fried to over-fried (burnt)

Although, the sensory evaluation showed a preference for the pan frying at lower temperature of 150-170°C and the frying time of 5 min.

It should be mentioned that consumer often prefer more crispy bacon slices with a golden brown color. One must consider that the content of MeIQx increased approximately 2.5 times for 1 min more pan-frying. The daily intake of these mutagenic substances may be increased. A guideline for the suitable pan frying conditions should be clearly stated on the package of bacon slices so that frying time chosen by the consumer is not too long and temperature is not too high.

- CONCLUSION

In pan fried bacon, high concentrations of MeIQx were found. The WCRF recommends that the intake of carcinogenic/mutagenic HAA in the diet should be reduced. The sensory tests illustrated that the preference of color and flavor plays a substantial role in the consumers being exposed to these substances. If consumers prefer a more fried very well done bacon slices, the risk of a higher intake of HAA will increase.

ABBREVIATIONS

HAA: Heterocyclic Aromatic Amines, MeIQx: 2-amino-3,8-dimethylimidazo[4,5*f*] quinoxaline, 4,8-DiMeIQx: 2-amino-3,4,8-trimethylimidazo [4,5-*f*]quinoxaline, PhIP: 2-amino-1-methyl-6-phenylimidazo[4,5-*b*] pyridine, Norharman: 9H-pyrido[3,4-*b*] indole,

Harman: 1-methyl-9H-pyrido [3,4-b] indole.

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