INFLUENCE OF COOKING TEMPERATURE AND TIME ON MEAT MUTAGEN FORMATION

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INTRODUCTION

Miller (1985) classified the mutagens formed in processed muscle foods into two groups: (1) mutagens induced by high temperatures, and (2) those formed at moderate temperatures. The high temperature-induced mutagens are likely to be produced during cooking of proteinaceous foods at temperatures in excess of 300°C (Sugimura et al. 1977). Most of these compounds are protein pyrolysates (Sugimura 1986) and are 2-amino-pyridine-type mutagens (Furihata and Matsushima 1986). The moderate temperature-induced mutagenic compounds are 2-amino-imidazole-type mutagens (Furihata and Matsushima 1986), and contribute most of the mutagenicity found in cooked meat (Kasai et al. 1979). These mutagens are probably produced from creatinine, aldehydes, and Maillard reaction products (Furihata and Matsushima 1986).

The effect of temperature on mutagen production in cooked ground beef was first described by Commoner et al. (1978). A number of investigators have subsequently shown that mutagen production increases with the temperature of cooking (Spingarn and Weisburger 1979; Hatch et al. 1982; Bjeldanes et al. 1983). Cooking methods that employ higher heating temperatures generally induce greater mutagenic activity than low temperature methods (Miller and Buchanan 1983). However, none of these studies have determined the internal temperature of the meat patties during frying. The objective of the present study was to investigate the relationship between the internal cooking temperature and time upon the amount of meat mutagens formed.

MATERIALS AND METHODS

Frozen ground beef was thawed and made into 100 g patties about 1 cm in thickness. The meat patties were fried at 0, 3, 6 and 9 min per side. The temperature of 5 points in the center of the meat and 4 points on the fry pan surface were monitored throughout the cooking process using a potentiometer equipped with a multipoint strip chart recorder. Thus, the surface heating temperatures were monitored along with the internal temperatures of the patties.

The fried patties were extracted using a modification of the methods of Bjeldanes et al. (1982), Hayatsu et al. (1983) and Felton et al. (1984a). A Versapack C18 10 300 x 4.1 mm reverse phase HPLC column was used with a C18 reverse phase guard column while a silica presaturation column was used in HPLC analysis. A mobile phase 1 M ammonium sulfate solution in methanol:ethanol: water (35:6:59, v/v/v) was used at flow rate 0.9 ml/min. Known concentrations of 2-amino-3-methylimidazo[4,5-f]quinoline (IQ), 2-amino-3,4-dimethyl-imidazo[4,5-f]quinoline (MeIQ), 2-amino-3,8-dimethylimidazo-[4,5-f]-quinoxaline (MeIQx), and 2-amino-3,4,8-trimethyl- imidazo-[4,5-f]quinoxaline (4,8-DiMeIQx) were used for identification and quantification of the above mutagens in HPLC analysis.

RESULTS AND DISCUSSION

The results of monitoring the internal temperature of the meat patties and the surface temperature of the fry pan are shown in Figure 1. In this test,the beef patties were fried for 35 min on one side only.

Results showed that even when the temperature setting of the fry pan was 215°C, the actual pan surface temperature was much lower. The initial pan surface temperature immediately after the beef patties were placed in the frypan was 42°C. The low initial temperature apparently occurred because the raw meat patties cooled down the surface temperature. As cooking proceeded, the pan surface temperature increased gradually, but did not reach over 160°C. Longer cooking times may be required in order to reach the pan setting of 215°C. These results showed that cooking time and cooking temperature are interrelated and must both be considered when evaluating mutagenicity produced during cooking of meat. Increasing the cooking time would increase the temperature effect to which the meat is exposed. The internal temperature of the meat patties reached a plateau after 15 min at about 75 - 80°C and remained in this temperature range until cooking was completed.

To determine the relationship between mutagen formation and the internal temperature of the beef patties, the pan surface temperature and the internal temperature of beef patties fried at 3, 6 and 9 min per side were monitored. The results are shown in Figures 2A, 2B and 2C, respectively. After extraction, the concentrations of IQ, MeIQx and 4,8-DiMeIQx were measured and are presented in Table 1.

The internal temperature of all meat samples increased steadily during frying on the first side. On turning the meat to the other side, however, the internal temperature suddenly increased from 34 to 61°C for 3 min, from 42 to

Table 1. Concentrations of IQ, MeIQx and 4,8-DiMeIQx in thick beef patties (1 cm) fried at 0, 3, 6 and 9 min per side[a,b,c].

SAMPLE TREATMENT	Mutagens in ng/g of Meat		
	IQ	MEIQX	4,8-DiMEIQx
Raw meat (0 min)	0	0	0
3 min	24±3	39±1	10±12
6 min	60±3	73±1	229±93
9 min	141±38	105±6	490±20

a) No MeIQ was detected in any of the samples.
b) The data show the means and the standard deviations for two replicate samples.
c) The concentrations of IQ, MeIQx and 4,8-DiMeIQx in thinner patties (0.5 cm in thickness) fried at 9 min per side were 1557, 5028 and 730 ng/g of meat respectively.

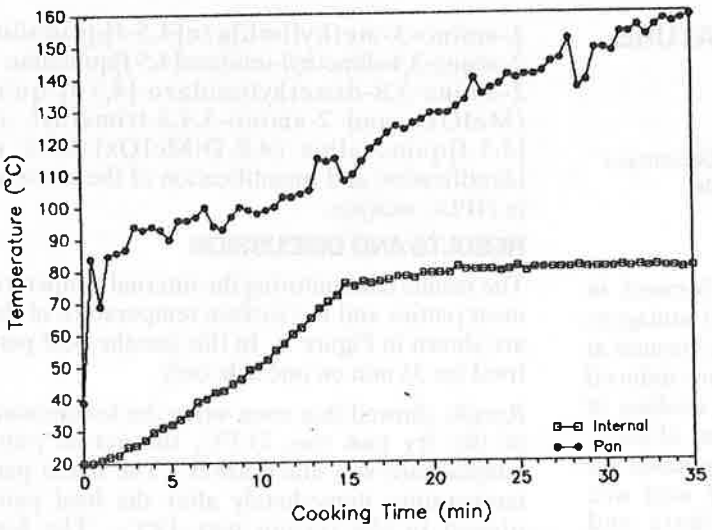

Figure 1. Pan Surface and Internal Temperature of Meat Patties Fried at 35min on Each Side. The Temperature of the Frypan was Set at 215°C.

73°C for 6 min and from 61 to 72°C for 9 min. Then the temperature tended to remain constant until frying was completed on the second side (Figures 2). The final internal temperatures were 60°C for 3 min, 74°C for 6 min and 73°C for 9 min per side. This phenomenon may be explained as being due to crust formation on the surface of the meat in contact with the frypan surface during frying on the first side. The moisture in the meat was evaporated from the other side of the patties and tended to keep the meat temperature low. Therefore, the internal temperature of the meat patties steadily increased during heating on the first side. On turning the meat to the other side, the frypan surface temperature was cooled down by the moist surface. In the meantime, the internal temperature of the meat patty increased markedly until the crust was formed and prevented moisture evaporation. Thereafter, the temperature tended to remain constant until frying was completed.

HPLC results showed that even though the internal temperature did not increase significantly with frying time, mutagen formation was positively correlated with frying time (Table 1). These results agree with Dolara et al. (1979) and Knize et al. (1985) who showed that the total mutagenic activity increased directly with cooking time. The present study also showed that less mutagens were formed in the thicker patties (1 cm) than in the thinner patties (0.5 cm), but the HPLC profiles were qualitatively similar. This is in agreement with the results of Knize et al.(1985) who pointed out that the thickness of the meat patties was negatively related to mutagenic activity.

CONCLUSIONS

The present study indicated: (1) An increase in frying time did not necessarily increase the internal temperature of the meat patties. (2) Even though the internal temperature did not increase significantly with frying time, mutagen formation was positively correlated with frying time. (3) Less mutagens were formed in the thicker than in the thinner patties. (4) This study clearly

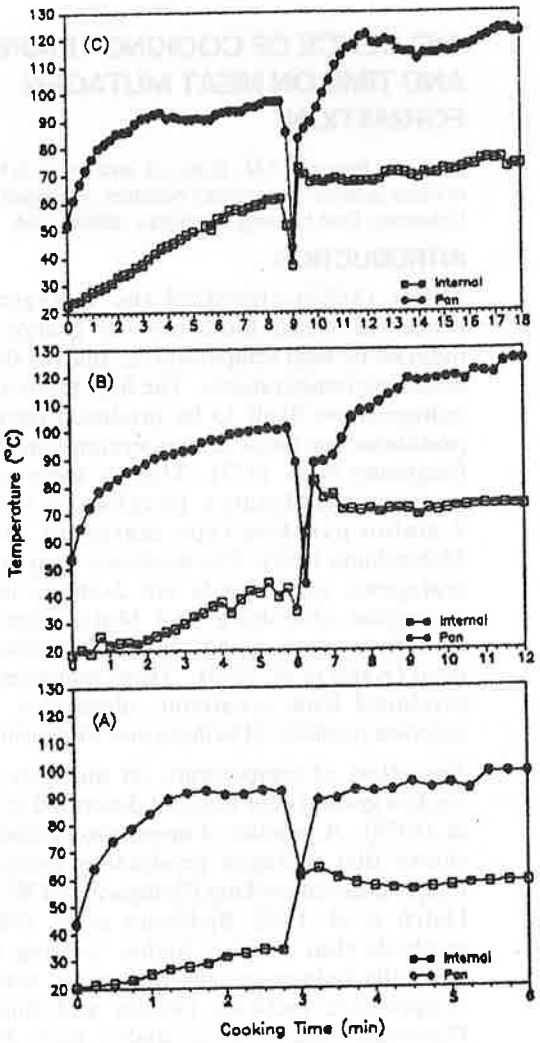

Figure 2. Pan Surface and Internal Temperature of Meat Patties Fried at (A)3min (B)6min and (C)9min on Each Side. The Temperature Setting of the Frypan Was Set at 215°C.

demonstrates that formation of meat mutagens during cooking is a function of both time and temperature.

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