EFFECTS OF SOME ADDITIVES ON MUTAGEN FORMATION DURING FRYING OF GROUND BEEF

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Summary

Amino-3-methyl-imidazo[4,5-f]quinoline (IQ) ,2-amino-3,4-dimethylimidazo[4,5-f]quinoline (MeIQ), 2-amino-3,8-dimethyl-imidazo[4,5-f]-quinoxaline (MeIQx) and 2-amino-3,4,8-trimethylimidazole[4,5-f] quinoxaline (4,8-DiMeIQx) are potent mutagens found in beef extract and fried beef. The effects that different food additives have on the formation of these mutagens during frying of ground beef were investigated. The food additives utilized included bisulfite, nitrite, phosphate, citrate, ascorbic acid, vitamin E and liquid smoke. Results demonstrated that all of the food additives studied inhibited formation of the meat mutagens in variable amounts at different concentrations, except for pyrophosphate at 10ppm which was ineffective. Bisulfite at 10ppm was the most effective blocker of mutagens and was followed in order by liquid smoke (100ppm), ascorbic acid (100ppm), vitamin E (10% of fat), nitrite (10ppm) and citric acid (100ppm).

INTRODUCTION

IQ and MeIQ were originally isolated from broiled fish (Kasai et al., 1980a,b). MeIQx (Kasai et al., 1981) and 4,8-DiMeIQx (Knize et al., 1985) were isolated from beef . These compounds, which are classified as IQ-like compounds, were also present in beef extract and fried beef (Chen et al., 1990). We showed earlier that several of the synthetic antioxidants (BHA, PG and TBHQ) decreased the formation of these IQ-like compounds in fried ground beef (Pearson et al., 1992a). It has been proposed that free radical reactions may be involved in the formation of these meat mutagens (Pearson et al., 1992b). The synthetic antioxidants can scavenge free radicals and block the formation of the IQ-like compounds. However, not all antioxidant activity is due to the effects of free-radical termination. Thus, we have added different food additives to ground beef and determined their effects on the IQ-like compounds formation during frying.

MATERIALS AND METHODS

Methods

Ground beef was prepared to contain one of the following food additives: bisulfite (10 and 100ppm), nitrite (10 and 100ppm), pyrophosphate (10 and 100ppm), citrate (10 and 100 ppm), ascorbic acid (10 and 100 ppm), vitamin E (1 and 10% of the fat content) and liquid smoke

(100 and 1000 ppm). The ground beef was made into 100g, 0.5cm thick patties, which were fried in a frying pan set at 215 C for 9 min. per side. The fried patties were extracted using modifications of the methods of Bjeldanes et al. (1982), Hayatsu et al. (1983) and Felton et al (1984). A Versapack C18 column with 1M ammonium sulfate in methanol:ethanol:water (35:6:59, v/v/v) was used as the mobil phase in the HPLC analysis.

RESULTS AND DISCUSSION

Table 1 shows the effects of adding different food additives upon the formation of the IQ-like compounds. MeIQ was not detected in any of the samples. IQ, MeIQx and 4,8-DiMeIQx were detected in the control patties at 1558, 5028 and 730 ng/g of meat equivalents, respectively.

Sulfiting agents and ascorbic acid are reducing agents and function by transferring hydrogen atoms, thus serving as oxygen scavengers. Sodium bisulfite significantly inhibited formation of IQ and MeIQx at both concentrations (P < 0.0005). Bisulfite also inhibited the formation of 4,8-DiMeIQx at 10 ppm (P < 0.025) but had no statistically significant effect at 100 ppm (P < 0.2). Ascorbic acid inhibited formation of IQ, MeIQx and 4,8-DiMeIQx, but was not as effective as bisulfite. At 100 ppm, ascorbic acid inhibited IQ and MeIQx (P < 0.025 and P < 0.01, respectively) but had no statistically

Table 1. Effects of Diffferent Food Additives on the Formation of IQ-Like Compounds During Frying of Ground Beef.

TREATMENT		IQ	MeIQx	4,8-DiMelQx
		Mean values	(ng/g of meat	equivalents)
CONTROL		1558	5028	730
Bisulfite	10 PPM	110	1272	17
Bisulfite	100 PPM	212	2127	494
Nitrite	10 PPM	1534	2077	204
Nitrite	100 PPM	214	2734	141
Pyrophosphate	10 PPM	436	2373	4958
Pyrophosphate	100 PPM	464	3627	370
Citric Acid	10 PPM	347	3760	121
Citric Acid	100 PPM	152	1695	709
Ascorbic Acid	10 PPM	178	1452	657
Ascorbic Acid	100 PPM	345	2464	290
Vitamin E	1% Fat	206	2299	493
Vitamin E	10% Fat	282	2094	0
Liquid Smoke	10 PPM	177	2033	35
Liquid Smoke	100 PPM	183	2232	202

gnificant effect on formation of 4,8-DiMeIQx ($P < 0.25$). At 1000 ppm, ascorbic acid gnificantly inhibited formation of IQ and MeIQx ($P < 0.005$ and $P < 0.05$, respectively), t caused only a slight inhibition of 4,8-DiMeIQx ($P < 0.1$).

th sodium bisulfite and ascorbic acid were more effective in blocking mutagen formation low levels than at high levels. On adding sodium bisulfite, the total meat mutagens etected amounted t0 1399 ng/g (meat equivalent) at 10 ppm but 2833 ng/g (meat equivalent) 100 ppm. For ascorbic acid, the total amount of meat mutagens amounted to 2287 ng/g eat equivalent) at 100 ppm and 3099 ng/g at 1000 ppm. The reason that the lower levels re more effective than higher levels is not clear. One possible explanation is that fferent pHs may effect the amount of mutagens formed. Nitrite and liquid smoke also owed a similar tendency in the present study, with higher concentrations producing more -like compounds than lower concentrations. However, the effects of high concentrations sodium bisulfite and ascorbic acid on mutagenicity were more pronounced than those of trite and liquid smoke.

trite significantly inhibited IQ, MeIQx and 4,8-DiMeIQx at both 10 and 100 ppm. Both ncentrations of nitrite were about equally effective in blocking mutagen formation.

the present study, at 100 ppm of added liquid smoke, formation of IQ ($P < 0.005$), eIQx ($P < 0.005$) and 4,8-DiMeIQx ($P < 0.025$) was significantly inhibited. At 1000 ppm, iquid smoke inhibited formation of IQ ($P < 0.0005$), MeIQx ($P < 0.025$) and 4,8-DiMeIQx (P 0.05).

oth citric acid and polyphosphates are chelating agents, which complex with prooxidant etal ions such as iron and copper thus, chelating agents can block the catalysis of lipid xidation (Dziezak, 1986). At 10 ppm, sodium citrate significantly inhibited formation of and 4,8-DiMeIQx ($P < 0.005$ and $P < 0.025$, respectively) but had little effect upon ormation of MeIQx ($P < 0.2$). At 100 ppm, sodium citrate significantly inhibited both IQ d MeIQx ($P < 0.0005$ and $P < 0.005$, respectively), but there was no great difference ($P >$ .25) in the concentration of 4,8-DiMeIQx in the control and the citrate treated samples. t has been reported that short chain polyphosphates, for example pyrophosphate, are etter heavy metal sequestrants than long chain polyphosphates (Steinhauer, 1983). In the resent study, 100 ppm sodium pyrophosphate slightly inhibited formation of IQ, MeIQx and ,8-DiMeIQx ($P < 0.1$). At 10 ppm, however, sodium pyrophosphate caused a small increase formation of 4,8-DiMeIQx ($P < 0.1$), but it had no great effect on formation of IQ and eIQx in comparison to the control.

educing agents (bisulfite and ascorbic acid) are more effective in inhibiting meat tagen formation than chelating agents (sodium citrate and sodium pyrophosphate). tocopherol mixture (Cavitol) was also tested in the present study using two concentrations (1 and 10% of fat content). The results indicate that 1% of mixed tocopherols significantly reduced IQ formation ($P < 0.0005$), but at 10% was less effective ($P < 0.1$). The tocopherols also inhibited formation of MeIQx at both concentrations tested ($P < 0.05$ for 1 % and $P < 0.01$ for 10%). Addition of tocopherols at a concentration of 1% slightly inhibited formation of 4,8-DiMeIQx ($P < 0.2$), but at 10% completely prevented its formation.

Results of the present study suggest that the compounds tested may stabilize the sugar fragment or react with the free radicals formed in the earlier stages of the browning reaction, and thus indirectly inhibit the formation of the meat mutagen precursors.

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