A Research Note

NITROSAMINE FORMATION IN HOME-COOKED BACON

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ABSTRACT

Randomized slices of bacon were cooked at home by 25 consumers by their usual method of preparation and the edible portions were analyzed for nitrosamines. N-nitrosodimethylamine (DMNA) and N-nitrosopyrrolidine (NPyr) were found in all samples. Of the 25 preparations, five contained DMNA and five contained NPyr in concentrations greater than 10 μg/kg; only one sample contained both nitrosamines in concentrations greater than 10 μg/kg. Although the association between nitrosamine concentration, time and amount of heat is not strong, it appears that frying bacon at low or medium heat for less than 10 min can result in less than 10 μg/kg DMNA or NPyr.

INTRODUCTION

N-NITROSOPYRROLIDINE (NPyr) forms in bacon on the application of heat during preparation for consumption. Although the precursor(s) of the nitrosamine and the mechanism of formation are still unknown, it has been observed that greater concentrations of the NPyr form in the adipose tissue than in the lean (Fiddler et al., 1974) and that nitrosoproline (NPro) is present in raw bacon (Kushnir et al., 1975; Ivey, 1974). The conversion of NPro to NPyr occurs through decarboxylation at elevated temperatures (Pensabene et al., 1974; Huxel et al., 1974). Several studies have demonstrated the formation of NPyr in bacon prepared by frying, broiling, or baking, with the lowest concentration in the product prepared in the microwave oven at, presumably, a lower temperature than the other methods (Herring, 1973; Pensabene et al., 1974). Pensabene et al. (1974) investigated the effects of time and temperature on NPyr formation and suggested that lower temperatures reduced the concentration of NPyr produced.

Practically all studies in the United States on the formation of NPyr in bacon have been carried out by frying for 3 min on each side in preheated electric fry-pans set at 172°, which is approximately the temperature recommended on most commercial packages of bacon. For research purposes such a standardized time and temperature program is essential, but it does not take into consideration the variations occurring during the preparation in the home. The formation of nitrosamines in bacon prepared by consumers was investigated and the results are reported here.

MATERIALS & METHODS

Bacon

For the first experiment a slab of bacon was obtained from a processor, sliced, and randomized into packages containing 10 slices each. The packages were given to 12 members of the Eastern Regional Research Center with instructions to prepare the bacon as they normally would cook it for family use. The participants completed the form shown in Figure 1 and returned it with the fried bacon strips. One package of bacon (control) was fried in the laboratory at 175°C in a preheated, calibrated electric fry-pan. This bacon was fried for 4 min on each side instead of the standardized 3 min in order to obtain a more edible-appearing product. The degree of doneness of the bacon samples was subjectively evaluated by the member of the staff responsible for preparing and evaluating bacon in the laboratory for the last 3 yr.

In the second experiment, carried out several months later, 1-lb packages of a nationally distributed bacon were purchased at a retail market, the slices were randomized as described above and distributed to 13 members of the Center staff who had not participated in the previous study. The instructions and evaluations of degree of doneness, carried out by the same evaluator, were as described above.

Please cook this bacon in the way you normally prepare it for your family. Keep a record of the length of time of cooking. Wrap cooked bacon strips in aluminum foil and return.

Please fill in questionnaire below.

1) Type of heat:
Gas Electric

2) Method:
Fried Broiled Baked Other

3) Pre-heat cooking utensil:
Yes No

4) Heat setting (gas flame or electric):
Low Medium High Broil Temp.

5) Time of heating (from time bacon is placed in the heat):

Fig. 1—Form used to collect information on home cooking conditions.

Nitrosamine analysis

Each bacon sample was ground and thoroughly mixed. Aliquots of each sample were analyzed for nitrosamines by a modification of a previously described procedure (Pensabene et al., 1974) in which direct extraction was used to remove nitrosamine from the sample instead of the methanolic-KOH digestion. The gas chromatographic detector used for the first part of the study was the alkali-flame ionization detector in the Perkin-Elmer Model 3920 GC. The second set of samples was analyzed with a Thermal Energy Analyzer (Fine et al., 1975) interfaced with the Varian-Aerograph Model 1720 GC. Confirmation of positive nitrosamines was carried out with the DuPont Model 492 GC-mass spectrometer (Pensabene et al., 1974) operated with a resolution of 1 in 12,000 in the peak matching mode.

RESULTS & DISCUSSION

THE DATA on the formation of nitrosamines during frying of bacon in consumers' homes are shown in Table 1. Electric heat was used by 10 of the 25 participants (40%) and gas by the remainder. One bacon sample was baked for 47 min and two were broiled for 5 and 9 min; the remainder were fried in the conventional manner for preparing bacon. Approximately 50% of the participants frying with gas (8 of 15) estimated low heat was used and the frying time ranged from 10–28 min. The five participants using medium heat fried the bacon from 4–9 min; one sample was fried at a high gas heat for 6 min. Electrically, prepared at a medium setting for times ranging from 5 min to 15 min. Two bacon samples were fried for 10 min at a medium-high heat. Only three samples (#2, 14 and 16) were prepared in preheated fry-pans. Five samples were judged to be well-done and 17 were either medium or medium-well done

three samples were medium-rare. The degree of doneness corresponded roughly with the amount of heat used and the time of heating.

Although the study was established to evaluate NPyr formation in the bacon samples, n-nitrosodimethylamine (DMNA) was also found. However, the formation of these nitroso compounds does not appear to follow a discernible pattern. In the first experiment, 5 of the 12 samples contained more than 10 μg/kg NPyr; only one of all the samples had more than 5 μg/kg DMNA. The most undesirable bacon, containing 31 μg/kg DMNA and 13 μg/kg NPyr, was fried electrically at a medium-high heat for 10 min, whereas the other four samples with more than 10 μg/kg NPyr were fried on low gas heat from 14–25 min. In the second experiment, however, there were no samples with 10 or more μg/kg NPyr. Two samples with high (39 and 28 μg/kg) DMNA concentrations were fried electrically at medium-high and high settings for 11 and 8 min, respectively. Two gas-fried bacon samples with 15 and 24 μg/kg DMNA were cooked at low heat for 28 and 10 min, respectively.

The formation of nitrosamines in random samples of bacon fried under home conditions emphasizes our lack of knowledge about the mechanism of formation of these compounds. While it is true that the amount of heat applied was estimated by those cooking the bacon, there is no obvious correlation between nitrosamine formation and the time and estimated heat applied. It appears, however, that frying at low to medium heat settings for less than 10 min could result in lower nitrosamine concentrations. The variation in nitrosamine content was probably not caused by the variation in composition of the bacon used since the strips were randomized, and greater randomization was achieved in the second experiment in which commercial bacon, presumably from different bellies, was used.

Nitrosamines were determined only in the edible product in this study. However, since larger concentrations of these compounds have been reported to occur in the rendered fat than in the lean tissue, the method of draining or blotting the fat from the edible portion could affect the residual nitrosamines determined.

No information is available on the possible health significance in the human diet of trace quantities of nitrosamines in the concentrations reported in this study.

Table 1—Formation of nitrosamines in bacon fried by consumers

Sample no.	Heat applied	Time (min)	Degree of doneness	DMNA[a] μg/kg	NPyr[b] μg/kg
		Experiment No. 1			
Electric heat					
Control	175°C	8	Well	3	7
1	Bake (175°C)	47	Well	3	3
2	Low	14	Medium	3	5
3	Medium	5	Medium	2	6
4	Medium	15	Med-rare	3	5
5	Med-high	10	Well	31	13
Gas heat					
6	Low	14	Med-well	—	14
7	Low	15	Med-well	3	12
8	Low	20	Well	5	14
9	Low	25	Well	4	12
10	Medium	7	Med-well	4	7
11	Medium	9	Med-well	3	9
12	High	6	Well	4	7
		Experiment No. 2			
Electric heat					
Control	175°C	8	Well	5	5
13	Medium	10	Med-rare	3	4
14	Medium	10–15	Medium	6	3
15	Med-high	11	Med-well	28	7
16	High	8	Medium	39	8
17	Broil	5	Med-well	4	4
Gas heat					
18	Low	10	Medium	24	5
19	Low	12	Medium	5	5
20	Low	20	Medium	3	8
21	Low	28	Med-well	15	8
22	Medium	4	Med-rare	4	1
23	Medium	5	Medium	3	2
24	Medium	6	Med-well	9	8
25	Broil	9	Med-well	5	7

[a] DMNA, N-nitrosodimethylamine
[b] NPyr, N-nitrosopyrrolidine

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