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EFFECT OF COOKING ON γ-HCH, DDE, DDD AND DDT LEVELS IN DUCK MUSCLE FAT

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Key words: manufacturing processes, culinary treatment, residues, foreign substances, pesticides.

A model system was used to investigate the effect of cooking on the level of selected chlorinated carbohydrate residues in muscle fat of fattened ducks and in decoction fat.

INTRODUCTION

In many research centers studies were conducted on the hygienic value of foods. These showed an alarming level of chemical pollution, not only of raw materials but also of intermediate products and finished foods. Heavy-metal content [4, 6] and pesticide residues [3, 5, 19, 20] are most often taken into account in such studies. Both world and national organizations supervising food production and turnover pay more and more attention to the threat to consumer health posed by foreign chemical compounds present in foods. Therefore, basing on the findings of numerous investigations, permissible daily and monthly uptakes of compounds which may adversely affect the human organism have been determined. Considering the limited adaptability of our organism to foreign chemical compounds, as well as the harmful effects on human beings of trace amounts of many compounds, especially those in associated systems, it would be desirable that no residues of pesticides, mercury, lead, cadmium be present in foodstuffs. Hence the importance of investigations concerning the possibilities of reducing levels of foreign chemical compounds in the course of preliminary and principal manufacturing and cooking processes. Little information on this subject is found in the available literature. In the Polish literature, there are mostly reports of the fate of chlorinated hydrocarbons in milk, dairy products, eggs and other products of animal origin [9, 11, 15, 17].

The purpose of the present study was to investigate the thermal degradation of chlorinated hydrocarbon residues in duck muscle fat and in decoction fat in the course of meat cooking in a model system.

EXPERIMENTAL

MATERIAL

Samples of selected muscles of fattened ducks were used. Birds were supplied by the Animal Breeding and Production Institute of the University of Agriculture and Technology at Olsztyn. After slaughter and dissection, eight samples of thigh muscles and eight samples of chest muscles were taken, all having similar contents of DDT and of DDT metabolites.

METHODS

In the experimental part, samples of thigh and chest muscles were cooked according to the following two procedures:

1) From hot water: A weighed 5-g portion of meat was placed in a 100 cm^3 conical flask containing 50 cm^3 of simmering distilled water. Then the flask, with its content, was placed under a ball reflux condenser and cooked for 25 min. After that time the meat attained consumption quality as regards texture.

2) From cold water: A weighed 5 g sample of meat was put in a 100 cm^3 conical flask, and 50 cm^3 of distilled water (at room temperature) was poured in. The flask was then placed under a ball reflux condenser and heated in such a manner as to bring the water to a boil after 10 min. The meat was then cooked for a further 25 min.

After cooking, the contents of the studied chlorinated hydrocarbons were determined in meat decoctions from both processes according to the following procedure:

a) Fat was isolated from meat samples by the method of Schmid and Bondzyński, as described by Budsławski and Drabent [2]. The same method, but with mineralization omitted, was used to isolate fat from the decoction.

b) Chlorinated hydrocarbons were isolated from meat samples using Wood's procedure as modified by Stec [18]; the same compounds were isolated from decoction fat by the one-step method as described by Smoczyński and Jaworski [16].

c) γ-HCH, DDE, DDD and DDT were separated and determined quantitatively by gas chromatography under the following conditions:

— Apparatus: Pye Unicam series 104 gas chromatograph, electron caption detector (ECD), glass column 1.5 m long with inner diameter of 4 mm,

filled with W chromosorb, A/W, DMCS, 60/80 mesh, with liquid phase applied — 5% DC 11.

— Temperature: detector — 250°C, column — 195°C, evaporator — 225°C.

— Carrier gas: argon; flow rate: 90 cm^3/min.

Results were calculated by comparing peak areas of tested samples with those of a quantitative standard applied onto the column every few samples. Measurements of height and width were carried out at mid-height of peaks, using a geodesic detail applier.

d) The significance of differences between contents of chlorinated hydrocarbons assayed in meat and decoction fat was calculated according to Bożyk and Rudzki [1].

RESULTS AND DISCUSSION

In this study, the hydrocarbons in meat and decoctions were expressed as p.p.m. of fat, i.e. in mg/kg of fat.

In the fat of cooked meat, the γ-HCH level was observed to decrease to 0.03 p.p.m. in thigh bone muscle and to 0.08-0.09 in chest muscle (Table 1). These values were lower by 25% in comparison to fat of the raw material (Table 4). However, these differences were not statistically significant.

Compared with the HCH level, the levels of DDT and its metabolites were lower after heat treatment (Tables 1 and 4). These differences were statistically significant, except in the case of DDT in thigh muscles cooked from cold water. The studied pesticides tend to decrease more in chest muscle than in thigh muscles, this being especially true of DDT and DDD. In chest muscles cooked from hot water the levels of DDT and DDD decreased on the average by 85 and 90%, respectively (Table 4).

Table 1. Chlorinated hydrocarbons in fat of raw and cooked muscles from thight and chest of fattened ducks (mg/kg fat)

Insecticide	Raw meat		Meat cooked beginning from			
			boiling water		cold water	
	thigh	chest	thigh	chest	thigh	chest
γ-HCH	0.04±0.02	0.12±0.06	0.03±0.01	0.08±0.06	0.03±0.02	0.09±0.07
DDE	0.07±0.04	0.12±0.03	0.03±0.02	0.04±0.03	0.02±0.01	0.05±0.03
DDD	0.06±0.02	0.19±0.07	0.03±0.02	0.02±0.01	0.04±0.03	0.07±0.05
DDT	0.25±0.04	0.78±0.11	0.14±0.06	0.12±0.08	0.09±0.07	0.17±0.12
DDE+DDD+DDT	0.38±0.06	0.78±0.15	0.20±0.09	0.18±0.14	0.15±0.10	0.29±0.13

Values differing significantly from values for raw material are underlined

Table 2. Chlorinated hydrocarbons in fat of duck meat decoction (mg/kg fat)

Insecticide	Decoction cooked beginning from			
	boiling water		cold water	
	thigh	chest	thigh	chest
γ-HCH	0.04±0.02	0.21±0.15	0.05±0.02	0.48±0.26
DDE	0.04±0.03	0.07±0.03	0.03±0.02	0.12±0.10
DDD	0.07±0.05	0.27±0.21	0.12±0.08	0.34±0.19
DDT	0.27±0.12	0.59±0.56	0.25±0.13	1.08±0.46
DDE+DDD+DDT	0.38±0.14	0.93±0.54	0.40±0.20	1.54±0.67

Values differing significantly from values for raw material (continuos line) nad from values for another way of cooking (broken line) are indicated.

Higher amounts of all the studied compounds except DDE were found in fat which passed to the decoction than in the fat of raw meat (Tables 1 and 4). The considerable variance of results caused that the only statistically significant difference in comparison to raw material was displayed by total DDT in thigh muscle cooked from cold water. In the fat from decoction of chest muscles cooked from cold water as well as of thigh muscles cooked from cold water, the DDE content was significantly lower, statistically, than in raw material fat.

Higher values of the analysed compounds in the fat of decoctions cooked from cold water (Table 1) were not statistically significant.

Table 3 presents the percentages of DDT and of its metabolites calculated for total DDT. In the material analysed, DDT clearly predominates, its average content being 60-70%, and attaining as much as 80% in individual samples. The percentage of DDE was from 7.9% to 27.5%, while that of DDD was 11.9% to 25.6%. DDD was obviously prevalent over DDE in decoction fat.

The statistical analysis of the percentage ratio DDE:DDD:DDT showed a significant increase of DDT percentage in fat of chest muscle cooked from hot water, while DDE decreased in the fat of the same muscle cooked from cold water. When comparing the decoction fat and the raw meat fat, the percentage of DDE was found to be significantly lower in the decoction of chest muscles cooked from cold water. On the other hand, when the proportions of pesticides in muscle cooked by both methods was examined, it was found that a statistically significant decrease of DDE and an increase of DDD concentration occurred in the fat of chest muscle cooked from cold water. In decoction fat the proportions of the analysed pesticides were found to be unaffected by the method of cooking.

The higher level of pesticides (except DDE) in decoction fat, as compared to the fat of raw and cooked meat (Table 4), that was observed in this experiment is most probably caused by a non-uniform distribution

Table 3. Percentiles of DDE, DDD and DDT in fat of raw and cooked meat and of duck meat decoctions

Insecticide	Raw meat		Meat cooked beginning from				Decoction cooked beginning from			
			boiling water		cold water		boiling water		cold water	
	thigh	chest	thigh	chest	thigh	chest	thigh	chest	thigh	chest
DDE	16.1±9.6	15.7±5.0	17.1±7.3	27.5±15.0	17.0±7.3	7.9±4.4	11.6±3.3	10.0±7.7	8.2±3.4	7.9±4.4
DDD	16.1±4.8	24.2±7.3	13.0±11.0	11.9±8.6	13.8±9.8	23.0±7.4	24.4±22.9	25.6±15.9	24.9±19.4	23.0±7.4
DDT	67.8±10.1	60.1±15.4	69.9±9.9	60.6±10.8	69. ±7.0	69.1±10.5	64.0±24.0	64.4±21.5	66.9±17.4	69.1±10.7

Values differing significantly from values for raw material (continuous line) and from values for another way of cooking (broken line) are indicated.

[25]

Table 4. Chlorinated hydrocarbons in fat of cooked duck meat and in decoction fat in comparison to raw material (in %)

Insecticide	Meat cooked beginning from				Decoction cooked beginning from			
	boiling water		cold water		boiling water		cold water	
	thigh	chest	thigh	chest	thigh	chest	thigh	chest
γ-HCH	75.0	66.7	75.0	75.0	100.0	175.0	125.0	358.3
DDE	42.9	33.3	28.6	41.7	57.1	58.3	42.9	100.0
DDD	50.0	10.5	66.7	36.7	116.7	142.1	200.0	178.9
DDT	56.0	15.4	36.0	21.8	108.0	75.6	100.0	138.5
DDE+DDD+DDT	52.6	23.1	39.5	37.2	100.0	119.2	105.3	197.4

of these compounds in meat fat. It is probable that the intertissual fat, which is the main fat passing to the decoction, is especially polluted with residues of pesticides. On the other hand, chlorinated hydrocarbons were determined with the use of acid hydrolysis with total fat of muscle taken into consideration, and this could have decreased the value of the result.

Of the chlorinated hydrocarbons studied, substantial heat resistance was shown by HCH; this is in agreement with observations of other authors, e.g. Nikonorow and Zimak [9].

The decrease of DDT in muscle fat is to be regarded as high. The greatest reduction of this compound was obtained by Ritchey et al. [12]. This decrease was higher than that observed by Liska et al. [7] in cooked poultry meat, and by Nikonorow and Zimak in cooked eggs. It may be suggested, as it is tentatively confirmed in this report, that heat treatment of meat causes a transformation of DDT into DDD; this is also confirmed by studies of other authors [8, 13, 14]. The increase of DDD content is especially manifest in decoction fat.

The demonstrated influence of cooking method on the residues of total DDT in fat and chest muscle decoctions (Table 2) and its influence on DDE and DDD percentages also in chest muscle fat (Table 3) is to be connected with the effect of extract compounds on pesticides, a phenomenon observed by Ralls and Cortes [10].

CONCLUSIONS

1. The cooking process caused the contents of the studied pesticides to decrease significantly in muscle fat. Changes in DDT were evidenced by increased DDD content in decoction fat. The lowest reduction was that of γ-HCH.

2. In this experiment, the levels of the studied pesticides were found to increase in the decoction fat (DDE being the only exception).

3. The daily uptake of chlorinated hydrocarbons contained in food may be significantly reduced by cooking the meat that is to be consumed.

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WPŁYW GOTOWANIA NA POZIOM γ-HCH, DDE, DDD I DDT W TŁUSZCZU MIĘŚNI KACZEK

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Streszczenie

W układzie modelowym badano wpływ gotowania na poziom pozostałości wybranych chlorowanych węglowodorów w tłuszczu mięśni tuczonych kaczek i w tłuszczu wywaru. Materiałem do badań były próbki mięśni udowych i piersiowych tuczonych kaczek. Chlorowane węglowodory (γ-HCH, DDE, DDD i DDT) oznaczano metodą chromatografii gazowej.

W tłuszczu mięsa surowego stwierdzono średnio 0,04 ppm γ-HCH i 0,38 ppm DDT (udo) oraz 0,12 ppm γ-HCH i 0,78 ppm DDT (pierś). Po gotowaniu od gorącej wody w tłuszczu mięśnia udowego obserwowano średnio 0,03 ppm γ-HCH i 0,20 ppm DDT, w tłuszczu mięśnia piersiowego 0,08 ppm γ-HCH i 0,18 ppm DDT. Podczas gotowania od zimnej wody wyniki wynosiły dla uda 0,03 ppm γ-HCH i 0,15 ppm DDT, dla piersi 0,09 ppm γ-HCH i 0,29 ppm DDT.

Podczas gotowania od gorącej wody w tłuszczu wywaru z uda poziom γ-HCH wynosił średnio 0,04 ppm, DDT 0,38 ppm, dla wywaru z piersi 0,21 ppm γ-HCH i 0,93 ppm DDT. Podczas gotowania od zimnej wody w tłuszczu wywaru z uda obserwowano 0,05 ppm γ-HCH i 0,40 ppm DDT, dla wywaru z piersi 0,48 ppm γ-HCH i 1,54 ppm DDT.

W tłuszczu wywaru wyraźnie wzrastała zawartość DDD w porównaniu z tłuszczem mięsa surowego.