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Smoking of Meat and Meat Products in Electrostatically Precipitated Smoke

Introduction

Modern progressive tendencies in smoke curing process in various countries are directed partly to the improvement of technology until now used (new types of smokehouses, smoke generators, automatic regulation of operating parameters, etc.), partly to the research of quite new technological processes (e.g. electrostatic smoking, treatment with liquid smoke condensates).

As the main defects of the existing smoke curing process we can consider the lengthiness of the mentioned process, the work under unhygienic and unhealthy conditions, irregular smoke flavour and color development on the surface of the smoked products, diffusion of unhealthy substances from the smoke into the smoked products, the deposition of tar and tarry substances on the walls of smokehouses and equipments which are removed with difficulty, uneconomical utilization of wood and sawdust, etc.

Research teams in many countries are engaged very intensively in the improvements of the smoking process, especially, in the removal of the defects mentioned above.

Some defects of the existing smoking process can be removed

by the electrostatic precipitation of the smoke) these conclusions are in agreement with findings of Englisch scientists F o s t e r et al. (1961) who have found that the electrostatically precipitated smoke from which the smoke particles were removed has under special conditions a similar composition and properties as the untreated smoke.

In this work we are dealing with the study of chemical and technological properties of electrostatically precipitated smoke; we took interest in the smoke colour of meat products produced by the smoke treated in this way and we studied whether the treated smoke gives the typical and required smoke flavour to the smoked products. Further we took interest in the elimination of the carcinogenic substances such as 3,4-benzo(a)pyrene by means of el ctrostatic precipitation of t e smoke.

Materials and Methods

Experimental equipment for smoking with treated and untreated smoke.

Smoke particles were eliminated from the whole smoke by means of the laboratory electrostatic precipitator ESA-S with a separated ionization section. Parameters of the used precipitator are as follows:

surface of the collector:	0,04 m^2
length of the collector:	27,5 cm
total collection surface:	0,72 m^2
number of the ionization fields:	2
number of the ionization electrodes:	8
voltage on the ionizer:	- 15 kV ef

separation in particles with the diameter 0,2 micron .. 94,5 %
effectiveness of separation in particles with the diameter from 1 to 20 microns ..... more than 99 %.

The smoke used for the experiments was produced by combustion of beech sawdust in a laboratory generator on the electrically heated plate (40 times 20 cm) at the temperature of

400°C. The generated smoke was exhausted through the flue gas ducting which was in connection with the smoking-chamber, eventually with the electric filter and the smoking-chamber, on the end of which a fan was installed. The conditions of smoking by electrostatically precipitated smoke are as follows:

temperature in the smoking-chamber:	80 to 90°C
voltage of the ionizer:	10 to 14 kV
ionization current:	0,10 to 0,30 mA

Samples used for smoking

In the technological experiments with the new way of smoking the following kinds of products have been used: fine frankfurters knackers, frankfurters of Debrezin type, frankfurters of Liberec type, Moravian sausages, kabanos, etc. Samples from the same rank were smoked partly in a conventional way, partly by means of the electrostatically precipitated smoke and the meat products produced in this manner were anonymously organoleptically evaluated.

Sensory evaluation

The sensory panel in the number of 10 to 16 persons, composed of workers of the Research Institute of Meat Industry has judged anonymously marked samples according to the following hedonic scale:

flavour	- 0 to 9 points
aroma	- 0 to 4 points
surface colour	- 0 to 4 points

Chemical methods

The preparation of smoke samples: simultaneously with technological tests we exhausted part of the smoke introduced in the smoking-chamber by an oil pump. We bubbled the smoke through a system of three washing bottles connected in single file and filled with water. The diameter

of the flue gas ducting was 90 mm, the diameter of the branch for the smoke exhaustion, used for chemical analyses was 12 mm. Each washing bottle was filled with 500 ml of distilled water and after finishing the experiment the content of all three washing bottles was connected and evaluated as one sample.

In this way the samples of aqueous solutions of smoke both from the normal smoke and from the precipitated smoke were prepared.

In the aqueous solutions of smoke the following substances were established:

a) Total content of acids was determined by titration with 0,1N sodium hydroxide solution (indicator phenolphthalein). The total content of carboxylic acids was expressed in mg % of acetic acid.

b) For the determination of the total content of phenols the colorimetric method with 4 - aminoantipyrine was used. The content of phenols was expressed in mg % of phenol.

c) Total content of carbonyl compounds was determined by the colorimetric method with 2,4 dinitrophenylhydrazine and expressed in mg % of acetone.

d) Determination of 3,4 benzo(a)pyrene.

For the determination of 3,4 benzo(a)pyrene in a normal and electrostatically precipitated smoke the aqueous solutions of smoke from some ranks were used. The ranks poured together on the volume of 8 litres which represented always one sample of a normal and precipitated smoke. These samples were successively evaporated on the water bath to dryness. The residue was extracted by 80 ml of hot benzene. After cooling and filtration the volume of the benzene extract was diluted to 100 ml; from this sample 50 ml (which corresponds to 4 litres of the aqueous solution of smoke) to the proper determination were used. The extract separa-

ted in this way was thickened on 5 ml and subjected to a column chromatographic separation and spectrophotometric evaluation of 3,4 benzo(a)pyrene according to the method elaborated by Král et al. (Chem. listy, 58, 1448/1964). The principle of this method is the application of column chromatography (column of Al_2O_3 and acetylcellulose) and of the spectrophotometric evaluation of the separated fluorescent fraction by means of UV-spectrophotometry. The ultraviolet spectrum of the samples was measured between 300 - 400 nm.

Results and discussion

1) Chemical composition of treated smoke.

Our experiments proved that there were some differences between the chemical composition of the normal and electrostatically precipitated smoke. From our experiments it is evident that the electrostatically precipitated smoke contains all technologically important components in a lower concentration than the untreated smoke. The results of these analyses are given in Table 1.

Table 1

Chemical Composition of Normal and Electrostatically Precipitated Smoke

Number of sample	Normal Smoke (mg %)			Electrostatically precipitated smoke (mg %)		
	Acids	Carbonyl compounds	Phenols	Acids	Carbonyl compounds	Phenols
1	372	465	15,6	120	136	2,7
2	324	400	14,2	120	140	3,2
3	276	460	12,4	180	164	5,5
4	136	350	4,6	150	230	2,2
5	162	329	4,6	132	215	2,2
6	132	280	5,0	111	173	2,0
7	156	330	5,4	150	212	2,4
8	300	500	9,6	129	218	2,6
9	252	410	6,2	216	254	2,6
10	264	460	8,6	174	208	2,6
11	174	340	5,4	156	212	3,2
12	132	265	4,2	126	180	2,2
13	174	224	6,2	153	170	2,3
14	172	206	5,8	180	191	2,9
15	144	188	5,0	156	173	2,3
Average	208	347	7,5	150	192	2,7

From the results follows that the most considerable decrease was found in the content of phenols followed by carbonyl compounds and the least decrease was found in the content of acids.

From the mentioned analyses follows that in an electrostatic precipitator not only solid particles but as well as drops, containing substances with relatively low boiling point, were separated. These substances can appear - according to the given conditions-either in a gaseous or in a liquid phase. It is in agreement with data of Foster and Simpson (J. Sci. Food Agric., 12, 635 (1961) advocating that the drops of organic substances form some of these compounds and they can release these substances in a gaseous phase at the change of conditions.

2) Sensory evaluation of products smoked by precipitated smoke

The important criterion for the judgement of applicability of the investigated method of smoking is the consumer's judgement of the finished products' quality.

The results of 13 anonymous sensory evaluations are given in Table 2.

Table 2

Sensory Evaluation of Meat Products Smoked with Normal and Precipitated Smoke

(N = normal smoke, F = precipitated smoke)

Kind of product	Number of judges	Method of smoking	Total number of points		
			flavour	aroma	surface colour
Fine frankfurters	14	N	79	39	41
		F	70	23	28
	14	N	69	22	21
		F	71	22	34
Knackers	16	N	99	46	46
		F	99	39	39
Frankfurters of Debrezin type	15	N	79	37	39
		F	83	32	37
Frankfurters of Liberec type	13	N	69	23	29
		F	81	34	31
Moravian sausages	16	N	97	38	45
		F	91	40	38
	10	N	56	20	22
		F	56	20	22
	16	N	94	44	30
		F	99	41	33
	12	N	53	25	24
		F	69	28	39
	14	N	68	31	46
		F	79	30	24
Kabanos	16	N	98	39	47
		F	80	27	22
	15	N	91	39	48
		F	81	29	29
	14	N	79	36	32
		F	81	31	31

From the results follows that the sums of the attained points in individual series of evaluation show a considerable variability. In some cases the product smoked in a convenient way is evaluated as a better one, at some other time a product smoked by a precipitated smoke is preferred to the former one. Sensory evaluation of experimentally smoked meat products showed that minimum differences were found in the whole flavour acceptance of these products.

The aroma and the surface colour of meat products smoked by the usual way in many cases were preferred to products smoked with the treated smoke. The cause of this fact is the settling of the tar on products smoked by a conventional smoke because the tar increases the aroma of product and contributes to its colour. As to the aroma, the aroma of products smoked by the precipitated smoke is milder without the unpleasant tarry flavour.

On the basis of results of the performed experiments became evident that the continuation in tests and the determination of optimal conditions of the smoke precipitation with respect to the quality of smoked products is advantageous.

3) Content of 3,4 benzo(a)pyrene in a conventional and electrostatically precipitated smoke

In our experiments we also paid attention to the question to a what extent is it possible to eliminate - by means of electrostatic precipitation - the carcinogenic substances from the smoke expecially 3,4-benzo(a)pyrene.

Our investigation was concentrated on the quantitative determination of 3,4 benzo(a)pyrene in samples of a conventional and electrostatically precipitated smoke. The aqueous solutions of smoke were evaporated to dryness and in the evaporation residue 3,4 benzo(a)pyrene was separated in the mentioned way. In these experiments 3,4 benzo(a)pyrene was ascertained in the following concentrations:

in a conventional smoke ..... 38,5 gamma/litre of aqueous sample

in an electrostatically precipitated smoke ..... 0,8 gamma/litre of aqueous sample

These significant original analytical results show that it is possible to reduce the content of harmful 3,4 benzo(a)pyrene in smoke about 50 times.

This finding is very important for the judgement of the electrostatic precipitation of smoke and its contribution in meat technology from the hygienical standpoint.

The smoking of meat and meat products in an electrostatically treated smoke represents a modern progressive method of smoking which could be to our opinion of use in practice in the close future.