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EFFECTS OF THE FEED NOZZLES STRUCTURE MODIFICATIONS IN A SMOKE-DRYING CHAMBER ON REDUCTION OF PAH COMPOUNDS CONTENT IN MEAT PRODUCTS[1]

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ABSTRACT

The objective of the study was to reduce PAH compounds content in meat products subjected to industrial conditions of smoking in a chamber when changing the feed nozzle structure in the smoke mixture. Smoked meat products oval shaped taken from two primary smoke chambers of different structure of feed nozzles and nozzles diffusing the smoke mixture constituted material samples. Qualitative and quantitative analysis of PAHs was carried out with the use of liquid chromatography with a selective detector (HPLC-FLD-DAD). Research on the content and compounds of the PAH group in meat products, smoked with the use of a modified feed nozzle compared to a traditional system of nozzles, indicate clearly to more favourable conditions for distribution of the smoke mixture in a smoking chamber due to their reduced level.

Introduction

Smoking is a treatment of food products, mainly meat and fish with smoke obtained during slow combustion of wood and sawdust. The basic purpose of this treatment is to provide products with suitable taste properties and increase their storing endurance (Wilms, 2000; Jensen et al., 2004; Toldrá, 2010; Kubiak, 2012a, 2012b). Smoke treatment with simultaneous partial drying, particularly during cold smoking is one of the manners of preservation of products. The most characteristic features of the smoked product are formed mainly as a result of smoke deposition on the surface and penetration inside the product. Smoke components dye the surface of products brown or golden giving them a characteristic appearance. Moreover, the smoke components influence the specific smell

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and taste and ensure antioxidizing and germinicide effect of smoking (Tóth and Potthast, 1984; Toldrá, 2010). Based on numerous information from researches in chemical technology of wood, many analogies may be conducted, which allows obtaining a precise notion on the formation of chemism of smoke components. However, one should remember that the quality and composition of smoke, changes in relation to the combustion conditions and the entire smoking process, including the use of devices and their characteristic structures (Bratzler et al., 1969; Tóth and Potthast, 1984). On account of small and average enterprises, where production is oriented to varied groups of meat products, smoking of which requires fast change of parameters of the process realization, single-trolley smoke-drying chambers are used (PEK-MONT, 2010). Both the amount of air flowing into the combustion zone and the speed of smoke removal, temperature and degree of combustion as well as moisture of used wood have an impact on the obtained mixture of smoke, particularly in this type of chambers. Despite many factors, which influence the intensity of colour, accumulation of compounds included in smoke, inter alia, contaminations, regularity of dye of the smoked products and the amount of harmful substances depends also on the appropriate structure of feed nozzles and the direction of setting towards the treated product (Kubiak, 2012b; Kubiak and Jakubowski, 2013). The progress related to civilization and technology caused the increase of exposure to harmful compounds, resulting from technologies of treatment, preservation and providing products with specific features. Thus, improvement of parameters, which may be controlled, seems to be so crucial. In case of smoke chambers, inter alia through adjustment of inlet nozzles (feed) structure. Regularity and intensity of smoke mixture and air flow in the smoke chamber and between the meat product allows reduction of the quality faults and decrease of concentration of pollutions from polycyclic aromatic hydrocarbons PAH group (Kubiak 2012a).

Objective of the paper

The objective of the paper was to reduce the content of PAH compounds in meat products, subjected to industrial conditions of smoking at the change of feed nozzles structure into the smoke mixture.

Materials and methods

The entire technological process of preparing raw material and smoking was carried out in industrial conditions in the meat processing plant I.Z. Grabowscy Sp. j. in Ościęcin. The smoking process was carried out in a single-trolley chamber of KWP-let type by Pek-Mont Sp. z o.o. company. (fig. 1a, b) with internal dimensions of the working part: length – 1,440 mm; width – 1,200 mm, height – 2,950 mm, with classic and modified length of feed nozzles into the smoke mixture and diffusing nozzles.

Variants of structure of feed nozzles and nozzles diffusing the smoke mixture in a chamber: the base one (classic arrangement of nozzles) – the structure of nozzles without modification (fig. 1a) and a suggested modification of structure of feed nozzles distribution which consists in elongation of nozzles 100 mm above the level of the chamber flow on both sides of the chamber (fig. 1 b). A variant of a modified structure was carried out as an arrangement contrary to the feed nozzles (inlet) into the smoke and air mixture in the chamber with a classic arrangement. Modification consisted in supplying the smoke mixture: into the chamber of a classic arrangement of nozzles from the top and in the suggested solution from the bottom.

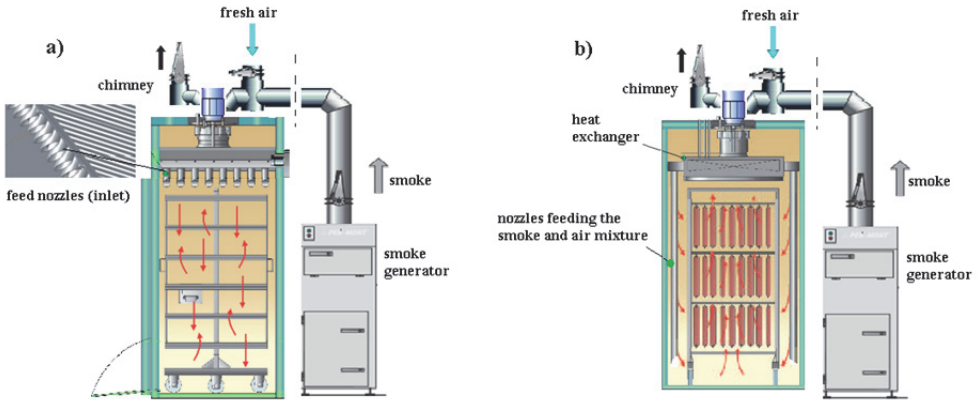

Figure 1. Graphic schematic representation of one-trolley smoke and cooking chamber KWP-1et type: a) classic input nozzles system-supplying; b) modified structure of supplying nozzles (www.pekmont.pl)

Conditions of the smoking process for products were modified and included in the programme of smoking. They included particular stages of the whole smoking treatment (tab. 1).

The plan of the research included 16 cycles for each smoke-drying chamber (a classic arrangement of nozzles and a modified arrangement of nozzles). Samples from each smoking cycle were collected by means of an envelope method (n=19). The collected samples from the smoked products by means of the envelope method (each time after the smoking process) were divided, uniformed and subjected to chromatographic analysis to check the content of polycyclic aromatic hydrocarbons (PAH). Preparation of samples consisted in taking out a collagen cover, which was also subjected to analysis of the content of PAH. Then, samples of the external layer to 1 cm were collected from bars and the external layer. All samples were averaged and subjected to freeze-drying, which facilitied further process of analysis.

Table 1
Stages and parameters of the smoking process

Stages of the smoking process	Time (min.)	Bar temperature (ºC)	Temperature in smoke chamber (ºC)
Drying	60	36.5	60
Smoking	50-60	48	60
Ventilation	2	-	60
Burning		72	75
Drying	>100	-	60
Drying of bars to the moment of obtaining a specific mass			

Source: www.grabowscy.pl

The analytical procedure for determination of PAH compounds included the use of liquid chromatography equipped with a fluorimetric detector. For isolation of PAH from the fixed matrix, accelerated solvent extraction (ASE), cleaning and enriching with the use of the solid-phase extraction (SPE) on silica gel was applied. An analytic unit consisted of a liquid chromatograph by Agilent Technologies company equipped with a four-fold pump, a degassing system of the mobile phase, a diode detector (DAD) (model 1100) and an automatic conveyor, a thermostat for a conveyor, a column thermostat and a fluorometric detector (FL) (Infinity 1260). ChemStation B. 04.03 software was used for data collection and processing. Division of analytes was carried out on the chromatographic column PAH Baker Bond (no of series G320Y010, batch number 993967-902) with dimensions 250 x 3 mm, seed diameter 5 μm) with a forecolumn. For isolation of PAH from fixed samples, an accelerated extraction by means of a solvent was carried out in Dionex ASE300 unit. The analytical procedure (isolation, cleaning and enriching PAH from samples) were subjected to validation (accuracy, precision of dosing and methods, linear character, limit of detection (LOD) and limit of quantitation (LOQ).

Results were set and subjected to statistical calculations (average, standard deviation, border of the measurement error), with the use of Statistica® 2012 and Microsoft Excel 2010 programme.

Research results

The research which was carried out proves that the average content of determined 15 PAH and the sum of 15PAH, 8PAH, 4PAH and BaP in the smoked products was varied on account of the system of nozzles.

In the chamber with the classic system of nozzles structure the content of PAH compounds for the oval batch, subjected to the smoking process was at a higher level in all collected samples (cover, external and internal part) compared to the products collected from the chamber, where the suggested variant of the structural solution of nozzles was used (tab. 2). The sum of the determined 4PAH (BaP, CHR, BaA, BbF) and 8PAH (BaP,

CHR, BaA, BbF, BkF, BgP, DhA, IcP) and the presence of BaP decreased in products collected from the chamber with the modified structure of feed nozzles. Insignificant differences were only reported in the content of BaP for covers, both in the classic system of nozzles and in the modified one.

Table 2
PAH content in meat products subjected to industrial conditions of smoking in chamber with classic and modified system of feed nozzles

PAH ng/g of the Product	Product with geometrical centre of the bar – oval					
	classic system of nozzles			modified system of nozzles		
	cover	external layer	internal layer	cover	external layer	internal layer
Naphthalene	47.53	39.68	25.35	45.03	34.25	25.02
Benza(a)anthracene	23.23	20.47	10.66	26.12	19.23	9.68
Chrysene	81.86	79.24	12.18	22.01	18.32	9.22
Acenaphthene	227.58	186.59	158.07	212.07	176.87	124.27
Fluorene	112.3	67.36	34.55	115.42	68.18	33.73
Benzo(b)fluoranthene	53.58	38.12	19.73	26.98	7.03	5.16
Benzo(k)flouranthene	7.96	6.23	nd	7.34	4.23	nd
Benzo(a)pyrene	11.22	5.37	3.83	10.94	4.04	1.42
Dibenz(a,h)anthracene	nd	nd	nd	nd	nd	nd
Anthracene	93.41	16.30	nd	90.78	17.69	nd
Benzo(g,h,i,)perylene	4.58	nd	nd	4.73	nd	nd
Indeno(1,2,3-c,d)pyren	1.02	nd	nd	0.97	nd	nd
Phenanthrene	10.52	nd	nd	3.15	nd	nd
Fluoranthene	84.35	nd	nd	86.18	nd	nd
Pyrene	nd	nd	nd	nd	nd	nd
Total of 15 PAH	759.14	459.36	264.37	651.72	349.84	208.50
Total of 8 PAH	183.45	149.43	46.40	99.09	52.85	25.48
Total of 4 PAH	169.89	143.20	46.40	86.05	48.62	25.48

nd- not detected

Thus, in a chamber, where the suggested solution for modification of the nozzles structure was used, the PAH compounds values in the smoked products differed significantly from the values obtained for products from the chamber with the classic structure of nozzles. Their level considerably decreased which proves lower accumulation of PAH compounds which results from the circulation of the smoke mixture in a chamber

and their deposition on the product. Although, the smoke and air mixtures had the same parameters, the method of supplying and then "washing" the product with smoke and deposition of compounds included in it had a significant meaning.

Work performed within the scope of optimization of the smoking process showed the next significant aspect related to the factor of propagation of the smoke mixture and enabled possibility of lowering accumulation of PAH compounds by modification of feed nozzles.

The suggested structural solution of the arrangement of feed nozzles and nozzles diffusing the smoke mixture inside the smoke chamber were more favourable on account of the values obtained from PAH analysis for the sum of 15, 8 and 4 PAH in comparison to the values obtained for products from a chamber with a classic arrangement of nozzles.

A classic arrangement of the structure of feed nozzles influenced the increased accumulation of PAH compounds contrary to the suggested modification, where the level of PAH compounds in the processed food products decreased significantly.

Meat products, smoked in the chamber with the modified structure of feed nozzles had a lower content of PAH compounds by 35-55% in all analysed samples (cover, external and internal layer) in comparison to the processed products from a chamber with a classic structure and arrangement of feed nozzles. It indicates a real possibility of lowering the PAH content in meat products subjected to smoking. Appropriate adjustment and regulation of the length of feed nozzles and the shape of arrangement towards each other on both side walls of a chamber will allow obtaining a product with required admissible limits of harmful compounds from the PAH group. After experimental verification which has been carried out, one may confirm with great possibility that such solutions should prevent the quality faults of both under-smoking as well as over-smoking of the processed meat products. The mentioned verification, carried out in industrial conditions, confirms the usefulness of structural changes, thanks to which a final product with a required standard with regard to reduction of pollutions (PAH) which result from the smoking process may be obtained.

In foreign publications there are no papers related to the change of structural elements of the smoke chamber, including feed nozzles (inlet). Thus, the issue related to modification of feed nozzles in the smoke chamber poses many new challenges in further research, which allow introduction of changes in multi-module smoke chambers. Probably, in many cases such solutions may also influence the production hygiene as well as effective use of the smoke mixture during appropriate smoking. Thus, the obtained information concerning the impact of the change of structure of chamber elements (feed nozzles) constitute a factor, which should be taken into account during the process of smoking.

Conclusions

1. The content of PAH in meat products from a smoke chamber with a classic arrangement and the structure of feed nozzles exceeded admissible limits of PAH compounds pursuant to EU Commission regulation.
2. The presented variant of modification of feed nozzles favourably influenced the conditions of the mixture flow in a smoke chamber, which resulted in reduction of accumulation of PAH compounds in meat products.
3. Modification of the structure of feed nozzles, which distribute the smoke mixture in connection to the possibility of introduction in the smoke process parameters, will allow many enterprises to meet the requirements for admissible levels of PAH in smoked meat products.

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WPŁYW MODYFIKACJI KONSTRUKCJI DYSZ ZASILAJĄCYCH W KOMORZE WĘDZARNICZO-PARZELNICZEJ NA OBNIŻENIE ZAWARTOŚCI ZWIĄZKÓW WWAW PRODUKTACH MIĘSNYCH

Streszczenie. Celem pracy było obniżenie zawartości związków z grupy WWA w przetworach mięsnych poddanych przemysłowym warunkom wędzenia w komorze przy zmianie konstrukcji dysz zasilających w mieszaninę dymu. Materiał do badań stanowiły próbki produktów mięsnych wędzonych o kształcie owalnym pobrane z dwóch komór wędzarniczych o różnej konstrukcji dysz zasilających i rozprowadzających mieszaninę dymu. Jakościową i ilościową analizę związków WWA wykonano techniką chromatografii cieczowej z selektywnym detektorem (HPLC-FLD-DAD). Badania nad zawartością i kumulacją związków z grupy WWA w przetworach mięsnych wędzonych z wykorzystaniem zmodyfikowanych dysz zasilających w porównaniu z klasycznym układem dysz wskazują jednoznacznie na korzystniejsze warunki rozprowadzenia mieszaniny dymu w komorze wędzarniczej ze względu na ich obniżony poziom.

Słowa kluczowe: przetwory mięsne, wędzenie, WWA, komora wędzarnicza, konstrukcja dysz