Preventive treatment with UV radiation and ozonization of the drying chamber for protection against spoilage of raw smoked sausages

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Introduction. In recent years increasing urgency for meat industry is a topic of increasing microbiological effectiveness of controlling food products and efficiency of their antimicrobial protection. This is associated with the fact that in Russia and other countries a numbers of diseases emerge (salmonellosis, dysentery, toxicosis, etc.), which are associated with the consumption of meat products infected with various microorganisms. Among the bacteria that cause spoilage, gram-negative rods are known, for example, *Pseudomonas*, gram-positive spore-forming bacteria, such as *Bacillus*, *Clostridium*. In addition, there is a large group of bacteria from the family *Enterobacteriaceae*. The surface of long-stored products are often colonized by mold from the genera *Penicillium*, *Aspergillus*, *Cladosporium*, etc. After smoking sausages are dried. Drying of smoked sausages is carried out at a temperature of 12 ° C and a relative humidity of 75%. Duration of drying is 25-90 days.

The purpose of our study was to assess the possible use of radiation energy with UV irradiators, as well as in combination with ozonation for disinfection of the drying chambers for smoked sausages of long-term storage.

Materials and methods. In our experiments, we used the drying chamber with a volume of 200 m^3, equipped with OBN-150 UV irradiators with two sources of irradiation of 30 W each, mounted on the walls, or UV irradiators with OZUF 40 W ozonizers. OZUF ozonizer is a recirculator, which can disinfect air in the “stagnant zones” of the room. Its UV lamp is in a closed housing with a fan that drives the air around the lamp and disinfects it with UV rays and ozone. This eliminates the undesirable oxidation of fats on the sausage surface. The greatest bactericidal action against microorganisms has a spectrum of rays of 240-280 nm. Irradiation was carried out in the dark for 30, 60 and 90 minutes. Sausages for drying were placed in tiers in several rows, so as to ensure free air circulation between sausage loaves of the same size. The determination of the total number of microorganisms and mold fungi in 1 m^3 of the chamber was carried out after taking air samples using a sampling device (PU-1B) (Russian) and taking into account the grown colonies (CFU / m^3) on Petri dishes with nutrient agar.

Results Experimental results after a 30-minute disinfection are presented in table 1, in which indicators of the total number of microorganisms (CFU / m3) and mold colonies are given. Prior to UV treatment with OBN-150, the number of mold colonies (0.827 ± 0.069) × 10^3 which was 33% of the total number of microorganisms in 1 m^3 of air - (2.47 ± .0.100) × 10^3. After processing, this value was about 40% (0.747 ± 0.076) × 10^3, i.e. the amount of mold, which is more resistant to UV radiation, has slightly increased in relation to the remaining total number of microbes - (1.88 ± 0.078) × 10^3.

Under the action of irradiation, about 24% of the number of all microorganisms and about 10% of mold fungi died. With a similar conduct of air disinfection using an ozonizer-irradiator OZUF during 30 minutes revealed a decrease in the total number of microorganisms after exposure by 3.1 times. However, due to the fungicidal action after the combined inactivation of microorganisms by UV rays and ozone, the number of mold fungi decreased only 1.5 times. The amount of mold before treatment was in the association with the microbiota 32%, and after 65%, i.e. with a decrease in the population of all microorganisms, molds dominated again. Therefore, after 30 minutes using the OZUF, a higher total biocidal and a separate fungicidal effect was in the air after treatment of the drying chambers (67.7% and 35%) than during the same time period with the irradiator OBN-150 (23,9% and 9,7%) This difference in performance is statistically significant ($p < 0.05$).

The data also indicate the statistical significance of differences in the viability of microorganisms and mold fungi before and after a 30-minute exposure (both using OBN-150 and OZUF). Comparison of the decline in the number of all microorganisms and molds with a 60-minute air treatment in the drying chamber showed that for OBN-150 the disinfecting effect led to a decrease in the average number of all microorganisms by 3.2 times (2.19 ± 0.096) × 10^3 against (0.693 ± 0.091) × 10^3, and the number of mold fungi 1.2 times (1.13 ± 0.105) × 10^3 against (0.920 ± 0.098) × 10^3. Total number of microorganisms, on average, decreased by 4.7 times, and mold fungi by 4.2 times. The share of mold fungi in the total number of microorganisms before the air treatment was 53%, and after disinfection 64%. Thus, the increase in the amount of mold in the remaining association of microorganisms is associated with a greater mortality of bacteria, that are more sensitive to two biocidal factors (UV and ozone). In order to more intensively affect for the microbes present in the drying chamber, a 90-minute treatment of the indoor air environment was carried out. As the data obtained with the use of OBN-150 irradiator, the death of the total number of microorganisms present in the air of the drying chamber increased from 23.7% to 75.7% with an increase in exposure from 30 to 90 minutes, and for mold fungi from 9.7 % to 56.3%. The combined irradiator-ozonizer OZUF turned out to be more effective. At the same time, the exposure provided an antibacterial effect with death from 67.7% to 90.3%, and fungicidal effect - from 35% to 84.5%. These were the highest rates of disinfection of air in the drying chambers for sausages, confirmed statistically ($p<0.05$)

Table 1. Comparative characteristics of bactericidal and fungicidal properties of UV irradiators OBN-150 and OZUF when treating air in a drying chamber

№	Irradiator	Numbers of colonies of microorganisms and molds in 1 m^3 of air, $(X \pm I_{95}) \times 10^3$, CFU/$m^3$				Significance of differences before and after treatment p p	Effectiveness of irradiators, %		Significance of differences in effectiveness (p)	
		before treatment		after treatment						
		total microorganisms	molds	total microorganisms	molds		total microorganisms	molds	total microorganisms	molds
	Treatment of the air for 30 min									
1	OBN-150	2,47±0,100 (2,37 – 2,57)	0,827±0,069 (0,758 – 0,896)	1,88±0,078 (1,802 – 1,958)	0,747±0,076 (0,671 – 0,823)	<0,05 --------- >0,05	23,9	9,7	p1-5 <0,05	p1-5 <0,05
2	OZUF	2,48±0,087 (2,393 – 2,567	0,800±0,074 0,726 - 0,874)	0,800±0,074 (0,726 - 0,874)	0,520±0,067 (0,453 – 0,587)	<0,05 ---------- <0,05	67,7	35	p2-6 <0,05	p2-6 <0,05
		>0,05	>0,05	>0,05	<0,05					
	Treatment of the air for 60 min									
3	OBN-150	2,19±0,096 (2,094 – 2,286)	1,13±0,105 (1.025 – 1,235)	0,693±0,091 (0,602 -0,784)	0,920±0,098 (0,822 – 1,018)	<0,05 ---------- ≤0,05	68,4	18,6	p3-5 >0,05	p3-5 <0,05
4	OZUF	2,25±0,107 (2,143 – 2,357)	1,29±0,085 (1,205 – 1,375)	0,480±0,087 (0,393 – 0,567)	0,307±0,042 (0,265 – 0,349)	<0,05 --------- <0,05	78,7	76,2	p4-6 ≤0,05	p4-6 <0,05
		>0,05	>0,05	<0,05	<0,05					
	Treatment of the air for 90 min									
5	OBN-150	2,63±0,096 (2,534 – 2,726)	1,19 ± 0,065 (1,125 – 1,255)	0,640±0,071 (0,569 – 0,711)	0,520±0,067 (0,453 – 0,587)	<0,05 --------- <0,05	75,7	56,3	p5-6 <0,05	p5-6 <0,05
6	OZUF	2,61±0,105 (2,505 – 2,715)	1,21±0,076 (1,134, 1,286)	0,253±0,067 (0,186 – 0,320)	0,187±0,070 (0,117 – 0,257)	<0,05 -------- <0,05	90,3	84,5	-	-
		>0,05	>0,05	<0,05	<0,05					

Conclusion. The data indicate the process of disinfection of the chambers for drying raw smoked sausages must be as a combined action of UV rays and ozonation, with exposure times of at least 90 minutes. It should be noted, that additional studies of the organoleptic properties of smoked sausages did not change the specific properties of the product. Observations on the possibility of infection of raw smoked sausages for four months showed the effectiveness of such treatment.