Electromagnetic Field of Super High Frequency as a Method for Controlling Microbial Exchange of Poultry Feed

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Abstract: Microbial contamination of feed reduces the efficiency of livestock and poultry production, negatively affects the quality of this product. The purpose of the work is to determine the degree of microbial contamination of feed and assess the effectiveness of using the electro-physical method of reducing it. A study of the quality of poultry feed was carried out at the Kemerovo State Agricultural Institute in 2018. The level of general microbial contamination of the studied feed lots was quite high. For feed grain, the total microbial number exceeded the standard indicator by 54 times. The total number of mushrooms for feed was $1.2 \cdot 10^2$ CFU/g, for feed mixtures - $1.9 \cdot 10^2$ CFU/g, for grain of wheat - $1.5 \cdot 10^3$ CFU/g. The total microbial number, respectively: $3.0 \cdot 10^5$ CFU/g; $6.3 \cdot 10^5$ CFU/g; $2.7 \cdot 10^6$ CFU/g. Processing of feed in the electromagnetic field of a traveling microwave wave using the technology of EcoMashService LLC (Russia) allows simultaneously drying and disinfecting the material. The microwave processing regime used in the study (60 kW power, magnetron frequency 915 MHz, exposure time 90 seconds) reduced microbial contamination: for compound feed, the decrease in the total microbial number relative to control was 142.9 times, feed mixtures - 7.9 times, wheat grains - 16, 9 times; a decrease in the total number of mushrooms in 4.0; 17.3 and 4.8 times, respectively. The results of the study let us to conclude that the electrophysical method used in the processing of feed for productive poultry effectively reduces their contamination.

Keywords: poultry feed, microbiological safety, microwave electromagnetic field, selected mode, effective disinfection.

1. Introduction

The feed sanitary quality is determined by the degree of its contamination by representatives of saprotrophic, opportunistic and pathogenic microflora, as well as toxic substances of anthropogenic and biological origin. Feed may be contaminated with pesticide residues that are used in a forage crop cultivation [1, 2], toxic elements released into the environment by industrial enterprises and motor vehicles [3], mycotoxins [4, 5], phytotoxins, nitrates and nitrites [6].

Low productivity, morbidity and death of farm animals are often associated with the contamination of raw materials and feed with pathogenic microorganisms: salmonella, enteropathogenic types of *Escherichia coli*, toxic strains of clostridia and others [7, 8].

Despite the undoubted successes of recent years in optimizing the feeding of farm animals and poultry, the role of microbial contamination of feed in reducing production efficiency requires additional attention and study [9].

The quantitative and qualitative composition of the microflora of poultry feed is very diverse and is formed under the influence of many factors. First of all, if the feed is a product of processing plant materials, then the epiphytic microflora of these raw materials and located on processing equipment, in workshops, warehouses, and so on, go to a large extent.

Phytopathogenic microorganisms, including mold fungi, constitute a special group of microflora of plant materials [10]. They infect plants even when developing in the field and can produce toxic substances that are diverse in chemical nature - mycotoxins.

Unfortunately, a significant part of the feed produced in Russia contains traces of unwanted microflora, including live saprotrophic, pathogenic and conditionally pathogenic microorganisms, as well as metabolites of toxigenic species. For example, in a long (six-year) experiment, it was shown that a significant part of compound feed for poultry does not meet the requirements of regulatory documentation on the degree of contamination with pathogenic microflora, microscopic fungi, and mycotoxins [11].

One of the methods to reduce the level of microbial contamination of feed and its individual ingredients is the influence of an electromagnetic field of ultrahigh frequency (EMF microwave). Such processing ensures effective neutralization of toxicogenic microorganisms and helps to preserve the necessary technological properties [12–14] improves the physicochemical parameters of products and ensures microbiological safety at the stages of processing and storage of grain and products from it [15, 16]. The feed is disinfected due to both the direct action of the microwave on microorganisms, leading to their death, and indirectly due to an increase in the temperature of the medium in combination with the action of the generated water vapor [14].

The purpose of the work is to determine the degree of microbial contamination of feed for poultry and evaluate the effectiveness of the electro-physical method of its reducing.

2. Materials and Methods

A study of the quality of feed for poultry treated with microwave radiation using the technology of EcoMashService LLC (Russia) was carried out at the Kemerovo State Agricultural Institute in 2018.

Technological line "Wave 100", developed by EcoMashService LLC, is a high-tech, environmentally friendly, energy-efficient complex that allows for 90 seconds carrying out efficient processing of various, including forage feed, materials. Productivity of the installation can reach up to 100 t/day at the consumed power of electricity of the order 50 kW/t of material. Simultaneous drying and disinfection occurs at a universally selected regime of dielectric heating in electromagnetic fields of a traveling microwave wave and at a continuous movement of material in a rotating dielectric retort tube installed in the waveguides of the drying chamber of the microwave path. The following microwave processing mode was used in the work: power - 60 kW, magnetron frequency - 915 MHz, exposure - 90 sec.

Objects of the study were the following samples of poultry feed:

- compound feed for laying hens KK-1 (GOST R 51581-2001). According to the manufacturer's information, it includes wheat bran, fodder grain product of category II, wheat, chalk, sunflower cake, salt, premix P1-2;
- granular feed mixture of plant origin (TU 9295-001-21432851-01), including wheat bran and crushed grain mix;
- spring wheat of the grade 5 (GOST 9353-2016 "Wheat. Technical conditions").

Sampling was carried out according to GOST 13496.0-2016 "Compound feed, compound feed raw materials. Sampling methods. " The prepared samples were divided into two equal parts - the control (without processing) and experimental (processed in the microwave field at a given mode). The mass of the combined sample was 4 kg for each type of feed (feed, feed mixture, feed grain), the weight of the control and experimental samples was 2 kg.

Determination of the total microbial number (TBC), *Escherichia coli* bacteria (ECB) and salmonella was carried out in accordance with the Rules for bacteriological research of feed (1975) and GOST ISO 7218-2015 "Microbiology of food and animal feed. General requirements and recommendations for microbiological research." The total number of fungi (TNF) was determined according to GOST 10444.12-2013 "Microbiology of food and animal feed. Methods for detecting and counting the number of yeast and molds. " In this case, preliminary dilutions were prepared in accordance with GOST R 51426-2016 "Microbiology. Feed, compound feed, compound feed raw materials. General guidelines for the preparation of dilutions for microbiological research." The following nutrient media were used to determine these indicators by cup methods: Saburo, Endo ("Nutrient media", RF), Kessler, KMAFanM ("Biocompas-S", RF), bismuth-sulfite agar ("Microgen", RF). The repetition of the experiment is threefold analytical. The results are presented as arithmetic means; the significance of differences compared with the control was found by the F-criterion at a significance level of 0.05.

3. Results and Discussion

Among the various indicators of microbiological contamination of feed products, the following should be considered the main ones: total microbial number (TMN), total number of fungi (TNF) and salmonella, *E. coli* (*Escherichia coli*). These indicators are indicated in the regulatory documentation (Table 1).

The level of microbial contamination of the presented food samples was different (Table 2). The highest concentration of bacteria was observed for feed grain of wheat - $2.7 \cdot 10^6$ CFU/g, slightly lower for feed mixtures - $6.3 \cdot 10^5$ CFU/g, which is higher than the permissible level. The total contamination of feed for laying hens was $3.0 \cdot 10^5$ CFU/g and corresponded to the requirements of CR EEU.

In relation to sanitary-indicative ECB and salmonella, all three presented samples of food are safe - indicator microorganisms in the required volumes of food were not found.

Table 1. Requirements for compound feeds for productive poultry according to the draft of the Customs Regulation of the Eurasian Economic Union (CR EEU) "On the safety of feed and feed additives"

Indicator	Allowable Level
Microbiological indicators:	
TNF, CFU/g, not more than:	$5 \cdot 10^4$
TMN, CFU/g, not more than:	$5 \cdot 10^5$
Presence of pathogenic microorganisms:	
Salmonella in 50,0 g	not allowed
<i>E. coli</i> в 1,0 г	not allowed
pathogenic Escherichia in 50,0 g	not allowed

Table 2. Bacteriological characteristics of the studied feed after microwave processing

Type of feed	Indicator	Unit	Feed Test Results	
			Control	After microwave
Compound feed	TNF	CFU/g	$1,2 \cdot 10^2$	$0,3 \cdot 10^2$
	TMN	CFU/g	$3,0 \cdot 10^5$	$2,1 \cdot 10^3$
	Salmonella	in 50,0 g	absent	absent
	ECB	in 1,0 g	absent	absent
Fodder mixture	TNF	CFU/g	$1,9 \cdot 10^2$	$1,1 \cdot 10$
	TMN	CFU/g	$6,3 \cdot 10^5$	$0,8 \cdot 10^5$
	Salmonella	in 50,0 g	absent	absent
	ECB	in 1,0 g	absent	absent
Feed grain	TNF	CFU/g	$1,5 \cdot 10^3$	$3,1 \cdot 10^2$
	TMN	CFU/g	$2,7 \cdot 10^6$	$1,6 \cdot 10^5$
	Salmonella	in 50,0 g	absent	absent
	ECB	in 1,0 g	absent	absent

Microwave treatment has led to a decrease in microbial contamination of all the studied feeds: 142.9 times for compound feed, 7.9 times for feed mixtures, and 16.9 times for wheat grains (Table 3). The complete destruction of the bacterial component of the microflora of feeds under the used microwave treatment regime was not achieved - the remaining viable bacteria are represented, for the most part, by representatives of the genus *Bacillus*. They are capable of spore formation and, apparently, are resistant to the mode of electrophysical influence used in the work.

A stronger decrease in the number of bacteria for feed compared with other samples is apparently due to its composition. Molecules of water and lipids differ in the maximum absorption of electromagnetic waves relative to other organic and inorganic compounds [17]. The composition of the feed, in contrast to the feed mixture, includes sunflower cake. This ingredient leads to an increase in the total amount of fats in the feed and accordingly increases their absorption capacity with respect to electromagnetic radiation.

Mycological analysis of the studied feed samples showed that the total number of fungi in them is small and below the upper limit of the permissible range (Table 2). However, even for feeds of this quality, microwave processing can be useful, since each achieved level of microbial load reduction provides an additional advantage when storing feeds, especially in the case of uncontrolled deterioration of storage conditions. While the contamination of feed with mycotoxins is significant, the content of them can grow along with an increase in the number of their producers.

The maximum in the experiment the number of spores of micromycetes was noted for untreated wheat grain - $1.5 \cdot 10^3$ CFU/g, the minimum - for compound feed - $1.2 \cdot 10^2$ CFU/g. Electro-physical effects have led to a decrease in the number of viable microscopic fungi. The difference with control was 4.0 times for compound feed, 4.8 times for wheat grain, and 17.3 times for feed mixtures.

Among the identified micromycetes, the genera *Penicillium* and *Aspergillus* (warehouse molds, some of which produce ochratoxin A), *Fusarium* (belongs to the category of field molds, some species produce T-2 toxin) were identified.

4. Conclusions

The microflora of the studied feed samples is represented by both a phyto-pathogenic and a saprotrophic component, however, no pathogenic microorganisms were found for humans and animals. By the value of the TMN, feed grain of wheat and feed mixture did not meet the permissible level. Microwave treatment reduced the microbial contamination of all the studied feeds: for compound feed, the decrease in TMN with respect to control was 142.9 times, feed mixtures - 7.9 times, wheat grains - 16.9 times; reduction in TNF - 4.0; 17.3 and 4.8 times, respectively. Thus, the electrophysical method of microwave processing of feed on the equipment of EcoMashService LLC in the used mode (power - 60 kW, magnetron frequency - 915 MHz, exposure - 90 sec.) has shown its effectiveness in reducing microbial contamination of feed for poultry.

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