MICROBIOLOGICAL QUALITY OF FEED MATERIALS USED IN POLAND

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Abstract

Microbiological quality of feed materials used in Poland in 2007-2010 was assessed. The examinations were conducted at all veterinary diagnostic laboratories. Feed samples were examined on Salmonella prevalence and level of contamination by aerobic mesophilic bacteria, microorganisms, Enterobacteriaceae and fungi. Salmonella sp. was the most often detected in feed materials of animal origin. The number of Enterobacteriaceae in most of the examined feed samples did not exceed 10 cfu/g. The demonstrated contamination by aerobic bacteria ranged most often from 10 to 10² cfu/g. Analysis of mycological status of feed materials indicated that the highest contamination by fungi was 10⁵ cfu/g in cereal grains.

Key words: feeds, microbiological quality, bacteria, fungi, Poland.

Composition of soil microorganisms results from geographical region, quality of soil, fertilisation, locally occurring animals (insects, rodents, birds), or weather conditions (14). Consequently, plant feed materials are contaminated by microflora characteristic for each field. As far as plant feeds are less fertile for growth of pathogens with the exception of oil seeds, feeds of animal origin are richer in nutrients and water, which may intensify the multiplication of bacterial organisms. However, it seems that the most important factors deciding about the microbiological quality of animal feeds are the health status of animals before slaughter and hygienic conditions at slaughterhouse. Moreover, both plant and animal materials may be additionally contaminated during harvesting, storage, transport, and retail sale.

The highest importance in microbiological quality of feed is attributed to pathogenic microorganisms like Salmonella sp., Clostridium perfringens, Clostridium botulinum, and some groups of microorganisms, which play a role of hygiene indicators of feed. Enterobacteriaceae, aerobic mesophilic bacteria, total microbial contamination, fungi or anaerobic bacteria classified to Clostridium sp. are included to this group (9). In order to recognise microbiological status of feeds used in Poland, for the last 8 years, the Department of Hygiene of Animal Feedingstuffs of the National Veterinary Research Institute (NVRI) in Pulawy has elaborated annual comparison of microbiological status of feeds (11, 12). This paper describes microbiological quality of feeds used in 2007–2010 in Poland.

Material and Methods

All feed samples were collected from the farmer granaries, feed factories, and imported batches. The samples were analysed at all veterinary diagnostic laboratories (national and regional) operating in the frame of official laboratory system, and the results of the analysis were collected at Central Data Base CELAB System led by Department of IT Systems in the NVRI. The number of the analysed samples is presented in Tables 1 and 2.


Results

The obtained results for quantitative methods were analysed according to distributive series. Figures 1–12 demonstrate the values of the count of different microorganisms presented in logarithmic scale (e.g. log₁₀=1 means range from 10¹ to 99 cfu/g; log₁₀=2 means range from 10² to 999 cfu/g; log₁₀=3 means range from 10³ to 9,999 cfu/g; log₁₀=4 means range from 10⁴ to 99,999 cfu/g, etc.). Levels of contamination of feeds in particular years were compared applying regression analysis.
Fig. 1. *Enterobacteriaceae* count in meat meal samples.

Fig. 2. *Enterobacteriaceae* count in animal fat samples.

Fig. 3. *Enterobacteriaceae* count in all feed material samples.

Fig. 4. Aerobic bacteria count in meat meal samples.

Fig. 5. Aerobic bacteria count in oil seed samples.

Fig. 6. Aerobic bacteria count in cereal samples.
Fig. 7. Microorganisms count in land animal origin samples.

Fig. 8. Microorganisms count in oil seed samples.

Fig. 9. Microorganisms count in cereal samples.

Fig. 10. Fungi count in meat meal samples.

Fig. 11. Fungi count in oil seed samples.

Fig. 12. Fungi count in cereal samples.
### Table 1
Number of feed samples analysed in 2007–2010

<table>
<thead>
<tr>
<th>Kind of feed</th>
<th>Enterobacteriaceae</th>
<th>Aerobic mesophilic bacteria</th>
<th>Microorganisms</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat meals</td>
<td>342</td>
<td>468</td>
<td>1471</td>
<td>1972</td>
</tr>
<tr>
<td>Oil seeds</td>
<td>-</td>
<td>12</td>
<td>10</td>
<td>39</td>
</tr>
<tr>
<td>Cereals</td>
<td>-</td>
<td>65</td>
<td>13</td>
<td>28</td>
</tr>
<tr>
<td>Materials of land animal origin</td>
<td>80</td>
<td>126</td>
<td>154</td>
<td>135</td>
</tr>
<tr>
<td>Total analysed samples</td>
<td>936</td>
<td>622</td>
<td>1,846</td>
<td>2,296</td>
</tr>
</tbody>
</table>

### Table 2
Feed contamination by *Salmonella* sp.

<table>
<thead>
<tr>
<th>Kind of feed</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of analysed samples</td>
<td>Number of positive samples</td>
<td>Percentage positive samples</td>
<td>Number of analysed samples</td>
</tr>
<tr>
<td>Oil seed or fruit origin – total</td>
<td>1,419</td>
<td>23</td>
<td>1.62</td>
<td>630</td>
</tr>
<tr>
<td>Rape seed derived</td>
<td>22</td>
<td>1</td>
<td>4.55</td>
<td>90</td>
</tr>
<tr>
<td>Sunflower seed derived</td>
<td>1,315</td>
<td>15</td>
<td>1.14</td>
<td>485</td>
</tr>
<tr>
<td>Soya derived</td>
<td>72</td>
<td>7</td>
<td>9.72</td>
<td>42</td>
</tr>
<tr>
<td>Animal meals – total</td>
<td>441</td>
<td>1</td>
<td>0.23</td>
<td>546</td>
</tr>
<tr>
<td>Poultry meal</td>
<td>4</td>
<td>0</td>
<td>0.0</td>
<td>2</td>
</tr>
<tr>
<td>Meat and bone meal</td>
<td>219</td>
<td>0</td>
<td>0.0</td>
<td>257</td>
</tr>
<tr>
<td>Fish meal</td>
<td>218</td>
<td>1</td>
<td>0.46</td>
<td>287</td>
</tr>
<tr>
<td>Cereals and derived – total</td>
<td>47</td>
<td>0</td>
<td>0.0</td>
<td>132</td>
</tr>
<tr>
<td>Maize</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
<td>23</td>
</tr>
<tr>
<td>Barley</td>
<td>7</td>
<td>0</td>
<td>0.0</td>
<td>13</td>
</tr>
<tr>
<td>Oats</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
<td>14</td>
</tr>
<tr>
<td>Wheat</td>
<td>12</td>
<td>0</td>
<td>0.0</td>
<td>57</td>
</tr>
<tr>
<td>Feeds of land animal origin</td>
<td>32</td>
<td>0</td>
<td>0.0</td>
<td>122</td>
</tr>
<tr>
<td>Unidentified feed</td>
<td>751</td>
<td>10</td>
<td>1.33</td>
<td>745</td>
</tr>
<tr>
<td>Water for animals</td>
<td>7</td>
<td>0</td>
<td>0.0</td>
<td>6</td>
</tr>
<tr>
<td>Feeds– total</td>
<td>2,697</td>
<td>34</td>
<td>1.26</td>
<td>2,181</td>
</tr>
</tbody>
</table>
The most often prevalence of *Salmonella* sp. in feeds (Table 2) was noted in products of land animal origin (average 15.3%). Percentage of *Salmonella* sp. contaminated samples in soya bean and its derivatives was 6.2. The pathogen was rarely detected in rape seed derivatives (3.3%) and sunflower seed derivatives (0.4%). The presence of *Salmonella* sp. (1.8%) was detected in animal meals, which can be considered as the source of this bacterium in feed chain. The percentage of contamination of fish meals and meat and bone meals were unstable during the reported years and amounted to 0.7% and 0.5%, respectively. Cereals contamination level was 0.4%, with barley being the important source of *Salmonella* sp. from among cereals. An average percentage of positive samples was remarkably similar in meat meals and oil seeds and amounted to 1.8% and 1.7%, respectively. Unfortunately, there are unknown details about 11.5% of positive feed samples detected in 2010. The study revealed also positive samples of animal water (6.4%). In regard to the reported years, the percentage of feed contamination by *Salmonella* sp. ranged from 1% to 3.6% with average value of 2.15%.

The best quality in respect to the *Enterobacteriaceae* parameter was shown by animal fat and meat meal samples, where nearly all analysed samples did not exceed 10³ cfu/g (Figs 1-2). However, the analysis of all results indicated few samples of plant origin, where these bacteria numbered 10⁴, 10⁵, 10⁶, or 10⁷ cfu/g (Fig. 3). Nearly all examined meat meal samples did not exceed 10⁵ cfu/g of aerobic bacteria (Fig. 4). Bacterial contamination of oil seeds and derivatives was lower by one order of magnitude than in case of cereals, where some samples contained nearly 10⁷ cfu/g (Figs 5-6). Four years’ analysis indicates samples from the land animal origin (without meat meals) as the most serious source of microorganisms among feeds (Fig. 7). Here, samples with 10⁵ cfu/g of microorganisms were noted, with average value circa 10⁶ cfu/g. The number of microorganisms in oil seeds and derivatives was assessed to be about one order of magnitude higher than the bacterial level (Fig. 8). Microbiological contamination between cereals and derivatives was similar to contamination by aerobic bacteria (Fig. 9).

Mycological contamination of feeds revealed that 100% of meat meal samples and nearly all oil seed samples did not exceed 10³ cfu/g (Figs 10–11). On the other hand, contamination level of cereals and derivatives was about four orders of magnitude higher and ranged from 10 cfu/g to 10⁸ cfu/g (Fig. 12). Crossing the upper value was noted only in cereals sampled in 2010. With the exception of the results from 2007, the majority of cereal samples contained not more than one million of fungi per gram.

**Discussion**

*Salmonella* sp. are Gram-negative rod shaped foodborne pathogens, which may originate from a variety of sources and are responsible for causing localised gastroenteritis in humans and animals. In 2008, salmonellosis was again the second most often reported zoonosis in humans accounting for 131,468 confirmed human cases. Comparison of studies from European countries regarding *Salmonella* occurrence in feed indicates oil seeds and derivatives, to be „the critical feed material” among other feeds (1, 2, 3), which confirmed also our previous study (11). As opposed to this result, current study indicates products of land animal origin, as the most serious source of *Salmonella* sp. in feed chain. Soya bean and its derivatives were nearly three times less contaminated, and animal meals were eight times less contaminated. It should be noted, that the usage of meat and bone meals in feed for slaughter animals is still prohibited. However, meat and bone meals are introduced to the environment with fertilisers. Similarly to the results obtained in the previous study, barley was ranked to be the main sources of *Salmonella* sp. among cereals (11). Additionally, it should be mentioned that cereals contamination noticed in our study was parallel with European Food Safety Authority (EFSA) data from 2007 and 2009 (21). The study confirms also the suspicion that the water for animals is the source of contamination by *Salmonella* sp. However, the most favourable information are data from 2003-2010 where a decline of positive samples for *Salmonella* sp. in oil seeds and derivatives and in animal meals is visible (11). Furthermore, following analogous data from the last thirty years, the decreasing trend is maintained (7, 13). Polish data are also convergent with the trends published by EFSA in this area.

*Enterobacteriaceae* family includes, among others, *Salmonella*, *Escherichia*, *Shigella*, and *Yersinia* species, where human and animal pathogens may occur. For nearly all bacteria of this family, natural life environment is human and animal intestine. Therefore, the number of *Enterobacteriaceae* is a reliable indicator of faeces contamination and indirectly assesses the probability of *Salmonella* occurrence. It is an important index of decontamination during feed production process and critical control point in feed production chain (10). In the current study, animal fat and meat meal samples demonstrated the best quality of this parameter, which for the second time confirms the effectiveness of good manufacturing practice (GMP) and good hygiene practice (GHP) at primary production stage (11). More and more frequently, materials of plant origin are shown to be the real source of *Enterobacteriaceae* in feed chain, where some species of this family may naturally occur (24).

Aerobic mesophilic bacterium count and total microorganism count are fundamental, although belong to the general hygienic criteria. These parameters inform about microbiological quality of used feeds, effectiveness of production process, and hygienic conditions during growing of plants, harvesting, feed processing, storage, and distribution. There is a popular opinion, which states that lower number of microorganisms decreases the probability of pathogens occurrence (6). Besides, proteolytic and lipolitic bacteria
lead to disintegration of proteins and lipids, which decreases feed nutritive value. As demonstrated above, plant materials (cereals, oil seeds, and derivatives) are the major source of aerobic bacterial contamination of feeds, while the animal feeds are of less importance. Parallel results regarding oil seeds and cereals, were obtained by Vlachou et al. (11) and Kwiatek et al. (25). However, the land animal origin samples should also be regarded as a possible source of microbial contamination.

Taking into account resistance for many factors, fungal spores are ubiquitous on the whole globe. Plant materials are the primary and most important source of fungi in feed (field fungi) and additional contamination takes place during storage (storage fungi). The average number of fungi in freshly harvested cereals is $10^4$ cfu/g, but it strongly depends on weather conditions during vegetative season (2). Apart from humidity and temperature, fungus growth is determined by the presence of nutritive substances, oxygen, and medium pH (5). Like bacteria, enzymatic activity of moulds decreases the nutritive value of feeds, causing adverse organoleptic changes. The presence of moulds in feeds creates a risk of occurrence of mycotoxins, which is really dangerous for animals and humans, taking into account their carcinogenic, teratogenic, and mutagenic properties (4, 9). In agreement with our results are data presented by other authors, who indicated cereals and derived as feeds with the highest risk of fungal contamination (5, 8, 25). Taking into account inconstancy of annual rainfall in Poland (average 600 mm), it is reasonable to suspect, that it will influence directly the microbiological quality of plant feeds (23). It is slightly notable for bacterial contamination of plant materials and more clearly visible for mycological contamination of these products. For example, when total annual rainfall in 2009 exceeded average annual rainfall by 13.8%, only 9.1% of cereal samples contained more than $10^3$ fungi per gram (22). But, when annual rainfall in 2010 exceeded average rainfall already by 38.7%, as many as 14.3% of cereal samples contained more than $10^5$ cfu/g of fungi. A weak, although positive correlation between moisture of feeds (materials and compound feeds) and number of bacteria and fungi was also proved by Vlachou et al. (25). It is worth noting that annual rainfall declared by Central Statistical Office is quotient of total annual rainfall with reference to all area of Poland. However, some regions had registered rainfalls higher than the average values even by 80% in 2010, which undoubtedly influenced more negatively the microbiological quality of feeds harvested from these regions.

Nevertheless, regression analysis used for statistical assessment of the obtained results indicates a gradual but systematic improvement of microbiological quality of feeds used in Poland. As far as weather factor is always unavoidable, which was revealed above, the current analysis proved the human efforts heading towards improvement of animals’ health and safety of the food of animal origin, which was expressed as an increase in microbiological quality of feed.

**References**


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