TITLE: Physical characteristics of feed collected from Italy and Serbia

AUTHORS: Radmilo Čolović, Matteo Ottoboni, Valentina Caprarulo, Adriano Pilotto, Vojislav Banjac, Đuro Vukmirović, Luciano Pinotti

RADMILO ČOLOVIĆ[1*], MATTEO OTTOBONI[2], VALENTINA CAPRARULO[2], ADRIANO PILOTTO[2], VOJISLAV BANJAC[1], DJURO VUKMIROVIĆ[1], LUCIANO PINOTTI[2]
*Corresponding author:
[1] University of Novi Sad, Institute of Food Technology, Novi Sad, Serbia
[2] Università degli Studi di Milano, Dipartimento di Scienze veterinarie per la salute, la Produzione animale e la sicurezza alimentare, Milano, Italy

Physical characteristics of feed collected from Italy and Serbia

KEYWORDS: *Feed, physical quality, mash, pellet, extrudate.*

ABSTRACT: *The aim of this study was to investigate the physical quality of a selected lot of twenty animal feed samples collected in Italy and Serbia. Granulation of cattle and pig feed was finer in Italian than in Serbian samples. Flowability of samples from both countries in mash form were rated from fair to good (angle of repose >30°) while granulated samples (pellets and extrudates) had improved flowability (angle of repose <20°). Extruded products had higher hardness (>10 kg) than pelleted products (<8 kg). Durability of most of the extruded and pelleted products was higher than 95%. Generally, it was observed that most of the physical characteristics of the samples responded to recommendations, which showed that the similar practices are in use in both countries.*

INTRODUCTION

The industrial compound feed sector is a key segment in the agro–food sector in general and in the chain of food products of animal origin in particular. According to den Hartog (1), an important aspect of feed quality (besides nutritional quality, safety for animals, environment and consumers, and emotional quality) is technical quality, i.e. physical properties of compound feed. Physical properties of single ingredients and the resulting pre-mix and/or compound feeds play a significant role in their resulting storage and flow behaviour, and are therefore essential to design appropriate, efficient, and economic bulk solids handling and storage equipment and structures (2), which are able to guarantee a good final quality, and which will respond to animals' preferences.
Important physical characteristic of feedstuffs within compound feed is particles size distribution. Goodband et al. (3) reported that particles size reduction increases the surface area per unit volume allowing greater access to digestive enzymes. Moreover, particles size reduction may affect handling and mixing of the ingredients (4). However, optimal particle size largely differs in respect of the target species.
Pelleting is a manufacturing process that is commonly used to densify, improve handling characteristics, nutritive and economical value of granular materials (5). Additionally, pelleting improves microbial stability of the product (6). Pellet quality mostly depends on raw materials that comprise compound mixture, but also on parameters of pellet press and up- and downstream equipment (7). Extrusion process is mostly used for pet food and fish feed production. In the extruder barrel, the material is exposed to thermal and mechanical treatment, plasticizing and shaping the material. Unlike pelleting process, extrusion process can be used for setting required density of the product, with high digestibility and improved physical characteristics (8).
Considering that the manufacture of compound animal feeds involves nowadays a wide variety of ingredients (9), which should respond to animals' nutritional demands, but also have significant effect on physical quality of feed (10), and that wide variety of process technologies can be utilized in compound feed production. in light of this, physical quality analysis of single ingredients as well of compound feed assume great importance in ensuring high quality product.
Starting from these assumptions, the aim of this study was to investigate the physical quality/properties of a selected lot of samples of animal feed collected in the frame of an Italian and Serbian bilateral project.

MATERIALS AND METHODS

Specific survey was conducted during the year 2014 for the purposes of the "Feedneeds" bilateral project. One of the subtasks of the survey was to obtain information about most representative product from Italian and Serbian animal feed companies. For this purpose, 10 samples from Italy and 10 samples from Serbia were collected. The samples belonged to the following categories: cattle feed (dairy cows), poultry feed (broilers and laying hens), pig feed, pet food (dog food), and fish feed (carp feed). Before the physical analysis determination, samples were categorized according to physical form of the samples (related to the production process) into the three groups: mash, pellet, and extrudate.
For testing of flowability of feed samples, angle of repose method was used (11). The angle of repose, α° was calculated using the following equation:

Where α° is the angle of repose (°), h is the height of the cone formed by material (cm), and r is the radius of the base of the cone (cm). According to the angle of repose, samples were classified into several categories related to their flowability (Table 1).

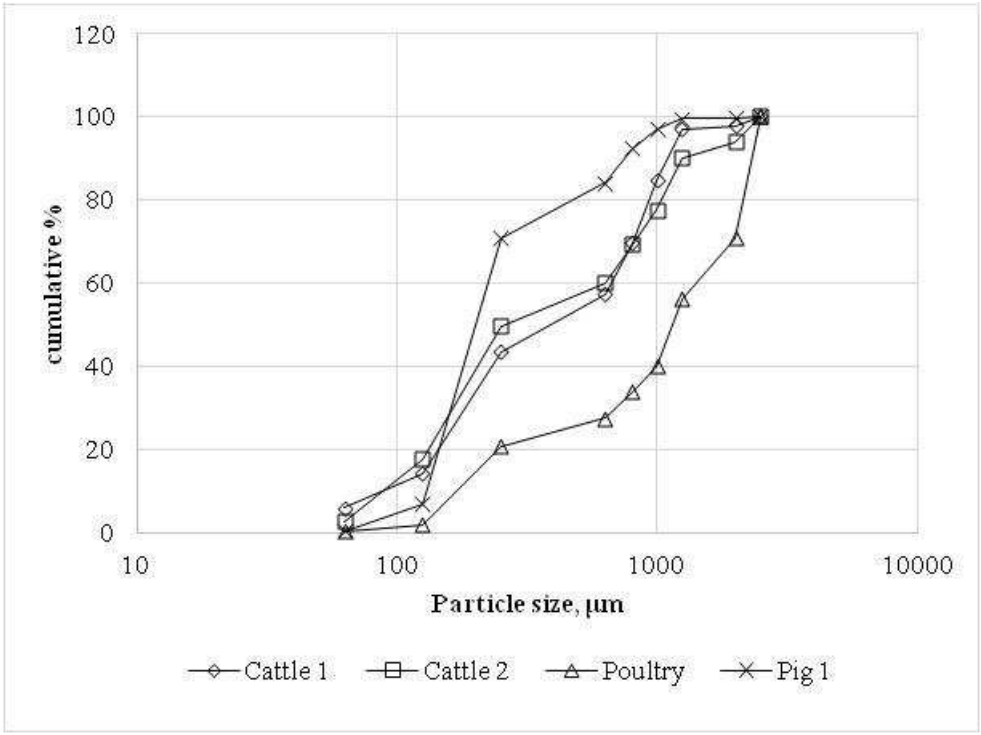
Flow rating	Angle of repose (degree)
Excellent	25-30 (or less)
Good	31-35
Fair	36-40
Passable	41-45
Poor	46-55
Very poor	56-65
Extremely poor	66-90

Table 1. Flowability ratings according to the angle of repose

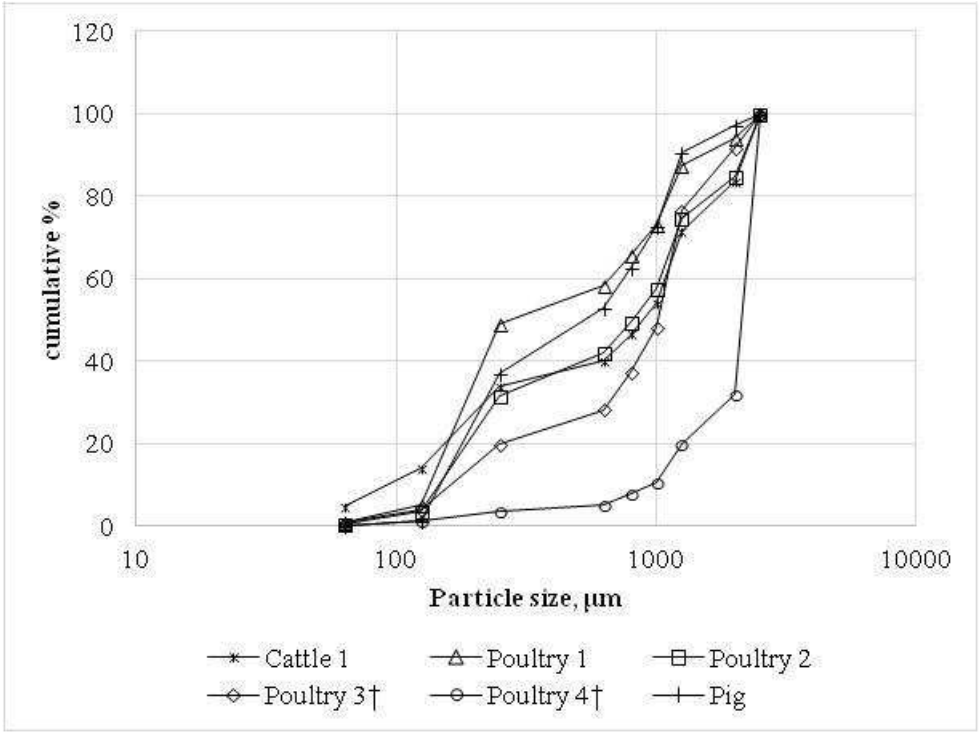
The mash samples were subjected to the sieving analysis, which was performed according to ISO 2591-1 (12) standard, using laboratory sieves ranging from 63 to 2500 μm (Endecotts Ltd., United Kingdom). Geometric mean diameter (dgw) was determined for evaluation of particle size of different samples (13). Pellet hardness was determined with Kahl Pellet Hardness Tester (Amandus Kahl GmbH & Co. KG, Germany) and fifteen replications were performed per each sample.
The Holmen Pellet Tester (NHP100, TekPro Ltd., Norfolk, UK) has been used for determining durability of both, pelletized and extruded feeds. Granulated samples were pre-sieved, before put into the test chamber of the tester, to remove fines and impurities. A sample was circulated in the air stream around a perforated test chamber for 30 s. The remaining pellets were collected, weighed, and the pellet durability index (PDI) was calculated as the ratio of the weight after testing over the weight before the testing, and given as percent.

RESULTS AND DISCUSSION

Italian and Serbian animal feed factories provided their most representative product for the purposes of this survey. Selection of representative sample of each factory was done according to the production aims and current market position.
Sieving analysis of Italian samples showed coarser structure of poultry feed comparing cattle and pig feed (Figure 1), which is in line with animals' requirements. Two different Italian cattle feed samples had almost the same particle size distribution, as well as the geometric mean diameter (Figure 2). On the other hand, granulation of Italian cattle and pig feed samples was finer compare to Serbian samples. When comparing Serbian poultry feed samples, samples Poultry 3 and Poultry 4 were in form of crumbled pellets, and consequently those samples had the coarsest structure and the highest geometric mean diameter, especially sample Poultry 4. This sample had almost 70% of particles larger than 2 mm. This feed was produced specially for laying hens, concerning that for layers medium and coarse particle size is preferable (14, 15).



(a)



(b)

Figure 1. Cumulative particle size distribution curves of Italian (a) and Serbian (b) mash samples
†Crumbled Pellets

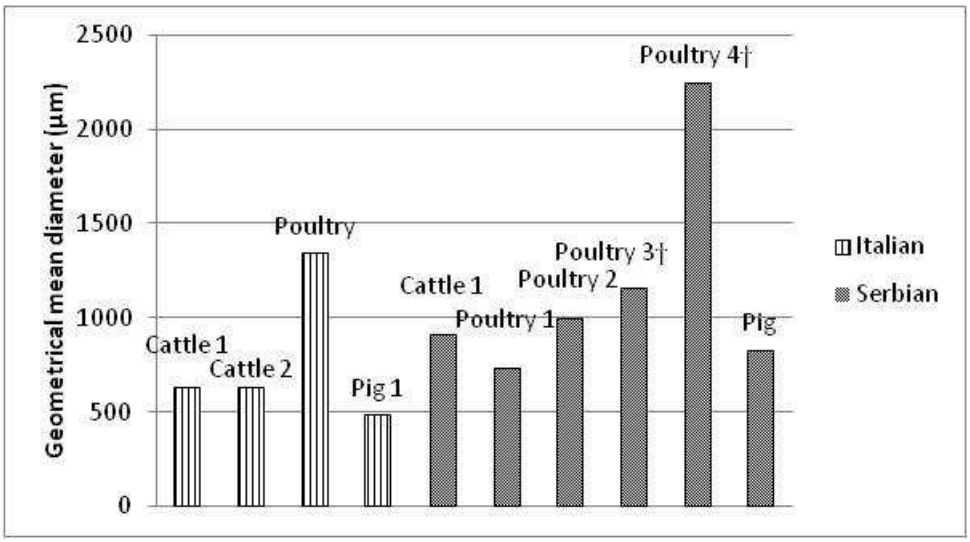
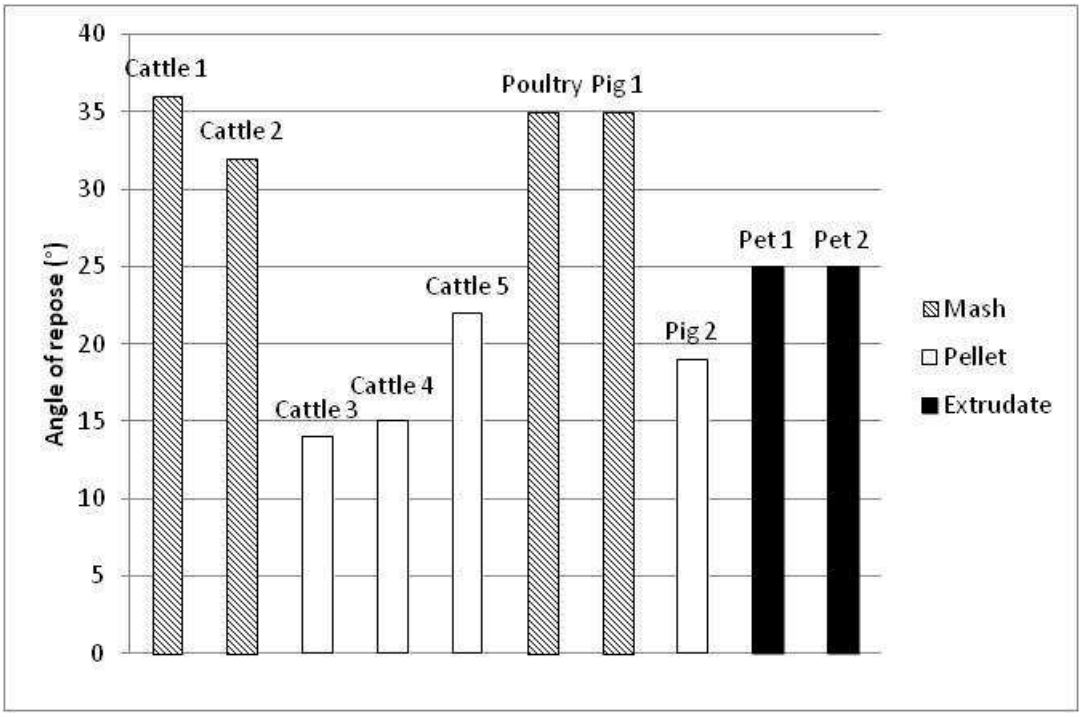
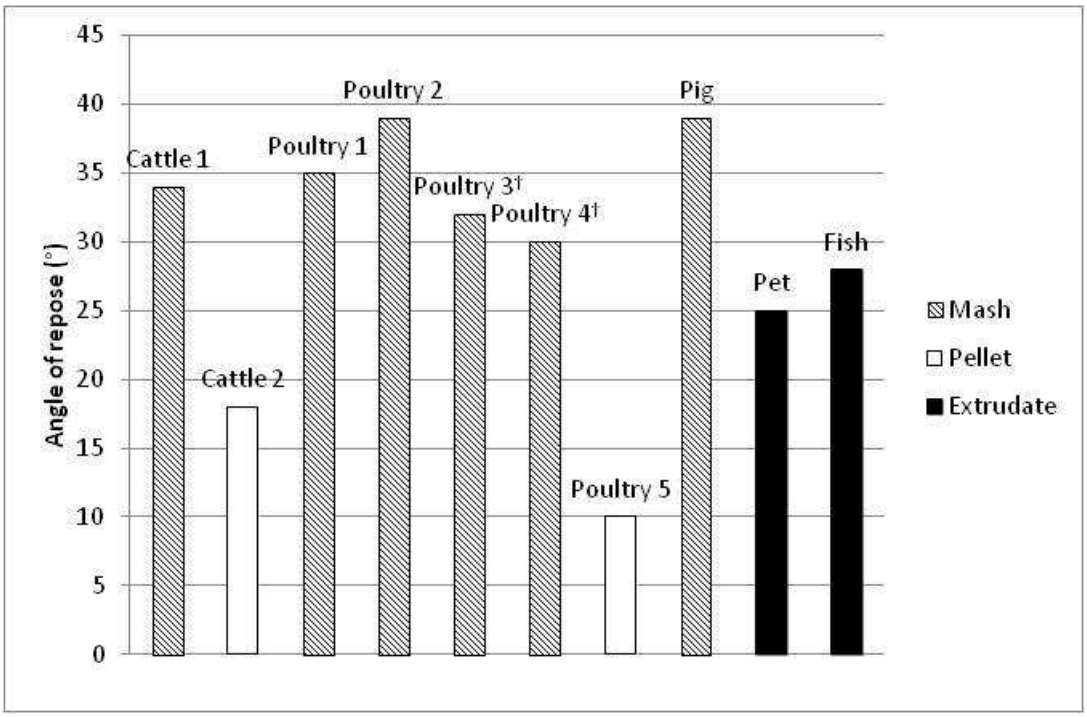


Figure 2. Particle geometrical mean diameters of mash samples
†Crumbled Pellets

Animal feed is a mixture of up to 40 components (16) that differ in terms of their flow properties, which determine the ease of transport in conveying equipment and the flow out process (e.g. from silo cells) (17). The flow properties of feed depend on its particle size distribution, particle form, as well as crop-specific properties such as fiber components and the dry matter content (18). Flowability of all collected samples from both countries in mash form were rated from fair to good (Figure 3), according to obtained values of angle of repose and flowability ratings taken from Table 1. Among Italian samples, sample Cattle 1 had the poorest flowability, rated as fair. The ruminant feeds generally have more fiber, which may have negative influence on flow properties of feed (18). Compared to the Serbian samples in mash form, Italian samples have slightly lower value of angle of repose within the same category of feed, indicating better flowability. Comparing the Serbian poultry feeds, samples in form of crumbed pellets had lowest values of angle of repose and thus better flowability since these samples had higher percentage of coarser particles and higher geometrical mean diameter of particles all which influences better flow properties (18). Pellets normally have better flow properties than mash (19), thus all collected samples of pellets from both Italy and Serbia had excellent flowability, as well as extruded samples of pet food and fish feed.



(a)



(b)

Figure 3. Angle of repose of Italian (a) and Serbian (b) samples
†Crumbled Pellets

Pellet hardness is important from the nutritional point of view since it may play a role with preference of animals. The pig feed pellets had lowest value of hardness (Figure 4). This result can be satisfying since, according to a study of Skotch et al. (18), pigs prefer softer pellets over the harder ones. Samples of cattle feed had higher values of hardness, ranging from 2.83 kg up to 7.83 kg, than samples of pig and poultry feed. The highest values of hardness were observed for samples of extruded pet food. During extrusion process, basic components of raw materials, such as proteins and starch, undergo physical and chemical changes, creating the shaped product which is harder than products obtained within the pelleting process (21).

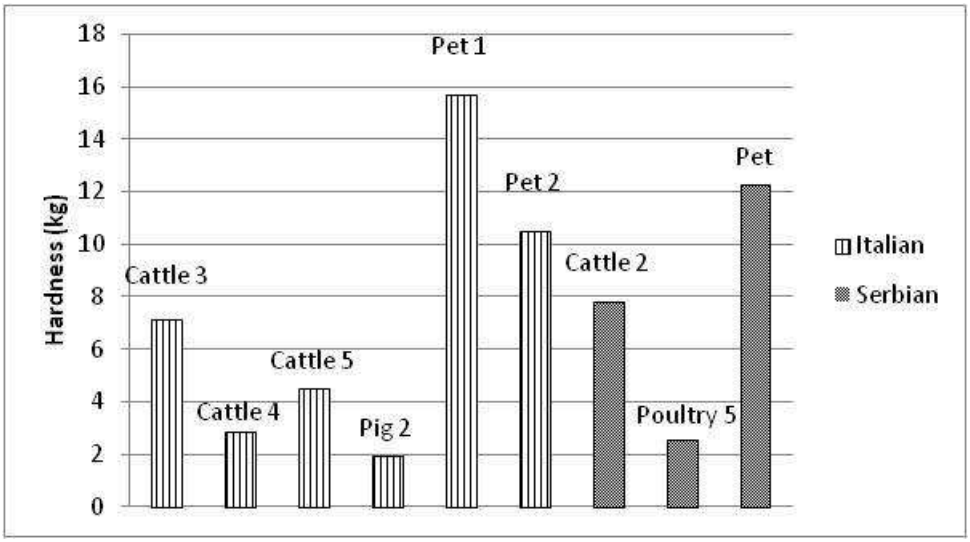


Figure 4. Hardness of pelleted and extruded samples

Results of durability test showed that almost all collected pellets had good durability (Figure 5) and therefore good resistance against the stresses exerted on them during transportation and distribution to the animals. Among Italian sample, the lowest PDI was observed in cattle feed (Cattle 4), slightly below 90% which is the limit of tolerance for good pellet durability. This sample also had softest pellets, so it may be that the production parameters or composition of starting mixture were not adequate and resulted in the lowest pellet quality of all collected samples. The sample of poultry feed (Poultry 5) from Serbia had the lowest durability of all samples,

since almost 22% of fines were produced from starting amount of pellets after durability test. This result was unacceptable in terms of pellet quality, indicating that improper setup of pelleting parameters was done in the production process (19).

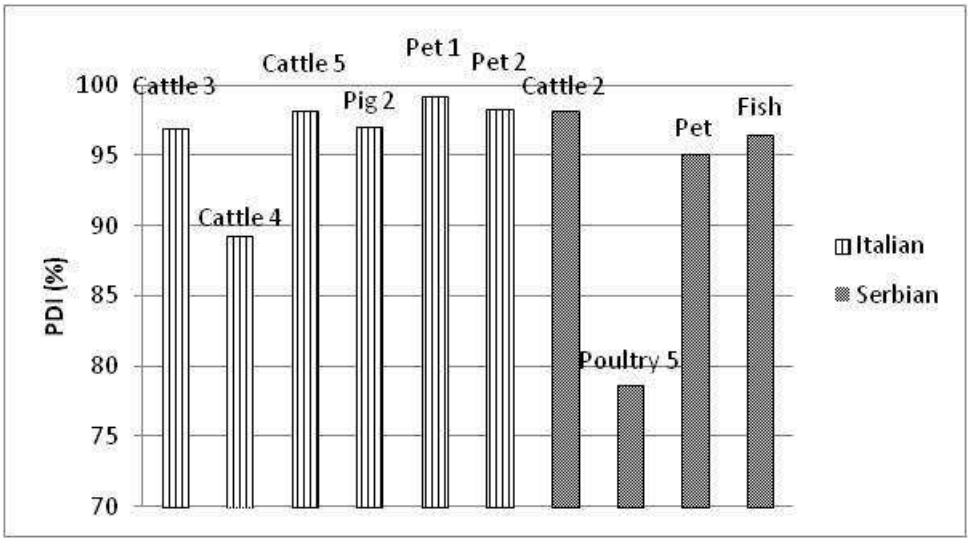


Figure 5. Pellet durability index of pelleted and extruded samples

CONCLUSION

Based on the physical analysis of collected animal feed samples, it was observed that most of the physical characteristics of the samples responded to recommendations for specific categories of the animals, despite the geographical area (Italy or Serbia) which showed that the similar practices are in use in both countries. Pelleted and extruded samples had better flowability than mash samples which makes transport and handling of granulated products much easier. Hardness of granulated samples was the lowest for pig feed which is in line with animals' preferences. Most of granulated samples had good durability which is very important from the nutritional and economical aspect.

ACKNOWLEDGEMENT

This study is part of the FEEDNEEDS project a GRANDE RILEVAZA Italian-Serbian bilateral project funded by the Italian Ministero degli Affari Esteri e per la Cooperazione Internazionale, coordinated by Prof. Luciano Pinotti, Università degli Studi di Milano, Italy.

REFFERENCES AND NOTES

1. den Hartog, J., *Food Control*, **14(2),** 95-99 (2003).
2. Ganesan V., et al., *Biosystem Engineering*, **101**, 425-435 (2008).
3. Goodband, R. D. et al., MF-2050 Feed Manufacturing, Kansas State University, Manhattan, USA (2002).
4. Koch K., MF-2048 Feed Manufacturing, Kansas State University, Manhattan, USA (2002).
5. Theerarattananoon, K., et al., *Industrial Crops and Products,* **33(2)**, 325-332 (2011).
6. Čabarkapa I., et al., *Archiva Zootechnica,* **13(3)**, 47-54 (2010).
7. Čolović R., et al., *Archiva Zootechnica*, **14(2)**, 17-27 (2011).
8. Rokey, G. J.: Single screw extrusion, Chapter 9, in Extruders and expanders in pet food, aquatic and livestock feeds, Edited by Riaz, M.N., Agrimedia GmbH., Clenze, Germany (2007).
9. Pinotti L., et al., *Biotechnology, Agronomy and Society and Environment*, **18**, 1-9 (2014).
10. Thomas, M. and van der Poel, A. F. B., *Animal Feed Science and Technology*, **70(1–2)**, 59-78 (1998).
11. Carr, R. L., *Chemical Engineering*, **72**, 163-168 (1965).
12. ISO 2591-1. Test Sieving-Part 1: Methods using test sieves of woven wire cloth and perforated metal plate. International Standards Organization, Geneva (1988).

13. ASAE standards 319.3. Method of determining and expressing fineness of feed materials by sieving. ASABE standards, American Society of Agricultural and Biological Engineers, 608. St. Joseph, MI, USA (2006).
14. Amerah, A. M., et al., *Worlds Poultry Science Journal*, **63**, 439-455 (2007).
15. Safaa, H. M., et al., *Poultry Science*, **88**, 608-614 (2009).
16. Kirchner, A., et al., *Powder Technology*, **239**, 358-365 (2013).
17. Für**ll**, C. and Hoffmann, T., *Powder Technology*, **235**, 838-841 (2013).
18. Für**ll**, C.: Lagern landwirtschaft**l**icher Schüttgüter in Behältern. Habil-Thesis, University Rostock, Germany (1985).
19. Thomas, M., van der Poel, A. F. B., *Animal Feed Science and Technology*, **61**, 89-112 (1996).
20. Skoch, E.R., et al., *Journal of Animal Science*, **57(4)**, 922-928 (1983).
21. Rokey, G. J. and Huber, G.: Extrusion processing of aquaculture feeds, in Feed manufacturing technology V, Edited by Schofield, E.K., American Feed industry association. Arlington, USA (2005).