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IMPACT OF FEED MIXTURE ON KINETIC STRENGTH OF PELLETS FOR POULTRY

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ABSTRACT

The paper presents the impact of feed mixtures for poultry on their kinetic strength determined with Holmen's method. Research material came from a production line and 9 pelleted feed mixtures for poultry with diameter of 3.2 mm were accepted for the research. Feed was prepared, pelleted and cooled with the use of the same devices and their exploitation settings were comparable with regard to the investigated feed pellet. The obtained research results proved that kinetic strength of the investigated feed pellets was statistically significant in relation to the composition of the feed mixture. Relations of kinetic strength of pellets to the composition of the feed mixtures were determined with the multiple regression method. From the determined models the highest utilitarian value may occur in case of a model with four explanatory variables: corn (x_1), wheat (x_2), soya meal (x_4) and fat (x_5).

Introduction

Many researchers confirm in a multi-trend evaluation, the prevailance of the pelleted feed quality over loose feed (Grochowicz, 1996; Thomas et al., 1997; Walczyński et al., 2000; Rynkiewicz, 2008; Obidziński and Hejft, 2012). Pelleted feed used in the feeding process is defined by: a higher nutritional value, uniformity of structure, no layering, better taste, lower content of bacteria and funghi, longer shell life and the fact that animals eagerly eat it. However, one of the most important quality features of the pellteted feed is their kinetic strength (Grochowicz, 1996; Rynkiewicz, 2008; Kulig and Laskowski, 2006; Obidziński, 2014; Zawiślak et al., 2010). High kinetic strength decides whether the feed will be more endurable and it means that pellets are minimally damaged during transport, storage and feeding. High quality of pellets related to kinetic strength results most often from:

- material composition of a mixture including fat content, fragmentation degree and uniformity of the mixture (Thomas et al., 1998; Walczyński et al., 2000; Walczyński and Zawiślak, 2000; Kulig and Laskowski, 2006; Rynkiewicz, 2008; Zawiślak et al., 2010),
- methods of preparation of a mixture for pelletization and pelletization and cooling method (Kulig and Laskowski, 2005; Rynkiewicz, 2007; Zawiślak et al., 2010),
- structures of working units and their setting parameters (Zawiślak 2006; Obidziński and Hejft, 2012, 2013).

When selecting a raw material composition of the mixture a compromise is made between its nutritional properties and susceptibility of particular components to pelletization. Kinetic strength of pellets is determined with reference to two types of forces:
– dynamic, which the most often are active during transport,
– statical, which load pellets during storage.

According to Obidziński (2014) kinetic strength of feed pellet is investigated with the following methods:
– "Handling system",
– by Schatter,
– Pfost,
– modified by Pfost,
– by Holmen.

On the other hand, hardness of pellet (Marks et al., 2006; Obidziński, 2014) may be determined with:
– Kahl's hardness tester,
– Schleuniger's tester,
– swing tester,
– with the use of strength machine e.g. Instron,
– Kramer's apparatus,
– spring static penetrometer.

The objective of the research was to determine the composition of feed mixtures for poultry on the kinetic strength of pellet which was investigated with Holmen's method.

Material and methods

Material for the research came from a production line which produced poultry feed. Pelletization was made on Sprout-Matador PM12K pelleting machine. 9 pelleted feed mixtures for poultry with a diameter of pellets 3.2 mm were used for the research. Conditioning of the mixture took place in the conditioner of a pelleting machine and lasted 12015 s at the pressure of steam of 1.8-2.4 at. Pellets were cooled in the column cooler Geelen Counterflow VK – KL Cooling time of pellets was 6-8 min. Moisture after cooling of the investigated pellets was within 10.9% to 13.6%.

A working unit comprised the driven vertical ring matrix with a diameter of 615 mm. A matrix with the width of the working surface of 150 mm had calibrating openings with the diameter of 3.2 mm and length 74 mm. 3 pressing rolls cooperated with the matrix. Working surfaces of roller sleeves were shaped as conical hollows.

Kinetic strength tests of pellets were carried out with the use of Holmen's NHM 100 apparatus. Material for research after the last production stage i.e. cooling was set aside for 24 hours in order to stabilize internal stresses. After that time, pellets were subjected to strength test. A sample for research was sieved through a sieve with dimension of meshes of 2.8 mm. From the siftings a sample of 100 g of pellets was placed in the tester chamber. A sample in the tester circulated in the forced air stream for 60 s hitting, among others, a steel obstacle. Firstly the sample then its part which stayed on the device sieve were weighted. Kinetic strength index P_{dx} was expressed with the relation of siftings remaining on a sieve of the device to the sample mass (100g) introduced to the tester (Obidziński, 2014). Kinetic strength of pellets was tested in 10 iterations for each investigated feed mixture. Statistical analyses were carried out with the use of Statistica 12 program.

Results and discussion

Composition of feed mixtures used in the experiment was presented in table 1. For statistical analyses of the impact of the raw material composition on kinetic strength of feed pellets, those elements were accepted which the most often occurred in the investigated pellets i.e. corn, wheat, rape cake, soya meal and fat.

Table 1.
Composition of the investigated poultry feed mixtures

Type of feed	Product	Element,									
		Barley	Corn	Wheat	Rape cake	Soya meal	Rape meal	Post-extraction sunflower meal	Wheat bran	Fat	Feed additions and other components
BFP	Brojler Finiszer Prestiż	0.00	15.20	49.97	7.00	19.25	0.00	0.00	0.00	5.85	2.73
BFPA	Brojler Finiszer Prestiż A-Cox	0.00	11.35	54.90	7.00	18.20	0.00	0.00	0.00	5.75	2.80
BFPG	Brojler Finiszer Prestiż G	0.00	16.35	49.89	7.00	18.30	0.00	0.00	0.00	6.80	1.66
BG1P	Brojler Grower1 Prestiż	0.00	15.00	49.53	4.00	23.30	0.00	0.00	0.00	3.35	4.82
BG2P	Brojler Grower2 Prestiż	0.00	15.00	47.56	6.00	22.61	0.00	0.00	0.00	5.44	3.39
BSP	Brojler Starter Prestiż	0.00	20.00	42.69	3.00	24.61	0.00	0.00	0.00	2.69	7.01
EK1	Efekt Kurka 1 B/K	5.00	15.00	52.70	0.00	4.40	7.00	9.50	2.50	0.50	3.40
EK2	Efekt Kurka 2 B/K	6.50	20.00	38.94	0.00	1.00	7.00	5.00	15.00	0.50	6.06
KR1	Kurka R-1 PLUS	5.00	15.00	52.32	0.00	5.30	7.00	9.00	2.50	0.50	3.38

Analysis of the investigated feed mixtures proves the highest participation of:

- corn for BSP and EK1 - 20% each.
- wheat for BFPA - 54.90 %, EK1 - 52.70% and KR1 - 52.32%.
- rape cake for BFP, BFPA and BFPG - 7% each.
- soya meal for BSP - 24.61% and BG1P - 23.30%.
- fat for BFG - 6.80% and BFP - 5.85%.

The lowest participation of particular components was reported for:

- corn BFPA - 11.35%,
- wheat EK2 - 38.94%,
- soya meal EK2 - 1.00%,
- fat EK1, EK2, KR1 - 0.50% each.

Kolmogorov-Smirnov test proved regularity of the distribution of kinetic strength for the investigated pelleted feed. The investigated distributions had uniform variations which were checked with Levene's test. The analysis of variance in a single classification proved statistically significant differences in kinetic strength of feed pellet in relation to the composition of feed mixture (Table 2). Kinetic strength within the investigated feed was within 77.10% for BFPG to 93.73% EK2 (Figure 1). Based on Duncan's test (Table 3) it was found out that on account of kinetic strength the following uniform groups were determined: 1st group Brojler Finiszer Prestiż G (BFPG), Brojler Finiszer Prestiż (BFP); 2nd group- Brojler Grower2 Prestiż (BG2P), Brojler Starter Prestiż (BSP), Brojler Grower1 Prestiż (BG1P), Brojler Finiszer Prestiż A-Cox (BFPA); 3rd group – Kurka R-1 PLUS (KR1), Efekt Kurka 1 B/K (EK1) and 4th group – Efekt Kurka 2 B/K (EK2). From the obtained values of kinetic strength of the investigated feed pellets two feeds i.e. of the 1st uniform group (Table 3) may be qualified according to Walczyń (1997) as unsatisfactory with regard to strength (P_{dx} less than 80%). Feed from the 2nd group should be qualified as pellets with satisfactory strenght and from group 3 and 4 as high quality pellets (Walczyński, 1997).

Table 2.
Analysis of variance in single classification. Impact of the feed type on kinetic strength of pellets

Effect	Freedom degrees	Mean square	Test F	The obtained level p
Feed type	8	283.9	26.78	0.0000

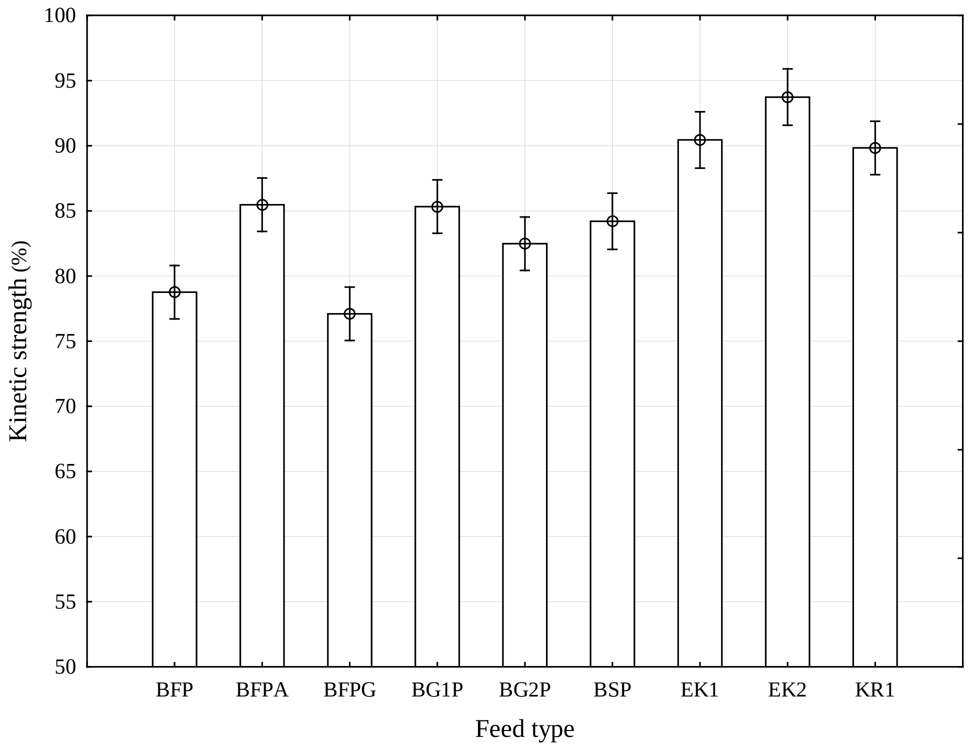

Figure 1. Impact of feed type on kinetic strength of pellets

Table 3.
Duncan test results for kinetic strength of pellets Uniform groups for the feed type

Feed type	Kinetic strength (%) Average	1	2	3	4
BFPG	77.10	****			
BFP	78.76	****			
BG2P	82.48		****		
BSP	84.20		****		
BG1P	85.33		****		
BFPA	85.47		****		
KR1	89.83			****	
EK1	90.44			****	
EK2	93.73				****

Relations of kinetic strength of pellets to the composition of the feed mixtures were determined with the multiple regression method (Table 4). Percentage shares of particular elements in the mixture were determined: corn (x_1), wheat (x_2), rape cake (x_3), soya meal (x_4) and fat (x_5).

For determination of models analyses for the entire collection of data (90 cases) were carried out. In the group:

– with one explanatory variable the highest participation of explained variation (R^2=59.36%) was obtained for model with a variable 'fat' (x_5),
– with two variables the best reflection of changes of kinetic strength of pellets (R^2=61.72%) was reported for variables 'corn' (x_1) and 'fat' (x_5),
– with three explanatory variables the highest participation of explained variation (R^2=69.76%) was obtained after introduction to the model the following variables corn (x_1), wheat (x_2) and rape cake (x_3),
– with four explanatory variables the highest participation of explained variation (R^2=70.56%) was obtained for a model, where the following variables were included: corn (x_1), wheat (x_2), soya meal (x_4) and fat (x_5),
– with five explanatory variables a compliance of the model with experimental data on a similar level was obtained (R^2=70.56%) which with four independent variables.

From the determined models the highest utilitarian value may occur in case of a model with four explanatory variables: corn (x_1), wheat (x_2), soya meal (x_4) and fat (x_5).

Table 4.
Results of estimation of model parameters

Item	Number of included independent variables	$y=a+b\cdot x_1+c\cdot x_2+d\cdot x_3+e\cdot x_4+f\cdot x_5$						Participation of explained variation R^2 (%)
		a (-)	b (-)	c (-)	d (-)	e (-)	f (-)	
1	1	78.9763	0.3888*	——	——	——	——	2.67
2	1	97.1964	——	-0.2473*	——	——	——	3.73
3	1	90.9629	——	——	-1.5094	——	——	56.30
4	1	92.1692	——	——	——	-0.4580	——	41.94
5	1	91.8842	——	——	——	——	-1.8988	59.36
6	2	104.534	-0.1844*	-0.3378*	——	——	——	3.83
7	2	99.0332	-0.4690	——	-1.6805	——	——	59.46
8	2	89.6810	0.1507*	——	——	-0.4510	——	42.33
9	2	98.7489	-0.3979	——	——	——	-2.0616	61.72
10	2	89.0759	——	0.0401*	-1.5280	——	——	56.39

Item	Number of included independent variables	$y=a+b\cdot x_1+c\cdot x_2+d\cdot x_3+e\cdot x_4+f\cdot x_5$						Participation of explained variation R^2 (%)
		a (-)	b (-)	c (-)	d (-)	e (-)	f (-)	
11	2	101.2750	——	-0.1887*	——	-0.4505	——	44.10
12	2	90.3997	——	0.0316*	——	——	-1.9158	59.42
13	2	91.8364	——	——	-1.2366	-0.1253*	——	57.60
14	2	92.6545	——	——	1.6855*	——	-3.9465	60.52
15	2	92.6959	——	——	——	-0.1284*	-1.5720	60.90
16	3	180.4219	-2.3425	-1.0445	-1.8791	——	——	69.76
17	3	144.0995	-1.0696	-0.7103	——	-0.4798	——	47.30
18	3	168.2020	-1.9829	-0.8971	——	——	-2.2265	69.53
19	3	98.6387	-0.4163	——	-1.5011	-0.0736*	——	59.87
20	3	98.2545	-0.3431*	——	0.9875*	——	-3.2390	62.08
21	3	98.4762	-0.3457*	——	——	-0.0993*	-1.7875	62.60
22	3	92.7910	——	-0.0020*	——	-0.1287*	-1.5701	60.90
23	3	91.7466	——	0.0019*	-1.2383	-0.1250*	——	57.60
24	3	92.1118	——	0.0114*	1.6664*	——	-3.9294	60.53
25	3	94.8326	——	——	3.2863	-0.2288	-5.3090	64.35
26	4	179.4960	-2.2891	-1.0363	-1.7458	-0.0540*	——	69.98
27	4	175.9059	-2.2093	-0.9892	-1.1471*	——	-0.8759*	69.92
28	4	168.6301	-1.9428	-0.9065	——	-0.1079*	-1.9304	70.56
29	4	96.7647	-0.1328*	——	2.8434	-0.2041	-4.8881	64.54
30	4	98.6849	——	-0.0767*	3.5577	-0.2491	-5.5455	64.65
31	5	168.4690	-1.9376	-0.9046	0.0245*	-0.1087*	-1.9568*	70.56

* statistically insignificant regression coefficient
—— variable not included in the model

Analysis of the obtained research results (Table 4) concerning the impact of particular components of feed mixtures confirms destructive impact for kinetic strength of fat introduced directly (x_5) and indirectly in the form of soya meal (x_4). The obtained research results are compliant with the research carried out by Kulig and Laskowski (2005). On the other hand, the impact of wheat components (including fiber) on kinetic strength was documented with a considerably high level of strength of the investigated feed. Slight variability of the impact on the kinetic strength of pellets, wheat (x_2) contrary to the research by Kulig and Laskowski (2005) and corn (x1) may result from a low variability of these components in the investigated feed.

Conclusions

1. Kinetic strength of the investigated pelleted feed with values within 77.10-93.73% was statistically significant in relation to the feed type.
2. Out of nine investigated feeds only two (BFPG – 77.10% and BFP – 78.76%) were qualified as pelleted feed with kinetic strength lower than satisfactory (below 80.00%).
3. The lowest kinetic strength was reported for feed KR1 (89.82%), EK1 (90.44%) and eK2 (93.73%).
4. 31 models were determined with the use of multiple regression, out of which 24 obtained the participation of explained variation above 50%.
5. The highest utilitarian value was reported in case of the model with four explanatory variables: corn (x_1), wheat (x_2), soya meal (x_4) and fat (x_5).

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WPŁYW SKŁADU MIESZANKI PASZOWEJ NA WYTRZYMAŁOŚĆ KINETYCZNĄ GRANULATU DLA DROBIU

Streszczenie. W pracy przeanalizowano wpływ składu mieszanek paszowych dla drobiu, na ich wytrzymałość kinetyczną, określaną metodą Holmena. Materiał do badań pochodził z linii produkcyjnej, a do analizy przyjęto 9 granulowanych mieszanek paszowych dla drobiu o średnicy granul 3,2 mm. Paszę przygotowywano, granulowano i schładzano wykorzystując te same urządzenia, a ich nastawy eksploatacyjne były porównywalne w odniesieniu do badanego granulatu paszowego. Uzyskane wyniki badań wykazały, że wytrzymałość kinetyczna badanych granulatów paszowych była statystycznie istotna w zależności od składu mieszanki paszowej. Zależności wytrzymałości kinetycznej granulatu od składu mieszanek paszowych wyznaczono metodą regresji wielorakiej. Z wyznaczonych modeli największą wartość utylitarną może mieć model z czterema zmiennymi objaśniającymi: kukurydza (x_1), pszenica (x_2), śruta sojowa (x_4) oraz tłuszcz (x_5).

Słowa kluczowe: pasze, granulat, surowce, wytrzymałość kinetyczna