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Determination of Chemical Composition and Physical Feed Quality with Different Processing Parameters in Broiler Feed Mill Factories

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ABSTRACT: The aim of this experiment was to evaluate the effect of moisture, the production rate, grain particle size and steam conditioning temperature on composition and physical feed quality of pellet in broiler feed. A 43 fractional factorial arrangement was conducted in starter, grower and finisher feeds with three production rate, three steam conditioning temperatures, three Particle sizes were achieved by grinding the whole grains in the hammer mill to pass through 6, 6.5 and 7.0 mm sieves respectively and three moisture content were added to broiler feed production. There was significant difference observed in T-test treatments with regards to the nutrients concentration (except fiber in starter, crude protein and ash in grower and ca in finisher). Also Processing Parameters has significant difference on feed physical quality in Chi-Square tests. Results of this experiment showed a significant effect of Processing Parameters on the feed composition and feed physical quality.

Keywords: Processing Parameters, feed composition, feed physical quality, broiler, Pellet.

INTRODUCTION

Broiler growth is the result of dietary nutrient content and feed intake. Feed intake is affected by feed form. The best feed intake occurs on good quality crumble, mini-pellets or pellets (Ross broiler management handbook, 2014). The pelleting process has been defined as “the agglomeration of small particles into larger particles by means of a mechanical process in combination with moisture, heat, and pressure” (Falk, 1985). This combination results in thermo mechanical changes in feed constituents and an improvement in feed form. The benefits associated with pelleting include improved animal performance and feed handling and decreased ingredient segregation and feed spillage (Behnke, 1994).In addition to diet formulation; pellet quality is affected by manufacturing technique. Currently, there are no industry standards for manufacturing pellets. Each mill may operate using different diet formulations, ingredient particle sizes, steam pressures, conditioning temperatures, and production rates (Moritz, 2007). For example, in a survey conducted by Moritz (Moritz, 2007), commercial feed mills in the eastern United States used conditioning temperatures ranging from 68 to 91°C (155 to 195°F), die length-to die hole diameter ratios (LDR) ranging from 6.5 to 13.1, and production rates ranging from 907 to 14,882 metric tons/wk (1,000 to 16,400 tons/wk). Variation in all these factors may affect the amount of heat and moisture that feed will accrue through the pelleting process. As a result, thermo mechanical changes in nutrients, such as starch gelatinization and protein denaturation, are widely variable. Inconsistency in manufacturing technique, coupled with constantly changing diet formulations, makes predicting and optimizing pellet quality difficult. A successful experiment mainly depends on a proper design. The traditional method of process optimization of factors with interaction effects involves the study of these factors at different levels, which is costly and labor- and time intensive. A full factorial design is extensively used in agricultural and poultry science for optimization of such factors and their interaction effects. The advantage of a full factorial design is that it is possible to calculate the main effects and all the possible multi-factor interactions of the factors, but the number of factors and their levels that can be tested are limited (Antony, 2003). Therefore, other statistical tools with a lower number of runs may replace full factorial designs.

The Taguchi method is an easy statistical tool, which enables a maximum number of main effects to be estimated with a minimum number of experimental runs (Chung *et al.,* 2007; Roy, 2010). The objective of the current study was to determine of effect the pelleting process based on manufacturing technique on analytically characterize for their nutritional constituents and physical feed quality.

MATERIAL AND METHODS

A. Experimental design and Data collection

The experiment conducted in Zardaneh-Dizbad Co in the Nishabour, Iran. A full factorial arrangement under a completely randomized design using the GLM procedure of SAS (Ver. 9, SAS Institute, 2003 Cary, NC).A 43 fractional factorial arrangement was conducted in starter, Grower and finisher feeds with three production rate (3.5, 4 and 4.5 ton/hr),three Steam temperatures conditioning (65°C, 75°C and 85°C), three Particle sizes were achieved by grinding the whole grains in the hammer mill to pass through 6, 6.5 and 7.0 mm sieves respectively, and three moisture content (0, 2.5 and 5%) were added to broiler feed production . In order to minimize the number of required tests, fractional factorial experiments, which are subsets or fractions of a full factorial design, are preferred since they are more cost-effective. In the present study a fractional factorial design was applied to test the effect of 4 factors with three levels. The Taguchi method has been proposed by Genechi Taguchi to overcome the limitations of full factorial designs by simplifying and standardizing the fractional factorial design (Chung *et al.,* 2007; Roy, 2010). In our study, the Taguchi L9 design was created using Minitab 16.1 software (Stat/DOE/Taguchi/Create Taguchi Design). The selected L9 (34) Taguchi OAs are shown in Table 1. The experimental diets are shown in Table 2. During the production process, sampling was done in the end-point of production line. To acquire the exact picture of broiler feeds, Samples analyzed in laboratory and then the feed composition evaluated (crude protein, crude fiber, ash, calcium, phosphorus and moisture) in broiler feeds (starter, grower and finisher).

Table 1: The L9(3^4) Taguchi orthogonal array of the experimental design.

L9(3^4)	A	B	C	D
Trial No.	Production rate	Particle size	Moisture	Steam conditioning temperature
1	3.5	6	0	65
2	3.5	6.5	2.5	75
3	3.5	7	5	85
4	4	6	0	65
5	4	6.5	2.5	75
6	4	7	5	85
7	4.5	6	0	65
8	4.5	6.5	2.5	75
9	4.5	7	5	85

Reagents: All reagents and chemicals were of analytical grade Sulfuric acid, copper sulfate, Boric acid, methylene blue, methyl red and sodium hydroxide and hexane were purchased from Fluka Chemie GmbH (Buchs, Switzerland). Hydrochloric acid, potassium sulfate, methanol was purchased from Merck (Darmstadt, Germany).

Poultry feed samples collection: For the determination of the nutritive value of poultry feeds, experiments were carried out by sampling of different broiler feeds the pelleting process based on manufacturing technique from zardaneh feed mill in neishabour city,Iran. Each sample was collected in duplicate about 1-2 kg, these feeds designated as being appropriate for broiler.

Preparation of poultry feed samples: Poultry feed samples were ground using a Mammonlex Super blender Mill Grater 3 (No: 4AO- 0018, Type JW-1001, Taiwan), sifted through a stainless steel screen having a mesh size of 1.0 mm to obtain a uniform particle size and kept in air tight plastic bags until required for analysis (Mahesar *et al.* 2010).

Analytical Methods: For the proximate analysis of poultry feeds Association of Official Analytical Chemists recommended methods (AOAC, 1990) were used to measure the levels of crude protein, ash, moisture, crude fat and crude fiber.

Moisture: An accurately weighed poultry feed sample (10 g) was placed in a petri dish and dried in a previously heated oven at 105 °C to a constant weight.

Table 2: Composition of experimental diets (0-42 d of age).

Ingredients	Starter(0-10 d of age)	Grower(11-24 d of age)	Finisher (25-42 d of age)
Corn	47	51. 2	52.5
Soybean meal	38	29.3	26.8
Meat meal	3	2	1.5
Canola meal	0	5	4
Soybean oil	1.93	2.1	3
Dicalcium phosphorus	1.71	1.72	1.72
Calcium carbonate	1.33	1.33	1.33
wheat	5	8	10
Mineral supplement	0.25	0.25	0.25
Vitamin supplement	0.25	0.25	0.25
Idoized salt	0.25	0.25	0.25
DL-Methionine	0.34	0.34	0.44
L-lysine	0.26	0.26	0.27
Total	100	100	100
Metabolizable energy	2970	3123	3207
Crude protein (%)	23.1	20.12	18.7 7
Crude fat (%)	4.6	6.1	3.81
Calcium (%)	1.31	1.00	1.00
Ava. phos(%)	0.47	0.47	0.47
Na (%)	0.11	0.11	0.11
Lysine (%)	1.37	1.37	1.37
Methionine + Cysteine (%)	1.028	1.028	1.128

Protein: The micro Kjeldahl method was used for the nitrogen (N) determination and crude protein determined by multiplied with a protein factor (N × 6.25).

Ash: Accurately weighed sample 2 g each was placed in a ceramic crucible and subjected to ashing in a muffle furnace maintained at 550°C until a constant final weight for ash was achieved.

Fiber: Dietary fiber content of the defatted poultry feed samples was determined by decomposing starch and protein with dilute acid, while fatty material with dilute base, and then filtering and igniting in the muffle furnace at 550°C.

Testing feed physical quality: Physical quality of feed is practically assessed by the size of the feed particles actually presented to the birds. It is often difficult to assess this on the farm. Aviagen has developed a method to measure feed quality using a shaker sieve device which quantifies the particle size distribution of feed in straight-forward and easily observable manner. Using this approach also allows a quantitative comparison to be done between feed deliveries or flocks at the farm level (Ross Broiler Management Handbook, 2014).

B. Statistical Analysis

Analysis for chemical composition parameters were calculated using T-test methods by the GLM procedure of SAS (Ver. 9, SAS Institute, 2003 Cary, NC) was done. Statistical treatment of the data was performed using the GLM procedure of SAS (Ver. 9, SAS Institute, 2003 Cary, NC). Analysis of quality of the feeds was done using Chi- square methods by SAS.

RESULTS AND DISCUSSION

A. Chemical composition

The major nutrients value of poultry feeds that are considered when formulating diets are crude protein, moisture, crude fiber, Ca and P. The results of proximate composition of analyzed broiler feed samples are shown in Table 3,4 and 5, respectively. The analysis of feeds showed the following composition: moisture ranged from 9.19-9.92, 8.94-10.44 and 8.52-9.98%, crude protein 23.59-24.21,19.9-20.84 and 19.4-19.9 %, crude fiber 2.89-6.6, 3.63-3.94 and 3.58-4.05%, ash 5.95-6.7,4.01-4.69 and 4.15-5.39 respectively, for starter, grower and finisher broiler.

Table 3: Proximate composition of broiler starter feeds.

Composition	Mean	Lower CL mean	Upper CL mean	Standard	Std Dev	P-value
Crude protein	23.59	23.59	24.21	23.1	0.41	0.0004
Moisture	9.55	9.19	9.92	10.3	0.47	0.0015
Ash	6.33	5.95	6.70	7.60	0.49	0.0001
Crude Fiber	4.77	2.90	6.64	3.80	2.44	0.27
Ca	1.05	0.90	1.21	1.31	0.20	0.0052
P	0.62	0.57	0.67	1	0.07	0.0001

Table 4: Proximate composition of broiler grower feeds.

Composition	Mean	Lower CL mean	Upper CL mean	Standard	Std Dev	P-value
Crude protein	20.37	19.90	20.84	20.12	0.66	0.2605
Moisture	9.69	8.94	10.44	11	1.04	0.0033
Ash	4.77	4.16	5.39	4.90	0.86	0.6580
Crude Fiber	3.81	3.58	4.05	4.20	0.33	0.0050
Ca	1.15	1.01	1.29	0.80	0.20	0.0003
P	0.56	0.53	0.59	0.70	0.04	0.0001

Table 5: Proximate composition of broiler finisher feeds.

Composition	Mean	Lower CL mean	Upper CL mean	Standard	Std Dev	P-value
Crude protein	19.64	19.40	19.88	18.77	0.34	0.0001
Moisture	9.25	8.52	9.98	11	1.02	0.0004
Ash	4.35	4.01	4.69	5.20	0.48	0.0003
Crude Fiber	3.79	3.63	3.95	3.94	0.22	0.0579
Ca	0.84	0.67	1.02	0.71	0.25	0.1222
P	0.44	0.43	0.45	0.60	0.01	0.0001

There was significant difference observed in T-test treatments with regards to the nutrients concentration (except fiber in starter, crude protein and ash in grower and ca in finisher). In general, the moisture content depicts the amount of moisture contained in the feeds. Moisture content in broiler feeds for starter, grower and finisher was determined in the range of 9.19-9.92, 8.94-10.44 and 8.52-9.98%, respectively.

Most of the operations in the compound feed manufacturing process impact on the nutritive value of the complete feed. The Nutritive effect is exerted mainly through nutrient digestibility and energy utilization (Peisker, 2006).

Crude protein is one of the most important nutrient to quantify in a prospective feeds due to the fact that is one of the most costly to supply and a deficiency of protein has a drastic effect on growth and production. Various diets are commonly utilized, depending on the bird's production stage. Generally starter rations are high in protein whereas grower and finisher diets usually contain less protein, because older birds need less. In this study crude protein was the second major constituent and found in the range 23.59-24.21,19.9-20.84 and 19.4-19.9 % of for broiler (starter, grower and finisher), respectively. There was significant difference observed in treatments ($p < 0.05$). Since feed processing involves a combination of shear, heat, residence time and water, it may result to partial denaturation of the proteins in the feed (Thomas *et al.*, 1998).

There was significant difference observed in crude fiber content. Crude fiber represents the non starch carbohydrate fraction of the feeds. It's considered the cell wall material of the plant, which is composed primarily of cellulose, hemicellulose and lignin. Generally these substances are non-digestible polymers.

Crude fiber content in broiler feeds (starter, grower and finisher) was determined in the range of 2.89-6.6, 3.63-3.94 and 3.58-4.05%, respectively. The ash content of a poultry feeds relates to the inorganic mineral content. In comparison to the literature non significant differences were found between. In this study ash content was found in the range of 5.95-6.7, 4.01-4.69 and 4.15-5.39 for broiler (starter, grower and finisher), respectively. Kirkpinar and Basmacioglu (2006) found that feeding a maize-soy diet pelleted at three different temperatures(65,75,85°C) had no effect on ash, Ca ,P, Na ,K, Mg, Zn, Fe, Mn and Cu contents of tibia of broiler chickens.

B. Feed Physical Quality

Processing Parameters has significant difference on feed physical quality in Chi-Square test treatments in starter, grower and finisher. The recommended particle size distributions for crumble and pellets are shown in Tables 6,7 and 8.

Table 6: Chi-Square Tests for feed physical quality of broiler starter feeds (Crumb).

Form	**>3mm**	**>2mm**	**>1mm**	**<1mm**	**Chi-Square**	**p-value**
Recommended particle size	**15**	**40**	**35**	**10**		
1	24.3	9.74	41.92	24.02	49.68	0.0001
2	62.36	23.79	5.9	7.9	180.82	0.0001
3	61.56	17.15	8.09	10.7	182.85	0.0001
4	30.23	15.64	37.38	16.72	74.89	0.0001
5	56.51	26.73	7.93	11.89	136.33	0.0001
6	45.92	28.57	10.2	15.31	85.63	0.0001
7	27.9	17.35	34.05	20.7	35.39	0.0001
8	58.55	19.22	7.08	15.15	162.16	0.0001
9	51	27	9	13	110.84	0.0001

Table 7: Chi-Square Tests for feed physical quality of broiler grower feeds (Pelllet).

Form	**>3mm**	**>2mm >1mm**	**<1mm**	**Chi-Square**	**p-value**
Recommended particle size	**70**	**20**	**10**		
1	91.05	2.46	6.48	22.3	0.0001
2	94.73	1.42	3.85	29.35	0.0001
3	84.13	4.24	11.63	14.97	0.0006
4	93.45	0.97	5.59	25.99	0.0001
5	98.3	0.47	1.23	37.99	0.0001
6	92.65	2.86	4.49	24.28	0.0001
7	98.85	1.76	2.4	31.35	0.0001
8	91.42	2.47	6.11	22.82	0.0001
9	96.9	1.68	1.42	33.98	0.0001

Table 8: Chi-Square Tests for evaluation of physical quality of feed of finisher feeds (Pelllet).

Form	**>3mm**	**>2mm >1mm**	**<1mm**	**Chi-Square**	**p-value**
Recommended particle size	**70**	**20**	**10**		
1	97.2	0.83	1.97	35.11	0.0001
2	94.88	1.82	3.37	29.19	0.0001
3	89.44	4.54	6.02	18.11	0.0001
4	94.38	1.81	3.82	28.35	0.0001
5	97.67	1.07	1.26	36.11	0.0001
6	88.66	4.36	6.98	17.35	0.0002
7	95.75	1.19	3.05	31.6	0.0001
8	88.9	3.89	7.21	18.16	0.0001
9	95.58	2.28	2.14	30.52	0.0001

Trials have shown that every 10% increase in fines(<1mm) results in a reduction of 40 g body weight at 35 days and therefore, the aim should be to minimize the amount of fine particles(<1mm) in the feed (Ross broiler management handbook, 2014). According to Svihus (2010), whilst pelleting moulds mash diets to macro particles in the form of pellets, it simultaneously reduces the size of the micro-particles that constitute the intact pellet. Reduction in particle size due to pelleting has also been reported by Peron *et al.,* (2005).
Amereh *et al.*, (2007) showed that feed form had a greater influence on performance parameters than did particle size.
Broiler growth and feed efficiency are improved by pelleting feed. These performance improvements are attributed to decreased feed wastage, reduced selective feeding, decreased ingredient segregation, less time and energy expended for eating, destruction of pathogenic organisms, Thermal modification of starch and protein and improved feed palatability. Poor quality crumble or pellets will result in reduced feed intake and poorer biological performance. On the farm, attention should be given to managing feed distribution to minimize physical deterioration in crumble and pellets.

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