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Factors that Affect Pellet Quality: A Review

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Abstract: Pelleting is the most popular thermal processing technique in poultry industry. Birds fed pelleted diets have greater feed intake and weight gain, and better feed conversion ratio. However, this better performance can only be achieved, if the pellets remain intact until they are ingested by the birds. Many factors may affect pellet physical quality, such as feed nutritional composition, ingredient particle size, conditioning temperature and time, feed moisture, etc.. Despite their importance, sometimes these factors are not managed properly, therefore, pelleted feed may not contain a high amount of intact pellets. In addition, the possible interactions among these variables may yield different responses in comparison with those expected when individual factors are considered. Very few experiments have been conducted to evaluate the impact of combined factors on pellet quality. This may be explained by the presence of many qualitative and quantitative factors in the manufacturing process. Research indicates that heat processing and feed formulation, especially fat inclusion level, are the factors which have the biggest influence on pellet quality. Strategies, such as the expansion process and fat inclusion restriction or post pellet liquid fat application could be implemented to produce high physical quality pellets. More research is needed to identify which factors have a positive or negative effect on pelleting process and to find new strategies to improve pellet physical quality.

Key words: Conditioning, broiler, feed formulation, particle size, pellet durability index, pellet quality, pelleting, moisture.

1. Introduction

Pelleting is the most used thermal processing method in poultry industry. The aim of pelleting processing is to agglomerate ingredients particles by mechanical action, in combination with moisture, pressure and temperature. Broilers fed pelleted diets present greater feed intake, better feed conversion ratio and greater weight gain [1-3]. The positive effect of pelleting on broiler performance is partly due to improved nutrients digestibility [4], increased feed consumption [5] and increased broilers resting time which favors lower energy expenditure in maintaining and increasing availability of net energy for production [6]. However, this better performance can only be achieved, if the pellets maintain their integrity until the time they are ingested by the birds.

Pellet quality is defined as the ability to resist fragmentation and abrasion during handling without breaking up and to reach feeders without generating a high proportion of fines [7, 8]. Pellet durability index (PDI) is one of the main parameters used to determine pellet quality, as it indicates the percentage of pellets that remain intact after being submitted to mechanical forces. Pellets are submitted to friction, impact and pressure during storage, transport and dispatch from the feed mill to the farms [9, 10], and poor-quality pellets disintegrate, resulting in a feed consisting of a few pellets and fines. The geometric mean diameter (GMD) of fine particles is equal or lower than that of mash diets, and these particles may cause a nutritional imbalance in feed chemical composition, which may negatively affect animal performance. Mckinney and Teeter [6] evaluated diets with different pellets and fines proportions, such as 100%, 80%, 60%, 40% and 20% of pellets, and 100% of fines on broilers performance, respectively. Birds fed 100% of pellets

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showed higher weight gain and better feed conversion, and the worst results were found in birds fed 100% of fines.

Several factors affect pellet quality, such as dietary nutritional composition, feedstuff particle size, conditioning time and temperature, feed moisture content, compression rate of pellet die, gap between the pellet press roll and die, etc. [11]. In addition, there may be interactions among these factors, producing different results in comparison with those expected when individual parameters are taken into account.

Considering the importance of pelleted diet quality for animal production, the objective of this review is to discuss the factors that influence pellet quality and their interactions.

2. Factors that Affect Pellet Quality

2.1 Particle Size

Particle size is the factor that causes the least influence on pellet quality [12]. Reducing particle size increases particle surface area relative to its volume, thereby increasing the number of contact sites among particles. As a result, interatomic adhesion forces increase (van der Waals forces, dipole-dipole forces, hydrogen bonding), as well as the capillarity between pellet solid-liquid phases and the penetration of heat and moisture to the centre of the feed particle, consequently reducing heat-treatment time [13, 14].

Dozier [1] suggests that for broiler diets based on corn and soybean meal, the optimal GMD for pellet durability should be between 650 μm and 700 μm. Particles ground larger than 1,000-1,500 μm may produce pellet breaking points [15, 16]. On the other hand, the larger surface area of low particle sizes favours heat and moisture transference to the mash inside the conditioner [9].

However, intense reduction of particle size of feedstuffs may not be beneficial to pellet quality. Fahrenholz [12] evaluated pelleted feeds formulated with corn with two different particle sizes (298 μm or 462 μm) and did not find any PDI differences. This lack of effect of particle size is possibly due to the fact that the evaluated GMD range was not sufficient to influence pellet quality. However, Wondra et al. [17] reported a PDI increase of 78.8% to 86.4% when particle size was reduced from 1,000 μm to 400 μm. Therefore, significant reductions in particle size may affect pellet quality.

2.2 Moisture Addition

Both the water added to the mixer and that added as steam during conditioning aid pellet particle binding. This agglutinating capacity is based on water capillarity properties and surface tension [18].

Moritz et al. [19] evaluated the effect of heat treatment (conditioning-pelleting) on feeds containing 927 g or 853 g of moisture per kg of dry matter and obtained 56.5% and 82.2% PDI, demonstrating the beneficial effect of high moisture on pellet quality. Evaluating three levels of water addition to the mixer (0, 25 or 50 g/kg), followed by conditioning for 10 s at 82.2 °C and subsequent pelleting, Moritz et al. [20] obtained increasing PDI values of 75.6%, 76.9% and 79.6%, respectively. The positive effects on pellet quality of the addition of 20 g and 40 g of water per kg of feed in the mixer obtained by Buchanan [21] are consistent with those results. Abdollahi et al. [22] verified that the addition of 24 g of moisture/kg of feed conditioned at 60 °C increased the PDI from 56.5% to 67.2%.

However, water may act as a lubricant and reduce the friction between pellet die holes and the roller [12, 23-25], negatively affecting pellet durability. This was shown in the study of Colovic et al. [11], who evaluated different die height to hole diameter ratios (18/6, 36/6, or 48/6 mm), and the highest moisture content of the last treatment (16.2%) annulled the progressive improvement of pellet durability expected with increasing die heights.

2.3 Fat Inclusion

High dietary fat content may result in less durable

pellets [8, 12, 20, 26]. Fat reduces the contact of the meal with die-hole walls, facilitating feed passage through the die and thereby reducing feed compaction inside the die holes [12]. The addition of fat before conditioning causes partial encapsulation of feed particles and hinders the penetration of steam, which thus reduces starch gelatinization and weakens capillary adhesion forces [9, 12].

The amount of added fat should be limited to 5-10 g per kg of feed, if a high percentage of intact pellets is required [27]. Moritz et al. [19] evaluated two oil addition levels (30 g/kg and 65 g/kg) in broiler diets and observed that PDI was reduced from 81.6% to 62.1% with the highest oil level. Fairfield [28] and the report of California Pellet Mill Co. [13] mentioned that adding more than 20 g of fat per kg of feed in the mixer previous to pelleting decreases the PDI of diets based on corn and soybean meal. Briggs et al. [8] also reported that when dietary ether extract increased from 29 g/kg to 75 g/kg, PDI was reduced from 88.8% to 57.2%.

The post pellet liquid fat application (PPLA) of supplemental fat is an alternative to maintain the integrity of the pellets. Schramm et al. [29] evaluated increasing levels of fat inclusion in the mixer (10, 15, 20, 25, 30 and 35 g/kg**)** and the application of supplemental fat by PPLA method (0, 5, 10, 15, 20 and 25 g/kg) to complete 35 g of fat per kg of feed on PDI. The PPLA increased the PDI from 86%, when all the fat was added in the mixer, to 97% with 25 g of fat per kg of feed added post pellet. The optimal level of PDI was obtained with 23.3 g of fat per kg of feed added post pellet and 11.7 g/kg added in the mixer.

2.4 Conditioning

Conditioning is essential to obtain good physical quality of the feed. During conditioning, steam breaks down the structure of starch, resulting in its gelatinization, as well as changes protein tertiary structure. Starch gelatinization combined with protein plasticization allows binding among feed particles, and thereby it is important for the manufacturing of durable pellets [30].

Abdollahi et al. [31] evaluated the effect of conditioning temperature on the pellet quality of broiler diets based on corn or sorghum, and observed that when increasing the temperature from 75 °C to 90 °C the PDI improved in both diets. Evaluating different feed retention times in the conditioner, Briggs et al. [8] reported that increasing retention time from 5 s to 15 s increased pellet durability in 4.5%. Skoch et al. [23] stated that the addition of moisture using steam improves pellet quality by reducing the proportion of fines and increasing pellet durability.

Feed expansion after conditioning may be an alternative to improve pellet quality by adding expansion benefits to pelleting. Exposure to high pressure and temperature for a short time may lead to an improvement in bioavailability of hard to digest feed components [32]. In the experiment of Lundblad et al. [33], when the effect of heat treatment on the pellet quality of corn-based broiler diets by conditioning feed at 82 °C for 30 s was compared to conditioning under the same conditions followed by expansion at 121 °C, a PDI improvement of 81.8% to 92.3% was obtained. Also, Fancher et al. [32] compared the PDI of broiler and turkey feeds of nine US feed mills before and after the installation of expanders, and reported that it improved from 72% to 89%.

3. Interaction among Different Factors on Pellet Quality

Several factors may affect pellet quality individually or in different combinations. Therefore, each factor and its interactions with other factors should be known to allow understanding their influence on the quality of pelleted diets.

Reimer [34] determined the following partitioning of the effects of different factors (particle size, conditioning, pellet press die, cooling/drying, and feed formulation) on pellet durability: 5% due to cooling/

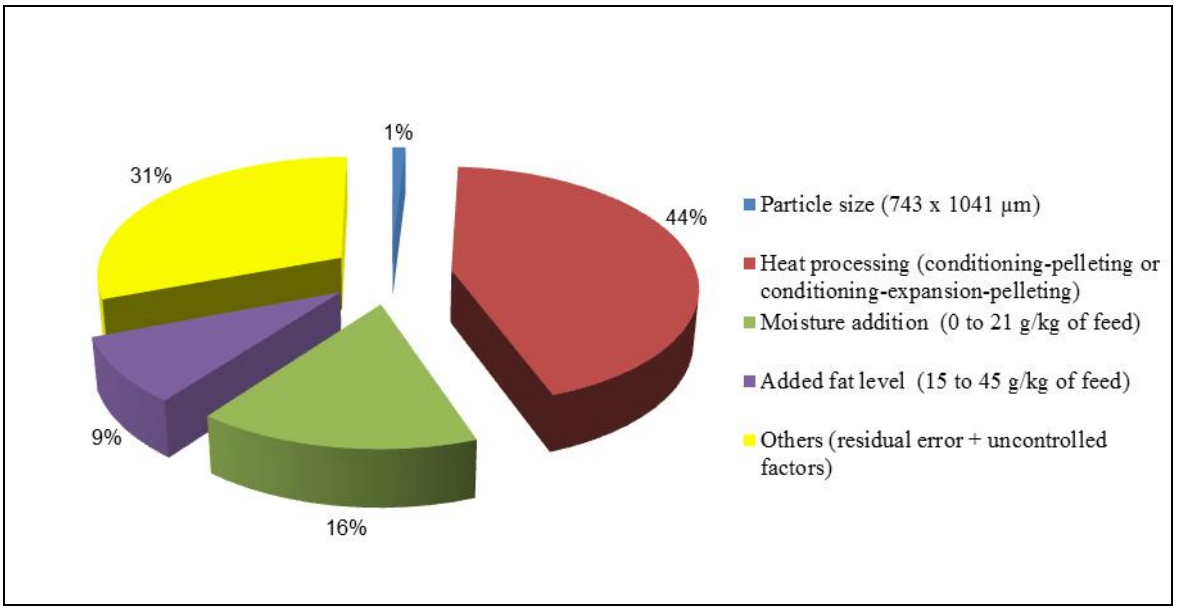

Fig. 1 Effect of different factors on PDI.

drying processes, 15% due to pellet press die specifications, 20% due to heat conditioning and 40% due to feed formulation. These ratios were calculated using European diets, which possibly contain winter cereals.

Muramatsu [35] evaluated the effect of the interactions among different factors on the pellet quality (PDI) of diets based on corn and soybean meal, including particle size (743 µm and 1,041 µm), heat processing (conditioning-pelleting or conditioning-expansion-pelleting), moisture addition (0, 7, 14, and 21 g of water per kg of feed) and added fat level (15, 25, 35 and 45 g of fat per kg of feed). When modelling the effect of all factors, heat processing was the factor that most influenced pellet quality, accounting for 44% of the observed PDI variability (Fig. 1). Under the conditions of that study, the most efficient alternative to improve pellet quality was diet expansion after conditioning, followed by, in decreasing order, increasing moisture level addition, fat inclusion restriction and finally particle size reduction.

4. Conclusions

Improving the efficiency of the pelleting process to produce high PDI pellets has been a permanent focus of the work of feed mill managers, production engineers and nutritionists. Despite the significant corpus of knowledge built in the last few years, further research on the interaction of factor that affect pellet quality is needed.

Strategies, involving changes in diet formulation, feedstuff particle size and adjustment of conditioning parameters, may be implemented to improve pellet quality. The research indicates that heat processing and feed formulation, especially fat inclusion level, are the factors which have the biggest influence on pellet quality.

Alternative procedures, such as the expansion process, increasing moisture level addition, fat inclusion restriction or post pellet liquid fat application, could be incorporated into the feed mill to produce high physical quality pellets.

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