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RESEARCH ARTICLE
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Optimization of Ground Corn Particle Size in the Diet to Improve Physical Pellet Quality in Native Chicken Feed Production

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ABSTRACT

This research evaluated the effect of ground corn particle size on the physical and chemical quality of pelleted feed for native chickens within the framework of developing strategies for the poultry feed industry to optimize corn-based formulations. The experimental material consisted of dry shelled corn (12% moisture) obtained from a commercial corn drying facility. The corn was cleaned to remove impurities and classified into three particle size categories: coarse (mesh 10–18, >1000µm), medium (mesh 20–30, 500–1000µm), and fine (mesh 40–100, <500µm). The experiment was arranged in a Completely Randomized Design with three dietary treatments (P1: coarse, P2: medium, P3: fine), each replicated ten times, resulting in 30 experimental units. Each unit consisted of a mash diet and its corresponding pellet form. Parameters measured included physical quality (particle size distribution, angle of repose, bulk density, pellet durability, pellet hardness, and pellet dimensions) and chemical quality (moisture, crude protein, amino acids, crude fat, crude fiber, ash, and calcium). The results demonstrated that particle size and feed form primarily affected physical rather than chemical quality. Finer particles reduced flowability and storage efficiency, thereby impairing mash quality without altering nutrient composition. In pellet feed, medium-sized particles produced the most favorable outcomes, characterized by the highest pellet durability index, balanced hardness, and the lowest fines. Coarse particles increased hardness, whereas fine particles reduced pellet durability. Overall, pelleting consistently improved physical quality compared with mash feed, while nutrient composition remained stable. These findings suggest that pelleting with a medium particle size is the most effective strategy for enhancing feed efficiency without compromising nutritional value.

Keywords: Ground corn, Particle size, Pellet quality, Native chicken

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INTRODUCTION

Poultry feed production plays a crucial role in Indonesia's livestock industry, particularly in supporting traditional (*kampung*) chicken farming. Corn serves as the primary energy source in poultry rations. At the same time, it represents a significant cost factor, as procurement often accounts for the largest share of raw material expenditures. In Indonesia, approximately half of the national corn production is allocated to the feed industry, about 30% is consumed directly, and the remainder is absorbed by other industrial sectors (Ariyanto et al., 2023). Within poultry diets, corn typically constitutes 40–55% of the total ration (Fajar et al., 2021) and provides the majority of metabolizable energy, often around two-thirds of dietary ME. Several studies confirm its central role as the primary energy grain, while also showing that its feeding value may vary depending on geographic origin, hybrid characteristics, and processing conditions (Cowieson, 2005; Melo-Durán et al., 2021).

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Feed ingredients incorporated into poultry diets generally undergo size reduction through milling prior to formulation. In the case of corn, grinding before mixing facilitates a more uniform distribution of particles within the diet and enhances the accessibility of nutrients. Reducing the particle size of feed substrates enlarges their surface area, enhancing enzyme–substrate interactions, improving pellet cohesion, and reducing ingredient segregation during mixing. Empirical evidence supports this: Bozkurt et al. (2019) showed that in white egg-laying pullets (n=864), coarse grinding with an 8mm screen improved feed conversion ratio (FCR; P<0.05) compared with a 4mm screen, while crumble diets enhanced crude protein digestibility and pancreatic amylase activity (P<0.01). Similarly, Niu et al. (2023) demonstrated that in Chahua chickens (n=192), finely ground corn with a particle size between 700–900µm significantly increased dry matter, crude protein, amino acid digestibility, and apparent metabolizable energy (P<0.05) at week 12. However, these improvements were not evident at week 19. Collectively, these results suggest that optimizing corn particle size involves balancing improved nutrient digestibility from finer grinding against the physiological and structural benefits of coarser particles.

Rueda et al. (2024) demonstrated that broilers fed diets containing 750µm corn particles had significantly greater body weight and feed intake at 39 d of age compared with those given 1,150–1,550µm particles (P<0.05), while nutrient digestibility was consistently higher in pelleted diets, notably when particle size increased from 750 to 1,550µm (P<0.05). Svihus et al. (2024) demonstrated that broiler chickens tolerated pellets larger than the current industry standard (3–4mm) without adverse effects on growth. Using a 5mm die preserved more coarse particles in the diet, and birds readily consumed feed particles larger than 4.8mm even at 16–22 d of age, showing a strong preference for these sizes by day 29. The authors concluded that larger pellets may enhance pelleting efficiency and energy savings, while maintaining the coarse microstructure that stimulates gizzard activity.

Feed particle size plays a critical role in broiler nutrition, though the optimal range may vary with age and processing conditions. Lemons et al. (2019) observed that increasing the average feed particle size during the starter phase (0–14d) improved long-term performance in Ross × Ross 708 broilers, with diets ≥2,800µm yielding approximately 30 g higher body weight gain and a 0.03 improvement in feed conversion ratio compared with finer diets. In contrast, Ghasemi-Aghgonbad et al. (2024) reported that finely ground corn (357µm) conditioned at 75 °C enhanced average daily gain, feed efficiency, and jejunal morphology in Ross 308 broilers, despite no significant interaction between particle size and temperature on growth performance. These findings highlight that the relationship between particle size and broiler performance is influenced not only by the growth phase but also by feed processing conditions, suggesting that particle size optimization should be context-specific.

The present study investigates the impact of ground corn's particle size on the physical quality of pelleted feed for native chickens. The results aim to provide practical guidance for the poultry feed industry in optimizing corn-based formulations to enhance production efficiency, improve animal performance, and strengthen the sustainability of feed production in Indonesia.

MATERIALS & METHODS

Experimental Procedures

The primary raw material used in this study was dry-shelled corn sourced from a corn drying facility. The corn was first cleaned to remove impurities and foreign materials, and then dried to a moisture content of approximately 12%. Grinding was carried out using a hammer mill (RD 85 DI-2S, 7.5 HP diesel engine, 200kg/h capacity, equipped with 16 hammers). The screen size used in the hammer mill was 4mm. To determine the particle size distribution of the ground corn, a sieve shaker with a set of sieves (mesh 10–100) was used. Based on this analysis, three particle size categories were obtained, namely coarse (mesh 10–18, ≥1000µm), medium (mesh 20–30, 500–1000µm), and fine (mesh 40–100, <500µm).

Ground corn from each particle size category was then used to formulate three types of experimental mash diets (P1, P2, and P3), specifically a mash diet with coarse ground corn, a mash diet with medium ground corn, and a mash diet with fine ground corn. The diets were formulated using other feed ingredients including rice bran, soybean meal, palm kernel meal, fish meal, and a mineral–vitamin premix. The chemical composition of the feed ingredients used in the experimental diets is presented in Table 1.

Table 1: Chemical composition of feed ingredients used in the experimental diets

Feed Ingredients	Chemical composition (%)				
	Moisture Content	Crude Protein	Crude Fat	Crude Fiber	Ash Content
Ground corn	11.27	7.80	2.84	2.49	1.56
Rice bran	10.55	12.88	15.59	8.34	9.58
Soybean meal	11.99	49.23	0.80	5.04	6.09
Palm kernel meal	9.14	16.12	7.31	16.62	4.18
Fish meal	15.33	34.23	5.12	0.13	22.65

Mixing was carried out using a horizontal ribbon mixer (single shaft type) with a capacity of approximately 250kg per batch, mixing time of 10–15min/batch, and powered by a 5–10 HP diesel motor. The ingredient composition of the experimental diet consisted of 49.50% ground corn, 19.00% rice bran, 8.00% fish meal, 15.00% soybean meal, 3.50% palm kernel meal, 2.00% dicalcium phosphate, and 3.00% mineral-vitamin premix. The formulated mash diets were subsequently processed into pellet form using a Pellet Machine KL-175 Roller 3 with a production capacity of 120–175kg/h. The pellets produced were dried at room temperature and stored in airtight containers until further physical and chemical quality analyses were conducted.

Experimental Design

The experiment was arranged in a Completely Randomized Design with three dietary treatments based on ground corn particle size, namely: P1: Coarse particle size of ground corn (Mesh 10–18, ≥1000µm); P2: Medium particle size of ground corn (Mesh 20–30, 500–<1000µm); and P3: Fine particle size of ground corn (Mesh 40–100, <500µm). Each treatment was replicated ten times, resulting in a total of 30 experimental units. The experimental unit was defined as one batch of mash diet and its corresponding pellet form prepared according to the treatment.

Parameters Measurements

Particle size distribution was analyzed using a sieve shaker according to the ASABE (2023) standard by operating stacked sieves for 10min and expressing the retained fractions as cumulative percentages of the sample. The angle of repose was determined by allowing ground corn to flow through a funnel and form a cone-pile; the angle was then calculated from the radius-height-to-radius ratio and expressed in degrees. Bulk density was determined by gently filling a graduated cylinder (volume known), recording the sample weight, and expressing it as the weight-to-volume ratio (kg/m^3) (Syamsu et al., 2015).

Pellet durability was assessed with a Holmen NHP100 Portable Pellet Durability Tester, and the proportion of intact pellets was expressed as the Pellet Durability Index (PDI). Hardness was measured using a Stokes Hardness Tester and reported in kilogram-force (kgf). The percentage of fines was determined by sieving a fixed amount of pellets, weighing the fraction that passed through, and presenting the proportion relative to the initial weight, following the method described by Stark and Fahrenholz (2015). Pellet dimensions (length and diameter) were determined using a digital vernier caliper, following the method described by Abdollahi et al. (2013). The average values were then recorded.

Chemical quality parameters, including moisture, crude protein, amino acids (methionine + cystine, methionine, lysine, threonine, and arginine), crude fat, crude fiber, ash, and calcium, were determined using Near Infrared Spectroscopy (NIRS) with a FOSS NIR System 5000 spectrometer. Feed samples were first ground to pass through a 1-mm screen and then thoroughly homogenized. Approximately 50 g of each sample was placed into a clean quartz sample cup, ensuring the surface was leveled and free from air gaps. The instrument was pre-calibrated and standardized against a reference material provided by the manufacturer before each set of measurements. During spectral acquisition, samples were placed on the instrument's scanning window, and near-infrared spectra were recorded across a wavelength range of 1,100–2,500nm with a resolution of 2nm. The raw reflectance data were automatically processed by the system's software and matched with the reference calibration library for poultry feed materials. Each sample was measured twice and the averaged spectrum was used in subsequent statistical evaluations.

Data Analysis

Data on particle size distribution were summarized using descriptive measures, namely the mean and standard deviation. Treatment effects of the different particle size groups (coarse, medium, fine) were evaluated through a one-way analysis of variance (ANOVA) and pairwise comparisons among means were performed using Tukey's post-hoc test. Comparisons between mash and pellet feed within each particle size were performed using an independent samples t-test. Statistical analyses were conducted using IBM SPSS Statistics, Version 22.0.

RESULTS & DISCUSSION

Particle Size of Ground Corn

The evaluation of the particle size distribution of ground corn (Table 2) indicated that the most significant proportion was derived from the coarse fraction, with mesh sizes ranging from 10 to 2000µm accounting for an average of 49.83%, followed by the mesh size 12–1680µm fraction at 24.18%. In contrast, the medium-sized particles (mesh 20–30, <1000µm) and fine particles (mesh 40–100, <500µm) contributed only small proportions, ranging from 2.6–8.9% and 0.16–3.1%, respectively. Similar observations have been reported in previous studies where hammer mill processing generated a wide range of particle sizes, with a predominance of larger particles compared to more uniform distributions obtained from roller mills (Ibrahim et al., 2019). This finding suggests that hammer mill grinding tends to produce an uneven distribution dominated by larger particles.

The angle of repose exhibited an increasing trend as the particle size decreased. Coarse particles (mesh 10–2000µm) had an average angle of repose of 29.18°, whereas fine particles (mesh 100–149µm) reached as high as 45.77. This increase reflects better flowability in coarse particles, while finer particles showed reduced flowability and a higher tendency to bridge or aggregate during handling. According to standard classifications, angles below 30° represent excellent flow properties, while values exceeding 40° indicate poor flowability. Hence, the presence of excessive fine particles may compromise processing

Table 2: Particle Size Distribution, Angle of Repose, and Bulk Density of Ground Corn

Particle Size (mesh-µm)	Particle Size Distribution (%)		Angle of repose (°)		Bulk density (kg/m^3)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
10-2000	49.83	2.82	29.18	0.68	1028.54	12.07
12-1680	24.18	0.89	31.87	0.53	976.29	16.19
18-1000	4.03	0.32	33.75	0.48	875.45	13.94
20-841	8.89	1.40	35.59	0.46	825.73	13.10
26-707	2.64	1.95	37.38	0.34	770.65	14.31
30-595	2.96	0.78	38.81	0.40	726.37	12.43
40-420	3.10	1.70	40.77	0.32	670.81	15.40
50-297	2.93	1.13	42.70	0.42	627.11	15.97
60-250	1.27	0.69	43.96	0.33	571.41	14.30
100-149	0.16	0.05	45.77	0.53	524.40	13.40

efficiency during feed mixing and transport. The angle of repose increases significantly as particle size decreases, due to stronger interparticle cohesion among fine powders (Zegzulka et al., 2020; Shah et al., 2023). Additionally, discuss here the importance of the angle of repose in animal nutrition, citing the latest references. Similarly, discuss all parameters in their place.

Bulk density also demonstrated a consistent pattern with particle size, declining as particle size decreased. Coarse particles (mesh 10–2000μm) exhibited the highest bulk density at 1028.54kg/m^3, whereas the fine fraction (mesh 100–149μm) recorded the lowest value at 524.40kg/m^3. The reduction in bulk density among finer fractions is attributed to greater interparticle voids, resulting in a lower weight per unit volume. From a feed manufacturing perspective, this phenomenon has important implications for storage efficiency, formulation accuracy, and pellet durability. Similar associations have been reported in poultry feed technology research. Cheah et al. (2017) reported that the inclusion of synthetic emulsifiers or natural biosurfactants in corn–soy broiler diets significantly improved pellet quality (P<0.05) and starch gelatinization (P<0.0001), without adverse effects on rancidity indices or microbial stability.

In contrast, Pope et al. (2018) demonstrated that the fat application method influenced pellet durability and processing efficiency. Pellets with post-pellet liquid application of fat (PPLA) were more durable than those with mixer-added fat (MAF) (P<0.01), but required greater pelleting energy. Furthermore, diets containing 30% fines absorbed more liquid fat under PPLA, resulting in increased gross energy and improved broiler performance compared with MAF diets.

Managing physical parameters such as particle size distribution, angle of repose, and bulk density is essential for maintaining efficiency in feed mills (Mustakin et al., 2021). A well-adjusted particle size helps ensure smooth material flow and reduces the risk of bridging, thereby supporting reliable storage and transport. In contrast, excessively fine fractions tend to produce higher angles of repose, which can impair flowability and handling properties. The nutritional perspective further emphasizes that larger particle sizes during the starter phase improve broiler performance (Lemons et al., 2019), highlighting the dual relevance of particle size in both feed technology and animal performance. Processing conditions, such as expander use and fat application, have been shown to improve pellet durability and efficiency directly (Ebbing et al., 2022; Pope et al., 2018). From a nutritional perspective, finer particles can enhance nutrient availability but may also reduce gizzard stimulation and increase grinding costs, indicating a biological–technical trade-off (Zaefarian et al., 2016; Naeem et al., 2024). Collectively, these findings emphasize that optimizing particle size distribution is critical for balancing feed mill efficiency, pellet quality, and bird performance.

Physical and Chemical Quality of Mash Feed with Different Ground Corn Particle Sizes

The physical and chemical characteristics of mash feed with different ground corn particle sizes for native chickens are presented in Table 3. The angle of repose showed significant differences among treatments. P1 (36.56°) and P2 (36.83°) had similar values and were not significantly different from each other, whereas P3 (39.20°) was significantly higher (P<0.05). This indicates that fine particles reduce mash feed flowability, while coarse and medium particles maintain better flow properties.

Table 3: Physical Characteristics and Chemical Quality of Mash Feed with Different Ground Corn Particle Sizes for Native Chicken

Parameters	Ground Corn Particle Size Treatments		
	P1 Coarse (Mesh 10–18, ≥1000μm)	P2 Medium (Mesh 20–30, 500–<1000μm)	P3 Fine (Mesh 40–100, <500μm)
Physical Quality			
Angle of repose (°)	36.56^a	36.83^a	39.20^b
Bulk density (kg/m3)	646.21^a	495.18^a	486.53^b
Chemical Quality			
Moisture Content (%)	11.97	11.95	11.99
Crude protein (%)	16.28	16.77	16.99
Methionine+Cystine (%)	0.48	0.46	0.47
Methionine (%)	0.27	0.28	0.29
Lysine (%)	0.85	0.84	0.85
Threonine (%)	0.71	0.70	0.72
Arginine (%)	1.21	1.27	1.22
Crude fat (%)	4.36	4.65	4.94
Crude fiber (%)	3.47	4.15	4.44
Ash Content (%)	7.55	7.50	7.66
Calcium (%)	1.30	1.25	1.30
Phosphorus (%)	0.51	0.53	0.54

Bulk density also differed significantly among treatments. P1 (646.21kg/m^3) and P2 (495.18kg/m^3) did not differ significantly, but both were higher than P3 (486.53kg/m^3), which was significantly lower (P<0.001). These results suggest that finer particle sizes lead to lower bulk density, which may reduce storage efficiency and compromise feed formulation stability. In contrast, the chemical composition did not show significant differences among treatments. Moisture content (11.95–11.99%), crude protein (16.28–16.99%), methionine + cystine (0.46–0.48%), methionine (0.27–0.29%), lysine (0.84–0.85%), threonine (0.70–0.72%), and arginine (1.21–1.27%) remained stable across particle sizes. Crude fat and crude fiber tended to increase in finer particle sizes (4.94% and 4.44% in P3 compared to 4.36% and 3.47% in P1), but the differences were not statistically significant. Similarly, the contents of ash, calcium, and phosphorus were consistent across treatments.

The significant decrease in bulk density observed in the finely ground mash (P3: 486.5 kg/m^3) compared to the coarser treatments underscores critical challenges in feed manufacturing and logistics. Lower bulk density not only diminishes silo storage efficiency and complicates volumetric feed measurements but can also impair mixer homogeneity and pellet quality, consistent with findings by Saensukjaroenphon et al. (2022), who reported that corn particle size directly influences feed form and digestive organ development in broilers Additionally, Novotný et al. (2023) observed that coarse feed particles enhance gizzard development and intestinal morphology, promoting better nutrient absorption and gut health. In contrast, finer particles may limit this physiological function. In terms of nutrient utilization, Lee et al. (2024) demonstrated that reducing corn particle size improves energy digestibility. However, these gains must be weighed against the physical handling drawbacks of finer mash. Thus, while the chemical composition remains stable across treatments—a valuable finding in itself—the practical implication is clear: optimum corn particle sizing must strike a balance between enhancing feed digestibility and maintaining bulk density for effective processing, handling, and bird gut health.

Pellet Feed Properties Influenced by Ground Corn Particle Sizes

Table 4 summarizes the physical and chemical characteristics of pellet feed produced with varying ground corn particle sizes for native chickens. The angle of repose was recorded between 26.56° and 27.43°, with no significant differences observed among treatments. Similarly, bulk density values ranged from 713.10 to 729.45kg/m³ and were not significantly different across P1, P2, and P3. These results indicate that, in pellet form, corn particle size has a minimal influence on flowability or bulk density, likely because the pelleting process compresses the particles into a uniform structure. However, differences became evident when pellet quality parameters were considered. The Pellet Durability Index (PDI) for the medium-sized treatment (P2: 97.45%) and the coarse treatment (P1: 96.94%) did not differ significantly; however, both were higher than the fine treatment (P3: 95.90%), which was statistically lower ($P<0.001$). This outcome indicates that medium and coarse particle sizes enhance pellet durability, whereas fine particles tend to compromise pellet quality.

No significant differences were found in angle of repose or bulk density among treatments, indicating that the pelleting process reduces the variability commonly seen in mash feed by compacting particles into a uniform structure. Similar observations have been reported, showing that pelleting often masks the effect of ingredient particle size on bulk density and flowability (Abadi et al., 2019). In contrast, the lower PDI in the finely ground corn treatment (P3: 95.90%) demonstrates that excessive grinding can weaken pellet durability. Very fine particles tend to disrupt bonding during compression, leading to more fines and reduced strength, whereas medium and coarse fractions allow stronger interlocking of particles and better pellet integrity (Kiarie & Mills, 2019). Overall, these results emphasize that while pelleting can standardize certain physical traits, careful selection of corn particle size remains essential to maintain pellet durability and minimize fines, both of which directly affect feed mill efficiency and bird performance.

Differences were also observed in pellet hardness. The coarse (P1: 2.63kgf) produced significantly more problematic pellets than the fine (P3: 2.59kgf), while the medium (P2: 2.56kgf) yielded intermediate values that were not statistically different from either group. These results indicate that coarse particles contribute to greater compactness, while medium particles have an intermediate effect. A similar trend was seen for fines percentage: P1 (0.11%) and P2 (0.12%) were comparable, but both were lower than P3 (0.14%). The greater proportion of fines in the fine-particle group aligns with its lower PDI, confirming that very fine particles produce more fragile pellets. In contrast, pellet length and diameter remained stable across treatments, suggesting that particle size did not influence pellet dimensions.

Table 4: Physical and Chemical Characteristics of Pellet Feed with Different Ground Corn Particle Sizes

Parameters	Ground Corn Particle Size Treatments		
	P1 Coarse (Mesh 10–18, ≥1000µm)	P2 Medium (Mesh 20–30, 500–<1000µm)	P3 Fine (Mesh 40–100, <500µm)
Physical Quality			
Angle of repose (°)	26.56	26.83	27.43
Bulk density (kg/m3)	713.10	727.29	729.45
Pellet Durability Index (%)	96.94[a]	97.45[a]	95.90[b]
Pellet Hardness (kgf)	2.63[a]	2.56[ab]	2.59[b]
Fines Percentage (%)	0.11[a]	0.12[ab]	0.14[b]
Pellet Length (mm)	7.06	7.05	6.94
Pellet Diameter (mm)	3.51	3.49	3.48
Chemical Quality			
Moisture Content (%)	8.55	8.79	8.26
Crude protein (%)	16.38	16.63	16.71
Methionine+Cystine (%)	0.46	0.47	0.45
Methionine (%)	0.29	0.29	0.28
Lysine (%)	0.84	0.82	0.84
Threonine (%)	0.75	0.73	0.75
Arginine (%)	1.34	1.35	1.31
Crude fat (%)	4.34	4.42	4.47
Crude fiber (%)	3.52	4.66	4.51
Ash Content (%)	7.56	7.65	7.76
Calcium (%)	1.28	1.27	1.24
Phosphorus (%)	0.52	0.51	0.50

The higher pellet hardness in coarse particles can be attributed to stronger mechanical binding, as larger particles interlock more effectively during the compression process. This mechanism also helps explain the lower fines observed. By contrast, excessive fine grinding reduces structural integrity by limiting particle interlocking, which increases fracture risk and fines production (Niu et al., 2023). The association between higher fines and lower PDI in the fine-particle group further confirms that particle size distribution is a critical factor for pellet durability. Pellet dimensions, however, were not affected, aligning with earlier findings that die characteristics and conditioning conditions exert more influence on pellet size than ingredient particle size (Abdollahi et al., 2014). Thus, while pellet dimensions remain stable, particle size plays a critical role in defining pellet robustness, with coarse to medium particles offering a balance between hardness, durability, and reduced fines.

The chemical composition of pellet feed did not differ significantly among treatments. Moisture content (8.26–8.79%), crude protein (16.38–16.71%) and essential amino acids such as methionine, lysine, threonine, and arginine remained relatively stable across particle sizes. Crude fat, crude fiber, ash, calcium, and phosphorus exhibited minor variations; however, none of these differences were statistically significant. Likewise, no treatment effects were observed for crude protein, amino acids, minerals, or moisture, indicating that the chemical composition of the pellets remained stable across particle sizes. This finding is consistent with previous reports, which have shown that particle size reduction and pelleting primarily affect physical quality and nutrient utilization, rather than altering nutrient concentration (Niu et al., 2023; Dhakal et al., 2024; Rueda et al., 2024). Among the treatments, P2 provided the best balance, producing pellets with high durability and low fines, while P3 tended to reduce physical pellet quality without altering nutrient composition.

Comparison of Mash and Pellet Feed at Different Ground Corn Particle Sizes

The independent samples t-test results for mash and pellet feed with coarse, medium, and fine ground corn particle sizes revealed a consistent pattern (Table 5). Physical parameters, such as angle of repose, bulk density, and moisture content, differed significantly between mash and pellet feed ($P < 0.001$). Mash feed consistently showed a higher angle of repose, indicating poorer flowability, whereas pellet feed exhibited lower values, reflecting improved handling properties. Bulk density was consistently lower in mash than in pellets, reflecting the compaction that occurs during pelleting and the resulting increase in weight per unit volume. In contrast, mash diets retained more moisture than pellets, which is reasonable given that the pelleting process applies heat and pressure that drive off water.

Comparisons of mash and pelleted diets generally reveal negligible differences in their proximate composition, including crude protein, fat, fiber, and ash, as well as in mineral concentrations such as calcium and phosphorus. Likewise, the levels of key amino acids (e.g., methionine, lysine, threonine, arginine) tend to remain consistent across feed forms. Although pellets sometimes show marginally higher protein values, while mash may display slightly elevated methionine + cystine or moisture, such deviations are not statistically significant. Thus, the pelleting process primarily enhances physical attributes of the feed rather than altering its nutrient composition (Vargas et al., 2023).

The comparable outcomes observed across coarse, medium, and fine corn particle sizes suggest that feed form (pellet vs. mash) has a more substantial influence on physical quality than particle size alone. Pelleted diets generally exhibit superior flowability, bulk density, and physical stability compared to mash, while their proximate composition remains unchanged mainly (Mustakin et al., 2021; Vargas et al., 2023; Svihus et al., 2024). Collectively, these findings emphasize that pelleting primarily modifies physical traits without substantially altering the chemical profile of the feed.

Conclusion

This study demonstrated that both corn particle size and feed form significantly influenced the physical characteristics of the native chicken diets, whereas the chemical composition remained stable across the treatments. As the particle size decreased from coarse to fine, the angle of repose increased from 29.18° to 45.77°, whereas the bulk density decreased from 1028.54 to 524.40kg/m^3, indicating reduced flowability and storage efficiency. In mash diets, fine particles further impaired physical properties, but the proximate composition (CP, EE, CF, ash, Ca, P, and amino acids) did not differ significantly ($p > 0.05$).

For pelleted feeds, the particle size determined the physical quality. Medium particles produced the most favorable results, with the highest pellet durability index (PDI, 97.45%), pellet hardness (2.56 kgf), and the lowest fines percentage (0.12%). In comparison, coarse particles increased hardness (2.63kgf) but reduced PDI, whereas fine particles increased fines (0.14%) and reduced durability. Across all particle sizes, pellets outperformed mash with lower angles of repose (26.56–27.43° vs. 36.56–39.20°), higher bulk density (713.10–729.45 vs. 486.53–646.21kg/m^3), and reduced moisture content, reflecting consistent improvements in physical quality.

Table 5: Independent Samples t-test Results of Mash and Pellet Feed on Physical and Chemical Parameters at Different Ground Corn Particle Sizes

Parameter	Coarse Ground Corn Particle Size					Medium Ground Corn Particle Size					Fine Ground Corn Particle Size				
	Feed Form	Mean	SD	t-value	Sig.(p)	Feed Form	Mean	SD	t-value	Sig.(p)	Feed Form	Mean	SD	t-value	Sig.(p)
Angle of repose (°)	Mash	36.56	0.79	28.27	.001	Mash	36.83	0.57	39.42	0.001	Mash	39.20	1.09	20.16	0.001
	Pellet	26.56	0.79			Pellet	26.83	0.57			Pellet	27.43	1.49		
Bulk density (kg/m^3)	Mash	646.21	11.35	-7.88	.001	Mash	495.18	19.84	-34.18	0.001	Mash	486.53	17.46	-39.94	0.001
	Pellet	713.10	24.33			Pellet	727.29	8.22			Pellet	729.45	8.07		
Moisture Content (%)	Mash	11.45	0.16	5.91	.001	Mash	11.95	0.06	7.49	0.001	Mash	11.99	0.08	7.09	0.001
	Pellet	8.56	1.54			Pellet	7.80	1.75			Pellet	8.26	1.66		
Crude protein (%)	Mash	15.28	0.52	-0.45	.662	Mash	16.77	0.28	0.93	0.367	Mash	16.98	1.48	-1.51	0.149
	Pellet	15.38	0.53			Pellet	16.63	0.36			Pellet	17.72	0.39		
Crude fat (%)	Mash	4.36	0.15	0.22	.830	Mash	4.65	0.08	0.97	0.346	Mash	4.95	0.05	1.62	0.122
	Pellet	4.35	0.10			Pellet	4.63	0.05			Pellet	4.79	0.30		
Crude fiber (%)	Mash	3.47	0.18	-0.62	.541	Mash	4.15	0.56	-0.78	0.447	Mash	4.45	0.20	-0.78	0.446
	Pellet	3.52	0.17			Pellet	4.36	0.66			Pellet	4.51	0.19		
Ash Content (%)	Mash	7.55	0.16	-0.13	.895	Mash	7.51	0.25	-1.46	0.161	Mash	7.66	0.22	-1.14	0.269
	Pellet	7.56	0.17			Pellet	7.66	0.22			Pellet	7.76	0.15		
Methionine+Cystine (%)	Mash	0.48	0.01	1.77	.095	Mash	0.46	0.01	-1.29	0.213	Mash	0.48	0.01	1.37	0.189
	Pellet	0.46	0.03			Pellet	0.47	0.01			Pellet	0.46	0.04		
Methionine (%)	Mash	0.28	0.06	-0.69	.496	Mash	0.28	0.04	-0.55	0.592	Mash	0.30	0.05	1.62	0.122
	Pellet	0.29	0.04			Pellet	0.30	0.05			Pellet	0.27	0.04		
Lysine (%)	Mash	0.85	0.03	0.27	.789	Mash	0.85	0.02	1.49	0.154	Mash	0.86	0.05	1.49	0.153
	Pellet	0.85	0.04			Pellet	0.83	0.04			Pellet	0.82	0.04		
Threonine (%)	Mash	0.71	0.06	-1.89	.075	Mash	0.71	0.03	-1.33	0.199	Mash	0.72	0.08	-0.77	0.453
	Pellet	0.76	0.06			Pellet	0.74	0.07			Pellet	0.75	0.09		
Arginine (%)	Mash	1.31	0.35	-0.20	.846	Mash	1.27	0.27	-0.93	0.362	Mash	1.22	0.11	-1.70	0.107
	Pellet	1.34	0.33			Pellet	1.40	0.35			Pellet	1.31	0.13		
Calcium (%)	Mash	1.30	0.10	0.58	.568	Mash	1.25	0.05	-1.00	0.329	Mash	1.30	0.10	-0.58	0.570
	Pellet	1.28	0.04			Pellet	1.28	0.05			Pellet	1.34	0.19		
Phosphorus (%)	Mash	0.51	0.07	-0.68	.508	Mash	0.54	0.08	0.73	0.477	Mash	0.54	0.05	1.53	0.144
	Pellet	0.53	0.06			Pellet	0.51	0.06			Pellet	0.50	0.07		

In conclusion, pelleting reliably enhanced feed physical traits without altering nutrient composition, with the medium particle size providing the best overall balance of durability, hardness, and fines. Practically, pelleting represents an effective strategy to improve feed handling, storage, and efficiency in native chicken diets without compromising their nutritional value. Future studies should evaluate the effects of these additives on feed intake, digestibility, and production performance.

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REFERENCES

Abadi, M., Moravej, H., Shivazad, M., Karimi Torshizi, M.A., & Kim, W.K. (2019). Effects of feed form and particle size, and pellet binder on performance, digestive tract parameters, intestinal morphology, and cecal microflora populations in broilers. *Poultry Science*, *98*(3), 1432–1440. https://doi.org/10.3382/ps/pey488

Abdollahi, M.R., Ravindran, V., & Svihus, B. (2014). Influence of feed form on growth performance, ileal nutrient digestibility, and energy utilisation in broiler starters fed a sorghum-based diet. *Livestock Science*, *165*, 80–86. https://doi.org/10.1016/j.livsci.2014.04.002

Abdollahi, M.R., Ravindran, V., Wester, T.J., Ravindran, G., & Thomas, D.V. (2013). Influence of pellet diameter and length on the quality of pellets and performance, nutrient utilisation and digestive tract development of broilers fed on wheat-based diets. *British Poultry Science, 54*(3), 337–345. https://doi.org/10.1080/00071668.2013.780285

American Society of Agricultural and Biological Engineers (ASABE) (2023). Method of determining and expressing fineness of feed materials by sieving (ANSI/ASAE S319.5). ASABE. https://webstore.ansi.org/standards/asabe/ansiasaes319aug2023

Ariyanto, Y., Mubarokah, M., & Hendrarini, H. (2023). Analysis of corn Supply in Indonesia. *Journal of Economics, Finance and Management*, *06*(07). https://doi.org/10.47191/jefms/v6-i7-45

Bozkurt, M., Koçer, B., Ege, G., Tüzün, A.E., Bıyık, H.H., & Poyrazoğlu, E. (2019). Influence of the particle size and form of feed on growth performance, digestive tract traits and nutrient digestibility of white egg-laying pullets from 1 to 112 D of age. *Poultry Science*, *98*(9), 4016–4029. https://doi.org/10.3382/ps/pez144

Cheah, Y., Loh, T., Akit, H., & Kimkool, S. (2017). Effect of Synthetic Emulsifier and Natural Biosurfactant on Feed Process and Quality of Pelletized Feed in Broiler Diet. *Revista Brasileira de Ciência Avícola*, *19*(spe), 23–34. https://doi.org/10.1590/1806-9061-2016-0228

Cowieson, A.J. (2005). Factors that affect the nutritional value of maize for broilers. *Animal Feed Science and Technology*, *119*(3–4), 293–305. https://doi.org/10.1016/j.anifeedsci.2004.12.017

Dhakal, S., Hetland, H., & Svihus, B. (2024). Effect of grinding method and extent of pelleting of broiler diets on performance, feeding behaviour and digestive tract functionality. *British Poultry Science*, *66*(2), 227–237. https://doi.org/10.1080/00071668.2024.2405208

Ebbing, M.A., Yacoubi, N., Naranjo, V., Sitzmann, W., & Gierus, M. (2022). Influence of Expander Conditioning Prior to Pelleting on Pellet Quality, Broiler Digestibility and Performance at Constant Amino Acids Composition while Decreasing AME(N). *Animals: An Open Access Journal from MDPI*, *12*(22). https://doi.org/10.3390/ani12223126

Fajar, A., Latief, M.F., & Syamsu, J. A. (2021). The assessment of corn quality as feed ingredients received at an animal feed mill. *Journal of Research in Agriculture and Animal Science*, *8*(8), 32–37.

Ghasemi-Aghgonbad, A., Olyayee, M., Janmohammadi, H., Abdollahi, M.R., & Kianfar, R. (2024). The interactive impacts of corn particle size and conditioning temperature on performance, carcass traits, and intestinal morphology of broiler chickens. *Animals*, *14*(5). https://doi.org/10.3390/ani14050818

Ibrahim, M., Omran, M., & EL-Rhman, E.A. (2019). Design and evaluation of Crushing Hammer Mill. *Misr Journal of Agricultural Engineering*, *36*(1), 1–24. https://doi.org/10.21608/mjae.2019.94437

Kiarie, E.G., & Mills, A. (2019). Role of Feed Processing on Gut Health and Function in Pigs and Poultry: Conundrum of Optimal Particle Size and Hydrothermal Regimens. *Frontiers in Veterinary Science*, *6*, 19. https://doi.org/10.3389/fvets.2019.00019

Lee, S.A., Rodriguez, D.A., Paulk, C.B., & Stein, H.H. (2024). Pelleting and particle size reduction of corn increase net energy and digestibility of fiber, protein, and fat in corn-soybean meal diets fed to group-housed pigs. *Journal of Animal Science and Biotechnology*, *15*(1), 52. https://doi.org/10.1186/s40104-024-01004-9

Lemons, M.E., McDaniel, Christopher, D., Moritz, Joseph, S., & Wamsley, K.G.S. (2019). Increasing Average Feed Particle Size During the Starter Period Maximizes Ross × Ross 708 Male Broiler Performance. *Journal of Applied Poultry Research*, *28*(2), 420–434. https://doi.org/10.3382/japr/pfz004

Melo-Durán, D., Perez, J.F., González-Ortiz, G., Villagómez-Estrada, S., Bedford, M.R., Graham, H., & Sola-Oriol, D. (2021). Growth performance and total tract digestibility in broiler chickens fed different corn hybrids. *Poultry Science*, *100*(8), 101218. https://doi.org/10.1016/j.psj.2021.101218

Mustakin, Purwanti, S., & Syamsu, J.A. (2021). Particle size and physical characteristic of corn milling results using hammer mill as poultry feed ingredients. *World Journal of Advanced Research and Reviews*, *11*(2), 298–302. https://doi.org/10.30574/wjarr.2021.11.2.0401

Naeem, M., Burton, E.J., Scholey, D.V., Alkhtib, A., & Broadberry, S. (2024). Efficacy of maize differing in particle size in low-density protein diets fed to broilers from day 1 to 21 of age. *British Poultry Science*, *65*(5), 615–624. https://doi.org/10.1080/00071668.2024.2356655

Niu, G., Zhang, T., Cao, S., Zhang, X., & Tao, L. (2023). Effect of Corn Grinding Methods and Particle Size on the Nutrient Digestibility of Chahua Chickens. *Animals*, *13*(14), 2364. https://doi.org/10.3390/ani13142364

Novotný, J., Horáková, L., Řiháček, M., Zálešáková, D., Šťastník, O., Mrkvicová, E., Kumbár, V., & Pavlata, L. (2023). Effect of Different Feed Particle Size on Gastrointestinal Tract Morphology, Ileal Digesta Viscosity, and Blood

Biochemical Parameters as Markers of Health Status in Broiler Chickens. *Animals*, *13*(15), 2532. https://doi.org/10.3390/ani13152532

Pope, J.T., Brake, J., & Fahrenholz, A.C. (2018). Post-pellet liquid application fat disproportionately coats fines and affects mixed-sex broiler live performance from 16 to 42 d of age. *Journal of Applied Poultry Research*, *27*(1), 124–131. https://doi.org/10.3382/japr/pfx054

Rueda, M.S., Bonilla, S., de Souza, C., Starkey, J.D., Starkey, C.W., Mejia, L., & Pacheco, W.J. (2024). Evaluation of particle size and feed form on performance, carcass characteristics, nutrient digestibility, and gastrointestinal tract development of broilers at 39 d of age. *Poultry Science*, *103*(3), 103437. https://doi.org/10.1016/j.psj.2024.103437

Saensukjaroenphon, M., Evans, C.E., Jones, C.K., Stark, C.R., & Paulk, C.B. (2022). Effect of feed form, corn particle size, and extrusion of corn on broiler performance. *Kansas Agricultural Experiment Station Research Reports*, *8*(11). https://doi.org/10.4148/2378-5977.8404

Shah, D.S., Moravkar, K.K., Jha, D.K., Lonkar, V., Amin, P.D., & Chalikwar, S.S. (2023). A concise summary of powder processing methodologies for flow enhancement. *Heliyon*, *9*(6), e16498. https://doi.org/10.1016/j.heliyon.2023.e16498

Stark, C.R., & Fahrenholz, A. (2015). *Evaluating pellet quality (MF3228)*. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. Retrieved from https://bookstore.ksre.ksu.edu/pubs/MF3228.pdf

Svihus, B., Storkås, C.G., Neteland, M.K., Reierstad, S.E.O., Dhakal, S., & Hetland, H. (2024). Effect of grinding and pellet dimensions on performance, digestive tract functionality and feeding behavior of broiler chickens fed diets based on wheat and maize. *Journal of Applied Poultry Research*, *33*(2), 100413. https://doi.org/10.1016/j.japr.2024.100413

Syamsu, J.A., Yusuf, M., & Abdullah, A. (2015). Evaluation of Physical Properties of Feedstuffs in Supporting the Development of Feed Mill at Farmers Group Scale. *Journal of Advanced Agricultural Technologies*, *2*(2). https://doi.org/10.12720/joaat.2.2.147-150

Vargas, J.I., Gulizia, J.P., Bonilla, S.M., Sasia, S., & Pacheco, W.J. (2023). Effect of corn origin on broiler performance, processing yield, and nutrient Digestibility from 1 to 35 Days of age. *Animals, 13*(7), 1248. https://doi.org/10.3390/ani13071248

Zaefarian, F., Abdollahi, M.R., & Ravindran, V. (2016). Particle size and feed form in broiler diets: Impact on gastrointestinal tract development and gut health. *World's Poultry Science Journal*, *72*(2), 277–290. https://doi.org/10.1017/s0043933916000222

Zegzulka, J., Gelnar, D., Jezerska, L., Prokes, R., & Rozbroj, J. (2020). Characterization and flowability methods for metal powders. *Scientific Reports*, *10*(1), 21004. https://doi.org/10.1038/s41598-020-77974-3