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Pellet Versus Marsh: Assessing the Impact of Feed Forms on Growth Performance, Nutrient Digestibility, Carcass Characteristics and Health of Broiler Chickens – A Review

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Abstract
The desire of every broiler farmer is to produce birds with fast growth rate and good weight for both marketing and consumption. This objective can only be achieved under a good feeding regime. The physical form of the feed offered is therefore a critical factor in achieving this goal. Commercial or on-farm feed for poultry are usually presented in the form of pellets, mash or crumble feed. There exists an abundance of published data supporting the superiority of pelleted diets over mash diets. This has been variously observed in the ability of pelleted diets to improve growth rate, FCR, feed intake and dressing percentages of broilers. The quality of pellet offered constitutes a major factor in ensuring improved productivity. Although mash diet is cheaper to produce, studies have shown that it is often not too palatable to broiler birds when compared with pellets. The choice of the type of feed to be adopted therefore depends on the production objectives of the farmer and the prevailing economic conditions. Cost effective pelleting and improvement in pellet quality can therefore offer a viable means for a wholesome broiler production especially in developing countries.

Key words: broilers, pellets, mash, feed form, productivity

Introduction
Feed constitute a major aspect of the broiler industry and feed cost accounts for about 70% of the entire cost of production (Behnke and Beyer, 2002). The forms in which these feed are prepared and offered to birds could impact observable effects on their productive performances (Amerah *et al.,* 2007a; Jafarnejad *et al.,* 2010). Consequently, different feed forms (pellets, mash etc.) have been developed for feeding these birds (Abdullahi *et al.,* 2011). Mash is a complete feed in which the constituent ingredients have been finely ground and mixed together so that birds cannot separate out ingredients. Pellets on the other hand is a form of feed obtained by mechanically compressing mash feed to form a harder dry form that looks like "artificial grains".

Better growth performances have also been attributed to the pe'llet form of feed than with the mash feed (Amerah *et al.,* 2008; Chewning *et al.*, 2012). Feeding pellets to broilers was also reported to improve metabolizabilty of organic matter compared with the mash form of feed (Zelenka, 2003; Svihus *et al.,* 2004). Jahan *et al.* (2006) reported that feeding ground feed to broilers is not palatable because it does not retain its nutritive value as the unground form. Although pelleting reduces feed and energy wastage during consumption (Mateos *et al.,* 2002; Lv *et al.,* 2015), it is more expensive to produce compared to mash feeds (Asha-Rajini *et al.,* 1998; Naderinjad *et al.,* 2016). Pelleting has also been shown to improve organ and carcass characteristics (Fasuyi and Arire, 2015) and enhance the quality of feed (Lahaye *et al.,* 2004) leading to better economic returns for farmers (Lilly *et al.,* 2011; Fasuyi and Odunayo, 2015).

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The choice of feed form largely depends on the production objectives of the farmer and the economic conditions prevalent during the production cycle. The objective of this review therefore was to compare the impact of pellet and mash forms of feed on the productive performance, nutrient digestibility, carcass characteristics and health of broilers.

Nutrition in Poultry

Nutrition constitutes a large chunk of the total cost outlay in a typical poultry set up (Moosavi *et al.,* 2011). Access to feed especially in the early phase of the life of birds is very important in ensuring optimum growth performance (El- Husseiny *et al.,* 2008; Batal and Parsons, 2002), health (Panda *et al.*, 2015; Kadam *et al*., 2009) and development of the gastrointestinal tract (Sklan and Noy, 2000; Sklan, 2001). As birds get older the pace of nutritional regime initiated during their early life ensures their overall productivity in the latter phase of development (Buteri *et al.,* 2009; Hervatovic *et al.,* 2015). Remarkable changes in the trends of poultry nutrition have been made over the last 100 years and these changes have been projected to be a continuous phenomenon (Elwinger *et al.,* 2016). These changes may have led to a growing use of unconventional feed resources as a means of minimizing production costs and boosting productivity in poultry (Kadam *et al.,* 2009; Fasuyi and Aletor, 2005; Ibeawuchi *et al.,*2007; Sanda and Abu, 2015). The use of synthetic additives and supplements with growth promoting properties has also been established (Akinleye *et al.,* 2008; Chowdhury *et al.,* 2009; Huyghebaert *et al.,* 2011; Mahima *et al.,* 2012). The use of organic growth promotants has also been reported (Attia *et al.*, 2016; Sethiya, 2016). Severity of certain diseases has been controlled through adoption of certain nutritional methods (Bennette *et al.,* 2002; Swiatkiewicz *et al.,* 2016).

Feed offered to birds comes in various shapes, forms and sizes. They could be in crushed coarse forms (Amerah *et al.,* 2008), finely ground (Svihus *et al.,* 2002; Kilburn and Edward, 2004; Naderinjad *et al.,* 2015) or whole grains (Cumming, 1994; Plavnik *et al.,* 2002). There is, however, a wider acceptability for three main feed forms in poultry namely: pellets, mash and crumbled feed (Jahan *et al.,* 2006; Abdullahi *et al.,* 2011). Pellet is a complete feed that is compacted and extruded to a diameter of about 1/8 inch and a length of ¼ inch (Banerjee, 1988). Mash diet is a form of feed that is finely ground and mixed so that birds cannot easily separate out ingredients; each mouthful provides a well-balanced diet. The Crumbled feed is a feed prepared by pelleting mixed ingredients and crushing the pellets to a consistency coarser than mash.

Impact of feed forms (pellet versus mash) on performance of broilers

The impacts of feed form on performance parameters have been variously reported. Xu *et al.* (2015) reported that pelleted feed produced a more consistent feed intake and reduced selective feeding in broilers than the mash form of feed. Similarly, improved feed intake, body weight and feed conversion ratio (FCR) were reported for birds fed pelleted feed compared with mash feed (Amornthewaphat *et al.*, 2005; Chewning *et al.,* 2012). With an increase in the protein content of pelleted feed, body weight and FCR were equally improved in broilers from 1-21 days compared to birds fed mash feed (Jafarnejad *et al.,* 2010). Conversely, a study by McAllister *et al.* (2000) showed that there was no significant difference in weight gain for broilers fed both the pellet and the mash forms of feed. According to a study by Lilly *et al.* (2011) which recognized three broiler sex groups (the male, the female and the equal male to female groups), pelleting

revealed that the female broilers showed the greatest uniformity, the males showed intermediate uniformity, better FCR and body weight while the equal male to female group showed the least uniformity when compared with mash diet. Although broilers fed pelleted feed have been reported to show increased feed intake, there exist a correlation between intake of pellets and the occurrence of certain metabolic diseases like ascites than with intake of mash feed (Arce-Menocal *et al.,* 2009; Ghazi *et al.*, 2012). Feeding of the mash feed on the other hand have been reported to slow down growth rate but reduced mortality caused by sudden death syndrome and ascites (Bennette *et al.,* 2002). Furthermore, improved growth performances have been reported with pellet feed than with mash (Serrano, *et al.,* 2013; Fasuyi and Odunayo, 2015). In contrast to the mash form of feed, pelleting offers a suitable nutritional strategy to boost productive performance in broilers especially those reared under high ambient temperatures (Hosseini and Afshar, 2017). In seeking to improve the efficiency of pelleting, supplementation of pelleted feed with enzymes and probiotics is a viable strategy that has been linked with improved growth performance and immunity of broilers compared with a mash diet without these additives (Hosseini *et al.,* 2017).

The heating (temperature) procedure adopted during feed preparation has also been reported to produce effects on the performance of broilers. According to Amerah *et al.* (2013), feed pelleted at a temperature of 85^0C reduced weight gain in broilers compared to those fed diet pelleted at 75^0C or 90^0C. Also, broiler chicks fed high temperature pellet diets had decreased feed intake and feed conversion ratio compared to broilers fed low temperature pellet (Cutlip *et al.*, 2008). This may not be unconnected with the fact that extremes of temperatures destroy certain feed nutrients and make them unavailable to the animal for utilization. Increased pelleting temperatures have also been reported to greatly affect the protein profiles of feed without affecting the carbohydrate profiles (Huang *et al.*, 2015).

Table 1: Average weight gain of broilers fed mash, pellet and crumble (g/bird/week)

Treatment	1 week	2 week	3 week	4 week	5 week	6 week
T1: mash	65.5±6.67[a]	129±12.35[a]	271.5±13.3[b]	399.5±28.94[b]	60.3±52.26[a]	478±62.59[a]
T2: crumble	68.5±11.56[a]	151±18.673[a]	364.5±24.29[a]	373±14.765[b]	658.75±145.2[a]	577.25±154.91[a]
T3: Pellet	76.75±6.69[a]	162.5±5.68[a]	374.5±50.88[a]	475.75±30.237[a]	538.25±32.66[a]	543±45.37[a]

a,b,c showed that there was significant difference between groups
Source: Chehraghi *et al.* (2013)

The study by Chehraghi *et al.* (2013) as indicated on Table 1, showed that there were significant differences in average weight gain in the broiler chickens fed mash diets from weeks 1 to 5. However, the pellet form of diets did not cause any significant influence on the average weight gain as the values obtained were statistically alike. Several studies have observed the capacity of pelleted feeds to influence weight gain. This perhaps could be due to the fact that there is better aggregation of feed nutrients in pelleted diets than in mash diets, although a few studies have proven otherwise. The better aggregation of these feed nutrients discourages selective feeding and promotes more uniform feed consumption (Xu et al., 2015) thereby leading to better weight gain.

Impact of feed forms (Pellet versus Mash) on Nutrient Digestibility

Usually, grains which are the major constituents of feed are crushed into smaller sizes and mixed with other constituent ingredients before being offered to birds. Coarse grinding results in increased gut motility and greater digestion of nutrients (Amerah *et al.,* 2007b). The above authors further reported that finer grinding which is thought to improve pellet quality is disadvantageous as it increases energy consumption during milling. According to Zelenka (2003), pelleting increased apparent digestibility of organic nutrients, improved percentages of metabolizable energy and nitrogen-corrected apparent metabolizable energy than mash diet. Similarly, Zang *et al.* (2009) reported that broilers fed pelleted feed had improved nutrient metabolizabilty and digestive tract development compared with those fed mash feed. Also, when feed (pellet and mash) were subjected to varying steam conditioning temperatures, pelleted feed reduced the Coefficient of Ileal Apparent Digestibility (CIAD) of nitrogen than the mash which improved Coefficient of Ileal Apparent Digestibility (CIAD) of starch (Abdollahi *et al.,* 2011). Another study by Abdollahi *et al.* (2014) showed that pelleting also reduced starch digestibility, CAID of fat and Ca but had no effect on the CAID of P. However, there is reduced incidence of nutrient segregation with pelleting thereby leading to greater retention of nutrients than with a mash diet (Schleideler, 1999). With xylanase enzyme supplementation, broilers fed mash diet produced lower values of ileal digestibility of nutrients compared with broilers fed pelleted feed which showed improved ileal nutrient digestibility and improved morphometric indices of the jejunum (Hosseini and Afshar, 2017). Furthermore, digestive enzymes such as amylase, lipase and chemotrypsin have been reported to produce greater activity in broilers fed mash than in those fed pelleted feed (Serrano *et al.,* 2013).

Impact of feed forms (Pellet versus Mash) on Organs and Carcass Characteristics

The impact of feed form on carcass parameters has been variously studied. According to Razaeipour and Gezani (2014), the relative weights of liver for birds fed pellets were greater than in birds fed mash but the relative weight of the gizzard was greater in birds fed mash feed than in birds fed pellets. The reduced weight of the gizzard in broilers fed pelleted diets may be an indication that pelleting decreases the grinding requirements of the gizzard thereby reducing its function to merely that of transit, hence its reduced weight (Razaeipour and Gezani, 2014; Amerah *et al.,* 2008; Nir *et al.,* 1995). Similarly, Attia *et al.* (2014) reported that pelleted diet decreased the relative weight of gizzard and caecum length of broilers compared with mash diet but no effect of feed form (pellet or mash) was observed on other carcass traits and physical characteristics of meat. The study by Attia and colleagues further revealed that broilers fed with pellets had increased deposits of abdominal fat and meat fat in contrast to those fed with mash diet which had decreased abdominal fat content and meat moisture. With Bioenzyme supplementation on pellet and mash diets, Sevastani *et al.* (2006) showed that broilers fed pellet diet had significantly greater breast weight, thigh, abdominal fat, heart and liver weights compared with broilers fed mash diet. Also, by progressively increasing the quality of pellet and mash diets, it was reported that birds fed pelleted diet showed higher carcass weight, back-half fat, abdominal fat and higher breast meat yield compared with those fed mash diet (Corzo *et al.,* 2011). Mirghelenj and Golian (2009) also showed that gizzard and caeca weights expressed as a percentage of the body weights were heavier in birds fed mash diets than in those fed pellets. The study further showed that carcass

yield, breast, thigh, liver, heart, pancreas and abdominal fat expressed as a percentage of the body weight were unaffected by the physical forms of diet (pellet and mash). However, Lv *et al.* (2015) reported that neither pelleted nor the mash form of feed produced any marked effect on carcass yield. Other studies have also reported interactions between feed form (pellet, mash) and particle size without corresponding influences on dressing percentages (Ebrahimi *et al.,* 2010; Sogunle *et al.,* 2013; Lv *et al.,* 2015). Larger particle size of corn was however reported to increase gizzard weight but without consistent on growth performance parameters (Jacobs *et al.,* 2010).

Table 2: Effect of feed forms and restriction periods on the growth performance and Apparent Nutrient Digestibility of broiler starter chickens

Parameters	Mash	Pellet	SEM	p-Value
Growth performance				
Initial body weight (g/b)	72.1	76.1	1.84	0.09
Final body weight (g/b)	1324	1337	0.15	0.09
Average daily feed intake (g/b)	87.07	90.01	1.04	0.31
Average daily weight gain (g/b)	44.61	45.09	0.10	0.92
Feed Conversion Ratio	1.91[b]	2.00[a]	2.75	0.01
Protein Efficiency Ratio	7.95[b]	8.83[a]	2.74	0.02
Water intake (ml/b/d)	22.30[b]	24.40[a]	16.30	0.12
Apparent Nutrient Digestibility				
Dry matter	82.00	81.20	0.37	0.72
Crude protein (%)	83.40	82.20	0.86	0.40
Crude fibre (%)	90.10	89.00	0.99	0.34
Ether extract (%)	91.60	90.80	0.88	0.39
Ash (%)	63.20	70.70	1.91	0.07
Carbohydrate (%)	82.30	82.90	0.30	0.77

a, b, : Means with different superscript letters on the same row differs significantly ($p<0.05$)
Source: Olukotun and Dairo (2020).

The authors in the study reported in Table 2 showed that there were no significant ($P>0.05$) differences of feed forms (pellet or mash) on the digestibility of dry matter, crude protein, crude fibre, ether extract, ash and carbohydrates of the broiler chicks at the starter phase. However, the values reported for broiler chicks fed the mash diet were better for dry matter, crude protein, crude fibre and ether extract compared to those fed on the pelleted diets. This could be due to the fact that the mash diets provided a better surface area for absorption in the GIT of the chicks relative to the pelleted feed.

Impact of Feed Form (Pellet versus Mash) on Broiler Chickens Health

Several species of bacteria were reported to inhabit the intestinal tract of broiler chickens (Zhu *et al.,* 2002). Among these, the beneficial microflora which inhabit the GIT of birds are considered to be advantageous as an increase in their population serves to ward off the effect of other bacteria by preventing potentially pathogenic bacteria from entering the intestinal tract (Engberg *et al.,* 2004). The beneficial bacteria such as the *Lactobacilli* and *Bifidobacteria* strains possess antimicrobial activity (Servin, 2004). They have equally been reported to establish defence mechanisms that protect the gut and guarantee health of their host (Bevins *et al.,* 1999; Corfield *et al.,*2000; Engberg *et al.,* 2004). According to Jacobs *et al.* (2010)

Lactobacilli spp count in broilers fed large maize particles was increased than in those fed finely ground maize particles. Similarly, Engberg *et al.* (2002) showed that with pelleting, birds had increased number of Coliform bacteria and enterococci in the ileum and a reduced number of *Clostridium perfringens* and *Lactobacilli* count than with mash diets. Although an increase in population of beneficial bacterial was observed, broilers fed whole grains had increased incidences of cecal coccidiosis compared with those fed mash diet (Gabriel *et al.,* 2003). Similarly, in broilers fed whole wheat grains there was an exacerbated severity of coccidiosis infection accompanied by enlarged gizzard development than in those fed ground wheat (Singh *et al.,* 2015). However, when broilers were challenged with *E. acervulina* parasite, neither whole wheat grains (pelleted) nor the dilute mixtures (pellet and ground wheat) showed any marked infection of coccidiosis in the birds observed (Banfield and Forbes, 2001). For most poultry farmers, the impact of feed on birds should result in rapid growth and increased body weight (Chewning *et al.,* 2012; Xu *et al.,* 2015). These fast-growing broiler strains have been reported to be susceptible to metabolic diseases such as ascites (Arce-Menocal *et al.,* 2009; Ghazi *et al.*, 2012). While pellet is shown to have increased the severity of ascites in broilers reared at high altitudes (Ghazi *et al.*, 2012), mash reduced mortality caused by sudden death syndrome and ascites (Bennette *et al.,* 2002).

Conclusion

The importance of the physical form of feed in poultry production cannot be overemphasized. There exists remarkable influence of pellet and mash forms of feed on broiler production. This review touched on various impacts of pellet and mash diets in broiler production. The choice of the form of feed to be adopted therefore depends on the production objectives and the prevailing economic conditions. Mash diet is cheaper to produce, reduces sudden deaths arising from certain metabolic diseases and enhances digestibility of certain nutrients. Pelleting on the other hand contributes positively to improving growth rate, feed efficiency, feed intake, organ and carcass characteristics. Pelleting also minimizes feed and energy wastage during consumption and reduces ingredient segregation thereby enhancing a greater retention of nutrients. The high cost of pelleting notwithstanding, it produces far-reaching benefits in broiler production. Cost-effective means of pelleting should therefore be adopted for wholesome production and greater economic returns.

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