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Effects of Feed Restriction on Metabolic Disorders in Broiler Chickens: A Review

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Abstract: Continuous genetic selection and improvement in nutrition have led to a very fast growth rate in modern strains of broiler chickens. Metabolic disorders such as ascits, sudden death syndrome and leg problems are related to a rapid early growth rate in poultry, especially in broilers and their incidence can be decreased by slowing early growth. The use of management tools to reduce metabolic disorders that rely primarily on decreasing feed consumption. The feed restriction programs is on of the main techniques in growth curve manipulation for increasing production efficiency in broiler chicken in alleviate the incidence of some metabolic disorders and can be used to reduction the unfavorable effects of fast growth rate in broiler chicken production industry and could be profitable in broiler chickens production efficiency. This study implicated on new findings in about different feed restriction programs effects on these problems in broiler chickens.

Key words: Broiler chicken, feed restriction, metabolic disorders, poultry, chicken production industry

INTRODUCTION

Metabolic disorders have been a fact of life in poultry productions farms for at least the last few decades, exacerbated by the fast pace of improvements in the genetic potential of poultry for growth and efficiency. The genetic potential for growth and feed efficiency has been greatly improved in the last 50 years, during the last 50 years, the amount of time required reaching market weight and the quantity of feed needed to produce a pound of meat have been reduced by 50% (Anthony, 1998). While concomitant significant improvements have been accomplished in husbandry practices, disease prevention and nutrition, it has been estimated that 90% of the phenotypic changes in poultry have come from genetic progress (Havenstein *et al*., 1994). Unfortunately, this growth rate is accompanied by increased body fat deposition, high mortality and high incidence of metabolic diseases and skeletal disorders (Zubair and Leeson, 1996). These situations more commonly observed in fast growing broilers that are *ad libitum* fed that led to metabolic disorders in broiler chickens (Pasternak and Shalev, 1983; Nir *et al*., 1996). This fact is of economical concern because high incidence mortality and be come uneconomical product production efficiency. To saving of production cost and reducing the unfavorable effect of fast growth rate, there is interest in manipulate growth curve in broilers. Also, about 60-70% of the expenditures involved in poultry production are feeding costs. As such, the most reasonable phase in reducing the cost of broiler chicken production would be find possible methods which are cheap, adequate and readily available for feeding livestock. One such method is restricting the amount of daily feed offer for sometime (Novel *et al*., 2009). Thus, feed restriction programs have been proposed to overcome these problems.

FEED RESTRICTION DEFINITION

Feed restriction is method of feeding that is time, duration and amount of feed were limited have an impact on whether a bird is capable of achieving the same body weight as unrestricted birds (Ballay *et al*., 1992; Yu and Robinson, 1992). In general, feed restriction included of quantitative and qualitative restriction that is in quantitative to limiting the amount of feed daily given to the animals whereas a qualitative restriction is related to nutrient dilution in the diet.

Feed restriction methods: Quantitative and qualitative feed restriction are procedures that con be applied to manipulate the feeding strategies of poultry in order to decrease growth and metabolic rate to some extent and so alleviate the incidence of some metabolic disorders, as well as improving feed conversion in broiler chickens. These methods include: Physical feed restriction, limiting the level of consumption of feed in time (skip-a-day feeding) or reducing the time of illumination of feeding (Religious *et al*., 2001), diet dilution, chemical methods of feed restriction and use of low protein or low energy diets (Zubair and Leeson, 1996).

Physical feed restriction: This method is one of the common procedure was used in controlling feed intake in poultry. Physical feed restriction supply a calculated amount of feed per bird which is often just enough to meet maintenance requirements (Plavnik and Hurwitz, 1989). But, practical application of physical feed restriction is not simple due to the problems of regularly weighing birds and calculating feed consumption on a daily basis. Moreover, it is necessary to provide sufficient feeder space in order to prevent competition among restricted birds and to prevent unequal growth of birds within a flock. Also, in this method should be attention to educate consuming of micronutrient, coccideoastat and etc. Physical feed restriction programs for broilers have been extensively studied (Sahraei and Hadloo, 2012; Scheideler and Baughmam, 1993). Severity of feed restriction, length of restriction and age at marketing are the main factors to take into account in a feed restriction program for broilers. Quantitative feed restriction has been observed to reduce mortality and culling (Fontana *et al*., 1992), improve feed conversion ratio (Lee and Leeson, 2001) and allow a complete recovery of body weight if the degree of restriction was not too severe and slaughter ages were extended beyond 6 weeks (Deaton, 1995). Dozier *et al.* (2002), referred to feed restriction programs of yielding inconsistent results in the literature and that variation maybe partially attributed to differences in bird management, lighting, strain and ventilation. Although, the level of early feed restriction is an important factor influencing the broiler chicken response, early feed restriction at 30% of *ad libitum* intake was not able to influence broiler chicken performance at market age of 49 days (Giachetto *et al*., 2003).

Skip-a-day feeding: Skip-a-day deprivation of feed is a technique for restricting early growth and has not been extensively studied in broiler chickens (Dozier *et al*., 2002). But, these programs providing limited allotments are commonly used in broiler breeder's growth restriction. Removing feed for 8-24 h periods during the starter period reduces early rapid growth and meat yield in broiler chickens. Skip-a-day feed removal has been reported in other studies to decrease early growth and reduce the incident of ascites without affecting final body weight (Arce *et al*., 1992; Ballay *et al*., 1992). Oyedeji and Atteh (2005), reported reduction in feed intake after exposing the birds to fasting on every other day, also showed that skip-a day feeding for 3 weeks starting at day old would improve carcass quality and reduce sudden death syndrome which is often associated with birds that are on *ad libitum* feed intake.

Lighting programs: Birds are very sensitive to light. Light allows the birds to establish rhythmcity and synchronize many essential functions, including body temperature and various metabolic steps that facilitate feeding and digestion (Olanrewaju *et al*., 2006). Light intensity, color and the photoperiodic regime can affect the physical activity of broiler chickens (Lewis and Morris, 1998). In the common production methods, broiler chickens are raising under 23 h light per day because it is thought that under this light regimen feed intake is greater and therefore growth rate is suitable. Although, lighting programs are not categorized in the literature, as a feed restriction method it has been applied. It is known that by changing lighting periods by either reducing the hours of light or developing intermittent schedules feed utilization is improved (Apeldoorn *et al*., 1999). The incidence of leg abnormalities is also lowered by reducing the hours of light per day (Classen and Riddell, 1990), as is mortality and specifically sudden death syndrome (Blair *et al*., 1993). The so called step-don and step-up lighting programs (Classen and Riddell, 1990) have attained popularity because of reduced incidence of leg abnormalities, sudden death syndrome and mortality while maintaining the same market weight for age. Broilers under different reduced lighting programs, therefore will reduce their feed intake and so this program can be included within the definition of feed restriction. However, broilers do learn to eat during darkness when hours of lighting are low (Morris, 1986). Buyse and Decuypere (1988) who showed improved feed conversion and compensatory growth in male broiler chickens at 41 days with a light schedule from day 7 of 1L:3D repeated 6 times daily. The use of lighting programs has the advantage of reducing electricity costs, the incidence of leg abnormalities and sudden death syndrome and of improving feed efficiency with no reduction of weight at market age.

Diet dilution: The most problems form of physical feed restriction is usually considered to be maintenance allowance described by Plavnik and Hurwitz (1989) at 1.5 kcal ME/gBW$^{0.67}$/day. But for very young birds, this means a very small quantity of feed is distributed daily and so this leads to the alternate concept of diet dilution. Therefore, many investigators have used diet dilution, as an alternative method of nutrient restriction because of the advantage of attaining a more consistent growth pattern within a flock (Sahraei and Shariatmadari, 2007). In this method, diets are mixed with non-digestible ingredients, such as fiber and so are of reduce nutrient density. The use of diluted diets relies upon the fact that broiler chickens eat close to their physical intake capacity (Newcombe and Summers, 1984). Jones and Farrell (1992) used 50-65% diet dilution with rice hulls in order to retard early growth. This technique appeared to be successful and even though, these birds ate more feed, adjustment was insufficient to normalize nutrient intake and so growth rate was reduced. In many of these physical feed restriction or diet dilution studies, there are reports of reduced body fat deposition, although this effect seems variable. The most consistent feature of all these studies, regardless of method of implementation is improved feed efficiency. Griffiths *et al*. (1977) lowered the energy of a broiler chicken diet to 2233 kcal ME kg DM^{-1} from 3087 kcal ME kg DM^{-1} of feed by substituting ground yellow corn with oat meal as the main ingredient. Chickens fed the low energy diet consumed significantly more feed than those fed the high energy diet. When fed the low energy diet from 0-3 weeks of age, the chicks were not significantly different in body weight or in abdominal fat pad development from the *ad libitum* birds at 4 weeks of age. Sahraei and Shariatmadari (2007) was used of different levels of finisher diet diluted with sand and wheat bran (wt.:wt.) (in levels 7, 14, 21 or 28%) of Arian strain showed that feed intake in different levels was more than control birds. But live weight (at 45 ages), body weight gain only in 28% levels were less than control birds.

Use of low protein or low energy diets: For retardations of growth rate in broiler chickens can be used of diets with low energy and protein concentrations. This method has an advantage in that it does not need any additional labor of weighing the feed and is accomplished by lowering the level of either protein or energy. In normal conditions broilers are given 22, 20 and 18% of crude protein in the starter, grower and finisher periods, respectively and 3200 kcal ME kg diet (NRC, 1994). When broilers are fed with low nutrient dense diets they will increase their feed intake in an attempt to maintain nuirient intake (Leeson and Zubair, 1997). The study of Plavnik and Hurwitz (1989), showed that broilers fed *ad libitum* with a 9.4% crude protein diet from 8-14 days markedly reduced their feed intake and weight gain by about 57 and 41%, respectively. This reduction in feed intake may have been due to of a protein and amino acid deficiency, since other nutrients were at normal levels. But Rosebrough and McMurtry (1993), showed the effect of 6 days of diet energy restriction in broiler chickens, the restriction period was from 6-12 days and was designed to only support the maintenance requirements for body weight. Body weight at 54 days was achieved for birds given feed *ad libitum* from day 13-54 and for those fed *ad libitum* from 21 days onward. Feed efficiency was not significantly different between restricted and unrestricted birds. Leeson and Zubair (1997) utilized finisher diets varying in energy level from 2700-3300 kcal ME kg and showed no significant difference in body weight at 49 days. There was increased feed intake by birds fed the lower energy level diets. Leeson *et al*. (1996) reported that diluting commercial broiler chicken diets from 35-49 days of age with oat hulls and sand which led to the diets deficient in energy content, caused a significant reduction in body weight at 42 days of age, although the growth was compensated thereafter. Birds seemed to maintain energy intake, therefore there was increased feed intake with energy deficient diet.

Feed textures: Feed forms such as pellet, crumble, mash and particle size also influencesbroiler growth and development (Jones *et al*., 1995). Broilers fed crumble-pellet diets show improved weight gain, feed intake and feed conversion ratio compared to birds fed mash (Calet, 1965). Also, the consume of mash feed at different phases of the broiler's growth may be employed as a method of limiting feed intake. Birds offered mash spend more time consuming their feed compare to birds fed pellets and therefore, expend more energy in this process. Nir *et al*. (1995) fed male and female broilers to 49 days with mash or crumble diets during the starter and grower periods and mash or pellets for the finisher period. Males showed a significant increase in body weight and improved feed conversion when fed pelleted compared to mash diets. On the other hand, the improvement in performance was not evident for females which showed no significant difference either in body weight or feed conversion ratio at 49 days of age. Mortality was higher in birds fed pelleted diets. These results are in agreement with those of Jones *et al*. (1995) and Hamilton and Proudfoot (1995) where an improved weight gain and feed conversion at 6 weeks of age were obtained in birds fed pelleted compared to mash diets. The improvement in broiler performance with pelleted diets may be attributable to a greater digestibility of carbohydrates together with increased daily nutrient intake (Hamilton and Proudfoot, 1995). Also because chicks fed pelleted diets spend less time and energy feeding, they were less active than mash-fed birds and so spend less energy for maintenance.

Chemical methods: The other method that has been used to reduce feed intake in broilers is the use of chemicals or pharmacological agents. It has an advantage of equally distributing the feed among flock and so decreasing the variations in growth than can take place with physical feed restriction. Restriction of feed intake of broiler chickens by chemical methods was suggested by Fancher and Jensen (1988). Also Pinchasov and Jensen (1989), used 1.5 or 3% glycolic acid as an anorectic agent from 7-14 days in order to suppress the feed intake of chicks. Feed intake was severely reduced, resulting in 22 and 50% weight reduction with 1.5 or 3.0% glycolic acid inclusion, respectively. Oyawoye and Krueger (1990) showed that 400 and 300 mg of phenylpropanolamine hydrochloride or monensin sodium per kg of diet, respectively significantly decreased body weight of the broiler chickens at 4 weeks of age. Savory (1974) used of 50 g kg^{-1} of calcium propionate, as an appetite suppressor and showed that weight gains of chemically restricted birds were close to those obtaining under a recommended program of quantitative feed restriction for female broiler breeders between 2-6 weeks of age.

EFFECT OF FEED RESTRICTION ON METABOLIC DISORDERS

Metabolic disorders may be classed, as illness associated with a failure in one of the body hormone or enzyme systems, storage disease related to lack of metabolism of secretary products because of the lack of production of a specific enzyme or the failure or reduced activity of some metabolic function in poultry, it is usual to include under the heading of metabolic disorders those conditions associated with increased metabolism, rapid growth rate or high egg production that result in the failure of a body system because of the increased work-load on that organ or system (Julian, 2005), early fast growth in modern broilers is associated with increased stress on the birds and can result in metabolic and skeletal disorders that lead to economic losses due to reduced animal performance, high mortality rates and carcass condemnation at slaughter houses (Cuddington, 2004). The benefits of early feed restriction are the monetary savings obtained by improved feed conversion, reduced sudden death syndrome (Bhatt and Banday, 2000), reduced death losses, ascites (Arce *et al*., 1992) and reduced skeletal disease (Robinson *et al*., 1992).

Ascites: Ascites is not a disease; it is a sign or lesion that may result from one or more of 4 physiological changes that cause an increased production or decreased removal of peritoneal lymph. Ascites may be associated with obstruction of lymph drainage, as occurs in peritoneal carcinosis secondary to carcinoma of the oviduct; ascites may result from decreased plasma oncotic pressure, as occurs in anaemia or hypoproteinaemia. Ascites or edema may result from fluid leakage secondary to increased vascular permeability following oxidative or chemical damage but by far the most frequent cause of ascites in birds is increased portal pressure, secondary to Right Ventricular Failure (RVF) or liver damage (Julian, 1993). The growth rate or body weight gain in broilers has been shown to positively correlate with incidence of ascites. Broilers genetically selected for fast muscle growth seem more susceptible to ascites compared with slow-growing strains. Manipulation of the early growth cycle of broilers with a subsequent compensatory gain, seems a practical and viable method to minimize losses caused by ascites. In this context, various feed restriction programs have been tested. Acar *et al*. (1995) studied the effect of early age feed restriction on the subsequent growth and the incidence of ascites in broilers. A feed restriction regimen was used from either 4-11 (feed restriction) or 7-14 (feed restriction) days of age, consisting of limiting daily intake of the birds to 75% of the ME required for normal growth. It was concluded that although, ascites mortality could be significantly reduced in early feed-restricted birds, there was a decrease in body weight and breast meat yield in restricted vs. full-fed birds increases in the incidence of ascites in broiler chickens coincide with continuing genetic and nutritional improvements in enhanced feed efficiency and rate of growth. Ascites is a condition in which the body cavity accumulates serous fluid, leading to carcass condemnation or death. It is a consequence of cardiopulmonary insufficiency in rapidly growing broiler chickens (Julian, 2000; Buyse and Decuypere, 1988). Changes in feeding and lighting regimens can cause growth restriction (Baghbanzadeh and Decuypere, 2008). The hypoxemia related to a high metabolic rate in broilers can be partially prevented by limiting the intake energy via feed restriction (Balog, 2003).

Sudden Death Syndrome (SDS): Sudden Death Syndrome (SDS) is the name given to death in healthy, fast-growing, commercial meat type broilers that die suddenly. It has been recognized, as a specific condition since the 1950's when broiler chickens began to be grown commercially in large numbers. SDS occurs in all countries where broilers are grown rapidly under intensive conditions, young, healthy, fast-growing boiler chickens die suddenly while standing, walking, sparring or feeding, they die with a short terminal wing-beating convulsion and frequently are found on their back (Julian, 1996). The important disorders that in feed restriction researches had been interested is SDS, this problems is own of the costly factors in broiler chickens production industry. This syndrome mostly is taking placed in heavier birds in the flock. Sudden Death Syndrome (SDS) has been recognized for over 30 years and is also referred to as acute death syndrome or flip-overs. It is most common in males when their growth rate is maximized. Mortality may start as early as 3-4 days but most often peaks at around 3-4 weeks of age with affected birds being found dead on their back. Mortality may be found at 1.5-2.0% in mixed-sex flocks and as high as 4% in male flocks only (Qiao, 2007). Poultry nutritionist suggested that the high growth rate in modern broiler chicks is the main reason for these problems. In the experiments of Bowes *et al.* (1988) by feed restriction about 25% of *ad libitum* feed intake showed that SDS occurrence in feed restriction groups 0% and in *ad libitum* feed intake groups 3.33%. But in some experiments, no significant difference were observed between control and feed restriction groups (Deaton, 1995; Scheideler and Baughmam, 1993). The reduction in body weight for the high-density group was attributed to an increase in metabolic stress because there was an increase in mortality (SDS and ascites) in broilers fed the high-density ration in contrast to those fed the low-density ration (Scott, 2002). Lowering energy intake by changing feed texture or density (mash) or management methods, such as feed restriction or long dark periods (Classen and Riddell, 1990) will reduce mortality from SDS.

Leg problems: Failure of change of the proliferating avascular, prehypertrophying, growth plate cartilage to hypertrophying cartilage to allow it to be replaced by bone at the lower edge of the growth plate results in an abnormal mass of cartilage under the growth plate. This lesion is called Dyschondroplasia (Farquharson and Jefferies, 2000). In growing birds of meat-type strains which have been selected over the past 50 years for fast growth, the most common skeletal defects occur in leg bones and joints. It has been generally assumed that rapid weight gain has been a major cause of TD (Tibial Dyschondroplasia). Despite evidence that there is no genetic correlation between TD and body weight (Kuhlers and McDaniel, 1996), nutritional evidence suggests that dietary regimens that depress growth rate decrease the incidence of TD (Lilburn *et al.*, 1989). The retardation in growth rate can be achieved by either qualitative or quantitative food restriction (Edwards and Sorensen,1987). Robinson *et al.* (1992) demonstrated that severe feed restriction in the 2nd week of growth significantly reduced the incidence of skeletal disease in broiler chickens. These researchers reported that in three separate experiments, the incidence of skeletal disease was three-fold higher in full-fed birds compared to birds that were feed-restricted. A reduction in the incidence of leg disorders and sudden death syndrome was also observed in broiler chickens exposed to intermittent light or a step-up lighting regimen (Wilson *et al.*, 1984; Ononiwu *et al.*, 1979). One strategy to reduce leg weakness includes manipulating the rate of growth. Altering dietary energy and protein levels, implementing early feed restriction and offering various feed forms have all been strategies previously used to manipulate the growth rate in broilers (Lilburn *et al.*, 1989). The use of low-density rations has been shown to significantly reduce the early growth rate of broiler chickens; however regulating broiler lighting programs is also a management factor that can be manipulated to lessen the occurrence of skeletal abnormalities by increasing exposure to darkness, the growth rate of broiler chickens can be reduced (Edwards, 2000). In conjunction with this reduced rate of growth, a corresponding decrease in the incidence of leg abnormalities and metabolic disorders has been reported (Wilson *et al.*, 1984; Lilburn *et al.*, 1989).

CONCLUSION

In general, the potential of feed restriction programs as a management's tool related to decreasing the incidence of metabolic disease, carcass fat deposition, reduce maintenance requirements and improvement of feed efficiency in broiler chickens production. Also, can be lead to economical saving in cost of feeding in broiler chicken production, thus may be usefulness for commercial broiler chicks production farms.

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