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Importance of Dietary Fiber in Poultry Nutrition

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ABSTRACT

The scientific term of fiber is comprised of very diverse group of polymers having various physicochemical properties. The dietary fiber can contribute remarkably to the nutritive value of poultry diets both directly, as energy source, and indirectly, through its effects on digestive and metabolic processes going on in the poultry bird. In order to more accurately predict the nutritive effect of fiber from raw materials, a better characterization of fiber fractions, their degradation in the chicken, and their physiological effects are required. Traditional analytical methods to analyze fiber, as crude fiber (CF) and neutral detergent fiber (NDF), recover only a changeable fraction of fiber and are hence unfit for evaluation fiber fractions in raw materials and poultry diets. In poultry feeding the fiber gives less amount of energy because of its limited role in digestion however its slight increased proportion (up to 50 g/kg) can be productive for GIT development, thereby improving the digestion of nutrient and also posing good impact on growth and performance. A better understanding on the relation between specific fiber fractions and factors as GIT development, digesta retention time, and microbial colonization will help to develop nutritional strategies using specific fiber fractions to steer GIT health and function to enhance performance, especially under suboptimal environmental conditions.

Introduction

The fiber is a natural component of plant derived feedstuff and is of great importance in poultry feed. Regarding the daily intake, growth performance and digestibility of nutrients, studies trials conducted in previous years have shown negative impact (Jorgensen et al., 1996; Sklan et al., 2003). The research trials conducted in recent past have elaborated the role of fiber in improving the growth of broilers (Jimenez-Moreno et al., 2009; Gonzalez-Alvaradoet al., 2010). The GIT development and overall growth depends on quality and quantity of fibers in the diet (Owusu-Asiedu et al., 2006). In this regard, the soluble fibers are composed of pectin which makes the digesta viscous in GIT to accelerate the absorption of nutrients (Iji at al., 2001; Forman and Schneeman, 2018). On the other hand the insoluble fiber e.g. rice hulls poses good impacts on gizzard and GIT, which improves nutrient digestion (Hetland et al., 2004). There have been some findings on the impact of soluble and insoluble non starch polysaccharide on physiology and morphology of digestive system of broilers (Banfield et al., 2002; Iji et al.,

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2001; Jimenez-Morenoet al., 2009).

The immunological effect of fiber depends on its fermentation and in the result the produced short chain fatty acids can safeguard the digestive system (Liévin-Le Moal and Servin, 2006). Saki et al. (2011) came to the conclusion that mixing the fiber fractions e.g. rice hulls, etc in different feeds could not be more effective and needed further research. The addition of fiber in ration in low levels poses a good effect but if the level accedes to 30 g/kg it can be harmful for the broilers (Jimenez-Moreno et al., 2013) found reduced weight gain in the broilers of 6 days old when he added SBP up to 75 g/kg of feed. Similarly the performance and nutrient absorption was reduced when the crude fiber contents of feed were raised from 30-90 g/kg of feed of turkeys (Sklan et al., 2003).

The dietary fiber (DF) is present in feedstuff in a considerable amount while in monogastric animals it has more proportion. The DF becomes beneficial nutritionally in such a way that it directly provides energy (Varel and Yen, 1997; Jamroz et al., 2002) and indirectly by invigorating the GIT and immune system of animals (Choct et al., 1996; Jha et al., 2010; Pieper et al., 2008). But previously the DF was rendered as an anti-nutritional factor because of its bad effect on the utilization of nutrients (Jha et al., 2010; Annison, 1993). However, in recent past, due to its positive role in uplifting the gut health of monogastric animals, the DF has gained special consideration (Jha and Berrocoso, 2015). The maintenance of gut health of animals is of great importance because it improves the feed efficiency, upholds the growth, and poses a good effect on overall health of animals. In past the antibiotic growth promoters (AGP) have been consecutively used in animals for their growth promotion but due to possible residual effect of antibiotics in humans which was a serious public health concern, the use of antibiotics for growth promotion was banned in several countries. So the alternative feed resources for growth promotion were sought and the DF was considered to be a good choice. These are plant derived feedstuff composed of cereals, tubers and agro-industrial by-products (Jha and Berrocoso, 2015; Tiwari and Jha, 2016; Tiwari and Jha, 2017). However there are some bad effects but, due to its good impact on digestion, the usage of DF is gradually increasing (Jha and Berrocoso, 2016). Microbial fermentation of DF leads to production of short-chain fatty acids (SCFA), which improves growth of productive bacteria in gut by improving intestinal health and immune function. The studies have shown the beneficial impacts of DF on fermentation, gut health and its physic-chemical characteristics (Jha et al., 2015).

Dietary Fiber

McDonald and Whitesides (2002) have defined the term "fiber" as part of plant cell wall, a non-starch polysaccharide (NSP), is composed of lignin, cellulose and hemicelluloses. According to (Branton et al., 1997) the addition of NSP in diet is responsible for necrotic enteritis in poultry which is due to increased microbial fermentation.

According to (Bach Knudsen, 2001) chemically the DF is composed of

NSP e.g. cellulose, arabinoxylans, inulin, chitins, pectins, beta-glucans and phenolic polymer lignin which are part of plant cell wall hence poultry birds don't effectively digest DF, therefore put no nutritional value. Analytically, the DF is rendered as a part of dietary fractions which remain present after the extraction with neutral detergent solution (Soest and Wine, 1967) it is called neutral detergent fiber (NDF). The researchers have found that dietary metabolizable energy (ME) and age of the bird increases side by side (Sell, 1996; Zelenka, 1968; Batal and Parsons, 2002). Shires et al. (1987) observed low feed passage rates in old age birds, and recommended that DF digestibility may be increased if the diet is exposed for more time in ceaca for microbial fermentation. However (Siregar and Farrel, 1980) reported no influence on ME by age of the broiler.

The poultry meat and eggs play an important role in fulfilling the protein needs of human beings in the form of cheap and economical protein source and the demand is increasing as the population of this world is increasing. It is estimated from the data of Food and Agriculture Organization (FAO) of the United Nations by (Henchionet et al., 2014), from the year 1900-2009, poultry meat consumption increased by approximately 77% to 126%, respectively. Feed is the most crucial input in poultry production for its enhanced meat production and it accounts for 50-70% of production costs (Rochell, 2018).

The microbes living in GIT of animals can ferment the NSP which can lead to the production of short chain fatty acids (SCFA), which are then absorbed and used as energy source (Dierick et al., 1989; Jorgensen et al., 1997; Just et al., 1983). However about 40% of NSP are degraded, the lower efficiency of energy utilization obtained from the process of microbial fermentation as compared to enzymatic digestion, and high energy requirements (Dierick et al., 1989) generally it establishes that the NSP contributes less amount of energy to the bird (Jorgensen et al., 1997). The DF can impede the digestion thereby reducing the nutrient absorption from diet (Choct and Annison, 1992; Annison, 1992; Montagne et al., 2003; Smits et al., 2000; Smits et al., 1998). Especially insoluble, recalcitrant, fiber fractions that resist fermentation in the gut may be important from this perspective due to their effects on gizzard function and digesta retention time in the GIT (Hetland et al., 2004). A better understanding on the relation between specific fiber fractions and factors as GIT development, digesta retention time, and microbial colonization will help to develop nutritional strategies using specific fiber fractions to steer on GIT health and function to enhance performance, especially under suboptimal environmental conditions.

Studies conducted

Two experiments were performed to find out the impact of fiber with voluntary or by choice feeding on some parameters including performance, intestinal health, immunity level, and fiber preference in broilers. In the first experiment, 240, one day-old broiler chicks (Ross 308) were randomly divided in 4 groups, comprising 5 replicates per treatment. The dietary treatments were: basal diet (control) or 30 g/kg sugar beet pulp (SBP), 30 g/kg rice hull (RH), or 30 g/kg equal combination of them (SBP/RH) added to the basal diet. Results showed SBP and SBP/RH reduced weight gain in the growing phase compared to control. on the other hand there was decreased FCR value in the groups which was given SBP during the entire rearing period. When the comparison was made to control and SBP treatment groups, administering SBP/RH considerably lowered the antibody titer level against Newcastle Disease Virus (NDV) at 23rd of age. Moreover the, the SBP decreased the villi height of duodenum and ileal region compared to control at 21st day of age. In 2nd experiment, 240 chicks were grouped into 4 different experimental treatments: 1) control; or by choice feeding, 2) control and SBP (C-SBP); 3), control and RH (C-RH); 4) control and SBP/RH (C-SBP/RH). The results depicted that the chicks had an inclination to utilize separate sources of fiber. RH remained less consumed than C-SBP/RH and C-SBP in starter and growing periods, respectively. In the group where the chickens took feed by choice, the RH and SBP/RH showed better daily feed intake than control across 14th to 28th day of age. In the same treatment group increased antibody titer against ND was also seen. However, reduced daily weight gain was reported in all the fiber fed birds which ultimately decreased FCR in broilers of the C-SBP group. So by concluding, the addition of fiber in both of the experiments put negative effects on the growth of birds but immunity level was improved. So the broilers had an inclination to use separate fiber sources (Sadeghi et al., 2006).

The direct emphasis has been on the nutrient intake to get optimum weigh gain particularly in growing phase in laying hens. The research trial is performed to appraise digestibility of nutrients, GIT development, and development of bone of two types of layers, semi-heavy (Hy Line Brown) and light-strain (Lohman LSL), are given feed in their 7th to 12th weeks of age. For this purpose 1,296 laying hens were randomly allocated in a completely randomized design in a 2 x 3 factorial arrangement (two strains x three levels of NDF) having four replicates of 54 birds each. The hens were divided to feeding treatments containing 14.50, 16.50, and 18.50% NDF and it was observed that light-strain pullets had lower performance with 18.50% NDF. It was also found that the descending ratio of NDF in the feed decreased the digestibility coefficients of dry matter, nitrogen and gross energy, and the values of ME. On the other hand the increased proportions of NDF in the feed ascended the weight of liver and intestines and decreased gizzard weight. The light and semi heavy strains also experienced difference in quality and composition of tibia and femur bones. In growing phase the increased levels, up to 14.50%, of NDF in diets lowered the digestibility of nutrients and ME but it didn’t impact the carcass quality, quality and composition of bone, feed intake and weight gain (Freitas et al., 2014).

A trial was performed on 360 male broilers, 240 were fast-growing strain

(Cobb 500) and 120 were slow-growing strain (Label Rouge), to find out the dietary effect of fiber on digesta, transit time and metabolism during 1st to 42nd days of their age. For this a completely randomized experimental design with a 3x2 factorial arrangement was framed, which was composed of 3 groups of birds (slow growing (SG); fast growing fed ad libitum (FGAL); and fast growing pair fed with SG broilers (FGPF) and two iso-protein diets containing 3100 kcal ME/kg low fiber diet (LFD) and 2800 kcal ME/ kg high fiber diet (HFD) having 14% wheat bran and 4% oat hulls). The decreased ME was observed in HFD fed birds group on the other hand lower dry matter metabolizability (DMM) was found out that was probably due to the reason of short digesta transit time of these birds. The DMM was decreased with age while ME remained at same level and this might be due to ascended levels of feed intake as the birds grew old. The HFD was not better utilized in slow growing strains relative to fast growing strain (Krass et al., 2013).

Conclusion

Only a varying portion of fiber fraction is analyzed in conventional or old procedures to analyze fiber as CF and NDF so these are not better enough for the evaluation of fiber for poultry feeds. For scientific purposes, the enzymatic-chemical (Englyst or Uppsala) methods are more appropriate, whereas for routine analyses the AOAC method for total, insoluble, and soluble dietary fiber can be used. The tract of digestibility of NSP in chicken range between 0 and 0.4 and generally reflects differences in solubility of the fiber fraction. Besides this the polysaccharides when stuck in cell wall, time available for fermentation and the lack of pertinent enzyme by the microbes residing in GIT are possible limiting factors for NSP degradation. The fiber in poultry diets sometimes provides less amount of energy which is due to the reason of its limited contribution in energy supply and less engagement with digestion; hence a moderate quantity of fiber (up to 50 g/kg) is productive for the development and health of digestive system which leads to improved nutrient digestibility and growth performance. A better understanding on the relation between specific fiber fractions and factors as GIT development, digesta retention time, and microbial colonization will help to develop nutritional strategies using specific fiber fractions to steer on GIT health and function to enhance performance, especially under suboptimal environmental conditions.

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