COMPREHENSIVE ENZYME APPROACH IN IMPROVING NUTRIENT AND ECONOMIC EFFICIENCY IN BROILERS

Dr. Yasir Bashir
Kemin Industries South Asia Pvt. Ltd.

Modern day broiler has reached to pinnacle of affordable meat production, thanks to tremendous improvements in genetics and in large part to improvements in nutrition. Over the last few decades, broiler nutrition is the most widely researched field to ideally match the nutrient requirements of broilers to achieve the improved genetic potential. Feeding constitutes a single major expense of the total production costs in broiler production, which indicates that profitability of poultry production has a strong proportionality with the feeding costs. Majority of broiler feed in India is usually composed of Corn and Soyabean meal (SBM) as a source of energy and protein, respectively. However, owing to increasing demand-supply gap, there has been a steep rise in the price of these ingredients in last two decades. Soya prices in India have almost tripled recently leading to a sharp reduction in profitability and lean margins for producers. A possible approach for the industry to overcome such crunch in profitably is the use of "non-conventional" feed ingredients which are essentially alternates to more costly corn and SBM. The whole premise of the usage of alternate raw materials (RM) in poultry feed is based on the inclusion of small quantity of such non-conventional ingredients which can be included as an alternate to more expensive ingredient but not negatively impacting growth and performance of the bird upon its dietary incorporation. This help producers to maintain feed quality at the same time reduce the feed cost. Various alternative feed ingredients like Dried distillers grains with solubles (DDGS), mustard cake (MDOC), sunflower cake (SFDOC), bajra, wheat, etc. are being constantly explored by the feed industry and used at varying levels in various phases of the broiler feed. However, these alternative feed ingredients pose a persistent problem of various potential anti-nutritional factors like non-starch polysaccharides (NSPs), phytate, etc. in cereals and low protein digestibility (**Table-1**).

Table-1: NSP components of Feed Ingredients (% dry matter).

Feed Ingredients	AX sol	AX insol	β-glucans	Cellulose	Mannose	Galactose	NSP	AX/ NSP %
Wheat	1.8	6.3	0.8	2.0	T	0.3	11.4	71
Rye	3.4	5.5	2.0	1.5	0.3	0.3	13.2	67
Maize	0.1	5.1	T	2.0	0.2	0.6	8.1	64
Wheat Bran	1.1	20.8	0.4	10.7	0.4	0.8	35.3	62
Corn (DDGS)	0.4	12.6	T	7.1	0.7	2.1	28.6	45
Rice Bran	0.2	8.3	T	1.2	0.4	1.2	21.8	39
Rice	T	0.2	0.1	0.2	T	0.1	0.8	25

These factors impact their inclusion levels in broiler diets for feed cost optimization substantially, as they can lead to problems of performance fluctuations, poor productivity and possible gut health problems.

PRACTICAL IMPLICATIONS OF ALTERNATE RAW MATERIALS

Alternate raw materials apart from corn soya contains number of anti-nutrition factors (ANF) which can limit their digestibility. There are two main areas to consider from enzyme usage point of view to prevent ANFs from reducing nutrient utilization and negatively affecting performance which are described as below.

- ### NON-STARCH POLYSACCHARIDES (NSPS)

  The major components of dietary fiber in poultry diets primarily composed of cellulose and non-cellulosic polysaccharides. In various cereal grains, including corn, the non-cellulosic polysaccharides consist of arabinoxylans and β-glucans, while in soybean and canola meals, arabinans, arabinogalactans, galactans, galactomannans, mannans, and pectic polysaccharides predominate are available. Ingestion of soluble fraction of NSPs like arabinoxylans, β- glucans and pectins, etc., increases the digesta viscosity in intestine of broilers by directly interacting with water molecules. Presence of NSPs in the feed raw materials reduces the digestibility and limits the apparent digestible energy (AME). Increased viscosity due to NSPs (soluble) reduces physical contact between endogenous enzymes and nutrients by acting as a barrier, which decreases the movement of enzymes

and substrate molecules. This affects digestibility of starch, proteins, lipids and leads to reduced performance of broilers because of impaired nutrient utilization. Increase in the digesta viscosity also leads to change in gut ecosystem, mostly due to the slow passage rate which can cause ideal environment in the gut where fermentative microflora can establish. Increased bacterial population in turn compete for nutrients with host, causing irritation and thickening of gut mucosa, and changes the morphology of villi.

- **PROTEIN DIGESTIBILITY**

  Protein digestibility is relatively high in typical corn and soybean meal-based broiler feeds but tends to be lower in those containing non-conventional animal-derived meals. A wide range of endogenous proteases are synthesized and released in the gastrointestinal tract (GIT) of bird, which are generally considered sufficient to optimize feed protein utilization. However, some amount of protein pass through GI tract without being completely digested. Dietary proteins from these alternate protein sources are poorly digested and consequently enter in the hind gut (caeca and colon). This can stimulate the growth of nitrogen utilizing microbiota that lead to increased toxic compound levels such as biogenic amines, phenols, and cresols. These compounds can seriously impact the performance and enteric health of the bird.

OVERCOMING WITH COMPREHENSIVE ENZYME USAGE

In order to completely make proper use of alternate raw materials and for efficient nutrient utilization in general, exogenous enzymes are vital tool. Inclusion of various exogenous enzymes improves access to the nutrients, which bird by itself is unable to utilize thereby improving the efficiency of nutrient utilization and cost savings. NSPases and proteases are two groups of enzymes that can be used in broiler diets with the aim of improving digestibility of unconventional feed ingredients.

- **NSPases**

  NSPases are called as carbohydrases, these enzymes are used to degrade various NSPs present in varying concentration in various cereals and oilseed cakes. These are essentially polymeric carbohydrate monosaccharides joined together by glycosidic bonds other than α (1-4) and α (1-6) that are primarily found in starch. These bonds are resistant to cleavage by birds enzyme but are readily digested by microbially derived enzymes. NSPs present in plant cell wall are of many types like Arbinoxylans, Beta glucans, galactomannans, some galactosides, etc. and are closely associated with other polysaccharides and noncarbohydrate material such as protein, lipids and lignin. Exogenous enzymes degrade NSPs in the diet by breaking the fiber chains of cell walls into smaller fragments. By breaking down the cell wall of grains, carbohydrase inclusion has shown to decrease intestinal viscosity, increase digestibility and performance. It is more effective to use a product containing a combination or “cocktail” of enzymes ranging in their specificity and action, which lead to degradation of NSPs, although improvements in degradation of NSPs have been observed with individual enzyme inclusion such as xylanases. Enzymes included in NSPase cocktails may vary, with enzymes such as xylanase, β-glucanase, mannanases, cellulase, and pectinase often included to increase their spectrum for substrates leading to better degradation of available non-starch polysaccharides. Exogenous enzymes supplemented in feed must be able to tolerate the changes in pH of the poultry gastrointestinal tract before they can reach the site of degradation as enzyme activity is also a function of pH of the medium in addition to temperature and substrate availability. Utilizing enzymes that aim at these substrates will allow the animal to efficiently degrade the cell walls and release encapsulated starch and protein. Mannanases and pectinases specifically target the soya portion of diet. Considerable enhancements in growth and feed conversion have been linked with exogenous addition of NSP enzyme combinations even on corn soya diets due to improvements in the nutrient utilization, dry matter retention, apparent ileal digestibility coefficients of dry matter, nitrogen, and energy.

  Furthermore, due to reduction in viscosity caused by the presence of soluble NSPs, an easy access of proteases and lipases with their respective substrates in the ingesta lead to better digestibility and utilization (**Figure-1**). Plant cell walls contain protein in their matrix, so degradation of NSPs makes the amino acids entrapped in fiber available for digestion and absorption. Improved degradation from NSPases improve the nutrient utilization in the proximal gut resulting in the reduction of fermentable substrates reaching hind gut, which decreases the harmful microbial population and also reduces viscosity in the gut and allows the ingesta to pass in optimum time.

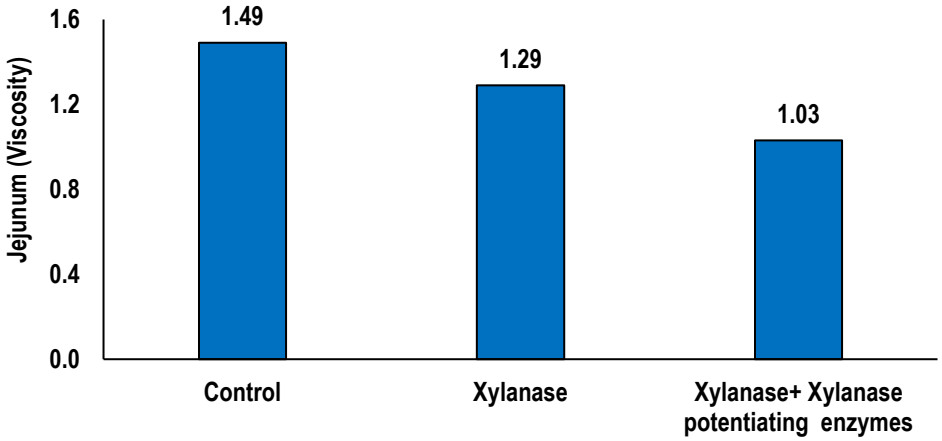

Figure-1: Effects of Enzymes Supplementation on the Viscosity of Digesta in Broilers Gut.

Breakdown of plant cell wall carbohydrates by NSP enzymes can eventually lead to the production of short-chain oligosaccharides (di- and trisaccharide). These oligosaccharides are known to be a substrate for bacterial fermentation, potentially positively altering bacterial populations within the gut.

Commercial NSPases which degrade the main chain of NSPs, especially xylanase, cellulase and glucanase, have an important role in improving their digestibility. However, this does not completely breakdown the complex structure involving the cross linkages containing ferulic acid which cross links the cell walls polymers. Interactions between xylans and polymers like β-glucans or cellulose also contribute to the cohesiveness of wall network. The closely interconnected cell-wall network would possibly impair arabinoxylan susceptibility to endoxylanase by limiting enzyme contact and mobility. Complete hydrolysis of hemicellulose fraction of the NSP group necessitates two groups of enzymes: one which cleaves the xylan main chain (endoxylanases) and the accessory enzymes like ferulic acid esterase (FAE), which remove the side chains and break crosslinks between xylan and other plant polymers (**Figure-2&3**). The latter group consists of α-L-arabinofuranosidase, α-glucuronidase, acetyl xylan esterases, and feruloyl esterase.

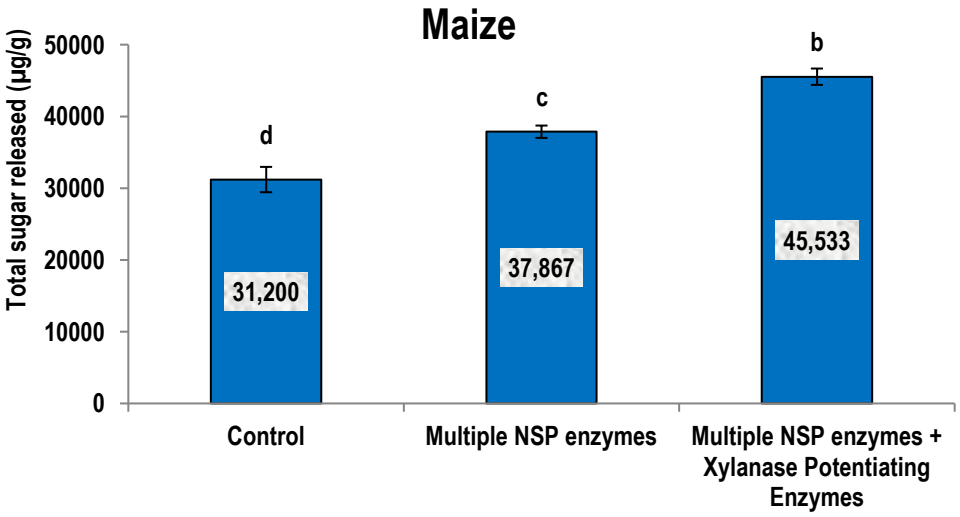

Figure-2: Effect of enzyme treatment on sugar release from maize. Enzyme supplementation showed significantly higher sugar release compared to control.

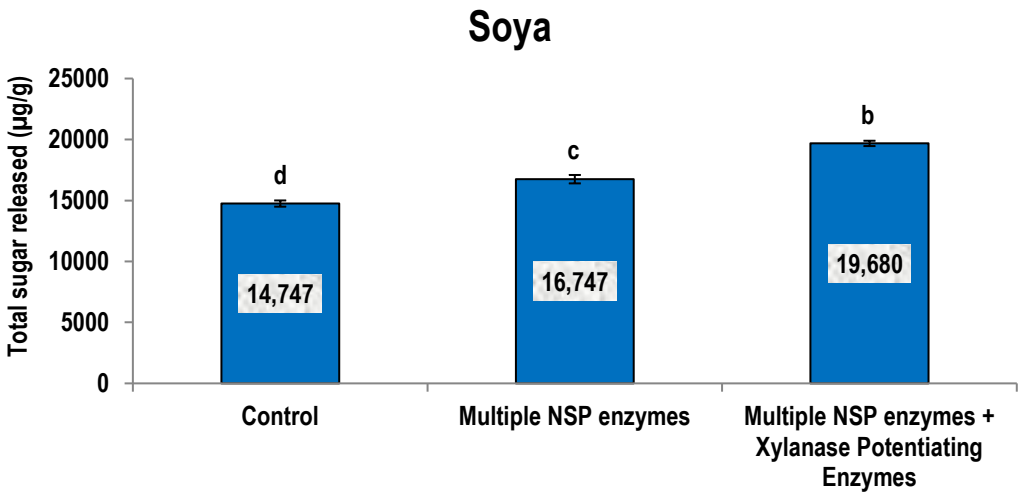

Figure-3. Effect of enzyme treatment on sugar release from soya. Enzyme supplementation showed significantly higher sugar release compared to control.

An innovative and holistic approach involves an enzyme preparation containing a blend of non-starch polysaccharide degrading enzymes including xylanase, mananase, beta gluconase and ferulic acid esterase (FAE), which aids to break the ferulic cross linkages in the plant cell wall. FAE was observed to be synergistic with xylanase. This synergy not only improves the access of xylanase, but also other main chain enzyme like cellulase and glucanase in NSP degradation. It also improves apparent metabolizable energy (AME) of broiler birds when compared to the single enzymes used.

- **Proteases**

One of the practical problems encountered during the use of alternate protein sources in low digestibility impacts the nutrient utilization and performance. Protease group of enzyme provides a way out by improving digestibility of such alternate protein sources, and over the years usage of alkaline proteases have been found beneficial in improving the protein digestibility and utilization. Protease enzymes typically work by hydrolyzing proteins or peptides, and thus improving protein digestibility. However, a closer look into the monogastric protein digestion reveals that protein digestion is two stage process. A gastric stage which occurs in acidic pH *via* pepsin, and the second stage occurs in gut under neutral environment of gut *via* trypsin, chymotrypsin. Furthermore, owing to faster transit time of digesta in the gut which impacts protein digestion, a more comprehensive approach is using a multi protease (acid, alkaline & neutral), which can complement the protein digestion throughout the gut. This approach not only improves the protein digestibility but also have a significant impact on gut health, since the quantity of undigested protein entering the distal gut is comparatively less and lead to lesser proliferation of harmful microbes. Efficacy of the protease is dependent on various factors, one of which is ingredients used in the diets. Thus, a diet containing less digestible protein sources like DDGS, MDOC, etc. provides more space for protease to act upon as there will be substantial amount of substrates that makes protease activity more efficient and help reduce the formulation costs.

Using a traditional alkaline protease may provide benefit of nutrient utilization to certain extent but considering the current high protein prices and inclusion of poorly digestible protein sources for cost benefits is incumbent to use a multi protease. This multi protease have a high activity across various pH ranges for proper degradation of proteins releasing more digestible amino acids for metabolism (**Figure-4**). Multi proteases in broiler feed have shown to improve the protein and amino acid digestibly both *in vitro* and *in vivo* animal trials.

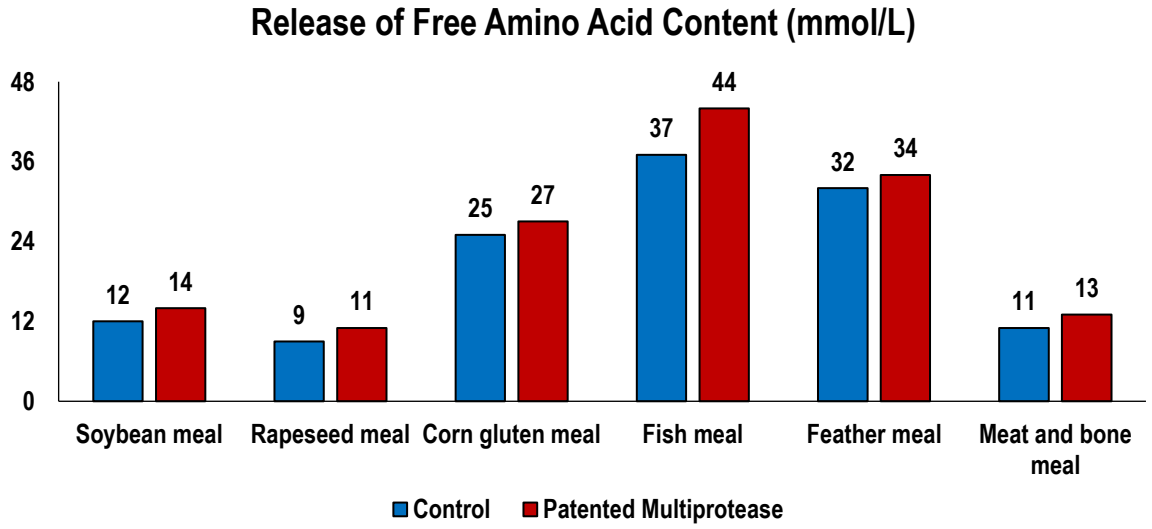

Figure-4: Release of free amino acids in digestive supernatant of protein raw materials.

A significant effect was noticed in the broilers on production parameters and economics with dietary inclusion of multi protease as compared to single alkaline protease (**Figure-5**).

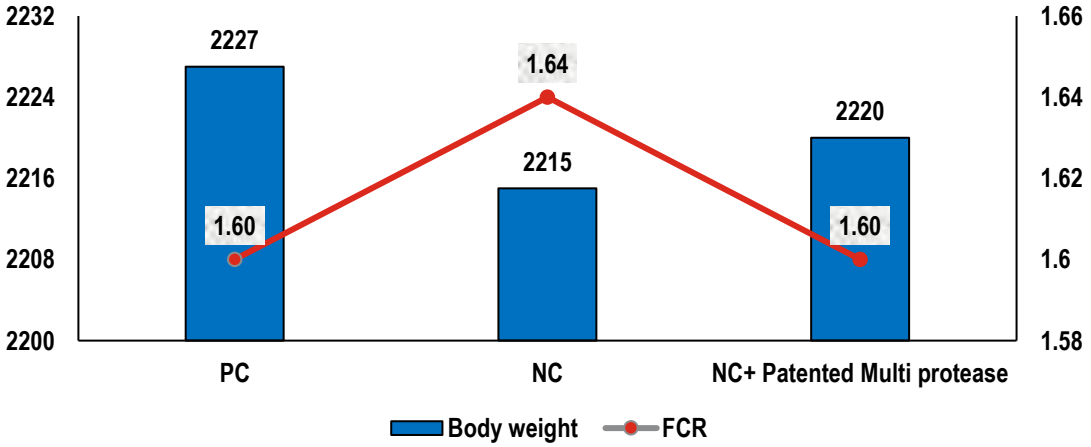

Figure-5. Release of free amino acids in digestive supernatant of protein raw materials.

INDUSTRY NEEDS INNOVATION

Frequent and very high price fluctuations in protein/ energy sources lead to erosion in profitability, which dictates that a keen interest should be shown to usage of alternate raw materials in practical broiler diets. Choosing the right alternate and considering accurate digestibility coefficients is vital for better feed quality and uniformity. However, the quality of alternate raw materials is generally poor and have their problems in digestibility. This can be achieved to an extent by judicious use of enzymes like NSPases and proteases. Considering the fast growth and rapid digestion dynamics in broilers, it is imperative to use innovative enzyme options to effectively counter the adverse effect in inclusion of alternate RMs on growth and nutrient utilization. Shifting from traditional Xylanase and other NSPase cocktails to a next generation NSPase combination containing the Xylanase potentiating factors for effective arabinoxylan degradation can be beneficial for cost saving and maintaining performance. Similarly, use of next generation protease in broiler diets involving a combination of acid, alkaline and neutral protease can be a superior alternate to typical alkaline proteases to improve protein digestibility of alternative RMs effectively and economically. A more practical effective approach will be use of an enzyme combo or cocktail which encompasses a combination of NSP enzymes and multi proteases in right proportion that can lead to substantial improvements in both protein and energy digestion in broiler diets. Utilizing these innovative & comprehensive enzyme solutions will make the dependence on costly feed ingredients like corn and soya lesser and provide economic advantage to broiler producers.