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Enzymes supplementation of non-conventional feedstuffs (A panacea to sustainable fish and livestock production in Nigeria)

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Abstract

The competition between humans and agro-allied industries including breweries for agricultural products especially cereals and legumes which are the major raw materials for these hitherto mentioned industries, has made it imperative to source for alternative feed materials for fishes and livestock. The current awareness in aquaculture and livestock production has increased participation and output but the snag in Nigeria is that these industries often faced with the problem of scarcity of feedstuffs especially during the dry season of the year. The cheap and relatively available unorthodox feedstuffs mostly plant materials are also plagued with phyto-toxins and very high fiber which are not tolerated by monogastrics. This problem has been partially solved in Europe, America and Asia through production and fortification of animal feeds with enzymes, hence, agro waste from barley, Rye, wheat and oil seeds are often used in feed formulation without compromising cost and performance. Enzymes produced either as specific or multi enzymes have proved a great potential in animal agriculture, hence, its adoption will greatly enhance aquaculture and livestock production towards increasing animal protein intake among Nigerians.

Keywords: Enzymes, Non-conventional, Panacea, Supplementation.

Introduction

The incessant high cost of orthodox feed ingredients such as cereals, oil seeds and fish meal has necessitated the need to investigate alternative feed resources otherwise known as non-conventional feedstuffs (Agbabiaka *et al.*, 2012). The resultant effect is high cost of animal protein, hence, inability of the average Nigerians to meet the minimum dietary intake of 56g per person per day as recommended by FAO (Fasuyi, 2005). Many attempts have been made to solving this problem of inadequate protein intake through the utilization of unorthodox feedstuffs in poultry such as maize offal (Vantsava *et al.*, 2008), palm oil sludge (Esonu *et al.*, 1996), cassava meal (Udedibie *et al.*, 2004) while attempts on non-conventional protein feedstuffs in poultry include jackbean meal (Esonu,1996; Agbabiaka, 1999), dried rumen digesta (Esonu *et al.*, 2006, Dairo *et al.*, 2010), mucuna bean (Emenalom *et al.*, 2009), potato leaf meal (Madubuike and Ekenyem, 2006).

Nevertheless, attempt on fishes fed non-conventional energy feedstuffs include wild variegated cocoyam (Agbabiaka *et al.*, 2006), cocoyam (Aderolu and Sogbesan, 2010), tigernut (Agbabiaka et al., 2013a,b), sweet potato peels (Omoregie *et al.*, 2009), cassava leaf (Bichi and Ahmad, 2010), mango seed (Agbabiaka *et al.*, 2010). However, some non-conventional protein resources have proved to have potential in the production of cheap and quality diets for fishes; these, include duckweed and water-fern (Fasakin *et al.*, 2001), water hyacinth (Ofojekwu *et al.*, 1994), *Amaranthus spinosus* leaf meal (Adewolu and Adamson, 2011), *Leucaena leucocephala* leaf meal (Aminsah *et al.*, 2009) and rumen digesta meal (Agbabiaka *et al.*, 2011a, b; Agbabiaka *et al.*, 2012a).

The major constraint is that almost all these readily available and cheap feedstuffs mentioned above cannot be included at high dietary levels because of their inherent anti-nutritional inhibitors such as phytates, alkaloids, tannins and non-starch poly saccharides (NSP) which impairs nutrient utilization in fish and monogastric livestock.

Enzymes supplementation in monogastric diets: The current reality to explore the novel feedstuff due to scarcity and high cost of commonly use feedstuffs such as maize, millet, soybean, Groundnut cake, fishmeal among others, has made the use of enzymes fortification very popular in monogastric nutrition. Early enzyme preparations included in animal diets were not formulated as feed additives but were produced for industrial or human food uses (Officer, 2000). Between the late 1980s and mid-1990s, enzyme product changed with the formulation of feed enzyme supplements has increased dramatically worldwide, but predominantly in pigs, poultry and fishes.

The importance of matching enzyme activity and feed composition has become evident as our understanding of the chemistry of non-starch polysaccharides (NSP) and other feed components have improved. To provide any benefit to the animal, feed enzymes must target specific feed components which are otherwise harmful or of little or no value (Officer, 2000).

Fortification of animal feeds with enzyme(s) has made a wider range of unorthodox and hitherto (rejected feedstuffs to be used in diets formulation without compromising cost or animal performance. For instance, feed enzymes are used to increase the amount of nutrients available from vegetable protein so that they can be used to substitute expensive fish meal or other high quality and expensive animal protein sources.

Nevertheless, feed enzymes can also be used to substitute a previously unacceptable energy sources such as wheat, tigernut, maize offals (Vantsava *et al.*, 2008, Agbabiaka *et al.*, 2012b).

Mechanism of feed enzyme action: There is evidence to support two main ways in which feed enzymes improve diet digestibility and animal performance (Pettersson and Aman, 1988, 1989; Annison, 1991). Firstly feed enzymes increase the access to nutrients previously bound in or by cell walls. For nutrients to be available at the cell level, large compounds must be broken into smaller molecules and absorbed by the intestinal wall. The role of feed enzymes is to work in combination with endogenous enzymes to degrade compounds to a size that can be utilized by the animal. Consequently, it is important to choose exogenous enzymes with complementary action to enzymes produced by the animal.

Secondly, feed enzymes must prevent increases in digesta viscosity which can impair nutrient absorption. Some compounds, once they are released from the cell walls, form gels which can increase digesta viscosity. Young animals, especially birds, are very sensitive to changes in digesta viscosity. If they eat diets containing high levels of gel-forming non-starch polysaccharides (NSPs), low digesta viscosity can be maintained with enzymes which reduce the chain length of the polysaccharides rather than remove side branches (Chesson, 1993).

Although it may seem attractive to be able to break down all of the carbohydrate in the diet into absorbable units, not all monosaccharide sugars are well utilized by all animal species or by all parts of the gastrointestinal tract of those species. Some sugars, such as xylose, are universally well utilized by both pigs and poultry (Longstaff *et al.*, 1988; Yule and Fuller, 1992). Other sugars, such as arabinose, are poorly utilized if released prior to the terminal ileum but well utilized if broken down and absorbed in the hindgut of the pigs (Yule and Fuller, 1992).

Therefore feed enzymes formulations should not contain glycosidases, other than glucosidase (Chesson, 1993), if optimal utilization of energy from pentose sugars is to be achieved. The interactions between the animal and the feed enzyme-supplemented diet are complex. For example, pentosanase supplementation of rye diets has been found to have adverse effects on digesta pH, viscosity and dry matter digestibility in piglets (Inborr *et al.*, 1991). Yet, piglets given b-glucanase-supplemented rye diets, and pentosanase- or b-glucanase-supplemented barley diets, showed no ill effects.

Role of fiber-degrading enzymes: Fiber in its various forms is a major cause of poor feed digestion especially in young animals. Even within a group of feedstuffs such as cereals, there is considerable variation in the amount and type of NSP they contain. The two main types of NSP found in cereals are the arabinoxylans (or pentosans) and the b-glucans. Arabinoxylans are made of a linear backbone of xylose substituted with arabinose (Bedford, 1995). b-Glucans are made up of a polymer of glucose which has kinks that are responsible for the antinutritional properties of barley and oats (Bedford, 1995). Given the typical arabinoxylan composition of wheat, the addition of a b-glucanase to a wheat-based diet will have significantly less effect than if it were added to a barley-based diet. Yet the addition of a xylanase (or pentosanase) to a wheat- or rye-based diet will have more effect than if it were added to a barley.

Role of phytase: Phosphorus is a major mineral required by animals in bone and is used in nerve and embryo development. Inorganic forms of phosphorus, although generally highly available, are relatively expensive. Plants store phosphate in the form of phytic acid which cannot be broken down by monogastric animals unless there is inherent phytase activity in the feed. The enzyme phytase breaks down phytic acid releasing six phosphate molecules, and has been available commercially since the mid-1990s. Addition of phytase to the diet allows substantially less inorganic phosphorus to be included in the diet and, as a result, reduces the amount of phosphorus excreted. Lower phosphorus waste is advantageous especially in intensively farmed environments where it is viewed as a pollutant.

Phytase, according to Jongbloed (1997), is used in greater than 80% of Dutch pigs feeds and has been partly responsible for a reduction of 60% in the excretion of phosphorus by pigs in Netherlands between 1973 and 1995. Phytase is also widely used in other parts of the world. Increasing environmental pressure for the inclusion of phytase in all animal diets is likely to continue. Unfortunately, addition of phytase, like other enzyme products, cannot be relied upon to release a fixed amount of phosphorus from every diet. Different ingredients have varying concentrations of Phytate phosphorus often called "phytin" phosphorus and an inherent level of plant phytase. This means that the availability of phytate phosphorus will be higher for ingredients with inherent phytase than would be expected from the concentration of phytate phosphorus.

Role of proteases: Many vegetable protein sources such as in soybean contain protease inhibitors, lectins and tannins which reduce animal performance. To remove the anti-nutritive effects of these compounds, legume seed is heat treated. Unfortunately heat treatment can reduce the availability of amino acids. As an alternative to heat treatment, enzymes have proved partially successful in deactivating anti-nutritional factors in legume seed (Bohme, 1997). For example, the addition of a protease to non-heat treated canola meal improved broiler chick growth (Simbaya *et al.*, 1996). Yet, it is in combination with other enzyme activities where proteases have been most successful. Two points are worth noting:

i. Multienzyme supplements containing protease have proven beneficial in both pigs and poultry.

ii. There is potential for further research into protease supplementation of non-heat-treated legume seed.

Feed enzymes are added to diets of many of the animal species we farm. The effectiveness of various types of enzymes is discussed for poultry, pigs and some aquaculture and ruminant animals.

Enzyme supplementation of poultry diets broilers: More than any other animal industry, it has been the broiler industry which has most widely adopted feed enzyme technology. Annison (1997) suggests that feed enzymes have proved successful with broilers, for the following reasons:

1. The digestive system of the chicken is relatively simple which makes it susceptible to digestive upsets that may be overcome by specific feed enzymes.

2. Considerable research effort into the additional enzyme activities required by chickens and the composition of feed ingredients has allowed nutritionists to target dietary components which at present either impair animal performance or are of no nutritional value without enzymes.

3. Research into the effects of feed enzymes in chickens can be done inexpensively, compared with larger animals. The favorable cost of research with chickens means observations can be made based on sound scientific principals in terms of statistics, chemistry and physiology. Also, experiments with broilers produce results quickly which in turn speeds up development of new products.

Broilers are particularly sensitive to the water-soluble polysaccharide content (mainly arabinoxyl) of cereals. The birds' sensitivity to water-soluble polysaccharides was detected when the apparent metabolizable energy content of approximately 25% of Australian wheat was found to be less than was predicted from proximate analysis and gross energy determinations (Rogel *et al.*, 1987). Annison (1991) showed that there is a negative correlation between water-soluble polysaccharide content (mainly arabinoxyl) and apparent metabolizable energy content. Therefore, any genetic or growing conditions which favor water-soluble polysaccharide production will reduce broiler performance. A rapid, cheap and effective method is required to measure soluble NSP, which will allow enzyme supplementation to be based on actual NSP content not typical values.

Enzyme supplementation of pig diets: Unlike the broiler industry, the pigs industry has been more cautious in accepting feed enzymes because the pig's response to them is less consistent. Compared with poultry, the efficacy of feed enzymes in pig diets has been less consistent. Young pigs rely on enzymatic digestion for the release of most of their nutrients, which means that they are more susceptible to anti-nutritional factors in their diet. By the time a pig reaches 50 kg, around 30% of its energy requirements come from fermentation in the hindgut (Rerat *et al.*, 1987).

Despite this two-pronged approach to digestion, some feed compounds are still not well utilized. Poor digestion of solid feed by piglets weaned at 21–28 days of age is especially obvious in the first 2–3 weeks after weaning (Cera *et al.*, 1988). Inappropriate choice of feed ingredients at this time can produce diarrhea, due in part to a lack of pancreatic and intestinal enzyme activity and/or by the colonization by enterotoxigenic coli bacteria (Cera *et al.*, 1988).

The lack of pancreatic and intestinal enzyme activity results in more nutrients passing through the digestive system rather than being absorbed by it. These nutrients provide the substrate for pathogenic bacteria such as *Escherichia coli* which produce enterotoxins (affecting the enterocytes in the wall of the intestine). These in turn increase intestinal secretions and further reduce digestion and absorption. Removal of dietary ingredients which may produce diarrhea or hypersensitivity reactions often means providing diets with minimal vegetable protein meals and cereals which are low in fiber and are more expensive.

Feed enzymes in aquaculture: Aquaculture has been relatively slow to adopt feed enzyme technology. This is possibly due to its reliance, until recently, on fish meal as the sole or major source of protein, especially for carnivorous species. Fish meal is highly digestible and meant there was little to be gained by adding either protease or carbohydrases.

Yet, in recent years, the world catch of wild fish has begun to decline and alternatives to fish meal protein have been sought Plant feed sources are cheaper than fish meal but are also higher in fiber and anti-nutritive factors such as phytin, gossypol, trypsin inhibitors, lectins, etc. Therefore, feed enzymes, now more than in the past, have a significant role to play in increasing the utilization of plant protein sources by aquaculture species. Experience from other animal species would suggest the young animals grown under aquaculture conditions should benefit most from the inclusion of feed enzymes. However, research with small fish, as with immature land animals, has produced variable responses to enzymes.

Kolkovski *et al*. (1997) found the feed intake and growth of sea bass larvae (*Dicentrarchus labrax*) were unaffected by a pancreatic enzyme supplement.

Most research with feed enzymes in aquaculture species has added the enzyme supplement to the whole diet. In contrast, Cain and Garling (1995) gave rainbow trout (*Onchoryhnchus mykiss*) diets containing phytase-treated or untreated soybean meal. Phytase treatment either produced equal or better trout growth rates and FCE than those given the control diet. The efficiency of phytase action can depend on the weight of the fish. Phytase supplementation reduced effluent PO_4 by 65% with 2g fish compared with 88% for fish weighing 17 g. These results show that inclusion of phytase can reduce the amount of inorganic Phosphorus required in fish diets by increasing the availability of Phosphorus in plant feed ingredients. In addition, the Phosphate/phosphorus concentration of fish effluent can be reduced by phytase supplementation, which may have significant implications for water quality.

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