IS SRI LANKA READY TO USE ALTERNATIVE FEED INGREDIENTS IN POULTRY DIETS?

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INTRODUCTION

Even the most optimistic forecasts do not guarantee that the animal feed industry can meet the future global requirements for traditional feed ingredients such as maize and soybean meal. Therefore, obtaining quality and sustainable feed ingredients at acceptable prices has become a significant challenge for the animal feed industry and is increasingly attended by nutritionists globally. In the Sri Lankan context, this issue has become a primary concern due mainly to the current escalation of raw material prices and the scarcity of imported raw materials and feed additives. The potentials of using alternative feed ingredients (AFI) in poultry diets are therefore increasingly discussed as a solution for this current crisis.

Alternative feed ingredients are generally referred to as feed ingredients available locally but not regularly included in commercial poultry diets, and their nutritional value and optimum inclusion level are not well defined (Dale, 2008). Despite their evident potential of being used in poultry diets, their use has been limited due to several nutritional, technical and socio-economic constraints and several strategies of overcoming these limitations have been developed. This review aims to discuss the challenges and opportunities of using AFI in poultry diets from a Sri Lankan perspective.

THE ‘MAIZE’ ISSUE

The feed cost accounts for 70% of the total cost of production of poultry operations. Maize is considered one of the high-quality cereals with minimum anti-nutritive effect on poultry. In Sri Lanka, however, being considered a human food item as tender green cobs and dried grains for *Thriposha* (a processed food item for pregnant and lactating mothers and infants) production, only a part of the local supply of maize is available for compounded feed manufacturing, indirectly restricting the industry's growth. Until 2005, up to 70% of the requirement for animal feed production, was imported and 2005 onwards, the attention was paid to lower the imported maize quantities by increasing the use of locally produced maize in feed formulation (Premarathne & Samarasinghe, 2020). For the year 2019, only 33% of maize that used for animal feed production was imported (Department of Animal Production and Health, 2020a). When the government's import ban on maize was imposed 15th January 2020 onwards to safeguard the local maize cultivators, Sri Lanka was not completely prepared to locally meet the demand for maize by poultry farmers. The maize import ban was implemented without precautions to face consequent limitations and therefore caused critical consequences on the poultry industry in Sri Lanka. One such consequence was increase of average price of maize (E.g., Rs. 68.58 in 2019 to Rs. 80.31 in 2020; Livestock statistical bulletin, 2020) which resulted in higher prices of compounded feed mainly for poultry birds. Even though wheat importations were allowed to replace maize, most stakeholders, in particular self-mixing poultry farmers, were not equipped with the necessary knowledge and access to the technology (E.g. enzymes) to overcome anti-nutritive factors present in wheat. Therefore, the use of wheat in poultry feed could not be considered a suitable alternative for self-mixed feed producers

(Department of Animal Production and Health, 2020b)

Moreover, the continuous depletion of the Sri Lankan rupee against the United States dollars affects the importation of essential feed ingredients that cannot be produced in Sri Lanka at sufficient levels to meet the demand for manufacturing poultry feed (E.g. soybean meal, fish meal). Detrimental consequences of this scenario are reflected in a 33% reduction in total self-mixed poultry feed production, in 2020, compared to 2019 (Department of Animal Production and Health, 2020b). In this context, the utilisation of locally available AFI is now getting increasing attention.

ALTERNATIVE FEED INGREDIENTS

Each region has its own range of AFI, and their feeding value has been evaluated locally. The rich biodiversity, availability of arable lands, and establishment of agro-industries in Sri Lanka support the sourcing of potential AFI. Information systems on globally available feed resources such as National Research Council, Spanish Foundation for the Development of Animal Nutrition (FEDNA), and web-based data sources such as Feedipedia (https://www.feedipedia.org/content/about-feedipedia) and AMINODat® are more established and published mainly in English medium. Comparatively, information systems on locally available feed resources are limited (Samarasinghe et al., 2007) and mostly inaccessible to the self-mixing poultry farmers.

Abdollahi & Ravindran (2019) listed few factors that determine the regular use of an alternative feed ingredient in animal feed formulation. First, for regular use in the commercial poultry feed formulation, a particular ingredient should be available in economic quantities, even if its availability is seasonal. Feed costs account for more than 70% of the total cost of production, and hence, the choice of ingredients should always be economical. Accordingly, AFI should hold a competitive price against conventional ingredients to justify their regular use in poultry diets. Furthermore, the level of understanding on nutritive value, variation, and digestibility of AFI would determine their regular use in poultry diets.

Limitations of using alternative feed ingredients

For an effective use of AFI in poultry diets it is important to understand the factors that can limit their use which can be categorized into nutritional, technical and socio-economic factors (Ravindran & Blair, 1991).

Nutritional limitations

The majority of the AFI are rich in anti-nutritional factors causing variability in nutrient composition and quality. High contents of non-starch polysaccharides can lower the metabolizable energy content (Perera et al., 2019a) hence decreasing the feeding value of such ingredients for poultry birds. When fibrous and poorly digested ingredients are used in poultry diets, it is recommended to formulate the diets based on the metabolizable energy and digestible amino acids (AA; Ravindran et al., 2005) enabling higher range and inclusions of AFI in poultry diets.

Abdollahi et al. (2016) used apparent metabolizable energy (AME) and digestible AA content of a palm kernel meal (Abdollahi et al., 2015) to formulate broiler diets, and reported that palm kernel meal can be included in broiler diets up to 16% with no deleterious effects on growth performance. Similarly, Perera et al. (2019b) used AME and digestible AA contents (Perera et al., 2019a) to formulate barley-based diets for broiler starters and reported that barley could be included up to 28.3% without compromising the growth performance.

Nevertheless, limited information is available on digestible AA and metabolizable energy content of AFI and new research can be laborious and need intended research and accredited laboratory facilities (Zaefarian et al., 2021). Furthermore, when even the table values on the chemical composition of AFI specific to Sri Lanka is comparatively limited to the majority of stakeholders in the Sri Lankan context, the access to the digestible AA and metabolizable energy can be more challenging and, therefore, justifies studies to fill the gaps on nutrient profiles of ingredients specific to Sri Lanka. Awareness of the prerequisite of using AME and digestible AA contents to formulate poultry diets, especially when poorly digested nutrients are used, should be built in stakeholders of the Sri Lankan animal feed industry. Moreover, the already published information on nutrient profiles should be easily accessible to the farmers.

When the AFI lack essential AA resulting in poor protein quality, it may create a need to supplement synthetic AA, adding the cost. In addition, when toxic factors are present in AFI such as cassava (Samarasinghe, 2007), it may require prior processing steps to overcome the anti-nutritional impact. A comprehensive discussion should be initiated to enable the commercial feed manufacturers and self-mixing producers to manipulate conditions to minimize the anti-nutritive impact of AFI and thereby increase inclusion in poultry diets.

Progress in biotechnology during the past two decades has offered new opportunities to enhance the productivity animals mainly through the development of enzymes. Compared to the anti-nutritive free maize, wheat was rich in arabinoxylan which can results in increased digesta viscosity when fed to poultry (Shakouri et al., 2009). The use of non-starch polysaccharides degrading enzymes (carbohydrases), in particular, xylanases is vital when using wheat in animal feed formulation (Ravindran, 2013). However, this knowledge on application was not readily available mostly to the medium-and scale farmers in Sri Lanka who are self-mixing the feed for their flocks.

In relation to AFI, feed enzymes can enable the use of certain ingredients in which otherwise may not be possible to use in poultry diets. When higher inclusion levels are detrimental to the nutrient utilisation and growth performance, added enzymes can minimise or eliminate the nutritional constraints and enable higher inclusion levels (Abdollahi & Ravindran, 2019). Moreover, supplemental enzymes can reduce variability in the nutritive value between batches (Kocher et al., 1997). Eventually, feed enzymes will increase the range of ingredients used in feed formulations.

It is necessary to understand and educate the feed manufactures about the substrate specificity of the enzymes, that the enzymes act only on a specific site on a specific substrate (Ravindran, 2013). To use enzymes in novel AFI, the chemical composition and structure of the target substrates should be studied beforehand to know the exact nature of the substrate and therefore to find the suitable enzyme and determine the optimum dosage.

Technical limitations

Several technical limitations can challenge the use of AFI in poultry diets. For example, when AFI are bulky or powdery in texture in particular in different plant-origin meal types, the storage and, handling of such ingredients can be problematic. Moreover, if those ingredients are higher in moisture content (e.g., fruit and vegetable waste, slaughterhouse by-products), it may create logistic issues in the collection, storage and delivery. Overall, Unfavourable physical characteristics may necessitate relatively expensive further processing steps such as drying and, physical and thermal processing.

Application of proper feed processing practices such as pelleting and extrusion, can enable increased use of AFI in formulation of poultry diets mainly through inactivation of anti-nutritional factors, and break-down of cell wall matrix exposing cell-encapsulated nutrients to digestive enzymes (Amerah et al., 2011). Nevertheless, caution should be taken in application of extreme thermal processing conditions to the ingredients that are rich in non-starch polysaccharides due mainly to the risk of exacerbating the adverse effects of viscosity (Samarasinghe et al., 2000; Perera et al., 2021). Moreover, information on the thermostability of different enzyme products should be clearly available to meet intended effect of adding the enzymes.

Socio-cultural limitations

When a particular feed ingredient is utilized as a human food item, it may require a strong justification for using them in animal feed production. For example, in 2005, when locally produced rice was increasingly used to replace maize in animal feed formulation, the government had to ban using rice in animal feed production to stabilize the rice prices in the local market (Premarathne & Samarasinghe, 2020).

Farmers lack the desire to plant feed crops, especially when they have low prices than other arable crops. On the other hand, when feed manufacturers and self-mixing poultry producers have to pay a high cost per unit of energy or essential AA relative to conventional sources, AFI can become less attractive for use in poultry diets.

Black soldier fly larvae is one of the novel alternative protein ingredients that is getting popularity worldwide. Black soldier fly larvae on average contains 36–39% protein and 28–34% lipid (Weththasinghe et al., 2021), making it a potential alternative protein ingredient (Wang & Shelomi, 2017). There is an apparent limitation in popularising the insect larva rearing for mass production in Sri Lanka due probably to social stigmas and religious concerns, which need to be surveyed beforehand.

A practical example from Sri Lanka

One typical example of an AFI available in Sri Lanka, jackfruit (*Artocarpus heterophyllus*) seeds can show the relevance of the discussed limitations in this review. Jackfruit seeds are abundant of starch, which makes up approximately 60–70% of its dry weight (Wong et al., 2021) and hence shows the potential of replacing maize in poultry diets. Ravindran et al. (1996) evaluated jackfruit seed as an alternative feed ingredient replacing maize in chick diets. Unprocessed jackfruit seeds inclusion at 125 and 250 g /kg diet severely depressed growth performance and increased mortality in chicks due mainly to the presence of lectins and trypsin inhibitors creating a toxic effect in raw jackfruit seed meal. Therefore, moist-heat treatments that involved the steps of chopping, cooking jackfruit seeds in boiling water, sun drying and grinding the dried materials through a hammer mill were applied to the raw jackfruit seed meal. Following the treatment, the anti-nutritional impact of lectin and trypsin inhibitors were eliminated. Consequently, the feeding value of processed jackfruit seed meal was comparable to that of maize up to 250 g/kg diet.

In practical situations, the knowledge of the requirement and clear instructions on the necessary steps of the prior processing of the jackfruit seeds should be made available to the farmers. Overall, limitations concerning jackfruit seeds such as their use as a human food item, seasonal supply, the requirement for additional efforts in collecting jackfruit seeds, the need for technical knowledge for prior processing may limit the frequent use of jackfruit seeds in poultry diets. To the author's knowledge, the digestible AA and metabolizable energy content of jackfruit seed meal are not studied and, therefore, not available in the literature. Moreover, phytic acid and other non-starch polysaccharides in jackfruit seeds (Ravindran et al., 1996) warrant the supplementation of phytate and carbohydrases, and the application of thermal processing should consider the maximum thermostability of any added enzymes. Likewise, the limitations and prospects will vary depending on the ingredient in hand.

ADDITIONAL REMARKS

When the importation of essentials in animal feed formulation, such as feed ingredients and additives, has been challenged by the prevailing economic crisis in the country, the attention should also be focused on the effective utilisation of the available resources.

Improved feed efficiency through enhanced fore-gut development

The efficacy of feed conversion into meat is known as feed efficiency, and it is commonly looked at to evaluate the efficacy of a poultry production system. The pressure of the antibiotic ban upon the poultry industry in the past years has led to sourcing alternatives for antibiotic growth promoters. At the global level, attention is being paid to alternatives for not only antibiotic growth promoters but also for other additives in order to improve feed efficiency. Accordingly, increasing attention is being paid to investigating the potential of enhancing the feed structure and promoting foregut development.

Rodrigues and Choct (2018) discussed the benefits of re-establishing the ancestral roles of the foregut of feed storage (crop) and feed grinding (gizzard) as a way of naturally enhancing the gut health of poultry and hence avoiding over-supplementation of additives in the diets. The benefits of the development of the foregut, in particular, gizzard, on feed efficiency and nutrient utilisation, has been well documented (Svihus, 2011a,b). Gizzard has been identified as a key site for regulating the digestibility of starch by preventing starch overload into the lower gut, and a positive correlation between gizzard weight and starch digestibility has been reported (Svihus, 2011b). As the primary energy-yielding nutrient, improved digestibility in starch can enhance energy utilisation and positively contribute to the performance of broilers (Perera et al., 2019b, 2020). The potential reduction of gizzard pH is an objective for which several feed additives (e.g., organic acids, prebiotics, and probiotics) are often supplemented through gizzard development (Perera et al., 2020). Promotion of foregut development by inclusion of insoluble fibre sources (Hetland et al., 2004), coarse cereal particles (Amerah et al., 2007) or whole grains (Singh et al., 2014) in the poultry diets has been found to prevent potentially pathogenic bacteria from entering the intestinal tract (Engberg et al., 2004). Out of these methods, the inclusion of insoluble fibre sources sounds more promising in the Sri Lankan context due to lesser technicality and more straightforward application by even small and medium scale poultry farmers. Such practices could bring immediate and enormous savings for producers and therefore should be evaluated in Sri Lankan context.

Proper ‘feed’ management practices

Contributing to the total cost of production by more than 70%, feed cost represents one of the main cost components in poultry operations. However, whilst the attention is always focused on increasing the input, effective utilisation of the feed resources that can support the economics of poultry operations are commonly overlooked.

Under poor management of feed resources, the expensive and limited feed resources will be added to the litter and wasted. Therefore, proper management practices should be encouraged to reduce feed wastage. Poor practices in feed management in the poultry houses should be minimised because this is wasteful, and excess nutrients are excreted in the manure and are ultimately a source of pollution. An excessive amount of feed waste on the ground may also attract rats and rodents, eventually creating a pest problem. Therefore, the farmers should always select the best feed form and maintain the correct feeder height and space.

An increased feed intake is a primary motivation for pelleting poultry diets (Abdollahi et al., 2013). Moreover, pelleting prevents birds from selecting larger particles from mash feed and the messy sorting and segregation of the feed particles in the feeders, which may cause the feed to be pushed out of feeders and increase feed wastage. However, the durability of the provided pellets should be a matter of concern as poor quality pellets will not meet the objectives of pelleting. Therefore, commercial feed manufacturers should guarantee higher durability, and frequent testing of the pellet durability index should be conducted. In addition, poor handling of the commercial feed bags that come in sizes of 25kg and 50kg, during loading and unloading, can result in crushing of the pellets that can result in increased waste in the poultry house.

CONCLUSIONS

In order to overcome the current crisis in the Sri Lankan animal feed industry, attention should be paid to formulating the least-cost diets that would not compensate for the nutritional requirements or production levels. Sourcing of potential AFI sounds promising; however, it is vital to realise the complexity of the associated limitations. Accordingly, nutritionists should apply multi-dimensional strategies to overcome these limitations and acquired knowledge should be made available from top to bottom of the stakeholders involved in the animal feed industry in Sri Lanka.

REFERENCES

Abdollahi, M. R., & Ravindran, V. (2019). Alternative feed ingredients for poultry diets: challenges and prospects. In Proceedings of the Australian Poultry Science Symposium (Vol. 30, pp. 102-108). Sydney, Australia.

Abdollahi, M. R., Hosking, B. J., Ning, D., & Ravindran, V. (2016). Influence of palm kernel meal inclusion and exogenous enzyme supplementation on growth performance, energy utilization, and nutrient digestibility in young broilers. Asian-Australasian Journal of Animal Sciences, 29(4), 539.

Abdollahi, M. R., Hosking, B., & Ravindran, V. (2015). Nutrient analysis, metabolisable energy and ileal amino acid digestibility of palm kernel meal for broilers. Animal Feed Science and Technology, 206, 119-125.

Abdollahi, M. R., Ravindran, V., &Svihus, B. (2013). Pelleting of broiler diets: An overview with emphasis on pellet quality and nutritional value. Animal Feed Science and Technology, 179(1-4), 1-23.

Amerah, A. M., Gilbert, C., Simmins, P. H., & Ravindran, V. (2011). Influence of feed processing on the efficacy of exogenous enzymes in broiler diets. World's Poultry Science Journal, 67(1), 29-46.

Amerah, A. M., Ravindran, V., Lentle, R. G., & Thomas, D. G. (2007). Feed particle size: Implications on the digestion and performance of poultry. World's Poultry Science Journal, 63(3), 439-455.

Dale, N. (2008). http://www.thepoultrysite.com/articles

/1185/alternative-feed-ingredients-anoption-to-combat-high-feed-prices/

Department of Animal Production and Health (2020a), Annual Report Department of Animal Production and Health, Getambe, Sri Lanka.

Department of Animal Production and Health (2020b) Poultry Sector Analysis and Forecast, Getambe, Sri Lanka

Engberg, R. M., Hedemann, M. S., Steenfeldt, S. & Jensen, B. B. (2004). Influence of whole wheat and xylanase on broiler performance and microbial composition and activity in the digestive tract. Poultry Science, 83, 925-938.

Hetland, H., Choct, M., &Svihus, B. (2004). Role of insoluble non-starch polysaccharides in poultry nutrition. World's Poultry Science Journal, 60(4), 415-422.

Kocher, A., Hughes, R. J., & Barr, A. R. (1997). β-Glucanase reduces but does not eliminate variation in AME of barley varieties. Proceedings of the Australian Poultry Science Symposium (pp. 142-145). Sydney, Australia.

Livestock statistical bulletin (2020). Department of Animal Production and Health, Getambe, Sri Lanka.

Perera, W. N. U., Abdollahi, M. R., Ravindran, V., Zaefarian, F., Wester, T. J., & Ravindran, G. (2019a). Nutritional evaluation of two barley cultivars, without and with carbohydrase supplementation, for broilers: metabolisable energy and standardised amino acid digestibility. British Poultry Science, 60(4): 404-413.

Perera, W. N. U., Abdollahi, M. R., Zaefarian, F., Wester, T. J., & Ravindran, V. (2020). The interactive influence of barley particle size and enzyme supplementation on growth performance, nutrient utilization, and intestinal morphometry of broiler starters. Poultry Science, 99(9), 4466-4478.

Perera, W. N. U., Abdollahi, M. R., Zaefarian, F., Wester, T. J., & Ravindran, V. (2021). High steam-conditioning temperature during the pelleting process impairs growth performance and nutrient utilization in broiler starters fed barley-based diets, regardless of carbohydrase supplementation. Poultry Science, 100(8), 101166.

Perera, W.N. U., Abdollahi, M. R., Zaefarian, F., Wester, T. J., Ravindran, G., & Ravindran, V. (2019b). Influence of inclusion level of barley in wheat-based diets and supplementation of carbohydrase on growth performance, nutrient utilisation and gut morphometry in broiler starters. British Poultry Science, 60(6):736-748.

Premarathne, S., & Samarasinghe, K. (2020). Animal Feed Production in Sri Lanka: Past Present and Future. In Agricultural Research for Sustainable Food Systems in Sri Lanka (pp. 277-301). Springer, Singapore.

Ravindran, V. (2013). Feed enzymes: The science, practice, and metabolic realities. Journal of Applied Poultry Research, 22(3), 628-636.

Ravindran, V., & Blair, R. (1991). Feed resources for poultry production in Asia and the Pacific region. I. Energy sources. World's Poultry Science Journal, 47(3), 213-231.

Ravindran, V., Hew, L. I., Ravindran, G., & Bryden, W. L. (2005). Apparent ileal digestibility of amino acids in dietary ingredients for broiler chickens. Animal Science, 81(1), 85-97.

Ravindran, V., Ravindran, G., &Sivakanesan, R. (1996). Evaluation of the nutritive value of Jackseed (*Artocarpus heterophyllus*) meal for poultry. The Journal of Agricultural Science, 127(1), 123-130.

Rodrigues, I., &Choct, M. (2018). The foregut and its manipulation via feeding practices in the chicken. Poultry Science, 97(9), 3188-3206.

Samarasinghe, K. (2007). Feeds and feed formulation for poultry in Sri Lanka. Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

Samarasinghe, K., Messikommer, R., &Wenk, C. (2000). Activity of supplemental enzymes and their effect on nutrient utilization and growth performance of growing chickens as affected by pelleting temperature. Archives of Animal Nutrition, 53(1), 45-58.

Shakouri, M. D., Iji, P. A., Mikkelsen, L. L., &Cowieson, A. J. (2009). Intestinal function and gut microflora of broiler chickens as influenced by cereal grains and microbial enzyme supplementation. Journal of Animal Physiology and Animal Nutrition, 93(5), 647-658.

Singh, Y., Amerah, A. M., & Ravindran, V. (2014). Whole grain feeding: Methodologies and effects on performance, digestive tract development and nutrient utilisation of poultry. Animal Feed Science and Technology, 190, 1-18.

Svihus, B. (2011a). The gizzard: function, influence of diet structure and effects on nutrient availability. World's Poultry Science Journal, 67(2), 207-224.

Svihus, B. (2011b). Limitations to wheat starch digestion in growing broiler chickens: a brief review. Animal Production Science, 51(7), 583-589.

Wang, Y. S., &Shelomi, M. (2017). Review of black soldier fly (*Hermetiaillucens*) as animal feed and human food. Foods, 6(10), 91.

Weththasinghe, P., Hansen, J.Ø., Mydland, L.T., &Øverland, M., (2021). A systematic meta‐analysis based review on black soldier fly (*Hermetiaillucens*) as a novel protein source for salmonids. Reviews in Aquaculture.

Wong, K. T., Poh, G. Y. Y., Goh, K. K. T., Wee, M. S. M., &Jeyakumar Henry, C. (2021). Comparison of physicochemical properties of jackfruit seed starch with potato and rice starches. International Journal of Food Properties, 24(1), 364-379.

Zaefarian, F., Cowieson, A. J., Pontoppidan, K., Abdollahi, M. R., & Ravindran, V. (2021). Trends in feed evaluation for poultry with emphasis on in vitro techniques. Animal Nutrition, 7(2), 268-281.