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Recent knowledge on the use of feed enzyme in view of the quality of feed resources

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Abstract. Several issues that would be challenging upon practical use of dietary enzyme were proposed and discussed. Five issues were raised in view of current feed resources and quality. Whether the dietary enzyme supplementation to ruminant animal is worth it was discussed by comparing the type of enzyme on rumen hydrolysis as well as milk production performance. A derivative action following the enzyme specific hydrolysis was discussed when it would be probably occurring in feed having complex substrate. Single or multiple combination enzymes were discussed whether and when each would be worth. Finally, whether the effect of enzyme would be different by either sex or age of animal was also discussed.

Key words: Dietary enzyme, Dairy cow, Derivative hydrolysis, Multiple enzymes, Age of poultry

1. Introduction

Enzyme supplementation to animal feed became the issues of interest in animal feed industry recently. The interest is likely induced by the increasing use of unconventional and rather poor quality feed resources. Along with that, many feed enzyme products have released with rather enticing prices. Upon using enzymes in the field however, all potential user have to confront many queries and uncertain issues although all enzyme products claim that they are equipped with stronger merits and breakthrough modes of action. But the reality still remains at the general knowledge of enzyme at large. Further, either science or enzyme developer would not be likely to give the solution for those various queries since the queries may not be developer's primary concern. Therefore, this paper intended to suggest and discuss about the several queries that could be raised by actual enzyme user.

In this paper, queries were raised if the query situation is likely happening in the field although no answer or solution is given yet. Following five queries were selected as issues for discussion. First of all, availability and reliable supply of feed resources became a huge challenge for the most part of the world especially tropical countries due to increasing animal production. Therefore, relatively poor quality and unconventional feedstuffs have been widely used for animal feed formulation to meet with the demand and to reduce the cost of the feed. However, this situation inevitably accompanies poor digestion of the feed thereby shortfall of the nutrients needed for the expected growth. Thereby, many feed formulator consider the use of feed enzyme even for ruminant animal although there are little scientific background yet. Whether enzyme supplementation to ruminant animal feed could be effective or not were not known yet. Secondly, more complex and diverse formulation became an unavoidable routine for the feed formulator especially in countries importing various feed ingredients. As a counter measure against those

challenge of various substrates, multiple enzymes combined supplementation has suggested. Therefore, this paper discusses whether a specific enzyme could affect other nonspecific substrate and whether multiple enzymes supplementation is worth it nevertheless the different circumstances and goals. Finally, separated feeding by either sex or age of animal has recommended as a precision feeding scheme recently. Discussion on whether the action of enzyme could be different according to sex or age of animal is followed. Overall, this paper intends to discuss the queries by compromising the result of several field studies with the basic principle of enzyme action thereby to suggest the possible solution.

2. Issues in feed enzme use

2.1. Could the enzyme supplementation to ruminant animal feed be effective?

Enzyme supplementation to ruminant animal diet has been rarely practiced since the ingested feed including enzyme primarily faces rumen and rumen microbial action. It is well known that the most of ingested feed can be hydrolyzed via the rumen and rumen microbial action unless the feed are protected. Thereby comparing the portion of hydrolysis by exogenous enzyme with whole portion, possible hydrolysis by exogenous enzyme have neglected as a meaningful route for feed nutrition. Could that assumption be still meaningful when the quality of feed are less- favorable for rumen hydrolysis and microbial action? In reality, the poor quality roughages and protein ingredients have been more or less used in almost every part of the world. That is also generally actual even in tropical and subtropical region where they have abundant amount of natural roughage resources. Exception would be a few region having good quality forages and grazing land.

Thereby, use of exogenous enzyme has suggested as a measure to alleviate the poor digestion problem although not much knowledge is available yet. Effect of enzyme supplementation varies by the quality of ingested feed including intake amount, type of enzyme, amount and structure of respective substrate in the feed, supplementation method and condition and certainly animal itself.

2.2. Degree of enzyme action is related with the ingested feed?

Primary role of enzyme is the hydrolysis of each respective substrate. However, degree, speed and mode of the hydrolysis varies with the physicochemical characteristic and amount of the substrate in the feed. Most of enzymatic hydrolysis is initiated by surface to surface contact between enzyme and substrate. If enzyme is sufficient, then degree of the contact is mainly decided by the availability of the substrate. Most of poor quality roughage contain relatively larger proportion of complex structure, including lignocellulosic matrix. In addition, poor quality protein feedstuffs also contains larger portion of protein-cellulose complex and cell wall trapped protein.

Those complex structures certainly need more time to be physically loosened enough and be ready for the surface to surface contact. It can be therefore hypothesized whether exogenous enzyme supplementation could contribute for accelerating the hydrolysis. In vitro and in sacco study(Lee, 2019) showed that exogenous enzyme supplementation is able to affect the rumen hydrolysis. Three type of feeds that are different in physicochemical characteristics were subjected for the above study. Those were tall fescue hay, lower (50° C) and higher (80° C) temperature pellet feeds. Degree and on set time of rumen hydrolysis were affected by either fiber hydrolyzing enzyme or protease supplementation. However, the degree and on set time were varied by the type of feed. Both in vitro digestibility and in sacco VFA production of pellet feeds were higher than that of tall fescue. Between lower and higher temperature pellet, degree of digestion and amount of VFA were higher in lower temperature pellet. High temperature processing could change the physical structure of feed by denaturation and compaction, which is able to retard the contact. It can therefore speculate that benefit by exogenous enzyme could be relatively remarkable if the ingested feed carries higher amount of complex structure. In another word, enzyme

supplementation would be needed when to use rather poor quality feed resources.

2.3. What type of enzyme would be appropriate?

Not much practical information is available to recommend the suitable enzyme for ruminant animal yet. Nevertheless, enzymes that could exert optimal enzyme activity in rumen-like temperature and pH condition should be selected at least. It would be better if an exogenous enzyme is able to conform to and to conciliate with the rumen endogenous enzyme as well as microbiota and rumen environment. Since bacteria is major microbiomes in typical rumen microbial community, it could hypothesize that fungal microbiomes would be less competitive. However, it is virtually impossible to assess the conformity at each different circumstance. In addition, there are not many enzyme products in the market especially for ruminant animal. Although three group of enzyme products by its origin are in the market, no information is known yet what would be the difference among plant-, bacterial- and fungal- enzymes. A comparative genomics study(Haitjema et al., 2017) found that cellulosomes in fugal enzyme would be less species-specific than that of bacterial enzyme, then suggested better breakdown of cellulose. Lee(2019) selected the fungal enzyme among three after *in vitro* and *in sacco* evaluation.

2.4. Could dietary enzyme on ruminant affect the practical performance?

It is too early to discuss whether the dietary enzyme could affect the performance due to limited amount of field study information, that are even varied study by study. No enzyme study had tested the suitability of an enzyme in rumen condition before dietary supplementation. Further, no study had evaluated the effect of dietary enzyme on performance by referring the quality of feed. Lee(2019) evaluated dietary fungal fibrolytic enzyme and fungal protease on the performance and milk quality in dairy cow recently. Fungal fibrolytic enzyme supplementation to diet containing tall fescue and oat hay increased daily milk yield significantly. In addition, the milk somatic cell count was lowered in dairy cow when fed dietary enzyme. Fungal protease supplementation increased milk protein and total milk solid although no difference was found in daily milk yield. The fungal protease also decreased the milk somatic cell count. Result of dairy cow study (Lee, 2019) would not be sufficient to support the practical benefit on performance by dietary enzyme. However, authors could hypothesize that performance of dairy can be improved when the appropriate enzyme is selected and when there is a contribution potential for enzyme in feed quality. Since the average daily milk yield(Lee, 2019) were on the range of 30 kg, the cow are believed in very critical stage in term of nutrients supply and demand status. This means even a little improvement in nutrient supply could contribute for the performance.

2.5. Could an enzyme exert derivative action along with the specific hydrolysis on its respective substrate?

It has been well known that action of enzyme is substrate-specific as illustrated by key and lock model. However, result of practical studies frequently showed that the remarkable improvement in digestibility of nutrients that were not the specific substrate for the supplemented enzyme. Those results could be explained by derivative action following preceded hydrolysis of specific substrate which is used as a part of whole matrix or entrapped structure in the ingested feed. Therefore, derivative action also occurs in another part of the matrix. Several studies(Lee, 2019; Lee, 2010; Lee et al., 2013) that applied fiber hydrolyzing enzyme, protease and β-mannanase showed improvements on hydrolysis and digestibility of enzyme-specific substrate as well as non-specific nutrients. However, most of phytase supplementation, although the references were not enlisted, only affect to its specific substrate and have not exerted derivative action to other nutrients except phosphorus. How there is such difference between phytase and other enzymes? That could be attributed to the amount of the enzyme-specific substrate in slowly

hydrolyzing structure in the feed. Amount of both phytin and phytin bound phosphorus are not high therefore amount of nutrients that could be potentially subjected to other enzyme action is also limited. β-mannanase was supplemented to broiler diet included with or without high mannan coconut meal(Lee, 2010) and to laying hen diet included with high mannan palm kernel meal(Lee *et al.*, 2010). Result of two studies showed improved utilization of protein and fat by the mannanase. In addition, the body weight gain in broiler(Lee, 2010) and hen day egg production in laying hen(Lee *et al.*, 2010) were also higher in the enzyme group than no enzyme group.

2.6. Could the multiple enzyme supplementation be worth it?

There have been increasing interest whether the multiple enzymes supplementation could exert better benefit. It would be theoretically reasonable to supplement all enzymes according to the proportion of each substrate. However, this theory remains as just theory since it is impossible to quantify the amount of endogenous enzymes for each meal of animal. Several multi-enzyme products for non-ruminant animal have entered to the market though it is still early to explain whether the multi-enzyme supplementation is worth it. Seo (2018) evaluated a multi enzyme products(10 different enzymes cocktail) in broiler. The multi-enzyme supplementation improved body weight gain and feed conversion ratio of broiler. One interesting result from nutrient utilization trial was the improved utilization of starch in the multi-enzyme supplementation group. Main starch hydrolyzing enzyme, amylase is an endogenous enzyme and generally believed to be secreted sufficiently. Considering the multi-enzyme products having four NSP enzymes and three proteases as well as three amylases, it could speculate that a kind of derivative action could trigger and increase the starch hydrolysis. In addition, the result of Seo (2018) brought somewhat delicate action by each enzyme since the multi-enzyme product was supplemented to rather good quality corn-soybean meal diet. Although the result could be a kind of proof for supporting the benefit of multi-enzymes, but it does not tell any cost-benefit effectiveness of the multiple enzyme supplementation. Certainly more studies are needed to know what would be the ideal cocktail ratio among each enzyme and what quality feeds would fit to the multi-enzymes.

2.7. Does the sex affect the response of animal fed dietary enzyme?

Growth rate of male animal especially broiler is faster than that of female, that accompanies the more supply of nutrients for the growth. For this context, a query is suggested to know whether there is a difference between male and female animal on response by enzyme supplementation especially to poor quality feed. Not many studies have evaluated the difference by far although female and male separate feeding management has already suggested as a way to implement the modern precision feeding. Seo(2018) compared the performance parameter using male and female broiler fed dietary enzymes although rather good quality corn-soy based diet was used. Percent improvement on weight gain of male was bigger than that of female. Instead, both feed conversion ratio and nutrients utilization of female were improved with more magnitude as compared to male broiler. Improved feed conversion ratio of female probably attributed by more decrease in feed intake and the intake decrease could escalate the nutrients utilization. However, this result suggest that nutrient supply would easily become not enough for the fast growing male broiler even fed good quality feed. Then, the enzyme could attribute certain role for increasing nutrients supply. In another word, this kind of nutrient shortage could be serious when to feed poorer quality feed. In other animal like piglet, female to male separate feeding of piglet has also practiced to reduce the aggressive behavior, though no study have compared the effect of enzyme by sex of animal. Therefore, enzyme study need to be expanded to other animals including laying hen, lactating cow and reproductive purpose animal to fully elucidate the sex characteristic response by dietary enzyme .

2.8. Does the age affect the response of animal fed dietary enzyme?

It would be ideal for feeding animal when to precisely meet the nutrient demand according to the age of animal. Path of growth and production of animal changes with age of animal as well as cycle(phase) of production. However, little knowledge is known yet how to precisely nurture the animal following the demand of each path and cycle. Dietary enzyme could be suggested as one of the tool to design the age-associated feeding regime. Magnitude of improvement by enzyme on nutrient utilization, feed conversion ratio and weight gain were relatively more remarkable in grower-finisher phase of broiler than those of starter phase(Seo, 2018; Lee, 2010; Ko et al, 2019), regardless of feed quality. Those result would be explained by higher amount of nutrients demand during fast growing phase. That explanation could be supported by the improved utilization of energy supplying nutrients in finisher stage broiler. It is also natural to speculate that the nutrient utilization could be higher when the animal got the signal of shortage in nutrient supply with more likely upon consuming poor quality feed.

Effect of age was also evaluated using aged laying hen (Lee et al., 2013). Since the old aged hens are known to consume less feed and to lay less egg, it is hypothesized that feed nutrient utilization efficiency of aged hens would be different from that of young hen. Dietary enzyme was able to improve egg production and energy nutrients utilization even in 79 weeks old hens. Daily feed intake of enzyme added diet was higher than that of no enzyme diet in the aged hens(Lee et al., 2013) although the feed intake of enzyme added diet was less than that of no enzyme diet in broiler(Seo, 2018; Ko et al., 2019), that are typically younger than 7 weeks of age. This difference could be attributed to age difference on the space for enzyme compared to the maximum energetic. However that space would be affected by the type of enzyme and substrate and its quality. If the feed contains the poorly utilizable substrate, its specific enzyme supplementation would increase feed intake as shown in the aged hen study.

3. Summary and conclusion

Dietary enzyme supplementation is emerging as a kind of conventional feeding practice due to use of many poor quality and unconventional feedstuffs. Several queries, upon practical use of the enzyme, were proposed and discussed here. Appropriate enzyme is able to impart significant benefit in dairy cow and the benefit would likely be bigger once fed poor quality feed. However, it is recommended to select the enzyme active in rumen circumstance at least. If the ingested feed contained serious amount of physically durable component, there could be further derivative action following the onset of specific hydrolysis by an enzyme. Potential of hydrolysis by endogenous enzyme would not be sufficient enough to maximize the nutrient, that would be a reason why multiple enzyme could be worth the supplementation even to rather good quality feed. Further consideration before using enzyme includes type and combination of enzymes, sex and age of animals. It can be conclude that dietary enzyme would be able to exert the expected benefit when the enzyme was implemented after careful design to avoid the raised concern.

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