International Journal of Agricultural Research and Review: ISSN-2360-7971, Vol. 3(7): pp 406-410, September, 2015.

Review

Roles of Carbohydrates Extracted from *Flammulina Velutipes* Mushroom as Nutraceuticals in the Development of Monogastric Animals: A Review

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Accepted 2nd September, 2015

This paper set out to review relevant literature on the role of carbohydrates extracted from the *flammulina velutipes* mushroom (FVM) as Nutraceuticals in monogastric animals, with a focus on pigs and poultry. The research investigated the nutritional and medicinal values of FVM mushroom, which is generally considered as one of the most edible specie of mushrooms. The study observed that quite recently, FVM which is much cheaper and readily available, has been used in the diet of animals as medicine because of its neutrocetical properties such as carbohydrates (oligosaccharides and polysaccharides), which have the capability to prevent and treat various diseases such as diarrhea and cancer in weaned piglets and growing birds respectively. It was also observed that the use of FVM as animal food supplement was caused by the spiraling cost of feed additives which puts them beyond the reach of most small holder farmers. The study therefore recommended that small scale farmers should embrace the use of carbohydrates extracted from the FVM as supplements in the feeds of their monogastric animals as a means of meeting their animals' nutritional needs and preventing diseases like diarrhea and cancer in weaned piglets and growing birds respectively.

Keywords: Carbohydrates, monogastric, mushroom, Nutraceuticals, prebiotics.

INTRODUCTION

Flammulina velutipes (enokitake) mushroom is the fourth most well known edible and medicinal mushrooms which also include *Agaricus bisporus* and *Lentinulus edodes* produced worldwide. Edible mushrooms are the fleshy and edible fruit bodies of several species of macrofungi (fungi) which bear fruiting structures that are large enough to be seen with the naked eye). They can appear either below ground (hypogeous) or above ground (epigeous), where they may be picked by hand. FVM grows on living and dead trees and they belong to the family of Tricholomataceace. This mushroom is native to Asia with China being the largest producer and followed by Japan and South Korea (Chang and Miles, 2004). They are rich in carbohydrates (estimated at 58%), proteins (estimated at 27.5%), vitamins (B1,B2,B12,C,D,E) and trace elements but poor in fats (estimated at 7%) and have lower ash content (estimated at 7.4%).

Recently, the increase in human population has resulted in an increase in animal products (eggs and meat) demand which have a corresponding impact on animal nutrition in small scale farming. Many feed additives such as *coccidostats* or *histomonstats* have been used as growth promoters and immune system stimulants for production of meat and eggs in monogastric animals (*Official Journal of the European Union*, 2013). However poor small holder farmers, due to unfavourable economic conditions, are unable to afford or buy these expensive feed additives and as a result, are always edged out of the market (Bingsheng et al.,

2010). In China, for instance, most indigent poultry and pork farmers abandon production because of poor skills on feed ration formulations to meet their animal needs (FAO, 2007). It is against this backdrop that *Fammulina velutipes* as a cheaper alternative to these feed additives recommends itself. *Flammulina velutipes* is native to Asia and produced in large quantities in China. It is highly recommended as an alternative source of food additives to small scale farmers, owing to its ready availability and affordability as well as its high nutritional and medicinal properties such as carbohydrates (Chang and Miles, 2004).

IMPORTANCE OF MONOGASTRIC ANIMALS TO SMALL HOLDER FARMERS

In developing countries, particularly in remote rural areas, crop production is affected by climatic conditions such as rain and high temperatures, which cause poor production of cereals resulting in poor domestic animal production and thereby reducing the country's capacity to alleviate poverty (FAO, 2007). Animal end-products, such as pork, poultry and eggs can be used as carbohydrates (starch in particular) to feed people with malnutrition (Murphy et al., 2003). Rural small holder farmers in developing countries usually keep monogastric animals as a source of income to feed their families and this is one of the most poverty alleviation strategies for poor farmers (Rutherford, 2000). Small animals such as pigs and chickens are easily manageable and require less feed costs and their maintenance costs are usually lower. They are also easy to slaughter when farmers need money to buy food, clothes and materials to build shelters (Alders et al., 2010).

INFLUENCE OF CARBOHYDRATES IN MONOGASTRIC ANIMALS

There are two main types of carbohydrates for monogastric animals and these are Oligosaccharides and Polysaccharides.

Oligosaccharides:

Oligosaccharides are defined as simple sugars of carbohydrates that are not easily degraded or digested by the stomach enzymes of monogastric animals, including humans, but can only be deposited in the large intestine where they will be fermented by the large population of micro-organisms harbored in the colon (Houdijk et al., 1998, Kontula, 1999 and Meyer, 2008). Some compounds which pigs and poultry are not capable of digesting are commonly referred to as prebiotics due to their revealed capability to expand the intestinal capacity (Krause et al.,2010). Dietary supplement of oligosaccharides in monogastric animals was proved to act as an antagonistic factor by positively influencing the beneficial microflora (such as Bifidobacteria and Lactobacillus) to protect gastrointestinal tract against toxic micro-organism or pathogens (Nakashimiada et al., 2010 and Kim et al., 2011).

Influence on Pigs Production:

In pig production, early-weaned piglets (18-21 days) are subjected to various stress factors which may include a sudden switch from a liquid diet (sow milk) to solid or dry diet and environmental health, which may cause changes into morphological structure and intestinal functioning. Pathogen such as *E.coli* may also colonize the entire area of gastrointestinal tract (GIT) causing diarrhea (Bailey et al., 1992, Katouli et al., 1999, Madec et al., 2000 and Laine et al., 2008).

Introduction of oligosaccharides in the pig's diet was reported to improve and stimulate Bifidobacteria and Lactobacillus for fermentation in the large intestine that produce Small Chain Fatty Acids (SCFA) which will be used by the animal as the source of energy (Batyrate), controls concentration of ammonia, lactice acids and pH level in the intestines. Dietary supplements of these fermentable compounds, fructooligosaccharides in particular, was found to reduce the incidence of colonial Bacteroids, fusobacteria and clostridia in the faeces of growing pigs (Roediger, 1982 and Gibson et al., 1995). However, due to less data available on the effects of fructooligosaccharides on growth performance, feed intakes and its efficiencies, the author suggests that the presence of oligosaccahrides in pig's diet can induce performance and reduce total cholesterol incidents.

Influence on Poultry Production

Like other monogastric animals, including pigs, the digestive system of a chicken mechanically and chemically breaks down food and allows nutrients to be absorbed and ready for use in the body. However, this is different when it is fed with fibrous feeds such as fructooligosaccharides (FOS) which are unable to degrade these feedstuffs. Dietary supplement of FOS in broiler chickens was found to improve the balance of beneficial microflora in the intestines, as well as performance and utilization of various essential nutrients e.g. proteins (Jiang et al., 2006 and Huang et al., 2007). Other researches and literatures found similar results on broiler performance and body weight gain (estimated at 5-8%) and conventions of feed increment (estimated at 6%). The intestinal pH of broiler chicken fed diet containing FOS was reported to be medium (at pH7) in the GIT, and digestion and absorption of nutrients was also found to be increased by the enlarged area of the intestines (Patterson and Burkholder, 2003).

Polysaccharides

Polysaccharides are polymeric carbohydrate molecules composed of long chains of monosaccharide units bound together by glycosidic linkages and on hydrolysis give the constituent monosaccharides or oligosaccharides. They range in structure from linear to highly branched. This carbohydrates function is divided into two classes: starch and non-starch polysaccharides. Non-starch polysaccharides are not easily digested by pigs and poultry because of its water holding capacity but can only be fermented in the large intestines and can also be utilized by gut Bifidobacterium and lactobacillus. Because of this factor, it has been used as dietary fiber in feedstuffs (Bach, 1997).

Influence on Pigs Production

The digestive system of growing pigs can be positively or negatively influenced by the presence of fibrous feeds (when moderate, too low or too much) in the diet (Bach, 1997). Non-starch polysaccharides (DF) in diet may improve the water retention capacity and be able to slow down the transit rate of the digesta (food under-going digestion) which will favor the available substrate in the large intestine for fermentation. The increase rate of fiber degradation and feed intake in pigs was also found to be the results of high water retention capacity. Furthermore, (De Leeuw et al., 2008 and De Longe, 2010) highlighted that the inclusion of fibrous feeds in the diet can improve growth, body weight, feed intake and viscosity as well as stimulating the gut health by changing the bacterial composition in the small intestines and large intestine.

Influence on Poultry Production

In broiler production, gastrointestinal tract environment was reported to be negatively affected by supplementing birds with diet containing NSP feeds, which will also affect the health and over-all performance of broiler chickens. The similarity between broiler chicken and pigs is that both they do not have endogenous enzymes to degrade and digest fibrous feeds, but the presence of digestive acid in the proventriculus can help the fermentation (Leeson et al., 2001; Owusu-Asielu et al., 2006 and Jimenez-moreno et al .,2009). In comparing the effectiveness of soluble NSP with insoluble NSP, it was documented that the inclusion of insoluble NSP can reduce the length of GIT but not negatively affecting digestion, absorption and body weight of growing birds. However, these findings are quite difficult and not clear (Gonzalez et al., 2007 and Saki et al., 2010).

SUPPLEMENTARY ROLE OF CARBOHYDRATES AS NUTRACEUTICALS IN MONOGASTRIC ANIMALS

The use of carbohydrates (oligosaccharides and polysaccharides), particularly non-starch polysaccharides (NSPs) in animal nutrition as Nutraceuticals to treat various types of diseases such as necrotic in birds and, preventing the incidences of pig intestinal inflammation upon fermentation in the colon has long been documented (Kaldhusdal and Hofshagen, 1992). It was later found that the presence of NSPs in the weaning diet may negatively influence the growth and gut health by increasing the incidence of *E.coli* in the gastrointestinal tract (Pluske et al., 1998).

According to some other research/literature, it was indicated that the dietary supplement of simple carbohydrates such as oligosaccharides and fructose in pigs found to improve the activities of beneficial gut bacteria such as bifidobactarium and lactobacilli can reduce the incidence of pathogenic bacteria such as clostridia and enterobactreria. The authors further suggested that these simple carbohydrates can stimulate the entire immune system and can result in an improved body weight, growth and feed intake (Nemcova et al., 1999 and Spring et al., 2000). Most researches on the use of carbohydrates as Nutraceuticals that haves been conducted in monogastric animals and because of their beneficial effects on the gastrointestinal track environment, in particular as host defenses, are commonly termed prebiotics. Although there is limited evidence of their mechanism in poultry, the author suggested that the inclusion of carbohydrates in the bird's diet may reduce the incident of pathogenic competition in the GIT (Alloui et el., 2013).

Similarly, Kim and Hyghebaet (2011) found that the administration of oligosaccharide such as FOS proves to result in beneficial effects on the gut microbiota and aid in removing the toxic bacteria from the gut in poultry. In contrast, Zhang et al. (2007) stressed that young pigs find it difficult to degrade and digest oligosaccharides diet due to their absence of enzymes stachyose and raffirose and the consequences of fermentation in the colon may cause incidents of diarrhea which may result in high mortality in the farm. However it is still difficult to conclude the above statement due to limited evidence. Therefore, more research is needed to validate and proof our findings.

CONCLUSION AND RECOMMENDATIONS

Dietary supplement of carbohydrates plays an important role by providing energy for the entire life of monogastric

animals. However some carbohydrate functions such as oligosaccharides and polysaccharides contain compounds like insoluble non-starch polysaccharides and undigested-oligosaccharides which can only be fermented by monogastric animals. These fermentable compounds/oligosaccharides and polysaccharides contain prebiotic activities which can be used as Nutraceuticals to improve both animal gut nutrition and health. With our current knowledge, we therefore conclude that the use of carbohydrates extracted from the FVM as supplements in feeds of monogastric animals can help the small holder farmers to meet their animal's nutritional needs and help to control and prevent diseases such as diarrhea in weaned piglets and colon cancer in growing birds because of its cheaper cost and ready availability. Consequently, it is recommended that small scale farmers should embrace the use of carbohydrates extracted from the FVM as supplements in the feeds of their monogastric animals as a means of meeting their animals' nutritional needs and preventing diseases like diarrhea and cancer in weaned piglets and growing birds respectively.

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