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Short Communication

The Importance of Flavonoids in Ruminant Nutrition

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Abstract

Recent scientific reports indicated that flavonoid could affect the rumen volatile fatty acids production along with a reduction in rumen methane concentration which resulted in improvement of performance and production. Flavonoids as polyphenolic compounds are powerful antimicrobials and antioxidants with anti-inflammatory and immune system benefits. Flavonoids can also promote the growth and development of animals as well as improve the quality of animal products. Therefore, these compounds are widely used as feed additives in animal production instead of antibiotics. Base on the research findings, addition of the flavonoids to ruminate diets could suppress methane production without influencing rumen microbial fermentation, fatty acid production and performance of beef or dairy cattle. Flavonoids are capable of the improvement of volatile fatty acids production together with a reduction in both rumen ammonia concentration and methane production which are considered as desirable changes in rumen environment. Also, the positive effect of flavonoids on rumen microbial fermentation and nutritional stress such as bloat or acidosis have been well demonstrated. Many factors such as chemical structure, absorption, its distribution and elimination determine the bioavailability of flavonoids. Isoflavones and flavanols seems to have lower bioavailability, whereas higher bioavailability of proanthocyanidins in ruminants were reported. Incorporation of flavonoids into dairy/beef products may provide a novel way to increase quantity and quality of future products of dairy farming.

Introduction

Flavonoids as benzo-pyrone derivatives of phenolic compound are included of a large family of thousands hydroxylated polyphenolic compounds. They have the general structure of a 15-carbon skeleton, which consists of two phenyl rings and heterocyclic ring [1]. The majority of flavonoids generally remain conjugated with sugars as glycosides [2,3]. Flavonoids have different roles in plants that includes help at pollination, reduce environmental stress, disposal of microbial infection and regulating cell growth [1,4,5]. Flavonoids are an important class of phytochemicals products found in most of herbs, fruits, vegetables and certain beverages. Certain plant-based food groups are known to be much higher in flavonoids family than others including some fruits (berries and apples, tree fruits, citrus fruits, tropical fruits), vegetables (all type of green vegetables, especially brussels cabbage- type sprouts and spinach), spices, nuts and beans, grains (cereals, soy and beans), beverages, tea of all types, acid forming foods, garlic and onion [1,2,3,4,5].

Some of the well-known flavonoids are quercetin, kaempferol and anthocyanidins. They can be classified into three main classes including bioflavonoids, isoflavonoids, and neoflavonoids [4,6,7]. Flavonoids are considered as promoter of the growth and enhancer of the products quality of animal due to its anti-microbial and anti-oxidative properties [8,9]. There is substantial interest to study the potential of natural bioactive compounds to modify ruminal microbial ecosystem and desirable changes in the fermentation conditions such as pH, propionate concentration, and protein degradation [10-13]. Recently, the flavonoids and the other members of phenolic compounds are widely used as feed additives in ruminant production [5,14,15,16].

Metabolism and bioavailability of flavonoids in ruminants

Flavonoids are transported to the liver after absorption, where they form glucuronide, sulfate or methyl-conjugates compounds

before being excreted through the urine or faeces [8,9,17,18]. This is well illustrated that the catechin and epicatechin as monomeric components of flavanols are the only derivatives absorbed in monogastrics [7,19]. In contrast to monogastrics, it was shown that ruminants can benefit from the strong antioxidant properties of polymeric proanthocyanidins by metabolizing them into bioavailable compounds with epicatechin as intact flavonoid-ring structure [17,18,20,21,22].

Several factors such as chemical structure, absorption rate, the level of distribution and elimination determine the biological effects of flavonoids [7,17,23]. The higher bioavailability of isoflavones and flavonols has been observed in monogastric compared with the other subclasses of flavonoids, while anthocyanins are reported to have the less bioavailability [4,24]. whereas, it was described higher proanthocyanidins bioavailability in ruminants compared to other flavonoids subclasses [4,14,16,22].

Significance of Flavonoids in Ruminant Ration

Recent advances in ruminant nutrition researches suggest that to control metabolic processes in the rumen to make it more efficient using natural feed additives such as flavonoids is desirable [14,15,16]. The improvement of volatile fatty acids production along with a decrease in both rumen ammonia and methane concentration are considered as desirable changes in rumen ecosystem [13,25,26].

The positive effect of flavonoids and phenolic compounds (saponins, tannins, essential oils, organosulphur containing compounds) on the productivity and health of animals as well as rumen fermentation and control of nutritional stress such as bloat and acidosis have been demonstrated in several studies [27,28]. Flavonoids as polyphenolic compounds have similar pattern of action similar to monensin and other type of antibiotics [29,30,31,32]. Higher rumen pH values were observed in high grain heifers diets supplemented with flavonoids compared to the control group, which likely due to the beneficial effect of flavonoid in enhancing lactate-consuming microorganisms i.e. *M. elsdenii* [12,14].

Effect on milk production

Both rumen microbial ecosystem and ruminant's performance can be influenced by the use of flavonoids in the diets. Generally, flavonoids can modify the fermentation characteristics [10,12,33], and can be served as anti-microbial agent to decrease pathogens and methane producing bacteria as well as improve the anti-oxidant content to decrease lipid oxidation and increase the quality of the milk/meat production [13,14,26].

Incorporation of moderate levels of flavonoids/polyphenols into milk/meat and dairy products through the feeding of animals with food sources rich in flavonoids and phytochemicals, may provide a novel way to increase flavonoids/polyphenol content of daily food for consumers [7,14]. It was reported that the increase in milk yield and lactation performance in dairy cows were observed after administration of sylimarin in the feed (10 g/d) which mainly consist of flavonolignans [34]. It is well reported that flavonoids can enter the circulation, where they may be spread across tissues and finally be renally excreted [35]. The other fate of absorbed flavonoids is the mammary gland, where they can incorporated into the milk of lactating animals [17,23,34]. Previous studies have demonstrated that the positive effect of various food processing waste and plant origin byproducts on the production and composition of milk [14,16,26].

Control of rumen production

The commonly used feed additives in ruminant nutrition have an important role as modulators of the end products of rumen fermentation [11,13,30].

Some rumen fermentation dysfunctions such as acidosis or bloat can cause after consumption of high-concentrate diets [16]. The dietary inclusion of monensin/antibiotics appears to reduce the incidence of rumen dysfunctions. However, use of antibiotics as feed additives were banned by the European Community since January 2006 [14]. From that time many feed additives such as flavonoids have been proposed as alternatives to antibiotic therapies [12,14,16,25,30,31].

In association with the anti-microbial properties of flavonoids extracts, the use of flavonoids extracts to rumen fermentation have been the subject of many experiments [10,16,6,30]. Using mixtures of plants flavonoids in continuous rumen culture system can modify fermentation conditions including pH, propionate proportion and/or protein degradation, although the results were not always homogeneous [11,12,13,14].

Diminution of methane production

A large population of methanogenic bacteria present in the rumen have been implicated in global warming, and high attempts to moderate rumen microbial fermentation towards reducing the methane production through application of feed additives remain a high priority [14,25,26]. Decrease in methane production have been considered as a valid index of rumen microbial fermentation inefficiency [13,14]. Furthermore, changes in VFA profile, i.e. improvement in the molar proportion of propionate to the expense of acetate, will be coming to reduction in CH_4 synthesis [26,28]. Moreover, CH_4 is a potent greenhouse gas with global warming capability and is 25 times more toxic than CO_2 [25,14,16].

Previous reports evidenced that the addition of plants extracts rich in secondary compounds such as saponins, tannins, essential oils and also extracts rich in flavonoids reduced rumen CH_4 production [25,14,15], showed that the addition of the flavonoids naringin and quercetin to ruminate diets could suppress methane production without influencing rumen microbial fermentation [14]. However, uncertainties in such processes arises from primarily, mechanism of methane depression are unidentified and secondarily, the plant extracts are constituted by complex mixtures whose action on rumen fermentation may derive from the synergistic and/or antagonistic action of the flavonoids/polyphenol mixtures [10,11]. Currently, various flavonoids/polyphenol rich feed additives

suppressing methane producing are available in the market However, these products mainly contain plant crude extracts, and it is rather difficult to determine the response of rumen microbes to the flavonoids/polyphenols. The presence of other components such as glycosides, phenolics, terpenoids, alkaloids, essential oils, and organic acids in the plant extracts may affect the results. In addition, awareness of the effect of flavonoids in the pure form on rumen microbial activity is still incomplete [12,13,14,26].

Conclusion

Flavonoids due to its anti-microbial and anti-oxidative properties are widely used as feed additives in animal production. They have potential to modify rumen microbial activity and desirable changes in the fermentation conditions such as pH, propionate proportion, and protein degradation. The positive effect of flavonoids and phenolic compounds on the productivity and health of animals as well as rumen fermentation, reduce methane production, and control of nutritional stress such as bloat and acidosis have been demonstrated in several studies. According to the recent findings, incorporation of flavonoids/polyphenols into milk/meat and dairy products using food sources rich in flavonoids and phytochemicals, may provide a novel way to increase flavonoids/polyphenol consumption and consequently promote health of society, particularly for people with a low diet of flavonoids/polyphenol content.

Acknowledgment

None.

Conflict of Interest

No Conflict of Interest.

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