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# Glycerol as Feedstuff for Ruminant

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**ABSTRACT**

The increase in bio-ethanol industry has created a need for alternative to corn for ruminants. In the other side there is an increase availability and promote favorable pricing for glycerol, a primary co-product material. Glycerol is used as energy additive in ruminant nutrition. Glycerol in particular, is used for their glycogenic and anti-ketogenic properties. Glycerol is ingested by ruminants with phospholipids in the cell wall or lipids in the seeds and is part of the lipidic fraction of the diet. Glycerol is considered to be rapidly fermented within the rumen thus its low concentration as free glycerol in rumen fluid.

**Key words:** Glycerol, ruminant digestibility, milk, caracas, characteristics

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## INTRODUCTION

The high global demand for energy led to an increasing production and trade of biofuel, especially liquid fuels for transportation, in order to substitute fossil energy sources, to enhance energy security and to respond to greenhouse gas emissions[1,2]. This led to an increasing competition for raw materials for food, feed and fuel usage and the disposability of more by-products. For example, starch and vegetable oils are converted into bioethanol and biodiesel during the production process, one of the by-products of this process is glycerin.

Glycerol is an important structural component of triglycerides and phospholipids and its glucogenic properties are well established[3]. Glycerol enters the metabolic pathway to glucose at a different step than other glucogenic precursors[4]. Thus, when cows use body fat reserves as a source of energy, glycerol and fatty acids are released into the bloodstream. The glycerol component can be converted to glucose by the liver or kidneys[5] to provide energy for cellular metabolism.

## USING GLYCEROL TO PREVENT KETOSIS IN RUMINANT

Satisfying the nutritional requirements of high producing dairy cows can be a challenge. Feed Dry Matter (DM) intake may decrease as much as 30% during the week before calving[6] and cows often continue to be in a negative energy balance during the first 5 week of lactation. Because of the frequent inability to overcome the DM intake depression, producers often use oral drenches and pastes to provide glucose precursors to prevent ketosis and other metabolic disorders.

Oral administration of 2 kg of glycerol was more effective in alleviating ketosis compared with propylene glycol[7]. the mode of action behind feeding glycerol could be attributed to an increase in feed intake and subsequent supply of more glucogenic substrate[8].

Glycerol has been shown to be an effective treatment against ketosis in dairy cattle[4]. Cows fed glycerol at 374 g day$^{-1}$ lost less Body Weight (b. wt.) and remained in more positive energy balance, than those fed 174 g day$^{-1}$ glycerol[9].

## USING GLYCEROL AS A RUMINANT FEEDSTUFF

From very limited research studies, glycerol has been fed as a feed ingredient to replace energy sources such as corn for up to 15% of the total ration DM for Holstein dairy cows[10] without deleterious effects on milk production or composition.

Glycerin has been fed to early postpartum dairy cows[9,11,12] or cows in early[8] to mid-lactation[13] as an energy supplement rather than as a major feed ingredient.

More recent studies[11,12], in which glycerol was fed as an energy supplement to periparturient dairy cows, also revealed no improvement in lactational response from glycerol supplementation.

Several researchers[14] have estimated the energy value of glycerol in beef and they have concluded to be similar to that of corn grain. Therefore, glycerol could be used as an energetic ingredient in animal diets replacing cereals. The inclusion of glycerol in animal nutrition has been studied in several species and reports indicate that moderate inclusions do not compromise animal performance[15,14]. The consequences of including glycerol in lamb concentrates have already been studied in heavy lambs from 44-58 kg[16].

## EFFECT OF FEEDING GLYCEROL ON THE RUMINAL FERMENTATION

Glycerol is used as energy additive in ruminant nutrition. Glycerol in particular, is used for their glycogenic and anti-ketogenic properties[17,18]. Glycerol is ingested by ruminants with phospholipids in the cell wall or lipids in the seeds and is part of the lipidic fraction of the diet[19]. Glycerol is considered to be rapidly fermented within the rumen thus its low concentration as free glycerol in ruminal fluid[20,17]. However, there is scarce information regarding the rate of fermentation and its fermentation products. There is some controversy regarding to the biochemical pathway and the end products of glycerol fermentation by ruminal microbes.

Some authors have proposed that propionic acid is the main volatile fatty acid derived from glycerol, supporting the glycogenic role of glycerol in ruminants[21,22]. Furthermore, feeding glycerol decreased the acetate: Propionate ratio and stimulated water intake, both of which would benefit transition dairy cows[23,24,25]. the fermentation of glycerol in anaerobic conditions *in vitro*[26]. They found that after 24 h of culture, approximately 80% of glycerol were metabolized. Addition of glycerol decreased acetate formation. The main routes of disappearance of it from the rumen are absorption and fermentation[27].

Linear increases in rumen propionate and butyrate molar proportions and a linear reduction in acetate to propionate ratio with increasing glycerol doses (100, 200 and 300 g head$^{-1}$ day$^{-1}$) in steers' diet[28]. In contrast, rumen molar proportions for acetate, propionate and butyrate were unaffected by feeding glycerol to beef cattle at levels up to 120 g kg$^{-1}$ of concentrate DM[14].

The addition of glycerol at 0.05 (v/v) to the *in vitro* media greatly inhibited the growth and cellulolytic activity of rumen bacteria and fungi[19]. Additionally, the cellulolytic activity of ruminal extract was reduced as glycerol concentration in rumen cultures increased from 50-300 mM[29].

However, other studies showed no inhibition of growth and cellulolytic activity of ruminal bacteria[29]. Glycerol also reduced the proteolytic activity of bovine rumen fluid by about 20% when concentrations of glycerol in the medium ranged from 50-300 mM[30].

## EFFECT OF FEEDING GLYCEROL ON RUMINANT PERFORMANCE

**Feed intake and body weight:** Glycerol act as an appetite stimulant when fed at 472 g day$^{-1}$ within the concentrate mix of a component based diet[8]. In a more extensive experiment using a larger number of cows and an 8 weeks treatment period, feeding glycerol at 174 or 347 g day$^{-1}$ was ineffective at improving feed intake relative to cows fed an un-supplemented control concentrate or propylene glycol[9].

Cows fed glycerol tended to increase body weight (b.wt.) at a higher rate relative to those fed the control diet[9], which found that cows fed glycerol at 374 g day$^{-1}$ during the first 8 week of lactation lost less BW than cows fed glycerol at 174 g day$^{-1}$, propylene glycol at 174 g day$^{-1}$, or a corn based control concentrate. On average, the cows fed glycerol lost only 30.8 kg of b.wt. during the first 21 day in milk (DIM\of lactation, as opposed to approximately 36 kg or 60 kg of b.wt. reduction observed[31,11].

**Rumen fermentation and kinetics:** Ruminal acetate to propionate ratio decreased when feeding glycerol at 1.1 and 0.216 kg day$^{-1}$, respectively[23,13]. With the exception of a tendency for a decrease in $NH_3$-N for cows fed glycerol, treatments did not affect pre-partum ruminal measurements; however, differences were notable postpartum. Substituting glycerol for corn in the diet altered rumen fermentation pattern toward more butyrate, valerate and isovalerate and less acetate. The reduction in the molar proportion of acetate and acetate to propionate ratio was consistent with the reduction in NDF digestibility. Studies that have reported reduction in NDF digestibility have also reported reductions in acetate concentration and acetate to propionate ratio[32,33]. Surprisingly, despite the reduction in starch availability, as a result of substituting glycerol for corn, the molar proportion for propionate was not affected. Previous studies have showed that glycerol is mostly fermented into propionate[22,34]. Additionally, drenching cows with 1 kg of glycerol[35] or supplementing steers with glycerol (200 or 300 g $day^{-1}$)[28] have been shown to increase rumen propionate relative to control (no glycerol) diets.

**Nutrients digestibility:** The 7 and 17% reduction in carboxy-methylcellulose digestibility when glycerol concentrations in ruminal cultures were increased from 50-200 and 300 mM, respectively[29]. substituting glycerol for corn had no effect on DM digestibility[24], however, feeding glycerol at 72 and 108 g $kg^{-1}$ DM reduced ($p<0.05$) NDF digestibility and tended ($p<0.12$) to reduce ADF digestibility when compared with the control diet.

Sheep fed 48, 78, 131, or 185 g $day^{-1}$ of glycerol (DM basis) in a low-starch, concentrate diet and found either no effect or positive effects on digestibility of organic matter, starch and cell-wall components[23]. However, feeding the same levels of glycerol in high-starch concentrate diets resulted in a decrease in cell-wall digestibility but no effect on the digestion of organic matter or starch. apparent digestibility of DM and OM increased with glycerol (5, 10, 15% DM) addition to the diet, while the digestibility of NDF was reduced with 5% glycerol compared with no addition but was similar between 10 and 15% glycerol addition[10]. Nitrogen digestibility showed a quadratic response ($p<0.05$) to increasing glycerol inclusion in the diet.

**Carcass characteristics and meat quality:** Carcass and meat quality of animals fed crude glycerin may have some differences due to the increase in the availability of gluconeogenic compounds[36,37]. As mentioned previously, glycerol could be absorbed by the ruminal epithelium and thus converted into glucose or converted to propionate in the rumen[38]. Inclusion of glycerin in ruminant diets might increase the unsaturated fatty acid in meat that may reflect that glycerol likely inhibits lipolysis which is responsible for the saturation of dietary fatty acids consumed by ruminant animals[39].

Many studies reported that there was no differences hot carcass weight and dressing when glycerin was added to the diets[40-42].

**Milk production and composition:** Production of milk and 4% FCM and percentages and yields of milk components were not significantly affected by addition of dry glycerin to early lactation Holstein cows[31], in agreement with[11,12,13,28] and previous[9] studies in which glycerol was also fed to early postpartum dairy cows. milk production increased of 14.6 and 12.5%, respectively[44], for cows fed glycerol at 300 and 500 mL $day^{-1}$ over 10 weeks of lactation[17,23]. These findings were also reported by other several studies[11,12] in which glycerol were fed to early postpartum dairy cows.

In other studies[10,28,43] reported that a similar amount of milk during the early lactation period as cows fed a diet containing glycerol and no added glycerol.

The trend towards lower milk fat content of cows fed glycerol versus control cows is consistent[11], who reported tendencies for a lower milk fat yield when glycerol was fed. This reduction in glycerol on milk fat proportion, however, did not occur in other studies[9,12]. While, in some other studies[45,10,43,28] No effect was found for milk components in the first 21 DIM.

## CONCLUSION

Experiments cleared that feeding the ruminant animals on diets replaced the corn by glycerol have no harmful differences on feed intake, nutrients digestibility and carcass and meat quality and production performance of lactating animal.

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