

# Pasture Bloat in Ruminants: Cause, Occurrence and Mitigation Strategies

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**P**asture bloat is a common digestive disorder of ruminants that was first alluded to in A.D. 60 (Majak et al. 2003). It is characterized by an accumulation of gas in the rumen and reticulum, the first two stomachs of ruminants. Pasture bloat can be classified into either free-gas or, more commonly, frothy bloat. Free-gas bloat is associated with obstruction of the oesophagus and is most often encountered when cattle are pastured on root crops such as beets or turnips. Frothy-pasture bloat is caused by entrapment of gas produced from fermentation of rapidly digestible forages such as alfalfa, clovers or wheat. In this condition, the formation of stable foam in the rumen prevents the escape of fermentation gases by eructation. Tubing is largely ineffective at overcoming frothy pasture bloat as froth prevents the gases from passing through the tube.

Owing to its negative impact on both beef and dairy

cattle production, defining the aetiology of pasture bloat has been a topic of intensive research for many years (Howarth et al. 1991; Cheng et al. 1998; Majak et al. 2003). Although some of the factors that precipitate and promote bloat have been defined, taking advantage of the productivity of clover and alfalfa pastures still requires the willingness to assume a certain degree of risk.

## Aetiology of pasture bloat

A unified theory of the three factors required for the onset of pasture bloat include: 1) a highly digestible high-protein forage (e.g. alfalfa, clover, non-mature wheat) that results in rapid growth of rumen bacteria and gas production; 2) presence of fine plant particles that promote the formation of gas bubbles that restrict the release of gas from the rumen and 3) conditions favourable for ruminal bacteria to produce an excessive amount of bacterial slime that



**Table 1. Bloat-causing, moderate-risk and low-risk forages used as pastures.**

Bloat-causing	Moderate-risk	Low-risk
Alfalfa	Arrowleaf clover	Sainfoin
Sweetclover	Berseen clover	Birdsfoot trefoil
Red clover	Persian clover	Cicer milkvetch
White clover	Spring wheat	Crownvetch
Alsike clover	Oats	Lespedeza
Kura clover	Canola	Fall rye
Winter wheat	Perennial ryegrass	Perennial grasses

stabilizes the foam, further entrapping fermentation gases (Majak et al. 2003).

Rapid lyses of alfalfa and clover cells and release of proteins into the rumen contributes to pasture bloat (Howarth et al. 1977). However, proteins in tannin-containing forages such as sainfoin and birdsfoot trefoil are precipitated, a response that likely accounts for the bloat-safe nature of these legumes.

The aetiology of pasture bloat is also related to physiological factors of the animal. Steers with a slower rate of liquid passage (12–17 h) were more prone to bloat than those that had a rapid rate of passage (8 h). Protein-rich chloroplast particles may more readily accumulate in cattle that have a slow liquid passage rate, thereby enhancing the formation of the stable bloat-causing foam.

### Plant-based strategies to mitigate pasture bloat (Fig. 1)

#### *Choice of low-bloat potential forages*

Pasture bloat can occur in ruminants fed most forages that are low in fibre and high in protein, but bloat is most common with immature alfalfa and clover. Some producers avoid seeding pure-stands of alfalfa because of its potential to cause bloat. Instead, they use forage stands with a low proportion of alfalfa and more bloat-resistant legumes such as sainfoin (*Onobrychis viciifolia*), birdsfoot trefoil (*Lotus corniculatus* L.), crownvetch (*Coronilla varia* L.) or cicer milkvetch (*Astragalus cicer* L.) (Table 1). However, the agronomic properties of these bloat-resistant legumes are often less desirable than those of alfalfa or clovers.

Some bloat-safe legumes contain condensed tannins which are phenolic compounds that exhibit a high degree of affinity for protein, a property that likely contributes to their bloat-safe nature. Condensed tannins can also directly inhibit rumen microorganisms and biofilm formation, factors that could slow the rate of forage digestion in the rumen (Min et al. 2005; 2006). However, most tannin-containing legumes are less suited to grazing (e.g. sainfoin) or are lower yielding (e.g. birdsfoot trefoil). Thus grazing multi-legume pastures can result in increasing dominance of alfalfa/clover and, hence, an increase in the risk of cattle bloating on mixed legume pastures. Agriculture and

Agri-Food Canada presently has a breeding program to select for sainfoin cultivars that are more grazing tolerant and persist in mixed legume pastures with alfalfa.

It is generally accepted that animal performance will improve if grass pastures are intercropped with legumes. The benefits of these pasture management systems were demonstrated for mixtures of alfalfa-grass (Popp et al. 2000) and white clover-grass (Papadopoulos et al. 2001). The nutritional advantages of grazing adjacent strips of monoculture of perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens*) were attributed to the animals' preference for the legume (Rutter 2006). Selection of legumes over grass was also reported for adjacent monoculture strips of alfalfa and orchardgrass (*Dactylis glomerata* L.) (Veira et al. 2010). Seeding of mixed legume-grass pastures with no more than 30% alfalfa in the stand is currently the most common approach to reducing bloat risk, but even with this approach the incidence of bloat can be significant if cattle selectively graze vegetative alfalfa.

#### *Breeding alfalfa and clover for reduced bloat risk*

Differences in rate of digestion in the rumen is a distinguishing feature among bloat-causing and bloat-safe legumes, the former being more rapid than the latter (Howarth et al. 1982). Agriculture and Agri-Food Canada undertook an alfalfa breeding program that spanned two decades that selected and crossed alfalfa based on selecting for plants that exhibited a lower initial rate of digestion in the rumen (Coulman et al. 2000). The resultant alfalfa cultivar, AC Grazeland<sup>®</sup>, exhibited a 15% reduction in initial rate of ruminal digestion when compared to the original parent, Beaver. Pasture bloat was 56% less in cattle grazing AC Grazeland<sup>®</sup> relative to Beaver in trials conducted at three different locations in western Canada (Berg et al. 2000). Alfagraze<sup>®</sup>, a cultivar developed for grazing tolerance, was also compared to AC Grazeland<sup>®</sup> and under continuous grazing conditions the frequency of bloat was lower for AC Grazeland<sup>®</sup> than Alfagraze<sup>®</sup> (Hall et al. 2001). When both cultivars were evaluated at early maturity, their propensity to cause bloat did not differ (Hall et al. 2001). A breeding program to develop a bloat-reduced alfalfa was

also conducted in Argentina. The resultant cultivar yielded a 23% reduction in initial rate of ruminal digestion and a 25% reduction in bloat as compared to its unselected parent (Bernáldez et al. 2009).

Similar work was undertaken with white clover in New Zealand where it was also selected for a reduced propensity to cause bloat. This program ended up selecting for plants with more flowers as the flowers contained the condensed tannins that were responsible for the bloat reduction. If the clover was not at the flowering stage the risk of bloat on the selected clover cultivars was still high. To date, none of the breeding programs have successfully produced bloat-safe varieties of either alfalfa or clover and it appears that achieving such a goal is highly unlikely.

#### *Fertilizer and irrigation*

Many attempts have been made to relate bloat to the mineral composition of the plant, generally with conflicting and inconclusive results. Bloat is associated with high levels of potassium and low levels of sodium in the rumen (Hall et al. 1988), but it is unlikely that these minerals can be altered in the plant in a manner that controls bloat. In contrast, N fertilization can increase the soluble protein content of the plant and promote the formation of the stable froth associated with bloat.

Irrigation may also contribute to pasture bloat in a

similar manner, promoting the lushness and increasing protein content as compared to forages grown on dryland (Majak et al. 2003). In western Canada, the occurrence of bloat in cattle grazing alfalfa under irrigation is higher than that grown under dry land when the crop is at the same stage of maturity.

#### *Crop maturity*

Stage of growth of alfalfa is the most important factor in controlling bloat in cattle. The risk of bloat is highest at the pre-bud stage declining as the plant advances through the bud and bloom stages (Thompson et al. 2000). In a 2-year study at Kamloops, 129 cases of bloat occurred during the vegetative as compared to only 20 cases at bud stage with no incidences after the alfalfa was in bloom. The leaf-to-stem ratio decreased as the forage matured, decreasing the intake of chloroplast particles that are known to contribute to the stable froth in the rumen. Although uncommon, bloat can occur in cattle grazing alfalfa in the bloom stage especially if they are hungry when turned into the pasture.

#### *Wilting of alfalfa*

Bloat can be controlled even in vegetative alfalfa if it is swathed and allowed to wilt prior to consumption (Majak et al. 2001). To minimize risk, swathed forage should be allowed to wilt for a period of 48 h prior to swath grazing, with consideration to the moisture level and the degree of drying that has occurred over this period. If the alfalfa is in the bud or flowering state, or constitutes a lower proportion of the stand, risk of bloat is likely minimal even after 24 h of wilting. Wilting likely reduces the risk of bloat by reducing soluble protein levels in the plant. Wilting can be implemented in a rotational grazing system but is more laborious as the forage must be cut daily.

#### *Genetic modification of alfalfa*

Although the introduction of condensed tannin-accumulating forage species into alfalfa pastures can effectively reduce bloat, the efficacy of bloat reduction in mixed legume pastures is contingent upon the ratio and the extent that the condensed tannin-containing forage is consumed (Wang et al. 2006a). Competition between forages and grazing preferences are important factors that affect relative intake and can limit the

**Low bloat potential forages**

- ▶ Low bloat potential forages
- ▶ Increase perennial grass in stand
- ▶ Condensed tannin containing legumes
- ▶ Wilt forage prior to consumption

**Fertilizer and irrigation**

- ▶ Avoid high levels of N fertilizer
- ▶ Avoid turnout after irrigation or morning dew

**Crop maturity**

- ▶ Graze at advanced maturity
- ▶ Avoid grazing immediately after frost

**Genetic modification**

- ▶ Introduce condensed tannin into forage

**Figure 1. Plant-based strategies to mitigate pasture bloat.**

persistence of individual forage types in a mixed pasture. Therefore, it would be of great benefit if a genotype of alfalfa that produced condensed tannins were available to livestock producers. In corn, the *Leaf Colour (Lc)* gene is one of several *bHLH* genes that induce expression of red anthocyanin pigments, one of the precursors to condensed tannins synthesis. Genes coding for production of this precursor have been introduced into alfalfa and a small amount of proanthocyanidin was successfully produced in the forage (Ray et al. 2003). *In vitro* studies comparing non-transgenic genotypes to the transgenic Lc-genotype found that the transgenic had a reduced level of soluble plant cell components, but a similar rate of digestion (Wang et al. 2006b). Nutrient solubility was found to be negatively correlated with the concentration of anthocyanidins in the forage. These results indicate that introduction of these condensed tannin precursors into alfalfa may reduce the risk of bloat, but the reduction is unlikely to be any greater than that achieved through the traditional breeding approaches described above. To achieve truly bloat safe alfalfa, condensed tannin synthesis in at least the leaves of alfalfa would have to be increased substantially. Scientists must understand the mechanisms of condensed tannin synthesis and how to introduce or turn on genes responsible for synthesis of these compounds to make such a strategy feasible.

## Animal-based strategies to mitigate pasture bloat (Fig. 2)

### Feeding schedules and duration of grazing

Cattle consuming alfalfa either under grazing or confinement conditions bloated at least twice as frequently if the forage was made available earlier (07:00 – 08:00 h) as compared to later in the day (11:00 – 12:00 h; Hall and Majak 1995). In agreement, rumen chlorophyll content, which correlates with chloroplast particles, was also higher in cattle on the earlier feeding schedule. The practice among cattlemen of delaying turnout to alfalfa pasture “until the dew has dried” was verified, but whether the dew is a causative agent as inferred by Mayland et al. (2007) is unknown. It is possible that this response is more related to diurnal fluctuations in the soluble protein content of the plant, with levels being higher early in the day than later in the afternoon.

The duration of grazing can also influence the risk of bloat. Uninterrupted grazing lowers the risk of bloat as compared to intermittent pasturing for short intensive grazing intervals (e.g. 6 h) (Majak et al. 1995). Feeding regimens that promote continuous clearance of digesta from the rumen and distribute gas production over the course of the day are less likely to cause bloat. Establishment of a grazing pattern that is based on photoperiod and adapted grazing periods are less likely to cause bloat than grazing events that are driven solely by hunger. There is evidence that cattle “learn” to graze alfalfa and that

grazing of cow-calf pairs where the cow has previously grazed alfalfa results in reduced bloat as compared to naive cow-calf pairs. These responses likely reflect behavioural adaptations on the part of cattle as they become accustomed to consuming alfalfa in a manner that reduces the risk of bloat. Environmental stresses such as inclement weather may disrupt this behavioural adaptation and increase the risk of bloat.

### Feed additives

The efficacy of a number of feed additives at preventing bloat was reviewed by Hall and Majak (1989) and again by Majak et al. (1995). The additives included ionophores such as monensin and lasalocid as well as pluronic detergents, various mineral mixes and other popular but unproven remedies. Except for intraruminal doses of the pluronic detergent, poloxalene, none of the additives completely prevented bloat under high-risk conditions (Hall and Majak 1994).

Inclusion of bloat-preventing additives in drinking water of grazing cattle ensures more consistent intake of the

**Feeding schedule**

- ▶ Turn cattle out on pasture later in day.
- ▶ Adapt cattle to grazing conditions, avoid introduction of hungry cattle onto pasture

**Duration of grazing**

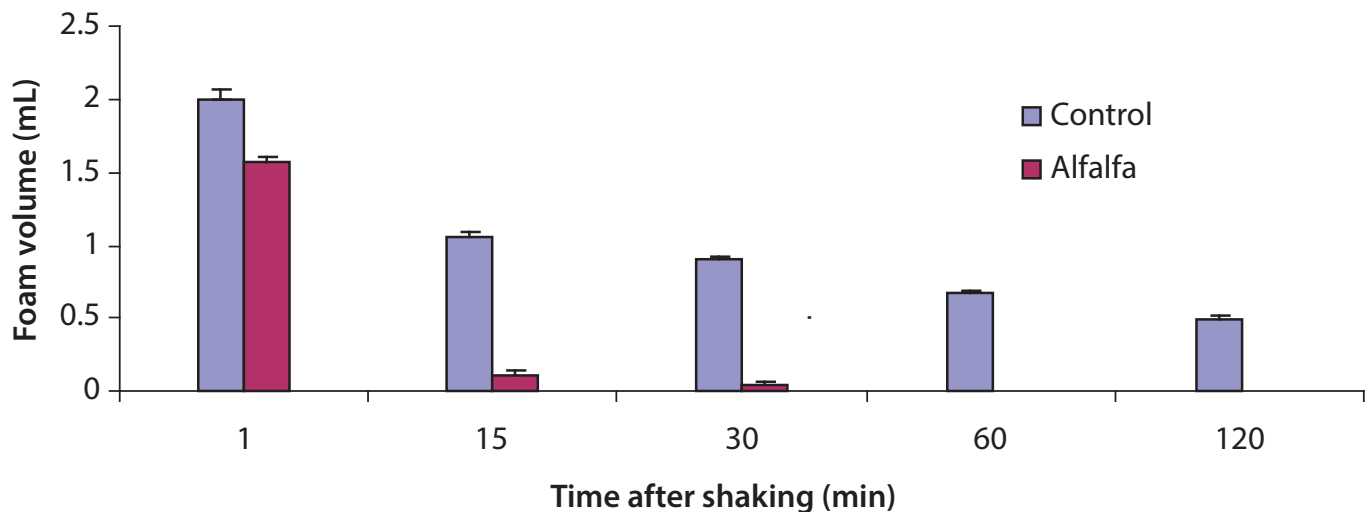
- ▶ Continuously graze cattle — avoid on and off pasture management strategies

**Feed additives—reduce bloat risk but do not eliminate it**

- ▶ Pluronic detergents
- ▶ Oil
- ▶ Ionophores

**Figure 2. Animal-based strategies to mitigate pasture bloat.**





**Figure 3.** Effect of Alfasure™ on the foam stability of rumen fluid, alfalfa extract and alfalfa protein (Wang et al. 2006c).

additive relative to when they are mixed with mineral or included in molasses blocks. The first such water-soluble product to be examined in North America was the synthetic polymer mixture of alcohol ethoxylate and pluronic surfactants (Blocare 4511®), an industrial defoaming agent widely used to control pasture bloat in Australia and New Zealand. The product completely prevented bloat in trials at three locations in western Canada (Stanford et al. 2001).

A mixture of pluronic surfactants (Alfasure™) became available to producers in Canada. Bloat was prevented if alfalfa was sprayed with Alfasure™ prior to grazing (Majak et al. 2005) or if it was administered directly to the animal. A 2-year grazing study, showed that including either Alfasure™ or its individual ingredients in the drinking water of steers reduced the viscosity and stability of foam in rumen fluid (Fig. 3) as well as the incidence of bloat (Wang et al. 2006c). *In vitro* studies also demonstrated that Alfasure™ reduced the stability of foam formed when an extract of alfalfa proteins was mixed with rumen fluid.

Administration of oil by stomach tube has long been recommended as a treatment for bloat in cattle (Majak et al. 2005; Majak et al. 2003b). The anti-bloat properties of some oils may be related to their fatty acid composition. Daily supplementation of corn oil at the rate of 7.5 and 15 g/kg of dry matter intake, significantly reduced bloat by limiting foam production and stability in the rumen of cattle grazing wheat pasture (Min et al. 2007). However, corn oil supplementation was found to promote the formation of bacterial slime associated with bloat. Treatment with oil is generally employed after the animal is clinically presenting bloat. This strategy of bloat control is risky as cattle are checked far less frequently on pasture than in confined feeding, making it likely that bloat in pastured animals will become fatal before any treatment can be administered.

### Conclusion

Although intensively studied for over 60 years, bloat continues to be an impediment to the production of cattle on alfalfa/clover pastures. Although a variety of management strategies have been developed to prevent pasture bloat, the most common avoidance strategy is to forgo grazing cattle on pastures that contain high levels of alfalfa or clover. This approach is often at the expense of a reduction in animal performance and an increased reliance on fossil fuel-based N fertilizer to maintain grass pasture productivity. Management practices such as grazing legume pastures at later maturities, including condensed tannin-containing legumes in the pasture or the use of water soluble pluronic detergents can reduce or in some cases eliminate pasture bloat. Developing transgenic alfalfa or clovers that produce condensed-tannins may offer a future long-term strategy for bloat prevention. In the meantime, the added animal productivity associated with grazing alfalfa or clover pastures comes with the risk of bloat and the cost of more intensive pasture management. Attempting to manage cattle grazing pure alfalfa or clover pastures in the same manner as grass pastures is almost certainly a recipe for disaster. 🌿

### References available online at [www.farmwest.com](http://www.farmwest.com)

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