Poloxalene as a bloat preventative for cattle fed barley and alfalfa rations
by Byron Richard Geissler

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Animal Science
Montana State University

Abstract:
Poloxalene, a nonionic surfactant, was evaluated in four trials utilizing Hereford, Angus, and Hereford-Angus crossbred steer calves and yearling Hereford heifers. Cattle of different breeds and from different sources were used to increase the possibility of bloat. Cattle receiving poloxalene were given 10 grams per head per. day in a premix.

In Trial I, 40 weaned calves averaging 178.9 kg. were stratified ac- -cording to source and weight and randomly allotted to four lots. In a 2 x 2 factorial design watered alfalfa hay or baled alfalfa hay was fed with or without poloxalene. The concentrate portion of the ration consisted of 80 percent steam rolled barley and 20 percent beet pulp the first 50 days and 90 percent barley and 10 percent beet pulp thereafter. During the 112-day trial, three steers in the untreated lots (no poloxalene) died, due to bloat. Average daily gains were about the same in all lots (0.88 kg./day).

In Trial II, 36 steer calves initially weighing 216.1 kg. were fed for 112 days. Calves were stratified according to breed, source and weight and were randomly allotted to four lots. All calves were fed baled alfalfa hay ad libitum. Lots 1 and 2 received 0.91 kg. barley and 0.45 kg. dehydrated alfalfa; lots 3 and 4 received 0.45 kg. barley and 0.91 kg. dehydrated alfalfa per head per day. Barley was increased in 0.45 kg. increments at 28-day intervals. Poloxalene was fed to calves in two lots. Observed cases of bloat were rated on a scale of one to five. Two calves not receiving poloxalene died of bloat. Chi-square tests showed that significantly ($P<.01$) fewer cases of bloat occurred in the steers receiving poloxalene. Daily gains of steers receiving poloxalene were slightly higher ($P<.10$) than those not receiving poloxalene.

Trial III consisted of 24 yearling Hereford heifers fed chopped alfalfa hay or sun-cured alfalfa pellets with or without poloxalene.

Barley was fed ad libitum. One heifer in an untreated lot required treatment for bloat during the trial, and two heifers bloated in previously treated lots after poloxalene was discontinued prior to slaughter. No other cases of bloat were observed. There were no statistical differences in gains or carcass data.

The steers in Trial II were continued in finishing Trial IV. Two similar steers were added to replace those that had died to make a total of 36 head (9 per lot). Alfalfa hay was 'decreased as barley was increased until ad libitum consumption of barley was reached. Two lots received 0.91 kg. soybean oil meal, and two lots received poloxalene in a 2 x 2 factorial design. Calves receiving soybean oil meal gained more ($P<.10$) than those receiving none. One steer died of bloat in an untreated lot when new crop (1966) alfalfa hay was fed. Chi-square tests showed that significantly ($P<.01$) fewer cases of bloat occurred in the steers receiving poloxalene. Calves receiving poloxalene dressed significantly lower ($P<.05$) than those receiving no poloxalene.

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ABSTRACT

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The steers in Trial II were continued in finishing Trial IV. Two similar steers were added to replace those that had died to make a total of 36 head (9 per lot). Alfalfa hay was decreased as barley was increased until _ad libitum_ consumption of barley was reached. Two lots received 0.91 kg. soybean oil meal, and two lots received poloxalene in a 2 x 2 factorial design. Calves receiving soybean oil meal gained more ($P < .10$) than those receiving none. One steer died of bloat in an untreated lot when new crop (1966) alfalfa hay was fed. Chi-square tests showed that significantly ($P < .01$) fewer cases of bloat occurred in the steers receiving poloxalene. Calves receiving poloxalene dressed significantly lower ($P < .05$) than those receiving no poloxalene.

INTRODUCTION

Bloat is one of the oldest problems encountered in ruminants. An indication of the long interest in alleviating bloat is the occasionally published reference to a bloat treatment prescribed in 60 A. D. by a Roman veterinarian. The treatment consisted of pouring vinegar through the left nostril and putting two ounces of grease in the jaws of the animal. More recent use of oils on pastures or in rations in bloat prevention suggests both a basic soundness in the Roman treatment and discouragingly slow progress in solving this ancient problem (Anonymous, 1962b).

Bloat, a digestive disorder of ruminants, is the distension of the rumen with gas. The rumen swells as gases formed in normal fermentation are kept from escaping. Swelling is first and greatest at the left flank above the rumen. Other symptoms include an arched back with feet drawn under the abdomen (especially in feedlot bloat), frequent urination and defecation, and labored breathing with nostrils dilated and tongue stretched out of the mouth.

Estimated bloat losses to livestock producers in the United States have been placed in a range of 40 to 45 million dollars annually (Dougherty, 1956). In the western states, including Montana, feedlot bloat is the second most common ailment of the non-infectious ailments and nutritional diseases affecting beef cattle. In a survey by Ensminger et al. (1955), feedlot bloat had a relative frequency of 14.7 percent of all nutritionally sick animals.

Early work in Montana indicated that feeding beet pulp in the ration reduced the incidence of bloat in the feedlot. That bloat is still a problem in Montana feedlots was manifested in a recent trial reported by

Thomas et al. (1964). Five out of forty steer calves were lost due to bloat when fed either baled or wafered alfalfa hay with barley. Because of the losses experienced, the experiments reported in this manuscript were undertaken to evaluate poloxalene as a bloat preventative for feedlot cattle on barley and alfalfa rations.

REVIEW OF LITERATURE

Classification of Bloat

The following classification of bloat was employed by Cole *et al.* (1956):

1. Chronic bloat - a condition of tympany occurring irrespective of the qualitative nature of the diet. This would include the type of bloat encountered in a conventional type of dwarfism, in calves with chronic digestive disturbances, or in ruminants suffering from perintonitis. Chronic bloat will not occur on a starvation diet, but will vary with the quantitative nature of the diet.

2. Sub-acute bloat - a condition resulting from a specific dietary regimen, such as succulent legumes, or a predominantly concentrate diet, in which distressing symptoms such as frequent urination, defecation, and labored breathing are not manifested. Ruminal pressure, as measured by use of the tympanometer will vary from slightly above zero to 57 mm. Hg.

3. Acute bloat - similar to sub-acute bloat, except that the condition is further advanced and distressing symptoms appear. Ruminal pressure will vary from 45 to 69 mm. Hg.

Feedlot bloat, by common usage, refers to bloat in fattening beef cattle on high concentrate rations in which the intake of roughages is restricted. Basically, feedlot bloat and bloat on legume pasture are similar, in that excess foaming of rumen ingesta is involved in both. There may be one distinguishing feature. Lindahl *et al.* (1959a) has reported a progression in severity of feedlot bloat with time. This phenomenon has not been reported on legume pasture.

Etiology of Bloat

The incidence of bloat depends on dietary components and upon the physiological or anatomical state of the animal. It is clearly recognized by all who have investigated the etiology of bloat that; bloat occurs under specific dietary regimes; individuals vary greatly in their susceptibility to this disease; and finally, certain animals will vary in susceptibility from time to time (Cole and Boda, 1960).

Bryant (1961) stated that the main cause of bloat is the entrapment of ruminal gases in a stable foam which cannot be eliminated.

Dietary Influence on Occurrence of Bloat

Until recently, the essential dietary conditions for bloat production have not been defined accurately enough to induce the condition at will. Now, acute bloat on legume pastures and in the feedlot have been readily produced in a number of laboratories (Barrentine et al., 1954; Cole et al., 1943; Lindahl et al., 1957a; Smith et al., 1953).

Generally, acute bloat on legume pasture requires relatively pure stands of immature legumes under optimal environmental conditions for rapid growth. Occasionally, bloat has occurred with stands containing 50 percent or more grasses. This has happened when animals selectively grazed succulent legumes in poorly managed pastures where the grasses became stemmy and unpalatable (Cole and Boda, 1960).

Some high concentrate diets have produced bloat in feedlot cattle. Mead and Goss (1935) noted a high incidence of bloat in cattle fed a diet of 61.5 percent ground barley, 26.3 percent wheat bran, 8.8 percent soybean oil meal, 1.9 percent salt, and 1.5 percent calcium carbonate.

Lindahl et al. (1957a) fed a ration of 61 percent barley, 16 percent soybean meal, 1 percent salt, and 22 percent alfalfa meal which consistently produced bloat in feedlot cattle. No significant differences in the bloating effect of the diet was obtained by substituting corn for barley, or alfalfa hay for the alfalfa meal.

Boda (1958) reported that dehydration of alfalfa greatly reduced the ability of that alfalfa to produce bloat.

Addition of four or eight percent crude degummed soybean oil to a bloat producing feedlot ration significantly increased the incidence of bloat in the feedlot (Elam et al., 1960; Elam and Davis, 1962b). The rations contained approximately 16 percent crude protein.

Chemical Constituents of Legumes Related to Bloat

Juices

There have been many theories and propositions as to the chemical constituents of legumes that may be responsible for bloat.

Acute bloat has been produced in cattle by oral or intraruminal administration of pressed juice from freshly cut alfalfa or clover (Blake et al., 1955; Ferguson and Terry, 1955; Moore et al., 1957). Such juices would contain many possible bloat-provoking substances. Ferguson and Terry (1955) fractionated this juice and found that removal of the precipitated chloroplastic material did not reduce its bloat provoking capacity. They concluded that the bloat provoking factor(s) in alfalfa is non-ionic and not absorbed on resins, i.e., properties shown by saponins.

Chemical and biological assays of aqueous residues, alfalfa juices, and rumen liquids by Dzuik et al. (1961) indicated that these substances in their crude form were not suitable for determining factors causing bloat. Bailey (1964) found no correlation between levels of lipid-bound sugars and bloatiness in clovers.

Proteins

There is ample evidence that cytoplasmic proteins are of major importance in producing foam in the rumen (Cole and Boda, 1960). Mangan (1959) found that cytoplasmic protein has an optimum pH for foaming at 5.4 to 6.0 which is in the normal pH range of the rumen contents. Other plant constituents had optimum foaming pH ranges above or below 5.4 to 6.0. Miltimore (1964b) observed that the nitrogen content of alfalfa accounted for 29 percent of the variation in bloat incidence. Miltimore et al. (1964) also found a significant correlation between nitrogen and sulphur content and postulated that bloating might be influenced by amino acids high in sulphur such as methionine and cystine.

Meyer et al. (1965a) was not able to establish any clear association between the amino acid content of the aerial portion of the alfalfa plant and its bloat provoking ability. Bartley (1965b) reported a relationship between foaming potential and soluble protein content of the plant. Alfalfa extracts gave maximum foam stability and maximum soluble protein content during prebloom growth, whereas bird's-foot trefoil was relatively low in soluble protein. It is known that bird's-foot trefoil, a leguminous plant high in total protein is seldom bloat provocative (Pressy et al., 1963b).

Recently, a protein foaming agent called 18-S protein has been isolated from alfalfa (McArthur et al., 1964). McArthur and Miltimore (1965) found that 18-S protein is a major component of plant protein and that bloat producing forages contained more 18-S protein than non-bloat producing forages. This supports the view that 18-S protein is the causative agent in plants which gives rise to legume bloat.

Pectins and hemicelluloses

Reports by Head (1959) and Conrad et al. (1961) have indicated that pectins and hemicelluloses function to produce foam in the rumen. Conrad and Pounden (1960) showed that hemicelluloses and pectic substances combined are the chief source of rapid gas production when alfalfa and Ladino clover are digested in the rumen. Conversely, Pressy et al. (1963a) failed to show a direct relationship between the level of pectic substances and occurrence of bloat in cattle, but did state that under some conditions pectins can serve as foam stabilizing agents. Pectin, a jelly-like substance, can serve to stiffen rumen contents and trap pockets of gas. Leafy alfalfa contains up to eight percent pectins (Anonymous, 1961).

There appears to be an enzyme interaction with pectins. Gupta and Nichols (1962) presented evidence that the highly viscous properties of pectins were produced chiefly by demethylation with pectin methylesterase. In the absence of pectin methylesterase, no jelling or carbon dioxide formation in pectin solutions was observed. An aqueous extract of fresh alfalfa contained demonstratable pectin methylesterase activity, whereas expressed juices of the plant did not. Alkyl-aryl sulfonate inhibited pectin methylesterase activity. Nichols (1963) found a 96 percent reduction in the incidence of bloat when alkyl-aryl sulfonate was fed to cows receiving fresh chopped legumes.

Saponins

Saponins, soap-like chemicals in legumes, have been found to play a role in the foaming of ruminal ingesta, and thus, in the production of bloat. Lindahl et al. (1957b) produced bloat by administering saponins.

Dosages used by these workers were toxic, and death without bloat occurred if the animal was not fed before treatment. It has been shown that administration of saponins resulted in reduced ruminal motility (Lindahl et al., 1957b) and formation of stable froth (Lindahl and Davis, 1957). Other researchers (Jackson et al., 1962; McNairy, 1963) have shown no relationship between saponins and incidence and severity of bloat. While saponins may contribute to ruminal bloat, it cannot be concluded that saponins per se, are the cause of naturally occurring bloat. Leafy alfalfa contains one-half to one percent saponin (Anonymous, 1961).

Jacobson et al. (1957) found that small amounts of saponin in the presence of glucose could aid greatly in the formation of stable froth.

Gutierrez and Davis (1962) stated that slime production from digestion of saponins by rumen bacteria may explain artificial bloat induced in animals by feeding large quantities of saponins, but this phenomena may not necessarily occur in animals which are grazing since the release of the compounds from the whole plant would be slower.

Plant lipids as antifoaming agents

That legumes contain antifoaming substances is a relatively new concept which was developed following the discovery concerning the effect of fats and other foam-dispensing agents on foaming of ruminal ingesta (Johns et al., 1957; Mangan, 1959; Mangan et al., 1959). Mangan et al. (1959) found ruminal liquor of penicillin-treated animals to have poor foam stability before and strong foam stability after centrifuging. This result was explained as being due to the throwing down of the lipid-carrying chloroplasts.

Bartley and Bassette (1961) stated that plant proteins, saponins, and pectic substances appear to be involved in foam formation. Pressy's (1963b) results suggested that the plant contains a complex system of foaming agents, foam inhibitors, and foam stabilizers and that its bloat producing potential may be the net effect of a delicate balance of these groups of substances.

Animal Factors Related to Bloat

Salivation

It has been postulated that bloat results when feeds containing foaming constituents fail to induce sufficient salivary secretion (Bartley, 1965b). Weis (1953) demonstrated that reflex salivary secretions could be induced by mechanical stimulation of the cardia; he postulated that succulent bloat producing legumes are ineffective in the stimulation of salivary flow.

Bartley and Yadava (1961) tested the antifoaming activity of bovine saliva, plant mucilages, and animal mucins on alfalfa saponin foams. Bovine saliva and animal mucins effectively inhibited foam formation *in vitro* and *in vivo*. They postulated that bloat results when feeds containing foaming constituents fail to induce sufficient salivary secretion. Mucin appeared to serve as a foam-inhibiting and foam-breaking agent.

Earlier reports by Bartley (1957) showed that saliva or mucilaginous extracts from linseed meal resulted in greater release of gas from incubated frothing rumen contents. Linseed meal fed to cattle reduced the incidence of bloat and caused the bloat to subside more rapidly.

It was postulated that if froth formation in cattle grazing legumes is due to a lack of salivary secretion, mucin in saliva or linseed meal could be responsible for the protective action of these materials. These results are in agreement with Van Horn (1961) and Bartley (1965b).

Conversely, studies by Phillipson _et al._ (1958) and Mendel and Boda (1961) indicated that carbon dioxide liberated from the bicarbonate in saliva aided in the increase of gas pressure in bloating animals. Surface active salivary mucoproteins have been shown to decrease the foaming of rumen ingesta (Mendel and Boda, 1961; Lyttleton, 1960).

Eructation

Inefficient eructation is commonly considered the immediate cause of bloat (Dougherty, 1960). Eructation is stimulated when the rumen and reticulum are stretched with gas. The eructation process may be described briefly as follows: the cardia is cleared of food; rumen gas is pushed forward into the reticulum, and by a series of muscular relaxations, it enters and is trapped in the esophagus. The gas is then expelled into the pharynx by contractions of the esophogeal wall (Anonymous, 1961).

In a bloated animal, the foam, instead of free gas, touches a sensitive area around the cardia. This sensitive area reacts to foam as it does to water and will not let the cardia open. It was concluded that when the receptors around the cardia are covered with ingesta, eructation is partially or completely inhibited. This may be why raising the front part of a bloated animal sometimes relieves the stress of bloat.

Leffel and Komarek (1961) stated that the eructation is controlled by the autonomic nervous system. If high enough levels of epinephrine and atropine were injected bloat occurred. Feedstuffs associated with bloat, such as green legumes, may contain substances, which either by themselves or as metabolic products of the microorganisms, affect the autonomic nervous system.

Inheritance

Over the years, many researchers have indicated that susceptibility to bloat is heritable. Knapp (1943) found a highly significant difference between progeny groups in frequency of bloat. In Oregon trials, when chronic bloaters were mated, 65 percent of the offspring were chronic bloaters (Anonymous, 1961). Lyttleton (1960) stated that bloating tendency and salivary protein patterns are both heritable. Bartley (1965b) observed that non-bloaters secrete greater quantities of saliva than do bloaters -- a logical explanation for hereditary differences among animals in susceptibility to bloat.

Hancock (1954) observed wide differences in bloat susceptibility between sets of twins and great similarities in this respect within twin sets. He noted 60 percent of the severe bloaters to be the daughters of one bull.

Rumen ingesta composition

Many characteristics of rumen ingesta have been studied, but few relationships to bloat have been observed. Mendel and Boda (1961) found no differences in total, soluble, and ammonia nitrogen of rumen liquor, buffering capacity of rumen ingesta, and rumen pH of bloaters and nonbloaters. Mangan (1959) found that the optimum pH for foaming of rumen liquor was 5.4 to 5.7.

Bartley and Bassette (1961) found the foam of bloated animals to have the following composition (on a dry matter basis):

		Percent
protein	-	63.3
ether extract	-	1.5
crude fiber	-	0.0
carbohydrate	-	17.0
ash	-	18.2
		100.0

Jacobson *et al.* (1957) found a highly significant negative correlation between the percentage liquid phase of the rumen contents and the incidence of bloat. There was no correlation between percent dry matter of rumen contents and bloat incidence. Jacobson *et al.* (1958) noticed that the concentration of volatile fatty acids increased when the animals were changed from a hay-silage diet to a bloat producing diet.

Blood components

Brown *et al.* (1960) determined levels of phosphorus, ammonia nitrogen, urea, and blood pigments of bloat-susceptible and non-susceptible animals. Plasma inorganic phosphorus was found to be significantly higher in bloated animals. Jackson *et al.* (1959) found higher blood cholesterol values in cattle pastured on alfalfa than on blue grass. A direct correlation was found between cholesterol levels and the severity of bloat. The significance of these blood studies in relation to the etiology of bloat is at present obscure.

Microbial Factors Related to Bloat

Bartley *et al.* (1961) studied the relationship between rumen microflora and bloat using four sets of fistulated identical twin dry cows. They found that cows deprived of practically all their rumen flora can consume normal quantities of alfalfa pasture by the third day and can bloat by the fourth day. Because the cows did not reach maximum bloat proportions during the second or third day even though optimum amounts of bloat producing feed were consumed, it indicated that microflora are involved in bloat and that bloat is not the result of simple physical breakdown of feed. Cows which received fresh rumen fluid bloated sooner, perhaps because bloat depends on establishing a certain concentration of microorganisms.

Gutierrez et al. (1959) noticed the increase in numbers of streptococci types of organisms during the onset of feedlot bloat and suggested that they play a role in the etiology of bloat.

Bryant et al. (1960) found no significant differences between animal groups in pH of ruminal contents, counts of cellulolytic bacteria, and total anaerobic bacterial counts. It was evident that the occurrence of bloat in animals consuming Ladino clover was not related to large differences in the numbers or species of ruminal microorganisms; however, he did find a high percentage of gas producing species.

A correlation of 0.94 was obtained by Jacobson et al. (1957) between the percentage of encapsulated microorganisms and the occurrence of bloat. Slime produced by rumen microorganisms may contribute frothing factors to legume or feedlot bloat (Gutierrez and Davis, 1962). Conversely, Elam and Davis (1962b) found no significant correlation between bloat and microbial activity.

Cultures of bacteria capable of breaking down salivary mucin have been isolated (Bartley, 1965b; Fina et al., 1961). This isolation has led to the proposal that the concentration of mucin necessary to prevent bloat can be destroyed by these mucinolytic bacteria.

Control of bloat by antibiotics further suggests an association between microorganisms and bloat (Bartley, 1965b).

The proportions of the major fermentation products in bloated and unbloated animals have been found to be quite similar (Hungate et al., 1955).

Prevention of Bloat

Several methods of bloat prevention including supplemental feeding of grass hays or pastures, legume soilage, the use of grass dominant pastures, and strip-grazing were reviewed by Cole and Colvin (1956). Encouraging cattle to fill up on feedstuffs of low bloat producing potential prior to grazing on bloat producing pasture has been effective in reducing the incidence of bloat. This is probably due to the reduced intake of lush forage. The effectiveness of supplementing legume pasture with oat hay was observed by Colvin et al. (1958).

Antibiotics

Barrentine et al. (1956) first proposed the use of antibiotics for preventing acute bloat and reported that single, oral doses of 50-75 mg. of procaine penicillin would prevent bloat for one to three days in steers grazing Ladino clover. A number of other antibiotics including chlortetracycline, oxtetracycline, bacitracin and streptomycin were ineffective. In the case of chlortetracycline and oxytetracycline, diarrhea was severe when large doses were given. These investigators also reported free-choice feeding of salt containing 800 mg. procaine penicillin per pound would provide practical control of legume bloat. That penicillin will reduce the incidence and severity of bloat within certain limits has been adequately confirmed (Brown et al., 1958; Essig et al., 1961; Johnson et al., 1958; Miltimore, 1964a; Thomas, 1956; Shawver and Williams, 1960). However, some animals receiving penicillin continued to bloat, and its effectiveness declined within about two weeks as the animals became refractory to the antibiotic (Essig et al., 1961; Johnson et al., 1958). A combination of antibiotics such as penicillin and erythromycin may control bloat for a longer period of time than when fed alone or in rotation, but even then effectiveness declines after three to four weeks (Essig et al., 1962b; Johnson et al., 1960; Van Horn, 1963). Essig and Shawver (1965) noted that a combination of terramycin and dimethylopolysiloxane in molasses blocks did not effectively prevent bloat in steers on Ladino clover pasture.

Results of several tests have indicated that penicillin prevents bloat by affecting the ruminal fermentation rate, and thus, gas production, and probably by inhibiting some bacterial process involved in the formation of intrarumen foam. Johns et al. (1957) reported that penicillin slows fermentation rate, with a resultant leveling off of gas production and the accumulation of soluble sugars and proteins in the rumen ingesta.

Preliminary observations by Shellenberger et al. (1964) suggested that oral administration of potassium levopropylcillin reduced the incidence and severity of bloat in cattle for a substantially longer period of time than penicillin. Essig et al. (1962a) found that dynafac exhibited no control of incidence and severity of bloat of steers on a conventional feedlot ration that produced bloat.

Antifoaming Agents

The use of antifoaming agents for bloat prevention in stall-fed and grazing animals has been extensively investigated (Brown et al., 1958; Colvin et al., 1959; Johnson et al., 1958; Miltimore, 1964). In general, various mineral and vegetable oils and animal tallows have been effective, whereas silicone preparations and detergents were less reliable. Conversely, such materials have not been effective in preventing feedlot bloat and in some trials have increased the incidence of the condition (Elam and Davis, 1959; Elam and Davis, 1962b; Elam et al., 1960).

Fat intakes of approximately 50-100 grams per head will prevent bloat for about three hours in cattle fed bloat provoking legumes. Fats and oils disappear quite rapidly from the rumen, and thus, their effectiveness in preventing bloat is limited to about three hours after administration. The need of a palatable, long lasting preventative is evident if cattle are to be allowed access to bloat provoking feed for longer periods of time.

With partial success, attempts have been made to control bloat by adding antifoaming agents to the drinking water (Brown et al., 1958). A major reason for the unreliability of this method is that drinking patterns, and thus, oil intake, varies greatly from animal to animal and day to day (Cole and Boda, 1960). Spraying of bloat provoking pastures, in conjunction with strip-grazing to insure ingestion of sprayed forages, with emulsified peanut oil or tallow, has provided effective and practical control in New Zealand (Johns, 1959; Reid, 1958; Reid, 1959). At the levels used (120-150 grams fat), there is little or no damage to forage or to subsequent pasture growth (Reid, 1958).

Fats and oils' antifoaming properties are due to a lowering of surface tension of rumen ingesta (Blake et al., 1957). Generally, the use of oils or antibiotics has been considered too costly and/or inconvenient for widespread use in the United States (Anonymous, 1962a).

Alkyl-aryl sulfonate

Wisconsin workers have developed a new compound for bloat control. After their discovery of the role of the enzyme, pectin methylesterase, in foam production, Gupta and Nichols (1962) found that alkyl-aryl sulfonate inhibited the enzyme action and effectively prevented bloat.

Poloxalene

The limitations previously mentioned of conventional antifoaming agents have caused researchers to seek a practicable agent. The following criteria were established at Kansas State University for selecting a successful agent to control bloat (Bartley, 1965a):

(a) one administration must effectively prevent bloat at least twelve hours;
(b) must act rapidly (within 10 minutes);
(c) must be palatable;
(d) must not deleteriously affect health, reproduction, rumen function, feed intake, or quality or quantity of milk;
(e) must not be eliminated in milk;
(f) must not be found in body tissue five days after administration;
(g) must be economical.

Poloxalene, a non-ionic surfactant, has been successful in meeting these criteria. The surfactant is a polyoxypropylene polyoxyethylene block polymer of high molecular weight. The marketed product contains poloxalene coated on feed grade vermiculite. The preservatives beta hydroxy tolulene and ethoxyquin are added to prevent product spoilage.

By use of labeled C^{14} Meyer et al. (1965b) showed that poloxalene is not eliminated in milk secreted from a few hours to ten days following administration, and that no residues of poloxalene remain in body tissues ten days after its administration.

Experiments by Helmer et al. (1965) showed that up to 40 grams per day of poloxalene had no deleterious effect on milk production, milk fat test, body weight, feed consumption, conception rate, or animal health. Ten grams of surfactant daily seemed not to affect rumen ammonia concentration, rumen pH, or rumen lactic and volatile fatty acid concentration.

Earlier experiments by Bartley (1965a) indicated that poloxalene would effectively prevent alfalfa bloat in fistulated, identical twin, dry cows. Later experiments (Bartley et al., 1965), which included four Kansas dairy herds and dairy steers at Iowa, showed that at high enough levels, poloxalene afforded complete control of legume bloat. Ten grams of poloxalene per 500 kilograms body weight appeared to be an effective level. Results indicated that effectiveness of poloxalene as a bloat preventative remained constant as the season progressed. Other experiments (Essig et al., 1965a; Essig et al., 1965b; Foote et al., 1965) have substantiated these results.

Poloxalene has been administered as a top dressing over grain before grazing (Bartley et al., 1965) and by incorporation into molasses blocks (Essig et al., 1965a). Either method appears to be equally effective. In extensive tests with rats, no deleterious toxicologic effects of poloxalene were observed (Leaf et al., 1965).

Poloxalene was approved by the Food and Drug Administration for use on

March 10, 1966 (Bartley, 1966). Warning statements on the label include:

(a) store in cool dry place;
(b) keep sealed to exclude air;
(c) if product develops strong acrid odor, discard immediately;
(d) treated animals are not to be slaughtered for food within ten days after receiving poloxalene.

It appears that poloxalene is much longer lasting and more effective than the usual surface acting agents (Bartley, 1966).

METHODS AND PROCEDURES

These experiments were conducted at the Montana Agricultural Experiment Station, Bozeman, Montana. Cattle used in the trials were produced at the Red Bluff Research Ranch, Montana Agricultural Experiment Station, Norris, Montana or were purchased locally. The calves were branded and vaccinated for Blackleg and Infectious Bovine Rhinotracheitis (Red Nose) upon arrival at the feedlot. All calves were treated with Ruelene for grub control.

The feed was weighed and mixed in large cans and spread in the bunks twice daily. Straw was used as bedding and was added to the back half of each pen as needed.

Initial and final weights of cattle were taken after an overnight shrink (15 hours) without feed and water. The calves were individually weighed every 28 days throughout the trial. All calves were eartagged for identification.

The data submitted in this manuscript are presented in the metric system. Appendix tables are presented in the English system.

Trial I

Forty steer calves were used in Trial I; twenty-four Hereford calves were produced at the Red Bluff Research Ranch at Norris, Montana; twelve Hereford steers were purchased from Lester Warwood of Belgrade, Montana; and four Angus-Hereford crossbred steer calves were produced at the Fort Ellis Farm east of Bozeman, Montana. Ten steers were randomly assigned to each of four lots on the basis of weight, source, and breed. Steers of different breeds and from different sources were included to increase the possibility of bloat.

The calves were located in a gravel base loafing pen and a liberally bedded loafing shed throughout the trial. The calves were fed in an open bunk located in the loafing shed. All steers had access to fresh, unheated water.

The steers were restricted to their respective loafing sheds the night of December 2, 1964. Following an overnight shrink, they were individually weighed onto the wintering trial the morning of December 3, 1964. The design of Trail I is given in Table I.

TABLE I. DESIGN OF TRIAL I.

Lot No.	2	3	4	5
No. Steers	10	10	10	10
Treatment:				
Alfalfa Hay	wafered	baled	baled	wafered
Poloxalene (gm.)	0.00	0.00	10.00	10.00
Concentrate mixture (kg.) 1/	1.35	1.35	1.35	1.35

1/ Concentrate increased 0.454 kg. each 28-day period.

The hay was second cutting alfalfa from the Plant and Soil Science Field Research Laboratory. Windrows in the same field were alternately wafered or baled the same day. Wafers were 3.81 centimeters square and were produced by a John Deere Company wafering machine.

The concentrate mixture fed consisted of 80 percent steam rolled barley and 20 percent beet pulp during the first 56 days of the trial. A 90 percent barley and 10 percent beet pulp mixture was fed the last 56 days of the trial. The percentage of barley was raised to possibly increase incidence of bloat. All calves were fed 1.35 kg. of the concentrate mixture per head daily at the onset of the trial. The concentrate mixture was increased in increments of 0.454 kg. each 28-day period. The hay was fed ad libitum with the lot of steers consuming the least governing the amount fed. The bloat preventative agent, poloxalene, was incorporated into a premix of soybean oil meal, wheat mill run, and dehydrated alfalfa meal. The premix was top dressed over the concentrate mixture at each feeding and was fed so that each calf in the treated lots received an average of 10 grams of poloxalene daily.

The percentage composition of the premix is shown in Table II.

TABLE II. PERCENT COMPOSITION OF PREMIXES FED IN TRIAL I.

	0 Premix	X Premix
Soybean oil meal	66.6	50.0
Dehydrated alfalfa meal	16.7	12.5
Wheat mill run	16.7	12.5
Poloxalene	00.0	25.0
	100.0%	100.0%

The active ingredient, poloxalene, was impregnated onto feed grade vermiculite so that 10 grams of poloxalene was contained in 0.28 kg. of the product incorporated in the premix. Iodized salt was available on an ad libitum basis throughout the trial. The cattle were observed for bloat several hours after feeding each day.

At the termination of the trial, all cattle were individually weighed after a 15-hour restriction from feed and water. These cattle were subsequently allotted to an unrelated trial, therefore, no carcass data was obtained. The final weights of the cattle were subjected to statistical analysis of covariance, using initial weights as the concomitant variable.

Trial II

Thirty-six steer calves were used in this trial. Twenty-four of the calves were Herefords; sixteen of which were produced at the Red Bluff Research Ranch, Norris, Montana, and eight of which were purchased from George Reich of Willow Creek, Montana. The remaining twelve calves were Angus; eight of which were purchased from Reich and four from Sandy Malcolm of Gardiner, Montana. Again calves of different breeds and from different sources were used to increase the possibility of bloat.

The experimental area consisted of four pens with fenceline bunks. Salt boxes were located at the end of the bunk in each lot. There was one electrically heated watering cup per two lots. A board fence completely surrounded the feeding area, and the surface of the feeding pens was covered with asphalt.

The steers were allotted to their respective lots prior to the start of the experiment. The steers were stratified according to individual weights and randomly allotted by source and breed into four lots. Individual initial weights were obtained on November 26, 1965 after an overnight shrink.

During the 112-day wintering trial, all calves were fed second cutting baled alfalfa hay, ad libitum, plus 0.908 kg. steam rolled barley and 0.454 kg. or 0.908 kg. of pelleted dehydrated alfalfa meal per head per day. Barley was increased in increments of 0.454 kg. each 28-day period. At the end of the first 28 days, the dehydrated alfalfa meal was increased to 0.908 kg. per head per day in lots 3 and 4, and the barley held at 0.908 kg. per head per day. Some 20 percent protein supplement was fed at the beginning of the trial while the calves were becoming accustomed to the dehydrated alfalfa.

Poloxalene was fed in the same premix as in Trial I and at the same rate (10 grams per head per day). The design of the epxeriment and the average daily ration are found in Table III.

TABLE III. DESIGN AND RATIONS FED IN TRIAL II.

Lot No.	1	2	3	4
No. Steers	9	9	9	9
Treatment:				
Steam rolled barley (kg.) 1/	1.76	1.76	1.42	1.42
Dehydrated alfalfa (kg.)	0.454	0.454	0.908	0.908
Poloxalene (gm.)	0.00	10.00	0.00	10.00
Alfalfa hay, baled	Ad lib.	Ad lib.	Ad lib.	Ad lib.

1/ Barley increased 0.454 kg. each 28-day period.

Calves were observed for bloat approximately two hours after feeding. Observed cases of bloat were rated on the following scale adapted from Elam *et al.* (1960).

Rating	Description
1 - No Bloat	No distension or very slight distension only
2 - Mild	Mild, but definite distension on left side
3 - Moderate	Marked distension on left side and full on right side
4 - Severe	Balloon like, distended on both sides
5 - Terminal	Died or would have if not treated

The 112-day wintering trial was terminated March 18, 1966. Individual final weights were subjected to analysis of covariance, using initial weights as the concomitant variable.

Chi-square tests, as described by Snedecor (1956) were performed on bloat observations. These steers were continued on a finishing trial, and carcass data was obtained at the termination of the finishing period.

Trial III

Twenty-four yearling Hereford heifers were used in this trial. The heifers were purchased at the local auction from four different producers. In addition to the usual vaccinations, the heifers were vaccinated for Leptospirosis, pregnancy tested and sprayed for lice. One heifer was found to be pregnant and was subsequently aborted. The heifers were stratified by weight and randomly allotted to four pens prior to the trial. Individual initial weights were obtained after an overnight shrink on December 4, 1965.

This trial was conducted in newly constructed facilities which consisted of a concrete surfaced bed area and a concrete slatted floor area 2.44 meters wide. Adjacent to the slatted floor were feed bunks. Concrete bunks were covered by a roof. The pens consisted of steel fencing, and the entire area was surrounded by a board fence. Each pen had access to a heated automatic watering tank. The bed area was bedded with sawdust as needed.

The heifers were fed for a 116-day period on a ration of steam rolled barley and alfalfa hay. Two lots of heifers were fed chopped alfalfa hay, and two lots were fed pelleted sun-cured alfalfa hay. Two lots (one fed each ration) were given the same premix as in Trial I. In addition, 0.454 kg. of dehydrated alfalfa meal was fed per head per day. At the onset of the trial, the heifers received 1.81 kg. of barley per head per day. The barley was increased rapidly until <u>ad libitum</u> consumption was reached in approximately two weeks. All the heifers had access to their respective type of alfalfa hay at all times. Boxes with salt and a mineral mixture were constantly available.

The design of this experiment is presented in Table IV.

TABLE IV. DESIGN OF TRIAL III.

Lot No.	5	6	7	8
No. Heifers	6	6	6	6
Treatment:				
Alfalfa hay	chopped	chopped	sun-cured pellet	sun-cured pellet
Poloxalene (gm.)	0.00	10.00	0.00	10.00
Barley	Ad lib.	Ad lib.	Ad lib.	Ad lib.

The trial was terminated on March 30, 1966 when individual weights were obtained after an overnight shrink. Poloxalene was deleted from the ration 10 days before slaughter. The heifers were transported to New Butte Butchering Company, Butte, Montana on April 3, 1966. The heifers were sold on the basis of carcass grade and weight. Upon arrival in Butte, the cattle were unloaded and allowed low-quality grass hay and water ad libitum and were slaughtered as a group the following day. Carcass identity was maintained during the slaughtering procedure. A record was made of the number of abscessed livers, and the rumen was examined for rumen parakeratosis. Carcasses were weighed warm following shrouding, and three percent shrink was used as an estimate of cold carcass weight.

Approximately 72 hours following slaughter, the carcasses were graded, and a marbling score of the rib eye at the twelfth rib was determined by a U.S.D.A. grader. At this time, rib eye area and backfat thickness at the twelfth rib were obtained. Final weights of the heifers were subjected to analysis of covariance. Other data was analyzed by analysis of variance or by Chi-square tests.

Trial IV

The thirty-six head of steer calves used in Trial II were used in Trial IV. The steers remained in the same lots. Initial weights were obtained on April 4, 1966.

The design of Trial IV is shown in Table V.

TABLE V. DESIGN OF TRIAL IV.

Lot No.	1	2	3	4
No. Steers	9	9	9	9
Treatment:				
Soybean oil meal (kg.)	0.908	0.908	0.00	0.00
Poloxalene (gm.)	10.00	0.00	10.00	0.00
Barley	Ad lib.	Ad lib.	Ad lib.	Ad lib.
Alfalfa hay, baled (kg.)	1.36	1.36	1.36	1.36

High moisture barley was fed the first 23 days of the finishing trial, after which steam rolled barley was fed. The high moisture barley was rolled once weekly. The cattle were brought up to full feed during the lapse between the wintering and finishing trial on high moisture barley. Soybean oil meal was fed at the rate of 0.454 kg. per head per day to lots 1 and 2 during the first 28 days of the trial and then increased to 0.908 kg. per head per day for the duration of the trial. Alfalfa hay was decreased as the grain portion was increased, until the steers were consuming 1.36 kg. daily, and barley was fed *ad libitum*. New crop (1966) first cutting alfalfa hay was fed from June 27, 1966 to the termination of the trial. Poloxalene was fed in the same premix to lots 1 and 3 which was a reversal from the wintering trial (Trial II). Cases of bloat were observed and subjectively rated as in Trial II. Poloxalene was deleted from the ration 10 days prior to slaughter.

Individual final weights were taken July 24, 1966, and the steers were immediately loaded onto trucks for transport to the packing company at Butte, Montana. Carcass data were obtained as in Trial III. The steers were sold on the basis of carcass grade and yield.

Statistical analyses of data were performed as in Trial III.

Trial V

Trial V consisted of a measurement of foam formation from feedstuffs in vitro. The process employed was adapted from Kendall (1964).

Air dry samples were kept in paper bags until ground through a Wiley mill equipped with a 40 mesh screen. Three grams of the forage and 150 milliliters of distilled water were placed in the mixing chamber of a blender. The blender was then run for two minutes to grind the plant tissues and liberate cell contents into the solvent. The extract was poured into the small bowl (1.42 liters) of a food mixer, and 150 milliliters distilled water was added. The food mixer was operated at maximum speed for two minutes to generate foam. The extract was then transferred immediately to a 1000 milliliter graduated cylinder and allowed to stand for two minutes, after which the cylinder was given a vigorous shake. Final volume of foam was read from the cylinder scale.

Phase 1 consisted of determining the foam formation of the forages fed in the four preceding trials. Phase 2 was the same as above plus the