MONTANA STATE UNIVERSITY

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
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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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TABLE OF CONTENTS

INDEX TO TABLES

INDEX TO APPENDIX

TABLES | Page

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 non-bloaters. 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 addition of 0.01 grams of poloxalene to the extract immediately before starting the blending operation. A sample of sanfoin hay was also analyzed. This relatively new variety of legume has been claimed to be of low bloat provoking potential.

RESULTS AND DISCUSSION

Trial I

The initial and final weights, average daily gains, average daily feed consumption and feed conversion data are presented in Table VI.

TABLE VI. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY AND COST OF GAIN OF STEER CALVES FED BALED OR WAFERED ALFALFA HAY WITH OR WITHOUT POLOXALENE. (Trial I -- December 3, 1964 to March 25, 1965 -- 112 days).

Lot No.	2	3	4	5
Treatment:				
Alfalfa hay	Wafered	Baled	Baled	Wafered
Poloxalene (gm.)	0.00	0.00	10.00	10.00
No. Steers	10 1/	10 2/	10	10
Average weights (kg.)				
Final	277.4 3/	275.1 4/	270.1	281.0
Initial	178.4	179.3	174.8	182.1
Gain	99.0	95.8	95.3	98.9
Daily gain	0.88	0.86	0.85	0.88
Average daily ration (kg.)				
Alfalfa hay	4.54 5/	4.49	4.45 5/	4.43
Concentrate mixture	2.00	2.02	2.04	2.02
Premix	0.10	0.10	0.10	0.10
Salt	0.01	0.01	0.01	0.01
Total	6.65	6.62	6.60	6.56
Kg. feed per kg. gain	7.57	7.63	7.74	7.30
Feed cost per kg. gain ($) 6/	0.23	0.24	0.24	0.23

1/ One Angus crossbred steer (266) died January 30; one Hereford steer (425) died February 25 of bloat.

2/ One Hereford steer (441) died of bloat January 31.

3/ Average weights and daily gains are presented for the eight calves which remained in lot 2 for the duration of the trial.

4/ Average weights and daily gains are presented for the nine calves which remained in lot 3 for the duration of the trial.

5/ Ration and efficiency figures were adjusted to include data only for those calves remaining in each lot for the duration of the trial.

6/ Feed prices: concentrate mixture, $0.0485/kg.; alfalfa hay, $0.022/kg.; premix, $0.0855/kg.; salt, $0.036/kg.

Analysis of covariance of the gains of steers (Table VI) fed wafered or baled hay with or without poloxalene indicated no significant differences ($P > .05$) due to treatment or interaction. The gains of calves fed the wafered second cutting alfalfa hay (lots 2 and 5) were not significantly greater than the gains of calves fed the baled alfalfa hay (lots 3 and 4). This is not in agreement with Matz (1965) who found that calves fed wafered second cutting alfalfa gained 16 percent more than calves fed the same hay in long form.

Because the steers within each lot were group-fed, a statistical analysis of feed per unit gain could not be conducted. However, as shown in Table VI, the steers which received wafered hay (lots 2 and 5) were slightly more efficient than those which received baled hay (lots 3 and 4).

The proximate chemical analysis of the feed ingredients used in this trial are given in Table VII.

TABLE VII. PROXIMATE CHEMICAL ANALYSIS OF FEED UTILIZED IN WINTERING CALVES IN TRIAL I. 1/

Feed	Moisture %	Crude Protein %	Ether Extract %	Ash %	Crude Fiber %	Phosphorus %	Calcium %	Carotene mg./kg.
Concentrate mixture	10.4	12.9	2.6	2.9	6.7	0.18	0.96	....
O-Premix	9.0	33.8	2.6	5.7	11.8	0.16	0.30	....
X-Premix	6.9	30.5	9.0	14.4	8.2	0.35	0.53	....
Alfalfa wafer	10.5	23.1	1.8	7.6	23.8	0.93	0.14	42.1
Alfalfa hay	10.0	14.0	2.1	6.9	29.8	0.21	0.49	30.0

1/ Analyses by Chemistry Department, Montana State University.

Average daily consumption of feed by the steers was similar in all lots. This is logical because the amount of hay fed was governed by the lot consuming the least hay. Equal amounts of other portions of the rations were fed to the four lots.

During the 112-day trial, three calves died of bloat in lots 2 and 3 which received no poloxalene. Only one calf was observed to have ruminal distension which required treatment. This calf died before he could be treated. No other cases of bloat were observed in any of the four lots. After termination of the trial, one chronic bloater developed in a lot which previously had received poloxalene.

Trial II

The initial and final weights, average daily gains, average feed consumption and feed conversion data are presented in Table VIII.

Analysis of covariance of the gains of steers (Table VIII) fed two levels of dehydrated alfalfa pellets with or without poloxalene indicated no significant differences ($P > .05$) due to treatment or interaction. However, gains of steers on the poloxalene treatment approached significance ($P < .05$). Inspection of Table VIII shows that gains of steers fed poloxalene (lots 2 and 4) were greater than those not fed poloxalene (lots 1 and 3). Investigators have noted that frequently-bloating cattle have reduced daily gains (Brown et al., 1958; Van Horn, 1963; Miller et al., 1965). If poloxalene prevented bloat in lots 2 and 4, the gains of steers in lots 1 and 3 may have been depressed by the frequent occurrence of bloat.

Steers fed 0.90 kg. dehydrated alfalfa pellets (lots 3 and 4) gained slightly, but not significantly, more than those fed 0.45 kg. dehydrated alfalfa pellets (lots 1 and 2). The additional 0.45 kg. of dehydrated alfalfa fed lots 3 and 4 replaced the 0.45 kg. steam rolled barley in the

TABLE VIII. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY, AND COST OF GAIN FOR STEER CALVES FED TWO LEVELS OF DEHYDRATED ALFALFA MEAL WITH OR WITHOUT POLOXALENE. (Trial II -- November 26, 1965 to March 18, 1966 -- 112 days).

Lot No.	1	2	3	4
Treatment:				
Dehydrated alfalfa (kg.)	0.45	0.45	0.90	0.90
Poloxalene (gm.)	0.00	10.00	0.00	10.00
No. Steers	9 1/	9	9 2/	9
Average weights (kg.)				
Final	296.5 3/	302.8	301.0 3/	311.4
Initial	213.4	216.1	216.1	217.5
Gain	83.1	86.7	84.9	93.9
Daily gain	0.74	0.78	0.76	0.84
Average daily ration (kg.) 4/				
Alfalfa hay	4.95	5.19	5.25	5.18
Barley	1.78	1.77	1.43	1.43
Dehydrated alfalfa	0.41	0.41	0.75	0.75
Premix	0.15	0.15	0.15	0.15
Salt	0.02	0.02	0.02	0.02
Total	7.32	7.54	7.60	7.53
Kg. feed per kg. gain	9.75	9.73	10.03	9.00
Feed cost per kg. gain ($) 5/	0.35	0.35	0.36	0.33

1/ Calf No. 515 died of bloat on December 7, 1965.
2/ Calf No. 516 died of bloat on December 22, 1965.
3/ Average weights and daily gains are presented for the 8 calves which remained in lots 1 and 3 for the duration of the trial (112 days).
4/ Ration and efficiency figures were adjusted to include 8 head per lot for the first 55 days and at that time one calf was added to each lot (1 & 3) to have a total of 9 head per lot for the remainder of the trial.
5/ Feed prices: steam rolled barley, $0.0530/kg.; alfalfa hay, $0.0275/kg.; dehydrated alfalfa, $0.0573/kg.; premix, $0.0855/kg.; and salt, 0.0360/kg.

ration. On this basis, it would appear that the addition of 0.45 kg. of dehydrated alfalfa as a replacement for 0.45 kg. barley would depend largely on the relative prices of the ingredients. Dehydrated alfalfa would supply additional crude protein, but less total digestible nutrients.

Because the steers within each lot were group-fed in a bunk, a statistical analysis of feed required per unit gain could not be conducted. However, as shown in Table VIII, lot 4 was 10.3 percent more efficient than lot 3. There was little difference between lots 1, 2 and 3. Average daily consumption was similar between lots. Some 20 percent supplement was fed the first 28 days of the trial while the calves were becoming accustomed to dehydrated alfalfa meal. This resulted in a lower average daily consumption of dehydrated alfalfa meal than had been planned.

The proximate chemical analysis of the feed ingredients used in Trial II are presented in Table IX.

TABLE IX. PROXIMATE ANALYSIS OF FEEDS FED STEER CALVES ON WINTERING TRIAL II. 1/

Feed	Moisture %	Crude Protein %	Ether Extract %	Ash %	Crude Fiber %	Phosphorus %	Calcium %	Carotene mg./kg.
Steam rolled barley	12.1	11.5	1.6	2.7	3.5	0.37	0.06	....
Dehydrated alfalfa	6.0	16.7	2.4	8.0	29.1	0.22	2.44	63.0
Baled Alfalfa hay	8.5	13.9	1.1	8.2	31.9	0.22	2.87	26.0
O-Premix	9.0	35.3	2.2	6.3	10.6	0.47	0.34	....
X-Premix	7.8	25.9	10.4	11.8	8.9	0.43	0.23	....

1/ Analyses by Chemistry Department, Montana State University.

The ratings of observed cases of bloat are presented in Table X.

Most of the observed bloat cases occurred during the first month of the trial. Bloat observations with a rating of three or higher were considered serious cases of bloat. One calf died of bloat in each of the untreated lots during the trial. Bloat was observed on 17 different days.

Non-bloated calves were given a rating of 1.

TABLE X. RATINGS OF BLOAT OBSERVED DURING TRIAL II.

Lot No.	1	2	3	4
No. Steers	9 1/	9	9 2/	9
Treatment:				
Dehydrated alfalfa meal (kg.)	0.45	0.45	0.90	0.90
Poloxalene (gm.)	0.00	10.00	0.00	10.00
Rating:				
1 - No bloat 3/	135	146	128	149
2 - Mild	10	7	14	1
3 - Moderate	7	...	10	3
4 - Severe	...	...	...	...
5 - Terminal	1 1/	...	1 2/	...
Total bloat cases observed	18	7	25	4

1/ Calf 515 died of bloat on December 7, 1965.
2/ Calf 516 died of bloat on December 22, 1965.
3/ Total of non-bloated cattle on days when bloat was observed.

There was not sufficient data to evaluate statistically the severity of bloat. When the data in Table X was assigned to bloat or no bloat categories, Chi-square analyses showed independence for the level of dehydrated alfalfa and incidence of bloat. This is in agreement with Boda (1958) who found that dehydration of alfalfa reduced its bloat-provoking potential. However, Chi-square analysis for incidence of bloat with or without poloxalene was highly significant ($P < .01$). Examination of the data in Table X reveals that feeding 10 grams poloxalene per head daily significantly ($P < .01$) reduced the incidence of bloat under the conditions of this trial.

Trial III

Initial and final weights, average daily gains, average daily feed consumption, feed conversion, and financial returns are presented in Table XI.

TABLE XI. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY, AND FINANCIAL RETURNS FOR YEARLING HEIFERS FED CHOPPED OR PELLETED SUN-CURED ALFALFA HAY WITH OR WITHOUT POLOXALENE. (Trial III -- December 4, 1965 to March 30, 1966 -- 116 days).

Lot No.	5	6	7	8
Treatment:				
Alfalfa hay	Chopped	Chopped	Sun-cured pelleted	Sun-cured pelleted
Poloxalene (gm.)	0.00	10.00	0.00	10.00
No. Heifers	6 1/	6	6	6 2/
Average weights (kg.)				
Final	383.7	379.2	388.7	379.7
Initial	283.5	277.6	279.4	274.4
Gain	100.2	101.6	109.3	105.2
Daily gain	0.86	0.88	0.94	0.91
Average daily ration (kg.)				
Barley	4.99	5.26	5.08	4.94
Alfalfa hay	2.27	2.63	2.68	2.68
Dehydrated alfalfa meal	0.45	0.45	0.45	0.45
Premix	0.18	0.18	0.18	0.18
Salt	0.02	0.02	0.02	0.02
Total	7.91	8.54	8.41	8.27
Kg. feed per kg. gain	9.21	9.73	8.94	9.08
Feed cost per kg. gain ($) 3/	0.43	0.45	0.47	0.48
Financial returns per heifer ($)				
Initial cost 4/	135.75	132.93	133.80	131.41
Feed cost	43.09	45.72	51.37	50.50
Trucking 5/	1.69	1.67	1.71	1.67
Total investment	180.53	180.32	186.88	183.58
Gross return 6/	209.74	203.23	213.63	204.59
Net return	29.21	22.91	26.75	21.01

1/ One heifer was bloated and treated at 10:00 p.m. on December 14, 1965
2/ Two heifers bloated after the feeding of poloxalene was terminated.
3/ Feed prices: steam rolled barley, $0.0530/kg.; dehydrated alfalfa meal, $0.0573/kg.; alfalfa hay, $0.0275/kg.; sun-cured alfalfa pellets, $0.0485/kg.; premix, $0.0855/kg.; and salt, $0.360/kg.
4/ Initial cost: $0.4788/kg. delivered at Bozeman, Montana.
5/ Trucking: $0.0044/kg. live weight.
6/ Sold on carcass grade and weight basis: Choice, $0.937/kg. and Good, $0.904/kg.

Analysis of covariance of the gains of heifers (Table XI) fed chopped alfalfa hay or sun-cured alfalfa pellets with or without poloxalene indicated no significant differences (P>.05) due to treatment. Examination of Table XI shows that heifers fed pelleted sun-cured alfalfa pellets gained slightly, but not significantly, more than those fed chopped alfalfa hay. There was no difference between lots fed with or without poloxalene.

The heifers fed sun-cured alfalfa pellets were slightly more efficient than those fed chopped alfalfa hay. In this case, the increased efficiency and gains were offset by a higher cost for sun-cured alfalfa pellets.

The proximate chemical analysis of the feed ingredients used in this trial are given in Table XII.

TABLE XII. PROXIMATE ANALYSIS OF FEEDS FED IN TRIAL III. 1/

Feed	Moisture %	Crude Protein %	Ether Extract %	Ash %	Crude Fiber %	Phosphorus %	Calcium %	Carotene mg./kg.
Steam rolled barley	12.1	11.5	1.6	2.7	3.5	0.37	0.06	....
Dehydrated alfalfa	6.0	16.7	2.4	8.8	29.1	0.22	2.44	63.1
Chopped alfalfa	11.7	19.4	1.8	7.4	22.2	0.23	2.56	46.9
Sun-cured alfalfa pellets	10.0	14.4	2.6	8.1	26.0	0.14	2.69	67.0
O-Premix	9.0	35.3	2.2	6.3	10.6	0.47	0.34	....
X-Premix	7.8	25.9	10.4	11.8	8.9	0.43	0.23	....

1/ Analyses by Chemistry Department, Montana State University.

Table XIII contains the pertinent carcass data of the heifers fed in this trial.

There were no significant treatment differences (P>.05) for the data in Table XIII as determined by analysis of variance or Chi-square tests.

TABLE XIII. CARCASS DATA FOR HEIFERS FED CHOPPED ALFALFA HAY OR SUN-CURED ALFALFA PELLETS WITH OR WITHOUT POLOXALENE. (Trial III -- December 4, 1965 to March 30, 1966 -- 116 days).

Lot No.	5	6	7	8
Treatment:				
Alfalfa hay	Chopped	Chopped	Sun-cured pelleted	Sun-cured pelleted
Poloxalene (gm.)	0.00	10.00	0.00	10.00
No. Heifers	6	6	6	6
Carcass grade				
High choice	..	..	1	..
Average choice	2	1	5	2
Low choice	3	1	..	3
High good	..	3	..	1
Average good	1	1	..	..
Carcass grade score 1/	19.0	18.3	20.2	19.2
Marbling score 2/	13.5	12.7	16.5	13.3
Dressing percent	58.0	57.7	58.5	57.7
Rib eye area (sq. cm./kg. carcass)	0.30	0.31	0.31	0.30
Fat cover over 12th rib (cm.)	1.32	1.40	1.45	1.32
Liver condition				
Condemned	..	1	..	..
Non-condemned	6	5	6	6

1/ 20 = Average choice, 19 = Low choice.
2/ Small = 12, Modest = 15, Moderate = 18.

There were no dark cutting cattle, and only one liver was condemned (lot 6). The dressing percents ranged from 57.7 to 58.5.

Very few cases of bloat were observed in Trial III. One heifer in lot 5 had to be treated for bloat. There were no other cases of bloat observed during the experiment. After poloxalene was removed from the ration (about two weeks prior to slaughter), two heifers which had previously received poloxalene bloated, but did not require treatment.

Trial IV

The pertinent data of this 111-day finishing trial are summarized in Tables XIV and XV.

The steers used were from wintering Trial II. The poloxalene treatment was reversed from Trial II. Analysis of covariance of the gains of steers fed zero or 0.90 kg. soybean oil meal with or without poloxalene indicated no significance due to treatment or interaction at the 0.05 probability level. However, gains of steers receiving 0.90 kg. of soybean oil meal were significantly higher ($P < .10$) than those receiving no soybean oil meal.

Because the cattle were group-fed, it was impossible to statistically analyze the feed efficiency data. However, examination of Table XIV shows some marked differences. Lot 1 was the most efficient, and lot 4 was the least efficient. Lot 1 required 1.05 kg. less feed for a kilogram of gain than did lot 4. On a percentage basis lot 1 was 11.0 percent more efficient than lot 4. Average daily feed consumption was similar in all lots.

TABLE XIV. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY, AND FINANCIAL RETURNS OF STEERS FED WITH OR WITHOUT SOYBEAN OIL MEAL AND WITH OR WITHOUT POLOXALENE. (Trial IV -- April 4, 1966 to July 24, 1966 -- 111 days).

Lot No.	1	2	3	4
Treatment:				
Soybean oil meal (kg.)	0.90	0.90	0.00	0.00
Poloxalene (gm.)	10.00	0.00	10.00	0.00
No. Steers	9	9 1/	9	9
Average weights (kg.)				
Final	430.9	437.7	430.9	425.5
Initial	304.8	318.4	314.8	315.7
Gain	126.1	119.3	116.1	109.8
Daily gain	1.13	1.09	1.05	0.99
Average daily ration (kg.)				
Barley	6.71	7.04	7.30	7.21
Soybean oil meal	0.78	0.78	....	....
Alfalfa hay	2.01	2.25	2.45	2.11
Premix	0.08	0.08	0.08	0.08
Salt	0.02	0.03	0.03	0.03
Total	9.60	10.18	9.86	9.43
Kg. feed per kg. gain	8.47	9.31	9.41	9.52
Feed cost per kg. gain ($) 2/	0.44	0.48	0.44	0.45
Financial returns per steer ($)				
Initial cost 3/	167.64	175.12	173.14	173.64
Feed cost	55.50	63.79	51.22	49.65
Trucking 4/	3.32	3.37	3.32	3.28
Total investment	226.46	242.28	227.68	226.57
Gross return 5/	205.71	218.56	206.20	205.58
Net return	-20.75	-23.72	-21.48	-20.99

1/ Calf 275 died of bloat.
2/ Feed prices: steam rolled barley, $0.053/kg.; soybean oil meal, $0.106/kg.; alfalfa hay, $0.0275/kg.; premix, $0.0855/kg.; salt, $0.036/kg.
3/ Initial cost: $0.55/kg.
4/ Trucking: $0.0077/kg.
5/ Sold on carcass grade and weight basis: Choice, $0.86/kg.; and Good, $0.82/kg.

Table XV contains the proximate chemical analysis of the feeds fed in Trial IV.

TABLE XV. PROXIMATE ANALYSIS OF FEEDS FED IN TRIAL IV. 1/

Feed	Moisture %	Crude Protein %	Ether Extract %	Ash %	Crude Fiber %	Phosphorus %	Calcium %	Carotene mg./kg.
Steam rolled barley	10.2	11.9	3.0	3.4	5.5	0.27	0.13	....
Soybean oil meal	9.5	43.9	2.1	6.3	6.4	0.65	0.34	....
Alfalfa hay 2/	8.5	13.9	1.1	8.2	31.9	0.22	2.87	26.0
Alfalfa hay 3/	6.2	17.5	1.5	7.5	27.6	0.15	1.00	14.1
O-Premix	9.0	35.3	2.2	6.3	10.6	0.47	0.34	....
X-Premix	7.8	25.9	10.4	11.8	8.9	0.43	0.23	....

1/ Analyses by Chemistry Department, Montana State University.
2/ Second cutting 1965.
3/ First cutting 1966.

Carcass data of steers in Trial IV are presented in Table XVI.

There were no dark cutters and no condemned livers in the cattle in Trial IV. There were no significant differences ($P > .05$) due to treatment or interaction in any of the carcass data with the exception of dressing percent. Cattle in lots 1 and 3 which received 10 grams poloxalene per head per day dressed significantly ($P < .05$) lower than lots 2 and 4 which did not receive poloxalene. Steers in lots 1 and 3 averaged 56.13 dressing percent while steers in lots 2 and 4 averaged 57.43 dressing percent. This was a difference of 1.32 percent.

TABLE XVI. CARCASS DATA FOR STEERS FED WITH OR WITHOUT SOYBEAN OIL MEAL AND WITH OR WITHOUT POLOXALENE. (Trial IV -- April 4, 1966 to July 24, 1966 -- 111 days).

Lot No.	1	2	3	4
Treatment:				
Soybean oil meal (kg.)	0.90	0.90	0.00	0.00
Poloxalene (gm.)	10.00	0.00	10.00	0.00
No. Steers	9	9	9	9
Carcass grade				
Low prime	1	..	..	..
High choice	..	2	..	..
Average choice	5	3	7	4
Low choice	1	2	1	4
High good	..	..	1	1
Average good	2	1	..	..
Carcass grade score 1/	19.4	19.6	19.7	19.3
Marbling score 2/	14.2	14.4	14.1	12.9
Dressing percent	56.3	58.5	56.0	56.5
Rib eye area (sq. cm./kg. carcass)	0.28	0.26	0.27	0.28
Fat cover at 12th rib (cm.)	1.66	1.76	1.66	1.46

1/ 20 = Average-Choice; 19 = Low Choice.
2/ Small = 12; Modest = 15; Moderate = 18.

The ratings of observed cases of bloat in Trial IV are given in Table XVII.

Non-bloated calves were given a rating of 1. Most of the bloat cases occurred during the first 21 days when high-moisture barley was fed and during the last 27 days when first crop 1966 alfalfa hay was fed. A possible explanation for increased incidence of bloat during consumption of high-moisture barley is given by Bartley (1965b). Succulent moist feeds (such as high-moisture barley) reduce salivary secretion. This reduced salivation means less mucin reaches the rumen. Since mucin is a defoaming agent, the reduced concentration of it allows foam to form, and the end result is bloat.

TABLE XVII. RATINGS OF BLOAT OBSERVED DURING TRIAL IV.

Lot No.	1	2	3	4
No. Steers	9	9	9	9
Treatment:				
Soybean oil meal (kg.)	0.90	0.90	0.00	0.00
Poloxalene (gm.)	10.00	0.00	10.00	0.00
Rating:				
1 - No bloat 1/	107	89	105	96
2 - Mild	...	13	3	11
3 - Moderate	1	3	11	1
4 - Severe	...	1	...	..
5 - Terminal	...	1 2/	...	..
Total bloat cases observed	1	18	3	12

1/ Total of non-bloated cattle on days when bloat was observed.
2/ Calf 275 died of bloat the first day new crop (1966) alfalfa hay was fed.

Again, too few cases of bloat occurred to statistically evaluate the ratings as to severity of bloat, so the data were pooled into bloat and no bloat classes and evaluated by Chi-square tests. There was independence as to the effect of level of soybean oil meal on incidence of bloat. The soybean oil meal treatment was included in this trial because some workers (Meyer et al., 1965a; Bartley and Bassette, 1961; Elam et al., 1960) have indicated that rations with high levels of plant protein were more bloat provocative. Their results were not confirmed in this trial. The average daily ration of steers in lots 1 and 2 contained 14.6 percent crude protein. Elam et al. (1960) and Elam and Davis (1962b) fed a ration which analyzed over 16 percent crude protein. Perhaps the protein content of the soybean oil meal treatments in Trial IV was too low to produce more marked results.

Chi-square tests showed that significantly more ($P < .01$) cases of bloat occurred in the lots not receiving poloxalene. One steer died of bloat in an untreated lot (lot 2) after new crop (1966) alfalfa hay was fed.

Trial V

Table XVIII gives the results of the in vitro foam test performed on forages fed in the previous trials. Readings given were taken after the foam had set in a 1000 milliliter graduated cylinder for two minutes.

TABLE XVIII. RESULTS OF IN VITRO FOAM DETERMINATIONS OF FORAGES FED IN PREVIOUS TRIALS.

Fed in trial	Replication	I ml.	II ml.	III ml.	Average ml.
I	Alfalfa wafer, 1964 1/	850	780	650	760
I	Alfalfa hay, 1964 2/	580	660	570	603
II, IV	Alfalfa hay, 1965 3/	500	410	475	462
II	Dehydrated alfalfa	5	10	40	18
III	Chopped alfalfa	500	565	460	508
III	Sun-cured alfalfa	5	50	50	35
IV	Alfalfa hay, 1966 4/	490	580	430	500
...	Alfalfa hay	560	580	450	530
...	Sanfoin hay	30	30	50	36

1/ Two calves died of bloat.
2/ One calf died of bloat.
3/ Two calves died of bloat.
4/ One calf died of bloat.

Examination of Table XVIII shows that forages with the relatively higher foam readings were the forages that calves were consuming when death occurred due to bloat. Dehydrated alfalfa had a low foam reading, which substantiates the work of Boda (1958) when he concluded that dehydration of alfalfa drastically reduced its bloat producing potential.

Sanfoin hay had low foam readings which would possibly indicate a low bloat producing potential. More work must be done with this legume to properly evaluate its relationship to bloat.

When the forage samples were tested with .01 grams of poloxalene, foam formation was not affected.

Although this method may give an indication of a feedstuff's ability to produce bloat, it is recognized that there are many other factors which affect bloat incidence and that this test should not be relied upon exclusively.

SUMMARY

The effect of adding poloxalene, a nonionic surfactant, to basal barley and alfalfa hay rations for wintering and fattening beef cattle was studied. Weight gains, feed intake, feed efficiency, bloat observations and carcass data were used to assess the value of poloxalene.

In Trial I, 40 steer calves were used to conduct this 112-day wintering trial. Wafered alfalfa hay or baled alfalfa hay was fed with or without poloxalene. There was no difference in gain of steers between lots. Three steers in lots not receiving poloxalene died due to bloat.

Trial II utilized 36 steer calves for a wintering period of 112 days. Calves were fed the basal ration plus 0.45 kg. or 0.91 kg. dehydrated alfalfa meal with or without poloxalene in a 2 x 2 factorial design. 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 among the steers receiving poloxalene. 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 for a 116-day finishing period. Barley was fed _ad libitum_. One heifer in an untreated lot required treatment for bloat during the trial. 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 used in finishing Trial IV. 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. Steers receiving soybean oil meal gained more ($P < .10$) than those receiving none. One steer died of bloat when first crop (1966) alfalfa hay was fed. Chi-square tests showed that significantly ($P < .01$) fewer cases of bloat occurred in the lots receiving poloxalene. Calves receiving poloxalene had lower dressing percents ($P < .05$) than those receiving no poloxalene.

During the two wintering trials, 5 calves out of 38 died of bloat in the untreated lots for a death loss due to bloat of 13.15 percent. No calves died of bloat in the lots receiving poloxalene.

A total of 136 head of beef cattle were fed in four trials. Half of the cattle in each trial received poloxalene. Six calves out of 68 died of bloat on barley-alfalfa rations in the untreated groups. This is a death loss of 8.8 percent due to bloat. No calves died of bloat in the lots receiving poloxalene.

On the basis of these trials poloxalene shows promise as a bloat preventative when fed with barley-alfalfa rations in the feedlot.

Foam tests conducted in Trial V showed promise as an indication of the bloat provoking potential of a forage, but should not be relied upon exclusively.

APPENDIX

APPENDIX TABLE I. INITIAL AND FINAL WEIGHTS OF INDIVIDUAL STEERS FED BALED OR WAFERED ALFALFA HAY WITH OR WITHOUT POLOXALENE. (Trial I -- December 3, 1964 to March 25, 1965 -- 112 days).

Lot No. 2 (Wafered, No Poloxalene)			Lot No. 3 (Baled, No Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Steer No.	Initial	Final	Steer No.	Initial	Final
266	415	Died 1/	270	430	710
329	385	620	326	365	555
331	400	635	333	405	585
339	350	515	335	360	520
341	410	620	338	410	570
425	360	Died 1/	455	350	600
426	390	550	458	385	620
454	395	680	463	420	650
446	405	605	413	430	640
447	410	660	441	415	Died 1/

Lot No. 4 (Baled, 10.0 gm. Poloxalene)			Lot No. 5 (Wafered, 10.0 gm. Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Steer No.	Initial	Final	Steer No.	Initial	Final
268	390	585	267	415	660
328	375	540	330	405	567
340	395	560	337	405	655
420	325	550	408	395	675
433	395	615	429	400	635
459	335	565	440	415	620
460	390	625	464	330	545
422	420	635	402	400	515
448	400	630	428	410	670
453	420	640	436	430	643

1/ Data not included in analysis of covariance.

APPENDIX TABLE II. ANALYSIS OF VARIANCE AND COVARIANCE OF INITIAL AND FINAL WEIGHTS OF STEERS IN TRIAL I. (112 days).

Source of Variation	D.F.	Sums of Squares due to: Initial	Initial x Final	Final
Hay	1	555	882	2,380
Poloxalene	1	28	-190	18
Hay x Poloxalene	1	737	610	999
Error	33	23,891	30,577	88,317
Total	36	27,211	31,879	91,714
Hay + Error	34	26,446	31,459	90,697
Poloxalene + Error	34	25,919	30,387	88,335
Hay x Poloxalene + Error	34	26,628	31,187	89,316

Deviations about Regression

	D.F.	Sum Squares	Mean Square	F Value
Hay Adjusted	1	1,027.7	1,027.7	0.629 1/
Poloxalene Adjusted	1	462.7	462.7	0.283 1/
Hay x Poloxalene Adjusted	1	541.7	541.7	0.332 1/
Error Adjusted	32	52,247.3	1,632.7	

1/ No significant differences in weight gains of steers fed baled or wafered alfalfa hay with or without Poloxalene ($P > .05$).

APPENDIX TABLE III. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY AND COST OF GAIN OF STEER CALVES FED BALED OR WAFERED ALFALFA HAY WITH OR WITHOUT POLOXALENE. (Trial I -- December 3, 1964 to March 25, 1965 -- 112 days).

Lot No.	2	3	4	5
Treatment:				
Alfalfa hay	Wafered	Baled	Baled	Wafered
Poloxalene (gm.)	0.00	0.00	10.00	10.00
No. Steers	10 1/	10 2/	10	10
Average weights (lbs.)				
Initial	393	395	385	401
Final	611	606	595	619
Gain	218	211	210	218
Daily gain	1.94	1.88	1.88	1.95
Average daily ration (lbs.)				
Concentrate mixture	4.41	4.45	4.50	4.45
Alfalfa hay	10.00	9.90	9.81	9.77
Premix	0.22	0.22	0.22	0.22
Salt	0.02	0.02	0.02	0.02
Total	14.65	14.59	14.55	14.46
Feed per cwt. gain (lbs.)	757.00	763.00	774.00	730.00
Feed cost per cwt. gain ($) 3/	10.62	10.74	10.94	10.30

1/ One Angus crossbred steer (266) died January 30; one Hereford steer (425) died February 25 of bloat; weights and feed values were adjusted accordingly.

2/ One Hereford steer (441) died of bloat January 31; weights and feed values were adjusted accordingly.

3/ Feed prices: grain mixture, \$2.20/cwt.; alfalfa hay, \$1.00/cwt.; premix, \$3.88/cwt.; and mineral mixture, \$1.62/cwt.

APPENDIX TABLE IV. INITIAL AND FINAL WEIGHTS OF STEER CALVES FED TWO LEVELS OF DEHYDRATED ALFALFA WITH OR WITHOUT POLOXALENE. (Trial II -- November 26, 1965 to March 18, 1966 -- 112 days).

Lot No. 1 (0.45 kg. Dehy., No Poloxalene)			Lot No. 2 (0.45 kg. Dehy., 10.0 gm. Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Steer No.	Initial	Final	Steer No.	Initial	Final
497	503	708	513	495	666
503	478	664	514	510	736
515	478	Died 1/	502	459	634
504	468	628	512	462	643
277	444	634	275	436	660
254	433	628	278	467	668
284	403	570	288	520	726
286	510	672	291	451	646
341	524	720	342	482	625

Lot No. 3 (0.90 kg. Dehy., No Poloxalene)			Lot No. 4 (0.90 kg. Dehy., 10.0 gm. Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Steer No.	Initial	Final	Steer No.	Initial	Final
516	502	Died 1/	522	517	740
520	486	662	501	498	720
509	449	650	505	455	642
532	425	633	523	438	630
279	440	646	276	449	670
283	508	708	281	460	678
285	504	666	287	494	694
289	498	689	290	521	710
344	500	654	348	482	690

1/ Data not included in analysis of covariance.

APPENDIX TABLE V. ANALYSIS OF VARIANCE AND COVARIANCE OF STEER CALVES FED TWO LEVELS OF DEHYDRATED ALFALFA WITH OR WITHOUT POLOXALENE. (Trial II -- 112 days).

		Sums of Squares due to:		
Source of Variation	D.F.	Initial	Initial x Final	Final
Dehydrated Alfalfa	1	183	590	1,898
Poloxalene	1	153	658	2,839
Dehy. x Poloxalene	1	11	-41	148
Error	30	33,399	31,859	42,927
Total	33	33,746	33,066	47,812
Dehy. + Error	31	33,582	32,449	44,825
Poloxalene + Error	31	33,552	32,517	45,766
Dehy. x Poloxalene + Error	31	33,410	31,818	43,075

Deviations about Regression

	D.F.	Sum Squares	Mean Square	F Value
Dehy. Adjusted	1	934.8	934.8	2.16
Poloxalene Adjusted	1	1,715.8	1,715.8	3.97 1/
Dehy. x Poloxalene Adjusted	1	236.8	236.8	0.55
Error Adjusted	29	12,536.2	432.3	

1/ Poloxalene treatment approached significance at $P < .05$ level and was significant at the $P < .10$ level.

APPENDIX TABLE VI. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY, AND COST OF GAIN FOR STEER CALVES FED TWO LEVELS OF DEHYDRATED ALFALFA MEAL WITH OR WITHOUT POLOXALENE. (Trial II -- 112 days).

Lot No.	1	2	3	4
Treatment:				
Alfalfa hay, baled	Ad lib	Ad lib	Ad lib	Ad lib
Steam rolled barley (lbs.)	4	4	3	3
Dehydrated alfalfa (lbs.)	1	1	2	2
Poloxalene (gm.)	0	10	0	10
No. Steers	9 1/	9	9 2/	9
Average weights (lbs.)				
Initial	470 3/	476	476 3/	479
Final	653	667	663	686
Gain	183	191	187	207
Daily gain	1.63	1.71	1.67	1.85
Average daily ration (lbs.) 4/				
Alfalfa hay	10.90	11.43	11.57	11.42
Barley	3.91	3.89	3.16	3.14
Dehydrated alfalfa	0.90	0.91	1.65	1.66
Supplement	0.32	0.33	0.32	0.33
Salt	0.05	0.05	0.05	0.05
Total	16.08	16.61	16.75	16.60
Feed per cwt. gain (lbs.)	975	973	1003	900
Feed cost per cwt. gain ($) 5/	16.08	15.92	16.46	14.81

1/ Calf No. 515 died of bloat on December 7, 1965.
2/ Calf No. 516 died of bloat on December 22, 1965.
3/ Average weights and daily gains are presented for the 8 calves which remained in lots 1 and 3 for the duration of the trial (112 days).
4/ Ration and efficiency figures were adjusted to include 8 head per lot for the first 55 days and at that time, one calf was added to each lot (1 & 3) to have a total of 9 head per lot for the remainder of the trial.
5/ Feed prices: steam rolled barley, $2.40/cwt.; alfalfa hay $1.25/cwt.; dehydrated alfalfa, $2.60/cwt.; premix, $3.88/cwt.; and salt, $1.62/cwt.

APPENDIX TABLE VII. INITIAL AND FINAL WEIGHTS OF YEARLING HEIFERS FED CHOPPED OR SUN-CURED PELLETED ALFALFA HAY WITH OR WITHOUT POLOXALENE. (Trial III -- December 4, 1965 to March 30, 1966 -- 116 days).

Lot No. 5 (Chopped, No Poloxalene)			Lot No. 6 (Chopped, 10.0 gm. Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Heifer No.	Initial	Final	Heifer No.	Initial	Final
479	576	820	486	550	756
480	628	785	490	612	834
483	665	876	492	670	902
489	625	817	495	634	872
567	636	848	566	608	858
573	623	932	571	597	796

Lot No. 7 (Pelleted, No Poloxalene)			Lot No. 8 (Pelleted, 10.0 gm. Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Heifer No.	Initial	Final	Heifer No.	Initial	Final
478	665	948	481	622	794
496	614	859	482	586	770
487	569	786	488	562	774
491	602	805	493	652	919
570	648	877	575	528	813
572	600	868	568	680	952

APPENDIX TABLE VIII. ANALYSIS OF VARIANCE AND COVARIANCE OF INITIAL AND FINAL WEIGHTS OF YEARLING HEIFERS FED CHOPPED OR SUN-CURED PELLETED ALFALFA HAY WITH OR WITHOUT POLOXALENE. (Trial III -- 116 days).

		Sums of Squares due to:		
Source of Variation	D.F.	Initial	Initial x Final	Final
Hay	1	384	-276	198
Poloxalene	1	937	1,131	1,365
Hay x Poloxalene	1	8	-35	156
Error	20	34,418	38,794	75,059
Total	23	35,747	39,614	76,778
Hay + Error	21	34,802	38,518	75,257
Poloxalene + Error	21	35,355	39,925	76,424
Hay x Poloxalene + Error	21	34,426	38,759	75,215

Deviations about Regression

	D.F.	Sum Squares	Mean Square	F Value
Hay Adjusted	1	1,298	1,298	0.787 1/
Poloxalene Adjusted	1	10	10	0.006 1/
Hay x Poloxalene Adjusted	1	250	250	0.152 1/
Error Adjusted	19	31,328	1,649	

1/ No significant differences in weight gains of heifers fed chopped or pelleted alfalfa hay with or without Poloxalene ($P > .05$).

APPENDIX TABLE IX. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY AND FINANCIAL RETURN FOR YEARLING HEIFERS FED CHOPPED OR PELLETED SUN-CURED ALFALFA HAY WITH OR WITHOUT POLOXALENE. (Trial III -- December 4, 1965 to March 30, 1966 -- 116 days).

Lot No.	5	6	7	8
Treatment:				
Steam rolled barley	Ad lib.	Ad lib.	Ad lib.	Ad lib.
Alfalfa hay	Chopped	Chopped	Sun-cured pelleted	Sun-cured pelleted
Poloxalene (gm.)	0	10	0	10
No. Heifers	6 1/	6	6	6 2/
Average weights (lbs.)				
Initial	625	612	616	605
Final	846	836	857	837
Gain	221	224	241	232
Daily gain	1.90	1.93	2.08	2.00
Average daily ration (lbs.)				
Steam rolled barley	11.00	11.60	11.20	10.90
Alfalfa hay	5.00	5.80	5.90	5.90
Dehydrated alfalfa meal	1.00	1.00	1.00	1.00
Supplement	0.40	0.40	0.40	0.40
Mineral mixture	0.04	0.04	0.04	0.01
Total	17.44	18.84	18.54	18.24
Feed per cwt. gain (lbs.)	921	973	894	908
Feed cost per cwt. gain ($) 3/	19.69	20.45	21.44	21.77
Financial returns per heifer ($)				
Initial cost 4/	135.75	132.93	133.80	131.41
Feed cost	43.52	45.81	51.67	50.51
Trucking 5/	1.69	1.67	1.71	1.67
Total investment	180.96	180.41	187.18	183.59
Gross return 6/	209.74	203.23	213.63	204.59
Net return	28.78	22.82	26.45	21.00

1/ One heifer was bloated and treated at 10:00 P.M. on December 14, 1965.
2/ Two heifers bloated after the feeding of poloxalene was terminated.
3/ Feed prices: steam rolled barley, $240/cwt.; dehydrated alfalfa meal, $2.60/cwt.; chopped alfalfa hay, $1.25/cwt.; sun-cured alfalfa pellets, $2.20/cwt.; premix, $3.88/cwt.; and salt, $1.62/cwt.
4/ Initial cost: $21.72/cwt. delivered to Bozeman, Montana.
5/ Trucking cost: $0.20/cwt.
6/ Sold on carcass grade and weight basis: Choice, $42.50/cwt. and Good, $41.00/cwt.

APPENDIX TABLE X. CARCASS DATA OF HEIFERS IN TRIAL III.

Lot No.	5	6	7	8
Carcass yield (%) 1/	58.0	57.7	58.5	57.7
Rib eye area, 12th rib (sq. in./cwt.) 2/	2.11	2.17	2.16	2.13
Fat thickness 12th rib (in.) 3/	0.52	0.55	0.57	0.52

1/ Based on warm carcass weight minus 3 percent pencil shrink. Final test weight used as live weight.

2/ Rib eye area at the 12th rib per cwt. cold carcass.

3/ Average of 3 measurements vertical to points 1/4, 1/2, 3/4 along line through widest part of rib eye.

APPENDIX TABLE XI. INITIAL AND FINAL WEIGHTS OF STEERS FED WITH OR WITHOUT SOYBEAN OIL MEAL AND WITH OR WITHOUT POLOXALENE. (Trial IV -- April 4, 1966 to July 24, 1966 -- 111 days).

Lot No. 1 (0.9 kg. SBOM, 10.0 gm. Poloxalene)			Lot No. 2 (0.9 kg. SBOM, No Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Steer No.	Initial	Final	Steer No.	Initial	Final
506	722	1032	513	710	982
503	686	927	514	777	1064
504	648	946	502	671	940
277	664	920	512	678	890
254	649	948	275	710	Died 1/
284	604	875	278	692	974
286	690	931	288	758	1026
341	760	1031	291	670	930
518	628	936	342	652	911

Lot No. 3 (No SBOM, 10.0 gm. Poloxalene)			Lot No. 4 (No SBOM, No Poloxalene)		
	Weights (lbs.)			Weights (lbs.)	
Steer No.	Initial	Final	Steer No.	Initial	Final
520	708	981	522	767	1072
509	696	985	501	730	995
532	688	1004	505	640	850
526	630	919	523	653	871
279	688	908	276	688	928
283	730	1007	281	688	946
285	696	952	287	702	978
289	724	924	290	703	874
344	686	873	348	690	929

1/ Data not included in analysis of covariance.

APPENDIX TABLE XII. ANALYSIS OF VARIANCE AND COVARIANCE OF INITIAL AND FINAL WEIGHTS OF STEERS FED IN TRIAL IV. (111 days).

		Sums of Squares due to:		
Source of Variation	D.F.	Initial	Initial x Final	Final
Soybean Oil Meal	1	711	-979	1,350
Poloxalene	1	1,971	85	4
SBOM x Poloxalene	1	1,521	1,653	1,630
Error	31	50,532	57,374	102,259
Total	34	54,735	58,133	105,243
SBOM + Error	32	51,243	56,395	103,609
Poloxalene + Error	32	52,503	57,459	102,263
SBOM x Poloxalene + Error	32	52,053	59,027	103,889

Deviations about Regression

	D.F.	Sum Squares	Mean Square	F Value
Soybean Oil Meal Adjusted	1	4,439	4,439	3.59 1/
Poloxalene Adjusted	1	2,275	2,275	1.84
SBOM x Poloxalene Adjusted	1	-151	-151	-.12
Error Adjusted	30	37,105	1,237	

1/ Soybean oil meal treatment approached significance at $P < .05$ level and was significant at $P < .10$ level.

APPENDIX TABLE XIII. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, FEED EFFICIENCY, AND FINANCIAL RETURNS OF STEERS FED WITH OR WITHOUT SOYBEAN OIL MEAL AND WITH OR WITHOUT POLOXALENE. (Trial IV -- April 4, 1966 to July 24, 1966 -- 111 days).

Lot No.	1	2	3	4
Treatment:				
Soybean oil meal (lbs.)	2.00	2.00	0.00	0.00
Poloxalene (gm.)	10.00	0.00	10.00	0.00
No. Steers	9	9 1/	9	9
Average weights (lbs.)				
Initial	672	702	694	696
Final	950	965	950	938
Gain	278	263	256	242
Daily gain	2.50	2.41	2.31	2.18
Average daily ration (lbs.)				
Barley	14.80	15.51	16.09	15.80
Soybean oil meal	1.72	1.72	....	....
Alfalfa hay	4.42	4.97	5.41	4.66
Premix	0.17	0.17	0.17	0.17
Salt	0.04	0.06	0.06	0.06
Total	21.15	22.43	21.73	20.78
Feed per cwt. gain (lbs.)	846.60	931.10	941.10	951.90
Feed cost per cwt. gain ($) 2/	20.05	21.78	19.98	20.48
Financial returns per steer ($)				
Initial cost 3/	168.00	175.50	173.50	174.00
Feed cost	55.50	63.79	51.22	49.65
Trucking 4/	3.33	3.38	3.33	3.23
Total investment	226.83	242.67	228.05	226.88
Gross return 5/	205.71	218.56	206.20	205.58
Net return	-21.12	-24.11	-21.85	-21.30

1/ One calf died of bloat.
2/ Feed prices: steam rolled barley, $2.40/cwt.; soybean oil meal, $4.80/cwt.; alfalfa hay, $1.25/cwt.; premix, $3.88/cwt.; and salt, $1.62/cwt.
3/ Initial cost: $25.00/cwt. delivered to Bozeman, Montana.
4/ Trucking cost: $0.35/cwt.
5/ Sold on carcass grade and weight basis: Choice, $39.00/cwt. and Good, $37.00/cwt.

APPENDIX TABLE XIV. CARCASS DATA OF STEERS IN TRIAL IV.

Lot No.	1	2	3	4
Carcass yield (%) 1/	56.3	58.5	56.0	56.5
Rib eye area, 12th rib (sq. in./cwt.) 2/	1.99	1.80	1.88	1.95
Fat thickness 12th rib (in.) 3/	0.65	0.69	0.65	0.57

1/ Based on warm carcass weight minus 3 percent pencil shrink. Final test weight used as live weight.

2/ Rib eye area at 12th rib per cwt. cold carcass.

3/ Average of 3 measurements vertical to points 1/4, 1/2, 3/4 along line through widest part of rib eye.

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