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Title: THE EFFECTS OF RYEGRASS STRAW AND MONENSIN ON PERFORMANCE OF FEEDLOT LAMBS

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Dr. D. L. Thomas

The objectives of this study were to investigate the effects of the by-product, ryegrass straw, and the feed additive, monensin, on the performance of feedlot lambs.

Four pelleted rations were fed *ad libitum*: Ration 1 - 50% barley, 50% alfalfa hay; Ration 2 - 50% barley, 50% alfalfa hay and 25g/ton monensin; Ration 3 - 50% barley, 25% alfalfa hay and 25% ryegrass straw; Ration 4 - 50% barley, 25% alfalfa hay, 25% ryegrass straw and 25g/ton monensin. The two levels of ryegrass straw (0 and 25%) and the two levels of monensin (0 and 25g/ton) were arranged factorially across the four rations. Sixty single-reared lambs sired by Hampshire rams started the trial shortly after weaning at an average weight of 29.15 kg. Fifteen lambs were fed each ration; five lambs in each of three pens. Lambs were weighed weekly and terminated from the trial when they reached 45.45 kg in unshrunk body weight. Two lambs from each pen were slaughtered and carcass traits obtained. A sample of the rumen fluid was taken from each slaughtered lamb to determine volatile fatty acid (VFA) concentrations. Some of the traits of interest were ration dry matter digestibility (DMD), lamb average daily gain (ADG), feed intake (FI) and feed efficiency (FE: feed/gain), carcass yield grade (YG), total volatile fatty acid content of rumen fluid (TVFA) and cost per unit of gain (CUG).

Results indicated that monensin-fed lambs had a lower feed intake (-7.8%, P<.10), TVFA (-24%, P<.01), and ADG (-7.3%); an improved FE (+4.7%); an increased DMD (+1.7%) and a similar YG as non-monensin-fed lambs. Ryegrass straw fed-lambs had a lower DMD (-8.0% P<0.05), TVFA (-18.3%, P<0.01) and ADG (-7.3%); a poorer FE (-5.4%); an increased FI (+6.0%) and a similar YG as non-ryegrass straw-fed lambs. The acetic: propionic acid ratio was 2.72, 3.02, 3.07 and 2.67 for monensin, non-monensin, ryegrass straw and non-ryegrass straw-fed lambs, respectively. CUG was lower (-1.8 for monensin than for non-monensin-fed lambs and lower (-8.0%) for ryegrass straw than for non-ryegrass straw-fed lambs. Estimated cost per kg carcass gain was lower (-1.1%) for monensin than for non-monensin-fed lambs and higher (12.6%) for ryegrass straw than for non-ryegrass straw-fed lambs.

THE EFFECTS OF RYEGRASS STRAW AND MONENSIN ON PERFORMANCE OF FEEDLOT LAMBS

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Head of Department of Animal Science

Redacted for Privacy

Dean of Graduate School

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INTRODUCTION

A major farming enterprise in the Willamette Valley of western Oregon is the production of ryegrass seed. An annual by-product of this enterprise is an estimated 700,000 tons of ryegrass straw. Field burning has been the most popular means of straw waste management for over 30 years. The air pollution caused by field burning, however, has become a heated environmental issue. Furthermore, it also seems to be a tremendous waste of energy which could possibly be utilized if the straw were fed to ruminant livestock.

Recently, a new product called monensin, known by its trade name - Rumensin, has been made available to the best feeding industry by Eli Lilly and Company. Monensin was originally used as an anticoccidial drug in poultry and recently its effectiveness as an anticoccidial in sheep has been realized (Fitzgerald and Mansfield, 1978). Monensin has been shown to improve feed utilization and alter rumen fermentation characteristics by causing an increase in propionic acid production in beef cattle (Boling _et al_., 1977; Richardson _et al_., 1974; Hanson and Klopfenstein, 1977). Studies have also indicated that monensin does not affect quantity of total volatile fatty acids (VFA) in the rumen (Cambell _et al_., 1973; Dinius _et al_., 1976; Potter _et al_., 1976).

The purpose of this study was to evaluate the effects of ryegrass straw and monensin on the performance of feedlot lambs.

LITERATURE REVIEW

Monensin

Since there are few studies on the effects of monensin as a feed additive in sheep rations, this discussion will focus primarily on the results of studies on use of this additive with feedlot cattle.

Monensin sodium, trade name Rumensin[1] is an antibiotic produced by the bacterial strain Streptomyces Cinnamonesis (Haney and Hoehn, 1967). The empirical formula is $C_{36}\ H_{61}\ O_{11}$ Na, with a molecular weight of 692. Monensin has been used as an anticoccidial in sheep (Fitzgerald and Mansfield, 1978) and poultry, proving to be effective against gram-positive organisms. Field studies during the last few years have shown monensin to have a good potential as a possible feed additive for ruminants (Hale *et al*., 1975 ; Raun *et al*., 1976).

The ruminant has a great advantage over many other food and fiber producing animals because of its ability to digest and utilize roughage containing plant fiber and cellulose. Millions of microbes work on the digestion of ingested feed. One of the results of this digestive process is volatile fatty acid (VFA) production. These are principle waste products of microbial action and represent about 50% of the ruminant animal's energy source (Hungate, 1966). The fermented carbohydrates are the main energy source for the microbes. In trials where a large amount of roughage is consumed, VFA distribution is about 70% acetic, 20% propionic and 10% butyric acids. As the concentrate level of the diet increases, the proportions of propionic acid also increase while acetic and butyric acid decrease.

Energy from the VFA's is obtained through a series of chemical reactions which occur as the acids are absorbed through the walls of the

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[1] Monensin sodium, Eli Lilly & Company (ELANCO).

rumen. Barcroft et al. (1944) indicated that the fatty acids are directly absorbed from the rumen, reticulum, omasum and large intestine with the most absorption occurring in the rumen. Propionic and butyric acids are almost entirely metabolized in the rumen and liver. Acetic acid passes through the liver into the peripheral circulation with the main sites of its oxidation being adipose and muscular tissue.

Energy is produced more efficiently from propionic than the other VFA's (Hungate, 1966). The conversion of energy from hexose (672 kcal/mole) to energy in acetic, propionic and butyric acids are 420, 734 and 524 kcal/mole of hexose fermented, respectively. Acetic, propionic and butyric acid efficiency, relative to glucose, is estimated to 62%, 109% and 78%, respectively. Also, in the production of acetic and butyric acid carbon dioxide and methane are produced which are waste products and little energy can be recovered from them (Hungate, 1966).

The pH of the rumen is affected by the type of ration. Wheat straw raises the pH of the rumen when compared to a ration containing a high level of maize (Leng and Brett, 1966). Armstrong et al. (1957) reported that changes in rumen pH affected the rate of propionic and butyric acid absorption. When a mixture of VFA's containing little or no acetic acid was fed to sheep, the rate of absorption of the other acids from the rumen increased. Butyric acid is absorbed more rapidly than propionic acid at a high pH. The pH of the rumen is largely a function of the VFA concentration in the rumen (Briggs et al., 1957).

The presence of a high level of acetic acid in the rumen disturbs the microbial population and results in an increased loss of energy in the feces (Armstrong et al., 1958). It is beneficial to point out that there is a relationship between VFA production and organic matter digestion in the alimentary tract (Weston and Hagon, 1968). Gray et al. (1967) estimated VFA production in sheep to be 53% of the digestible energy content of the diet. In an in vitro study, Stewart et al. (1958) calculated that VFA's accounted for 38% of the digested energy; furthermore, VFA concentration reached a higher peak after the evening feeding than after the morning feeding.

The heat increment can be used as a measurement of the efficiency of food utilization. The less the proportion of heat given off as compared to the energy taken up by the animal, the more efficient the utilization of the feed consumed (Hungate, 1966). The heat increment from propionic acid is less than that from acetic acid. This is further evidence to indicate that propionic acid is more efficient than the other VFA's. About 40 to 50% of butyric acid produced in the rumen comes from interconverted acetic acid (Leng and Brett, 1966). In addition, it was found that interconversions between propionic and butyric acid as well as between propionic and acetic acid, were small in the rumen of sheep grazing on mixed herbage (Leng, 1968). The results of feedlot and pasture animals were similar.

After the VFA's are absorbed into the blood stream, all three acids can be used to furnish energy through the carboxylic acid cycle. Acetic acid is changed to acetyl-Co-A which requires two molecules of adenosine triphosphate (ATP). Its complete oxidation to CO_2 and H_2O yields ten molecules of ATP. Propionic acid reacts with Co-A to form methylmalonyl Co-A which is changed to succinyl Co-A and this enters the carboxylic acid cycle. The net yield is 18 ATP's. Propionic acid can also go through the glycogen pathway. Butyric acid can be changed to butyryl Co-A which is transformed to acetyl Co-A and this then goes the same route as acetic acid. The complete oxidation of one mole of glucose yields CO_2, H_2O and 27 moles of ATP (Maynard and Loosli, 1969).

It has been demonstrated that monensin alters rumen fermentation both _in vitro_ and _in vivo_ (Richardson _et al_., 1974). It has also been shown that with the use of monensin, molar percentages of VFA's are altered, with less acetic and butyric acids being produced but more propionic (Perry _et al_., 1976; Dinius and Simpson, 1975; Thorntor _et al_., 1976). These alternations have been implicated as the primary factor responsible for the increased feed efficiency seen with monensin supplementation (Richardson _et al_., 1974).

The exact mode of action has not been established, however, monensin does increase the molar percentage of propionic acid in the rumen up to 40% (Hanson and Klopfenstein, 1977; Horton and Christensen, 1978; Raun et al., 1976 ; Prange et al., 1978). In addition, monensin may cause a 30% decrease in rumen methane production (Muir et al., 1977 ; Van Nevel et al., 1974). These changes in rumen fermentation occur quickly after the initiation of monensin feeding and persist indefinitely (Beede and Farlin, 1975). Hungate (1966) pointed out that methane production is a valuable index of the extent of rumen fermentation, because it is a direct measure of activity in the rumen. There is no evidence that methane is converted to other materials after it is formed, therefore the quantity liberated by the rumen is the amount produced.

Hale et al. (1975) and Dinius et al. (1976) evaluated monensin and its effects on ruminal activity. In both studies the propionic acid production was increased while acetic and butyric acids were decreased.

Campbell et al., (1973) reported that the addition of monensin to the diet of grazing steers had little effect on VFA concentration. However, in a second trial using monensin in a finishing ration for steers, Campbell et al. (1973) reported changes in VFA concentrations.

Different results have been obtained on total VFA production with monensin supplementation. Prange et al. (1978) and Raun et al.(1976) reported that monensin decreased total VFA concentration in the rumen fluid. This is in agreement with the results of Horton (1978) which indicated that monensin depressed total VFA concentration by about 30% in lambs and 9% in steers fed 30 and 50% barley.

Hanson and Klopfenstein (1977) reported that in lambs fed monensin, the acetic/propionic ratio was decreased with different levels of monensin and rations. This is in agreement with results obtained with cattle reported by Boling et al. (1977), Dinius et al. (1976) and Richardson et al. (1974).

Potter et al.(1976) and Dinius et al. (1976) found that monensin had no effect on the total concentration of the VFA's. On the other hand, the mean propionate production rate for steers fed the monensin diet (33 ppm) was 44% higher than that obtained for steers fed the control diet (Prange et al., 1978).

There are several ingredients that cause reduction in acetic acid production. Wright (1970) found a significant decrease in the molar percentage of acetate and increase in the molar percentage of propionate as the amount of molasses increased in the ration. Total concentration of VFA's increased significantly as the amount of urea increased from 0.5 to 1.5 %in the ration.

The improved feed efficiency resulting from monensin feeding is thought to be due to increase propionic acid production and possibly some reduction in methane production (Wilson et al., 1972 ; Prange et al., 1978).

The studies on effects of monensin on microbial population in the rumen indicated that there is a decrease in protozoal population in lambs fed monensin (Hanson and Klopfenstein, 1977). Raun et al.(1976) reported a reduction in bacterial population and increase in protozoal population for monensin fed cattle and initial reduction in dry matter and acid detergent fiber digestibility. In vitro Dinius et al.(1976) have shown that monensin has no major effect on total protozoal, bacterial or cellulolytic bacterial numbers when included in the diet at a level of 33 ppm, nor does it affect dry matter, crude protein, hemicellulose or cellulose digestibility. Horton (1978) reported 3% increase in dry matter digestibility for lambs fed monensin. The rumen ammonia (NH_3) levels remained lower and blood glucose levels remained higher for monensin-fed lambs and streers (Glenn et al., 1977; Raun et al., 1976 ; Dinius et al., 1976). In a study with a brood cow herd,Zobell (1978) found that 200 mg per head per day provided the best results. This resulted in an increase in propionic acid and a decrease in acetic and butyric acid. Total VFA concentration was significantly different ($p < 0.01$) between different levels of monensin.

There are numerous studies to evaluate the effect of monensin on cattle under both feedlot and pasture conditions. There is a reduction in feed intake and an improvement in average daily gain and feed efficiency when monensin is present in animal rations (Hanson and Klopfenstein, 1977; Davis and Erhart, 1976 ; Boling et al., 1977). The reduction in feed intake varies from 5-15% during the entire period of study (Raun et al., 1976; Boling et al., 1977 ; Utley et al., 1976). On the other hand, Horton(1978) found that monensin did not depress feed intake in feedlot lambs or steers. Raun et al. (1976) reported that steers fed monensin (30 gm per ton) have a feed/gain ratio of 3.8 which compared with 4.3 for control animals. Riley et al. (1976) showed that feed efficiency increased by up to 12% and rumen VFA samples indicated an increase in propionic acid production. Wolfe and Matsushima (1975), Lofgreen (1976) and Riley et al. (1976) reported less feed intake with increased feed efficiency for cattle fed monensin in feedlot trials.

Glenn et al. (1977) found that lambs fed monensin (2.2 mg/kg of diet) had a 5.6 feed/gain ratio compared with 5.8 for controls. On the other hand the average daily gain was 0.24 and 0.26 kg/day for monensin-fed and control animals, respectively. This is in agreement with the results of Brown et al. (1974) with feedlot cattle fed 33 ppm monensin.

Utley et al.(1975) reported that heifers fed 200 mg monensin/head/day gained 0.75 kg/day compared with 0.63 kg/day for controls. Steen et al. (1977) reported that total dry matter intake was decreased for variable monensin levels and feed/gain ratios were improved for all monensin-treated steers.

When monensin was fed (200 mg/steer/day), daily forage intake was depressed by 15.6% (Lemenager et al., 1978). Cows grazing similar quality dry winter range grass had a 19.6% intake reduction (Lemenager et al., 1978). A partial explanation for decreased feed intake with monensin feeding may be that rumen digestion, solids turnover and liquid turnover rates were decreased when monensin was fed.

Potter et al. (1976) found that feeding monensin to cattle grazing pastures improved the carrying capacity 10 to 15 %. The problem under pasture conditions was finding an effective carrier of the monensin in order to regulate feed intake. Grain or molasses was used as a carrier (Demuth et al., 1976).

Glenn et al. (1977) reported that average daily gain decreased for lambs fed monensin when protein percentage increased from 11 to 13. Monensin was shown to improve feed efficiency by influencing bacterial activity (Fitzgerald and Monsfield, 1978). Leek et al.(1976) found, in general, when monensin was fed to lambs, it caused weight loss and reduced feed intake.

Several studies have focused on effects of monensin on carcass characters. Potter et al.(1976) reported monensin had very little effect on carcass composition, but the same study indicated monensin depressed dressing percentage at 79 ppm in fattened steers. There were no effects on carcass fat or lean percentage. Carcass bone percentage was decreased when 14.5 ppm monensin was fed.

Monensin fed steers had heavier carcasses, slightly more kidney, pelvic and heart fat, more fat over the 12th rib, higher yield grades, similar quality grades and higher marbling scores than the controls (Potter et al., 1976).

Steen et al. (1977) and Jerry et al. (1977) reported that carcasses from steers fed urea plus monensin were slightly heavier and yield grades slightly higher than from steers fed soybean meal plus monensin. There were no adverse effects associated with feeding monensin on carcass characteristics (Davis and Erhart, 1976 ; Goodrich et al., 1976). There is no withdrawal time associated with monensin prior to slaughter.

Wolfe and Matsushima (1975) concluded that steers fed 30 gm/ton monensin showed some side effects due to the monensin treatments. Less feed intake and loose feces occurred in the early part of the study. It has been suggested by an Elanco representative that the rumen needs time to adjust to the feed additive.

In a study on horses, Stocker (1975) found monensin to be toxic at 100 ppm, with higher levels being fatal.

Ryegrass Straw In Ruminant Rations

Tremendous quantities of ryegrass straw are produced in the Willamette Valley of Oregon. The ryegrass seed industry produces an estimated 700,000 tons of straw by-product each year. The straw is a low quality roughage with a high fiber and lignin content (Anderson and Ralston, 1973).

Several studies have indicated the negative effects of high lignin content on fiber and dry matter digestibility (Dehority et al., 1962 and Tomlin et al., 1965). The poor digestibility of straw has limited its use in ruminant rations to any great extent because growth performance is apt to be poor.

Soybean meal can be fed with ryegrass straw to improve its digestibility (Fernandez 1974). Han et al.(1975) reported that ryegrass straw is low in nitrogen-free-extract content and in its digestibility. Church and Kennick (1977) point out that molasses may decrease fiber digestibility of straw, depending on the amount added.

Chemical treatment of ryegrass to improve its digestibility has been suggested. Champe (1977) found that soluble nutrients are not lost by treating ryegrass straw with sodium hydroxide (NaOH). Furthermore, the digestibility coefficient in vivo of ryegrass straw treated with NaOH are significantly increased. It is useful to point out that the process of pelleting low quality roughage or hay has been shown to improve the dry matter digestibility from 57 to 63 % (Ali Nik-Khah, 1977). Also Dirk Axe et al., (1978) reported the dry matter digestibility in vitro was decreased by 6.6% when wheat straw was increased in the ration from zero to 25%.

Lambs consuming high roughage rations normally have tremendous fill in the stomach and gut as compared to lambs fed rations with moderate amounts of roughage or good quality roughage (Church and Kennick, 1977).

Church and Kennick (1977) have found that lambs fed 60% ryegrass straw in the total ration had very poor feed conversion. This poor response was due to the low protein content and low dry matter digestibility of the straw. The animals could not eat enough to gain at a high rate. It is likely that an amount of 20 to 30 % grass straw would be more suitable for use with lambs.

Digestibility studies with straw indicate a total digestible nutrient value of about 41 % (dry basis) for untreated chopped annual ryegrass straw when fed with 50% alfalfa. Treating with NaOH increased the TDN value to 46 % (Church and Kennick, 1977).

Puch and Dehority (1977) reported higher bacterial and lower protozoa numbers by feeding a high protein concentrate (22%) as compared to a lower protein concentrate (8%). Alfalfa appeared to support high numbers of both bacteria and protozoa. Leng and Brett (1966) found that the amount of rumen fluid increased with straw roughages and decreased with concentrate rations. Also, straw rations raised the pH of the rumen if compared to rations with high levels of maize.

Church and Kennick (1977) found that lambs fed rations of 60% ryegrass straw gained 0.117 kg of carcass weight/day. The same study pointed out that back fat thickness and kidney fat percent decreased by using ryegrass straw instead of alfalfa hay as a source of roughage in the feedlot ration for lambs.

Generally speaking, increasing energy levels in the diet usually results in greater fat deposition in lambs (Glimp et al., 1968 ; Arehart and Banbury, 1973). Also, there was no significant difference in quality traits or carcass composition of lambs fed 50 or 80 % concentrate. There is an increase in yield grade when protein percentage increases within a 50:50 ratio of concentrate to roughage diets (Craddock et al., 1974).

MATERIALS AND METHODS

Diets

Diets containing two levels of perennial ryegrass straw (Lolium perene L) (zero and 25%) and two levels of monensin (zero and 25 gm / ton) were produced in a 2x2 factorial arrangement to produce the following four pelleted rations.

Ration 1: 50% barley, 50% alfalfa hay (0,0).

Ration 2: 50% barley, 50% alfalfa hay + Monensin (0,25 gm).

Ration 3: 50% barley, 25% alfalfa hay and 25% ryegrass Straw (25%,0).

Ration 4: 50% barley, 25% alfalfa and 25% ryegrass straw + monensin (25%, 25 gm).

All rations were prepared and pelleted in the Oregon State University Animal Science feed mill. The experiment took place in the sheep barn at Oregon State University. The experiment began the 13th of May and ended the 7th of July.

Animals

Lambs for the trial were sired by Hampshire rams and from mixed crossbred ewes. They were born in February and March, 1978,and were weaned the 4th of May at an average age of 60 days, pre and post weaning, the lambs grazed improved pastures (subclover-ryegrass) with their dams and did not have access to creep feed.

The lambs were vaccinated for enterotoxemia and pneumonia, drenched for intestinal parasites, drenched with selenium (3.75 mg/head) to protect them from white muscle disease and implanted in the ear with Zeranol (12 mg head). They were not shorn.

Each diet was fed to three pens of five lambs each, therefore, 60 lambs were involved in the study with 15 lambs receiving each diet. They were placed in the test pens on self feeders eight days following weaning.

All lambs were single reared and each pen of five lambs contained three wether and two ewe lambs. The lambs' average weight was 29.15 kg.

Lambs were drenched again with Loxon (10 cc/head) during the third week of the study. Salt mixed with phenothiazine was fed *ad libitum* to all pens.

Data Collected

All pens were fed *ad libitum*. Samples of the ration ingredients were analyzed for dry matter and crude protein contents. Samples of rations were taken weekly for lab analysis. Feces was collected directly from the rectum of three lambs in each pen during the third and fifth week of the experiment using plastic bags. Individual lamb weights, gain per pen and pen feed consumption were recorded weekly. As each lamb reached an unshrunk weight of 45.45 kg in body weight, it was terminated from the study and removed from the pen. The first two wethers that reached 45.45 kg in each pen were slaughtered at the Oregon State University Meat Laboratory. The last two lambs in each pen were terminated when their mean weight reached 45.45 kg.

Carcass data collected on the 24 slaughtered lambs included cold carcass weights obtained ten days following slaughtering, fat thickness at the 12th rib, percentage kidney fat, lion eye area, leg conformation score, quality grade yield grade and dressing percent based on cold carcass weight. Fluid samples were taken from the rumen shortly after removal of the rumen from the carcass by straining rumen contents through cheese cloth, five ml of every sample was added to 1 ml of 25% metaphosphoric acid. The samples were centrifuged at 12500 r.p.m. for 20 min. The fluid was poured into small plastic test tubes and stored in a freezer until analyzed for volatile fatty acids.

Analytical Methods

Air dried samples were ground through 40 and 20 mesh screens in the lab mill. Feces were freeze-dried and ground through 40 and 20 mesh screens.

The lignin technique was used in calculating digestibility and total digestible nutrients. Crude protein was determined by the macro kjeldahl method as given by A.O.A.C. for feed and by micro modification of A.O.A.C. for fecal matter. Ether extract was determined with a Golfish extraction apparatus. Nitrogen-free-extract was calculated by the difference. Ash was determined by combustion at 550°C for 7 to 8 hr. Dry matter was determined by dried samples for 48 hr at 105°C. Gross energy was determined by samples in a bomb calorimeter (table 1). Volatile fatty acid concentration in the rumen fluid samples were determined by the gas chromatography method. Carcass yield grade was determined by using the general equation: 1.66 - (0.05 x leg conformation score) + (0.25 x % kidney fat and pelvic) + (6.6 x fat thickness in inches).

Economic Analysis

Costs used in the economic analysis included:

1. Alfalfa hay - 11¢/kg.
2. Ryegrass straw - 2.2¢/kg.
3. Barley - 12.43¢/kg.
4. Monensin - 0.170¢/kg.
5. Ration pelleting and processing - 2.5¢/kg.
6. Health costs - 40¢/kg.
7. Yardage and labor - 4¢/head/day.

Ingredient and processing costs resulted in the following ration costs:

1. Ration 1 - 14.22¢/kg.
2. Ration 2 - 14.39¢/kg.
3. Ration 3 - 12.02¢/kg.
4. Ration 4 - 12.19¢/kg.

TABLE 1. RATIONS, THEIR NUTRIENT CONTENT AND THEIR GROSS ENERGY

Ration no.	Monensin (grams/ton)	Ryegrass straw %	DM	Dry basis, %							Gross energy KCal/g
				CP	EE	ADF	NFE	CF	Ash	Lignin	
1	0	0	91	14.11	2.21	22.32	47.34	17.90	5.12	5.61	4.15
2	25	0	91	14.11	2.21	22.32	47.34	17.90	5.12	5.61	4.15
3	0	25	90	11.02	2.10	27.15	44.71	22.50	5.02	5.90	4.20
4	25	25	90	11.02	2.10	27.15	44.71	22.50	5.02	5.90	4.20

Statistical Analysis

The study was designed as a randomized block design with blocks being groups of four pens located in three areas of the O.S.U. sheep barn. Data were analyzed using analysis of variance procedures for a replicated 2x2 factorial arrangement of treatments design. Feed efficiency, carcass traits, ration digestibility, total VFA and cost per kg gain were analyzed using a randomized block design while average daily gain was analyzed using split plot design with ration as a main plot treatment and sex as a sub plot treatment.

RESULTS AND DISCUSSION

Ration Nutrient Content and Digestibility

Apparent average digestibility of ration nutrient contents (ADNC) are summarized in table 2. Dry matter digestibility (DMD) was different ($P<0.05$) among the four rations. Ryegrass straw depressed ($P<0.05$) DMD by 8.0%. Monensin improved DMD by 1.7% but this was not a significant effect. Horton (1978) reported 3% increase in DMD for lamb rations containing monensin. However, Raun et al.(1976) reported an initial reduction in DMD and acid detergent fiber digestibility(ADFD) for monensin-fed cattle. Overall, DMD is slightly low for the four rations. This can perhaps be explained by the fact that when animals are fed free choice, an increase in the level of the plane of nutrients usually results in a reduction in digestibility of energy supplying nutrients (Church, 1976).

Organic matter digestibility (OGMD) was different ($P<0.01$) among the four rations. Addition of monensin resulted in an improvement in OGMD of 1.75% but this was not a significant effect. Ryegrass straw significantly decreased OGMD by 8.6%.

Crude protein digestibility (CPD) was different ($P<0.01$) among the four rations. Monensin improved ($P<0.05$) (CPD) by 3.44%. Addition of ryegrass straw significantly decreased CPD 14%.

Generally speaking, Dinius et al. (1976) have shown that monensin does not significantly affect in vitro DMD, CPD and hemicellulose or cellulose digestibility.

Ether extract digestibility (EED) was different ($P<0.01$) among the four rations. Monensin significantly improved EED by 8.75%, ryegrass straw improved EED 1.45% but this was not a significant effect. The monensin X ryegrass straw interaction was significant for EED. Acid detergent fiber digestibility (ADFD) was different ($P<0.05$) among the four rations. Monensin significantly improved ADFD by 16.6%, and ryegrass straw significantly depressed ADFD by 26.2%. Dirk Axe et al.(1978)

TABLE 2. RATION DIGESTIBILITY AND TOTAL DIGESTIBLE NUTRIENTS, AND MONENSIN AND RYEGRASS MAIN EFFECTS

Ration no.[f]	Apparent average digestiblity, %						
	DM	OGM	CP	EE	ADF	NFE	TDN
1	58.72[a]	60.43[c]	67.37[c]	52.71[cd]	22.90[a]	76.40[a]	53.35
2	58.60[a]	60.40[c]	68.23[c]	54.55[d]	24.72[a]	75.21[a]	53.40
3	53.01[b]	54.20[d]	56.60[d]	50.80[c]	27.13[a]	70.15[b]	47.40
4	55.04[b]	56.22[d]	60.01[d]	58.02[c]	33.60[b]	70.42[b]	50.00
				Main Effects			
Monensin vs. no monensin	0.95±1.176	1.0±0.785	2.13±.802*	4.53±.656**	4.15±1.553*	-0.48±1.121	1.33±1.779
Ryegrass straw vs. no ryegrass	-4.65±1.176*	-5.2±0.785**	-9.50±.802**	0.78±.656	-6.55±1.553**	-5.50±1.121**	-4.67±1.779*
Interaction	NS	NS	NS	**	NS	NS	NS

[ab]Means in each column with different superscripts are significantly different (P<0.05).
[cde]Means in each column with different superscripts are significantly different (P<0.01).
[f]Means are average of three pens fed each ration.
*P<0.05.
**P<0.01.

reported that DMD *in vitro* was reduced by 6.6% when 25% wheat straw was included in the ration.

The analysis of variance for nitrogen free extract digestibility (NFED) showed a significant difference among the four rations. Ryegrass straw significantly decreased NFED by 7.26%. Monensin also slightly decreased NFED by 0.66% but this was not a significant effect.

Total digestible nutrients (TDN) was not significantly different amont the four rations. Ryegrass straw significantly depressed TDN by 8.75%. Monensin improved TDN by 2.7%, but this was not a significant effect.

The general analysis of variance table used for apparent digestibility of the ration nutrient contents along with the associated degrees of freedom and the mean squares are given in table X.

Lamb Growth and Feed Efficiency

Table 3 shows mean daily gain, days on trial and final weight of lambs fed each ration. Results indicate that differences due to ryegrass straw and monensin were not significant. There was considerable difference in average daily gain (ADG) between animals within a pen. Ration 4 (ryegrass + monensin) resulted in the lowest ADG. Differences were significant between sexes for ADG with male lambs having ADG values of 0.045 kg more than female lambs. The results differ with Hanson and Klopfenstein (1977) and Davis and Erhart (1976) who showed increased ADG when monensin was fed to feedlot cows and steers, but it agrees with Glenn *et al*. (1977) who reported that ADG decreased for lambs fed monensin compared with the controls.

Overall, these results indicate that the use of by-product ryegrass straw at the 25% level in feedlot lamb rations resulted in little or no decrease in ADG. This is in agreement with Church and Kennick (1977) who also suggested reasonable ADG from using ryegrass straw at 25-30% in feedlot lamb rations.

The analysis of variance used for ADG along with the associated degrees of freedom and the mean squares is given in table VII.

TABLE 3. AVERAGE INITIAL WEIGHT, FINAL WEIGHT, DAYS ON THE TRIAL, AVERAGE DAILY GAIN AND MAIN EFFECTS OF MONENSIN AND RYEGRASS STRAW

Ration no.[a]	Initial wt. (kg)	Final wt. (kg)	Days on trial	Average daily gain (kg) live wt.	Average daily gain (kg) carcass wt.[e]
1	29.18	46.62	43.87	0.41	0.20[b]
2	29.06	46.48	42.47	0.41	0.18[bc]
3	29.15	46.90	43.40	0.41	0.16[cd]
4	29.21	45.77	48.07	0.35	0.14[d]
			Main Effects		
Monensin vs. no monensin	-0.03±0.074	-0.64±0.464	1.63±1.862	-0.03±0.041	-0.02±0.013
Ryegrass straw vs. no ryegrass	0.06±0.074	-0.22±0.464	2.56±1.862	-0.03±0.041	-0.04±0.013**
Interaction	NS	NS	NS	NS	NS

[a]Means are average of fifteen lambs fed each ration.
[bcd]Means in each column with different superscripts are significantly different ($P<0.05$).
[e]Means are average of six lambs fed each ration.
**$P<0.01$.

Average days or trial per treatment indicate that differences due to ryegrass straw and monensin are not significant. There was considerable difference in days on trial between animals within a pen. Ration 4 (ryegrass straw + monensin) resulted in a non-significant increase in days on trial. Monensin fed lambs and ryegrass straw-fed lambs had a higher number of days on trial than non-monensin (+1.63) and non-ryegrass fed lambs (+2.56), respectively.

Average final weights indicate that differences due to ryegrass straw and monensin were not significant. This is as would be expected since lambs were terminated from the study weekly at weights of 45.45 kg or greater. The analysis of variance table used for final weight and average days on trial along with the associated degrees of freedom and the mean squares is given in table VIII.

Table 4 summarizes mean total gain per pen, total feed intake and feed efficiency. Total feed intakes for the four groups were not significantly different. Monensin decreased ($P<0.10$) feed intake during the study by -7.8%. This is in agreement with studies of Riley et al. (1976) and Brown et al.(1974) working with cattle, but disagrees with the studies of Horton et al.(1978) who reported monensin did not depress intake of feedlot lambs and steers. Ryegrass straw resulted in a non-significant increase in feed intake of 6.03%. This agrees with the finding of Church and Kennick (1977) who reported an increase intake of diets containing ryegrass straw.

The analysis of variance for total gain (TG) indicated that differences were not significant between the lambs fed the four rations. The effects of ryegrass straw and monensin were also not significant. However, monensin-fed lambs had lower total pen gains (-2.8 kg) and ryegrass straw-fed lambs had higher total pen gains (+0.53 kg) than non-monensin and non-ryegrass-fed lambs, respectively.

There was no significant difference between the four rations for pen feed efficiency. Monensin resulted in a non-significant improvement feed/gain ratio of 4.6%. This result is in the same direction as work done by Utely et al. (1975) and Raun et al. (1976) using feedlot heifers and steers, Potter et al. (1976) working with cattle grazing pastures

TABLE 4. AVERAGE TOTAL GAIN, TOTAL FEED INTAKE, FEED EFFICIENCY AND MAIN EFFECTS OF MONENSIN AND RYEGRASS STRAW

Ration no.[a]	Total gain/ pen (kg)	Total feed intake/pen (kg)	Feed efficiency/ pen
1	86.50	358.06	4.14
2	86.04	325.08	3.78
3	89.37	374.16	4.19
4	84.23	350.20	4.16
	Main Effects		
Monensin vs. no monensin	-2.8 ± 2.63	$-28.47 \pm 13.975^{\dagger}$	-0.195 ± 0.223
Ryegrass straw vs. no ryegrass	0.53 ± 2.63	20.61 ± 13.975	0.215 ± 0.223
Interaction	NS	NS	NS

[a]Means are average of three pens fed each ration.
$^{\dagger}P<0.1$.

and Glenn et al. (1977) working with feeder lambs that all found improved feed efficiency with the addition of monensin to ruminant rations. However, Leek et al. (1976), working with feedlot lambs reported a reduction in feed conversion with monensin. Ryegrass straw resulted in a non-significant depression of feed/gain ratio of 5.4%. Lambs fed ration 2 had the best feed efficiency.

It is worth noting that lambs fed monensin had significantly lowered feed intakes during the first week of study. Seventy four percent of the total reduced feed intake per pen for monensin-fed lambs was due to reduced feed intake during the first week of the trial. This may be explained in terms of monensins effect on feed palatability and the adaptation of the animal to the taste of monensin. Lofgreen (1976) and many other reports indicate that monensin fed animals have lower feed intakes during the first week to ten days after addition of monensin to the ration.

The analysis of variance used for total gain, total feed intake and feed/gain ratio along with the associated degrees of freedom and the mean squares is given in table IX.

Lambs Carcass Traits

Table 5 shows average values for carcass traits of lambs fed each of the four rations. The average of quality grade is almost choice for the four groups fed the four rations. This is in agreement with Boling et al. (1977) who reported similar grades for monensin-fed animals and controls.

Monensin improved quality grade by a small but significant amount (+0.34), and ryegrass straw depressed quality grade by the same amount. Although not significant, lambs fed ration 3 (ryegrass straw and zero monensin) had the lowest (10.83) quality grade. Carcass yield grades were not significantly different among the four rations.

Although not significant, lambs fed 25% ryegrass straw and zero monensin had the best yield grade. Monensin resulted in a non-significant poorer yield grade of 5.06% and ryegrass straw resulted in a non-significant improvement in yield grade of 4.83%.

TABLE 5. MEAN VALUES FOR CARCASS TRAITS OF LAMBS FED THE FOUR RATIONS AND MONENSIN AND RYEGRASS STRAW MAIN EFFECTS

Ration no.[d]	Leg conformation score[c]	Fat thickness (cm)	% kidney and pelvic fat	Yield grade	Quality grade[c]	Dressing %	Loin eye area (cm^2)
1	12.81	0.48	2.55	2.85	11.17	45.66	13.49[a]
2	13.20	0.51	2.46	2.95	11.50	45.05	12.59[ab]
3	12.70	0.43	2.22	2.68	10.83	43.58	13.04[a]
4	13.02	0.46	2.64	2.85	11.17	42.75	11.52[b]
			Main Effects				
Monensin vs. no monensin	0.34	0.03	0.17	0.14±.165	0.34±.176†	-0.75±.836	-1.21±0.366*
Ryegrass straw vs no ryegrass	-0.17	-0.05	-0.08	-0.14±.165	-0.34±.176†	-2.19±.836*	-0.76±0.366†
Interaction	NS	NS	NS	NS	NS	NS	NS

[ab]Means in each column with different superscripts are significantly different ($P<0.05$).

[c]13 = low prime, 12 = high choice, 11 = average choice, 10 = low choice.

[d]Means are average of six lambs fed each ration.

†$P<0.10$.

*$P<0.05$.

Church and Kennick (1977) reported a decrease in back fat thickness and kidney fat percentage by using ryegrass straw instead of alfalfa hay as a source of roughage in feedlot rations for lambs. Although the ryegrass effect was not significant, a similar trend was observed here for these two traits.

Monensin resulted in a non-significant decrease in dressing percentage and ryegrass straw significantly ($P<0.05$) decreased dressing percentage by 2.19%. Since the lambs were terminated from the trial using unshrunk weights, the lowered dressing percent of ryegrass fed lambs probably indicates greater rumen fill for these lambs.

Loin eye areas were significantly different among the four groups fed the four rations. Lambs fed rations 1 and 3 had the largest loin eye areas. Lambs fed monensin had a significantly smaller loin eye areas (-9.12%). Ryegrass straw fed lambs, also, had significantly smaller loin eye areas (-5.83%).

The effects of monensin on lamb carcass traits in general agree with the results obtained by Potter et al.(1976) with cattle where it was found that monensin-fed steers had lower dressing percents at 79 ppm monensin, slightly more kidney, pelvic and heart fat, more fat over the 12th rib and poorer yield grades than the controls.

The analysis of variance used for carcass traits along with the associated degrees of freedom and the mean squares is given in table XI.

Volatile Fatty Acid Production

There are many variables that affect the concentration and molar percentage of volatile fatty acids (VFA) in ruminants. Rumen bacterial and protozoa populations are affected by the solubility of carbohydrates, the mixture of the carbohydrates and the amount of protein and its solubility. The microbial population sustained in the rumen determines the amount and proportion of VFA found in the rumen contents.

Table 6 presents the VFA traits of rumen fluid samples obtained from the 24 slaughtered lambs. Results indicate significant differences in molar percentage of acetic, propionic and butyric acid and total VFA

TABLE 6. VOLATILE FATTY ACID CONTENT OF RUMEN FLUID

Ration[e]	Molar % Acetic	Molar % Propionic	Molar % Butyric	Acetic/ propionic	Total VFA concentration (mM/liter)
1	57.72[a]	24.88[c]	17.40[ab]	2.48[c]	100.83[c]
2	62.36[b]	22.14[c]	15.50[ab]	2.86[cd]	88.36[c]
3	63.09[b]	17.65[d]	19.27[a]	3.56[d]	90.00[c]
4	61.81[b]	24.79[c]	13.40[b]	2.58[c]	64.62[d]
			Main Effects		
Monensin vs. no monensin	1.68±1.805	2.20±.741**	-3.88±1.357*	-0.30±.181	-18.93±4.775**
Ryegrass straw vs no ryegrass	2.41±1.805	-2.29±.741*	-0.12±1.357	0.40±.181*	-17.29±4.775**
Interaction	**	**	**	**	NS

[ab] Means in each column with different superscripts are significantly different ($P<0.05$).
[cd] Means in each column with different superscripts are significantly different ($P<.01$).
[e]Means are average of six lambs fed each ration.
*$P<0.05$.
**$P<0.01$.

concentration in the rumen among the four groups of lambs fed the four rations. Lambs fed ration 3 (ryegrass straw + zero monensin) had VFA concentrations that were significantly higher for acetic and butyric acid and lower for propionic acid when compared to the VFA concentrations of lambs fed the other three rations. This indicates that acetic and butyric acid were produced at a faster rate when lambs were fed ration 3. The significantly different results obtained from lambs fed ration 3 accounts for the highly significant interactions observed in table 6.

Monensin and ryegrass straw fed lambs had higher acetic acid concentrations than non-monensin and non-ryegrass straw fed lambs, respectively. Acetic acid molar percentage was significantly different among the four group of lambs fed the four rations. However, Dinius et al. (1976), working with steers,and Hanson and Klopfenstein(1977),working with lambs, reported a reduction in acetic acid and an increase in propionic acid concentration in the rumen.

Monensin-fed lambs had a +2.2%greater propionic acid concentration than non-monensin-fed lambs. This agrees with Richardson et al. (1974) who reported an increase in propionic acid production in animals fed different levels of monensin compared to the control animals. Ryegrass straw-fed lambs had a 2.2% lower propionic acid concentration than non-ryegrass straw-fed lambs. Propionic acid molar percentage was highly significant among the four groups of lambs fed the four rations.

Differences were highly significant for propionic acid concentration between lambs fed ration 3 compared to lambs fed the other three rations. Ration 3 had the lowest ($P < .01$) propionic acid concentration.

Monensin and ryegrass straw-fed lambs had lower butyric acid concentration than non-monensin and non-ryegrass straw-fed lambs, respectively. Butyric acid was significantly different among the four groups of lambs fed the four rations. Butyric acid concentration was significantly greater (5.87%) in lambs fed ration 3 than in lambs fed ration 4. Although non-significant, butyric acid concentration was greater in lambs fed ration 1 than in lambs fed ration 2.

The acetic:propionic ratio was significantly different among the four groups of lambs fed the four rations. Lambs fed ration 3 had the highest acetic/propionic ratio. Monensin-fed lambs had a lower acetic/propionic ratio (-0.30) compared to non-monensin-fed lambs. Ryegrass straw-fed lambs had a higher (+0.4) acetic/propionic ratio than non-ryegrass-fed lambs. Hanson and Klopfenstein(1977) reported that lambs fed monensin had lowered acetic/propionic ratios. Also, Prange et al. (1978) working with steers,observed the same results.

Monensin resulted in a significant ($P < 0.01$) decrease in total VFA concentration by 19.82%. This agrees with studies done by Prange et al. (1978) and Raun et al.(1976). They found that monensin depressed total VFA concentration by 30% in lambs and 9% in steers fed 30 and 50% barley,respectively. On the other hand Potter et al.(1976) and Dinius et al. (1976) found that monensin had no effect on total concentration of VFA's. Ryegrass straw depressed ($P < 0.01$) total VFA concentration by 18.28%. This may be related to the fact that feeding straw rations raises the pH of the rumen compared to rations with high levels of concentrates (Leng and Brett, 1966).

Total VFA concentration was lower (-36.21, -25.38 and -23.74 mM/liter, $P < 0.01$) for lambs fed ration 4 compared to lambs fed ration 1, 3 and 2, respectively.

The analysis of variance used for total VFA's concentration, molar percentage of VFA's in the rumen fluid and acetic/propionic ratio along with the associated degrees of freedom and the mean squares is given in table XII.

Economical Results

Table 7 presents an economic evaluation of each of the rations and of the monensin and ryegrass main effects. Results indicate that differences in cost per kg of live weight gain due to ryegrass straw and monensin are not significant. Although there were no significant differences among treatments, the highest cost per kg gain was for lambs fed zero ryegrass straw and zero monensin.

TABLE 7. COST PER KILOGRAM OF LIVE AND CARCASS WEIGHT GAIN OF LAMBS FED THE FOUR RATIONS AND THE MAIN EFFECTS OF MONENSIN AND RYEGRASS STRAW

Ration no.[a]	Average feed intake /lamb (kg)	Cost/kg ration (cent)	Average feed cost/ lamb ($)	Veterinary cost/lamb (cent)	Average yardage cost/lamb ($)	Average total cost/ lamb ($)	Average total gain/lamb (kg)	Average cost/kg gain (cent)	Estimated carcass gain/lamb (kg)[b]	Estimated cost, carcass kg gain ($)
1	71.61	14.22	10.18	40	1.75	12.33	17.30	71.27	7.20	1.72
2	65.02	14.39	9.36	40	1.70	11.46	17.21	66.59	7.27	1.60
3	74.83	12.02	8.99	40	1.74	11.13	17.87	62.29	6.33	1.83
4	70.04	12.19	8.54	40	1.92	10.86	16.85	64.45	5.79	1.91
									Main effects	
Monensin vs. no monensin								-1.26 ± 3.668		$-.02 \pm 0.202$
Ryegrass straw vs. no ryegrass								-5.56 ± 3.668		$.21 \pm 0.202$
Interaction								NS		NS

[a]Fifteen lambs fed each ration, five in each pen.
[b]Means are average of 6 lambs from each ration.

Both monensin and ryegrass straw resulted in a non-significant reduction in the cost of a kg of live weight gain (-1.26 and -5.56 cents, respectively). The lowered gain cost with ryegrass fed lambs may be in part due to a large amount of rumen fill. A large rumen fill is suggested from the dressing percent figures.

From the economical point of view, the study suggests that the use of ryegrass straw at the 25% level, even with early weaned lambs, will decreased the cost per kg gain. The addition of monensin resulted in a small decreased in cost per kg gain. Also presented in table 7 is the estimated cost per kg of carcass weight gain. In calculating an estimated carcass weight gain for each lamb, an initial dressing percent at the beginning of the trial of (47%) was assumed. Monensin-fed lambs produced a kg of carcass for two cents less than non-monensin-fed lambs and ryegrass straw-fed lambs produced a kg of carcass for 21 cents more than non ryegrass straw-fed lambs. The increased cost of a kg of carcass weight gain of the ryegrass-fed lambs is due to the poor dressing percents of these lambs. Results indicate that estimated differences in cost per kg of carcass gain due to ryegrass straw and monensin are not significant. Although there were no significant differences among treatments, the highest estimated cost per kg carcass gain was for lambs fed 25% ryegrass straw and 25 gm /ton monensin. Both monensin and ryegrass straw resulted in a non significant reduction in the cost of a kg of estimated carcass gain.

The analysis of variance used for cost per kg of live and carcass weight gain along with the associated degrees of freedom and the mean squares is given in table XIII.

Since all lambs producers should be concerned with cost/kg of carcass weight gain whether they sell on a live or carcass weight basis, these data would tend to indicate that it is not in the best interest of the lamb feeder to replace alfalfa hay with ryegrass straw in his lamb rations. The question of whether or not monensin is a desirable feed additive for lambs is still unanswered since addition of monensin was beneficial in the alfalfa-barley ration and detrimental in the alfalfa-ryegrass-barley ration for cost/kg of both live and carcass weight gain.

It is evident that more work needs to be done with the use of monensin in lamb feedlot rations. If proven to be a desirable additive, steps should be taken to obtain approval of its use in sheep rations. Perhaps the use of ryegrass straw in maintenance rations for ewes deserves more future research than does the use of ryegrass straw in lamb rations.

SUMMARY AND CONCLUSION

The objectives of this study were to examine the by-product ryegrass straw and the feed additive monensin for their effects on performance traits of feedlot lambs. The study lasted for 56 days.

Sixty-single reared lambs sired by Hampshire rams started the trial shortly after weaning. Fifteen lambs were fed each ration; five lambs in each of three pens. Data for feed efficiency, carcass traits, ration digestibility, total VFA,and VFA molar percentage and cost per kg of live and carcass weight gain were analyzed using a randomized block design while average daily gain was analyzed using a split plot design.

Monensin significantly improved CPD and ADFD by 3.44 and 16.6%, respectively, and highly significantly improved EED by 8.75%.

Although non-significant, monensin resulted in an increase in DMD, OGMD and TDN by 1.7, 1.75 and 2.75%, respectively, and a decrease in NFED of 0.66%.

Ryegrass straw decreased ($P < 0.05$)DMD and TDN by 8.0 and 8.75%, respectively, and decreased ($P < 0.01$) OGMD, CPD ADFD and NFED by 8.6, 14, 26.2 and 7.26%, respectively.

The use of by-product ryegrass straw and the feed additive monensin resulted in a little or no decrease in ADG. Differences were highly significant between sexes for ADG with male lambs having ADG values of 0.045 kg more than female lambs.

Average days on trial, final weights, total gain and feed efficiency indicate that differences due to ryegrass and monensin were not significant. Monensin decreased ($P < 0.1$) feed intake by 7.8%. Seventy four percent of this reduction in feed intake was due to reduction in feed intake during the first week of the trial of monensin fed lambs. On the other hand, ryegrass straw resulted in a non-significant increase in feed intake by 6.03%.

Monenensin resulted in a significant increase in carcass quality grade, and a significant decrease in loin eye area of 9.12%. Ryegrass straw decreased carcass quality grade ($P < 0.10$) loin eye area ($P < 0.10$) and dressing percentage ($P < 0.05$) by 3, 5.83 and 2.19%, respectively.

Results fluctuate somewhat for VFA molar percentage because lambs fed ration 3 had the highest acetic and butyric acid and the lowest propionic acid concentration which resulted in a highly significant interaction between the levels of monensin and ryegrass straw.

Monensin and ryegrass straw resulted in a highly significant decrease in total VFA of 19.82% and 18.28%, respectively.

Differences in cost per kg of live weight gain due to ryegrass straw and monensin were not significant. However, both resulted in a reduction in the cost of a kg of live weight gain (-1.26 and -5.56 cents, respectively).

Estimated cost of a kg of carcass gain showed that monensin-fed lambs produced a kg of carcass for 2 cents less than non-monensin-fed lambs. On the other hand, ryegrass straw-fed lambs produced a kg of carcass for 21 cents more than non-ryegrass-fed lambs.

The question now is whether or not monensin at 25 gm per ton is a desirable feed additive for lambs? The monensin main effects indicate that monensin resulted in reasonable lambs performance. Also, from an economical point of view, cost per kg of live and carcass weight gain was slightly less for monensin than non-monensin-fed lambs. However, cost of gain results were not in favor of using monensin in a combination with ryegrass straw.

Ryegrass straw resulted in a satisfactory lamb performance. Ryegrass straw-fed lambs, which had a greater feed intake, still produced a kg of live weight gain for less (-5.56¢) than lambs fed no ryegrass straw. However, due to lowered dressing percentage, ryegrass-fed lambs produced a kg of carcass weight gain at a greater cost than non-ryegrass-fed lambs.

This study will hopefully add useful information about the use of monensin and ryegrass straw for young ruminants. Results indicate that ryegrass straw fed at 25% of the ration is inferior for the production of carcass weight in growing-fattening lambs. Monensen resulted in improved performance in the non-ryegrass-fed lambs but decreased performance in the ryegrass-fed lambs.

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APPENDIX

TABLE I. PERFORMANCE OF LAMBS USED IN TREATMENT NO. 1

Rep. no.	Total feed intake	Lamb no.	Initial weight kg	Turnover weight kg	Total gain kg	Days in the trial	ADG kg
1	351.07	315	28.18	43.64	15.45	56	0.28
		442	29.09	45.68	16.36	35	0.46
		466	27.73	46.36	18.63	35	0.53
		469	30.00	48.63	18.63	35	0.53
		617	29.55	49.54	20.00	56	0.36
2	334.98	309	27.73	44.09	16.36	49	0.33
		474	30.00	46.36	16.36	35	0.47
		500	28.64	46.81	18.18	49	0.37
		568	31.82	46.81	15.00	35	0.43
		589	28.18	47.72	19.54	42	0.47
3	338.13	263	28.18	48.63	20.45	56	0.37
		427	29.09	44.54	15.45	56	0.28
		470	29.55	45.90	16.36	42	0.39
		504	30.91	46.36	15.45	35	0.44
		592	30.91	48.18	17.27	42	0.41

Average initial weight for lambs involved in this treatment = 29.18 kg.

TABLE II. PERFORMANCE OF LAMBS USED IN TREATMENT NO. 2

Rep. no.	Total feed intake	Lamb no.	Initial weight kg	Turnover weight kg	Total gain kg	Days in the trial	ADG kg
1	322.68	476	30.45	50.90	20.45	42	0.49
		518	29.55	45.90	16.36	35	0.47
		524	27.27	42.27	15.00	42	0.36
		671	29.55	50.00	20.45	42	0.49
		629	27.73	47.27	19.54	42	0.47
2	346.57	367	30.00	46.61	16.81	42	0.40
		368	31.36	46.81	15.45	42	0.37
		467	30.45	46.61	15.90	56	0.28
		471	27.27	44.54	17.27	56	0.31
		567	28.18	46.36	18.18	42	0.43
3	306.00	261	30.91	45.00	14.09	42	0.34
		328	27.73	45.90	18.18	42	0.43
		357	30.91	45.90	15.00	35	0.43
		543	27.27	47.72	20.45	35	0.49
		672	30.45	45.45	15.00	42	0.43

Average initial weight for lambs involved in this treatment = 29.06 kg.

TABLE III. PERFORMANCE OF LAMBS USED IN TREATMENT NO. 3

Rep. no.	Total feed intake	Lamb no.	Initial weight kg	Turnover weight kg	Total gain kg	Days in the trial	ADG kg
1	397.66	450	30.45	47.27	16.81	56	0.30
		369	30.91	47.72	16.81	35	0.48
		522	28.64	45.00	16.36	56	0.29
		530	29.55	46.36	16.81	42	0.40
		615	27.73	45.45	17.72	49	0.36
2	370.11	308	29.55	47.72	18.18	42	0.43
		433	31.82	50.00	20.90	42	0.43
		555	28.18	50.00	21.81	42	0.52
		570	28.64	45.90	17.27	42	0.41
		679	27.73	45.90	18.18	42	0.43
3	354.70	224	29.55	47.27	17.72	42	0.42
		358	29.55	45.00	15.45	42	0.37
		421	27.27	47.72	20.45	42	0.49
		426	30.45	45.90	15.45	35	0.44
		648	28.18	46.36	18.18	42	0.43

Average initial weight for lambs involved in this treatment = 29.15 kg.

TABLE IV. PERFORMANCE OF LAMBS USED IN TREATMENT NO. 4

Rep. no.	Total feed intake	Lamb no.	Initial weight kg	Turnover weight kg	Total gain kg	Days in the trial	ADG kg
1	345.86	267	28.18	41.36	14.09	56	0.25
		343	30.45	48.18	17.73	56	0.32
		465	28.18	45.45	17.27	42	0.41
		521	28.64	45.90	17.27	42	0.41
		620	30.91	46.18	15.90	42	0.38
2	366.08	281	29.55	45.45	15.90	42	0.38
		340	26.36	45	18.64	56	0.33
		425	27.27	45.45	18.18	56	0.32
		515	29.55	45.45	15.90	49	0.41
		554	28.18	45.45	17.27	42	0.32
3	338.65	254	29.55	47.72	18.18	56	0.39
		376	31.81	48.18	16.36	42	0.40
		590	28.64	45.45	16.81	42	0.39
		681	30.45	46.81	16.36	42	0.30
		714	27.73	44.54	16.82	56	0.30

Average initial weight for lambs involved in this treatment = 29.21 kg.

TABLE V. VOLATILE FATTY ACID DATA FOR THE SLAUGHTERED LAMBS

Treatment no.	Lamb no.	Acid concentration mM/liter				Acetic/ Propionic ratio
		Acetic acid	Propionic acid	Butyric acid	Total VFA	
1	442	58.20	16.24	27.11	101.55	3.58
	469	61.41	27.78	21.60	110.79	2.20
	474	65.80	21.12	15.65	102.57	3.10
	568	64.11	27.15	14.97	106.23	2.36
	504	55.42	24.70	15.50	95.62	2.24
	470	45.10	31.96	11.18	88.24	1.41
2	518	55.59	17.18	11.83	84.60	3.24
	629	54.12	22.78	11.97	88.87	2.38
	367	56.93	20.62	16.34	93.89	2.76
	567	54.81	22.71	13.03	90.55	2.41
	357	52.85	15.32	13.60	81.77	3.45
	672	55.92	19.12	15.44	90.48	2.92
3	369	54.04	13.46	14.92	81.42	3.94
	530	50.24	13.58	12.38	76.20	3.70
	433	71.25	18.45	26.02	115.72	3.86
	570	54.54	16.46	15.02	85.02	3.25
	426	61.91	15.66	22.37	99.94	3.65
	421	49.82	16.78	15.11	81.71	2.97
4	521	36.03	13.92	7.64	57.59	2.59
	620	43.90	14.14	9.32	67.36	3.10
	554	36.62	13.05	9.21	58.88	2.81
	515	34.47	20.04	6.42	60.93	1.70
	376	55.22	25.92	10.96	92.10	2.13
	681	32.74	10.35	7.74	50.83	3.16

TABLE VI. CARCASS DATA FOR THE SLAUGHTERED WETHERS

Treatment no.	Lamb no.	Live wt. (kg)	Carcass hot wt. (kg)	Cold wt. (kg)	Dress-ing %	Leg conf.	Fat thick-ness (cm)	Kidney fat wt. (kg)	% kidney fat	Yield grade	Quality grade	Loin eye area (cm²)
1	442	46.36	22.28	21.12	45.56	14	0.45	0.52	2.46	2.74	11	13.73
	469	49.09	23.54	22.12	45.06	12	0.53	0.38	1.72	2.65	11	14.06
	474	46.36	22.90	21.30	45.94	12	0.44	0.64	3.00	2.95	11	11.66
	568	45.91	22.96	21.76	47.40	13	0.49	0.50	2.29	2.86	12	14.18
	504	47.72	23.32	22.04	46.19	13	0.47	0.76	3.45	3.11	11	13.15
	470	45.90	21.56	20.10	43.79	13	0.46	0.48	2.39	2.82	11	14.18
2	518	47.27	22.34	21.06	44.55	14	0.49	0.48	2.23	2.78	11	15.61
	629	47.27	21.80	20.54	43.45	13	0.59	0.54	2.63	3.22	11	15.22
	367	46.80	22.80	20.72	44.27	12	0.43	0.46	2.22	2.75	11	7.32
	567	46.36	21.68	20.40	44.00	12	0.36	0.36	1.76	2.43	11	13.80
	357	47.27	22.68	21.32	45.10	14	0.52	0.64	3.00	3.08	12	10.88
	672	46.36	23.80	22.68	48.92	14	0.69	0.66	2.91	3.48	13	14.44
3	369	46.81	22.42	21.22	45.33	12	0.48	0.58	2.73	2.99	10	12.76
	530	46.36	21.34	19.92	42.97	13	0.48	0.40	2.00	2.76	11	14.96
	433	45.45	20.58	19.10	42.02	12	0.23	0.36	1.88	2.13	11	10.01
	570	45.90	21.00	19.68	42.66	12	0.62	0.42	2.13	3.20	11	11.79
	426	47.27	22.00	20.82	44.04	14	0.41	0.48	2.31	2.60	11	13.47
	421	47.70	22.36	21.20	44.44	13	0.33	0.48	2.26	2.44	11	15.22
4	521	45.90	21.06	19.84	43.22	13	0.34	0.48	2.42	2.51	11	9.00
	620	46.80	22.44	21.08	45.04	13	0.40	0.52	2.47	2.68	12	13.67
	554	45.45	20.96	19.62	43.17	13	0.63	0.60	3.06	3.45	11	9.46
	515	45.45	20.60	19.12	42.07	13	0.64	0.62	3.24	3.50	11	11.79
	376	48.18	22.12	20.72	43.01	13	0.49	0.50	2.41	2.89	11	13.47
	681	46.80	19.86	18.74	40.00	13	0.21	0.42	2.24	2.12	11	11.72

TABLE VII. ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN

Source	D.F.	MS	Error[a]	Error[b]
Total	59			
Reps	2	0.0005		
Monensin	1	0.0107		
Straw	1	0.0101		
Monensin X straw	1	0.0147		
Reps X monensin	2	0.0088		
Reps X straw	2	0.0130	0.0245	
Reps X monensin X straw	2	0.0027		
Sex	1	0.02916**		
Sex X monensin	1	0.0025		
Sex X straw	1	0.00015		
Sex X straw X monensin	1	0.0035		
Sex X reps	2	0.0015		
Sex X reps X straw X monensin	6	0.0042		0.0035
Animals/sex/rep/ration	36	0.0035		

[a]Error was calculated by pooling the sums of squares of the following interactions: rep X monensin, rep X straw and rep X monensin X straw.
[b]Error was calculated by pooling the sums of squares of the following interactions: rep X sex, sex X rep X straw X monensin and rep X sex X animal X ration.
**$P < 0.01$.

TABLE VIII. ANALYSIS OF VARIANCE FOR FINAL WEIGHT, INITIAL WEIGHT AND DAYS ON TRIAL

Sources	D.F.	MS		
		Final weight	Initial weight	days on trial
Ration	3	3.789	0.069	92.28
Monensin	1	6.26	0.028	39.35
Straw	1	0.73	0.068	89.2
Monensin X straw	1	4.48	0.111	148.3
Replication	2	0.0045	0.133	17.65
Ration X replication	6	2.706	0.143	59.28
Anima/rep./ration	48	3.303	0.076	51.08

Error was calculated by pooling the sums of squares of the following interactions: replication X ration + animal X replication X ration.

TABLE IX. ANALYSIS OF VARIANCE FOR TOTAL GAIN, TOTAL FEED INTAKE AND FEED EFFICIENCY

Sources	D.F.	MS		
		Total gain	Total feed intake	Feed efficiency
Ration	3	13.59	1256.41	0.111
Monensin	1	23.69	2433.5†	0.114
Straw	1	0.86	1274.9	0.140
Monensin X straw	1	16.26	60.83	0.070
Replication	2	7.39	96.25	0.003
Ration X replication	6	20.88	585.94	0.1499

†P<0.10.

TABLE X. ANALYSIS OF VARIANCE FOR RATION NUTRIENTS CONTENT DIGESTIBILITY

Sources	D.F.	MS						
		DM	OGM	CP	EE	ADF	NFE	TDN
Ration	3	23.85*	27.10**	46.40**	28.30**	54.50*	31.73*	23.80
Monensin	1	12.80	3.10	13.65*	61.66**	51.56*	0.69	5.20
Straw	1	43.50*	81.20**	270.75**	1.82	99.71**	90.75**	65.40*
Monensin X straw	1	15.25	2.92	4.80	20.80**	12.13	3.76	0.70
Replication	2	0.23	0.96	0.08	0.17	1.50	0.98	0.70
Ration X replication	6	4.15	1.85	1.93	1.29	7.24	3.77	9.50

*P<0.05.
**P<0.01.

TABLE XI. ANALYSIS OF VARIANCE FOR CARCASS TRAITS

Sources	D.F.	MS			
		Quality grade	Yield grade	Dressing %	Loin eye area
Ration	3	0.47	0.075	10.62	4.3*
Monensin	1	0.69	0.112†	3.07	8.78*
Straw	1	0.69	0.106†	28.73*	3.47†
Monensin X straw	1	0.14	0.008	0.80	0.65
Replication	2	0.32	0.030	0.61	13.25
Ration X replication	6	0.24	0.282	4.19	1.06
Animal/rep./ration	12	0.16	0.103	1.25	0.67

†P<0.10.

*P<0.05.

Error was calculated by pooling the sums of squares of the following interactions: replication X ration + animal X replication x ration.

TABLE XII. ANALYSIS OF VARIANCE FOR VOLATILE FATTY ACID TRAITS OF THE RUMEN CONTENTS

Sources	D.F.	MS				
		Acetic acid	Propionic acid	Acetic/ propionic	Butyric acid	Total VFA
Ration	3	436.3**	105.1**	1.38**	111.76*	1397.16**
Monensin	1	16.94	29.1**	0.54	90.4*	2136.7**
Straw	1	34.4	31.5*	0.96*	0.8	1782.7**
Monensin X straw	1	1257**	254.7**	2.54**	244.1**	272.1
Replication	2	303.6	17.76	0.27	0.79	68.95
Ration X replication	6	20.83	1.71	0.225	19.91	127.1
Animal/rep./ration	12	18.86	4.11	0.183	6.63	140.1

*$P<0.05$.

**$P<0.01$.

Error was calculated by pooling the sums of squares of the following interactions: replication X ration + animal X replication X ration.

TABLE XIII. ANALYSIS OF VARIANCE FOR COST PER KG OF GAIN

Sources	D.F.	MS	MS
Ration	3	43.39	0.108
Monensin	1	15.6	0.004
Straw	1	91.96	0.264
Monensin X straw	1	32.61	0.056
Replication	2	0.30	0.127
Ration X replication	6	40.37	0.247