WHEAT AND BARLEY SILAGES
FOR STEERS AND LAMBS

by

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INTRODUCTION

Kansas is known as the "Wheat State". In 1973 there were 10.6 million acres of hard, red-winter wheat grown in Kansas. This is six times the corn and two and one-half times the grain sorghum acreages. About 92% of this wheat was harvested as grain and the remainder utilized as pasture. In addition, 225 thousand acres of oats and 120 thousand acres of winter barley were planted and harvested almost entirely for feed grain (Kansas State Board of Agriculture, 1972-73).

Fluctations in price have often made wheat competitive with other feed grains for livestock rations. Wheat is equal or superior to corn and grain sorghum as a source of energy and protein. In the United States most of the 800 million bushels of wheat used domesticly each year is for human food. However, 200 million bushels are fed annually to livestock with this amount increasing in times of wheat surplus. In 1970, 27.3% of the total wheat produced in the U. S. was fed to livestock (Schoeff, 1972).

When harvesting wheat or other grain crops, approximately 50% of the total dry matter produced is left in the field after the grain has been removed. Wheat and other cereal crop residues are usually plowed down and not used as feed for ruminants. The greatest amount of plant dry matter could be harvested when the grain has reached physiological maturity. The forage portion of most grain crops declines in feeding value as the grain ripens. Limited data appear in the literature regarding the harvesting, storing and feeding of whole-plant cereal crops.

Objectives of this research were to study the feeding value of wheat and barley harvested as silage; to determine the effects of stage of maturity and type of cereal grain on silage quality, palatability and digestibility and to evaluate soybean meal and urea as sources of supplemental nitrogen in wheat silage rations.

LITERATURE REVIEW

Wheat Utilization in Beef Cattle Rations

Since wheat has been predominantly thought of as human food, there is less information available concerning its feeding value for livestock than there is for most other grains. Although wheat has often been fed to livestock, only in recent years has large quantities and low prices made it competitive with other feed grains.

Some early work by Haney *et al*., (1904) showed average daily gains of 1.56 and 1.85 lbs. per day for steers fed wheat and corn, respectively. However, wheat rations were more efficient with one pound of wheat replacing 1.02 pounds of corn.

Results of Baker *et al*., (1960) and Talor *et al*., (1945) supported the conclusion of Haney and coworkers that wheat fed alone decreased consumption and increased efficiency compared to corn fed alone. However, these data also indicate that gains are quite similar when comparing wheat and corn.

Recent research indicates that wheat can be fed to the greatest advantage in combination with other feed grains. Brethour *et al*., (1966) reported that relative intake was substantially increased when wheat was fed as 50% of the concentrate with either corn or sorghum grain instead of 100% of the concentrate According to the above investigators, when a concentrate of wheat, another feed grain and supplement was fed, one lb. of wheat was equal in value to 1.17 lbs. of corn and 1.24 lbs. of sorghum grain. When the concentrate portion of the ration was all wheat, one lb. of wheat was equal in value to 1.07 lbs. of corn and 1.15 lbs. of sorghum grain. Wheat used in this research was the hard, red winter type commonly grown in Kansas.

Several factors affect the feeding value of wheat. Ruminants fed high-concentrate rations normally have ruminal conditions conducive to lactic acid production, thus lowering the pH (Hungate *et al*., 1952). No digestive disorders result unless the rate of lactic acid production exceeds the rate of utilization to the extent that lactic acid acidosis occurs. The main lactic acid producing organism in the rumen is Lactobacillus.

Slyter _et al._, (1970) studied the microbial population of twin steers fed _ad libitum_ either 90% corn or 90% soft, red winter wheat diets. Steers fed wheat had a lower pH and higher concentrations of _Lactobacilli_ than those fed corn. In the same study, these authors compared corn, soft wheat, barley and milo in all-concentrate diets. Ruminal ingesta of steers fed wheat had the lowest pH and the greatest concentrations of Lactobacillus and other aciduric bacteria.

In a similar trial, Oltjen _et al._, (1966) studied the fermentation pattern of steers fed _ad libitum_ , one of four all-concentrate diets containing 90% cracked corn, 90% cracked wheat or 60:30 ratios of the two grains. Steers fed 90 and 60% wheat diets had lower rumen pH and greater concentrations of ruminal volatile fatty acids than steers fed 90 and 60% corn diets, even though the cattle fed high-wheat diets consumed less daily feed than cattle fed high-corn diets. These data may account in part for some of the problems associated with feeding high levels of wheat.

Varner _et al._, (1972) found that wheat variety had a definite affect on _in vitro_ and _in vivo_ lactate levels with hard wheats producing higher lactate levels than soft wheats. Williams (1967) reported that kernel hardness of wheat influenced the amount of starch damage during processing. Hard kernel wheats had a higher level of damaged starch compared to soft kernel wheats. Williams also observed that starch from a hard wheat was more susceptible to enzymatic attack than starch from soft wheat. Thus, Varner concluded that because hard wheat was more readily digestible than soft wheat, it caused more digestive disorders, higher rumen lactate levels and lower feed intake compared to soft wheat.

Brethour et al., (1971) compared Gaines, Golden 50 and Scout wheat varieties to milo in high-grain finishing rations for beef cattle. Wheat varieties ranked from degree of kernel softness to hardness as follows: Gaines, Golden 50 and Scout. When these wheats were evaluated by rate of gain, feed efficiency and feed intake, Gaines supported the highest performance followed, in order, by Golden 50 and Scout. These results and other data (Brethour et al., 1966) comparing soft and hard kernel wheats in high-grain finishing rations support the findings of Williams and Varner.

Morphological Development of the Wheat Plant

As a wheat plant matures it passes through various stages of growth. The following discussion defines each stage of growth using Peterson, 1965 as the principle reference.

The "emergence" stage of wheat seedlings occurs as the coleoptile appears above the surface of the ground usually within 7 to 14 days after the seed has been sown. When the first few leaves have appeared, branches known as tillers grow from the nodes of the stem just below the soil surface introducing the "tillering" stage. During the tillering stage usually the only parts of the wheat plant visible above the ground are the leaf sheaths and blades. This tillering process in winter wheats usually begins in the fall and is completed in the spring, after winter dormance.

Following the tillering stage, the plant enters a period of rapid growth known as "stem extension" or "jointing" stage. Here both stems and leaf sheaths elongate rapidly starting at the bottom of the plant and working upward. The uppermost internode, within the uppermost leaf is the last to lengthen. Like the other intermodes, it has a growing region at its base, but it also bears the head. This stage usually lasts approximately 30 days.

As the head grows in size, it visibly distends the sheath of the flag leaf and this time is known as the "boot" stage. The head of the main stem usually enters the boot stage first, followed by the tillers in the order of their origin. This stage lasts about 10 days.

Emergence of the head from the sheath marks the beginning of the "heading" stage, lasting about 5 days. After emergence of the head, the uppermost internode continues to lengthen until the head is several centimeters above the upper leaf. A few days after heading is completed, flowering begins followed by fertilization.

In the "watery-ripe" stage of development, lasting 1 to 2 weeks after fertilization, the grain increases rapidly in size. The plant is green, but the lower leaves have begun to die beginning with the bottom leaf.

The watery stage is followed by the "milk" stage; a white, milk-like fluid can be expressed from the kernel. This white fluid consists of a watery sap containing many starch granules. During this stage several bottom leaves die. At the end of the milk stage, lasting 15 to 18 days, the embryo in the kernel is fully developed.

The "dough" stage, or "mealy" stage, is reached when the water content of the kernel has decreased to the point where the material pressed out of it has a dough consistency. Lower leaves are continuing to die and plant color starts to change from green to yellow. This stage lasts 10 to 14 days.

In the "fully-ripe" stage the plant becomes completely yellow in color and the kernel is firm and hard. Finally, the "dead-ripe" stage is reached, when the plant becomes brittle and the kernel fragments when crushed.

Feeding Value of Cereal Grain Silages

Feeding value of cereal crop silages can be influenced by many factors. The cereal grain, stage of maturity at harvest and moisture content have significant affects on feeding value. Likewise, the portion of the plant harvested, fineness of chop, rapidity of silo filling and type of storage structure all influence feeding value to some degree by affecting the ensiling process.

McCullough and Sisk (1966) studied the influence of stage of maturity at harvest on the voluntary intake of wheat silage fed to dairy cows. Boot silage was consumed in significantly greater quantities at all levels of grain feeding. When no grain was fed, 20% more boot silage dry matter was consumed than milk or dough silage dry matter.

In a similar study boot barley and oat silages were compared to alfalfa haylage (Marx et al., 1974). No differences in milk yield, milk fat or weight gain were observed when lactating dairy cows were fed each silage free-choice. Crude protein content and dry matter intake as a percent of body weight were: 11.5, 1.65; 13.6, 1.58 and 18.3, 1.83 for the barley, oat and alfalfa silages, respectively. These authors also reported that two cuttings of barley and oats could be harvested if the first crop was cut above the first node.

Boot wheat silage was compared to corn or alfalfa silages as the main energy source in growing rations for steers (Baxter et al., 1971). Over twice as much digestible dry matter was consumed by steers fed corn or alfalfa silages versus those fed boot wheat silage. However, when corn silage and boot wheat silage were mixed in equal proportions, digestible dry matter intake was equal to corn or alfalfa silages fed alone. No explanation was offerred by the authors for the advantage of mixing boot wheat silage with corn silage.

Wheat can be harvested in the milk and dough stages as head silage, thus lowering the roughage to grain ratio and raising the energy concentration. By definition, head silage contains only the upper one-third to one-half of the plant. Wagner et al., (1973) compared wheat head silage to dry rolled wheat, high-moisture harvested wheat stored in an oxygen-limiting silo or high-moisture harvested wheat preserved with propionic acid in a steer finishing trial. Head silage produced the highest feed intake, lowest gain, poorest efficiency and lowest dressing percentage of any of the four wheat treatments. However, when the higher roughage content of the head silage ration was considered, the amount of grain per unit of gain was similar for all treatments.

One alternative to head silage would be to harvest the whole plant thus maximizing dry matter yield per acre. Burgess et al., (1972) compared whole-plant silages of wheat, barley, forage oats and corn when fed as the sole forage to lactating dairy cows. The cereal silages were all harvested in the dough stage. Corn silage dry matter intake was lower, but more efficiently utilized for milk production than that of the three cereal silages. Wheat, barley and forage oat silages were equal in feeding value.

In a similar trial using yearling steers, wheat and oat silages (both early-dough maturity) were compared to direct-cut alfalfa silage to which eight lbs. of sodium metabisulfite and 200 lbs. ground corn cobs were added per ton (Perry et al., 1957). Gains (kg/day) and dry matter intake (kg/day) were: 0.63, 4.1; 0.68, 4.0 and 0.90, 5.1 for the wheat, oats and alfalfa silages, respectively.

Recently there has been increased interest in feeding whole-plant barley silage in growing and finishing rations. Mowat et al., (1971) fed whole-plant barley silage (dough stage), ground mature whole-plant barley or corn silage in two experiments. Average gain (kg/day) and dry matter intake (kg/day) of yearling steers were: 0.78, 8.90; 0.85, 9.31 and 1.01, 8.49 in the first trial and 0.82, 7.35; 0.93, 7.94 and 0.93, 7.35 in the second trial for barley silage, ground whole-plant barley and corn silage, respectively. In trial one gains were significantly different; in trial two steers fed barley silage gained significantly slower than those fed ground whole-plant barley or corn silage.

Cereal grains have often been harvested as hay. Whole-plant barley harvested as hay in the milk stage and as silage in the milk, soft-dough and firm-dough stages were fed to lactating dairy cows (Fisher et al., 1972). Forage dry matter intake was significantly lower for cows receiving hay than for those receiving any of the three silages. Milk stage silage was consumed in significantly lower amounts and yielded a lower milk protein content compared to the other two silages. In a similar study, barley grain and straw were harvested seperately and combined in equal parts on a dry matter basis at feeding time (Krall et al., 1973). This barley-straw ration was compared to a barley head silage ration and a ration of dry barley and corn silage combined in equal amounts on a dry matter basis. Gain (kg/day) and dry matter intake (kg/day) were: 0.73, 4.84; 0.85, 6.15 and 0.80, 5.95 for the barley-straw, barley head silage and barley-corn silage rations, respectively.

Miller et al., (1967) and Polan et al., (1968) studied the feeding value of barley silage harvested at the boot, milk, and dough maturities when fed to dairy cows. In two studies dry matter intake and weight gain were lowest for the boot silage compared to the milk and dough silages. Milk yields were not affected by stage of maturity. Martz et al., (1958) harvested oats for silage in the boot, milk and dough stages and fed them ad libitum to lactating dairy cows receiving 2 kg of alfalfa hay and 1 kg of grain per 6 kg of milk produced daily. Silage dry matter consumptions were: 9.95, 9.54 and 11.54 kg per day for the boot, milk and dough oat silages, respectively. The boot, milk and dough silages were 97, 92 and 80%, respectively, as valuable for milk production as was a control alfalfa-bromegrass silage.

Neuman et al., (1963) fed beef calves dough stage oat silage supplemented with either 1.73 kg mixed hay, 1.70 kg corn or 1.31 kg hay plus 0.45 kg soybean meal. They found that oat silage supplemented with corn resulted in a faster average daily gain (0.47 vs. 0.41 kg/day) than oat silage supplemented with mixed hay. Oat silage supplemented with hay plus soybean meal gave the fastest gain (0.55 kg/day).

Dough stage oat silage was compared to sorghum and corn silages by Whetzal et al., (1967). Steers fed oat or sorghum silage did not differ significantly in gain. However, steers fed corn silage gained 21.6% faster than steers fed oat silage and 27.6% faster than steers fed sorghum silage. Oat silage produced the highest dry matter consumption and the poorest feed efficiency. Lyons et al., (1938) reported that dairy cows fed atlas sorgo silage produced slightly more milk than those fed oat silage.

Quality and Composition of Cereal Grain Silages

Stage of maturity at harvest is the largest single factor influencing the quality and composition of cereal grain silage. Chemical changes that occur in wheat, barley and oats as they mature are quite similar.

Generally, under conditions of adequate moisture and fertility, dry matter yields increase rapidly from the jointing through the milk stages. From the milk stage through the dough stage, dry matter yield tends to increase only slightly (Polan et al., 1968) or may decrease (Miller et al., 1967) depending upon the particular variety and climatic conditions.

In most instances dry matter digestibility decreases with increasing plant maturity. Cannell et al., (1968) reported an average digestibility of 70% for the early-boot stage decreasing to 59% for the dough stage in wheat, barley or oat silages. Swift et al., (1968) found that dry matter digestibility decreased from 70.0 to 58.8% for barley and 75.9 to 50.1% for oats as maturity increased from early-boot to late dough. Polan et al., (1968) reported that barley in the boot, milk and dough stages had dry matter digestibilities of 67.8, 67.9, and 64.2%, respectively. No explanation was given for the slight increase in digestibility from the boot to the milk stage. However, it has been shown that in high-grain yielding cereals, dry matter digestibility may increase from the milk to dough stage (Meyer et al., 1957).

Crude protein content decreases rapidly from the jointing through the boot stages, but changes little from the milk to the dough stages (Meyer et al., 1957, Lawes et al., 1971 and Swift et al., 1967). Increased nitrogen fertilization has little affect on crude protein content but does increase dry matter yields at moderate levels of application (Lawes et al., 1971). Lower crude protein digestibility has been observed as plants become more mature (Meyer et al., 1957).

Crude fiber tends to increase from jointing through the boot stages and decreases as grain formation begins. Polan et al., (1968) reported crude fiber levels of 32.1, 31.1 and 27.8% in barley boot, milk and dough stages, respectively. Barley crude fiber content declined from 31.3 to 19.5% from the early-boot to the late-dough stages but increased to 25.4% when the grain was fully mature (Edwards et al., 1965). Other workers have reported higher crude fiber values. Fisher et al., (1972) reported crude fiber values of 34.1, 29.2, and 25.0% for whole-plant barley in the milk, soft-dough and firm-dough stages, respectively.

Higher nitrogen-free extract (NFE) values have been observed as cereal grains mature. NFE increased steadily from 49.0% in the early-boot stage to 69.5% in the dough stage for barley (Edwards et al., 1968).

Lignin content increases linearly up to the milk stage in oats, followed by a decrease as the plant further matures (Meyer et al., 1957). Norman et al., (1933) noted the same trends with barley and concluded that grain formation was responsible for the decrease in lignin.

In order to make high quality, palatable cereal grain silage, the forage should be within the range of 30 to 50% dry matter to insure a desirable fermentation. Boot stage cereal grain forage is often less than 20 to 25% dry matter and must be wilted prior to ensiling. Most milk and dough stage cereal grain forage can be direct-cut and ensiled satisfactorily (Marty et al., 1958).

Dry Matter Yield of Cereal Grain Silages

Dry matter yields of cereal grains harvested for silage are influenced by stage of maturity, climate conditions, fertility, variety and cereal specie. Limited data have been reported in the literature and these data are quite variable due to the many factors that can affect dry matter yield.

Miller et al., (1967) reported yields for barley in the boot, milk and dough stages of 8,438; 11,231 and 9,165 kg dry matter per hectare, respectively. Yield of dry matter (metric tons/hectare) was 10.0, 11.0 and 11.5 for wheat, oats and barley, respectively, when harvested in early-dough stage with 75 kg nitrogen fertilizer per hectare (Lawes et al., 1970). In the same study, a 40 to 50% reduction in yield was reported when no nitrogen was applied.

Harvesting cereal grains for whole-plant silage will give a higher yield of dry matter per acre compared to harvesting only the grain. Krall et al., (1971) harvested barley as dough stage head silages, high-moisture grain and dry grain and reported digestible dry matter yields (lbs./acre) of 2771.9, 2478.5 and 1734.5, respectively.

EXPERIMENTAL PROCEDURE AND RESULTS

Limited information is available about feeding wheat grain or forage in beef cattle rations. Wheat, fed in combination with other feed grains, results in increased feed efficiency and feed intake; particularly, if it is less than one-half the total ration. Beef finishing rations containing wheat as the only grain are not recommended. An alternative to feeding wheat as grain would be to feed the whole wheat plant as hay or silage. Limited research has been done utilizing whole-plant cereal grain silages in beef cattle rations. The primary objective of this research was to study the feeding value of wheat and barley silages in rations for beef cattle and lambs.

Data showing the effect that stage of maturity at harvest has on the feeding value of cereal grain silages are inconsistent. As wheat and barley plants mature from boot through dough stages, dry matter and NFE contents increase while protein and crude fiber contents decrease. The greatest dry matter yield occurs in the milk or dough stages. A second objective of this research was to study the effect that stage of maturity has on digestibility and voluntary intake of wheat and barley silages.

Research and practical experiences of cattlemen have shown a difference in the feeding value of hard and soft kernel red-winter wheats when fed at high levels in beef cattle rations. A third objective of this research was to determine if this same trend exists when these two types of wheat were harvested and fed as silage.

Research indicates that wheat is more rapidly fermented in the rumen than other feed grains. Theoretically, this should improve the utilization of non-protein nitrogen in wheat rations. A fourth objective of this research was to compare performance of lambs fed sorghum or wheat silages supplemented with either soybean meal or urea.

Statistical analyses of the data were by analysis of variance as described by Steele and Torrie (1960). When statistical significance occurred, Duncan's Multiple Range Test as described by Steele and Torrie (1960) was used to determine differences between treatment means. Analysis of variance tables for all data appear in the Appendix.

Experiment I - Steer Growth Trial

Objectives of this trial were: (1) to compare the feeding value of wheat and barley silages supplemented with soybean meal to corn silage supplemented with either soybean meal or urea; (2) to compare the feeding value of an awned, hard red-winter wheat (Parker) and an awnless, soft red-winter wheat (Arthur) silages; (3) to determine the relative feeding value of Parker whole-plant silage to Parker-head silage and (4) to evaluate a mixture containing equal parts of Parker-head and corn silages.

Cereal grain forages were harvested in the dough stage between June 1 and June 12, 1973 in the following order: Paoli barley, Arthur wheat and Parker wheat. All forages were direct-cut with a self-propelled forage harvester equipped with a 3.7 m cutterbar and a 5.06 cm recutter screen. Whole-plant forages were cut as near to the soil as possible leaving 7 to 10 cm of stubble. The upper one-half of the wheat plant was harvested for Parker-head silage. Lodging in the Paoli barley was the only problem encountered in harvesting any of the forages. Approximately 23 metric tons of each cereal grain forage were ensiled in upright, concrete stave silos (3.1 x 15.2 m). The whole corn plant was harvested in the dent stage from corn yielding approximately 6288 kg of grain per hectare and ensiled in an upright, concrete, stave silo.

One hundred twenty-six Hereford, Angus and mixed-breed steers averaging 266.4 kg were randomly alloted by weight and breed to each of the seven experimental rations. There were three pens of six steers per treatment.

The seven silage and supplement treatments compared were: (1) Paoli barley, (2) Arthur wheat, (3) Parker wheat, (4) Parker-head wheat, (5) Parker-head wheat and corn silage (equal parts, dry matter basis), (6) corn silage plus soybean meal and (7) corn silage plus urea. Treatments 1 to 5 contained soybean meal supplements. The complete mixed, fixed percentage rations were 86% silage and 14% supplement (table 1) on a dry matter basis and all formulated to contain 12.5% protein. Silage and supplement combinations are shown in table 1. Steers were fed twice daily and had water available free-choice. Samples of each silage were taken weekly for dry matter determination. When a silage dry matter changed by more than one percentage unit, adjustments were made in amounts of silage and supplement fed.

The trial began October 10, 1973 and lasted 100 days. Initial and final weights of the steers were taken after 15 hrs without feed or water. Intermediate weights were taken every 42 days.

Weekly samples of each silage were composited, mixed and subsampled. Aliquots were dried at 13^{o}C and ground with a Wiley Mill to pass through a 40 mesh screen. Proximate analyses (A.O.A.C., 1970), volatile fatty acid and lactic acid (Parks, 1970) and neutral detergent fiber (NDF) and acid detergent fiber (ADF), Goering (1970) were determined for each silage.

Results of the silage analyses are shown in table 2.

Steer performance data is presented in table 3. Steers receiving Paoli barley, Parker-head wheat plus corn silage, corn silage plus soybean meal and corn silage plus urea rations had similar performance. Daily gain and dry matter intake were lowest ($P<.05$) for steers fed whole-plant Parker and Parker-head silage rations. Steers fed whole-plant Parker silage were less efficient ($P<.05$) than those fed Paoli barley, Arthur wheat, Parker-head wheat plus corn silage and corn silage plus soybean meal rations.

Table 1. COMPOSITION OF SUPPLEMENTS AND SILAGE AND SUPPLEMENT COMBINATIONS FED IN EXPERIMENT I.

	Supplement			
Ingredients	A	B	C	D
	%, Dry matter basis			
Soybean meal	38.21	82.83	---	62.74
Urea	---	---	12.12	---
Milo	53.37	11.24	76.24	30.17
Fat	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.19	1.92	8.09	1.72
Limestone	3.68	0.46	---	1.85
Salt[1]	2.14	2.14	2.14	2.14
Trace minerals	.05	.05	.05	.05
Vitamin A[2]	.09	.09	.09	.09
Aureomycin[3]	.27	.27	.27	.27

[1]Formulated to be 0.3% of the total ration.

[2]Formulated to provide 30,000 IU/head/day.

[3]Formulated to provide 70 mg/head/day.

Silage treatment	Supplement
1. Paoli barley	A
2. Arthur wheat	B
3. Parker wheat	B
4. Parker-head wheat	A
5. Parker-head wheat + corn silage	D
6. Corn silage + soybean meal	B
7. Corn silage + urea	C

Table 2. ANALYSES OF SILAGES FED IN EXPERIMENT I.

Item	Paoli barley	Arthur wheat	Parker wheat	Parker-head wheat	Corn silage
Dry matter, %	32.9	36.9	34.6	41.2	40.9
	%, Dry matter basis				
Crude protein	9.5	7.5	7.4	9.9	8.3
Crude fiber	23.1	26.5	30.8	21.3	19.4
Ether extract	2.5	2.4	2.1	2.6	2.7
NFE	55.7	54.7	51.7	59.1	63.0
NDF	47.03	48.84	57.35	50.15	45.53
ADF	50.06	52.95	62.34	44.58	42.91
Acetate, molar %	2.11	1.35	1.04	.90	1.12
Propionate, molar %	.17	.17	.19	.18	.15
Butyrate, molar %	.36	.21	.13	.20	.27
Lactate, % of the dry matter	6.10	3.86	4.61	4.79	2.14

Table 3. EFFECT OF SOURCES OF SILAGE AND SUPPLEMENTAL NITROGEN ON STEER PERFORMANCE IN EXPERIMENT I.

	Silage and supplement treatments						
						Corn silage +	
	Paoli barley	Arthur wheat	Parker wheat	Parker-head wheat	Parker-head + corn silage	soybean meal	urea
No. of steers	18	18	18	18	18	18	18
Initial wt, kg	263.7	266.0	263.5	269.8	265.3	270.5	265.7
Final wt, kg	367.2	361.0	333.7	349.2	366.3	382.9	369.5
Avg daily gain, kg	$1.04^{a,b}$	$.95^{b}$	$.70^{c}$	$.79^{c}$	$1.01^{a,b}$	1.12^{a}	$1.04^{a,b}$
Avg daily feed, kg[2]	7.90^{a}	7.90^{a}	6.68^{b}	6.70^{b}	8.19^{a}	8.47^{a}	8.66^{a}
Feed/kg gain, kg[2]	7.60^{a}	8.32^{a}	9.54^{b}	$8.48^{a,b}$	8.11^{a}	7.56^{a}	$8.33^{a,b}$
Intake, % body wt	2.50	2.52	2.24	2.17	2.59	2.59	2.73

[1]October 10, 1973 to January 18, 1974 (100 days).

[2]100% dry matter basis.

[a,b,c]Means on the same line with different superscripts differ significantly ($P<.05$).

Statistical analyses of the data appears in Appendix table 1.

Experiment II - Lamb Growth Trial

One objective of this trial was to determine the effect of stage of maturity at harvest on performance of lambs fed wheat silage. Parker wheat was ensiled in the boot, milk, and dough stages. A second objective was to compare the feeding value of Parker wheat, Arthur wheat and Paoli barley harvested for silage in the dough stage.

All forages were harvested as previously described in Experiment I, except Parker boot was swathed and allowed to field-wilt to approximately 70% moisture before ensiling. All forages were ensiled in 208 l drums lined with polyethlene plastic and tied-off at the top. Parker boot, milk and dough silages were harvested May 12, May 30 and June 11, 1973, respectively; Paoli dough, June 1, 1973, and Arthur dough, June 12, 1973.

Forty-five crossbred wether and ewe lambs weighing 24.2 kg were randomly assigned to one of the five rations according to weight, breed and sex. There were nine lambs per treatment in three pens of three lambs each.

All rations contained 86% of the appropriate silage and 14% supplement on a dry matter basis and all were formulated to contain 12.5% crude protein and equal amounts of vitamins, minerals and additives. Composition of the supplements is shown in table 4. Supplement A was fed with Parker boot silage; supplement B, with Parker milk and Paoli dough silages and supplement C, with Arthur and Parker dough silages. Water was available free-choice. Silage and supplement samples were collected weekly and frozen for analyses.

Table 4. COMPOSITION OF SUPPLEMENTS FED IN EXPERIMENT II.

Ingredients	Supplement A	Supplement B	Supplement C
	%, Dry matter basis		
Soybean meal	28.24	86.44	67.71
Milo	57.30	---	18.58
Dicalcium phosphate	3.25	1.95	2.40
Limestone	3.50	3.90	3.60
Salt[1]	1.80	1.80	1.80
Molasses	5.00	5.00	5.00
Trace minerals	.10	.10	.10
Aureomycin[2]	.72	.72	.72
Vitamin A[3]	.08	.08	.08
Vitamin D[4]	+	+	+
Vitamin E[5]	+	+	+

[1]Formulated to be .25% of the total ration.

[2]Formulated to provide 20 mg of aureomycin/head/day.

[3]Formulated to provide 3,000 IU/head/day.

[4]Formulated to provide 300 IU/head/day.

[5]Formulated to provide 20 IU/head/day.

The trial started October 17, 1973 and ended December 4, 1973 (48 days). Initial and final weights of the lambs were taken after 15 hrs without feed or water. Intermediate weights were taken every 21 days to follow the progress of the lambs.

Table 5 shows the chemical analyses of the five silages.

Table 6 shows lamb performance. Lambs receiving Parker milk and Parker dough rations gained slower and less efficiently ($P<.05$) than lambs fed any of the other three silage rations. Lambs fed Arthur dough silage gained faster and were more efficient ($P<.05$) than those fed Parker boot silage. Feed intake was lower ($P<.05$) for lambs fed the Parker milk silage ration than for those fed Parker boot, Arthur dough or Paoli dough silage rations.

Statistical analyses of the data appear in Appendix table 2.

Experiment III - Lamb Finishing Trial

The objective of this trial was to compare the performance of lambs fed forage sorghum or Arthur dough silages supplemented with either soybean meal or urea. Forty-eight crossbred wether lambs averaging 34.2 kg were randomly alloted by weight to one of the four experimental rations in a two x two factorial design. There were 12 lambs per treatment in three pens of four lambs each.

Forage sorghum was of the high-grain type, harvested in the dent stage and ensiled in an upright concrete stave silo (3.7 x 17.4 m). Arthur dough silage was the same as that described in experiment I.

The trial was divided into two phases. In phase I rations contained 60% silage, 26% milo and 14% supplement (dry matter basis). Rations during phase II were 40% silage, 46% milo and 14% supplement (dry matter basis). All rations were formulated to contain 12.5% crude protein and all

Table 5. ANALYSES OF SILAGES FED IN EXPERIMENT II.

Item	Parker boot	Parker milk	Parker dough	Paoli dough	Arthur dough
Dry matter, %	29.41	27.16	34.10	30.68	36.66
	%, Dry matter basis				
Crude protein	12.42	9.60	7.77	9.35	7.79
Crude fiber	32.99	32.79	30.08	23.29	25.81
Ether extract	2.80	2.57	2.29	2.70	2.38
NFE	37.42	46.59	51.80	55.95	55.63
Ash	14.37	8.45	8.06	8.71	8.39

Table 6. EFFECT OF SILAGE TREATMENT ON LAMB PERFORMANCE IN EXPERIMENT II[1].

Item	Parker boot	Parker milk	Parker dough	Paoli dough	Arthur dough
No. of lambs	9	9	9	9	9
Initial wt, kg	27.0	27.5	27.0	26.8	28.3
Final wt, kg	29.6	27.7	28.2	30.3	32.8
Avg daily gain, kg	.054[c]	.002[a]	.025[a]	.073[b,c]	.092[b]
Avg daily feed, kg[2]	.736[b]	.460[a]	.617[a,b]	.794[b]	.862[b]
Gain/kg feed, kg[2]	.071[c]	.003[a]	.039[b]	.1068[d]	.092[c,d]
Intake, % body wt[2]	2.60	1.69	2.24	2.78	2.82

[1]October 17, 1973 to December 4, 1973 (48 days).

[2]100% dry matter basis.

[a,b,c,d]Means on the same line with different superscripts differ significantly (P<.05).

were equal in vitamins, minerals and additives. Composition of the supplements is shown in table 7. Water was available free-choice. Ration components were sampled weekly and frozen for analyses.

Phase I was 25 days (January 17, to February 10, 1974); phase II, 29 days (February 11, to March 12, 1974). Initial weights of the lambs were taken after 15 hrs without feed or water; 25-day weights were calculated using a 4% shrink and final weights were calculated by dividing the hot carcass weight by the average dressing percentage.

Chemical analyses of the silages and milo are shown in table 8.

Performance of the lambs is shown in tables 9 and 10. Results during the two phases was nearly identical and are averaged for presentation.

Lambs fed forage sorghum silage plus urea gained slower ($P<.05$) and required more feed per gain ($P<.05$) than lambs fed the other three rations (table 9). Lambs receiving Arthur dough silage were more efficient ($P<.05$) than those receiving forage sorghum silage (table 10). Rations supplemented with soybean meal supported faster and more efficient gains ($P<.05$) than those supplemented with urea.

Statistical analyses of these data appear in Appendix table 3.

Experiment IV - Lamb Voluntary Intake and Metabolism Study

The objectives of this study were to determine the effects of stage of maturity at harvest and type of cereal grain silage on voluntary intake, digestibility, nitrogen retention and rumen fermentation in growing lambs. The nine silages compared in the three x three factorial experiment were: Paoli barley, Arthur and Parker wheats; each harvested in the boot, milk and dough stages. All silages were harvested and stored as described in Experiments I and II.

Table 7. COMPOSITION OF SUPPLEMENTS FED IN EXPERIMENT III.

Ingredients	Supplement: Soybean meal	Supplement: Urea
	%, Dry matter basis	
Soybean meal	78.71	--
Milo	--	65.69
Alfalfa meal	7.50	7.50
Urea	--	11.63
Molasses	5.00	5.00
Dicalcium phosphate	2.30	4.80
Limestone	3.94	2.8
Salt[1]	1.80	1.80
Trace minerals	.08	.08
Aureomycin[2]	.57	.57
Vitamin A[3]	+	+
Vitamin D[4]	+	+
Vitamin E[5]	+	+

[1]Formulated to be .25% of the total ration.

[2]Formulated to provide 20 mg aureomycin/head/day.

[3]Formulated to provide 3,000 IU/head/day.

[4]Formulated to provide 300 IU/head/day.

[5]Formulated to provide 20 IU/head/day.

Table 8. ANALYSES OF SILAGES AND MILO FED IN EXPERIMENT III.

	Silage		
	Forage sorghum	Arthur dough	Milo
Dry matter, %	28.81	38.32	84.46
	%, Dry matter basis		
Crude protein	7.46	8.08	10.22
Crude fiber	23.87	25.97	2.05
Ether extract	2.29	1.87	1.87
NFE	58.53	54.72	83.43
Ash	7.85	9.36	1.77

Table 9. EFFECT OF SOURCES OF SILAGE AND SUPPLEMENTAL NITROGEN ON LAMB PERFORMANCE IN EXPERIMENT III.[1]

	Forage sorghum		Arthur dough	
Item	Soybean meal	Urea	Soybean meal	Urea
No. of lambs	12	12	12	12
Initial wt, kg	34.1	33.9	34.2	34.1
Final wt, kg	44.7	39.6	44.3	42.5
Avg daily gain, kg	.193[a]	.105[b]	.186[a]	.161[a]
Avg daily feed, kg[2]	1.21[a]	1.06[b]	1.25[a]	1.15[a,b]
Feed/kg gain, kg[2]	6.31[a]	10.30[b]	6.75[a]	7.21[a]
Intake, % body wt	3.08	2.88	3.18	3.00

[1]January 17, 1974 to March 12, 1974 (54 days).

[2]100% dry matter basis.

[a,b]Means on the same line with different superscripts differ significantly (P<.05).

Table 10. EFFECTS OF SOURCE OF SILAGE AND SOURCE OF SUPPLEMENTAL NITROGEN ON LAMB PERFORMANCE IN EXPERIMENT III (continued).

	Silage		Supplemental nitrogen	
Item	Forage Sorghum	Arthur Dough	Soybean Meal	Urea
No. of lambs	24	24	24	24
Initial wt, kg	34.00	34.15	34.15	34.00
Final wt, kg	41.10	44.50	43.40	42.15
Avg daily gain, kg	.149[a]	.174[b]	.190	.133
Avg daily feed, kg[1]	1.14	1.20	1.23	1.11
Feed/kg gain, kg[1]	8.31[a]	6.98[b]	6.53[x]	8.76[y]
Intake, % body wt[1]	2.98	3.09	3.13	2.94

[1]100% dry matter basis.

[a,b]For forage sorghum versus Arthur dough comparisons. Means on the same line with different superscripts differ significantly (P<.05).

[x,y]For soybean meal versus urea comparisons. Means on the same line with different superscripts differ significantly (P<.05).

Twenty-seven crossbred wether lambs weighing 34.4 kg were randomly assigned to the nine silages (three lambs/silage). The trial consisted of two consecutive 8-day pre-feeding, 5-day voluntary intake, 2-day ration adjustment, and 6-day collection periods. All lambs received approximately 600 g of dry matt daily of the appropriate ration during the collection periods. All rations were iso-nitrogenous (12.5% crude protein); contained 86% silage and 14% soybean meal supplement (dry matter basis) and were mixed and fed twice daily.

Lambs were fed in metal digestion crates designed for separation of feces and urine and fitted with a canvas harness equipped with a fecal collection bag. Lambs were shorn prior to start of the trial to limit wool contamination of the urine and feces. Daily fecal collections were weighed and a 10% aliquot sample frozen. Crates were equipped with stainless steel trays to direct the urine into plastic buckets containing 50 ml of 50% HCl to maintain acidity. Urine collections were diluted with water to the next highest 1 and a 10% aliquot sample was taken and stored in glass bottles. At the end of each 6-day collection period, feces and urine were each composited, mixed, subsampled and frozen for laboratory analyses.

Approximately 200 g of feces from each period was placed in aluminum pans and dried in a forced-air oven at 13°C for 48 hours. Feces were then ground in Wiley mill, using a 40 mesh screen, prior to proximate analyses. Ration components were sampled daily, composited and aliquots prepared the same as feces for laboratory analyses. Feces, feed and urine samples were analyzed for nitrogen by the Kjeldahl method as outlined by A.O.A.C. (1965). Dry matter determination on both feces and feed was according to A.O.A.C. (1960).

Rumen fluid samples were taken from each lamb following the last day of collection in both periods using a stomach tube and suction strainer as described by Raun and Burroughs (1962). Samples were taken at 1, 3 and 6 hrs after feeding. Lambs were fed at intervals so that they could be sampled in succession to maintain the desired length of time post-feeding. The initial 15 to 20 ml of rumen fluid was discarded to flush the tube and avoid saliva contamination. A 30 ml sample was drawn and deposited into a plastic bag and its pH determined using a Beckman pH meter. The strainer, suction tube and syringe were washed between each collection. One ml of 5% mercuric chloride was added to the sample to stop microbial activity. Samples were frozen and later analyzed for volatile fatty acids. Lactic acid determinations were made using the colorimetric technique of Barker and Summerson (1941).

In final preparation for analyses, rumen fluid samples were thawed and centrifuged at 42,000 g for 10 minutes. Ten parts of the supernatant was mixed with one part of 50% sulphuric acid and allowed to stand at room temperature for 10 minutes. After a second centrifugation, the supernatant was collected and used for analyses.

Gas chromatographic analysis was used to seperate volatile fatty acids as described by Parks (1970). Voltaile fatty acids were separated on 183.0 cm x 3.18 cm stainless steel column packed with 60-80 chromosorb 101, using a flash vaporization inlet, hydrogen flame detection and an oven temperature 109° (isothermal). The carrier gas was nitrogen.

Volatile fatty acid and lactic acid analyses were run on the nine silages. One-hundred grams of as-fed moisture silage was mixed with 250 ml of 0.1 N H_2SO_4 and allowed to set overnight. The liquid was decanted and strained through cheese cloth. Analyses were with a gas chromatograph using the same technique as described above.

Chemical analyses of the nine silages are shown in tables 11 and 12.

Both type of cereal grain silage and stage of maturity significantly affected voluntary intake (table 13). Lambs fed the Parker silages consumed less ($P<.01$) dry matter than those fed Arthur or Paoli silages. Arthur silage

Table 11. PROXIMATE AND VAN SOEST ANALYSES OF SILAGES FED IN EXPERIMENT IV.[1]

Silage	Dry matter,%	Ash	Crude protein	Crude fiber	Ether extract	NFE	CWC	ADF	Lignin	Cellulose
		%, Dry matter basis								
Arthur boot	32.9	13.88	11.65	32.39	2.13	39.95	60.8	68.3	6.7	53.3
Arthur milk	26.9	9.53	9.55	32.58	2.02	46.32	61.6	65.4	9.1	51.5
Arthur dough	36.0	8.55	8.05	28.88	2.41	52.11	54.1	55.8	6.6	43.9
Parker boot	28.7	14.39	12.08	33.48	2.16	37.89	64.8	70.5	9.4	54.9
Parker milk	27.4	8.89	9.73	35.12	2.02	44.24	63.4	68.1	7.4	57.0
Parker dough	33.5	8.15	8.02	32.29	1.97	49.57	61.4	62.2	6.2	51.6
Paoli boot	27.0	15.59	11.57	33.84	2.71	36.29	64.9	70.7	7.3	57.3
Paoli milk	25.3	12.10	10.05	33.16	2.08	42.61	61.6	66.0	5.9	54.6
Paoli dough	30.3	8.49	8.98	24.51	1.92	56.10	50.5	51.2	7.3	39.5

[1]Average for periods one and two.

Table 12. VFA AND LACTIC ACID ANALYSES OF SILAGES FED IN EXPERIMENT IV.[1]

	C_2	C_3	C_4	Lactate
	Molar %			% of the dry matter
Arthur boot	1.71	.16	.52	7.64
Arthur milk	1.93	.22	.14	9.16
Arthur dough	1.03	.18	.07	5.72
Parker boot	3.55	.66	.15	5.27
Parker milk	2.36	.11	.19	9.40
Parker dough	1.23	.16	.04	6.02
Paoli boot	3.00	.43	2.34	2.92
Paoli milk	2.55	.24	.56	9.50
Paoli dough	1.43	.19	.09	7.88

[1]Average for periods one and two.

Table 13. VOLUNTARY INTAKE AND DIGESTIBILITY IN LAMBS FED THREE TYPES OF SILAGE HARVESTED AT THREE STAGES (Expt. IV).[1]

Item	Voluntary intake[3]	Dry matter intake, g/day[4]	Digestion coefficient		
			Dry matter	Crude fiber	Crude protein
				%	
Silage Treatment[2]					
Arthur boot	$51.1^{d,f}$	582.5	60.4^{a}	$66.7^{c,d}$	$68.3^{b,c,d}$
Arthur milk	$47.8^{c,d}$	566.4	60.0^{a}	58.6^{b}	$66.7^{a,b,c}$
Arthur dough	55.5^{f}	588.3	61.1^{a}	50.6^{a}	$71.8^{d,e}$
Parker boot	$48.3^{c,d,e}$	585.3	61.3^{a}	69.0^{d}	$66.2^{a,b}$
Parker milk	36.6^{a}	445.4	61.5^{b}	64.0^{c}	64.3^{a}
Parker dough	$44.6^{b,c}$	557.4	60.3^{a}	56.2^{b}	$70.5^{d,e}$
Paoli boot	$46.4^{b,c,d}$	582.8	$62.5^{b,c}$	68.4^{d}	$68.0^{b,c}$
Paoli milk	41.9^{b}	569.5	59.4^{a}	57.7^{b}	$69.9^{c,d,e}$
Paoli dough	$53.7^{e,f}$	597.8	63.7^{c}	49.7^{a}	$65.2^{a,b}$
Type of Silage[5]					
Arthur	51.6^{m}	579.1	60.5^{m}	58.6^{m}	68.9^{m}
Parker	43.2^{n}	529.4	61.0^{n}	63.1^{n}	67.0^{m}
Paoli	47.3^{o}	583.4	61.8^{n}	58.6^{m}	67.8^{m}
Stage of Maturity[5]					
Boot	48.6^{x}	583.5	61.4^{x}	68.0^{x}	67.5^{x}
Milk	42.1^{y}	527.1	60.3^{y}	60.1^{y}	66.9^{x}
Dough	51.4^{x}	581.2	61.7^{x}	52.2^{z}	69.2^{y}

[1] Average for periods one and two.

[2] Six observations per treatment mean.

[3] g dry matter/kg body wt$^{0.75}$ per day.

[4] Mean dry matter intake during collection periods.

[5] Eighteen observations per treatment mean.

[a,b,c,d,e,f] Means in the same column with different superscripts differ significantly ($P<.05$).

[m,n,o] Means in the same column with different superscripts differ significantly ($P<.05$).

[x,y,z] Means in the same column with different superscripts differ significantly ($P<.05$).

was consumed in larger ($P<.05$) quantities than Paoli silage. Lambs fed boot or dough silages consumed more ($P<.01$) dry matter than those fed milk silage. Type of cereal grain silage by stage of maturity interaction influenced ($P<.05$) voluntary intake. Less ($P<.05$) Parker milk silage was consumed than any of the other eight silages. Voluntary intakes of Arthur and Paoli dough silages were not significantly different, but Arthur dough was consumed in larger ($P<.05$) amounts than any of the other seven silages. Lambs tended to consume more dough silage than boot silage, but this difference was not significant ($P<.05$). Other significant differences in voluntary intake are indicated in table 13.

Dry matter digestibility was affected by type of silage, stage of maturity and their interaction at ($P<.05$) (table 13). Paoli and Parker silages had higher ($P<.05$) dry matter digestibilities than Arthur silages. Milk stage silages had a lower ($P<.05$) dry matter digestibility than boot or dough silages. Paoli boot, Paoli dough and Parker milk silage dry matter was more ($P<.05$) digestible than any of the six other silage dry matters. A significant ($P<.05$) period effect was also observed.

Type of cereal grain silage and stage of maturity significantly affected crude fiber digestion coefficients (table 13). Parker silages had higher ($P<.05$) crude fiber digestibilities than Arthur or Paoli silages. Crude fiber digestibility decreased ($P<.01$) as stage of maturity increased. Arthur and Paoli dough silages had the lowest ($P<.05$) crude fiber digestibilities.

Crude protein digestibility was affected by stage of maturity, but not by type of cereal grain silage (table 13). A type of silage by stage of maturity interaction was significant ($P<.05$). Dough silages tended to have a higher crude protein digestibility followed, in decreasing order, by milk and boot silages. Arthur and Parker dough silages crude protein

Table 14. NITROGEN INTAKE AND RETENTION IN LAMBS FED THREE TYPES OF SILAGE HARVESTED AT THREE STAGES (Expt. IV).[1]

Item	N intake, g/day	N retained, g/day	N retained, % of N consumed/day
Silage Treatment[2]			
Arthur boot	12.3	1.53[b,c]	12.4[b]
Arthur milk	10.3	1.13[b,c]	10.8[b]
Arthur dough	12.4	2.32[c,d]	18.6[c]
Parker boot	11.7	.55[b]	4.6[a,b]
Parker milk	8.3	.85[b]	8.7[b]
Parker dough	11.9	2.95[d]	25.0[c]
Paoli boot	12.3	.65[a]	-5.3[a]
Paoli milk	11.7	2.00[b,c,d]	17.2[c]
Paoli dough	10.3	1.60[b,c]	15.5[b,c]
Type of Silage[3]			
Arthur	11.7	1.66	14.0
Parker	10.6	1.45	12.8
Paoli	11.4	.98	9.1
Stage of Maturity[3]			
Boot	12.1	.47[x]	3.9[x]
Milk	10.1	1.33[y]	12.2[y]
Dough	11.5	2.29[z]	19.7[z]

[1]Average for periods one and two.

[2]Six observations per treatment mean.

[3]Eighteen observations per treatment mean.

[a,b,c,d]Means in the same column with different superscripts differ significantly ($P<.05$).

[x,y,z]Means in the same column with different superscripts differ significantly ($P<.05$).

digestibilities were higher ($P<.05$) than those of Parker milk, Paoli dough, Parker boot, and Arthur milk silages. Other significant differences in crude protein digestibilities are indicated in table 13. A significant ($P<.05$) period affect was also observed.

Variation in nitrogen intake between lambs fed the nine silage rations was observed (table 14). Feed refusals accounted for most of this variation. Nitrogen balance was affected ($P<.05$) by stage of maturity and by the type of silage by stage of maturity interaction. An increase ($P<.05$) in g nitrogen retained was observed with each increase in stage of maturity. Paoli boot was the only silage that resulted in a negative nitrogen balance. Other significant differences are indicated in table 14. Percent nitrogen retained followed a similar trend as g of nitrogen retained.

Rumen fermentation data are presented in tables 15, 16 and 17.

Rumen fluid pH values are affected ($P<.01$) by type of silage, stage of maturity, sampling time, type of silage by stage interaction, type of silage by hr interaction, stage by hr interaction and type of silage by stage by hr interaction (table 15). Lambs fed Arthur wheat and dough stage silages had the lowest ($P<.05$) pH (table 16). pH values were lowest at hr 1, and highest at hr 6 ($P<.01$). Lambs receiving Paoli and Arthur dough silages had lower ($P<.05$) pH values than those fed any of the other seven silages (table 17). All silages tended to produce the highest pH values at hr 6, although not significant at $P<.05$.

Total volatile fatty acid (VFA) concentrations were not affected by type of silage, but were affected ($P<.01$) by stage of maturity and sampling time (table 16). Lambs fed milk silages had lower ($P<.05$) total VFA's than lambs fed boot or dough silages. Rumen samples taken 1 hr after feeding were higher ($P<.05$) in total VFA's than those taken at 3 or 6 hrs after feeding.

Table 15. RUMEN FERMENTATION PATTERNS FOR HOURS ONE, THREE AND SIX FOR LAMBS FED NINE SILAGE TREATMENTS (Expt. IV).[1]

Hr after feeding	pH	Total VFA u moles/ml	Molar percent VFA C_2	C_3	C_4	Lactate u moles/ml
			Arthur boot			
1	6.73	95.7	54.2	28.3	9.9	324.7
3	6.89	65.3	61.2	22.0	10.4	108.2
6	6.94	65.3	60.4	21.7	10.2	74.0
			Arthur milk			
1	6.66	88.3	49.8	30.5	13.1	495.0
3	6.90	58.2	54.6	23.9	13.0	92.8
6	7.07	59.8	54.4	23.9	14.3	76.5
			Arthur dough			
1	6.60	98.3	51.2	27.9	14.2	611.8
3	6.72	73.6	56.8	21.2	14.4	107.3
6	6.90	78.9	56.6	20.8	15.2	87.2
			Parker boot			
1	6.94	94.3	62.3	23.2	6.5	78.8
3	7.02	60.9	63.1	20.7	8.7	328.0
6	6.97	74.0	62.5	20.1	8.5	76.0
			Parker milk			
1	6.86	78.1	55.2	28.4	12.4	85.8
3	6.92	55.4	59.6	22.6	10.7	80.0
6	7.00	60.3	57.8	23.8	10.5	82.3
			Parker dough			
1	6.79	91.9	53.1	26.6	11.0	102.5
3	6.87	63.7	59.0	21.7	11.3	100.0
6	6.93	67.1	58.7	21.1	11.5	65.0
			Paoli boot			
1	7.12	84.6	53.4	18.5	14.4	61.2
3	7.09	64.5	59.6	17.3	13.4	78.0
6	6.93	66.4	62.2	16.7	11.8	76.7
			Paoli milk			
1	6.86	70.7	50.3	26.6	12.3	161.4
3	70.3	53.4	59.1	22.3	11.9	86.3
6	71.3	60.5	57.1	21.8	12.1	197
			Paoli dough			
1	6.37	85.6	47.5	27.2	17.6	1440.7
3	6.67	76.0	51.7	22.8	18.2	145.0
6	6.80	80.9	52.2	23.8	17.2	94.5

[1]Six observations per treatment mean.

Table 16. EFFECT OF TYPE OF SILAGE, STAGE OF MATURITY AND SAMPLING TIME ON RUMEN FERMENTATION PATTERNS IN LAMBS (Expt. IV).[1]

Item	pH	Total VFA u moles/ml	Molar percent VFA C_2	C_3	C_4	Lactate u moles/ml
			Type of silage			
Arthur wheat	6.82	75.9	55.5	24.5	12.7	219.7
Parker wheat	6.92	71.7	59.1	23.1	10.1	111.0
Paoli barley	6.89	71.4	55.2	21.9	14.3	260.0
			Stage of maturity			
Boot	6.96	74.6	59.9	20.9	10.4	134.0
Milk	6.94	65.0	55.3	24.9	12.3	150.8
Dough	6.74	79.5	54.1	23.7	14.5	306.0
			Sampling time			
Hr 1	6.77	87.5	53.5	26.3	12.4	373.6
Hr 3	6.90	63.4	58.3	21.6	12.5	125.2
Hr 6	6.96	68.1	58.0	21.5	12.4	92.1

[1]Fifty-four observations per treatment mean.

Table 17. EFFECT OF TYPE OF SILAGE AND STAGE OF MATURITY ON RUMEN FERMENTATION PATTERNS IN LAMBS (Expt. IV).[1]

Silage	pH	Total VFA u moles/ml	Molar percent VFA C_2	C_3	C_4	Lactate u moles/ml
Arthur boot	6.86^{c}	75.4	$58.6^{e,f}$	24.0^{c}	10.2^{b}	$168.9^{a,b}$
Arthur milk	6.88^{c}	68.8	52.9^{b}	26.1^{d}	$13.5^{d,e}$	$221.4^{a,b}$
Arthur dough	6.74^{b}	83.6	$54.9^{b,c}$	23.3^{c}	14.6^{e}	268.8^{b}
Parker boot	6.98^{d}	76.4	62.6^{g}	21.3^{b}	7.9^{a}	$160.9^{a,b}$
Parker milk	6.92^{c}	64.6	$57.5^{d,e}$	$24.9^{c,d}$	$11.2^{b,c}$	83.0^{a}
Parker dough	6.87^{c}	74.2	$57.0^{c,d,e}$	23.2^{c}	$11.3^{b,c}$	89.2^{a}
Paoli boot	7.04^{d}	71.8	59.7^{f}	17.5^{a}	$13.3^{d,e}$	71.9^{a}
Paoli milk	7.01^{d}	61.6	$55.5^{c,d}$	23.6^{c}	$12.1^{c,d}$	$148.1^{a,b}$
Paoli dough	6.62^{a}	80.8	50.5^{a}	$24.6^{c,d}$	17.7^{f}	560.1^{c}

[1] Fifty-four observations per treatment mean.

[a,b,c,d,e] Means in the same column with different superscripts differ significantly ($P<.05$).

Molar % acetate was influenced ($P<.05$) by type of silage, stage of maturity, sampling time and their interactions (table 15). Rumen fluid from lambs fed Parker silages and boot silages had higher acetate values than rumen fluid from the other types of silage and stages of maturity (table 16). Acetate values were higher ($P<.05$) for hrs 3 and 6 than hr 1.

Molar % propionate was affected ($P<.05$) by type of silage, stage of maturity and sampling time (table 16). Paoli silages produced the lowest rumen propionate values followed, in increasing order, by Parker and Arthur silages ($P<.05$). Lambs fed boot stage silages had the lowest rumen propionate concentrations followed, in increasing order, by lambs fed dough and milk silages ($P<.05$). Rumen samples taken at hr 1 had higher propionate values ($P<.05$) than samples taken at hrs 3 or 6.

Type of silage and stage of maturity significantly affected rumen molar % butyrate concentrations (table 16). Paoli silages and dough silages produced higher ($P<.05$) butyrate values than the other two types of silage or stages of maturity. Sampling time did not affect rumen butyrate concentration

Lambs fed Paoli dough silage had a higher ($P<.01$) lactate level at hr 1 than any other type of silage by stage of maturity by sampling time combination (table 15). Rumen lactate concentrations were affected ($P<.05$) by type of silage, stage of maturity and sampling time (table 16). Lambs fed Parker silage had lower ($P<.05$) and dough silage higher ($P<.05$) lactate values than lambs fed the other two types of silage or stages of maturity. Rumen samples taken at hr 1 had higher ($P<.01$) lactate levels than samples taken at either hr 3 or 6.

Statistical analysis of the data appears in Appendix tables 4, 5, 6 and 7.

DISCUSSION

In experiments reported here, cereal grains were successfully harvested, ensiled and fed in intermediate and high-silage rations for steers and lambs. However, type of cereal grain and stage of maturity had varying affects on silage quality and feeding value.

In the steer growth trial, animals fed Paoli barley dough silage, equal parts Parker-head wheat and corn silages, corn silage plus soybean meal and corn silage plus urea gained similarly. In contrast, Mowat et al., (1971) reported that steers fed corn silage gained faster and more efficiently than those fed barley dough silage. Performance differences between these two trials may be the result of different grain concentrations in the respective silages.

Similar feed intake of steers fed equal parts Parker-head and corn silages and those fed corn silage agrees with previous research. Baxter et al., (1971) observed that dairy cows fed a ration of equal amounts boot stage wheat and corn silages had digestible dry matter intake equal to that of cows fed a corn silage ration.

Steers fed corn silage plus soybean meal gained 8.3% faster and 10.7% more efficiently than those fed corn silage plus urea. This agrees with results reported by Woods and Tolman (1966), Mieske et al., (1967) and Woods and Tolman (1968). Steers fed corn silage gained significantly faster and more efficiently than those fed Parker-head silage. This agrees with data of Conway et al. (1973).

Steers receiving Arthur wheat (awnless, soft, red-winter) silage gained faster and consumed more feed than those fed whole-plant Parker wheat (awned, hard, red-winter) or Parker-head silages. These results agree with data of Conway et al., (1973) who compared dough head-silages made from Blue Boy, (awnless, soft red-winter wheat) and Parker wheats. Krall (1972) fed Nugaines-head wheat silage to steers for only 6 weeks before the awns caused sore mouths, thus resulting in termination of the trial. Presence of awns may explain why steers receiving Parker and Parker-head silage rations gained slower and consumed less feed than steers fed any of the other five silage rations in the steer growth trial. Combining Parker-head silage with corn silage increased consumption of head silage. This suggests that diluting awned wheat silage with another silage will overcome the negative effect of awns on silage intake.

Steers receiving Parker-head silage gained 12.8% faster on 12.5% less feed than those fed Parker silage. This is probably the result of a higher grain to roughage ratio in the Parker-head silage.

Crude protein values of cereal grain silages fed in the steer growth trial were three to four % lower than those reported by Conway et al., (1973). Nitrogen fertilizer was applied to the latter's cereal grains and probably explains their higher crude protein values.

Type of cereal grain silage affected performance in the lamb growth trial; those fed Parker dough silage gained slower and less efficiently than those fed Arthur dough or Paoli dough silages. As previously shown, steers receiving Parker silages also had the slowest and least efficient gains.

Stage of maturity also affected lamb performance; lambs fed Parker milk silage gained slower, consumed less feed and were less efficient than those fed Parker boot, Arthur dough or Paoli dough silages. These results agree with a similar trial by Bolsen et al., (1974) who reported that lambs fed Parker milk silage failed to consume sufficient amounts of silage for maintenance.

In the trial reported herein, lambs consumed 60.0% and 19.3% more Parker boot silage than Parker milk or dough silages, respectively. This agrees with data of McCullough and Sisk, (1966), who found that dairy cows consumed 20.0% more boot wheat silage dry matter than milk or dough silage dry matter. However, contrasting results have been observed, especially with other types of cereal grain silages. Miller et al., (1967) and Polan et al., (1968) observed that dry matter intake by dairy cows was lowest for barley boot silage and weight gains highest for barley milk and dough silages. Similarly, Marty et al., (1958) reported that dairy cows consumed more oat dough silage than oat boot or milk silages. These data indicate that optimum stage of maturity to harvest cereal grains for silage may depend on the type of cereal grain, ration or livestock being fed.

Results of the lamb finishing trial, in which rolled milo was added to the silage rations, indicated that Arthur dough silage supported a higher level of performance than forage sorghum silage when both silages were supplemented with urea. Lambs fed forage sorghum supplemented with soybean meal and Arthur dough supplemented with soybean meal or urea gained faster and more efficiently than those receiving forage sorghum supplemented with urea (graph 1). Arthur dough supported a 16.7% faster and 19.0% more efficient gain than forage sorghum. Lambs fed soybean meal gained 42.8% faster and 34.3% more efficiently than those receiving urea. These results agree with data reported by Brethour (1971), who found that steers fed a 75% silage - 25% wheat grain ration supplemented with urea gained 10.9% faster and 10.4% more efficiently than steers fed a 75% silage - 25% milo grain ration.

Data reported by Oltjen et al., (1966) and Slyter et al., (1970) showed that wheat was more rapidly fermented in the rumen than other feed grains, resulting in a lower pH and higher ruminal volatile fatty acid concentrations. Perhaps this explains the advantage of wheat grain over other feed grains in high-silage-urea rations. Wheat, because of its rapid fermentation, might allow peak energy and ammonia levels in the rumen to more nearly coincide, thus permitting a more efficient conversion of ammonia to microbial protein. More total protein would then be available for maintainance and growth. Further research is needed to verify this possible explanation.

Results of the lamb voluntary intake-digestion and nitrogen balance study substantiated many observations in the lamb growth and finishing trials. Lambs fed milk silages consumed less dry matter per kg of metabolic body size than lambs fed either boot or dough silages. Parker milk was consumed in the smallest amount. Within the scope of the data in this paper, no clear explanation exists for the poor consumption of milk silages, particularly Parker milk silage. However, similar results have been observed by other workers. Fisher et al., (1972) reported that dairy cows consumed less barley milk silage dry matter than boot or dough silage dry matter.

Dry matter digestibility was not greatly affected by type of cereal grain or stage of maturity, but it tended to be slightly higher for barley and dough silages. This agrees with data reported by Meyer et al., (1957), but is contrary to the findings of Cantell et al., (1968), Swift et al., (1968) and Polan et al., (1968). The latter authors reported that dry matter digestibility decreased with increasing maturity. The fact that dry matter digestibility held constant or increased slightly through the dough stage in this study is possibly the result of particularly high grain contents of the cereal grain silages.

Crude fiber digestibility decreased significantly as stage of maturity increased.

Crude protein digestibility remained constant through the boot and milk stages but increased in the dough stage. This disagrees with data reported by Meyer et al., (1957), who observed that crude protein digestibility decreased with each successive increase in stage of maturity.

Nitrogen retention increased as stage of maturity increased. This increase possibly resulted from an increase in crude protein digestibility with increasing maturity.

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APPENDIX

Appendix Table 1. ANALYSIS OF VARIANCE FOR STEER PERFORMANCE DATA IN EXPERIMENT I.

Source of variation	d.f.	Mean square: Average daily gain	Mean square: Average daily feed	Mean square: Feed per unit of gain
Total	20			
Treatment	6	.3288[b]	9.2615[a]	1.326[a]
Replications	2	.0156	.0195	.154
Treat. x rep.	12	.0361	1.0568	.436

[a]P<.05.

[b]P<.01.

Appendix Table 2. ANALYSIS OF VARIANCE FOR LAMB PERFORMANCE DATA IN EXPERIMENT II.

Source of variation	d.f.	Mean square: Average daily gain	Mean square: Average daily feed	Mean square: Gain per unit of feed
Total	14			
Treatment	4	.008872[a]	.368018[a]	.006221[b]
Replication	2	.001849	.047100	.000357
Treat. x rep.	8	.000669	.066816	.000450

[a]P<.05.

[b]P<.01.

Appendix Table 3. ANALYSIS OF VARIANCE FOR LAMB PERFORMANCE IN EXPERIMENT III.

Source of variation	d.f.	Mean square: Average daily gain	Mean square: Average daily feed	Mean square: Feed per unit of gain
Total	11			
Treatment	3	.023287[b]	.09047[a]	9.8057[b]
Silage	1	.008427	.05602	5.248
Nitrogen	1	.045880[b]	.20831	14.819[b]
Sil. x nitr.	1	.015553[a]	.00707	9.350[a]
Replications	2	.002715	.02252	.7900
Treat. x rep.	6	.002292	.01488	1.17100

[a]P<.05.

[b]P<.01.

Appendix Table 4. ANALYSIS OF VARIANCE OF VOLUNTARY INTAKE AND DRY MATTER, CRUDE PROTEIN AND CRUDE FIBER DIGESTIBILITIES IN LAMBS IN EXPERIMENT IV.

		Mean square			
Source of variation	d.f.	Voluntary intake	Dry matter	Crude protein	Crude fiber
Total	53				
Period	1	3137.32[b]	49.59[b]	98.12[b]	68.07[b]
Silage	2	314.16[b]	8.14[a]	16.77	115.03[b]
Stage	2	413.25[b]	9.05[a]	24.05[a]	1111.47[b]
Period x silage	2	23.35	10.43[a]	4.95	4.95
Period x stage	2	55.08	4.37	16.51	9.28
Silage x stage	4	54.24[a]	12.05[a]	54.65[b]	15.54
Period x silage x stage	4	18.32	7.22	9.56	12.04
Error	36	20.59	2.24	6.84	6.71

[a]P<.05.

[b]P<.01.

Appendix Table 5. ANALYSIS OF VARIANCE OF NITROGEN RETENTION DATA IN LAMBS IN EXPERIMENT IV.

		Mean square		
Source of variation	d.f.	% N retained	g N retained	% N absorbed
Total	53			
Period	1	1066.25[b]	12.573[b]	1909.59[b]
Silage	2	115.13	2.188	204.98
Stage	2	1095.26[b]	14.530[b]	2222.50[b]
Period x silage	2	4.98	.014	8.25
Period x stage	2	156.02	1.289	324.73
Silage x stage	4	317.02[b]	5.987[b]	636.54[b]
Period x silage x stage	4	28.00	.562	48.13
Error	53	82.51	1.018	176.88

[a]P<.05.

[b]P<.01.

Appendix Table 6. ANALYSIS OF VARIANCE OF MOLAR % ACETATE, PROPIONATE AND BUTYRATE OF RUMEN SAMPLES FROM LAMBS IN EXPERIMENT IV.

		Mean square		
Source of variation	d.f.	Acetate	Propionate	Butyrate
Total	158			
Variety	2	242.137[b]	87.352[b]	235.787[b]
Stage	2	582.276[b]	211.452[b]	227.654[b]
Hours	2	387.233[b]	401.341[b]	.162
Period	1	31.482	15.499	80.817[b]
Variety x stage	4	60.447[b]	71.148[b]	42.250[b]
Variety x hours	4	11.451	17.081[a]	4.609
Variety x period	2	16.781	38.605[b]	32.545[a]
Stage x hours	4	9.303	6.992	2.512
Stage x period	2	12.560	39.445[b]	8.416
Hours x period	2	662.188[b]	52.225[b]	44.773[b]
Variety x stage x hours	8	96.427	2.267	4.404
Variety x stage x period	4	35.051	7.126	8.831
Error	121	10.380	6.142	7.149

[a] $P<.05$.

[b] $P<.01$.

Appendix Table 7. ANALYSIS OF VARIANCE OF TOTAL VFA, pH AND LACTATE OF RUMEN SAMPLES FROM LAMBS IN EXPERIMENT IV.

Source of variance	d.f.	Mean square		
		Total VFA	pH	Lactate
Total	158			
Variety	2	337.95	.13427[b]	312288.8[b]
Stage	2	2824.79[b]	.77791[b]	481089.2[b]
Hours	2	8571.27[b]	.52486[b]	1249537.0[b]
Period	1	1863.01[b]	.00024	24252.7
Variety x stage	4	204.54	.19282[b]	412746.3[b]
Variety x hours	4	336.04	.05148[b]	412498.6[b]
Variety x period	2	302.80	.14717	10953.7
Stage x hour	4	73.51	.10596[b]	596830.6[b]
Stage x period	2	371.39	.02375	132417.9
Hours x period	2	4588.12[b]	.07291	145630.4
Variety x stage x hours	8	64.68	.03657[a]	317196.5[b]
Variety x stage x period	4	481.17	.04788[a]	26543.1
Error	121	168.02[b]	.01410	47435.6

[a]$P<.05$.

[b]$P<.01$.

WHEAT AND BARLEY SILAGES
FOR STEERS AND LAMBS

by

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Abstract

The objectives of this research were: to study the feeding value of wheat and barley harvested as silage; to evaluate the effects of stage of maturity and type of cereal grain on silage quality, palatability and digestibility and to evaluate soybean meal and urea as sources of supplemental nitrogen in wheat silage rations.

One-hundred twenty six steers were fed in a 100-day growing trial to compare these silage and ration treatments: Whole plant (WP), Paoli barley (WPB); WP Arthur wheat (WPA); WP Parker wheat (WPP); Parker head wheat (PH); equal parts PH and corn silage (CS); CS plus a soybean meal (SBM) supplement (CS+SBM) and CS plus a urea supplement (CS+urea). Cereal grain silage rations contained a SBM supplement and all rations were 86% silage and 14% supplement on a dry matter basis. Steers receiving WPB, PH+CS, CS+SBM and CS+urea rations had similar performance. Daily gain and dry matter intake were lowest ($P<.05$) for steers fed WPP and PH silages. Steers fed WPP were less efficient ($P<.05$) than those fed WPB, WPA, PH+CS and CS+SBM.

A lamb growth trial was conducted to determine the effects of stage of maturity and type of cereal grain on the feeding value of cereal grain silages. The five WP silages were Parker wheat harvested in the boot (b), milk (m), and dough (d) stages; d-stage Arthur wheat and d-stage Paoli barley. All rations contained 86% silage and 14% SBM-based supplement on a dry matter basis. Lambs receiving Parker-m and Parker-d rations had the slowest and least efficient gains ($P<.05$). Feed intake was lower ($P<.05$) for lambs fed the Parker-m silage than those fed Parker-b, Arthur-d or Paoli-d silage.

A two x two factorial lamb finishing trial was used to compare forage sorghum silage plus milo with Arthur-d silage plus milo and a SBM supplement with a urea supplement. During phase I (25 days), all rations contained 60%

silage, 26% milo and 14% supplement; in phase II (29 days) ration compositions were 40% silage, 46% milo and 14% supplement on a dry matter basis. Lambs fed forage sorghum and urea had the slowest and least efficient gains (P<.05). Lambs fed Arthur-d rations were more efficient (P<.05) than those fed forage sorghum rations. Silages supplemented with SBM supported faster and more efficient gains (P<.05) than those supplemented with urea.

Twenty-seven wether lambs were used in a three x three factorial voluntary intake and metabolism study to evaluate Arthur and Parker wheats and Paoli barley harvested for silage in the b, m, and d stages. Ration and supplement compositions were the same as those fed in the lamb growth trial. Parker wheat and m-stage silages were consumed in the smallest amounts (P<.01). Dry matter digestibility was not affected by type of cereal grain; however, d-stage silages had higher dry matter digestion coefficients (P<.05) than m-stag silages. Crude fiber digestibility decreased (P<.01) and crude protein digestibility and nitrogen retention increased (P<.05) as maturity increased. Rumen pH was lowest (P<.01) and total volatile fatty acids and lactic acid levels were highest (P<.05) at 1 hr post-feeding. Total volatile fatty acids were highest (P<.05) in lambs fed d-stage silages.