STUDIES ON GRASS SILAGE FROM PREDOMINANTLY *PASPALUM DILATATUM* PASTURES IN SOUTH-EASTERN QUEENSLAND

2. INFLUENCE OF LENGTH OF CUT ON SILAGES WITH AND WITHOUT MOLASSES

By M. S. LEVITT, B.Sc., A. HEGARTY, B.Sc., and M. J. RADEL*

SUMMARY

Five experimental small-scale tower silos, each of approximately 0·75-ton capacity, were used to compare silages produced from predominantly *Paspalum dilatatum* pasture. The pasture was at a fairly mature stage of growth with a dry-matter content of approximately 35 per cent. and a protein level of 6·9 per cent. The total sugar content was low, approximately 2·5 per cent. on dry matter.

The treatments compared were as follows:

(1) Pasture harvested with a flail type of commercial harvester and ensiled without molasses.

(2) Pasture harvested with a flail type of commercial harvester and ensiled with the addition of molasses at the rate of 40 lb per ton of green matter.

(3) Pasture mown, chaffed and ensiled without molasses.

(4) Pasture harvested with a cutter-bar type of commercial harvester and ensiled without molasses.

(5) Pasture harvested with a cutter-bar type of commercial harvester and ensiled with the addition of molasses at the rate of 40 lb per ton of green matter.

The experimental procedure of rapid filling and maximum compaction resulted in low-temperature silages for all treatments. Fermentation losses were low, ranging from 5 to 8 per cent. There was no effluent. Excessive mould formation occurred only in the flail-harvested product ensiled without molasses.

Optimum silage quality was not obtained in any treatment, but quality, as evidenced by decreased pH and increased lactic acid production, was influenced both by the method of harvesting and by the addition of molasses. The best product resulted from material harvested by the cutter-bar type of harvester and ensiled with molasses.

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* Queensland Department of Primary Industries.

The ensiling process resulted in a significant decrease in dry-matter digestibility, due largely to a reduction in the digestibility of the nitrogen-free-extract. Silages made from pasture harvested by the cutter-bar showed digestibility coefficients for dry matter, organic matter, protein, fibre and nitrogen-free-extract, which were significantly greater than those for products from either flailed or chaffed material. No improvement in digestibility due to molasses was evident.

Limited comparative palatability studies suggested that the most palatable silage resulted from material harvested by the cutter-bar type of harvester and ensiled with molasses.

I. INTRODUCTION

Levitt, Taylor, and Hegarty (1962) compared the use of the additives molasses and sodium metabisulphite in the making of silage from predominantly *Paspalum dilatatum* pastures. Further studies were undertaken to compare methods of harvesting, attention being given particularly to the length of cut of the pasture being ensiled. Molasses was evaluated as an additive in the ensiling of long-cut and short-cut products.

The chopping of crops for silage has been practised for many years, but more severe treatments such as lacerating and bruising or shredding have only been in use since 1944. Steensberg (1952) discussed the making of silage without additives and suggested that the material should be chopped as finely as possible. Murdoch *et al.* (1955) found that chopped and lacerated herbage resulted in a more vigorous lactic acid fermentation and gave consistently better silage. Wieringa (1959) showed in laboratory-scale experiments that crushing was advantageous to the course of fermentation only after a certain degree of laceration had been exceeded.

Nash (1952) produced a better fermentation in a lacerated silage from a grass/clover mixture than from uncut material with added molasses. Maximum temperature was lower in the lacerated silage, as also were pH and dry-matter loss. He found little difference in the digestibility of lacerated and ordinary molassed silage, and stated that application of molasses to chopped or lacerated pasture may not be necessary. However, Murdoch *et al.* (1955) used both chopping and the addition of molasses to give optimum silage quality.

Because of the rather stemmy nature of *Paspalum dilatatum* when cut for silage it was considered desirable to examine the influence of both length of cut and the use of molasses on the quality of silage made from this material.

II. METHODS AND MATERIALS

Experimental Area.—An experimental area of approximately 2 ac was selected at the Animal Husbandry Research Farm at Rocklea, near Brisbane. At the time of harvesting the predominant pasture species was *Paspalum dilatatum*. However, an appreciable quantity of mature Queensland blue couch grass (*Digitaria didactyla*) was also present.

Pasture Yield Measurements.—Pasture yield in the experimental area was determined by the quadrat procedure described previously (Levitt, Taylor, and Hegarty 1962).

Harvesting Procedure.—The pasture was harvested in three ways:—

(1) Approximately 0·75 ton of pasture was mown, immediately harvested and transported to a stationary chaff cutter and cut into lengths of about 0·5 in.

(2) A commercial harvester of the cutter-bar type with the blades set to give a product chopped in lengths of 1–2 in. was used on each of two successive days to harvest approximately 0·75 ton of pasture.

(3) Approximately 0·75 ton of pasture was harvested on each of two successive days with a commercial flail-type harvester, giving a product varying in length from 6 to 12 in.

The chaffed, chopped or flailed material was transported without delay approximately 2 miles to the experimental silos and ensiled immediately.

Experimental Silos and Filling Procedure.—These were essentially the same as previously described by Levitt, Taylor, and Hegarty (1962).

Measurements.—Silage quality tests were those of Barnett (1954). The methods of the Association of Official Agricultural Chemists (1955) were used in proximate analyses. Digestibility and palatability procedures were those described previously (Levitt, Taylor, and Hegarty 1962). Total sugar in pasture and silage was essentially by the method of Wiseman, Mallack, and Jacobson (1960).

III. EXPERIMENTAL

This experiment was conducted in the summer of 1959-60. Pasture yield measurements commenced on November 24, 1959, and continued until December 18, 1959. Digestibility measurements on the pasture cut daily from the experimental area commenced on December 5, 1959. After a 7-day preliminary period, apparent digestibility of the experimental pasture was determined from December 12 to December 18 inclusive. The pasture was harvested for silage on December 15 and 16, 1959.

Silage treatments were:—

Silo 1. Pasture cut with the flail-type harvester and ensiled without molasses (harvested December 15).

Silo 2. Pasture cut with the flail-type harvester and ensiled with molasses at the rate of 40 lb per ton of green material (harvested December 16).

Silo 3. Pasture cut and then chaffed with a stationary chaff cutter and ensiled without molasses (harvested December 15).

Silo 4. Pasture cut with the cutter-bar type harvester and ensiled without molasses (harvested December 15).

Silo 5. Pasture cut with the cutter-bar type harvester and ensiled with molasses at the rate of 40 lb per ton of green material (harvested December 16).

The experimental tower silos were opened for chemical evaluation, digestibility and palatability studies on July 12, 1960, approximately seven months after the silage was laid down.

IV. RESULTS

Rainfall data and the yield and protein content of pasture on a dry-matter basis are shown in Figure 1. Proximate analyses are presented in Table 1. Changes during the experimental period from November 24 to December 18 were small, the slight increase in pasture yield being associated with the slight fall in protein and the slight rise in fibre. The sugar content was low.

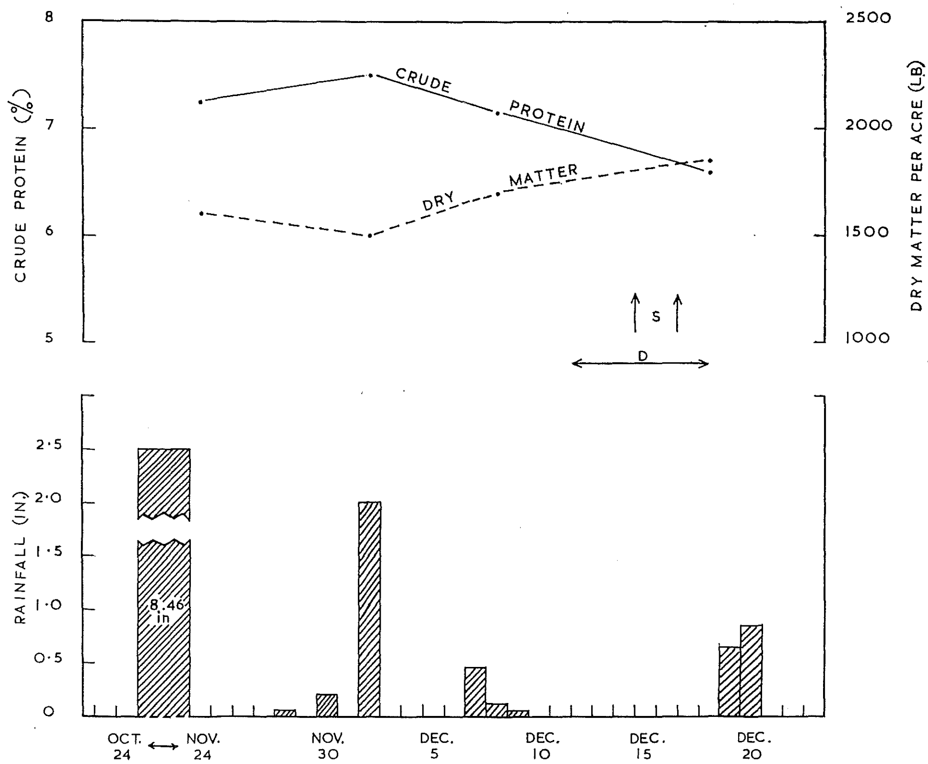

Fig. 1.—Dry-matter yield and protein content of pasture, and rainfall data.

↑S↑ Time of harvesting for silage.

D ⟷ Period of digestibility measurement.

TABLE 1

COMPOSITION OF PASTURE

(Percentage on Dry Matter)

—	Protein	Fat	Fibre	N.F.E.	Ash	Calcium (Ca)	Phos-phorus (P)	Sugar
Quadrat cut 24.xi.59	7·2	1·7	30·0	51·8	9·3	0·24	0·17	3·5
Quadrat cut 1.xii.59	7·5	1·9	30·3	50·6	9·7	0·26	0·22	2·6
Quadrat cut 8.xii.59	7·2	1·9	32·0	48·4	10·5	0·24	0·18	1·8
Representative sample from digestibility trial 12.xii.59 to 18.xii.59	6·6	2·0	33·2	48·3	9·9	0·30	0·20	..
Representative sample from pasture at ensiling on 15.xii.59	7·1	2·1	31·7	48·7	10·4	0·27	0·18	2·7
Representative sample from pasture at ensiling on 16.xii.59	6·6	2·0	32·0	48·7	10·7	0·27	0·18	2·6

The maximum temperature reached in each silo is recorded in Table 2, together with the air temperature taken at the same time. Maximum temperature was reached on either the second or third day after filling. The highest temperature recorded was 33·5°C in the chaffed material (Silo 3). The temperature of all silages had declined to that of the environment within 8 days of filling.

TABLE 2

MAXIMUM TEMPERATURE RECORDED IN EACH SILO

Treatment	Maximum Temperature (°C)	Air Temperature Recorded at Same Time (°C)	Number of Days after Filling when Maximum Temperature Recorded
Silo 1 (flail control)	30·5	28·0	2
Silo 2 (flail + molasses)	33·0	26·0	2
Silo 3 (chaffed)	33·5	26·0	3
Silo 4 (cutter-bar control)	30·5	26·0	3
Silo 5 (cutter-bar + molasses)	31·5	26·0	2

Fermentation losses for each silage treatment are shown in Table 3. There was little difference between treatments, losses ranging from 5 to 8 per cent. of the dry matter. No effluent was produced in any of the treatments.

TABLE 3

FERMENTATION LOSSES IN EACH SILO

Treatment	Amount Ensiled (lb)	Additive (lb)	Amount Recovered (lb)	Fermentation Loss (%)
Silo 1 (flail control)	1334 (464)*	0	1231 (442)	5
Silo 2 (flail + molasses)	1362 (520)	24·3 (18·6)	1277 (505)	6
Silo 3 (chaffed)	1794 (700)	0	1782 (665)	5
Silo 4 (cutter-bar control)	1578 (557)	0	1544 (526)	6
Silo 5 (cutter-bar + molasses)	1528 (540)	27·7 (21·2)	1442 (516)	8

* Values in parenthesis are expressed on a dry-matter basis.

TABLE 4

SILAGE QUALITY TESTS ON SAMPLES FROM DIFFERENT LEVELS IN EACH SILO

Treatment	pH	Dry Matter (%)	Volatile Acidity† (% Acetic Acid)	Residual Acidity† (% Lactic Acid)	Nitrogen†			Comments
					Total (% N)	Volatile Base (% N)	Amino Acid (% N)	
Silo 1 (flail control) ..	4·9 (±0)*	35·9 (±0·9)	2·6 (±0·3)	1·2 (±0·2)	1·21 (±0·04)	0·23 (±0·02)	0·16 (±0·01)	Light-brown leaves and stems; acetic acid smell
Silo 2 (flail + molasses) ..	4·6 (±0·1)	39·5 (±0·9)	2·1 (±0·4)	1·6 (±0·4)	1·07 (±0·03)	0·16 (±0·01)	0·16 (±0·01)	Light mid-brown leaves; very stemmy with a high proportion of dark-brown couch; sweet smell
Silo 3 (chaffed)	4·8 (±0·1)	37·3 (±1·4)	2·2 (±0·3)	1·4 (±0·2)	1·23 (±0·03)	0·18 (±0·02)	0·16 (±0·01)	Yellow to light-brown in colour; very sweet smell
Silo 4 (cutter-bar control) ..	4·7 (±0·1)	34·0 (±0·5)	2·4 (±0·2)	2·3 (±0·4)	1·20 (±0·02)	0·21 (±0·01)	0·18 (%0·02)	Light-brown and yellow leaves and stems; acetic acid smell
Silo 5 (cutter-bar + molasses)	4·6 (±0·1)	35·8 (±0·8)	2·2 (±0·1)	2·4 (±0·4)	1·19 (±0·01)	0·19 (±0·01)	0·17 (±0·01)	Light-brown and yellow leaves and stems; strong sweet smell

* Values in parenthesis show the standard deviation from the mean of samples analysed from top, mid-upper, middle, mid-lower and bottom levels in each silo.

† Values expressed on a dry-matter basis.

Silage quality findings are tabulated in Table 4. In all products, quality was assessed on samples taken at five different levels in the silo, namely top, mid-upper, middle, mid-lower and bottom. The pH was lowest in the silages made with molasses. Lactic acid concentration was highest in the silages from pasture cut with the cutter-bar type harvester.

Table 5 records the proximate analyses of the five silage treatments. There were some differences between treatments and also between different sites in the silo. The silages showed higher levels of crude protein than the pasture before ensiling. This was due to fermentation losses of carbohydrate during the ensiling process. There was also a reduction in the sugar content during ensiling.

TABLE 5

COMPOSITION OF SILAGES

(Proximate Analyses on Dry Matter (%))*

Treatment	Protein	Fat	Fibre	N.F.E.	Ash	Sugar
Silo 1 (flail control)	7·5±0·3	2·2±0·2	33·9±1·0	43·6±0·6	12·8±0·2	0·3
Silo 2 (flail + molasses) ..	6·7±0·2	1·8±0·3	31·5±1·0	44·5±0·9	15·5±1·5	0·9
Silo 3 (chaffed)	7·7±0·2	2·2±0·3	35·1±0·5	44·0±0·6	11·0±0·2	0·4
Silo 4 (cutter-bar control) ..	7·5±0·2	2·1±0·3	34·7±0·7	44·6±0·8	11·1±0·3	0·6
Silo 5 (cutter-bar + molasses)	7·5±0·1	2·3±0·4	33·9±0·4	44·6±0·5	11·7±0·2	1·1

* Values shown give the mean and standard deviation for samples taken from top, mid-upper, middle, mid-lower and bottom levels in each silo.

Digestibility data and the statistical analyses of these data on the pasture and the five silage treatments are shown in Tables 6 and 7. There was a significant decrease in the dry-matter digestibility, due largely to the reduced digestibility of the nitrogen-free-extract (N.F.E.) in silage compared with freshly harvested pasture. The silages made from pasture harvested with the cutter-bar type of commercial harvester showed digestibility coefficients for dry matter, organic matter, protein, fibre and N.F.E. which were significantly greater than those for products from either flailed or chaffed material. No improvement in digestibility due to molasses was evident. In fact, with the flail-harvested product the addition of molasses appeared to result in an adverse effect.

TABLE 6

Mean Digestibility Coefficients, Approximate Standard Errors and Significance of Differences on Pasture and Silage

Treatment and Number of Determinations	Dry Matter (%)	Organic Matter (%)	Crude Protein (%)	Fat (%)	Fibre (%)	N.F.E. (%)
Pasture (6)	47·3	51·0	35·0	17·9	58·8	49·2
Silo 1 (flail control) (8) . .	45·1	48·9	35·4	31·4	60·3	43·1
Silo 2 (flail + molasses) (10)	43·1	47·2	24·3	27·4	57·7	44·5
Silo 3 (chaffed) (10) . .	44·8	47·8	36·0	25·0	59·1	41·9
Silo 4 (cutter-bar control) (10)	49·1	52·5	40·5	28·1	62·6	47·8
Silo 5 (cutter-bar + molasses) (10)	48·1	51·2	38·4	33·4	60·9	46·8
S.E. difference pasture mean and a silage mean . .	±0·68	±0·63	±1·04	±1·31	±0·81	±0·69
S.E. difference Silo 1 and Silos 2–5	±0·77	±0·71	±1·18	±1·49	±0·92	±0·78
S.E. difference any two silos 2–5	±0·70	±0·65	±1·07	±1·35	±0·84	±0·71
Significance—						
Effect of ensiling	Pasture >1–5*	N.S.	N.S.	Pasture <1–5***	N.S.	Pasture >1–5***
Effect of harvesting method	4>1*** 4>3*** 5>2***	4>1*** 4>3*** 5>2***	4>1*** 4>3*** 5>2***	4<1*** 4>3* 5>2***	4>1* 4>3*** 5>2***	4>1*** 4>3*** 5>2**
Effect of molasses . .	2<1*	2<1*	2<1***	2<1* 5>4***	2<1**	N.S.
Other effects	5>3, 1*** 4>2*** 3>2*	5>3**, 1** 4>2***	5>3*, 1* 4>2*** 3>2***	5>3***	5>3* 4>2***	5>3, 1*** 4>2*** 3>2***

N.S. No significant differences.
* Significant at 5% level.
** Significant at 1% level.
*** Significant at 0·1% level.

TABLE 7

Digestible Protein, Total Digestible Nutrients, Metabolizable Energy and Starch Equivalent per 100 lb of Moisture-free Material

Sample	Digestible Protein (lb)	Total Digestible Nutrients (lb)	Metabolizable Energy (therms)	Starch Equivalent (lb)
Pasture	2·3	46·4	71·3	27·0
Silo 1 (flail control)	2·7	43·5	64·6	23·3
Silo 2 (flail + molasses) . .	1·6	40·7	61·0	22·4
Silo 3 (chaffed)	2·8	43·2	64·4	22·5
Silo 4 (cutter-bar control) . .	3·0	47·3	71·0	26·7
Silo 5 (cutter-bar + molasses) . .	2·8	46·1	69·0	26·0

The daily dry-matter intakes of each silage during palatability tests are shown in Table 8. There was insufficient material to completely define the order of preference but the following comparisons are evident:

(1) The addition of molasses at the rate of 40 lb per ton at the time of ensiling of pasture harvested with the flail type of commercial harvester resulted in a less palatable product.

(2) The addition of molasses at the same rate to pasture harvested with the cutter-bar type of commercial harvester improved the palatability of the product.

(3) The silage from pasture harvested by the cutter-bar type of equipment and containing molasses was more palatable than the silage made from chaffed pasture without molasses.

TABLE 8

MEAN DAILY DRY-MATTER CONSUMPTION AND STANDARD DEVIATIONS AS AN INDEX OF PALATABILITY

Sheep No.	Mean Daily Dry-matter Intake (g)					
	Silo 1 v. Silo 2		Silo 3 v. Silo 5		Silo 4 v. Silo 5	
	1	2	3	5	4	5
1	826±113	46±47				
2	887±55	61±41				
3			137±97	818±63		
4			299±36	974±43		
5					234±147	729±193
6					359±50	705±200
Mean Ratio	16 : 1		1 : 3		1 : 2·4	

V. DISCUSSION

Despite reasonably good November rains in 1959 (8·46 in.), growth of pasture was slow during the experimental period from November 24 to December 18. The dry-matter content of the pasture was higher and the protein content lower than in the previous studies (Levitt, Taylor, and Hegarty 1962). The stemmy nature and low sugar content of this relatively mature and dry pasture militated against the preparation of satisfactory silages at this time.

Zelter (1960) reported that for optimum fermentation conditions in silage the soluble sugar content of the material to be ensiled should be in the range of 12·6 to 16·1 per cent. on a dry-matter basis. Wieringa (1960) stated that the amount of sugar required for satisfactory lactic acid production is dependent on the dry-matter content of the herbage; to produce 2 per cent. lactic acid in herbage containing 15 per cent. dry matter requires about 14 per cent. sugar on a dry-matter basis; at 30 per cent. dry matter only about 7 per cent. sugar on a dry-matter basis is required. The dry matter of our pasture at ensiling ranged from 34 to 39 per cent., while the mean sugar content was 2·5 per cent. on dry matter.

The pasture cut with the flail-type harvester showed little or no bruising or laceration and was equivalent only to long-cut material. Compaction was more difficult with this material than with either the chaffed pasture or that cut with the cutter-bar type harvester. Under the experimental conditions, which permitted maximum trampling during the filling procedure, mould development was appreciable only in the silage made from flail-harvested material without molasses.

All silages would be classed as low-temperature products (Watson and Ferguson 1937*a*, 1937*b*). The highest temperature of 33·5°C (92·3°F) was found in Silo 3 (chaffed material) and the lowest temperature of 30·5°C (86·9°F) was recorded in Silo 1 (flail-harvested control) and Silo 4 (cutter-bar control). All silages reached maximum temperature within 2–3 days after filling. The higher temperature in Silo 3 was associated with a higher initial temperature at ensiling due to the more tedious method of harvesting, which involved mowing, raking, transport to the chaff cutter, chaffing and then transport to the silo. The temperature in all silos gradually fell until environmental temperature was reached about 8 days after filling. Thereafter, the temperature in the silos did not vary more than 0·5°C per day.

Due to the high dry-matter content of pasture at ensiling, no effluent was produced in any of the treatments. Fermentation losses were very low and this is in keeping with the findings of other workers, reported by Watson and Nash (1960), who have shown that high dry matter in the silage is usually associated with low fermentation losses provided that the silage is well compacted and that the temperature has not risen above 110°F. Murdoch (1961) suggests that low fermentation losses in small pilot silos may have no direct relation to those obtained from farm-type silos because of the greater measure of control which can be exercised when small quantities of silage are made.

The use of molasses at the rate of 40 lb per ton had only a limited effect on the quality of silage in this experiment. There was some lowering of pH but in no treatment did the pH fall below 4·2, the level below which the residual carbohydrates and the produced lactic acid are relatively stable (Barnett 1954). Some improvement in silage quality from the addition of molasses was evident from the increased levels of residual acidity expressed as lactic acid—Silo 2 compared with Silo 1, and Silo 5 compared with Silo 4. Watson and Ferguson (1937*a*, 1937*b*) stated that in a good quality silage the residual acid content, expressed as lactic acid, should exceed the volatile acid level. This ratio was improved by the addition of molasses and also by the cutter-bar type of harvesting but exceeded unity only in Silo 5. In all silages the residual acidity expressed as lactic acid is lower than in previous studies (Levitt, Taylor, and Hegarty 1962) and much lower than the values quoted for satisfactory silage by Watson and Nash (1960).

The amount of protein breakdown, as evidenced by the production of volatile bases and amino acids, is comparable for all silage treatments but less than that encountered in previous experiments with paspalum silage (Levitt, Taylor, and

Hegarty 1962). This is in agreement with the finding reported by Watson and Nash (1960) that the production of ammonia and volatile bases in silage decreases as the moisture content decreases. The average moisture content in these silages was 63·5 per cent., compared with 74·9 and 77·1 per cent. in earlier experiments. In the present study the ratio of amino acids to volatile bases approached unity in all silages except the flail-harvested product containing no additive.

The physical characteristics of the silages suggest poor to fair quality products, the cutter-bar harvested silages being superior to the chaffed and flail-harvested products. Failure to get optimum quality is most probably related to the impossibility of compacting adequately this relatively dry and fibrous material.

The proximate analyses indicate a slightly higher protein and fibre content and a lower N.F.E. level in silage compared with the pasture at the time of ensiling. These changes are due to fermentation losses of predominantly carbohydrate. However, fermentation losses are low in all silage treatments and analyses indicate that differences between treatments are small. It would be expected that differences between treatments would have been greater under field conditions, which would not permit the degree of compaction obtained in the small-scale experimental silos.

Statistical analyses showed differences in digestibility due to treatment. As in previous experiments (Levitt, Taylor, and Hegarty 1962), the ensiling process adversely affected digestibility: dry-matter digestibility was significantly lower for silage than for pasture prior to ensiling ($P<0\cdot05$), due largely to the lowered digestibility of the N.F.E. fraction in silage ($P<0\cdot001$). The method of harvesting influenced the digestibility of silage: the digestibility of dry matter was significantly greater in silages made from pasture harvested with the cutter-bar type of commercial harvester than in silages from pasture harvested either by the flail type of commercial harvester or by mowing and chaffing ($P<0\cdot001$). This increased digestibility of dry matter usually comprised highly significant increases ($P<0\cdot001$) in the digestibility of organic matter, protein, fibre and N.F.E.

Contrary to previous findings (Levitt, Taylor, and Hegarty 1962; Watson and Nash 1960) the addition of molasses did not result in increased digestibility. This may be related to the rather low digestibility of this dry and mature pasture at the time of harvesting. The indication of an adverse affect of molasses on silage from flail-harvested pasture could be due to the particularly high dry-matter content of the silage in this treatment.

Palatability studies were limited by the amount of silage available. In general, there was no difficulty in getting sheep to eat silage from any treatment but it took a little longer to accustom sheep to the long-cut material. The addition of molasses to material harvested by the cutter-bar type increased the relative palatability of the silage. This product was also preferred to the silage from the mown and chaffed pasture. With the flail-harvested pasture the addition of molasses would appear to have resulted in an adverse effect on palatability. This is unexpected and may be due to particularly high dry-matter content of the silage in this treatment.

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