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# Voluntary intake and digestibility of straw and hay supplemented with silages or lucerne by yearling cattle

M. Basery* and R. C. Campling**

Key words: voluntary intake, cattle, straw, hay, grass silage, lucerne silage, maize silage, lucerne

**Abstrak**

Tiga ujikaji telah dijalankan untuk menentukan pengambilan makanan secara bebas yang terdiri daripada campuran dua foraj, khususnya untuk mengkaji penggunaan silaj rumput, silaj lucerne, silaj jagung dan lucerne sebagai makanan tambahan kepada lembu yang diberi jerami barli dan rumput kering. Tambahan silaj rumput dengan kadar 1.14, 2.27 dan 3.40 kg (bahan kering) kepada lembu yang diberi jerami barli secara ad lib. telah meningkatkan jumlah pengambilan foraj ke tahap yang sama. Ini disebabkan oleh penurunan pengambilan jerami yang seimbang pada setiap tahap tambahan. Tambahan 3.20 kg lucerne dan silaj rumput pada lembu yang diberi jerami barli juga meningkatkan jumlah pengambilan foraj ke tahap yang sama tetapi pengambilan jerami menurun dengan kadar 0.53 kg bagi sekilogram silaj. Begitu juga dengan pemberian tambahan silaj lucerne kepada lembu yang diberi silaj jagung ad lib. yang meningkatkan jumlah pengambilan, tetapi menurunkan pengambilan silaj jagung dengan kadar 0.67 kg bagi sekilogram silaj lucerne. Pengambilan rumput kering rye tidak berubah apabila diberi tambahan lucerne sebanyak 67%. Keputusan daripada ujikaji-ujikaji tersebut mengesahkan pendapat yang menyatakan bahawa apabila dua foraj panjang diberi dalam campuran, jumlah pengambilan bahan kering dipengaruhi oleh pengambilan maksimum tiap-tiap komponen foraj yang ditentukan secara berasingan. Walau bagaimanapun terdapat juga tanda-tanda perbezaan daripada pendapat ini. Kesan gantian satu foraj pada yang lain dan kesan campuran pada pencernaan bahan organan dibincangkan.

**Abstract**

Three experiments were conducted with yearling cattle to measure the voluntary intake of diets composed of two long forages and especially to examine the use of grass, maize and lucerne silages as well as lucerne forage as supplements to diets consisting of barley straw and hay. Giving supplements of 1.14, 2.27 and 3.40 kg DM grass silage to cattle receiving barley straw ad lib. increased total forage intake to a similar extent because straw intake decreased proportionately. Supplement of 3.20 kg DM lucerne and grass silage to barley straw diets increased total forage intake to the same extent and straw intake fell by 0.53 kg DM per kg DM silage. Similarly,

*Livestock Research Division, MARDI, P.O. Box 525, 86007 Keluang, Malaysia
**Wye College, Ashford, Kent TN25 5AH, England
Authors' full names: Basery Mohamad and Robert C. Campling

supplements of lucerne silage to diets of maize silage increased total intake and reduced intake of maize silage by 0.67 kg DM per kg supplement. The voluntary intake of a mature rye grass hay was not altered by supplementing it with 67% fresh lucerne. The results confirmed the hypothesis that the intake of mixtures of long forages were proportional to the maximal intake of the individual components when offered as the sole feed, although there were evidence of small deviations from this general finding. The substitution of one forage by another is discussed as are the associative effects on voluntary intake and digestibility which was observed.

**Introduction**

Little is known about the voluntary intake of diets consisting of two or more long forages by cattle, the extent to which substitution of one forage for another occurs and whether there are associative effects on intake. One such relevant work was reported by Blaxter et al. (1966) which stated that when restricted amounts of higher quality forage was given to cattle and sheep which were offered a lower quality forage ad lib. the total intake of food was proportional to the voluntary intakes of each forage offered separately. This conclusion implied that there are no associative effects on voluntary intake of one forage on another.

Three experiments were conducted in order to test this conclusion and to examine whether there was any associative effects in digestibility of long forages in mixture. The first experiment was to determine the voluntary intake of barley straw supplemented with three levels of grass silage. The second experiment examined the effect of supplementing barley straw with lucerne and maize silages and the effects of supplementing maize silage with lucerne silage and the third experiment investigated the effect on the voluntary intake of a medium quality hay supplemented with fresh lucerne.

**Materials and methods**

***Experiment 1***

Two forages were used, grass silage and the basal forage of barley straw. The silage was prepared from the second regrowth of perennial rye grass (*Lolium perenne*), cut using a double chop forage harvester, picked up unwilted and ensiled without additive in a bunker silo. The average content of dry matter (DM) was 226 g/kg, nitrogen 26.2 g/kg DM and cellulose 343 g/kg DM. The silage had a pH of 3.4 and ammonia-N of 61 g/kg total N. The barley straw was from a spring sown crop grown on the College farm and consisted of a mixture of three varieties: Athos, Koru and Keg. It had a dry matter content of 823 g/kg and contained 7.1 g N and 441 g cellulose per kg DM.

Ten Friesian and Sussex x Friesian yearling heifers with initial liveweights (W) of 288 ± 7.6 kg (s.e.) were used. They were tethered in individual stall fitted with rubber matting and had free access to water. Five treatments were compared in two replicates of an incomplete latin square design with 10 animals in four periods. Each period was of 21 days duration.The treatments were:

G – grass silage ad lib.
G15 – 15 kg silage + straw ad lib.
G10 – 10 kg silage + straw ad lib.
G5 – 5 kg silage + straw ad lib.
S – straw ad lib.

Each animal was also given 1.5 kg rolled barley daily to ensure a liveweight gain of about 0.5 kg/day and 0.5 kg cereal pencils containing 16 g $Cr_2O_3$/kg DM to determine faecal output. The concentrate and silage were given at 0830 h and 1530 h daily immediately before straw was offered at 110–115% of consumption.

Individual animal intakes of silage and straw were recorded daily by weighing refusals beginning from day 8 and continuing through to day 21 of each period, but only data from the last 7 days were used in calculating the mean intakes. Faecal samples from all dung pats of individual animal were taken in the morning and afternoon from day 15 to day 20 inclusive, and were bulked and dried in the oven at 100 °C. Dry matter content of silage was determined daily from day 13 to day 20, while that of straw and rolled barley, thrice weekly.

***Experiment 2***

Three forages were used; lucerne silage, maize silage and the basal forage of winter barley straw (cv Igri). Both silages were well conserved with pH of 4.3 and 3.9 for lucerne and maize respectively. The lucerne silage had a DM content of 410 g/kg, cellulose 358 g/kg DM, total N concentration of 24.8 g/kg DM and ammonia N of 88 g/kg total N. The maize silage had a DM content of 352 g/kg, cellulose 234 g/kg DM, total N concentration of 13.1 g/kg DM and ammonia N of 74 g/kg total N. In vitro DOMD values (DOMD = digestible organic matter in the dry matter) of lucerne and maize silages were 0.53 and 0.65 respectively. The DM in the straw was 849 g/kg and it had a total N of 6.0 g/kg DM and cellulose content of 451 g/kg DM.

Twenty seven Friesian yearling heifers with average initial liveweight of 275 ± 5.6 kg (s.e.) were blocked into triplicates of similar weight and the animals allocated at random to Part A, Part B and Part C. In each part, three treatments were compared using 3 x 3 latin square in 3-week period. The treatments were:

Part A

S – barley straw ad lib.

SL – barley straw ad lib. + 3 kg DM lucerne sil.

SM – barley straw ad lib. + 3 kg DM maize sil.

Part B

ML1 – maize sil. ad lib. + 1.5 kg DM lucerne sil.

ML2 – maize sil. ad lib. + 3.0 kg DM lucerne sil.

ML3 – maize sil. ad lib. + 4.5 kg DM lucerne sil.

Part C

L – lucerne sil. ad lib.

M – maize sil. ad lib.

L + M – lucerne and maize silages ad lib. both being offered simultaneously in adjacent mangers.

All animals were also given 0.5 kg cereal pencils containing chromic oxide marker as in Expt. 1.

***Experiment 3***

The feeds consisted of fresh cut lucerne and a basal forage of mature rye grass hay. The lucerne was from a second regrowth, cut daily by a flail harvester beginning from the age of 40 days through to 70 days. This increasing age was divided into six 5-day periods, i.e. P1 (day 40–44), P2 (day 45–49), P3 (day 50–54), P4 (day 55–59), P5 (day 60–64) and P6 (day 65–69). Thus it was possible to determine the effect of increasing maturity of lucerne on intake and digestibility.

Twelve Friesian incalf heifers with average liveweight of 437 ± 8.8 kg (s.e.) were blocked into pairs on the basis of similarity in weight and within pairs allocated at random to either of the following treatments:

L – fresh lucerne ad lib.

HL – hay ad lib. + fresh lucerne at 65% of maximum intake

Determination of intake and digestibility of hay (H) alone was made immediately after the treatments using eight of the animals.

***Chemical analysis and calculation of digestibility coefficients***

All forage samples in the three experiments were analysed for content of DM, ash, nitrogen (Mitcheson 1969) and cellulose (modified Crampton and Maynard 1938). Chromic oxide in the cereal pencil and faecal samples was determined by the method of Stevenson and De Langen (1960) as modified by Mathieson (1970). For each animal, faecal DM output was calculated using the formula:

$$\text{Faecal DM (kg/day)} = \frac{Cr_2O_3 \text{ intake (g/day)}}{Cr_2O_3 \text{ in faeces (g/kg DM)}}$$

The organic matter digestibility (OMD) coefficients for the diet were then calculated as follows:

$$\text{OMD} = \frac{\text{Food OM (kg)} - \text{Faeces OM (kg)}}{\text{Food OM (kg)}}$$

The cellulose digestibility coefficients were similarly calculated. The OMD of the forages was calculated by difference by assuming an overall OMD coefficient of 0.80 for concentrate i.e. rolled barley and cereal pencil (Anon. 1976).

***Animal weighing***

All animals were weighed at the beginning and at the end of each experimental period. Weighing was conducted at 0830 h before the morning meal to minimize the effect of fluctuations in the gut fill (Hughes 1976).

***Test of Blaxter's et al. conclusion***

The conclusion of Blaxter et al. (1966) on the proportionality of intake of long forages in mixtures, was tested by comparing the value of the expected intake with the observed actual intake of the basal forage given ad lib. The expression used in the calculations were:

$$\text{Expected intake of Fb} = 1 - \frac{\text{Intake of Fs in mixture (kg)}}{\text{Max. intake of Fs when offered as a sole diet (kg)}}$$

$$\text{Observed intake of Fb} = \frac{\text{Intake of Fb in mixture (kg)}}{\text{Max. intake of Fb when offered as a sole diet (kg)}}$$

(*Fs = forage designated as supplement and given in restricted amount

Fb = forage disignated as basal and given ad lib.)

With OMD however, the graphical method was used. It was assumed that the OMD of the mixture altered in a linear manner by the amount which was proportional to the OMD of the individual forage constituent in the mixtures. Agreement in the observed values (for intakes or OMD coefficients) to the corresponding expected values, indicate confirmation of the finding of Blaxter et al. (1966).

***Statistical analysis***

All analyses of variance were made using Genstat Statistical Package (Genstat V Mark 4.03, 1980, Lawes Agricultural Trust, Rothamsted Expt. Station).

**Results**

***Experiment 1***

The mean daily DM intake of grass silage and barley straw given ad lib. as a sole diet were 5.72 kg and 3.51 kg respectively (*Table 1*). In the mixtures i.e. treatment G15, G10 and G5, the allocated silage supplements were 3.40, 2.27 and 1.14 kg respectively, and were completely consumed. The basal feed straw, which

Table 1. Daily dry matter intake, organic matter and cellulose digestibility coefficients and digestible organic matter intake of 5 diet treatments by heifers

| | G | G15 | G10 | G5 | S | s.e.d |
|---|---|---|---|---|---|---|
| No. of animals | 8 | 8 | 8 | 8 | 8 | |
| Liveweight (kg) | 320 | 318 | 324 | 318 | 323 | 2.4 |
| Intake (kg DM/day) | | | | | | |
| Concentrate | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | |
| Grass silage | 5.72 | 3.40 | 2.27 | 1.14 | – | |
| Barley straw | – | 0.77 | 1.95 | 2.69 | 3.51 | |
| Total forage | 5.72 | 4.17 | 4.22 | 3.83 | 3.51 | 0.179 |
| OMD of diet | 0.725 | 0.691 | 0.649 | 0.612 | 0.551 | 0.0123 |
| Cellulose digestibility | 0.771 | 0.714 | 0.652 | 0.607 | 0.529 | 0.0149 |
| OMD of forage | 0.699 | 0.646 | 0.593 | 0.535 | 0.427 | 0.0194 |
| DOMI of diet (kg/day) | 4.596 | 3.807 | 3.571 | 3.183 | 2.699 | 0.125 |

G = grass silage
G15 = 15 kg grass silage + straw
G10 = 10 kg grass silage + straw
G5 = 5 kg grass silage + straw
S = straw

was given ad lib. was consumed at 0.77, 1.95 and 2.69 kg/day in G15, G10 and G5 respectively, making total intakes of the forage mixtures of 4.17, 4.22 and 3.83 kg DM/day respectively. These intakes were lower than the mean maximum intake of the silage given alone ($p < 0.01$) but were not significantly higher than the intake of straw. The OMD of the forages in the mixtures also decreased progressively as the amount of silage in the mixture was reduced ($p < 0.001$). Similarly there was also a steady decrease in the daily intake of digestible organic matter (DOMI) from 4.60 kg with silage alone to 3.80 kg (G15), 3.57 kg (G10), 3.18 kg (G5) and to 2.70 kg with straw as the only diet.

***Experiment 2 Part A***

The mean daily DM intake of straw given alone was 3.73 kg/animal. When supplemented with 3.28 kg DM of lucerne silage (SL), intake of straw decreased to 2.15 kg but total forage intake increased to 5.43 kg. With supplement of 3.18 kg DM of maize silage (SM), intake of straw was 1.84 kg and total forage intake was 5.02 kg/day (*Table 2a*). The rate of substitution in the intake of straw were similar in both mixtures i.e. 0.48 kg per kg of lucerne silage (SL) and 0.59 kg per kg maize silage (SM). The daily intake of digestible organic matter (DOMI) increased from 1.88 kg with straw alone to 2.97 kg in SL and 3.04 kg in SM.

***Experiment 2 Part B***

In Part B, the actual DM intake of the supplement (lucerne silage) were 1.68 kg (ML1), 3.35 kg (ML2) and 4.21 kg (ML3). Intakes of the basal forage given i.e. maize silage, in the three mixtures were 5.72 kg (ML1), 4.53 kg (ML2) and 3.78 kg (ML3) giving total DM intake of forages of 7.40, 7.88 and 7.99 kg/day per animal respectively ($p < 0.05$). The reduction rate in the consumption of maize silage as a result of increasing lucerne silage supplement were 0.65 kg (ML1), 0.68 kg (ML2) and 0.72 kg (ML3) per kg lucerne silage. Digestibility of OM and intake of DOM were similar in the three mixtures (*Table 2b*).

***Experiment 2 Part C***

The DM intake of maize silage given alone (S) was 6.81 kg which was significantly less than the intake of lucerne

Table 2a. Daily dry matter intake, organic matter and cellulose digestibility coefficients and digestible organic matter intake of 3 diet treatments by heifers

| | S | SL | SM | s.e.d. |
|---|---|---|---|---|
| No. of animals | 9 | 9 | 9 | |
| Liveweight (kg) | 299 | 299 | 303 | 16.1 |
| Intake (kg DM/day) | | | | |
| Concentrate | 0.43 | 0.43 | 0.43 | |
| Barley straw | 3.73 | 2.15 | 1.84 | |
| Lucerne silage | – | 3.28 | – | |
| Maize silage | – | – | 3.18 | |
| Total forage | 3.73 | 5.43 | 5.02 | 0.210 |
| OMD of diet | 0.477 | 0.552 | 0.590 | 0.018 |
| Cellulose digestibility | 0.580 | 0.603 | 0.593 | 0.018 |
| OMD of forage (by diff.) | 0.442 | 0.532 | 0.573 | 0.021 |
| OMD of diet (kg/day) | 1.879 | 2.972 | 3.039 | 0.170 |

S = straw
SL = 3 kg lucerne silage + straw
SM = 3 kg maize silage + straw

Table 2b. Daily dry matter intake, organic matter and cellulose digestibility coefficients and digestible organic matter intake of 3 diet treatments by heifers

| | ML1 | ML2 | ML3 | s.e.d. |
|---|---|---|---|---|
| No. of animals | 9 | 9 | 9 | |
| Liveweight (kg) | 331 | 330 | 341 | 20.1 |
| Intake (kg DM/day) | | | | |
| Concentrate | 0.43 | 0.43 | 0.43 | |
| Lucerne silage | 1.68 | 3.35 | 4.21 | |
| Maize silage | 5.72 | 4.53 | 3.78 | |
| Total forage | 7.40 | 7.88 | 7.99 | 0.423 |
| OMD of diet | 0.684 | 0.670 | 0.660 | 0.006 |
| Cellulose digestibility | 0.654 | 0.649 | 0.648 | 0.008 |
| OMD of forage (by diff.) | 0.677 | 0.663 | 0.653 | 0.006 |
| DOMI of diet (kg/day) | 5.01 | 5.17 | 5.14 | 0.282 |

ML1 = 1.5 kg lucerne silage + maize silage
ML2 = 3.0 kg lucerne silage + maize silage
ML3 = 4.5 kg lucerne silage + maize silage

silage (L) at 8.11 kg (*Table 2c*). In the mixture when both forages were given side by side simultaneously (L + M) the total intake was 8.14 kg. It was observed that when first introduced, most animals preferred lucerne silage, but their choice shifted gradually to maize silage. The average intake of lucerne silage as a percentage of total forage DM intake in the mixtures was 60% in week 1, 53% in week 2 and 45% in week 3.

The OMD of maize silage (0.686) was significantly higher than that of lucerne silage (0.629), but because of the higher intake of lucerne silage, intake of DOM by animals given this forage was better i.e. 4.86 vs 4.68 kg/day. The OMD of the mixture (L + M) was 0.666 while the daily DOMI was 5.29 kg.

***Experiment 3***

Six consecutive 5-day periods (P1 to P6) were completed. During this time the DM in the lucerne increased from 200 g/kg in

Table 2c. Daily dry matter intake, organic matter and cellulose digestibility coefficients and digestible organic matter intake of 3 diet treatments by heifers

| | L | M | L + M | s.e.d. |
|---|---|---|---|---|
| No. of animals | 9 | 9 | 9 | |
| Liveweight (kg) | 332 | 333 | 337 | 16.0 |
| Intake (kg DM/day) | | | | |
| Concentrate | 0.43 | 0.43 | 0.43 | |
| Lucerne silage | – | – | – | |
| Maize silage | – | 6.81 | – | |
| Total forage | 8.11 | 6.81 | 8.14 | 0.514 |
| OMD of diet | 0.629 | 0.686 | 0.666 | 0.009 |
| Cellulose digestibility | 0.652 | 0.631 | 0.647 | 0.013 |
| OMD of forage (by diff.) | 0.627 | 0.685 | 0.658 | 0.014 |
| DOMI of diet (kg/day) | 4.86 | 4.68 | 5.29 | 0.306 |

L = lucerne silage
M = maize silage
L + M= lucerne silage + maize silage

Table 3. Daily dry matter intake, organic matter and cellulose digestibility coefficients and digestible organic matter intake of lucerne cut at 6 different cutting ages and mixture of lucerne and hay

| | P1 | P2 | P3 | P4 | P5 | P6 | s.e.d. |
|---|---|---|---|---|---|---|---|
| Intake (kg DM/100 kg W) | | | | | | | |
| Lucerne | 1.98 | 1.93 | 2.06 | 2.11 | 2.10 | 2.06 | 0.036 |
| Lucerne + hay | 1.88 | 1.86 | 1.83 | 1.91 | 1.95 | 1.98 | 0.037 |
| s.e.d. | 0.129 | 0.124 | 0.083 | 0.093 | 0.079 | 0.078 | |
| OMD of diet | | | | | | | |
| Lucerne | 0.635 | 0.579 | 0.561 | 0.585 | 0.504 | 0.529 | 0.0184 |
| Lucerne + hay | 0.646 | 0.588 | 0.552 | 0.587 | 0.575 | 0.533 | 0.0145 |
| s.e.d. | 0.009 | 0.016 | 0.022 | 0.006 | 0.027 | 0.016 | |
| Cellulose digestibility | | | | | | | |
| Lucerne | 0.633 | 0.586 | 0.546 | 0.581 | 0.512 | 0.541 | 0.0193 |
| Lucerne + hay | 0.653 | 0.610 | 0.560 | 0.594 | 0.608 | 0.565 | 0.0166 |
| s.e.d. | 0.013 | 0.013 | 0.022 | 0.009 | 0.031 | 0.017 | |
| OMD of forage (by diff.) | | | | | | | |
| Lucerne | 0.627 | 0.568 | 0.550 | 0.576 | 0.491 | 0.517 | 0.0194 |
| Lucerne + hay | 0.638 | 0.578 | 0.539 | 0.576 | 0.565 | 0.520 | 0.0154 |
| s.e.d. | 0.101 | 0.017 | 0.023 | 0.006 | 0.028 | 0.017 | |
| DOMI of diet (kg/100 kg W) | | | | | | | |
| Lucerne | 1.196 | 1.044 | 1.094 | 1.176 | 1.011 | 1.041 | 0.0498 |
| Lucerne + hay | 1.165 | 1.043 | 0.948 | 1.080 | 1.082 | 1.012 | 0.030 |
| s.e.d. | 0.075 | 0.071 | 0.058 | 0.050 | 0.052 | 0.060 | |

P1 = day 40–44 P4 = day 55–59
P2 = day 45–49 P5 = day 60–64
P3 = day 50–54 P6 = day 65–69

P1 to 259 g/kg in P6, nitrogen declined from 32 to 26 g/kg DM and cellulose increased from 333 to 371 g/kg DM. In terms of intake, no changed was observed throughout the experiment. In the mixture (treatment LH), the total intake of lucerne and hay were similar to the intake of lucerne alone (*Table 3*).

The OMD of lucerne declined at the rate of 0.004 unit/day from 0.627 in P1 to

0.517 in P6. These values were similar to the OMD of the mixture within each period i.e. 0.638 (P1) to 0.520 (P6).

**Discussion**

For the conclusion of Blaxter et al. (1966) on proportionality of intake to be true, the expected and the observed intake of the basal forage given ad lib. must have similar values over all levels of supplementation. This was demonstrated in their work with three forages i.e. dry grass, hay and barley straw, but the largest amount of restricted forage supplement being only 55% of the total forage DM intake. The present experiment thus provide an opportunity to test this hypothesis with a wider range of forages and levels of supplementation ranging from 23% to 82% of total intake.

As indicated in *Table 4*, deviation to this general rule did occur with different forage combinations. Intakes of barley straw and grass hay were negatively affected in Expt. 1 and Expt. 3, while intake of barley straw and maize silage were positively affected when they were given with lucerne silage (Expt. 2). These deviations were apparently related to the type as well as the level of the supplements used. In Expt. 1, for example, the negative associative effect on the intake of straw was found when the high quality silage supplement was given in large amount, and not when in small amount. Similar situations occurred in Expt. 3, although the deviation was small. On the other hand in Expt. 2 the positive effect on the intake of the basal forage (maize silage) occurred at all levels of lucerne silage supplementation. Report by Mosi and Butterworth (1983; 1985), showed that consumption by sheep of low quality forages (maize stover, oat straw and wheat straw) have also showed a similar trend when supplemented with high quality legume hay. Thus providing further evidence on the importance of quality, types as well as the levels of inclusion of the forage identified as supplement.

The intake of a forage low in N can be improved by supplementing with a legume or high protein forage to provide N for rumen microbial activity (Allden 1981; Coombe 1981). In Expt. 1 and Expt. 2 the contents of crude protein in barley straw were less than the minimum 8% required for optimum microbial activity. Thus a positive associative effect on

Table 4. Comparison of the expected and observed intakes and the expected and observed organic matter digestibilities (OMD) of the basal forages in the mixtures expressed as proportions of their maximum intakes or OMDs

| Expt. | Treatment | Basal forage | Observed intake | Expected intake | Observed OMD | Expected OMD |
|---|---|---|---|---|---|---|
| 1 | G15 | Barley straw | 0.22 | 0.35 | 0.66 | 0.59 |
| | G10 | Barley straw | 0.56 | 0.57 | 0.59 | 0.54 |
| | G5 | Barley straw | 0.77 | 0.78 | 0.54 | 0.48 |
| 2 | SL | Barley straw | 0.58 | 0.55 | 0.54 | 0.54 |
| | SM | Barley straw | 0.49 | 0.49 | 0.57 | 0.58 |
| | L1M | Maize silage | 0.84 | 0.79 | 0.68 | 0.67 |
| | L2M | Maize silage | 0.67 | 0.58 | 0.66 | 0.66 |
| | L3M | Maize silage | 0.54 | 0.49 | 0.65 | 0.65 |
| 3 | LH(P1) | Hay | 0.27 | 0.29 | 0.64 | 0.62 |
| | LH(P2) | Hay | 0.25 | 0.26 | 0.58 | 0.58 |
| | LH(P3) | Hay | 0.27 | 0.33 | 0.54 | 0.56 |
| | LH(P4) | Hay | 0.33 | 0.36 | 0.58 | 0.58 |
| | LH(P5) | Hay | 0.34 | 0.35 | 0.56 | 0.53 |
| | LH(P6) | Hay | 0.34 | 0.33 | 0.52 | 0.54 |

intake of straw might have been expected when a supplement of protein-rich silage was given. That it had occurred only with lucerne silage and not with grass silage or maize silage further suggest the importance of quality and levels of supplements used, which was probably also related to the degradability and retention time of the mixture in the rumen. Alternatively, the associative effects on the intake may have been due to the influence of palatability, that is the interaction of the feed with the sense of touch, smell and taste (Demarquilly 1980). Greenhalgh and Reid (1971) showed palatability to be important in limiting the intake of poor quality forages such as straw by sheep, and Kenney and Black (1984) have measured preferences between forages by sheep. In Expt. 2 in which two forages were offered simultaneously to determine feed preferences, the animals preferred maize silage to lucerne silage. This may also explain the positive and negative associative effects of the basal forages in Expt. 1, Expt. 2 and Expt. 3.

Another important feature of the results was the variations in the substitution rate of the basal forages by different amounts of supplementary forages. In Expt. 1, the substitution rate of straw intake decreased from −0.72 to −0.81 kg DM per kg DM silage, as the proportion of silage in the mixture increased from 30% to 82%. In Expt. 2A the reduction in the intake of maize silage changed from −0.63 to −0.66 to −0.76 kg DM per kg of lucerne silage as the lucerne silage component was raised from 23 (ML1) to 42 (ML2) and 53% (ML3) of the total forage intake respectively. These effects are therefore contrary to the finding of Blaxter's et al. (1966) in which it is implicit that the same rate of substitution should occur with all supplementary levels.

Other workers have also reported similar changing substitution rates. McIlmoyle and Murdoch (1977) gave suppplement of dried grass processed as cobs to steers offered grass silage ad lib. They found that the depression in the intake of silage was −0.32 kg when dried grass constituted 26% of the diet and −0.40 kg per kg dried grass, when dried grass inclusion was raised to 50%. Mosi and Butterworth (1985) found intake of teft straw offered ad lib. to sheep decreased progressively by −0.33 kg to −0.66 kg per kg legume hay supplement as the supplement was increased from 24% to 90%. These reports as well as that in the present work, indicate that the substitution rate of a forage offered ad lib. by another forage given to supplement it, increases with increasing levels of supplementation. The fact that the supplements were of lower-fill capacity relative to the basal forage and should have resulted in a decreasing substitution rate, suggest that a different factor may be responsible for this phenomenon.

Small, consistent and positive associative effect in the digestibility of the diets were observed in Expt. 1. In the other two experiments there was close agreement between the expected and observed OMD coefficients. Possible causes of such effects were discussed by Schneider and Flatt (1975).

In practise, the overall results of the experiments reported here, provide evidence to support the conclusion of Blaxter's et al. (1966). On this basis, therefore, supplementing basal forage with high quality forage will not show positive effect on intake of the basal forage if nitrogen in the basal forage is adequate. Similarly, no positive associative effect on digestibility will occur from the extra nitrogen that might be available from the supplement if the nitrogen in the basal forage is sufficient for microbial requirement (Fahmy et al. 1984). Therefore the supplement will only substitute for the basal forage and increase the digestibility of the diet, in proportion to the amount of the supplement given and its maximum intake. It also follows that the change in DOMI is predictable from the amounts of the supplement given. But if palatability is an important factor, the animals may select forage on this basis and intake will not be accurately predicted by the proportionality theory. The effects of this factor on the intake of forages in mixtures therefore merit further investigation.

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