ANIMAL SCIENCE RESEARCH CENTRE

Fermentation characteristics and nutritional value of crimped maize grain

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FOR EBLEX

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1.0 Summary

A series of three experiments were undertaken to investigate the effects of different additive treatments on the fermentation characteristics of crimped maize and to compare the rumen degradability and whole tract digestibility characteristics of crimped maize with rolled barley.

In experiment 1, crimped maize was ensiled in laboratory scale silos using either Pioneer 11A44© or Crimpstore© additives at either the recommended or twice the recommended rate. The fermentation characteristics of crimped maize treated with each additive reflected their mode of action. The initial decline in pH was more rapid and NH_3-N content higher for crimped maize treated with Crimpstore© than either the untreated or Pioneer 11A44© treated crimped maize because Crimpstore© is an acid based additive containing formic acid, ammonium formate, propionic acid, benzoic acid and ethyl benzoate as active ingredients. The rate of pH decline was slower and similar to the control for crimped maize treated with Pioneer 11A44© because the initial WSC of the crimped maize was high (235 g/kg DM) and Pioneer 11A44© it is inoculant containing *Lactobacillus buchberi* as the active ingredient.

The higher crude protein in the Crimpstore© treated crimped maize indicates the presence of non-protein nitrogen derived from ammonium formate as an active ingredient. The lower NDF content and slightly higher predicted 'D' value and ME content of the Pioneer 11A44© treated crimped maize may reflect the breakdown of NDF by *Lactobacillus buchneri* during ensiling. The nutritional value of all crimped maize treatments was high, with the mean predicted 'D' value and ME content being 880 g/kg DM and 13.8 MJ.kg DM respectively.

In experiment 2, the rumen degradability characteristics of crimped maize and rolled barley were determined in three wether sheep fitted with permanent rumen cannullae using the *in situ* technique. Crimped maize and rolled barley were both highly degradable in the rumen. However, the rates of DM and starch degradation were lower for crimped maize than rolled barley (DM, 0.056 *vs* 0.072; starch, 0.059 *vs* 0.075 respectively). At rumen outflow rates of 0.05 and 0.08 the effective degradability of starch was lower for crimped maize than rolled barley (*0.05*, 0.622 vs 0.660; *0.08*, 0.503 vs 0.544 respectively). As a consequence, the amount of undegradable starch supplied by crimped maize at rumen outflow rates of 0.05 and 0.08 was greater than that of rolled barley (*0.05*, 246 vs 228 g/kg DM; *0.08*, 361 vs 305 g/kg DM).

In experiment 3 whole tract digestibility coefficients and energy values for crimped maize and rolled barley were determined in nine wether lambs using the bag and harness technique. Nutrients digestibility coefficients for crimped maize were generally lower than those for rolled barley. However, the digestibility of starch was high (1.0) in both feeds. Although the GE digestibility of crimped maize was lower than that of rolled barley (0.784 *vs* 0.818 respectively), the GE value was higher (18.7 vs 18.1 MJ/kg DM respectively). Consequently, the calculated DE values for both crimped maize and rolled barley were similar (14.7 and 14.8 MJ/kg DM respectively).

The predicted ME values for both crimped maize and rolled barley were similar (11.9 vs 12.0 MJ/kg DM respectively). However, the ME value of the crimped maize was lower than that predicted in experiment 1 (13.8 MJ/kg DM). Lower values may be attributed to experimental error, or urinary and methane energy losses being lower than the 0.19 assumed by AFRC (1993) using ME = 0.81 DE.

The results indicate that crimped maize grain has a similar ME value to rolled barley. However, the site of digestion may be different, with a lower proportion of the starch being degraded in the rumen. This may results in a higher proportion of energy being derived from glucose rather than volatile fatty acids which may influence the efficiency of energy utilisation and animal performance.

2.0 Introduction

There is growing interest in the feeding of grain maize to cattle due to its potentially high energy (ME 14.5 MJ/kg DM) and starch (710 g/kg DM) content. A relatively high proportion of the starch (350 g/kg DM) is thought to be rumen undegradable compared to barley (150 g/kg DM), which should reduce the potential for problems associated with rumen acidosis and change the nature of energy substrate supply, such that a greater proportion of the energy is available as glucose instead of volatile fatty acids. In the UK, the majority of grain maize is fed to dairy cows although there is increasing interest in its use in beef finishing diets. However, there is currently limited information on feeding grain maize to beef cattle.

According to Grove (2009) grain maize is generally grown south of a line from Bristol to East Anglia, any further north and yields and maturity are likely to suffer. However, the development of early maturing varieties and the use of plastic can lift this growing area to a line from Lancaster to Durham. The average yield is 9-11 tonnes/ha at 300-350 g/kg moisture, but this is only on good land. It is not possible to obtain lower moisture levels without drying. The crop is typically harvested 3-6 weeks later than forage maize, crimped and treated with an acid or inoculant additive, prior to ensiling. Jones (2009) states that there is significant interest in growing grain maize in the livestock dense areas of the Midlands and North of England. Arable farmers in the West Midlands also consider the crop to be an ideal alternative to sugar beet since the closure of the Allscott factory just outside Shrewsbury, and are selling the crop to livestock farmers.

Morgan (2009), states that grain maize needs to be combined with a special header attached to the front of a normal forager. Since grain maize is harvested later than other crops it therefore extends the working season of machines, which is appreciated by contractors. The “straw” is then incorporated. There are also benefits in terms of nutrient return, particularly P & K, which are estimated by Jones (2009) to be approximately 30 kg P and 50 kg K. Harvesting of maize grain also reduces soil on roads and the chopped stalks act as a carpet and keep machines cleaner than might be expected.

Crimped grain maize can be stored in a clamp or ag-bag and therefore farmers do not need expensive, dry grain storage. In principle, production costs for grain maize are similar to forage maize as ‘no extras’ are required.

Traditionally rolled barley is used as the main energy source in intensive beef ration since wheat can cause problems with acidosis, although standard advice suggests that up to 0.5 of the cereal component can be replaced with wheat without causing significant problems. Crimped maize grain potentially offers a cheaper alternative to either barley or wheat (Marsh 2010) which may reduce problems associated with acidosis and enhance animal performance by changing the nature of energy substrate supply. The objective of the current series of experiments was to investigate the effects of different additive treatments on the fermentation characteristics of crimped maize grain and to determine its rumen degradability and whole tract digestibility characteristics in sheep.

3.0 Experiment 1 (fermentation characteristics)

3.1 Objectives:

To investigate the effects of additive type and application rate on the fermentation pattern, chemical composition and nutritional value of crimped maize grain

3.2 Materials and methods:

Maize was grown, harvested and crimped as described by Marsh (2010). Following harvest untreated crimped maize grain was either left untreated, or treated with one of two additives at either the recommended rate, or twice the recommended rate, to give five experimental treatments:

1. Control (no additive, C)
2. Pioneer 11A44© (2 l/tonne, P1)
3. Pioneer 11A44© (4 l/tonne, P2)
4. Crimpstore© (4 l/tonne, C1)
5. Crimpstore© (8 l/tonne, C2)

Crimpstore© (Kelvin Cave Ltd) is an acid based additive containing formic acid, ammonium formate, propionic acid, benzoic acid and ethyl benzoate as active ingredient, whereas Pioneer 11A44© (Pioneer Hi-Bred International Ltd) is a innoculant containing *Lactobacillus buchneri* as the active ingredient. After treatment the crimped maize was used in two experiments. In experiment 1a the crimped maize was ensiled in small scale silo's (2.0 kg) for; 1, 2, 4, 8 or 16 days with 3 replicates per treatment (75 silos in total) in a randomised block design. In experiment 1b the crimped maize was ensiled in larger scale silos (20.0 kg) for 100 days with 3 replicates per treatment (15 silos in total) in a randomised block design.

Each additive was made up as specified by the manufacturer and applied to small quantities of crimped maize using a pre-calibrated hand held plant sprayer at the required rate. During experiment 1a, each silo was lined with a plastic bag prior to ¾ filling with crimped maize and compacting. The plastic bag was then sealed with tape and the silo filled to the top with sand prior to sealing with black plastic and tape (Figure 3.1). After ensiling for the required time (1, 2, 4, 8 or 16 days) each silo was opened and the sand and tape removed. The plastic bags containing the maize were then removed and stored at -20 °C prior to further analysis. During experiment 1b, the procedure was similar to experiment 1a, however the larger silos was opened after 100 days. After opening subsamples of the ensiled material were taken and frozen at -20 °C prior to further analysis

Laboratory analysis

In experiment 1a, ensiled crimped maize samples were analysed for DM, pH, and NH_3-N. In experiment 1b, ensiled crimped maize samples were analysed for DM, pH, NH_3-N, CP, NDF, NCGD, starch, WSC and ash. Metabolisable energy (ME, MJ/kg DM) was predicted using the equation for compound feeds, as ME = (0.0140 NCGD) + (0.025 EE) and digestibility (D value) was predicted as D value = ME / 0.016 (AFRC 1993).

Statistical analysis

Both experiments were analysed by ANOVA using Genstat 13 (VSN International Ltd) as randomised block designs.

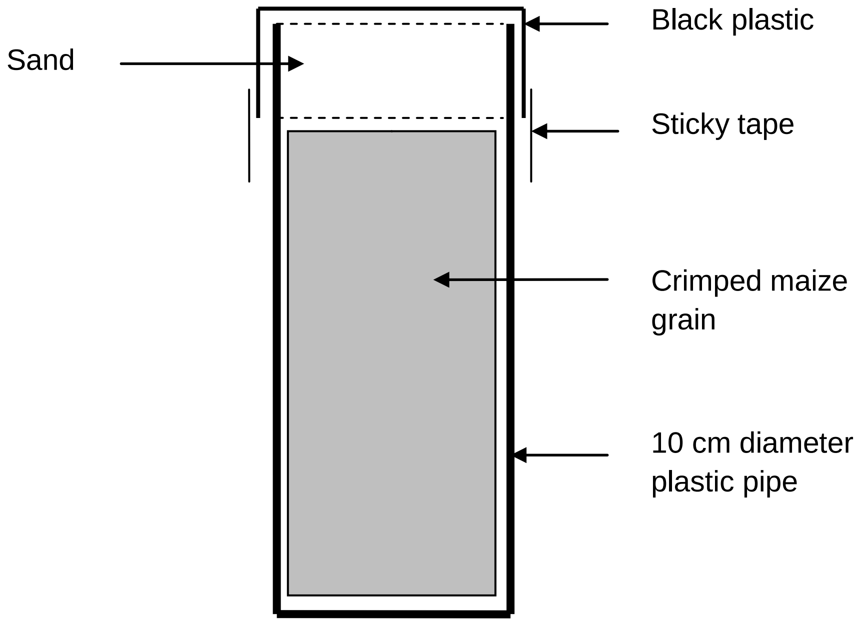

Figure 3.1

Diagram of the small scale experimental silos used in experiment 1a

Table 3.1

Chemical composition (g/kg DM) of the untreated crimped grain used in experiments 1a and 1b

Dry matter (g/kg)	630
Crude protein	73.6
Ether extract	45.1
Ash	15.6
Neutral detergent fibre	111.0
WSC	235
Gross energy (MJ/kg DM)	18.7

3.3 Results

The effects of time after ensiling on the pH of crimped maize ensiled with different additives are presented in table 3.2 and figure 3.2 There was no difference between treatments in initial pH. However, the rate of pH decline was significantly greater ($P<0.001$) for crimped maize treated with treatment C1, and C2 compared to treatments C, P1 and P2, with treatment C1 obtaining a pH of 4.7 within 2 days of ensiling and treatment C2 achieving a significantly lower ($P<0.001$) pH of 3.9. All treatments achieved a relatively stable pH by day 8 and a final pH of about 4.0 by day 16, except treatment C1 where the final pH of 4.4.

Table 3.2

Effect of time after ensiling (days) on the pH of crimped maize ensiled with different additives

	C	**P1**	**P2**	**C1**	**C2**	**s.e.d**	**P**
0	6.2	6.2	6.2	6.2	6.2	---	---
1	6.2	5.7[a]	5.5[a]	5.1	3.9	0.11	***
2	5.4[a]	5.1[a]	5.1[a]	4.7	3.9	0.14	***
4	4.4[a]	4.2	4.4[a]	4.6	3.8	0.05	***
8	4.0[a]	4.0[a]	4.2	4.5	3.9	0.04	***
16	3.9[ab]	3.8[a]	4.1[c]	4.4	4.0[bc]	0.03	***

*Means with the same superscript are not significantly different (P>0.05)

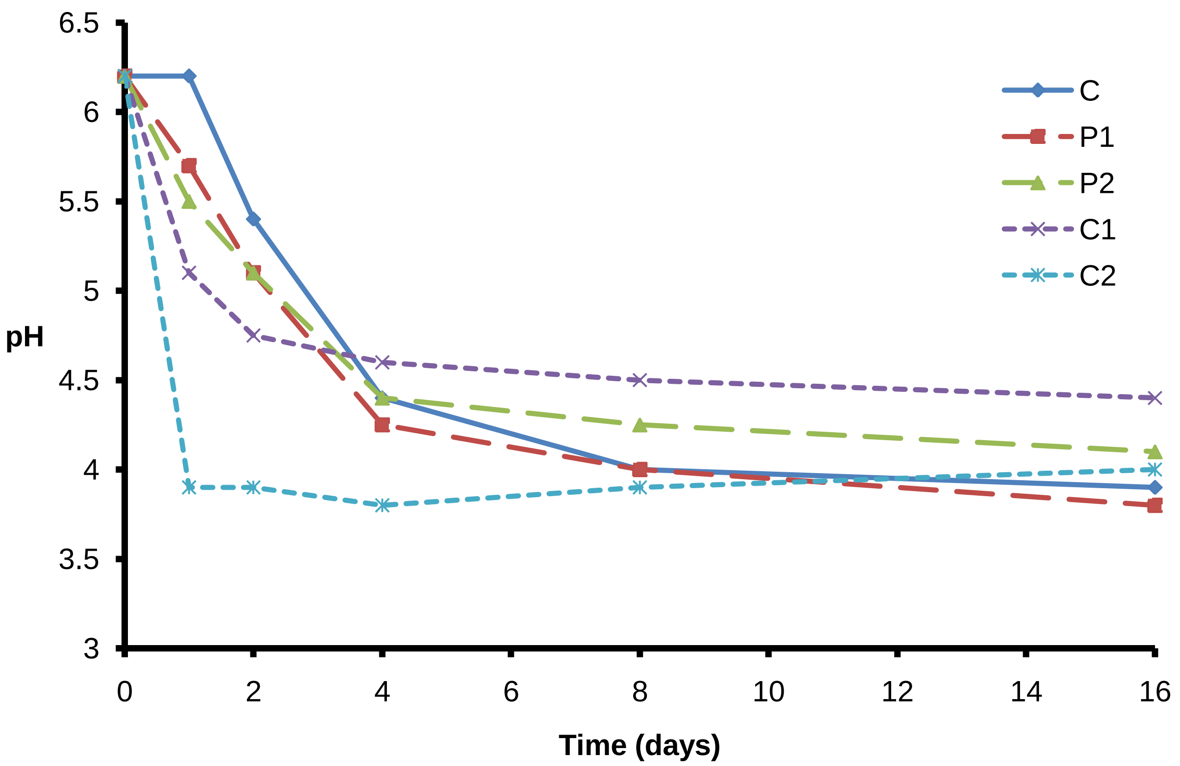

Figure 3.2

Effect of time after ensiling (days) on the pH of crimped maize ensiled with different additives

The effect of time after ensiling on the NH_3-N (g/kg TN) of crimped maize ensiled with different additives is presented in table 3.3 and figure 3.3 The initial NH_3-N content of crimped maize, prior to ensiling, was low (2.8 g/kg TN) and consistent across all experimental treatments, however throughout the experiment, treatment C1 had a significantly higher (P<0.001) NH_3-N content than treatment C, P1 and P2, and treatment C2 had a significantly higher (P<0.001) NH_3-N content than treatment C1.

Table 3.3

Effect of time after ensiling (days) on the NH_3-N (g/kg total N) of crimped maize ensiled with different additives

	C	**P1**	**P2**	**C1**	**C2**	**s.e.d**	**P**
0	2.8	2.8	2.8	2.8	2.8	---	---
1	2.8[a]	2.6[a]	2.8[a]	20.0	79.0	4.72	***
2	3.0[a]	2.9[a]	2.8[a]	25.0	79.0	5.41	***
4	6.0[a]	6.0[a]	5.5[a]	30.0	98.0	5.46	***
8	10.0[a]	11.0[a]	11.0[a]	32.0	90.0	5.80	***
16	15.0[a]	15.0[a]	17.0[a]	40.0	69.0	3.63	***

*Means with the same superscript are not significantly different (P>0.05)

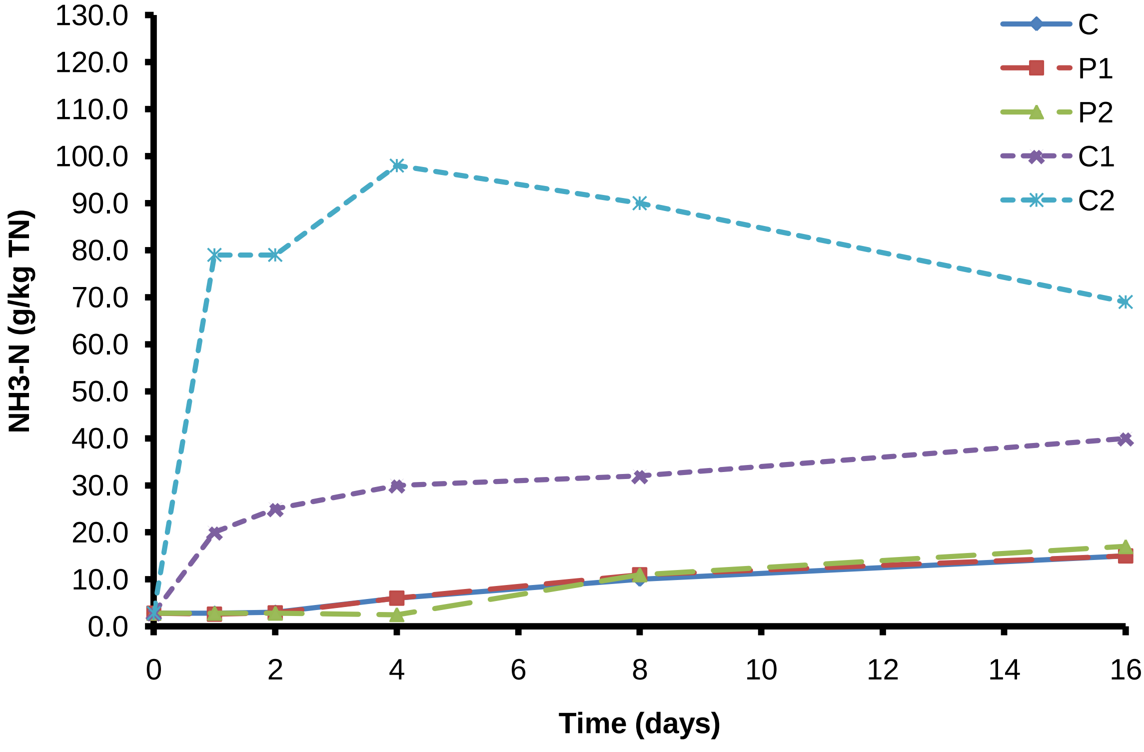

Figure 3.3

Effect of time after ensiling (days) on the NH_3-N (g/kg total N) of crimped maize ensiled with different additives

The final fermentation characteristics, chemical composition and predicted nutritional value of crimped maize treated with different additives after 100 days of ensiling are presented in table 3.4 There was no significant difference (P>0.05) in final DM, pH, WSC, EE ash and GE between treatment. All treatments were well fermented with a pH less than 4.0 and a residual WSC of less than 12.0 g/kg DM. However, treatment C1 had a significantly higher (P<0.001) NH_3-N content than treatments C, P1 and P2, and treatment C2 has a significantly higher ($P<0.001$) NH_3-N content than treatment C1. The CP and NDF content of treatments C1 and C2 was significantly ($P<0.001$) higher than that of treatments C, P1 and P2. However, the predicted 'D' value and ME contents were significantly lower ($P<0.001$).

Table 3.4

Fermentation quality, chemical composition and predicted nutritional value of crimped maize grain treated with different additives after ensiling for 100 days

	C	P1	P2	C1	C2	s.e.d	P
Fermentation quallity							
Dry matter (g/kg)	621	609	607	605	601	9.27	NS
pH	3.8	3.8	3.8	3.8	4.0	0.05	NS
NH_3-N (g/kg TN)	41.3[a]	52.7[a]	46.2[a]	104.3	119.6	5.17	***
WSC	9.3	11.2	10.5	11.7	12.2	2.06	NS
Chemical composition (g/kg DM)							
Crude protein	75.8[a]	74.3	75.9[a]	79.4	82.6	0.12	***
Ether extract	27.0	24.1	27.0	24.3	25.4	1.51	NS
Ash	14.1	14.6	14.3	14.6	15.1	0.57	NS
Neutral detergent fibre	110.9[a]	99.1[a]	103.1[a]	125.7[b]	127.1[b]	8.57	*
Gross energy	18.5	18.5	18.5	18.5	18.5	0.07	NS
Nutritional value (g/kg DM)							
Neutral cellulose digestibility	947[a]	950	948[a]	935	930	0.3	***
'D' Value	888[a]	885[a]	888[a]	873[b]	870[b]	0.4	**
Metabolisable energy (MJ/kg DM)	13.9[a]	13.9[a]	13.9[a]	13.7[b]	13.7[b]	0.06	**

*Means with the same superscript are not significantly different ($P>0.05$)

3.4 Conclusions

1. Crimped maize was successfully ensiled using no additive, Pioneer 11A44© and Crimpstore© at both the recommended rate and twice the recommended rate.

2. The fermentation characteristics of different additive treatments reflect their mode of action. The initial decline in pH was more rapid and NH_3-N content higher for crimped maize treated with Crimpstore© than either the untreated or Pioneer 11A44© treated crimped maize because Crimpstore© is an acid based additive containing formic acid, ammonium formate, propionic acid, benzoic acid and ethyl benzoate as active ingredients. The rate of pH decline was slower and similar to the control for crimped maize treated with Pioneer 11A44© because the initial WSC of the crimped maize was high (235 g/kg DM) and Pioneer 11A44© it is inoculant containing *Lactobacillus buchberi* as the active ingredient.

3. The higher CP in the Crimpstore© treated crimped maize indicates the presence of non-protein nitrogen derived from ammonium formate as an active ingredient. The lower NDF content and slightly higher predicted 'D' value and ME content of the Pioneer 11A44© treated crimped maize may reflect the breakdown of NDF by *Lactobacillus buchneri* during ensiling.

4. The nutritional value of crimped maize ensiled using no additive, Pioneer 11A44© and Crimpstore© was high, with a predicted 'D' value of 880 g/kg DM and a predicted ME content of 13.8 MJ.kg DM.

4.0 Experiment 2 (rumen degradability characteristics)

4.1 Objective

To determine the rumen degradability characteristics of crimped maize grain and compare them with rolled barley.

4.2 Materials and methods

The rumen degradability characteristics of the crimped maize grain used in the beef production trial (Marsh 2010) were determined according to the method of Sinclair *et al*. (1993). Three wether sheep weighing approximately 90 kg and fitted with permanent rumen cannulae were group housed on straw under continuous lighting with free access to water and a mineral lick. The sheep were fed a basal diet consisting of grass nuts, rolled barley, and distillers grains with a protein content of approximately 180 g/kg DM. Fresh feed was offered twice daily at approximately 09:00 and 16:00 h at a rate of 1.1 x maintenance (AFRC 1993). Approximately 5.0 g of dried crimped maize or rolled barley was weighed into synthetic fibre bags (4 bags per time point per sheep) with a pore size of 42 um and inserted into the rumen of each sheep 30 minutes after the morning feed and retrieved after incubation for 4, 8, 12, 24 and 48 h. After retrieval from the rumen the bags were rinsed in cold water prior to washing using the cold rinse cycle of an automatic washing machine. In addition, 6 synthetic bags containing each test feed were washed using the cold rinse cycle of an automatic washing machine to determine the immediately soluble fraction (*a*).

Chemical analysis

Both the crimped maize and rolled barley was analysed for DM, CP, EE, NDF ash and GE (Table 4.1). The residue samples were bulked within sheep for each time point and analysed for DM, CP and starch.

Statistical analysis

The DM, CP and starch degradability characteristics of the crimped maize and rolled barley were determined by fitting the data to the first order model of Orskov and McDonald (1979):

$$p = a + b\,(1 - e^{-ct})$$

Where '*p'* is the quantity degraded at time *'t'; 'a'* is the immediately soluble fraction; *'b*' is the insoluble but potentially degradable fraction; and '*c'* is the rate of degradation of fraction *'b*'. Effective degradability was calculated for rumen outflow rates of 0.05 and 0.08 as:

$$P = a + (b \times c) / (c + k)$$

Where 'P' is effective degradability and k is rumen outflow rate.

Differences between crimped maize and rolled barley in *'a', 'b*' and '*c'* values were determined by ANOVA using Genstat 13 (VSN International Ltd) as a randomised block design.

Table 4.1

Chemical composition (g/kg DM) of the crimped maize grain and rolled barley used in experiment 2

	Crimped maize	Rolled barley
Dry matter (g/kg)	630	840
Crude protein	73.5	115.1
Ether extract	13.2	5.3
Ash	15.6	23.2
NDF	111.0	217.3
Starch	727	669
Gross energy (MJ/kg DM)	18.7	18.1

4.3 Results

The DM degradation characteristics of the crimped maize and rolled barley are presented in table 4.2 and figure 4.1. The crimped maize had a higher immediately soluble DM fraction *('a')* and a significantly higher (P<0.05) insoluble but potentially degradable DM fraction ('*b*') than the rolled barley. Consequently the potentially DM degradability (*a*+*b*) was also significantly higher (P<0.01). However, the rate of DM degradation (*'c'*) was significantly lower (P<0.05) for the crimped maize than the rolled barley. The effective DM degradability of the crimped maize at rumen outflow rates of 0.05 and 0.08 was only slightly lower than that of the rolled barley.

The CP degradation characteristics of the crimped maize and rolled barley are presented in table 4.3 and figure 4.2.The rolled barley had a higher immediately soluble CP fraction ('*a*') than the crimped maize, but a significantly lower (P<0.05) rate of CP degradation ('*c*'). However, there was no significant difference (P>0.05) between the rolled barley and crimped maize in the both the insoluble but potentially degradable fraction ('*b*') and the potential CP degradability (*a*+*b*). The effective CP degradability of the crimped maize at rumen outflow rates of 0.05 and 0.08 was only slightly lower than that of the rolled barley.

Table 4.2

Dry matter (DM) degradation characteristics (dg) of barley and crimped maize in sheep

	Barley	Maize	s.e.d	P
Potential *dg*				
a	0.05	0.07	---	---
b	0.87	0.93	0.016	*
c	0.072	0.056	0.0047	*
a+*b*	0.92	1.00	0.016	**
r^2	98.5	97.9	---	---
Effective *dg*				
0.05	0.563	0.561		
0.08	0.462	0.453		

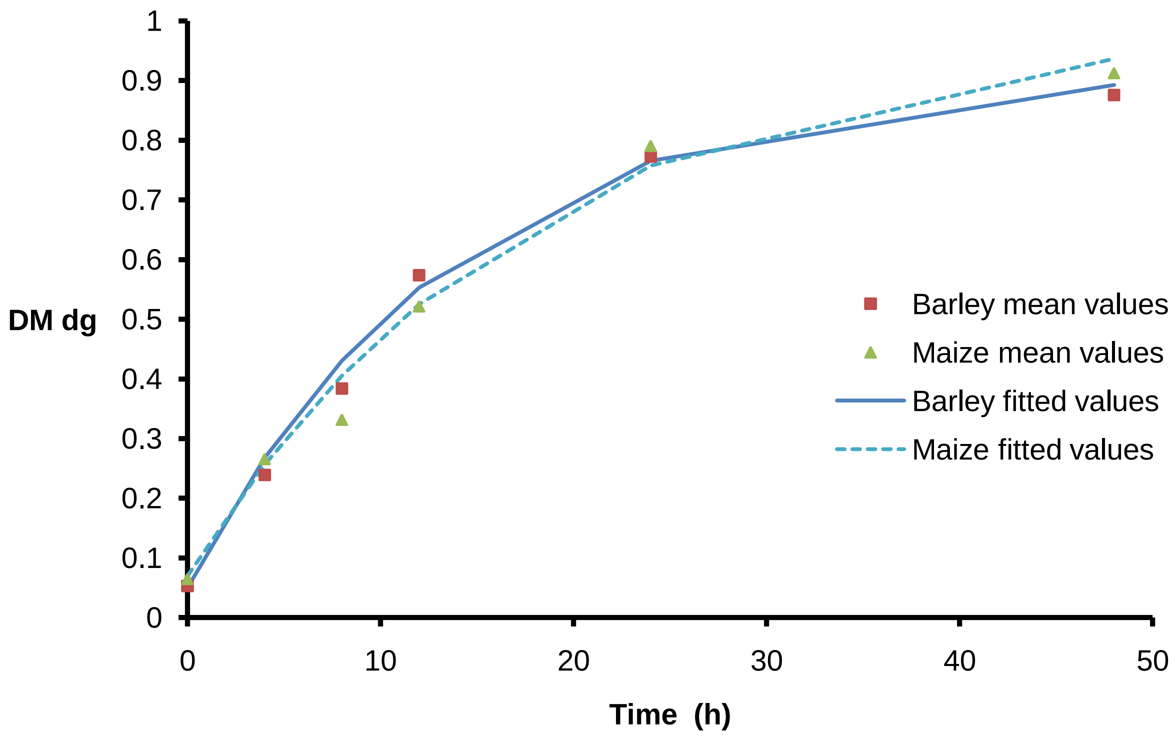

Figure 4.1

Dry matter (DM) degradation characteristics of barley and crimped maize in sheep

Table 4.3

Crude protein (CP) degradation characteristics (dg) of barley and crimped maize in sheep

	Barley	Maize	s.e.d	P
Potential *dg*				
a	0.25	0.18	---	---
b	0.90	0.79	0.081	NS
c	0.028	0.045	0.0058	*
a+b	1.15	0.97	0.081	NS
r^2	97.0	92.1	---	---
Effective *dg*				
0.05	0.573	0.554		
0.08	0.483	0.464		

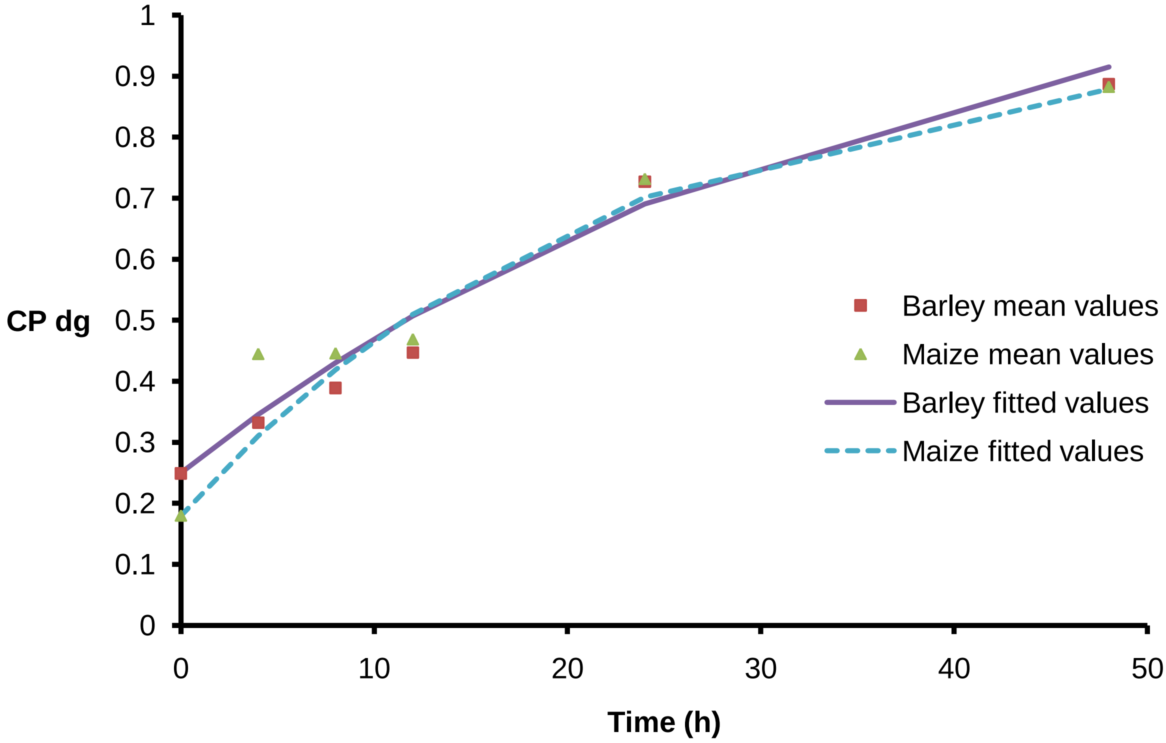

Figure 4.2

Crude protein degradation characteristics of barley and crimped maize in sheep

The starch degradation characteristics of the crimped maize and rolled barley are presented in table 4.4 and figure 4.3. Both the immediately soluble starch ('*a*') and the insoluble but potentially degradable starch fractions ('*b'*) for both the rolled barley and crimped maize were similar. However, crimped maize had a significantly higher (P<0.05) potential starch degradability (*a*+*b*) and a significantly lower (P<0.05) rate of starch degradability (*c*) than rolled barley. The effective starch degradability of the crimped maize at rumen outflow rates of 0.05 and 0.08 was lower than that of the rolled barley.

Table 4.4

Starch degradation characteristics (dg) of barley and crimped maize in sheep

	Barley	Maize	s.e.d	P
Potential *dg*				
a	0.06	0.07	---	---
b	1.00	1.02	0.010	NS
c	0.075	0.059	0.0054	*
a+*b*	1.06	1.09	0.010	*
r^2	97.1	95.7	---	---
Effective *dg*				
0.05	0.660	0.622		
0.08	0.544	0.503		

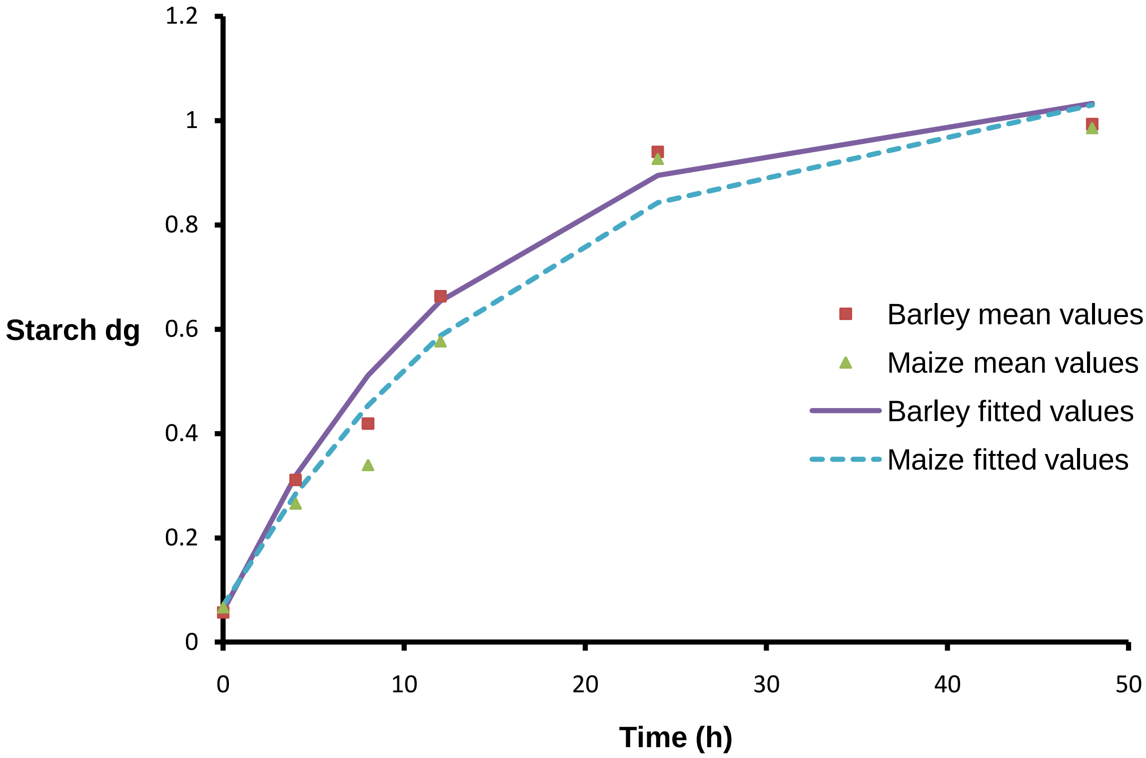

Figure 4.3

Starch degradation characteristics of barley and crimped maize in sheep

4.4 Conclusion

1. The DM fraction of both crimped maize and rolled barley was highly degradable in the rumen. However, the rate of DM degradation was lower for crimped maize than rolled barley.

2. The CP fraction of both crimped maize and rolled barley was highly degradable in the rumen. However, the rate of CP degradation was higher in crimped maize than rolled barley.

3. The starch fraction of both crimped maize and rolled barley was highly degradable in the rumen. However, the rate of starch degradation in crimped maize was lower than rolled barley.

4. The results indicate that at rumen outflow rates of 0.05 and 0.08 the amount of undegradable starch in crimped maize grain and rolled barley would be 246 *vs* 228 g/kg DM and 361 *vs* 305 g/kg DM respectively.

5.0 Experiment 3 (determination of the whole tract digestibility)

5.1 Objective:

To determine the whole tract digestibility and energy value of crimped maize grain and rolled barley in sheep.

5.2 Materials and methods:

The apparent whole tract digestibility of crimped maize and rolled barley was determined using the method described by Sinclair *et al.* (2003). Nine Texel wether lambs with a liveweight of 35-40 kg were housed in individual wire mesh floored pens (1.5 m x 2.0 m) with *ad-libitum* access to water and offered one of three dietary treatments:

1. Chopped hay (H)
2. Chopped hay + rolled barley (40:60 DM basis, H+B)
3. Chopped hay + crimped maize (40:60 DM basis, H+M)

All three diets were formulated to supply 1.1 x maintenance requirements as predicted by AFRC (1993) and offered as two equal meals at 08:30 and 1600 h daily. With a standard lamb mineral vitamin supplement added at the recommended rate. The experiment consisted of two periods each containing a 4 day adaptation period, a 7 day preliminary period and a 10 day collection period where faeces was collected using the bag and harness technique. Three lambs were offered each diet during each period. Throughout the trial feed intake was recorded and during the collection period the bags were emptied once daily at 08:30 h and the weight of faeces produced was recorded. A subsample of each days output (0.1) was stored at -20 °C prior to bulking within animals for subsequent analysis.

Chemical analysis:

Feed and faeces samples were analysed for DM, CP, EE, ash, NDF and GE (Table 5.1).

Statistical analysis:

Whole tract digestibility coefficients for chemical component were calculated from component intake and faecal output over the 10 day collection period as follows:

$$\text{Digestibility} = \frac{\text{Intake (kg)} - \text{faecal output (kg)}}{\text{Intake (kg)}}$$

Whole tract digestibility coefficients for the crimped maize and rolled barley were calculated by difference as follows:

$$\text{Digestibility} = \frac{\text{Intake from test feed} - (\text{faecal output} - \text{faecal output from hay})}{\text{Intake from test feed}}$$

5.3 Results

The whole tract digestibility coefficients and energy values of the three diets evaluated in experiment 3 are presented in table 5.2 There was no significant difference between diets H+B and H+M in DM, OM or GE digestibility. However, digestibility coefficients for both diets were significantly higher (P<0.001) than diet H. Diet H+B had a significantly higher (P<0.001) CP digestibility than diets H and H+M. However, the NDF digestibility of diet H was similar to that of diet H+B, but significantly higher (P<0.01) than that of diet H+M. There was no significant difference between diets H+B and H+M in DE or ME values. However, both diets had significantly higher values than diet H.

The digestibility coefficients and energy values of rolled barley and crimped maize, calculated by difference are presented in table 5.3. In general, the digestibility coefficients for all chemical components were higher for rolled barley than crimped maize. However, the DE and ME values for both crimped maize and rolled barley were similar.

Table 5.1

Chemical composition (g/kg DM) of the hay, crimped maize grain and rolled barley used in experiment 3

	Hay	Crimped maize	Rolled barley
Dry matter (g/kg)	877	630	840
Crude protein	75.7	73.5	115.1
Ether extract	2.6	13.2	5.3
Ash	75.5	15.6	23.2
NDF	685.2	111.0	217.3
Starch	---	727	669
Gross energy (MJ/kg DM)	16.84	18.7	18.1

Table 5.2

Whole tract digestibility coefficients and energy values for the three experimental diets in lambs

	H	H + B	H + M	s.e.d	P
Dry matter	0.555	0.677[a]	0.661[a]	0.0258	***
Organic matter	0.568	0.705[a]	0.688[a]	0.0241	***
Crude protein	0.376[a]	0.554	0.313[a]	0.0381	***
Neutral detergent fibre	0.615[a]	0.572[a]	0.487	0.0331	**
Gross energy	0.509	0.686[a]	0.667[a]	0.0219	***
DE (MJ/kg DM)	8.58	12.06[a]	11.96[a]	0.381	***
ME (MJ/kg DM)	6.95	9.76[a]	9.68[a]	0.309	***

*Means with the same superscript are not significantly different (P>0.05)

Table 5.3

Whole tract digestibility coefficients and energy values for rolled barley and crimped maize in lambs

	Rolled Barley	Crimped Maize
Period 1		
Dry matter	0.830	0.769
Organic matter	0.855	0.790
Crude protein	0.667	0.393
Neutral detergent fibre	0.683	0.022
Starch	1.000	1.000
Gross energy	0.846	0.776
DE (MJ/kg DM)	15.30	14.51
ME (MJ/kg DM	12.40	11.76
Period 2		
Dry matter	0.779	0.787
Organic matter	0.807	0.814
Crude protein	0.678	0.366
Neutral detergent fibre	0.491	0.297
Starch	1.000	1.000
Gross energy	0.790	0.791
DE (MJ/kg DM)	14.30	14.79
ME (MJ/kg DM)	11.58	12.98
Mean (periods 1 & 2)		
Dry matter	0.805	0.780
Organic matter	0.831	0.802
Crude protein	0.673	0.380
Neutral detergent fibre	0.587	0.159
Starch	1.000	1.000
Gross energy	0.818	0.784
DE (MJ/kg DM)	14.81	14.66
ME (MJ/kg DM	11.99	11.87

5.4 Conclusions

1. Crimped maize had a higher starch and GE content, but a lower CP and NDF content than rolled barley

2. Rolled barley had higher digestibility coefficients for most chemical components than crimped maize. However, the digestibility of starch was high (1.0) in both feeds.

3. Although the GE digestibility of crimped maize was lower than that of rolled barley the GE value (MJ/kg DM) was higher. Consequently, the calculated DE values for both rolled barley and crimped maize were similar at 14.8 and 14.7 MJ/kg DM respectively.

4. The predicted ME values for both crimped maize and rolled barley were similar at 11.9 and 12.0 MJ/kg DM respectively. The ME value of crimped maize was lower than that predicted in experiment 1 (13.8 MJ/kg DM). Lower values may be attributable to experimental error, or urinary and methane energy losses may be lower than 0.19 assumed by AFRC (1993) using the equation ME = 0.81 x DE.

6.0 Conclusion

The results indicate that crimped maize grain can be successfully ensiled using either no additive, Pioneer 11A44© or Crimpstore© at either the recommended, or twice the recommended rate. The fermentation characteristics and nutritional value may be influenced by the mode of action of the additive used. In the current experiment, the DE and ME values of crimped maize were similar to those of rolled barley. However, the site of digestion may be different, with a lower proportion of the starch being degraded in the rumen. This may results in a higher proportion of energy being derived from glucose rather than volatile fatty acids which may influence the efficiency of energy utilisation and animal performance.

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8.0 Acknowledgements

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