PARTIAL REPLACEMENT OF GRASS SILAGE WITH WHOLE-CROP CEREAL SILAGE FOR GROWING BEEF CATTLE

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Summary

A study was conducted to investigate the effect of different inclusion levels of urea treated whole-crop wheat silage (UWCWS) in grass silage based rations on the performance of growing beef cattle. The winter wheat (variety, Riband) was harvested (in the summer of 1991) at a dry matter proportion of 520 g/kg and treated with feed grade urea at the rate of 37 kg/tonne crop dry matter and preserved in a heavy duty plastic bag using a silo press. The urea treated whole crop wheat silage (UWCWS) was mixed with grass silage to replace 0.00 (S100), 0.33 (S33) and 0.67 (S67) parts of the forage dry matter and fed *ad libitum* in a cross over design to 18 Simmental X Holstein Friesian growing beef animals. Two energy sources {one high in starch, rolled barley (RB) and one high in digestible fibre, sugar beet pulp (SBP)} were fed to supply sufficient energy for the efficient use of nitrogen by the rumen micro-organisms. The data on DMIF (dry matter intake of forage), TDMI (total dry matter intake), DLWG (daily live weight gain), FCR (feed conversion ratio) were recorded and faecal samples were collected to determine the digestibility coefficients. Results revealed that with the inclusion of UWCW in the animals' diets the DMI of the forage was significantly increased ($p < 0.05$). The highest DMIF was found in the treatment "S33" (6.28 ± 0.25 kg) where 67% of the silage dry matter was replaced with the UWCW and the lowest value for DMIF was observed in the control treatment (5.03 ± 0.23 kg). The DLWG did not differ significantly between the treatments. However, treatment "S100" showed a trend towards a superior DLWG. Feed conversion ratio in the control treatment differed significantly from "S67" and "S33". The addition of the UWCW in the animals' diet resulted in the lower FCR. There was no effect of type of energy supplement on any aspect of performance either overall or in interaction with grass silage : UWCWS ratio. The regression and correlation coefficients for DMIF ($r = 5.22 + 0.0184x^{*}$), DLWG ($r = 1.04 - 0.00086x^{NS}$) and FCR ($r = 4.78 = 0.022x^{*}$) on the inclusion of UWCW in the diet were calculated. The effect of the inclusion of UWCW on the overall digestibility coefficients was significant ($p < 0.05$). The addition of the UWCWS in the diet decreased the digestibility of the DM, OM, ADF and NFE but effect on the protein digestibility was non significant. The results of present study suggests that a DLWG slightly over 1 kg can be achieved with UWCW during the store period (period in which animal performance targets are low especially during winter) and the prediction of ME was overestimated as the high intake of DM did not reflect in improved animal performance.

(Key Words : Urea Treated Whole-Crop Wheat Silage (UWCWS), Grass Silage, Growing Beef Cattle)

Introduction

Many managemental, feeding and environmental problems has been observed to be associated with grass silage feeding (Raza and Rowlinson, 1992), therefore, for the future sustainable livestock production these factors should be given due attention and considered with priority due to the increase in public concern on the environment and ground water pollution. The whole crop cereals silage has drawn attention of the workers as a suitable alternative to grass silage. It offers a single harvesting cost with high dry matter yield, predictable nutritive value and no effluent problem (Tetlow, 1990). The whole-crop cereals silage (WCCS) is characterised by low protein content (Tetlow, 1990) and this deficiency can be rectified by treating the crop with urea that would not only increase

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the nitrogen (N) content but also improves the stability of the WCC silage in the air.

When grass silage is fed to the animals, it undergoes an extensive and rapid degradation in the rumen and a high concentration of NH_3-N is available to the rumen microorganisms immediately after feeding with a lack of readily available source of energy. The lack of readily available source of energy for rumen micro-organisms to use rumen degradable nitrogen (RDN) efficiently, eventually allows the NH3-N losses across the rumen wall with subsequent excretion in the urine (Dawson et al., 1988). The treatment of the WCC silage with urea will also increase the N content of the silage and in the absence of sufficient and immediately available energy source to utilise this nitrogen, the fate of the non-protein nitrogen (NPN) would not be different than NPN of silage. The ability of the rumen micro-organisms to utilise the rumen degradable nitrogen (RDN) more efficiently can be improved by providing readily available source of energy to them (Thomas and Rea, 1988). There is sufficient literature (Tetlow and Wilkinson, 1990) on the use of WCC silage in the animals' diets but much work has not been done on the nutritive value and production potentials of the mixture of the WCCS and grass silage and its comparison with the grass silage only forage. When these two forages are fed in combination (one acidic; grass silage and one alkaline; urea treated whole crop cereal silage, UWCCS) they would neutralise each other and chances of the twist gut, rumen stasis and acetonaemia would be also minimised which have been reported on WCCS only forage.

Thus, a study was planned using cross over design with the aims to investigate (1) a suitable inclusion level of UWCWS (urea treated whole-crop wheat silage) in the animals' diet to replace the silage dry matter (2) to find out an appropriate energy source for efficient use of NH_3-N (3) the effect of different energy sources, at different inclusion levels of UWCWS in the animals' diets, on their performance.

Materials and Methods

Experimental animals

Animals used in this study were randomly selected from Simmental X Holstein Friesian herd maintained at experimental station (Cockle Park Farm, Morpeth) of University of Newcastle UponTyne, UK. The average weight and age of these animals were 335.81 ± 4.80 kg and 11.5 months respectively. These animals were allotted to 3 experimental diets in such a way that there were 6 animals on each diet and fed *ad libitum*. The records of individual feed intake were maintained through out the experimental period. Animals were fed through automatic Calan feeders.

Experimental diets

1) Urea treated whole-crop wheat silage (UWCWS)

The winter wheat (variety, Riband) was harvested at proportion of 520 g DM KG-1 in the summer of 1991. The whole-crop was chopped to a length 3−8 cm (Avg. length 5.5 cm) and treated with feed grade urea @73 kg urea/tonne whole-crop wheat dry matter. The urea was manually sprayed on the crop during ensiling and treated crop was preserved in heavy duty plastic bag using Silo press. This urea treated whole-crop wheat (UWCW) in conjunction with grass silage was fed to Simmental X Holstein Fiesian growing cattle from the winter of 1992 to the March of 1993. The ammonia released from the urea was not fully percolated in the crop and the pockets of the moulds were found in the treated material. The predicted ME value of UWCWS was calculated using the following equation (Rea, 1990);

$$ME = 0.15^{*} D$$

2) Grass silage

The rye grass silage was formed and preserved at Cockle Park Farm, Morpeth, in the summer of 1992 to use in this experiment.

3) Mixed forages

The urea treated whole-crop wheat silage was mixed with the grass silage to replace the 0.0, 0.33 and 0.67 dry matter of the grass silage. The mixing of these two forages was manually with fork. These experimental diets were fed to the growing beef cattle *ad libitum* in cross over design. The proportion of the forages in the mixed diets is given in table 1.

TABLE 1. PROPORTION OF THE FORAGE COMPOSITION OF THE DIETS ON DRY MATTER BASIS

Treatments	Silage	UWCWS
S100	1.0	0.0
S67	0.67	0.33
S33	0.33	0.67

4) Energy sources

The animals were offered two different types of energy sources. One energy source was high in starch

(Rolled barley, RB) and one energy source was high in digestible fibre (Sugar beet pulp, SBP). These two energy sources were fed along with the experimental mixed diets. The experiment was completed in two phases. In first phase, half of the animals in each treatment received the rolled barley and the other half received sugar beet pulp. In second phase energy sources were reversed. These two energy sources were fed in such amount that they supplied equal amount of metabolisable energy (25 MJ) to the animals. Each experimental diet supplied the sufficient metabolisable energy (ME), rumen degradable protein (RDP) and undegradable protein (UDP) to meet the growth requirements (ARC, 1988) of the animals to achieve the live weight gain targets of 1.00 kg/day.

Chemical composition of diets

The chemical composition of silage, urea treated whole-crop wheat silage (UWCWS), untreated whole-crop wheat silage (WCWS), rolled barley and sugar beet pulp is given in table 2.

TABLE 2. CHEMICAL COMPOSITION OF SILAGE, UWCW, BARLEY AND SUGAR BEET PULP ($g\ kg^{-1}$ DM)

Forages	Silage	UWCW	Barley	S.B.Pulp
OM	910.53	943.31	924.00	870.00
CP	130.57	145.04	111.00	99.26
ADF	297.30	282.46	41.22	136.32
NFE	440.04	503.81	757.48	628.56
EE	38.62	12.00	14.30	5.86
ASH	89.47	56.69	76.00	130.00
ME* (MJ/kg DM)	10.5	10.5	13.7	12.7

* Predicted (Rea, 1990)

Digestibility of the experimental diets

Digestion trial was conducted at the end of the experimental period to get more information about the nutritive value of the experimental diets. The digestibility coefficients of these diets were investigated. An external marker (Cr_2O_3) was mixed in the concentrates and fed to the animals at least 10 days before the collection of fecal samples to establish a uniform flow of the marker in the feces. The faecal samples were collected by grab method at the end of the production trial and stored in freezer (−20℃) for their further chemical analysis. The samples of rolled barley (RB), sugar beet pulp (SBP), grass silage, UWCWS and mixed forages were also collected and stored for chemical analysis. The DM, organic matter (OM), Ash, modified acid detergent fibre (MADF) and nitrogen free extracts (NFE) were determined by methods described by MAFF (1974). The crude protein (CP) and Cr_2O_3 were quantified by the methods Bradstreet (1965) and William et al. (1962) respectively. The pH of the silage, UWCWS, and mixed forages was recorded by method described by MAFF (1974).

Data collection

The refusals were collected daily to calculate the DM intake. The animals were weighed weekly before the next feeding to measure the daily live weight gain. The data on DMIF, TDMI (total dry matter intake), DLWG, pH of different diets and FCR were collected and statistiacally analysed using Minitab Inc. (window version 9.2, State college, U.S.A.) analyses programme.

Results and Discussion

Dry matter intake

The average daily dry matter intake of forage (DMIF) of animals on different treatments is given in table 3. The highest DMIF was found in treatment "S33" (6.28 ± 0.25 kg/day) where 67% dry matter of the silage was replaced with UWCWS and the lowest value for DMIF was in "S100" treatment (5.03 ± 0.23 kg/day) where grass silage was the only forage. The statistical analysis of data showed that effect of the treatments on the DMIF was significant ($p < 0.05$).

TABLE 3. THE INFLUENCE OF DIFFERENT RATES OF REPLACEMENT OF GRASS SILAGE DM WITH UWCW ON DMIF, LWG AND FCR (kg) RATIO

Treatments	S100	S67	S33
DMIF**	5.03 ± 0.23^{b}	6.15 ± 0.14^{a}	6.28 ± 0.25^{a}
TDMI**	6.67 ± 0.25^{b}	8.10 ± 0.09^{a}	8.11 ± 0.27^{a}
DLWG (NS)	1.12 ± 0.08^{a}	1.10 ± 0.06^{a}	1.06 ± 0.05^{a}
FCR*	6.57 ± 0.31^{a}	7.81 ± 0.32^{b}	7.98 ± 0.33^{b}
Forage pH	3.95	4.76	5.98

^{ab} = All the maens with the same superscript are showing non-significant difference between them.
± = SEM (standard error means)

The DMIF in treatment "S100" differed significantly with all other treatments while differences between treatment "S67" and treatment "S33" were nonsignificant (table 3). The effect of the different energy sources on the DMIF in the all treatments or in interactions with grass : UWCW ratio was non significant ($p < 0.05$). The regression and correlation coefficients for dry matter intake of forage on inclusion of UWCWS in the animals diet were significant ($p < 0.05$). The regression equation is given below;

$$DMIF = 5.22 + 0.0184X$$

where, X = Inclusion rate of UWCWS in diet.

The correlation coefficient between DMIF and addition of UWCWS in the diet was positive ($r = 0.55$).

These results clearly indicate that by replacing the dry matter of the silage with urea treated whole-crop wheat silage, the DMIF and TDMI of the animals on the mixed diets was markedly increased than the animals in control treatment where grass silage was the sole forage. The findings of the present study are also supported by the results of Hill and Leaver (1991, 1993); Phipps et al. (1990); Rea (1990) and Tetlow and Wilkinson (1990). Hill and Leaver (1993) mixed the UWCW silage with grass silage to replace the 0.0, 0.50 and 1.0 dry matter of the grass silage and found that by including the UWCW silage in the animals diets, the DMI was significantly increased and maximum intake was observed in that treatment where UWCW silage was the only forage. Phipps et al. (1990) reported a positive relationship between inclusion of WCW silage and maize silage in the animals' diets and their DMI. In contrast, some other workers (Tetlow and Wilkinson, 1990) reported a depression in the dry matter intake when inclusion level of UWCW silage was more than 75% on dry matter basis. They found a optimum inclusion rate of 72 : 25 grass silage : UWCW silage. At this inclusion rate dry matter intake of forage was observed to be the highest (2.5% of the live weight) and the DMI was found to be identical (2.46% of live weight) for the mixed diets when ratios between grass silage and UWCW silage was 27 : 25 and 50 : 50. The silage used by these workers was of very high quality.

All these findings suggest that by replacing the dry matter of the grass silage with WCC silage (treated or untreated) the dry matter intake of the mixed diets was significantly increased. This increase in the dry matter intake might be due to the high pH of the mixed diets than silage only fodder and this high pH might have improved the rumen environment for the fibre digestion (Rea, 1990; Tetlow and wilkinson, 1990).

Daily live weight gain

The effect of the inclusion of the different levles of the urea treated whole-crop wheat silage on daily live weight gain was found non significant ($p < 0.05$) between all treatments (table 3). However, animals in treatment "S100" showed a trend towards a superior (1.12 ± 0.08 kg) daily live weight gain (DLWG). The regression and correlation coefficients ($r = -0.10$) for DLWG on inclusion of UWCW silage in the animals diets were calculated and found to be nonsignificant ($p < 0.05$). The regression equation for DLWG is given below;

$$DLWG = 1.04 - 0.00086X$$

where, X = Proportion of the UWCWS in the diet.

The consumption of the different nutrients/kg live weight gain is given in table 4 and shows a marked increase in the intake of the forage components on inclusion of UWCWS in the diet.

TABLE 4. THE INFLUENCE OF DIFFERENT RATES OF REPLACEMENT OF GRASS SILAGE DM WITH UWCWS ON NUTRIENTS INTAKE (kg / kg LWG)

Treatments	OM*	CP*	ADF(NS)	NFE**
S100	5.84 ± 0.40^a	0.82 ± 0.06^a	1.54 ± 0.11^a	3.39 ± 0.21^a
S67	6.99 ± 0.32^{ab}	0.98 ± 0.04^{ab}	1.83 ± 0.08^a	4.19 ± 0.19^{ab}
S33	7.42 ± 0.48^b	1.05 ± 0.06^b	1.84 ± 0.13^a	4.62 ± 0.29^b

The effect of the treatments on the consumption of the different nutrients was found to be significant except for ADF ($p < 0.05$). Intake of CP/kg gain was found to be the highest in "S33" diet. Braun and Kolar, (1989) reported the similar findings. They found 905 and 964 g intake of CP/ kg gain in red spotted Bohemian bulls for maize and whole-crop barley silage respectively.

The results given in table 3 and 4 indicate that inclusion of UWCW silage in the animals' diets significantly increased the dry matter and feed nutrients intake but this increase was not reflected in any improvement in daily live weight gain. The estimated intake of the ME in treatment "S100" was enough to meet the ME requirements for "1" kg DLWG target but in treatments "S67" and "S33" the intake of the estimated ME was greater than the energy requirements for daily live weight gain. This estimated extra intake of ME than the requirements did not appear in any improvement in the DLWG than the control treatment. Leaver and Hill (1990), Phipps et al. (1990), Pahl (1992) and Mowat and Slumskie (1971) also reported the similar findings, the markedly high intake of whole-crop cereal silage did not reflect in high live weight gain. Tetlow and Wilkinson (1990) reported that daily live weight gain was equal with control treatment (grass silage) in beef cattle when only 25% dry matter of the grass silage was replaced with UWCWS and suggested that DLWG showed more response to the digestibility of the DM than DMI. The digestibility of the mixed forage was decreased with the increments of UWCW in the animals' diet and consequently a decreasing trend in the DLWG was observed.

The possible reasons for this discrepancy in the estimated ME intake and out put could be that the actual value for the ME of WCC silage may be lower than the estimated value and as well as from the grass silage. The inclusion of UWCW silage in the mixed diets might have diluted the energy value of the forage component of the ration and might be due to this reason some farmers also add molasses in the animals' diet when WCC silage is fed to the animals (Phipps et al., 1990). However, due to the higher intake of the dry matter the total energy consumption probably remained the relatively constant. But if the reverse is true, than high intake of the energy might have reduced the efficiency of energy utilisation (Pahl, 1992). The grain makes 40−60% of (Tetlow, 1990) the dry matter of the WCC silage and the energy value of the whole-crop cereals silage would be related to their loss at harvest (80 g/kg grain DM) and this loss could be substantial. Some part of the grain would be lost during preserving the WCC silage and feeding to the animals. Grains would also be lost in the faeces as in this study undigested whole grains were found in the animals' faeces and also in the feed refusals. It is reported that about 12% of the grain fed in the whole-crop wheat appeared as whole grain in the faeces. The work at Bernard Weitz Centre showed that at least 90 g/kg grain ingested may be excreted in the faeces (Phipps et al., 1990). It could be speculated that a considerable part of the animals' ration in form of grain passes through the digestive tract (Rea, 1990) with out under going any digestion and consequently with out providing energy to the animals. The excretion of the grain and starch in the faeces increases with the advancement in the crop maturity and excretion rate is found to be higher in the cattle than sheep (Kumai et al., 1987) and this difference might be due to the larger reticulo-omasal orifice (Deschard et al., 1988). Some part of the total energy intake is also used to excrete the excessive amount of urea from the body and the extent to which the energy cost of excreting excessive urea could account for the discrepancy between intake of ME and out put needs to be measured (Phipps et al., 1990).

Feed conversion ratio

The feed conversion ratio was adversely affected with the inclusion of UWCW silage in the animals' diet. The animals on the control treatment showed better feed conversion ratio (6.57 ± 0.31 kg DM/kg weight gain) than treatments "S67" and "S33" (table 3). The statistical analysis of the data revealed that with the inclusion of the UWCW silage in the diets of the animals significantly ($p < 0.05$) increased the feed conversion ratio (FCR). The FCR in the control treatment differed significantly (table 3) with "S67" and "S33" while differences between the "S67" and "S33" were non significant. The FCR was regressed against the inclusion of UWCW silage in the diet and a significant coefficient was found ($p < 0.05$). The regression equation is;

$$FCR = 4.78 + 0.022X$$

where, X = Proportion of UWCW in the diet.

The correlation between FCR and inclusion of UWCW silage was negative ($r = -0.43$) and significant. The high dry matter intakes of mixed forages in treatments "S67" and "S33" accompanied with low DLWG consequently resulted in poor FCR. The high dry matter intakes of WCC silages with poor utilisation was also reported by Hill and Leaver (1991).

Digestibility of the experimental diets

The digestibility coefficients of the experimental diets are given in table 5. The digestibility coefficients for ash and ether extract (EE) did not differ significantly between all the treatments. The effect of the treatment was found to be significant ($p < 0.05$) on the digestibility coefficients of dry matter (DM), organic matter (OM), crude protein (CP), acid detergent fibre (ADF), nitrogen free extract (NFE) and D value. The digestibility coefficients between treatments "S67" and "S33" did not differ significantly (table 5) except for the D value. The digestion coefficient of the fibre was found to be low on higher inclusion rate of UWCW silage than grass silage inspite of its high pH which should favour the fibre digestion but results in table 5 does not prove this theory. A possible explanation could be that additional load of the starch might have nullified the advantage of the high pH of UWCW.

ab = All the maens with the same superscript are showing non significant difference between them.

By increasing the proportion of the UWCW silage in the animals' diets the digestibility was decreased. The results of the other workers (Tetlow and Wilkinson, 1990; Hill and Leaver, 1993) also support the findings of the present study. Hill and Leaver (1993) replaced 1.0 (A), 0.5 (B) and 0.0 (C) dry matter of the grass silage with UWCW and fed to the animals. The digestibility coefficients were found to be lower in those treatments where part of the grass silage was replaced with the urea treated whole-crop wheat silage than grass silage only diet. The digestibility coefficients for DM, OM, and ADF were 0.68, 0.70 and 0.66; 0.66, 0.67 and 0.68 and 0.51, 0.62 and 0.66 for treatments A, B, and C respectively. With the inclusion of UWCW silage the digestibilities of nutrients were decreased. In the present study concentrates were also fed that reflected in higher digestibility coefficients than found by Hill and Leaver (1993), but followed the same trend as reported by these workers.

TABLE 5. THE INFLUENCE OF THE DIFFERENT INCLUSION LEVELS OF THE UWCW ON THE DIGESTIBILITY COEFFICIENTS OF THE EXPERIMENTAL DIETS

Tr.	DM**	OM**	CP**	ADF**	NFE**	EE (NS)	D-VAL.*
S100	0.83 ± 0.01^{b}	0.84 ± 0.00^{a}	0.72 ± 0.02^{a}	0.81 ± 0.01^{a}	0.90 ± 0.00^{a}	0.73 ± 0.02^{a}	0.76 ± 0.0^{a}
S67	0.80 ± 0.01^{ab}	0.80 ± 0.01^{ab}	0.71 ± 0.01^{a}	0.77 ± 0.01^{ab}	0.85 ± 0.00^{bc}	0.71 ± 0.02^{a}	0.74 ± 0.0^{a}
S33	0.76 ± 0.01^{a}	0.78 ± 0.01^{b}	0.69 ± 0.02^{a}	0.71 ± 0.02^{b}	0.84 ± 0.01^{b}	0.70 ± 0.01^{a}	0.71 ± 0.0^{b}

^{ab} = All the maens with the same superscript are showing nonsignificant difference between them.
± = SEM (standard error means)

One possible reason for this decrease in the digestibility coefficients on the inclusion of the urea treated whole-crop wheat silage could be the marked increase in water intake in animals on UWCWS diet as reported by Hill and Leaver, (1993). They found that water intake was 3.29 L kg^{-1} DMI of WCCS compared to the intake of water 1.74 L kg^{-1} DMI of silage only forage. This marked increase in the water intake might have increased the rumen outflow rate and decreased the retention time of the UWCW silage which consequently resulted in the low digestibility (Jackson, 1977). The excretion of a considerable potentially highly digestible portion of the ingested ration in the form of grains with out undergoing digestion could be another reason for poor digestibility of the WCC forages.

Conclusions

The results of the present study can be summarised as, that the dry matter intake of the forage was significantly increased with the different inclusion of the urea treated whole-crop wheat silage in the animals diet than the control treantment. The markedly increased dry matter intake did not relfect in improved daily live weight gain. Daily live weight gain was found to be nonsignificant between all treatments and feed conversion ratio was poor in treatments where urea treated whole-crop wheat was included in the aminals rations. There was no effect of the type of the energy source on the any performance aspect over all or in interaction grass silage : UWCW ratio. The effect of the treatment on the digestibility coefficients was significant and it depressed the digestibility coefficients for DM, OM, ADF, NFE and D-Value. A slightly over 1 kg DLWG achieved with supplements suggests that urea treated whole-crop wheat silage can be used during the store period when perforance targets are low, with out supplements for a satisfactory growth rate.

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