BRIEF COMMUNICATION: Feed value of maize silage in New Zealand - a review

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Keywords: maize silage; feed value; starch; NDF; digestibility; metabolisable energy; maize kernel processing.

Introduction

Maize silage is a major dietary component for dairy cows in the USA and Germany with average feeding rates of 2.7 and 4.1 tDM per cow per year respectively (Table 1).

Maize silage usage in NZ has increased over the past two decades. It currently accounts for approximately 6% of feed energy supplied to the national herd, calculated using national herd energy requirements (based on cow numbers and milk processed 2013/14 in NZ (New Zealand Dairy Statistics 2013/14)) and the amount of maize silage harvested (AIMI 2015).

It is important to establish maize silage feed quality in NZ to better understand its potential to support pasture-based farms. Published NZ research has measured *in-vivo* digestibility of maize silage in animal trials (Kirley 1977; Smith 1973); however, the number of trials is limited and they were not performed using standard protocols to allow pooling of data.

The aim of this paper was to compare the nutrient composition of overseas and NZ maize silage to determine if overseas *in-vivo* energy measurements are applicable to local maize silage and to determine how well NZ maize silage kernel is processed.

Table 1 Average maize silage production and use statistics (DMK 2014, USDA 2014, AIMI 2015) and laboratory results from NZ (Hill Laboratories pers. comm.) and overseas laboratories (DairyOne 2015, LUFA Nord-West 2015) based on yearly averages over six years (2010 to 2015) of maize silage nutrient composition and metabolisable energy (ME) MJ/kgDM.

	USA	Germany	NZ		
Maize silage area '000 ha	2,579	2,093	65		
Yield tDM/ha[1]	15.8	16.6	20.8		
Maize silage fed per cow tDM/cow and year[2]	2.7	4.1	0.22		
	DairyOne	LUFA Nord-West	Hill Laboratories	LSD (5%)	P
DM%	33.6[c]	34.7[b]	37.8[a]	0.834	<0.001
Starch %DM	32.8[a]	31.0[b]	30.4[b]	1.63	0.021
NDF %DM[3]	42.7[a]	39.5[b]	38.0[b]	2.02	0.001
Crude Protein %DM	8.8[a]	7.9[b]	7.7[b]	0.339	0.01
ME MJME/kgDM	11.5[b]	11.2[a]	10.8[c]	0.190	<0.001
Number of samples	> 20,000	> 80,000	> 3,000		

[1]calculated assuming 35%DM [2]calculated assuming 80% of harvested maize is offered to cows (Germany and USA) and 20% losses from harvest to consumption. [3]Neutral detergent fibre. abc = values within rows with different superscripts differ significantly.

Composition of maize silage and in-vivo measurement of metabolisable energy

Agronomic practices and environmental factors (including heat, moisture and soil type) determine the yield and quality of maize silage crops. On average, NZ maize- growing conditions are favourable when compared to the USA or Germany. Average NZ yield of maize silage was reported at 20.8 tDM/ha in 2014. German and USA statistics for 2014 showed silage yields of 15.8 and 16.6 tDM/ha, respectively (Table 1).

Maize silage laboratory analysis results for nutrient composition and metabolisable energy were retrieved as yearly averages from three different prominent laboratories in NZ, USA and Germany for six years (2010-2015). The data were analysed using the ANOVA model of Genstat (Version 18) comparing differences in traits among laboratories.

NZ maize silage was on average higher in dry matter and lower in estimated metabolisable energy (ME) than German and USA silages. Values for starch, neutral detergent fibre (NDF) and crude protein were similar in NZ and German laboratories; however, values were significantly lower than in the USA.

Starch and NDF concentrations reflect the proportion of grain and stover (green parts of the maize plant) and are influenced by growing conditions. NZ's maize growing conditions seem to be closer to the northern European maritime than the more-continental USA climate. This is supported by the historical better fit of northern European-bred maize hybrids into NZ (SB McCarter Pers. communication). Dry matter content was highest in NZ analysis, a reflection of harvest at later maturity and the impact of drought conditions in recent years.

Higher estimated ME results from the USA laboratory can partly be explained by a significantly (P=0.021) higher starch concentration; however, this does not explain the difference in ME content between NZ and Germany. Estimation of ME via laboratory analysis is more complex than measuring nutrient components. Each laboratory used different *in-vitro* methods

Table 2 Metabolisable energy (ME) and chemical composition from northern European *in-vivo* measurements (total collection of faeces with 4-5 wethers in each trial) of typical maize silage.

ME MJ/kg DM	NEL[1] MJ/kg DM	DM%	NDF[2] % DM	starch % DM	CP[3] % DM	*in-vivo* trials (n)	Source
10.86		29.5	43.9	22.1	8.9	50	de Boever et al 1996
11.06	6.71	38.0		34.5	8.0	51	DLG 1997 high cob%[4]
10.70	6.45	35.0		28.6	8.1	71	DLG 1997 medium cob%[4]
10.41	6.23	32.0		21.3	8.2	40	DLG 1997 low cob%[4]
10.86						214	Hertwig et al 2005
10.78						426	

[1]Net energy lactation. [2]Neutral detergent fibre. [3]Crude protein. [4]Maize silage is categorised based on cob proportion of whole plant to account for different maize grain % in the crop.

and prediction equations, and this can introduce a bias. A more accurate estimate of ME can be determined by measuring *in-vivo* digestibility using a reference protocol (GfE 1991). However, this is costly and rarely done on a routine basis.

The widespread use and economic importance of maize silage in northern Europe over many decades led to comprehensive research of maize silage feed value. Multiple *in-vivo* digestion studies (n = 426) were performed to determine digestibility, net energy of lactation (NEL) and ME of maize silage. On average, northern European maize silage had an estimated ME of 10.78 MJME/kgDM (Table 2). Given the similarity between the nutrient composition of NZ and German maize silages, it is reasonable to assume a similar ME content for NZ maize silage. NZ laboratory analysis (n>3,000 samples) showed an almost identical estimated ME.

Monitoring of maize kernel processing in New Zealand

Maize kernel digestion in ruminants is incomplete when kernels are intact. Honig and Rohr (1982) demonstrated significant reductions in faecal starch when kernels in maize silage were processed at harvest. Kernel processors are a common feature of modern forage harvesters, however the degree of kernel processing is variable. Ferreira and Mertens (2005) described a method to measure the degree of maize silage kernel processing called the Corn Silage Processing Score (CSPS). This is performed as a standard procedure by some commercial laboratories in the USA. It measures the starch fraction that passes through a 4.75 mm screen as a percentage of the total starch in the sample. Laboratory analysis defines three categories of CSPS: 70% = optimum, 50 – 70% = adequate, less than 50% = inadequately processed.

During the seasons 2012 (n=83) and 2013 (n=59) one-kilogram whole plant maize samples were taken from Waikato crops at harvest. They were oven-dried and sent to Dairyland Laboratories in Wisconsin, USA for CSPS analysis. After analysis, samples were categorised as either optimum, adequate or inadequate. The data were analysed using the Chi-square analysis of Genstat (Version 18) comparing changes in proportion in each category over the two years.

There was a significant change in kernel processing quality from 2012 to 2013 (χ^2 (2, N-141) =17.93, P<0.001) explained by an increased proportion in the optimum processed category in 2013 when compared to 2012 (Table 3). This is partly due to improved kernel processor settings as farmers and harvest machinery operators became more informed of the benefits of good kernel processing. Forage harvester manufacturers have also produced new improved kernel processors and more local contractors are using them.

Table 3 Corn silage processing scores (CSPS) measured in two seasons (2012 n=83, 2013 n=59) on Waikato farms expressed in % of samples analysed in categories of processing quality.

Year	Categories of processing quality		
	inadequate	adequate	optimum
2012[a]	35%	54%	11%
2013[b]	7%	66%	27%

ab = sample distribution over categories differed significantly between years (P<0.001).

Conclusion

Maize silage grown and fed in NZ compares well in nutrient composition with northern European maize silage. Average metabolisable energy of maize silage measured in *in-vivo* trials in northern Europe is 10.78 MJME/kgDM almost identical with NZ laboratory analysis.

An analysis of CSPS results shows kernel processing improved by NZ harvesting contractors from 2012 to 2013 meaning more of the energy in maize silage is available to the dairy cows that consume it.

References

AIMI (Arable Industry Marketing Initiative) 2015. Survey of maize areas and volumes June 1, 2015. https://www.far.org.nz/assets/files/editable//e9f8c956-a2a2-4fcb-8608-7d11fff8ceed.pdf [accessed 5 May 2016]

DairyOne 2015. Interactive feed composition libraries. http://dairyone.com/analytical-services/feed-and-forage/feed-composition-library/interactive-feed-composition-library/ [accessed 5 May 2016]

de Boever JL., Cottyn BG, Brabander DL, Boucque ChV 1996. The evaluation of the feeding value of maize silage for ruminants european maize meeting 9 to 11 September 1996. Silage maize quality and feed value forum of the Federal Research Center of Agriculture Braunschweig/Germany.

DLG 1997. DLG-Futterwerttabellen - Wiederkäuer. Deutsche Landwirtschafts-Gesellschaft (Feed tables for ruminants. German agriculture society). ISBN 978-3-7690-0547-9.

DMK (German maize grower association) statistics 2014. http://www.maiskomitee.de/web/public/Fakten.aspx/Statistik [accessed 5 May 2016]

Ferreira G, Mertens DR 2005. Chemical and physical characteristics of corn silages and their effects on in vitro disappearance. Journal of Dairy Science 88. Pg. 4414–4425.

GfE (German society of nutrition physiology) 1991. Leitlinien für die Bestimmung der Verdaulichkeit von Rohnährstoffen an Wiederkäuern (Guidelines for determining the digestibility of crude nutrients in ruminants). Journal of Animal Physiology and Animal Nutrition 65. Pg. 229–234.

Hertwig F, Spiekers H, Losand B, Greef JM, Südekum KH, Rodehutscord M, Meyer U, Kaiser E, Weißbach F, Schwarz F, Jilk T, 2005. Energetische Bewertung von Maisprodukten - Schlussfolgerungen aus einer bundesweiten Auswertung von Verdauungsversuchen. Proceeding of conference on feed conservation and feeding of the german maize committee *(german maize growers association).* Pg 16-17.

Honig H, Rohr K 1982. The influence of chopping on losses by undigested kernels and kernel fragments of maize, when feeding ruminants. in: H.J. Oslage, R. Daccord (Eds.) Proceedings of the seminar on cost-project 82. Maize as basic feed for beef production, held at Grangeneuve/Switzerland 28.-30.September. Pg 32-41.

Kirley TJ 1977. Supplementary feeding of dairy cows. A study of the value of greenfeed maize as a summer supplement. Master thesis in animal science at Massey University. Pg 47-49.

LUFA Nord-West (Agriculture Analysis and Research Institute North West) 2015. Maissilage Inhaltsstoffe und Energiegehalte 2009-2015. http://www.lufa-nord-west.de/data/documents/Downloads/IFF/Maissilage_Endauswertung_2015.pdf [accessed 5 May 2016]

New Zealand dairy statistics 2013/14. http://www.dairynz.co.nz/publications/dairy-industry/new-zealand-dairy-statistics-2013-14/ [accessed 5 May 2016]

Smith AL 1973. Maize silage: a study of the nutritive value of ensiled Zea mays L. for growth in young cattle. Master thesis in Animal Science at Massey University. Pg 65-66.

USDA crop production summary 2014. USDA's national agricultural statistics service (NASS) http://www.usda.gov/nass/PUBS/TODAYRPT/cropan15.pdf [accessed 5 May 2016]