Research Report

Ensiling crimped high moisture barley with different additives

Arja Seppälä, Terttu Heikkilä, Marketta Rinne

30th May 2011

MTT project number: 7201266

Experiment: Pleksi 1121/10

Sisältö

Photo 1. Barley with 40 % moisture content was easily crimped using Murska 1000 HD crimper. Simo Horkka and Terttu Heikkilä discussing. Photos: Arja Seppälä.

Photos on the cover: Spring barley Annabell just prior harvesting, after crimping and after silo opening.

Baground information

Parties in research agreement

MTT Agrifood Research Finland, Animal Production Research,

Contact person: Arja Seppälä

and

Kemira Ltd, ChemSolutions, Feed,
Porkkalankatu 3, P.O. Box 330, FI-00101 Helsinki, Finland

Contact person: Harri Miettinen

Recearch objectives

Crimped high moisture barley was ensiled with different additives (**Kemira AIV 2000 Plus or Biotal Biocrimp**) or without additive in laboratory scale silos. After 107 days the silos were opened and fermentation quality and aerobic stability of the ensiled barley was analyzed.

Timetable

The study was performed at MTT Agrifood Research Finland in Jokioinen. The ensiling was done on 17th August 2010. The silos were opened after a 107-day ensiling period. Aerobic stability of the ensiled barley was measured immediately after the opening silos. Preliminary results have been presented to the research parties in a meeting on 2nd May 2011.

Introduction

Benefits of high moisture storage of grain in Nordic conditions have been proven already some decades ago (Palva et al. 2005, Jaakkola et al. 2005. No drying cost, less weather dependent and extended harvest season are the main arguments that keep the method increasing in popularity. The method has become more common on farms together with bigger herd size and TMR feeding. This experiment was conducted at laboratory scale to compare the efficacy of two additives (**Kemira AIV 2000 Plus or Biotal Biocrimp**) marketed for ensiling high moisture grain versus no additive treatment.

Materials and methods

Barley

Spring barley variety Annabell (Bor) was between dough stage and yellow stage of ripening at the time of harvesting 17th August 2010. The harvested barley grain was crimped using Murska 1000 HD farm scale crimper. After crimping, barley was devided into equal batches , which were sprayed manually with the additives and mixed well trough before filling the silos. The used additives were Kemira AIV 2000 Plus (formic acid 425, ammonium formate 303, propionic acid 100, benzoic acid 22 and water 150 g/kg; application rate 3 or 4 l/t) or Biotal Biocrimp (*Pediococcus pentosaceus* NCIMB 12455, *Lactobacillus buchneri* NCIMB 40788) according to the instructions of the manufacture, meaning application level of 612 000 cfu/g. The treatments were ensiled in laboratory scale silos in triplicate, 4.5 kg fresh matter of

barley in each. The silos were compacted, sealed and lead plummets were used for weighing the silos. Silos were opened after a107-day ensiling period. A 5 cm layer from the surface and the bottom of each silo was discarded and the rest of the material was mixed well trough and sampled for analyses.

Analyses

Chemical analyses were carried out at the MTT Laboratory in Jokioinen. The laboratory has a quality system which follows the SFS-EN ISO/IEC 17025:2005 standards and it is accredited by FINAS (the Finnish Accreditation Service) with number T024. The DM was determined by drying at 105°C for 16 h. Ash concentration was determined using a standard method of AOAC (1990, method 942.05). Nitrogen (N) concentration was determined by the Dumas method (AOAC method 968.06) using a Leco FP 428 nitrogen analyzer. Crude protein concentration was calculated as 6.25 × N concentration. Crude fibre was determined with method of AOAC (1990, method 962.09) and starch was determined according to Salo et al. (1968).

Ensiled barley was analysed for volatile fatty acids according to Huhtanen et al. (1998), lactic acid according to Haacker et al. (1983), water soluble carbohydrates according to Somogyi (1945) and ammonia according to McCullough (1967). Formic acid of the ensiled barley was measured using a commercial kit (Cat.No. 979 732, Boehringer Mannheim GmbH, Mannheim, Germany). Ethanol concentration was measured using enzymatic kit (Cat No.981680, KONE Instruments Corporation, Espoo; Finland) and the selective clinical chemistry analyser Pro 981489 (KONE Instruments) according to application instructions given by KONE. Oven DM concentration of silage was corrected for the loss of volatiles according to Huida et al. (1986).

The samples for microbiological analyses were mixed and 25 g was weighed in stomacher bags and mixed with 225 ml of ¼-strength Ringer solution (Merck 1.15525.0001). The samples were homogenized with stomacher (Stomacher® 400 Circulator) for 2 min at 230 rpm. Serial decimal dilutions were prepared by mixing 1 ml of sample with 9 ml of Ringer solution. Yeasts and moulds were determined on DRBC agar medium (Difco 258710) which was supplemented with 50 µg ml^{-1} of oxytetracycline hydrochloride (AppliChem BioChemica A5257). The petri dishes were incubated at 25 ± 1ºC. The colonies were counted after 3 and 6 d. Total number of aerobic bacteria was determined on PCA agar dishes incubated at 30ºC 72 hours.

Aerobic stability of the ensiled crimped barley was determined by monitoring temperature changes of the feeds when exposed to air. Triplicate samples (900 g) were weighed and placed in 2.5 dm3 styrox containers. Temperature was automatically recorded at 10 minute intervals using a thermocouple wire connected to a data logger for 300 h. Aerobic stability was defined as the time taken to increase the temperature of the feed for 2.0 degrees above the ambient temperature.

Statistical analysis were performed using SAS GLM-procedure and a statistical model including treatment (additive application) as an independent variable. Differences between treatments (lsmeans) were compared using Tukey test (Kramer 1956).

Results and discussion

Barley

Dry matter concentration of the ensiled barley was well within the general recommendations (550-650 g/kg, Palva et al. 2005) for this type of grain ensiling (Table 1) and crimping was trouble-free.

Table 1. Composition of the crimped barley before ensiling.

Dry matter	Ash	Crude protein	Crude fibre	Starch
g/kg		g/kg ka		
605	32.1	118	50	567

Fermentation quality

At the time of silo opening the only silos without any moulds on the surface layer were those ensiled with Kemira AIV 2000 Plus 4 l/t. The color of the treatments Biotal Biocrimp and control was different (straw-coloured in the middle of the silo) from the Kemira AIV 2000 Plus (pale brown whole silo; see photos below). Fermentation quality of the ensiled barley in presented in Figure 1 and Attachment 1. Kemira AIV 2000 Plus restricted fermentation resulting in a lower amount of fermentation products than Biotal Biocrimp or control treatment. Biotal Biocrimp treatment produced clearly more acetic acid than the other treatments ($p<0,001$).

Photo 2. Visual differences between the treatmemtns

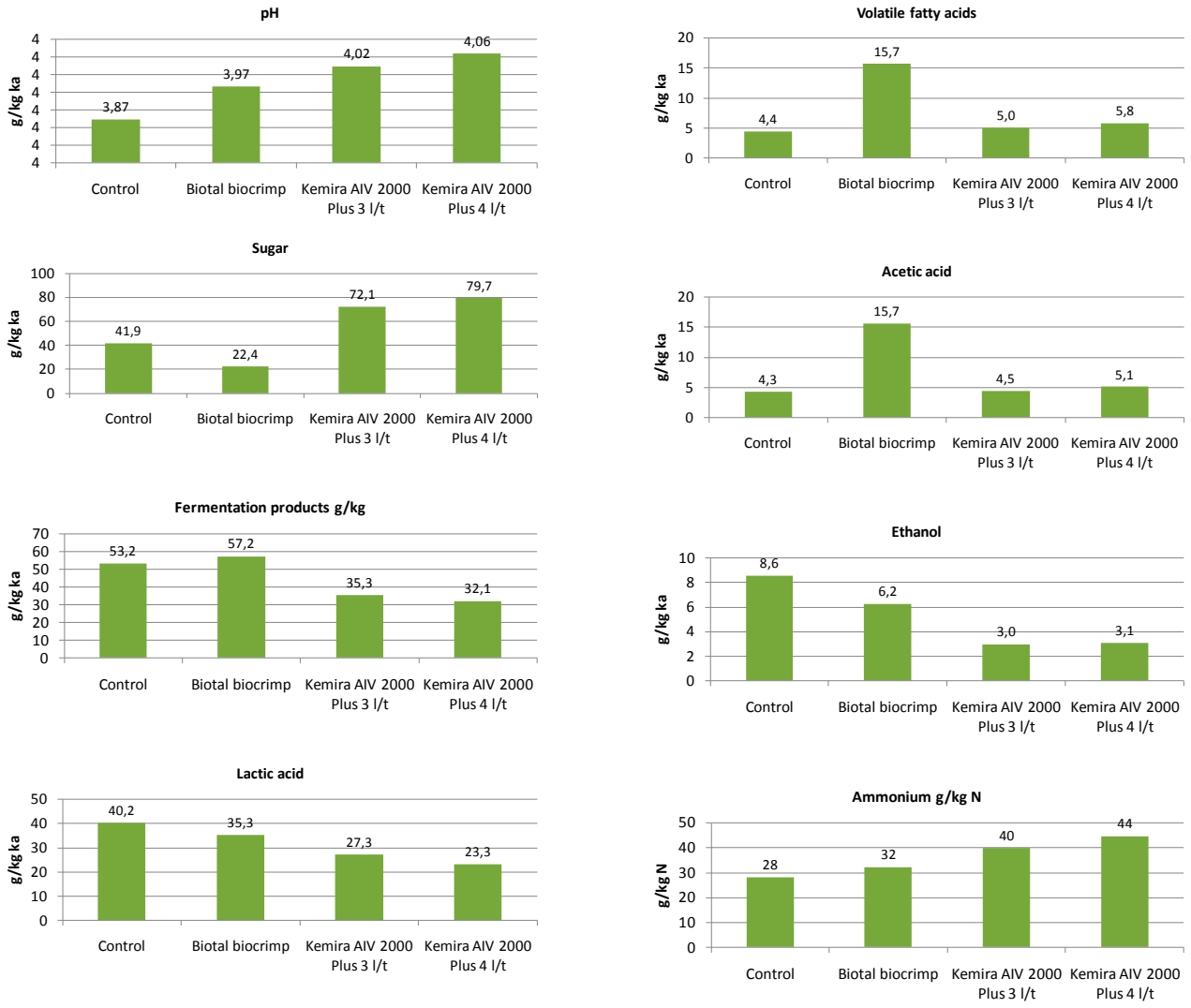

Figure 1. Fermentation quality parameters of the crimped barley when ensiled with different additives. The differences between treatments are statistically significant ($p<0.05$) in all the other cases except the differences between the two applications levels of Kemira AIV 2000 Plus on the amount of ethanol or the sum of volatile fatty acids.

Photo 3. Barley was crimped using farm scale crimper Murska 1000 HD.

Microbial analysis

Microbial counts of the crimped barley prior to ensiling are presented on the Figure 2 and in the Attachment 2. After silo opening yeast and mould counts were low (less than 1000 cfu/g) in all treatments. Count of aerobic bacteria was high for Biotal Biocrimp due to the added lactic acid bacteria (Figure 3).

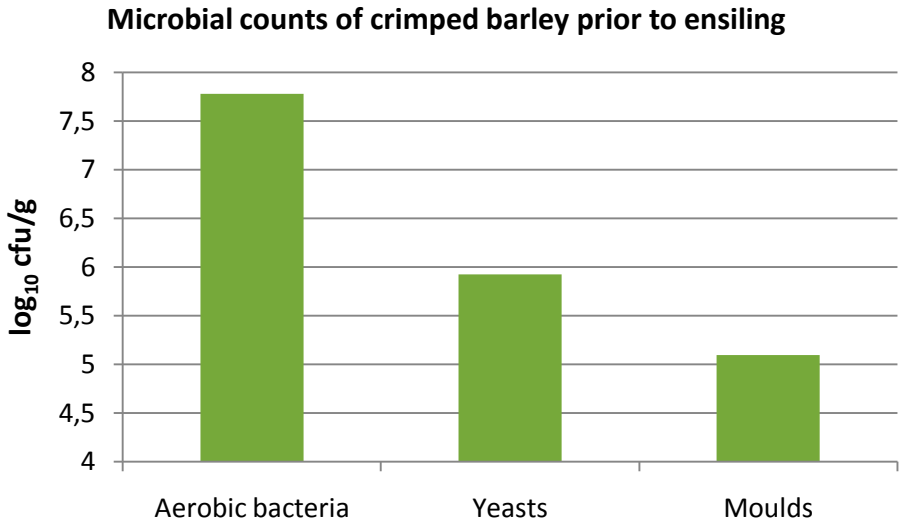

Figure 2. Microbial counts of the crimped barley prior to ensiling.

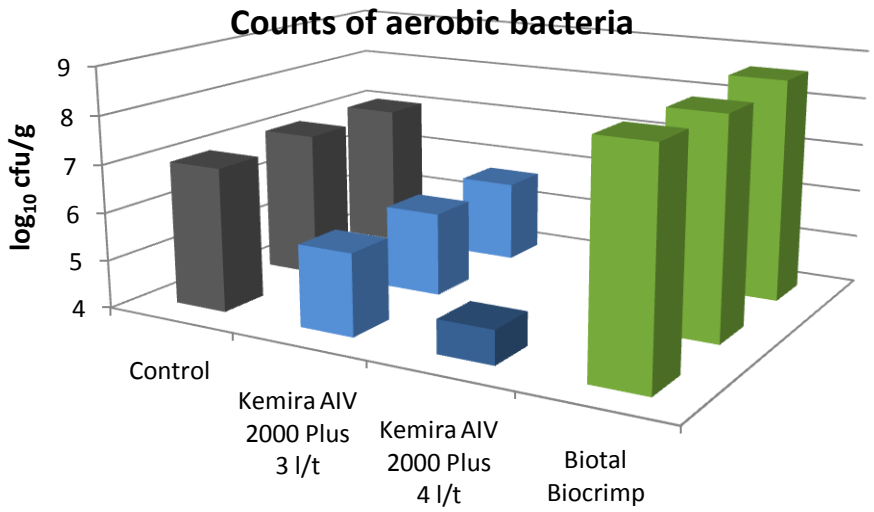

Figure 3. Counts of aerobic bacteria of the crimped ensiled barley

Losses during ensiling

Weight changes during ensiling were small (between 3-10 g/kg) as no effluent losses were detected. However the small differences between treatments (Figure 4) were all statistically significant ($p<0,001$). Measurements of DM losses gave insight that DM content of raw material was slightly underestimated, as

the actual measured DM-losses were negligible. DM losses arising from fermentation should lie between 2 and 4 % (McDonald ym. 1991) and it may be anticipated that fermentation losses increase with more extensive fermentation. In this experiment all the measured DM losses were within range of 0.6 %-units. Although there were differences between the treatments (losses being highest for Biotal Biocrimp and lowest for the Kemira AIV 2000 Plus treatments) the differences were too small to have practical effect at farm level.

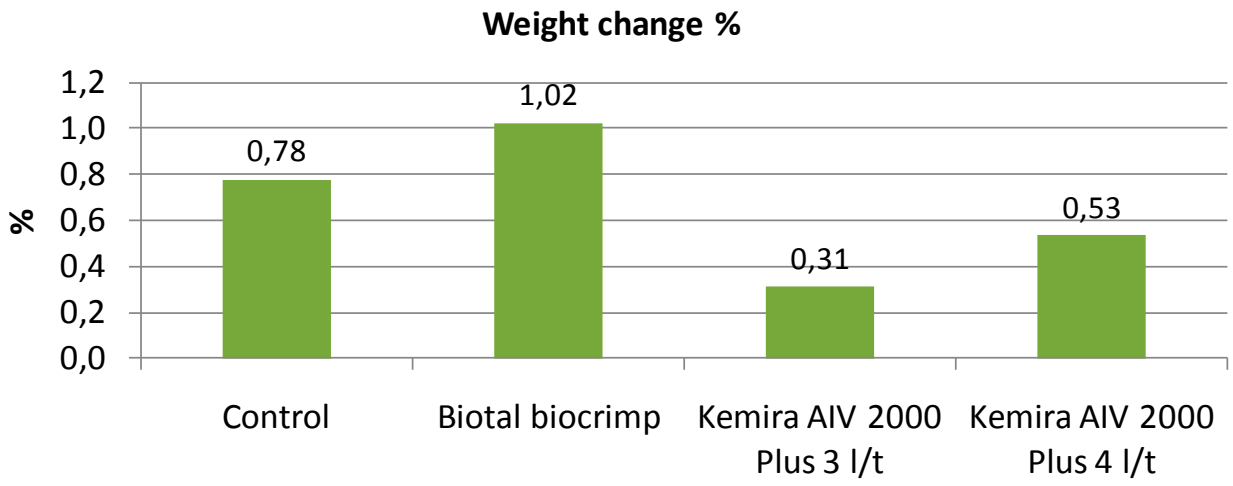

Figure 4. Fresh weight changes during ensiling crimped barley.

The DM concentration of the silages was corrected for the volatile compounds which are lost during oven drying. The correction was made according to Huida et al. (1986). There are other correction equations available as well (see Huida et al. 1986, Weiβbach 1995, Weiβbach and Strubelt 2008a, 2008b 2008c). The pH value is the main factor affecting the losses of volatile components during oven drying. In the pH range of this experiment most of the volatile fatty acids and alcohols are lost during oven drying. Thus the correction for the volatile components is needed to get a realistic estimate of the level of losses. Further, comparison of treatments may become biased, if the concentration of volatile compounds varies between treatments and losses of them are not accounted for.

However when observing the losses of DM between silo opening and ingestion of the silage by its final consumer it can be assumed that part of the volatile components might be partly lost also in practical conditions at farm level. Especially in TMR feeding the volatile components might be partly volatilized during mixing. Without correction for the volatile components the DM losses were 30 g/kg for Biotal Biocrimp, 23 g/kg for control treatment and 15 g/kg for Kemira AIV 2000 Plus.

Aerobic stability

Both of the used additives improved the aerobic stability compared to the control treatment (Table 2 and Figure 5.)

Table 2. Aerobic stability of ensiled crimped moist barley.

Treatment	Aerobic stability, hours
Control	162
Biotal Biocrimp	>300
Kemira AIV 2000 Plus 3 l/t	>300
Kemira AIV 2000 Plus 4 l/t	273

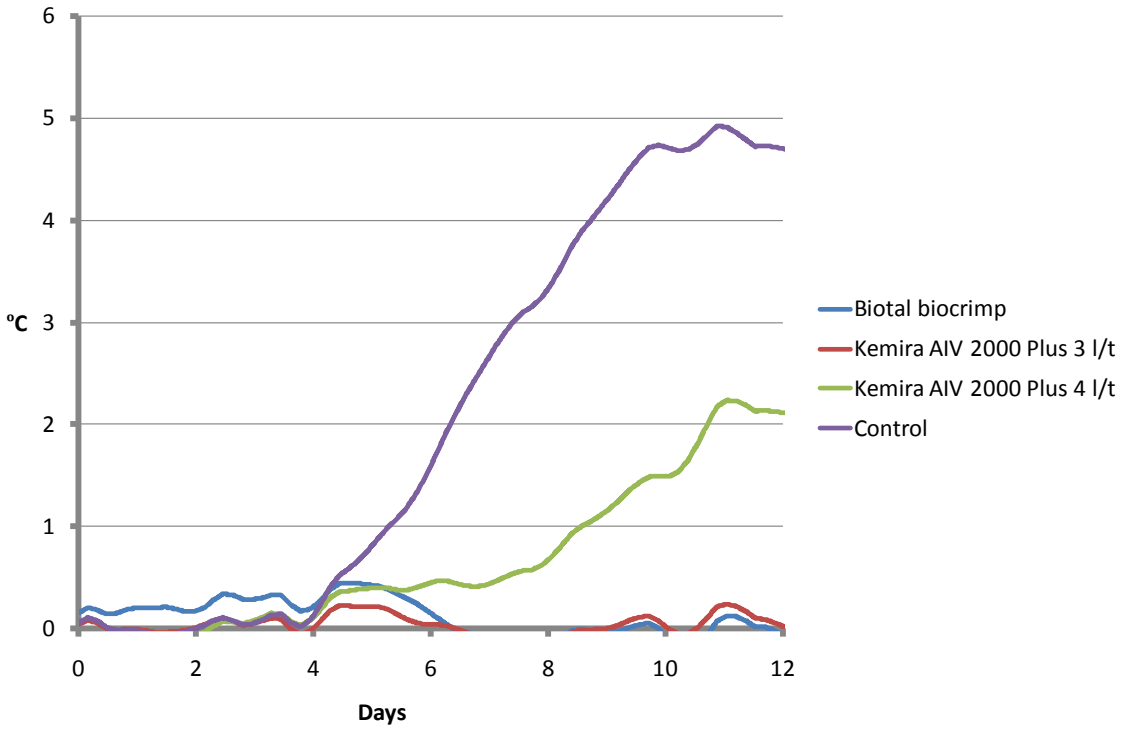

Figure 5. Aerobic stability of crimped moist barley after silo opening presented as temperature difference between the treatments and the environment. The temperature curves are means of 3 replicates per treatment.

Conclusion

In this experiment a clear benefit from the use of additives was seen in the aerobic stability of the ensiled material, although yeast and mould counts were low in all the treatments. Fermentation type of control and Biotal Biocrimp differed as more acetic acid was produced by Biotal Biocrimp. Kemira AIV 2000 Plus was able to restrict fermentation giving lower amount of fermentation products and sparing more sugar in the ensiled barley.

References

AOAC, 1990. Official Methods of Analysis. Association of Official Analytical Chemists, Inc., Arlington, VA. 1298 p. ISBN 0-935584-42-0

Haacker, K., Block, H.J. and Weissbach, F. 1983. Zur kolorimetrischen Milchsäurebestimmung in Silagen mit p-Hydroxydiphenyl. [On the colorimetric determination of lactic acid in silages with p-hydroxydiphenyl]. Archiv für Tierernährung, 33: 505-512.

Huhtanen, P.J., Blauwiekel, R. and Saastamoinen, I. 1998. Effects of intraruminal infusions of propionate and butyrate with two different protein supplements on milk production and blood metabolites in dairy cows receiving grass silage based diet. Journal of the Science of Food and Agriculture 77: 213-222.

Huida, L., Väätäinen, H. and Lampila, M. 1986. Comparison of dry matter contents in grass silages as determined by oven drying and gas chromatographic water analysis. Annales Agriculturae Fenniae 25: 215-230.

Jaakkola, S., Saarisalo, E., Kangasniemi, R. 2005. Ensiled high moisture barley or dry barley in the grass silage-based diet of dairy cows. In: edited by: R.S. Park, M.D. Stronge. Silage production and utilisation : proceedings of the XIVth international silage conference, a satellite workshop of the XXth international grassland congress, July 2005, Belfast, Northern Ireland. Wageningen: Wageningen Academic Publishers. p. 184.

McCullough, H. 1967. The determination of ammonia in whole blood by direct colorimetric method. Clinica Chimica Acta 17: 297-304.

McDonald, P., Henderson, N., Heron, S. 1991. The biochemistry of silage. Chalcombe Publications.

Kramer, C. Y. 1956. Extension of Multiple Range Tests to Group Means with Unequal Numbers of Replications. Biometrics, 12, 307–310.

McDonald, P., Henderson, N. & Heron S. 1991. The Biochemistry of Silage. Second edition, Marlow : Chalcombe Publications. 340 s. ISBN 0-948617-22-5

Palva, R., Kirkkari, A-M., Teräväinen, H. (Eds.) 2005. Viljasadon käsittely ja käyttö: Viljan tuoresäilöntä. Maaseutukeskusten Liiton julkaisuja 1012: Tieto tuottamaan 108.

Salo, M-L. and Salmi, M. 1968. determination of starch by the amyloglucosidase method. Jounal of the Scientific Agricultural Society of Finland, 40: 38-45.

Somogyi, M. 1945. A new reagent for the determination of sugars. Journal of Biological Chemistry 160: 61-68.

HPLC-method:

Weiβbach, F. 1995. Arbeitsvorschrift zur Korrektur des Trockensubstanzgehaltes von Silagen und Grünfutter, gültig seit 01.07.95. Bundesforschungsanstalt für Landwirtschaft Braunschweig-Völkenrode, (FAL), Institutionen für Grünland und Futterpflanzenforschung.

Weissbach, F., Strubelt,C. 2008a. Die Korrektur des Trockensubstanzgehaltes von Maissilagen als Substrat für Biogasanlagen. LANDTECHNIK 2/2008.

Weissbach, F., Strubelt, C. 2008b: Die Korrektur des Trockensubstanzgehaltes von Zuckerrübensilagen als Substrat für Biogasanlagen. LANDTECHNIK 6/2008.

Weissbach, F. und Strubelt, C. 2008c: Die Korrektur des Trockensubstanzgehaltes

von Silagen als Substrat für Biogasanlagen. *VDLUFA-Kongress*, 29-31.

Attachments

Atttachment 1. Fermentation quality of the crimped ensiled barley. treatment means and standard deviations. Units g/kg DM unless otherwise stated.

Treatment	DM g/kg	pH	Sugar	Formic acid	Acetic acid	Propionic acid	Isobutyric acid	Butyric acid	Isovaleric acid	Valeric acid	Caproic acid	VFA	Lactic acid	Ethanol	Ammonium N g/kg N
Treatment means															
Control	611	3.87	41.9	0.00	4.32	0.02	0.00	0.06	0.03	0.00	0.01	4.4	40.2	8.57	28.2
Biotal biocrimp	612	3.97	22.4	0.00	15.67	0.00	0.00	0.01	0.00	0.00	0.00	15.7	35.3	6.23	32.3
Kemira AIV 2000 Plus 3 l/t	610	4.02	72.1	3.54	4.47	0.40	0.01	0.07	0.07	0.00	0.01	5.0	27.3	2.97	39.9
Kemira AIV 2000 Plus 4 l/t	610	4.06	79.7	3.48	5.11	0.49	0.02	0.08	0.07	0.00	0.00	5.8	23.3	3.10	44.5
Standard deviations															
Control	01.2	0.006	0.50	0.000	0.010	0.017	0.000	0.012	0.000	0.000	0.012	0.03	0.87	0.208	0.61
Biotal biocrimp	00.7	0.006	1.01	0.000	0.684	0.000	0.000	0.012	0.000	0.000	0.000	0.69	0.23	0.252	0.53
Kemira AIV 2000 Plus 3 l/t	00.7	0.006	0.40	0.451	0.075	0.040	0.012	0.000	0.000	0.000	0.012	0.11	0.20	0.058	0.81
Kemira AIV 2000 Plus 4 l/t	01.0	0.000	0.92	0.069	0.102	0.031	0.006	0.006	0.006	0.000	0.000	0.14	0.32	0.173	0.53

Attachment 2. Results of microbial analysis

		Aerobic bacteria. total number	Yeasts	Moulds
			log $_{10}$ cfu/g	
Crimped barley prior to ensiling		7.78	5.92	5.10
Ensiling treatments	Replicate			
Control	1	6.99	< 3.0	< 3.0
Control	2	7.05	< 3.0	< 3.0
Control	3	7.04	< 3.0	< 3.0
Kemira AIV 2000 Plus 3 l/t	1	5.70	< 3.0	< 3.0
Kemira AIV 2000 Plus 3 l/t	2	5.74	< 3.0	< 3.0
Kemira AIV 2000 Plus 3 l/t	3	5.70	< 3.0	< 3.0
Kemira AIV 2000 Plus 4 l/t	1	4.70	< 3.0	< 3.0
Kemira AIV 2000 Plus 4 l/t	2	< 4.0	< 3.0	< 3.0
Kemira AIV 2000 Plus 4 l/t	3	< 4.0	< 3.0	< 3.0
Biotal Biocrimp	1	8.57	< 3.0	< 3.0
Biotal Biocrimp	2	8.51	< 3.0	< 3.0
Biotal Biocrimp	3	8.63	< 3.0	< 3.0