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Valorisation of Ensiled Fodder Beets

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Abstract. Fodder beets (*Beta vulgaris* L.) are especially respected for their high feeding value and high netto-energy yield per hectare. The price per nutritive value is lowest as compared to other forages. Preservation of fodders beets demands thorough cleaning without damaging and regularly occurs as a whole in well closed piles. In addition, feeding them to the animals is labour demanding. These disadvantages enforce the research towards other preservation methods which may be able to valorise this valuable type of roughage. The preservation of fodder beets in silages using silo bags, either separately or in combination with maize was investigated. Fodder beets were harvested and ensilaged at the ideal moment of maize harvest (October) or fodder beets were harvested at the ideal moment for fodder beet harvest (November) and consequently ensilaged with previously ensilaged maize. Highest energy yields of the silages were recorded at optimal harvest time for fodder beets. Ensilaging fodder beets separately resulted in large energy losses due to effluent and dry matter losses. Using lab scale silage, possible solutions for these large losses were investigated. Addition of 10% maize did reduce the effluent losses but dry matter losses remained at a high level. Addition of 4,5 l propionic acid per ton beets reduced effluent and dry matter losses sufficiently. Ensilaging foliage was another point of interest. This appeared to result in a lowered energy yield at organic and dry matter basis, an increased amount of ashes and doubling of the iron (Fe) concentration.

Keywords: Agriculture – fodder beet – roughage – cattle – energy – silage.

INTRODUCTION

In Europe, fodder beets (*Beta vulgaris* L.) are classified as valuable forages (Van Waes et al., 2007). General characteristics are a low dry matter (DM) content of 15% (Prins et al., 2004), low in fiber (5% of DM) (De Vliegher et al., 2006), proteins (9-16% of DM) (Aerts et al., 1979) and minerals (calcium, phosphorus and magnesium) and rich in soluble carbohydrates (50-70% of DM) (De Vliegher et al., 2006). In cattle rations, fodder beets may partially replace concentrates because of their high energy concentration (Otto et al., 1994; Meijer et al., 1994).

Since the 18th century, fodder beets represented an important part of the roughages consumed by cattle during winter in West-European countries (Lenkens, 1990). Since the Second World War, the total number of hectares used to cultivate fodder beets decreased substantially due to its labour demanding handling, eg. from 59% of the surface available for roughages in 1950 to less than 1% in 2002 (Meul et al., 2004; De Vliegher et al., 2006). The introduction of the completely mechanised maize cultivation contributed to this phenomenon (Aerts et al., 1979; De Brabander et al., 1989; Boucqué et al., 1994).

Today, an increased interest in fodder beets exists because of the complete mechanisation of its cultivation, the development of *Rhizoctonia*-tolerant varieties, the highest energy yield per hectare of forage crops, the increased grain prices on the market and less available sugar beet pulp due to European reformations (De Brabander et al., 1989; Otto, 1991; Boucqué et al., 1994; De Vliegher et al., 2006; Du Ville, 2009). The productivity of fodder beets is highest compared to the most frequently used roughages in cattle herds, eg. maize and grass (De Brabander et al., 1989; Lenkens, 1990 and Albayrak and Çamas, 2006). Apart from forages in cattle herds, fodder beets gain interest in the search for biomass to produce energy (Scherer et al., 2003; 2009).

Alternating maize with fodder beets would interrupt the existing maize monoculture in West-European countries, resulting in a decreased need for herbicide use, an improved soil structure and a better control over maize related diseases (De Vliegher and De Campeneere, 2008). Another advantage above maize is the stable production of at least 12 tonnes per hectare, independent on the whether (Otto, 1991; Anoniem, 1997). These authors clearly prefer fodder beets above maize at altitudes above 400 m. Fodder beets utilise nitrogen and minerals from the soil more efficiently compared to maize. In countries with a positive nitrogen and phosphor balance, this may be an additional argument to extend the fodder beet areal (Morvan et al., 2000; De Vliegher and De Campeneere, 2008).

Even though they are still considered as less attractive since their need for proper cleaning, difficulties during preservation (especially at temperatures below 0°C) and labour demanding feeding properties (De Vliegher et al., 2006; Anonymous, 1997a). Previous attempts made to overcome these obstacles are the ensilaging with other roughages, eg. maize, grass and hay (De Brabander et al., 1989; De Vliegher and De Campeneere, 2008). In these studies, fodder beets were harvested before their optimal harvest time, at the moment of maize harvest and sliced at the moment of ensilaging. The fodder beet / maize ratio was approximately 25% / 75% at dry matter basis. Other studies suggested a ratio of 33% / 67% (Bries et al., 2002). Effluent losses were absorbed by the other roughages. A major disadvantage of this method is the suboptimal beet production per hectare because of a too early harvest. Ensilaging pure sliced fodder beets was researched by O'Kiely and Moloney (1999) but effluent losses equalled 33% of the dry matter at 201 days after the start of ensilaging. Another concept was developed by Deininger et al. (1996) who tried to preserve fodder beets as a liquid by grinding and crushing them and consequently pumping them into a silo. In the silo, the ensilaging process could start resulting in a pH below 4 after 8-10 days. Apart from satisfying results, this method warrants though investments by the farmer.

An ideal method to combine optimal production results with optimal preservation methods and ease to feed the animals is not yet found. Therefore, in the presented study, the use of a recently developed ensilaging method 'the silobag' for ensilaging fodder beets, separately or in combination with maize was evaluated.

MATERIALS AND METHODS

Silages

Fodder beets were harvest at 2 time points: at the optimal time of maize harvest at 15 October 2008 and at optimal time of fodder beet harvest at 28 November 2008. All maize needed for this study was harvested at 15 October 2008.

Ensilaging occurred at 2 time points. The first at 15 October 2008. Following silages were prepared:

- Silage with fodder beet and maize
- Silage with fodder beet, fodder beet foliage and maize
- Maize

The second ensilaging moment occurred at 5 December 2008. Following silages were prepared:

- Silage with fodder beet and maize ensiled at 15 October 2008
- Silage with fodder beet, fodder beet foliage and maize ensiled at 15 October 2008
- Silage with pure fodder beets
- Classical preservation method: fodder beets as a whole (without foliage) in a well closed pile

Before ensilaging, fodders beets needed thorough cleaning with water. Fodder beet foliage was not cleaned since this would cause too much damage. Fodder beets were mechanically cut in small slices while mixing the maize and fodder beets. Maize and beets were weighed to obtain the correct proportions. The ratio fodder beet / maize was 33% / 67% in order to obtain a final dry matter content of 30% in the mixed silages. Ensilaging occurred in silo bags using the *Bagmaster cr 940*, as shown on Fig. 1. The diameter of each silo bag was 1,22 m and contained 10 ton each.

Fig. 1. *Bagmaster cr940* and silo bag with diameter of 1,22 m

Samples of all silages were taken at 9 March 2009. Analyses for feeding value (for cattle), minerals and trace elements were performed by BLGG Oosterbeek (www.blgg.be).

Lab scale silages

To seek for possible solutions to overcome the large effluent losses in pure fodder beet silage, fodder beets were treated in several ways before ensilaging them on lab scale basis (volume of 2,75 liter). Nine lab scale silages were prepared per treatment. Following treatments occurred:

- boiling during 20 minutes
- blanching during 5 minutes
- addition of propionic acid (99%), 4,5 l / ton
- addition of lactic acid bacteria, $2,5*10^{10}$ CFU / ton (Pioneer 1188)
- addition maize, ratio fodder beet (fresh) / maize (ensiled): 90% / 10%

- chopping into to small parts of 1 x 1 cm and a length of 3-7 cm
- control = normally sliced fodder beets

Dry matter content of each treatment was determined at the start of ensilaging.

To estimate the effluent losses during the ensilaging process, all lab scale silages were weighed at the start of the experiment and consequently every week after removing the sticking effluent losses.

Three weeks after the start of ensilaging, 4 lab scale silages per treatment were randomly selected and subjected to a final analysis:

- final weighing of the entire lab scale silage
- removing and weighing of the residual effluent
- sampling for dry matter analysis
- pH determination
- determination and counting the present microflora (lactic acid bacteria, fungi and yeasts)
- determination of the alcohol percentage
- determination of the percentage of volatile fatty acids

Five weeks after the start of ensilaging, the 5 remaining lab scale silages were subjected to the same final treatment.

RESULTS AND DISCUSSIONS

Silages

No effluent losses were detected in silages containing maize, maize and fodder beets and maize, fodder beets and fodder beet foliage. Large effluent losses, estimated to be 50% of the volume, were detected in the pure fodder beet silage.

The results of sample analyses of the different silages are summarized in Tab. 1.

Tab.1

Feed value, mineral and trace element analyses of the different silages

Results silage analyses (g/kg)	Maize		Maize + fodder beet (October)		Maize + fodder beet + foliage (October)		Maize + fodder beet (December)		Maize + fodder beet + foliage (December)		Pure fodder beet	
	fresh	DM	fresh	DM	fresh	DM	fresh	DM	fresh	DM	fresh	DM
DM	380	-	326	-	289	-	299	-	315	-	156	-
pH	-		3,83		3,86				4,4		4,4	
Ash		35		47		64		58		92		170
Protein		78		73		79		78		70		68
Fibre		173		151		163		171		186		74
Sugar		<12		<12		<12		<12		<12		152
Starch		372		352		319		340		301		15
VEM[1]	369	970	292	896	240	828	280	939	253	805	152	977
VEVI[2]	385	1011	304	933	246	850	297	996	258	820	168	1078
DVE – 1991[3]	19	49	11	34	6	21	14	45	6	19	10	63
OEB – 1991[4]	-10	-25	-3	-8	3	10	-5	-17	1	3	-9	-55
VOS[5]	277	729	234	719	204	706	212	710	215	685	115	740
FOS – 1991[6]	189	498		436		390		466		402	112	717
Na		<0,1		0,4		0,7		0,4		0,5		2,0
K		10,0		11,0		14,0		11,0		10,0		21,0

Mg	1,3	1,1	1,5	1,1	1,1	1,6
Ca	1,4	1,7	2,3	1,7	2,1	2,7
P	2,3	2,1	2,5	2,2	1,9	2,4
S	1,0	1,0	1,1	1,0	0,9	0,8
Mn (mg)	17,0	21,0	32,0	26,0	35,0	74,0
Zn (mg)	26,0	30,0	40,0	29,0	28,0	57,0
Fe (mg)	163,0	297,0	441,0	444,0	847,0	1355,0
Cu (mg)	2,8	3,8	4,0	4,3	4,1	7,3
Mo (mg)	0,6	0,6	0,6	0,6	0,6	0,5
I (mg)	0,2	0,2	0,3	0,2	0,2	0,2
Co (µg)	<40,0	104,0	164,0	108,0	228,0	433,0
Se (µg)	10,0	17,0	25	26,0	33,0	58,0

[1]: Energy valorisation for dairy cattle; [2]: Energy valorisation for meat cattle; [3]: Protein digestible in the small intestine; [4]: Correction for unbalanced nitrogen / energie ratio in the feed, negative value means shortage of nitrogen; [5]: digestible organic matter; 6: fermentable organic matter

The DM content of the maize + fodder beet silages varied among 30% as was our initial goal. A very low DM content of 15,6% was found in the pure fodder beet silage, but according to the literature (O’Kiely and Moloney, 1999). Silages with such a low DM content were found to have a volume loss from 30-50% (Devillers, 1998) as we also observed.

In contrast to our expectations, the netto-energy yield of the mixed silages was lower compared to pure maize silage, although ash-values were not that high. Ashes are the main reason for a decreased energy content of roughages (De Brabander et al., 1989 and Boucqué et al., 1994). Ash percentages in fodder beet silages may be reduced by aggressive mechanical harvesting practices. Preservation of fodder beets in classical closed piles do not allow this aggressive harvesting since damage results in a strongly reduced preservation time (Lenkens, 1990). The energy content of the pure fodder beet silage was high, as expected (Aerts et al., 1979), but not explaining the low energy yield of the mixed silages. Possible explanations for the energy loss in our mixed silages are possibly an energy loss during the mechanical mixing and slicing process. Further optimalisation of this process is warranted. Adding fodder beet foliage to the silages further decreases the energy yield. This can be explained by the lower netto-energy content of the foliage and by a higher percentage of ashes since the foliage was not previously cleaned. Ensilaging fodder beets at the ideal harvest time with previously ensiled maize does not negatively influence the energy yield, nor the further ensilaging process. It can therefore be recommended to wait for optimal production of the fodder beets to reduce economic losses.

DVE-results were somewhat surprising since the DVE content of the mixed silages was lower compared to both components separately. No clear explanation may clarify this phenomenon.

Adding fodder beets to maize silages increases the selenium content. The amount of Se present in fodder beets however is strongly dependent on the Se-fertilisation and the Se content of the soil (Clark et al., 2001). The iron content also strongly increases by adding fodder beets to maize silages and even stronger when also the foliage was included. This Fe may interfere with the Cu and Zn resorption in the animal (Clark et al. 2001). High Fe yield of the ration may also result in free Fe in the animal which may activate reactive oxygen radicals. Oxidative stress increases the need for anti-oxidants (eg. Se and vitamin E) in the animal (Clark et al., 2001).

Lab Scale Silages

Results of the most important analyses of the lab scale silages are summarised in Tab. 2. Determination and counting of the micro flora present in the different silages revealed a very limited number of fungi. Little variation in the number of lactic acid bacteria was present between the different treatments. Numbers varied between $2,9*10^6$ and $7,6*10^6$, with the lowest value in silages of blanched fodder beets and the highest number in silages of fodder beets supplemented with 10% maize. Numbers of yeast varied considerably among the different treatments. Lowest values ($9,9*10^3$) were present in silages of fodder beets supplemented with maize, highest values ($1,7*10^5$) were present in silages of blanched fodder beets.

Only addition of propionic acid and 10% maize to fodder beets silages seemed to reduce the mass losses. Maize is known to contain several lactic acid bacteria, but is also able to absorb the effluent losses of the ensiled fodder beets. However, DM losses in maize supplemented silages are still high. Only addition of propionic acid had a satisfying effect and reduced the DM losses to an acceptable amount. Adding lactic acid bacteria did not give the expected results, in contrary, DM losses are even higher compared to the control silages.

Silages were not stable after 3 weeks since there was a further decrease in pH from week 3 to 5.

Lactic acid was the most dominant acid, which is preferable since these results in the lowest pH and the best preserved silages (Mc Donald et al., 2002).

Tab. 2

Analyses per treatment of the lab scale silages

Silage Analysis	Fodder beet treatment before silaging or additive at the moment of silaging						
(average)	Control	Boiled	Blanched	Propionic acid	Lactic acid bacteria	Chopped	Maize
Mass losses at 3w (%)[1]	25,2	15,9	22,6	11,7	25,5	27,6	9,3
Mass losses at 5w (%)	27,8	27,3	30,2	13,1	25,8	28,8	10,8
DM at ensilaging (%)	14,2	9,8	13,8	14,6	15,0	13,7	16,2
DM at 3w (%)	13,8	12,7	13,8	15,3	12,1	13,3	11,0
DM at 5w (%)	12,6	12,6	13,8	15,6	12,0	13,1	11,3
DM losses at 3w (%)	28,5	-12,0	22,8	7,8	39,2	29,7	36,6
DM losses at 5w (%)	38,0	4,0	30,2	7,5	39,4	32,3	35,8
pH at 3w	3,8	4,2	4,0	3,6	3,7	3,7	3,8
pH at 5w	3,5	4,0	3,8	3,4	3,5	3,6	3,7
Lactic acid at 3w (%)	0,9	0,3	0,5	1,2	1,0	1,0	1,0
Lactic acid at 5w (%)	1,3	0,5	0,9	1,6	1,3	1,3	1,2
Acetic acid at 3w (%)	0,5	0,3	0,4	0,1	0,5	0,5	0,4
Acetic acid at 5w (%)	0,6	0,3	0,4	0,1	0,5	0,6	0,4
Propionic acid at 3w (%)	0,0	0,0	0,0	0,3	0,0	0,0	0,0
Propionic acid at 5 w (%)	0,0	0,0	0,0	0,4	0,0	0,0	0,0
Butyric acid at 3w (%)	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Butyric acid at 5w (%)	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Alcohol at 5w (vol%)	0,4	0,8	0,5	0,6	0,6	1,5	0,4
Protein (g/kg DM)	67,0	64,2	63,3	53,5	78,5	70,0	91,6

[1]: Total losses of fresh mass is the result of respiration gasses and effluent losses.

CONCLUSIONS

Ensilaging fodder beets in combination with maize using silo bags is possible and makes the use of fodder beets in animal nutrition less labour intensive. Care should be taken to lower the ash percentage as much as possible to gain a highest possible energy yield in the silages. In addition, energy losses during mixing and slicing should be reduced as much as possible. Further optimalisation of the harvesting, mixing and slicing technique is needed. The best economic results will be achieved when ensilaging fodder beets at their ideal harvest time. In this study the use of previously ensiled maize did not result in further ensilaging problems nor in energy losses. Ensilaging of the fodder beet foliages is not recommended since this strongly reduces the energy-yield and adds high Fe values. The ensilaging of pure, sliced fodder beets results in too high effluent and dry matter losses, even when using silo bags. The addition of a minimum percentage of maize is needed to reduce the effluent losses. The addition of propionic acid seems promising for lab scale silages, its use under practical conditions needs further research.

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