Ensilability and silage quality of grass from intensive permanent grasslands of contrasting botanical composition

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Abstract

Grasslands cover nearly 80% of the agriculturally used area in Switzerland. Their botanical composition is highly diverse, and so is the quality of the forage they produce. Within this project, 154 forage samples were collected on intensively managed permanent grasslands across Switzerland to investigate the influence of botanical composition and regrowth cycle on silage quality. Specifically, samples were collected in 2018 and 2019 from the first to the fifth regrowth cycle of the year on 20 different grasslands, which were each assigned to one of four types of botanical composition. Forage was prewilted, chopped and ensiled in laboratory silos. Before ensiling, subsamples were taken for determination of dry matter (DM) and nutrient contents. After a storage period of 90 days, DM, nutrient contents, pH and acid contents were analysed to determine silage quality. Results showed that forage samples were ensiled with an average DM content of 33%. From spring to autumn, the crude protein and nitrate contents increased. Some samples had butyric acid, and the silage quality was generally moderate, particularly for those types of grasslands with a higher proportion of ryegrass.

Keywords: permanent grassland, botanical composition, nutrient content, silage quality

Introduction

In Switzerland, permanent grasslands cover more than 70% of the agriculturally used area. Their botanical composition and growth conditions vary widely (Lüscher *et al.*, 2019). Herbage silages from Swiss farms often have low nutrient values and poor fermentation characteristics (Augsburger *et al.*, 2019). The question arises if this is caused by the inherent characteristics of the forage in the course of the year or by the method of ensiling. To answer the first part of this question, forage samples were collected on diverse intensively managed permanent grasslands to investigate the influence of botanical composition and regrowth cycle of the year on silage quality following a standardised ensiling process.

Materials and methods

The permanent grasslands were located at altitudes ranging from 440 to 1000 m a.s.l. They had been frequently defoliated and fertilised. The relative abundance of grass species in the plant community ranged from 30 to 96%. The relative abundance of legumes and forbs ranged from 1 to 42 and 1 to 50%, respectively. The grasslands were classified into four classes (G, G_r, A, A_r) according to their botanical composition (Agroscope, 2016). In particular, the proportion of grasses was between 71 and 100% in the grassland types G and G_r and between 50 and 70% in types A and A_r. The letter 'r' means that ryegrass biomass was more than 50% of total grass biomass.

Forage samples were collected at 14 grassland sites in 2018, and at 19 grassland sites in 2019. Sampling was performed on three plots (replicates) per grassland and sampling event. The number of samples collected per regrowth cycle, respectively per grassland type, is given in Table 1. The forage was pre-wilted, short chopped and ensiled, each repetition separately, in laboratory silos each having a volume of 1.5 litres. No silage additives were used. Before ensiling and after a storage time of 90 days, dry matter (DM) and nutrient contents of samples were analysed by near infrared spectroscopy (NIRS) (Ampuero Kragten and Wyss, 2014). Fermentability coefficients (FC) were calculated (Weissbach and Honig,

Table 1. Dry matter (DM), nutrient contents and fermentability coefficient (FC) of fresh forage at ensiling from different grassland sites in Switzerland.[1]

		n	DM	Ash	Crude protein	Nitrate	ADF	NDF	Lignin	WSC	FC
			%	g kg^{-1} DM	g kg^{-1} DM	g kg^{-1} DM	g kg^{-1} DM	g kg^{-1} DM	g kg^{-1} DM	g kg^{-1} DM	
Regrowth cycle	1st (spring)	72	29.8	87	143	0.37	285	505	28	123	49
	2nd+3rd (summer)	49	36.1	98	141	1.00	384	490	33	95	50
	4th+5th (autumn)	33	35.3	130	177	3.21	231	400	34	103	46
Botanical composition	A	70	33.7	97	149	0.67	265	457	34	109	48
	A_r	6	32.1	127	161	3.79	244	417	34	110	48
	G	51	33.5	94	140	0.85	296	522	29	106	49
	G_r	27	30.1	111	169	2.54	255	461	25	120	48
Significance	SEM		0.77	1.9	2.5	0.19	3.4	5.6	0.7	2.7	0.8
	Regrowth cycle		**	**	**	**	**	**	**	**	ns
	Botanical composition		ns	**	*	**	**	**	**	*	ns

[1] n = number of samples; ADF = acid detergent fibre; NDF = neutral detergent fibre; WSC = water-soluble carbohydrates; A, A_r = proportion of grasses between 50 and 70%; G, G_r = proportion of grasses between 71 and 100%; A_r, G_r = ryegrass biomass >50% of total grass biomass; SEM = standard error of the mean; ns = not significant; * P<0.05; ** P<0.01.

1992). The FC summarizes the potential effects of DM and of the ratio of sugar content to buffering capacity on the fermentation process. Additionally, fermentation parameters (pH, acids, ethanol and NH_3) were analysed in the silages. Silage quality was classified by using the point scoring system of the 'Deutsche Landwirtschafts-Gesellschaft' (DLG) (Pahlow and Weissbach, 1999). This method considers concentrations of butyric and acetic acids together with pH in relation to DM content. The maximum value is 100 DLG points for the highest fermentation quality.

Data were evaluated by a general linear model both on the fresh material before ensiling and on the silages, with 'regrowth cycle' (with three categories: a) first cycle, b) second and third cycles and c) fourth and fifth cycles) and 'botanical composition' as fixed effects. Differences among arithmetic means were considered significant at P<0.05.

Results and discussion

The forage was wilted on the field to an average DM content of 33%, with a range from 18.2 to 67.7%. From spring to autumn, the crude protein and nitrate contents (NO_3) increased in the fresh forage (Table 1). 91% of the samples were characterized as free of NO_3 (i.e. nitrate content under 4.4 g kg^{-1} DM). These results agree with those of Weiss *et al.* (2006), who also found 90% of the fresh forage under practical conditions was free of NO_3.

The contents of ash and water-soluble carbohydrates (WSC) were different among regrowth cycles and among botanical compositions. In general, forage from the first regrowth cycle and forage with a high proportion of ryegrass (G_r and A_r) had higher WSC contents. The FC showed that 6% of the samples were difficult, 26% moderately difficult and 69% easy to ensile. All the silages showed relatively high pH values and differed among regrowth cycles (Table 2). The butyric acid content was influenced by the grassland botanical composition. In particular, forage from the first regrowth cycle with a high ryegrass proportion showed the highest butyric acid content. The silages reached on average 70 DLG points, which were significantly influenced by botanical composition. This value indicates a moderate to good silage quality.

Table 2. Dry matter (DM), fermentation parameters and DLG points of silages from different grassland sites in Switzerland.[1]

		n	DM %	pH	Lactic acid $g\ kg^{-1}$ DM	Acetic acid $g\ kg^{-1}$ DM	Propionic acid $g\ kg^{-1}$ DM	Butyric acid $g\ kg^{-1}$ DM	Ethanol $g\ kg^{-1}$ DM	NH_3-N/ N total, %	DLG points
Regrowth cycle	1st (spring)	72	28.8	4.7	53	21	1	9	16	8.9	64
	2nd+3rd (summer)	40	36.9	5.0	44	12	0	7	9	7.8	74
	4th+5th (autumn)	33	34.8	5.2	60	20	0	4	9	9.5	78
Botanical composition	A	64	33.4	4.9	49	17	0	4	13	7.7	79
	A_r	6	31.2	5.1	65	25	1	11	10	10.8	59
	G	48	33.1	4.9	44	18	1	11	14	8.8	62
	G_r	27	29.0	4.8	71	22	1	10	10	10.6	65
Significance	SEM		0.80	2.6	1.2	0.2	1.1	0.5	0.4	2.3	0.80
	Regrowth cycle		**	**.	ns	ns	ns	ns	**	ns	*
	Botanical composition		*	ns	**	ns	ns	*	ns	*	**

[1] n = number of samples; NH_3-N/N total = ammonia nitrogen per total nitrogen; DLG = Deutsche Landwirtschafts-Gesellschaft; A, A_r = proportion of grasses between 50 and 70%; G, G_r = proportion of grasses between 71 and 100%; A_r, G_r = ryegrass biomass >50% of total grass biomass; SEM = standard error of the mean; ns = not significant; * P<0.05; ** P<0.01.

The correlation between FC and DLG points was 0.47, indicating that other factors such as ash and fibre content affected silage quality. Furthermore, forage with high NO_3 content showed low butyric acid content with a correlation of -0.12, as described also by Weiss *et al.* (2006).

Conclusions

The nutrient contents of forage with different botanical composition varied markedly, and differences among regrowth cycles were detected. This finding confirms results from analyses of silages produced on Swiss farms. The quality of the silages varied, and some samples contained butyric acid. The average silage quality was moderate for grasslands with a high proportion of grasses. This was also the case for the silage from grasslands with a high proportion of ryegrass, even if this could not be expected from the higher WSC contents.

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