Description of significant influencing factors on butyric acid content of grass silage by means of a multi-factorial linear model

RESCH, R.
Institute Plant Production and Cultural Landscape, LFZ Raumberg-Gumpenstein, Altirdning 11, 8952 Irdning, Austria, Tel.: +43-3682-22451-320, E-Mail: reinhard.resch@raumberg-gumpenstein.at

Introduction

The content of butyric acid is an important indicator for the quality of fermentation of grass silages, therefore detailed knowledge of how various influencing factors (dry matter (DM), crude fibre (XF), crude protein (XP), crude ash (XA), type of forage, growth, silage system, particle length, silage additives etc.) have an impact on the butyric acid content is of great importance in consulting and agricultural practice.

Material and Methods

Within the framework of farm mentoring, a nationwide silage project (Resch, 2008) with consistent and comprehensive samplings, chemical analyses (examination using standardized methods in the Laboratory Rosenau of the agricultural chamber of Lower Austria) and interviews concerning silage management on dairy farms, was conducted in the years 2003, 2005 and 2007 in order to build up a database, both up-to-date and statistically evaluable, for mentoring. By means of a **G**eneral **L**inear **M**odel (GLM) categorical and quantitative effects of 1,429 Austrian grass silages were statistically analysed concerning the parameter butyric acid at the LFZ Raumberg-Gumpenstein. Analysis by means of GLM modelling enables the coordination and lock-out of fix effects and regression variables, for this reason this method is well suited for the evaluation of multiple influences on a dependent variable. All calculations were carried out with the software package Statgrafics, Version 5.1.

Results and Discussion

The GLM data-examination of 1,429 grass silages of Austrian farms showed an explanation of variance (r^2) of 40.4 % and a standard error of the model for butyric acid in the amount of +/- 7.1 g/kg DM for the dependent variable butyric acid content [g/kg DM].
As can bee seen in table 1, DM content [g/kg FM] exerts a highly significant and also the strongest influence (P-Value 0.000, F-Ratio 427.8) on the content of butyric acid. At a constant content of XP (148.1 g/kg DM), XF (265.5 g/kg DM) and XA (103.4 g/kg DM) as well as the lock-out of the factors type of forage, growth, silage system, particle length and silage additives, content of butyric acid decreases by about 0.06 g/kg DM, when dry matter increases by 1 g/kg FM. There is also highly significant influence of the regression variables XF and XA on the content of butyric acid and a positive correlation with the content of butyric acid. The proportion of butyric acid content increases by 0.06 g/kg DM (XF-effect) and by 0.04 g/kg DM (XA-effect), when the content of XF resp. XA are increased by 1 g/kg DM. Using coordination and lock-out of the mentioned factors, also the XP content exerts highly significant influence on the content of butyric acid. An increase of the content of XP by 1 g/kg DM causes a decrease in the butyric acid content by 0.04 g/kg DM.

Table 1: Description of significant influencing factors on butyric acid content of grass silage by means of a multi- factorial linear model (data source: Austrian silage project 2003/05/07)

source	**F-ratio**	**P-value***	**r-squared (r^2)**	**res. standard error**
categorical factors			40.4	7.1
type of forage	5.5	0.0042		
growth	11.4	0.0000		
silage system	11.7	0.0000		
particle length	18.6	0.0000		
silage additives	21.4	0.0000		
quantitative factors			**average of reg. variable**	**regression coeffizient**
dry matter	427.8	0.0000	382.4	-0.0566
crude protein	14.2	0.0002	148.1	-0.0429
crude fibre	55.2	0.0000	265.5	0.0638
crude ash	20.7	0.0000	103.4	0.0400

* P-values less 0.05 point to a significant influence

Apart from the clear influences of the above mentioned quantitative factors, highly significant influences by fix effects were verified by means of the GLM model. For instance, content of butyric acid can be decreased to a level of 6.3 g/kg DM using lactic acid bacteria and coordination of DM, XP, XF and XA, whereas untreated silage shows a butyric acid content of 9,5 g/kg DM (see Table 2).

Particle length of the harvested forage also has a highly significant influence on the butyric acid content. Grass with a length not exceeding 3 cm contained at constancy of quantitative factors less than 4 g butyric acid/kg DM while long grass that was not cut or chaffed contained 11.6 g butyric acid/kg DM. Comparison of various silage systems shows a highly significant influence on the content of butyric acid. Big bales had the lowest contents of butyric acid (6.5 g/kg DM), bunker silos showed average contents of 9.9 g butyric acid/kg and silage heaps reached top contents of 12.2 g butyric acid/kg DM.
Analyses proved a highly significant influence of the factor growth regarding the level of butyric acid content. The first growth contained at constancy of quantitative variables explicitly higher values of butyric acid (10.9 g/kg DM) than the following cuts (8.1 to 8.4 g/kg DM). In the GLM model, type of forage was also tested regarding its effect on the content of butyric acid. Forage of permanent meadows shows significantly higher contents of butyric acid at a level of 9.9 g/kg DM than forage of intensive ley farming areas (red clover, red clover - grass, lucerne, lucerne-grass, etc.) at a level of 8.4 g butyric acid/kg DM.

Table 2: Statistical values of categorical factors influencing the content of butyric acid of grass silage (data source: Austrian silage project 2003/05/07)

categories	**count**	**mean**	**stnd. error**	**confidence interval 95 %**	
				lower limit	**upper limit**
grand mean	1429	8.9	0.65	7.7	10.2
forage					
permanent grassland (pg)	982	9.9	0.66	8.6	11.2
ley faming (lf)	310	8.4	0.73	7.0	9.8
mixture of pg/lf	137	8.6	0.85	6.9	10.2
growth					
first	1041	10.9	0.60	9.8	12.1
second	190	8.3	0.77	6.8	9.9
third	44	8.1	1.22	5.7	10.5
combination of two or more	154	8.4	0.82	5.8	10.0
silage system					
bunker silo	1004	9.9	0.58	8.7	11.0
silage heap	28	12.2	1.45	9.3	15.0
monolith silo	65	7.2	1.01	5.2	9.2
big bales	332	6.5	0.71	5.1	7.9
particle length					
less 3 cm	114	3.8	0.94	1.9	5.6
3,1 to 6 cm	626	9.2	0.69	7.8	10.5
6,1 to 10 cm	385	10.2	0.71	8.8	11.6
10,1 to 20 cm	222	10.0	0.81	8.4	11.6
long grass	82	11.6	1.04	9.5	13.6
silage additives					
without additives	1135	9.5	0.56	8.4	10.6
acid or salts	44	11.0	1.19	8.7	13.3
microbiogical inoculants	250	6.3	0.71	4.9	7.7

Conclusions

Statistical data analysis of 1,429 Austrian grass silages using the GLM model shows that 5 categorical (silage additives, particle length, silage system, growth, type of forage) and 4 quantitative variables (dry matter, crude fibre, crude ash, crude protein) exert a highly significant influence on the content of butyric acid [g/kg DM]. The multiple model explains 40.4 % (r^2) of the variance of the butyric acid content.
In Austria, tolerance limit for butyric acid in grass silage was set at a level of < 3 g/kg DM. The current situation of silage quality in Austria is in need of improvement as there are too many grass silages showing butyric acid contents above the tolerance limit. The illustrated GLM model facilitates a multiple validation of reliable recommendations in order to reduce the content of butyric acid of grass silages in agricultural practice and is therefore of great importance for official consulting.

References

Resch, R., 2008: Ergebnisse Silageprojekt 2003/2005/2007. Bericht über die 35. Viehwirtschaftliche Fachtagung zum Thema "Milchquote, Strukturversorgung Wiederkäuer, Forschungsergebnisse LFZ, Aufzucht und Nutzungsdauer, Rindermast und Qualität", 9. und 10. April 2008, LFZ Raumberg-Gumpenstein, 33-46, [Proceedings of the 35th Animal Production Conference about themes “milk quota, physical structure of ruminant diets, research results LFZ, rearing and longevity, cattle fattening and product quality”, 9th and 10th of April 2008, LFZ Raumberg-Gumpenstein, 33-46]