Strategy of Silage Systems

Ernst Zimmer

Institute of Grassland- and Forage Research

Federal Research Center of Agriculture (FAL))

Braunschweig-Völkenrode, Bundesallee 50, Federal Republic of Germany

What should be "an effective strategy of silage systems in the future" is truly a good question. It is also a real challenge of trying to answer it after more than 35 years, having

- smelled the perfume of silages of many different types,
- watched carefully chewing cows and spitting choppers,
- correlated particle size and epiphytic LAB's or ENTERO's,
- tried to achieve Anaerobiosis with "point zero, zero" plastic,
- always looked for "the" additive, working on its own, sitting in a bag on the top of the bunkers, and being also convinced as you are too, that

the whole technology has to be for no cost, just for farmer's exercise during our always bright and sunny summers.

Trying to answer, technical systems should not stand in the centre. Reflecting available information and experience some elements of a strategy should be discussed, which from the authors point of view should become a higher priority in thinking, doing and decision making.

A strategy always has to be based on the framework of external conditions and circumstances influencing an existent farming situation. Also the targets, which one wants to achieve, play a key role. Last but not least, silage making as "biotechnology on farm level" has its own rules, such of a complex microbial ecosystem.

A brief analysis of what is behind situation, targets, ecology may explain the thoughts.

The situation

For the given subject one should only consider the fully market oriented livestock production in the temperate, humid climate. Here one can neglect manifold constraints from climate, forage suitability, availability of storage facilities, equipment or skilful manpower etc., which interfere silage making in other regions of the world.

Facts and tendencies then are the following:

- A still broad and continuous movement towards more silage can be observed, the positive effect on farm economy being the main reason (Wilkinson/Stark);
- hardly influenced by farm size the labor productivity in forage conservation reached a high level as indicated by a well adapted, diversified mechanisation, systematic division of labor, contractor systems;

- the average quality of silage steadily increased, but one realizes a wide range in its productivity; farms producing as much as 5000 kg FCM over maintenance from forages, or others, just maintaining their animals;
- there is strong evidence, that even with the best technology and its management we still cannot avoid poor fermentations completely, causing hazards in feeding, health and dairy processing; silage making still suffers from being far less controllable and predictable as other biotechnological processes;
- a huge amount of information is scattered, but needs critical evaluation and clearing off;
- the society no longer will tolerate effluent pollutions and calls for less chemistry in agriculture;
- cow numbers will continue to decrease, while individual milk yields further increase, so the nutrient and hygienic standard of feeding has to be kept on a high level;
- for the environment of a particular region it will be favorable to reduce the import of feed-nutrients from abroad; other ecological reasons demand for re-developing of grasslands; this also favors more attention to the improvement of quality and utilization (CORRALL, NEAL, WILKINSON 1982);
- finally, the decreed limitation of production only left a few possibilities for farmers to keep up with their cost and demand for better income; to improve utilization of the own forage resources is one of the promising chances.

The targets

At first I clearly want to concentrate only on silage. This is lactic acid fermentation in forages or other biomasses on its own, supported or initiated to some extent but never suppressed or eliminated completely.

At the moment ist seems impossible to speculate whether we can expect much of a "complete chemical conservation" as we had already several times in the history of silage making, although there are many promises. Its biology, the acceptance by animal and man, its economy for example need more consideration.

To argue with other targets, beside the fundamental one for an economic production, one really has to resume the claim for "better quality and utilization".

The fact, that labor productivity already has achieved a high level and complete, adapted mechanization has been widely considered, nevertheless created manifold quality problems for the silage on farms and in dairies too. A main reason to me seems an over-estimation of what is called the "technical organizational progress" in agriculture and its effect with respect to the unalterable biological requirements of a silage fermentation process. Too often the silage systems are seen only as a simple technical system to do the job as soon and quick as possible and thinking exclusivly in engineering and economic categories pushes away biology.

Ensiling is understood well enough to keep up with the normal and average situations. But to optimize silage fermentation, to manage unexpected situations, to make it more predictable really means more. This needs to "turn the little screws" in the right way. Therefore we should give "the farming community a much clearer appreciation of storage principles emphazizing the importance of

adhering to these" (NASH, 1978).A main target therefore in our strategy should be to optimize the understanding of fermentation by the customer, followed by the application of such facts into a working technology.

Another target is set from the resources. No longer livestock production only depends on the classic grasses and clovers, accompanied by maize. Manifold residues, by products and wastes from agro-industrial processes, food industry, non-food production offer nutrients and can be utilized as a valuable feed. Often this is an undispensable chance to make the whole production process running or to reduce pollution. The specific substrate suitability and microbial ecology of such sources need special attention. Adaptation to or development of complete systems of collection, conservation, storage and feeding need our efforts.

Finally the given uncertainty in agriculture needs to keep in view enough flexibility for future development. So the terms "cheap and expensive", investment cost and running cost have to be related much more carefully to the quality and utilization of particular silages. Systems ensuring high flexibility for a farm simultaneously with satisfactory quality are of strategic interest to us.

The meaning of future

Defining strategies always implicates some kind of timing. For the immediate future farmers always appreciate intensive transformation of available information and better exploitation of that into recipes how to do the job. So far it's the continuous mandate of the advisory service. But this can be implemented effectively by science in two ways:

- modelling biological as well as technical processes of silage making should evaluate and integrate the available information; this will allow simulation, and even more desired, will open the way to prognosis (CORALL et al. 1982, MEIERING et al. 1988, McGechan 1990).
- analytical tools, as NIR, together with modern information technology will allow checking the actual crop, silage, feed quality on the spot and so can help to better managment decisions (PAUL & ZIMMER, 1989).

For the time behind science needs a strategy for closing the gaps in our knowledge. This strategy just recently has been described by LINDGREN: "...do more research, not so many trials!" To find out "why it will be" and not only "how it is" should become the working philosophy, implying more collaboration. And here far less crop science, engineering, economy are requested, but microbiology, biochemistry, ruminant physiology. The recent activities from our midst support that statement, the catchwords highlighting a few examples fields, where the little srews obviously have to be turned more carefully.

- The Clostridia, a better methodical approach for evaluation, their role, physiology, condition of spore forming (JONSSON 1989);
- ...their nitrate sensitivity and interaction with additives (WEISSBACH 1989);
- Bacteria -induced instability, the role of Acetobacteria (WOOLFORD 1990, SPOELSTRA et al. 1988, PAHLOW);
- The epiphytic flora, its relation to environmental factors and fermentation pattern (PAHLOW 1989, 1990, RUSER 1989, MUCK 1990, MÜLLER 1990);

- The efficacy of Lactobacteria, their genetic variability, its use, the chances of genetic engineering (EUROBAC group, industrial efforts, SEALE 1986, TEUBER 1987);
- Animal performance and the reasons of its variability in relation to silage quality (many different reports);
- More efficient silage evaluation with respect to feeding and utilization or the requirements of the dairy industry.

The ecosystem silage and an optimization strategy

The ecosystem silage as we have to handle it always depends on

- the forages, their supply of nutrients and physical properties,
- the microorganisms, their requirements and capabilities,
- the environmental conditions, man made by technique and supported by additives.

But the inhomogenity and sometimes contamination of the forages,the inconstancy and a wide, unknown diversity of the natural flora,

an insufficient technology or storage environment achieved are the main constraints of silage making compared to other industrialized, biotechnological processes.

A strategy for optimization therefore always has to focus upon

- the ensiling characteristics of the "substrate", the forages, feeds etc;
- the fermentation itself.

The possibilities of improving the natural ensiling characteristics of forages by agronomic measures are rather limited and will be in all probability in the future too.

Still the most simple and efficient measure of preparation here remains prewilting. The well known "But's" are quick, intensive, even. Good management assumed the advantages outweigh the risks in some regions, in others because of climatical reasons hardly.

To know, not only to estimate the actual crop quality in a system always should be self-evident.

To maintain a given forage quality during conservation, minimizing the nutrient losses and risk of deterioration in some simplification then means to deal above all with the following phenomena:

- The shift from an epiphytic flora, dominated e.g. by Enterobacteria, to a silage flora, dominated by Lactobacteria;
- the activity of the ubiquitous Clostridia, the secondary fermentation and following bacterial deteriorations ;
- the different fungal activities, first of all aerobic instability and mycotoxin forming metabolism;
- the reduced intake and utilisation of silage, presumably as a combined effect of microbial metabolism and not yet fully understood.

One may claim, that for long time in history the basic principles of lactic acid fermentation are known to be

- sufficient sugar and complete anaerobiosis for a quick and lasting acidification.

Therefore the question may come up, where are the news?

From our experience at Völkenrode it simply means, to substantiate another understanding of the relations between the requirements of the biological system and the modern technology to manage the system; to give a better definition of the meaning of quick, sufficient, lasting, complete,uniform and to translate that into instructions farmers can adhere to.

... the term quick

During the very first phase of fermentation obviously much more matter of facts will be set as we know yet. For a particular lot of forage this is far less time as for the whole bulk and silo filling procedure. Therefore we are working for a rather long time with an "open system", neglecting more or less

- continuous plant respiration and plant enzyme based proteolysis,
- activities of the aerobes and of Enterobacteria,
- many other, still unknown metabolic activities from all the other participants of that shift, which includes also the competition between desirable species, even within a genus.

There is much evidence that even on the basis of good forage suitability and an efficient technology the factor time is of high importance:

- Any support towards a significant speed-up in acidification by use of inoculants or acids is improving animal performance, while common quality parameters, measured at the end of the storage period, seem identical; higher amounts of residual sugars will be a helpful criteria, but never can be *per se* the only reason for better animal performance;
- any support for a significant and quicker selection of the epiphytes in favor of the Lactobacteria has a similar effect;
- the "grassage-story" with none fermentation depends on the same phenomena.

... the terms sufficient and lasting

A sufficient acidification and pH, to be achieved quickly and maintained over the storage period, can avoid secondary clostridial fermentation. The sugar content as a parameter of the actual crop quality here needs more consideration. Cheap, quick detection methods in independent institutions, available to everybody, and crop growth models for prediction should become integrated parts of all strategies. Here also the fructane content of grasses, its availability and metabolism as an important source of carbohydrates needs more attention too.

Regarding the problem of Clostridia dairy industries increasingly blame silage the devil and the hygienic standard of silage, but also the feeding system, the farm as a whole have to be considered. To avoid soil contamination, but in any case propagation during fermentation and spore forming

later on have to do something with an even, sufficient and lasting acidification achieved by technical measures.

But obviously they have to do also something with complete and lasting anaerobiosis. While the Clostridia are obligate anaerobic their evidence that the presence of some oxygen acts as stress-factor inducing formation of spores (JONSSON 1989). So creeping gas exchange, insufficient sealing or compaction may play a key role and the inhomogenity of stacks, even if the average quality is defined as good, will have its explanation.

In relation to these technical terms we cannot neglect the Fungi. They are obligate Aerobes, stand low pH but are sensitive against undissociated fatty acids. With a really quick acidification by a homolactic fermentation there will always be some acetic acid for example. These being undissociated at the respective pH-level has its direct fungicidal effect against yeast, perhaps also others. Propagation not only is restricted but initial population can be decimated too (PAHLOW 1986).

The wrapping of big bales may be an example, how immediate and tight sealing of small lots of carefully prewilted material optimizes the fermentation and one could multiply such examples of good adaptation of different techniques for a better efficiency of systems.

Conclusions

Summarizing own and other experience the conclusions for our strategy will be therefore:

There can be no new basic principle in fermentation of high or low moisture materials, but

- we need a clearer appreciation of the biological requirements with respect to our management and technical decisions,
- we need to fill up gaps in our understanding by systematic research.

The basic elements of our strategy, calling for better quality and utilization by livestock should be therefore

- improvement of substrate suitability, controlled prewilting, being still the most promising technique;
- more complete information about the actual crop quality and hopefully an estimate of the given epiphytic situation an integrated part;
- systematic support of the initial shift to the "silage flora" by using additives as a strategic key element three options are available:
  - inoculation, if substrate availability is ensured by nature or prewilting;
  - inoculation in addition with chemical additives, to limit the field time, eliminate sugar shortage and directlyinhibit
  - clostridial propagation for many cases;
- chemical additives with an immediate and direct effect on acidification;
- priority for all measures to achieve a quick, complete and lasting anaerobic environment, high density and airtight sealing here belong together.

There is not much news in such a concept, perhaps only a clearing up:

The efficiency of silage systems first and exclusively relies on the promotion and development of this specific "microbial ecosystem fermentation". Here our understanding in the last years improved

distinctively. To give the development of this ecosystem more chance than only the labor productivity, will improve both the quality and economy of silages.

Literature

Corall, A. J.; Neal, Heather St.; Wilkinson, J.M. 1982. Silage in Milk Production. Techn. Rep. No. 29, G.R.J. Hurley.

Jonsson, A. 1989. The Role of Yeast and Clostridia in Silage Deterioration. Diss. Univ. Uppsala, Dept. Mikrobiology.

McGechan, M.B. 1990. A Cost-benefit Study of Alternative policies in Making Grass Silage. J. Agric. Engng. Res.46, p.153-170.

Meiering A.G; Courtin M.G; Spoelstra S.F; Pahlow G.; Honig H.; Subden R.E.; Zimmer E. 1988. Fermentation Kinetics and Toxic Gas Production of Silages. American Soc. Agric. Engng. 31/2, p. 613-621.

Muck, R.E. (1990). Prediction of lactic acid bacterial numbers on lucerne. Grass and Forage Science, 45, 273-280.

Pahlow, G. Determination of epiphytic Micro-organism on grass as influenced by harvesting and sample preparations.

Nash, M.J. 1978. Crop conservation and Storage in cool temperate Climates; the immediate future. The Royal Agric. Soc. England 139, p. 64-73.

Pahlow, G. 1989. Ecological Studies of Epiphytic Lactic acid Bacteria on whole plant Maize and in inoculated Silage. Proc. II. Forage Symposium Johnston/Iowa, p. 11-28.

Pahlow, G. 1986. Advances in establishing Silage Stability. Proc. Int. Res. Advances in Forage Preservation, p. 71-86.

Paul, Chr.; Zimmer, E.(Ed.) 1989. Nahinfrarotsprektroskopie für Industrie und Landwirtschaft - Stand und Ansichten. Vorträge 2. Deutsche NIRS Informationstagung, Landbauforschung Völkenrode, Sonderdruck Heft 107.

Ruser, B. 1989. Erfassung und Identifizierung des epiphytischen Milchsäurebakterienbesatzes auf Gras und Mais. Diss. Techn. Univ. Berlin. Landbauforschung Völkenrode, Sonderdruck Heft 103.

Seale, D. 1986. Bacterial Inoculants as Silage Additives. J. appl. Bact., Sympos. Supplement p. 95-265.

Spoelstra S.E.; Courtin M.G.; v. Beers J.M.C 1988. Acetic acid Bacteria can initiale Aerobic deterioration of maize silage. J. Agric. Soc. Cambridge, 111, p. 127-132.

Teuber, M. 1987. Genetisch veränderte Mikroorganismen in Lebensmitteln. Kieler Milchwirtsch. Forschungsberichte 39 (4), p. 265-274.

Weißbach, Fr.; Haacker, Kati 1989. On the Butyric acid Fermentation in Silages of whole Crop Cereal. Int. Symposium Production, Evaluation and Feeding of Silage, Rostock, p. 205-212

Wilkinson, J.M.; Stark, Barbara 1987. Silage in Western Europe. A survay of 17 Countries, Chalcombe Publications.

Woolford M.K. 1990. The detrimental Effects of Air on Silage - a review. J. appl. Bact. 68, p.101-116.

FORAGE CONSERVATION TOWARDS 2000

SUMMARY PAPER

R J Wilkins

AFRC Institute of Grassland and Environmental Research
Hurley, Maidenhead, Berks SL6 5LR, United Kingdom

This paper considers major issues in relation to forage conservation which have developed since the previous European Grassland Federation Conference on this topic held in Brighton, England, in 1979 (Thomas, 1980). It considers possible future trends and then discusses progress in science and technology from papers presented to this Conference, highlighting areas of achievement.

Developments in the last decade

Although much recent and ongoing research was presented to the Brighton Conference it is notable that no technical papers dealt with silage effluent or big-bale silage and that biological additives were barely mentioned. Yet these are three of the most important issues that have developed in technology and in practice over the last decade. It is, perhaps, sobering to reflect that this probably means that key issues that will affect forage conservation towards 2000 will not have been dealt with in this Conference.

At Brighton, however, Raymond (1980) in his concluding paper was extremely perceptive in identifying key pressures on grassland farming and grass conservation for the next decade. He stressed the impending importance of overproduction in Europe with possibilities of quota limitations to output, policies for the setaside of land and the need for farmers to make best use of home resources. He stressed the importance of environmental issues anticipating increased concern for the visual environment, for the prevention of chemical pollution and the need for food of high nutritional and hygienic quality. Finally he drew attention to the need to reduce costs of production and indicated possibilities for more effective use of animal wastes and for greater use of legumes.

We have throughout Europe been very much grappling with these issues and they are having dominant effect both on our research activity and on practice. I can only see intensification of these concerns as we move towards 2000.

Environmental pressures

With the progressive reduction throughout most of Europe of the pressure on land for food production and the generally high affluence of the population, agriculture will become increasingly constrained in order to achieve a high level of environmental protection.

Actions to preserve and enhance the quality of water and of aquatic ecosystems will have the greatest effect on forage conservation. Restrictions, at least in some areas, on the use of N fertilisers