Received: 31 October 2018 | Revised: 26 March 2019 | Accepted: 3 April 2019

DOI: 10.1111/gfs.12432

REVIEW PAPER

Grass and Forage Science | BGS | EGF | WILEY

Efficacy testing of silage additives—Methodology and existing schemes*

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Abstract

In the period between 1979 and 1996 several national silage additive approval schemes appeared in Europe. Today only two approval schemes are still in use, the European Union (EU) authorization of additive components (compulsory) and the German DLG approval scheme of complete additives (voluntary). The EU authorization focuses on safety and environmental properties. Since EU authorization is compulsory for all additives and most additives are composed of more than one single active component, it offers no immediate help to advisors or farmers to help selecting a suitable additive. The DLG approval scheme has a more consumer-oriented approach and can test complete additives under a rather large variety of conditions. Approved additives get the privilege to carry a DLG Quality Mark. Comparative trials from 1995 between the German and the French approval schemes were described as well as trials from 2010 to evaluate a DLG test protocol for testing additives in round bales. The DLG test scheme has to take into account that there are different aims of action, which cannot be covered by one additive. There are therefore six aims of action, directly related to the ensiling process.

KEYWORDS
approval scheme, ensiling trial, methodology, silage additive

1 | INTRODUCTION

Many farmers and agricultural entrepreneurs find it difficult to choose a suitable silage additive among the large variety of additives on the market. Often additive retailers offer farmers an early season discount, which encourages farmers to buy an entire season's supply of additive long before they know which type of challenges they will encounter and hence which type of additive they require. The only way farmers can get unbiased information about an additive is through repeated ensiling tests made by independent test institutes. Without independent testing of silage additives, it is more or less impossible for the farmer or adviser to judge objectively the efficacy of an additive and to make a sensible choice from the vast variety of products.

This contribution will focus on different approval schemes for silage additives within Europe, in particular in which way they test the efficacy of silage additives for the benefit of silage-producing farmers and entrepreneurs (Kung & Muck, 2015). The focus will be on today's two active approval systems, the European Union (EU) authorization of silage additives (compulsory) and the German DLG approval scheme (voluntary).

Through the papers presented at successive International Silage Conferences, the use and the efficiency of different silage additives was always a main topic (Wilkins & Wilkinson, 2015).

1.1 | National silage additive schemes in Europe

France and Switzerland started already in 1979 to test silage additives. At the 11th International Silage Conference in Aberystwyth, Wales in 1996 five approval schemes for silage additives had been

This contribution will focus on different approval schemes for silage additives
*Based on a paper presented at the XVIII International Silage Conference, Bonn, Germany, 24 to 26 July 2018

TABLE 1 Characteristics of European silage additive approval schemes active in 1996

Country	Start	Compulsory	Positive control required	Farm or lab scale silos	Reference
Finland	1987	Yes	Yes	Both	Mannerkorpi et al., 1996
France	1979	Yes	Yes	4 m^3-silo	Demarquilly & Andrieu, 1996
Germany	1990	No	No	Lab	Honig & Pahlow, 1993 Pahlow & Honig, 1996 Staudacher, Pahlow, & Honig, 1999 Honig & Thaysen, 2002
Ireland	1994	No	No	Both	Fitzgerald, O'Kiely, Fitzgerald, & Murphy, 1996
UK	1995	No	No	Both	Haigh, O'Kiely, Pahlow, & Viuf, 1996a Weddell, Haigh, & Steen, 1996 Weddell, Agnew, & Cottrill, 2002
Switzerland	1979	Yes	Yes	Lab	Wyss & Vogel, 1997 Wyss, 1997

presented. In Table 1, characteristics of different silage additive schemes are presented.

One by one national approval schemes were abolished and by the time EU regulation No. 1831 acquired legal force (2004), only the German DLG approval scheme was still in use and is so still today.

1.2 | The European Union authorization of silage additives

At the 11th International Silage Conference in Aberystwyth, Wales, Haigh, Weddel, and Agnew (1996b) presented a proposal for an EU additive approval scheme. Haigh, Weddel et al. (1996b) stated that active ingredient authorization has to be the responsibility of the EU. The prove of effectiveness of formulations had to be delegated to the respective national authorities of individual member states. It was envisaged that approval at EU level allowed an active ingredient to be used throughout the entire EU. However, individual member states could appeal against the decision, if they could present good reasons against it. In this article, comparative only chemical active ingredients are listed. At this time, microorganisms and enzymes had not been incorporated into the scheme.

Since 2004 all silage additives in the EU require authorization according to EC Regulation No. 1831/2003 before they can appear on the market. Silage additives are considered to be "technological additives" if their primary effect targets the improvement of silage quality (EFSA, 2012). Additives that are expected to exert their primary effect on animals are categorized as "zootechnical additives" and their authorization is stipulated by other regulations and guidelines, which usually require animal trials.

When active components have passed through the authorization process, which is administrated by EFSA (European Food Safety Authority), and appear on an official whitelist, they can be marketed within the entire EU. The EU authorization process focuses on safety (regarding handling and intake) and efficacy (regarding mainly improved fermentation or aerobic stability) of single, active components of an additive. All active components of an additive must be authorized before the additive is allowed to appear on the market. Once an active component is authorized, it can be used by any additive company thereafter. This means that the EU certification has only limited value for farmers since most additives contain more than one active component. The main objective with the EU approval system is to make sure that only safe products are sold within the EU and not to help farmers to choose a suitable silage additive.

To prove the active component's efficacy at least three successful laboratory-scale trials, lasting ≥90 days, are required. Depending on the claimed mode of action, treated silages have to show a significant improving effect against an untreated control treatment. Guidelines resemble the German DLG approval system, but are less versatile regarding which problems they might be able to alleviate. Aerobic stability is determined by monitoring silage temperature over time

as applied by most research institutes, but unlike the German guidelines, stability should be determined after about 90 days of anaerobic storage and without any air stress treatment (i.e., air infusion in silos during storage). The lack of an appropriate air stress treatment during storage increases the risk that the less well-fermented silages—usually the untreated controls—will demonstrate better aerobic stability than additive-treated silages. Completely anaerobic conditions such as in laboratory-scale silos do not mimic farm conditions and make it difficult to demonstrate an additive effect with regard to aerobic stability.

For prove of statistical significance between treated and untreated silages, EU guidelines recommend the use of non-parametric statistical tests such as the Wilcoxon–Mann–Whitney test. This type of test has the advantage that the collected data do not have to follow normal distribution like with commonly practiced analysis of variance (ANOVA) tests. ANOVA evaluations make it sometimes difficult to explain significant differences because not normally distributed parameters have to be mathematically transformed to make them normally distributed. This means that non-parametric tests usually produce probabilities, which would be often more reliable and easier to interpret for a majority of readers.

1.3 | The German DLG additive approval scheme

The German approval system for silage additives was introduced in 1990 by DLG (German Agricultural Society in Frankfurt). DLG is a non-governmental agricultural organization that has a long history in quality approval of agricultural commodities such as concentrates, plastic films, disinfectants for stables and milking parlours, teat dips, fuels and lubricants, fertilizers, food and wines and other agricultural goods. Quality-approved goods receive a "DLG Quality Mark," which is usually printed on the package of the approved product and signals to the user that this product had passed through a series of tests and complies with the minimum quality criteria set up by DLG. These tests must be carried out at independent research institutes and in accordance with detailed DLG guidelines (DLG, 2018; Thaysen, Honig, Kalzendorf, Spiekers, & Staudacher, 2007). The DLG committee for silage additives, consisting of 10 independent and two DLG-employed scientists, recommends then, based on the delivered trial dossiers, to approve or not approve the "DLG Quality Mark" for the tested additive. The certification process is kept confidential and only approved products appear on an open DLG website (http://www.guetezeichen.de/cgi-bin/gz_silier.cgi?sort=Firma).

The DLG test scheme has to take into account that there are different aims of action, which cannot be covered by one additive. There are therefore six aims of action, directly related to the ensiling process.

The DLG Guidelines thus facilitate:

- Compliance with DLG requirements
- Harmonized test procedures
- Reproducible test results
- Minimum test failures
- Improved transparency of testing
- Optimum validity of testing
- Minimum margins for the interpretation of test results
- Objective evaluation by the DLG commission.

Several of the listed additives are identical and are sold under different names by different retailers. All identical products that wish to carry the DLG Quality Mark of the original product must apply for it and are checked by DLG if they really are identical. Once each year all products on the DLG list of approved additives are sampled and analysed to check that composition and recommended application rates of each additive comply with values from the time of approval. The procedure for the DLG Quality Mark for ensiling agents is shown in Figure 1.

If an additive company or retailer considers an application for a DLG Quality Mark, the first step would be to choose which of the different "action categories" (AC) would be suitable for the additive. Fermentability coefficients (FC) define how easy or difficult forages are expected to ensile. FC values are calculated from DM, sugar (WSC) and buffering capacity (BC) values of the respective forage (Weissbach, 1975, 1996). Table 2 lists the available AC within the DLG approval system.

The DLG committee requires a dossier describing at least five successful laboratory-scale ensiling trials for ACI (fermentation quality), ACII (aerobic stability) and ACVa (*Clostridium* reproduction) and at least three feeding trials for ACIV (animal performance). For ACVI (methane yield) at least three or five laboratory-scale trials are required depending on if the DLG Quality Mark is intended for a single substrate (three trials) or for several different substrates (five trials). In addition, the applicant is encouraged not to withhold unsuccessful trials. Unsuccessful trials often come to the DLG committee's

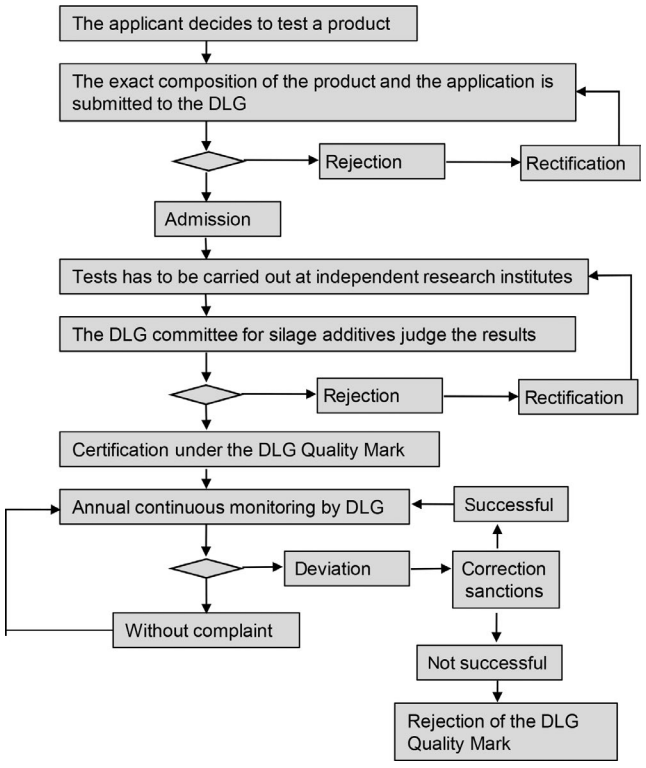

FIGURE 1 Procedure of the test for the DLG quality mark (DLG: German agricultural society)

TABLE 2 Action categories (AC) within the DLG approval system. FC values indicating ensilability of herbage: FC = DM, % + (8 × WSC, % DM/BC, g lactate/100 g DM).

Action category I Field of application	Improved fermentation processes
a	Difficult to ensile forages Fermentability coefficient (FC) <35 Roughage forages with an insufficient content of water-soluble carbohydrates and/or dry matter (DM)
b	Moderately difficult to easy to ensile forages in the lower DM range FC ≥ 35; DM < 35% e.g., grasses, forage legumes, silage maize, whole cereal plants, millet, Sudan grass
c	Moderately difficult to easy to ensile forages in the upper DM range FC ≥ 35; DM ≥35%–≤50% e.g., grasses, forage legumes, silage maize, whole cereal plants, millet, Sudan grass Each with a sufficient content of water-soluble carbohydrates
d	Grain silage e.g., corn cob mix, earlage, moist cereal grains
e	Special types of forages Forages requiring ensiling agents to develop specific actions e.g., beets, pulps, pressed pulp, stillage, brewers grains or forages for which an ensiling agent is specifically designed
Action category II	Improved aerobic stability
Forage/substrate type	Grasses or forage legumes, preferably wilted Silage maize and maize cob products Whole cereal plants Cereal crops (cereals, maize) and forage legumes Root crops By-products of the food and fermentation industries Depending on the test reports submitted with the application, the use of the DLG Quality Mark may be limited to specific forages/substrate types
Action category III	Reduced effluent production
Field of application	Forage with low dry matter contents
Action category IV	Secondary effect
a	Ensiling agents also capable of improving the feed intake value of treated silage
b	Ensiling agents also capable of improving the digestibility of treated silage
c_{Meat}	Ensiling agents also capable of improving the beef production value of treated silage
c_{Dairy}	Ensiling agents also capable of improving the milk production value of treated silage
Action category V	Additional effects
a	Prevention of *Clostridium* endospore reproduction
b	Specific effects defined by the applicant
Action category VI	Improved methane yield value of silage by:
a	Reducing fermentation losses
b	Preventing secondary heating
c	Specific effects defined by the applicant

Abbreviations: BC: buffering capacity; DM: dry-matter content; WSC: water-soluble carbohydrates.

attention anyway because its members are part of an informal silage science network in Northern Europe. Other trial reports not complying with DLG guidelines are appreciated as additional information.

ACI tests (improved fermentation quality) are carried out with laboratory-scale silos (approx. 1.5 L volume, at least 3-fold replication) comparing untreated controls with additive-treated silages. Silos are stored anaerobically at 25°C for at least 90 days before silo contents are sampled and analysed for DM (corrected for volatiles lost during drying), pH, ammonia-N, organic acids and alcohols. Weight losses (% of initial DM) of silo contents during storage are determined by frequent weighing of silos.

ACII tests (improved aerobic stability) require an air infusion 28 and 42 days after sealing. The air infusion is achieved by removing plugs from two holes ([inline graphics removed]6 mm) on the lid and bottom of each silo for the duration of 24 hr. This will stimulate yeast growth and make most control silages aerobically instable—a

vital prerequisite to test the claimed effect of the additive. Exactly 7 days after the last air infusion (i.e., on day 49), silos are sampled and analysed. Aerobic stability is determined by transferring silo contents aseptically to insulated vessels (approx. 1–2 L). Electronic temperature sensors inserted into the centre of each vessel, monitor individual silage temperatures for a period of at least 7 days at 20°C ambient temperature. A temperature increase in a silage sample is interpreted as increased activity of aerobic microorganisms (commonly yeasts or acetic acid bacteria), which consume mainly sugars (WSC) and lactate for their growth. Aerobic instability is defined as the time for the silage sample to reach 3°C above ambient temperature. Other analyses such as pH, weight losses and yeast counts at start and end of the stability test are used as supporting information.

The ACIII tests (reduced effluent formation) must be conducted with plant material with short chop lengths and a DM content of <25%. The tests take part at least 90 days and the effluent quantities were determined after 3, 7 and 14 days and on the day of opening.

ACIV tests (improved animal performance value) require feeding trials with growing or lactating cattle depending on if the ACIV application concerns improved DM intake (ACIVa), improved forage digestibility (ACIVb), improved beef production value (ACIVc $_{MEAT}$) or improved milk production value (ACIVc $_{MILK}$). Understandably, these studies are considerably costlier than laboratory-scale ensiling trials. This might be the reason why no new applications were handed in during the last decade. Another complication might be a possible conflict with EU regulations, which require that feed additives improving animal performance, are authorized according to guidelines for "zootechnical additives." This is why the DLG approval system emphasizes that all ACIV claims are secondary effects in contrast to primary effects in categories ACI (improved fermentation) and ACII (improved aerobic stability). If companies would be willing to conduct such trials, they have to prioritize compulsory EU legislation over the voluntary DLG approval system.

The ACVa test (reduced clostridial spore reproduction) should be conducted with wet forages analogous to the ACIa test. However, the forage should be inoculated with a sufficiently high amount of clostridial endospores (≥10^3 cfu/g silage) and the test requires the quantification of spores at the start and end of the storage period (≥90 days). Increased spore counts, butyrate and ammonia-N levels are taken as an indication of increased clostridial activity in silages. As to the question of suitable spore strains for the inoculation of forages, Pauly, Paula Sousa, Spörndly, and Christiansson (2008) tested 10 different *Clostridium* spore cocktails in four different forages with respect to their ability to produce clostridial fermentation in silage. Each cocktail contained between 1–3 different strains. This study confirmed that our previously selected *Clostridium tyrobutyricum* strain (strain 213) produced reliably clostridial activity compared to other inoculated silages and was found to be a suitable challenge organism for ensiling trials that focus on the inhibition of clostridial activity.

ACVI tests (improved methane yield value) determine the effect of a silage additive on the methane yield from ensiled crops by comparing each substrate to untreated controls in two procedure tests.

These tests are (Figure 2).

- Procedure test 1:90 days fermentation, no air stress (analogous to ACI)
- Procedure test 2:49 days fermentation, with air stress and aerobic stability test (analogous to ACII).

The ensiling tests and associated test methods are analogous to those in ACI or ACII.

The specific methane yield is determined:

- In the fresh material
- In procedure test 1 immediately after removal from the silo, i.e., after 90 days fermentation without air stress

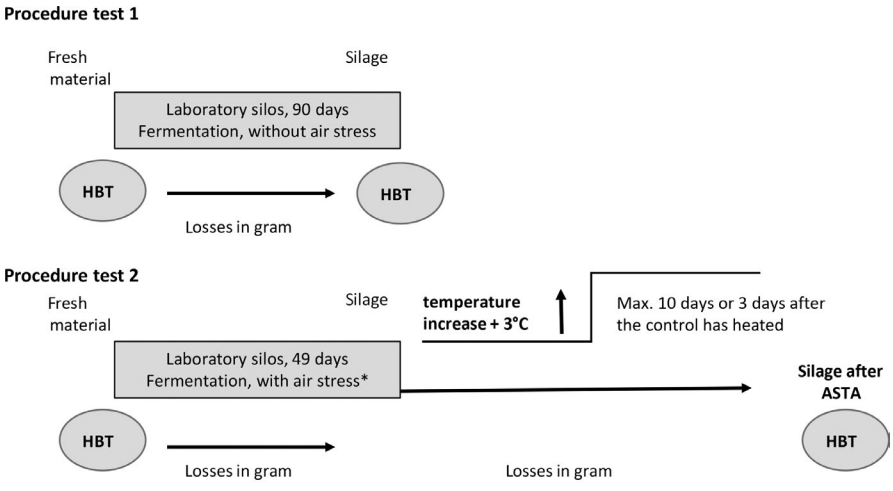

FIGURE 2 Test scheme for changes in methane yield values of silages associated with the use of ensiling agents for DLG quality mark purposes

* air stress: full-day exposure to air on the 28th and 42th day of fermentation
HBT = Hohenheim Biogas yield test = lab-scale test to determine methane yield potential of silages (Helffrich and Oechsner 2003)
ASTA = aerobic stability test (see ACII)

- In procedure test 2 after 49 days fermentation with air stress after aerobic stability has been tested (ASTA test).

Silage must be removed from the aerobic stability test after 10 days at the latest, or 3 days after control silages have heated up. The control silage is classified as heated up, if two of the three sample replicates have heated up (>23°C).

However, the weight losses during the fermentation period plus the losses during the aerobic stability test (both in g DM) must be taken into account in any event when calculating the overall effects.

This test was developed by Nussbaum (Nussbaum & Staudacher, 2012) and Thaysen (Thaysen & Ohl, 2015). In 2015, the first product received the DLG Quality Mark in this category.

The number of DLG-approved silage additives and number of brand owners with at least one DLG-approved silage additive in their portfolio is used in Figure 3. The approved additives are listed each year on an open DLG website. This web list represents the only source of impartial information about silage additives in the German-speaking regions of Europe and is used extensively by many advisors and farmers. Smaller lists with DLG-approved additives marketed in Sweden and in Switzerland are published in Swedish on a Swedish web site and in German and French on a web site in Switzerland.

1.4 | Osmotolerance

All biological ensiling agents for the DLG Quality Mark are additionally tested for osmotolerance during the annual quality test. Lactic acid bacteria with a low osmotolerance do not perform well in high DM silages such as in AC Ic. If detected levels of microbial counts in products certified for action category Ic are below 30% of the declared counts from the last 3 years, the manufacturer is addressed accordingly.

The osmotolerance test or "Rostock Fermentation Test" (RFT) is an in vitro test using forage juice in test tubes at room temperature. By adding a defined amount of potassium chloride (KCl) to the juice, it is possible to increase osmolality and simulate higher dry-matter levels in the test tubes (osmolality expresses the total concentration of soluble ingredients with osmotic behaviour). The test analyses the activity of naturally occurring and supplemented lactic acid bacteria together with the contents of fermentable carbohydrates in the forage (Richter, Spieker, Schuster, & Baranowski, 2010). The pH decrease after 3 days fermentation in tubes with and without KCl will give a good indication how osmotolerant the tested additive is. The basic principle of the test is the adaption of the fermentation media to good conditions in grass-based silage fermented for 3 days.

One application of the RFT is the check-up of different silage additives from 1 year to the next for the DLG. A great advantage of this test is the good standardization of the test conditions and the short test period compared to ensiling trials. With the help of a cluster analysis, it is possible to identify additives that do not work very well (Cluster IV).

1.5 | Comparison of the German DLG and the French INRA schemes

The big difference between the German DLG and the French INRA (Institut National de la Recherche Agronomique) schemes was the size of the silos and the wilting degree of the forage (Pflaum et al., 1997). In France the test silos had a capacity of 4 m^3, which were close to practical conditions and the forage was cut and ensiled without any wilting. In Germany, laboratory silos with a volume of 1.5 L were used and the forage was wilted to different DM contents. Furthermore, the French approval scheme was compulsory for the authorization for a product and included an obligatory determination of silage intake and digestibility with sheep for chemical additives. In Germany, the DLG scheme is on a voluntary basis and the applicant chooses among various AC tests according to the additive's specific mode of action

In 1994 and 1995, comparative ensiling trials with the same forage and the same wilting degree were carried out in Theix, France,

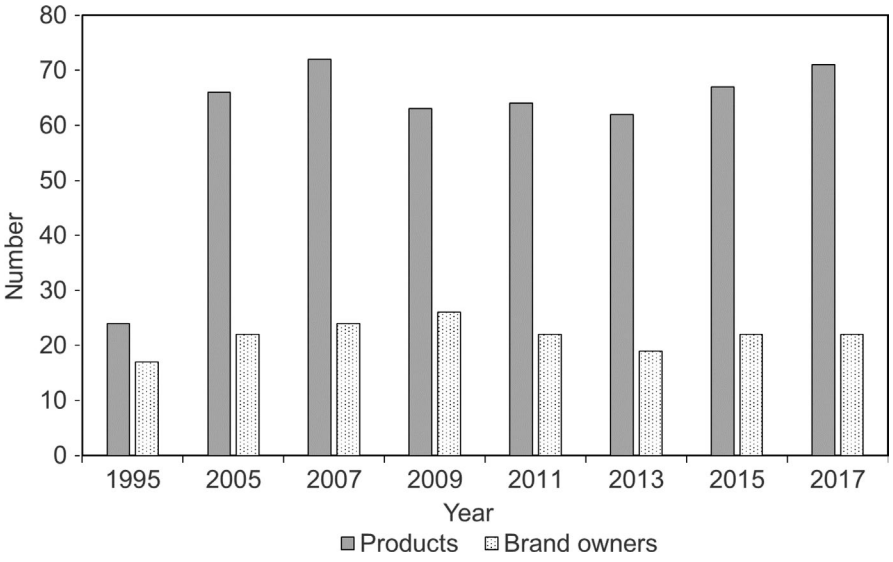

FIGURE 3 Products and brand owners with a DLG quality mark

for a direct comparison between the DLG and INRA schemes. In 1995, Switzerland joined in on the comparison. The Swiss approval system is similar to the DLG method.

In Figure 4, fermentation acids of the first trial of 1995 are presented. All silages treated with the inoculant contained in comparison to the untreated silages more lactic acid and less acetic and butyric acid. Also the second trial, where besides a negative control without additive, a chemical additive and an inoculant were tested in 1 L laboratory-scale silos (Germany) and 4 m^3 silos (France), showed similar results (Figure 5). The differences between the fermentation acids between the three countries can partly be explained by the different storage temperatures (inside or outside).

In general, the aim of the silage additive testing system was fulfilled with both methods.

1.6 | Testing silage additives in round bales

Experience from many round bale experiments indicated that some additives, which have proved their efficacy in bunker silos, were often failing in round bales, concerning the efficacy. Two important differences to bunker silage are (a) bale silage is recommended to be wilted to 45%–55% DM and (b) bale silage is often unchopped. We believe that the key issue is how the additive is distributed within the herbage. During baling, the additive is sprayed on top of the windrow just when it is fed into the pick-up unit of the baler so with unchopped material, the conditions are more difficult in comparison to chopped material. A reasonable assumption is that any blending of additive and forage in a baler is rather inefficient given that the forage usually is unchopped. Efforts to apply an additive to moist hay (Charlick, Holden, Klinner, & Shepperson, 1980; Holden & Sneath, 1980) demonstrate the problem of distributing an additive evenly in unchopped forage.

A test scheme for the approval of silage additives for big bales was already presented at the 15th International Silage Conference in Madison (Pauly & Rubenschuh, 2009). In 2010 and 2011 trials were carried out in Germany, Sweden and Switzerland with the main goal to compare laboratory-scale silos (1.5 L) with round bales (Wyss, Thaysen, Pauly, & Rubenschuh, 2012).

In 2010 round bale trials with identical protocols were conducted in Germany, Sweden and Switzerland to compare the effect of two additives against an untreated control. The inoculant contained the strains *Lactobacillus plantarum*, *Lactobacillus rhamnosus*, *Pediococcus pentosaceus*, *Lactobacillus buchneri* and *Lactobacillus brevis* and was

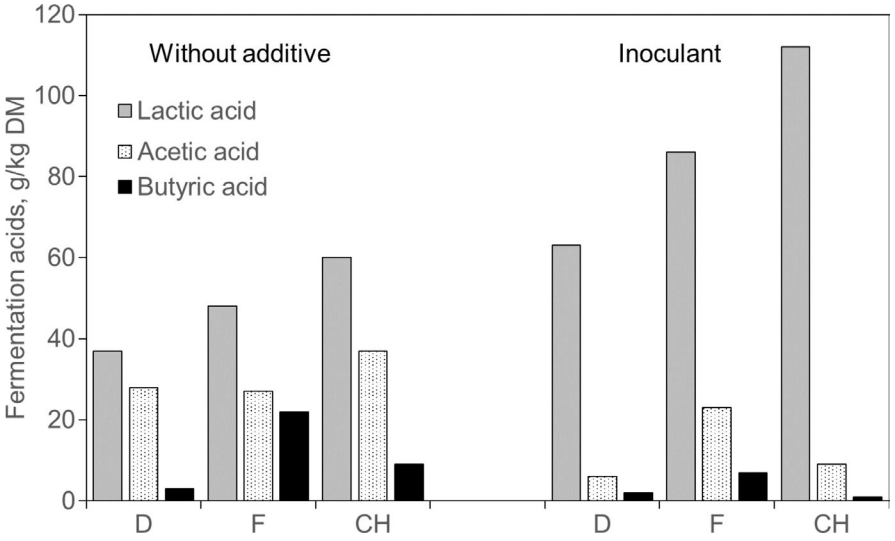

FIGURE 4 Results of trial 1 in 1995 – ryegrass, second cut, 25% DM, 84 g crude protein/kg DM and 120 g WSC/kg DM (D: Germany; F: France; CH: Switzerland; Pflaum et al., 1997).DM: dry matter content. WSC: water-soluble carbohydrates

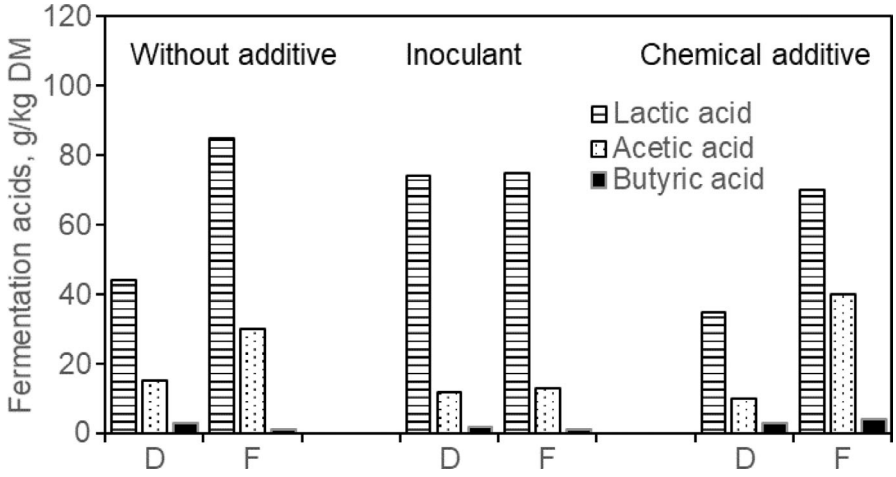

FIGURE 5 Results of trial 2 in 1995 – ryegrass, second cut, 25% DM, 80 g crude protein/kg DM and 122 g WSC/kg DM (D: Germany; F: France; Pflaum et al., 1997). DM: dry matter content, WSC: water-soluble carbohydrates

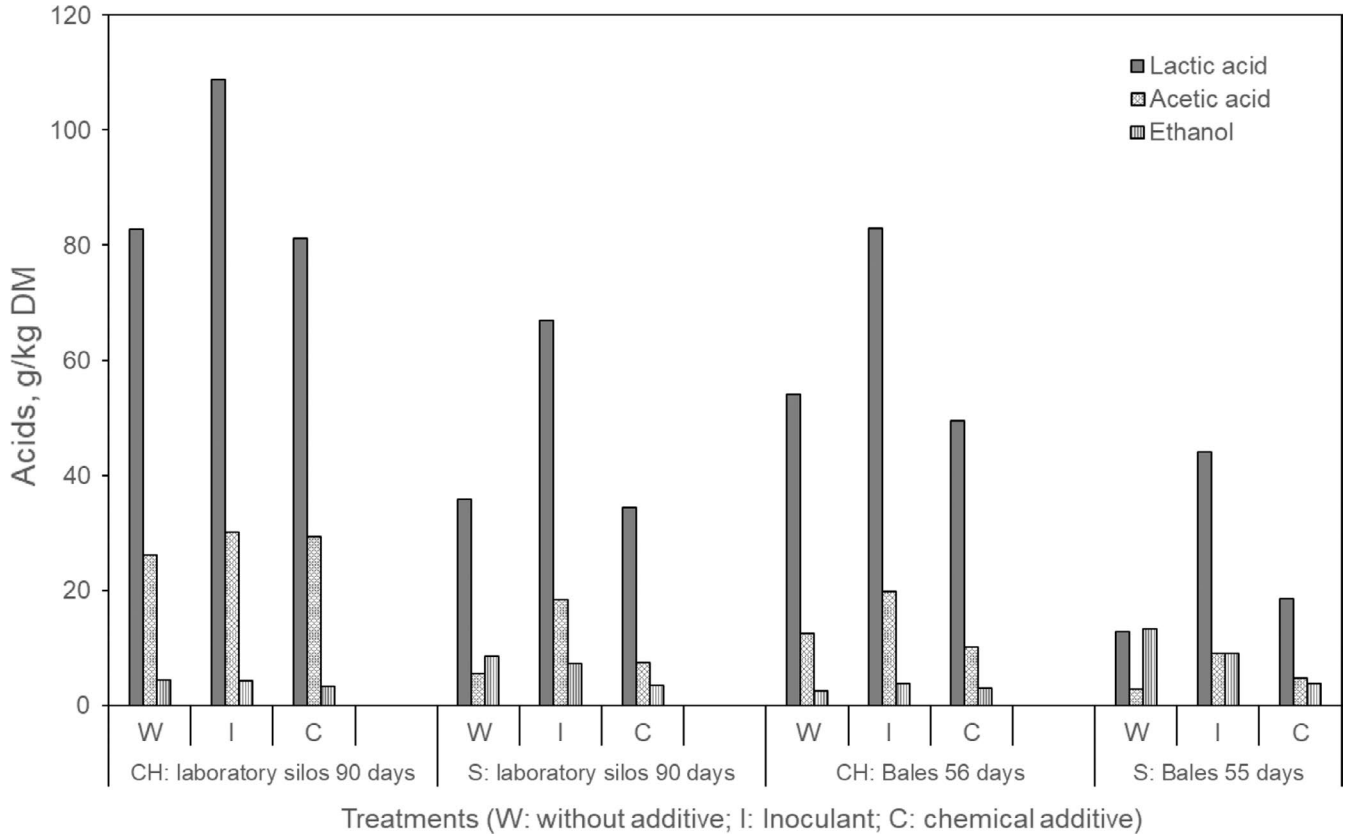

FIGURE 6 Fermentation acids of the silages from Switzerland CH made from the same herbage (Herbage: DM 37.1%, crude protein 128 g/kg DM, crude fibre 290 g/kg DM, WSC 98 g/kg DM) and of the silages from Sweden S made from the same herbage (Herbage: DM 40.6%, crude protein 147 g/kg DM, crude fibre 231 g/kg DM, WSC 167 g/kg DM (Wyss et al., 2012).DM: dry matter content, WSC: water soluble carbohydrates

applied at a rate of 1 g per tonne, respectively, 100.000 cfu/g FM. The product was diluted with water and the application rate was 4 L/tonne FM. The chemical product contained hexamine, sodium nitrite, sodium benzoate and sodium propionate and was applied undiluted at a rate of 4 L/tonne FM. The applied dosage of the inoculant amounted 118%, 148% and 108% and for the chemical product 131%, 138% and 103% of the targeted doses in Germany, Sweden and Switzerland respectively. This showed us that the application of silage additives in round bales, especially sticking to the target rate, was not easy and required skill and experience (Figure 6).

In 2011, the study was repeated in Germany and Switzerland but with a slightly modified protocol. The DM contents were 37% and 41% in Germany and Switzerland respectively. This time the applied rate for the inoculant amounted to 67% and 113% respectively. In addition, a part of the laboratory silos and round bales were exposed to an air stress treatment. In laboratory silos two 6 mm holes were opened for 24 hr (stress 1) 1 week before silos were sampled. In bales, four holes (diameter 20 mm) were made and closed again (taped) after 24 hr (stress 2). For another air stress variant 20 holes were made with a nail (diameter 2 mm) and holes were not sealed until bales were sampled 7 days later (Figure 7).

In general, the silages from the laboratory silos and round bales had a good fermentation quality. The fermentation was more intensive and the pH was lower in small scale laboratory silos in comparison to round bale silages. The acid profiles of the silages from Sweden and Switzerland (Figure 6) show similar responses to the additive treatments and bales versus laboratory silos. As expected, acid formation was larger in the wetter Swiss than drier German forages. The more intensive fermentation in the laboratory silos can be partly explained by the different length of cut of forages.

The results of the aerobic stability tests are presented in Figure 7. In Germany, the aerobic stability in the treated bales was improved in only 2 of 5 cases. Here, the low dose rate (67% of the recommended dosage) can explain this result. In Switzerland, the inoculant improved the aerobic stability of all laboratory and round bale silages.

The experiments indicated that silage additives can be tested in round bales when treated and untreated forages have the same DM content and when silage additives have been applied evenly and at the targeted dose. Furthermore, it is possible to expose round bales to an air stress treatment and thereby create more suitable conditions (i.e., aerobically instable controls) for the testing of silage additives.

Aerobic stability of bales is usually not an issue for most farmers since bales are consumed within a day or two. However, an increasing number of horse owners taking care of only few animals require a long aerobic stability when they buy silage or haylage from farmers.

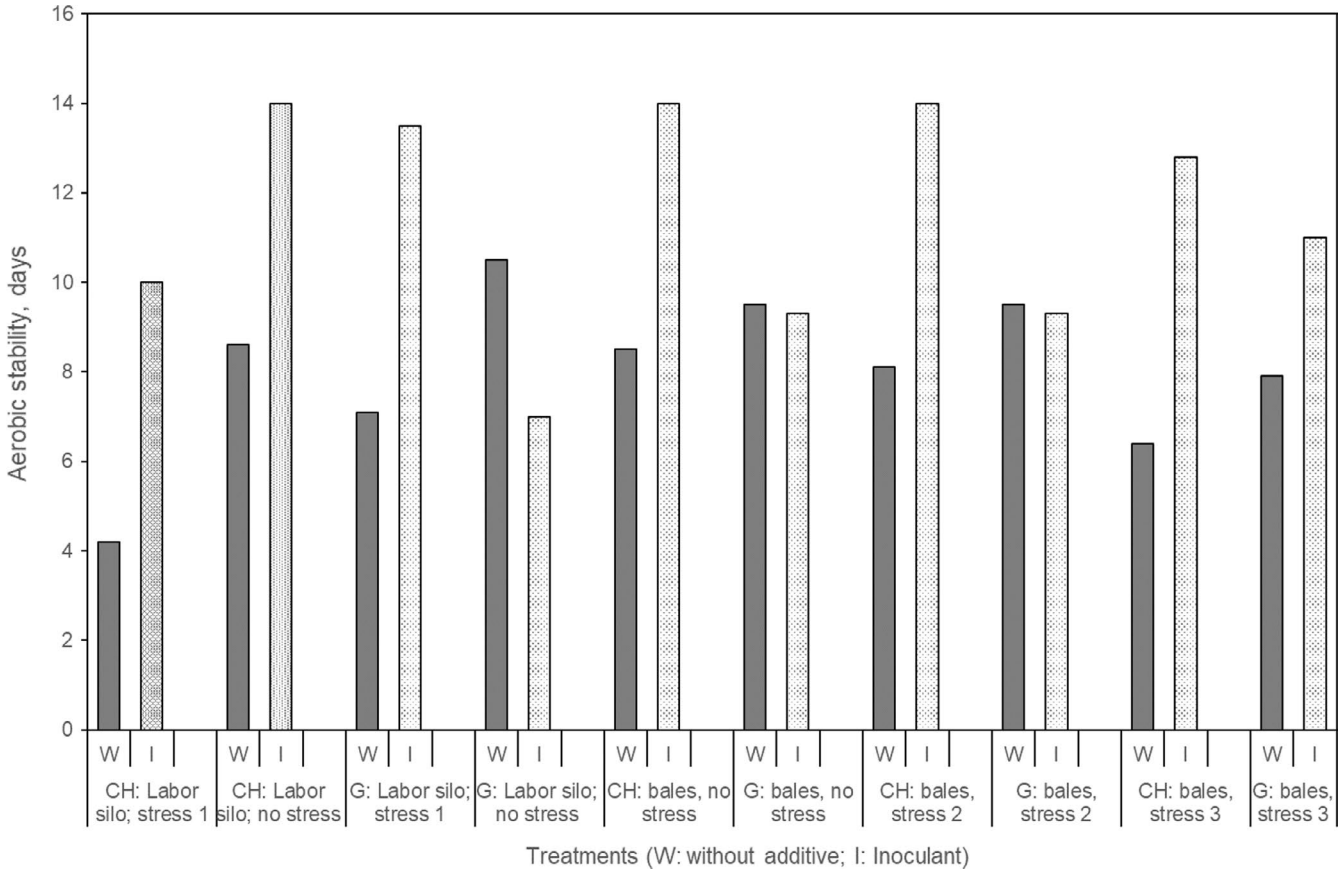

FIGURE 7 Aerobic stability of the silages from Switzerland CH made from the same herbage (Herbage: DM 37.1%, crude protein 128 g/kg DM, crude fibre 290 g/kg DM, WSC 98 g/kg DM) and of the silages from Germany G made from the same herbage (Herbage: DM 40.6%, crude protein 147 g/kg DM, crude fibre 231 g/kg DM, WSC 167 g/kg DM. "Stress" indicates different air stress treatments applied during storage (Wyss et al., 2012).DM: dry matter content, WSC: water-soluble carbohydrates

2 | CONCLUSIONS

In the period between 1979 and 1995 several national silage additive approval schemes appeared in Europe. Today only two approval schemes are still in use, the EU authorization of additive components (compulsory) and the German DLG approval scheme of complete additives (voluntary). The DLG approval scheme has a more consumer-oriented approach and can test complete additives under a rather large variety of conditions.

Comparative trials between the German and the French approval schemes showed that the aim of the silage additive testing system was fulfilled with both methods. Furthermore, comparative trials with laboratory silos and round bales were made. These experiments indicated that silage additives could also be tested in round bales when treated and untreated forages have the same DM content and when silage additives have been applied evenly and at the targeted dose.

Guidelines for the test of silage additives should not be static but should be updated regularly to meet new arising challenges. The DLG Commission for Silage Additives investigates currently the possibility to introduce new test protocols for a) silage additives, which show a positive response after a shorter storage time (AC2), b) silage additives that reduce the extent of protein degradation during ensilage or c) TMR additives, which extend the aerobic stability of total mixed rations (TMR).

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How to cite this article: Pauly T, Wyss U. Efficacy testing of silage additives—Methodology and existing schemes. *Grass Forage Sci*. 2019;74:201–210. https://doi.org/10.1111/gfs.12432