Chemicals additive used in silages

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Abstract

The objective was to describe the characteristics referent to chemical additives with emphasis to the preservatives or inhibiters of microorganism development which act on the ensiled material. Ensilage is a method used in the preservation of forage quality during the storage process, not increasing nutritional values besides those comprehended on forage. Non conventional forage species, which are not maize or sorghum, when ensiled required special precautions, since the possibility of loss during the stages of the ensilage process do not indicate that every productive and qualitative potential of the culture should be maintained in the resulting silage. Due to occurrence of nutritive loss of the ensiled material, it may have necessity of utilization of additives. Various additives have been used with several purposes, as the urea (increase on content of crude protein and neutral detergent fiber), the calcium carbonate (reducer of fermentation process and calcium fountain), sodium benzoate (conservation of carbohydrates, effect reducer on ethanol concentration and leavens inhibition), sodium pyrosulphite (cellular respiration inhibition and bactericide), sodium hydroxide (reduction on the components of the cellular wall and increase on values of "*in vitro*" digestibility of dry matter) formic acid (dehydrate effects and bactericide) and the formol (bacteriostatic action and protection of protein adversely action of microorganisms). The employment of chemical additives which inhibit the microorganism development is explained in critical cases as material with low content of dry matter and/or low content of soluble carbohydrates, difficulty on compaction of the ensiled mass and when the impediment of garner to present high oxygen percentage in inner silo.

Keywords: crud protein, dry matter content, fermentation process, nutritive loss, non conventional forages

Introduction

Ensilage is a method used in the preservation of the quality of the forage in the process of storage, not improving nutritional values besides those contained in the forage. According to VIEIRA et al. (2004), the ensilage method presents risks which may generate losses of nutrients from undesired fermentation. Non conventional forage species, which are not the culture of maize or sorghum, when they are ensiled they need special cares, since the possibility of the occurrence of losses during the stages of the ensilage process may not assure that all the productive and qualitative potential of the culture is maintained in the resulting silage (REZENDE et al., 2008). NUSSIO et al. (2000) emphasize the importance of the quantification of the process losses and the search for techniques which may contribute to minimize them.

Silage produced with a material with low content of dry matter (DM) present hiher production of total acid, demanding higher availability of soluble carbohydrates, which compose the substrates promptly available for the development of lactic bacteria. For MCDONALD et al. (1991), in these conditions, the range of pH in which the material may be considered stable, will be lower than the plants which present higher content of DM, indicating the necessity of a more prolonged fermentation. HENDERSON (1993) reports that, according to the type of additive and/or chemical treatment used in the material in the ensilage, the pH of the ensilage may be superior to 4, without modifying the quality of the resulting material.

According to EVANGELISTA and LIMA (1999), when certain forage species are ensiled, with humidity content above 70% or below 55% associated to the content of soluble carbohydrate inferior to

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8% demand special care, e.g. sugarcane *Saccharum officinarum* L.) (BALIEIRO NETO et al., 2007; MATOS, 2008) and elephant grass (*Pennisetum purpurium* Schum) (LIZIERE and NASCIMENTO JÚNIOR, 1989; LIMA and EVANGELISTA, 2001; ANDRADE and MELOTTI, 2004; REZENDE et al., 2008), since if they are ensiled without the use of some additive and/or chemical treatment, they may present losses on nutritive quality, in levels superior to 40%.

Due to the occurrence of nutritional losses of the ensiled material, it may have the necessity of the use of additives, which are substances which contribute to the reduction of losses, stimulate the desired fermentation and enrich the nutritive value, contributing with the improve of the palatability and the consumption of the resulting silage (EVANGELISTA and LIMA, 1999).

Several additives have been used in silages of various species, presenting variable results (FREITAS et al., 2006). The changes on the development of the fermentation of silages due to the application of additives may change the final composition of food and affect the consumption of dry matter, as well as the digestibility of the nutrients. The additives are substances which, when added to the forage in the moment of the ensilage, have aim at improving the fermentative pattern of the ensiled matter and, consequently, their nutritive value (LIMA and EVANGELISTA, 2001).

Among the acting functions of each additive, it is noteworthy the importance in promoting desirable fermentation and/or inhibition of the undesirable fermentation of the ensiled forage. ACCORDING to HENDERSON (1993), the ideal additive to be employed to the silage is that which provide improvement in the hygienic quality of silage, restrict the secondary fermentation (acting of clostridial bacteria or enterobacteria), increase the nutritive value, improve the aerobic stability and offer a higher return in animal production in relation to the cost presented by the use of the additive.

FREITAS et al. (2006) emphasized the importance of the use of additives in silages of sugarcane, since this culture, when ensiled alone, present steep reduction in the nutritive value, due to the fast fermentation of the sugars soluble in ethyl alcohol by yeasts. According to FANCIELLI and DOURADO NETO (2000) the undesirable chemical reactions which occur in the interior of a silo may be inhibited trough the application of preservative chemical additives (or inhibitors).

Among the main products which represent the inhibitor chemical additives, it is emphasized the urea (CH_4N_2O), the calcium carbonate, the sodium hydroxide (NaOH), the sodium benzoate (C_6H_5COONa), the sodium metabissulfite (NaS_2O_5), the formic acid (CH_2O_2), formalin (HCO_2) and mixture composed by formalin and formic acid. Therefore, the present revision has as objective to describe the particular characteristics of these additives commonly used in silages of non conventional forage species.

Chemical additives inhibitors of the undesirable fermentation

The inhibitors chemical additives (preservatives) are substances which have the function of controlling chemical and biological reactions in the ensilage, however the lack of technical knowledge concerning the additive, dosage and methods of application of them, may generate negative consequences to the development of microorganisms benefic to the fermentation, as homolatic bacteria, acting in an inhibitor way in the production of lactic acid and consequent reduction on the palatability of the silage (FANCELLI and DOURADO NETO, 2000).

In the moment of the choice of an additive to be used in the silage, EVANGELISTA and LIMA (1999) emphasize some important factors to be considered by the producer when choosing which additive should be used, as for example: availability of acquisition of the product; present facility in the management; not leaving toxic waste; efficiency in promoting fermentation; increase of the energetic or protein value in relation to silage without additives and whose cost is compatible with the quality provided in the final product.

Even though the additives are substances which can be added in the moment of the ensilage, it is important to emphasize that the obtaining of good quality silage is not constituted only by using adjectives, but also all the care demanded by the culture since the implantation of the tillage, as the appropriated cultural treatments, period of forage cut, degree of material processing, hygiene of the silo, silo type, period of silo closure, silo compaction and seal, are some allied factors which contribute with the production of quality silage.

The application of chemical additives inhibitor of the development of microorganisms is justified in critical situations as material with low or high content of dry matter and/or low content of soluble carbohydrates, difficulty in the compaction of the ensiled matter and in deficient seal since it results in high percentage of oxygen in the interior of the silo, which provide aerobic degradation trough development of microorganisms former of acetic acid, butyric acid and alcohol, responsible for the occurrence of losses of quality of the storage forage.

The preservative chemical additives are characterized by being chemical compounds which aid in the reduction of pH (RUIZ and MUNARI, 1992) or by having bateriostatic action (LIZIERE and NASCIMENTO JÚNIOR, 1989). Besides reducing the growth of aerobic microorganisms, they also contribute to the reduction of protein solubility, preservation of soluble nutrients (BALIEIRO NETO, 2007), reduction of the constitutes of the cell wall (SIQUEIRA et al., 2007b), improvement in the protein content (VIEIRA et al., 2004) and reduction of the cellular respiration of the ensiled material (EVANGELISTA and LIMA, 1999).

In a general way, the inhibitor additives act either selectively over microorganisms and undesirable processes, as aerobic growth or solubilization of protein, or indistinctly over all processes.

Urea (CH_4N_2O)

The additives compound by non protein nitrogen are used in silages of species which present low content of crude protein (EVANGELISTA e LIMA, 1999), with the objective of increasing the nutritional value of the ensiled forage, besides adding in the preservation of the silage. Maize (*Zea mays* L.) and sorghum (*Sorghum bicolor* L. Moench) present low content of crude protein when ensiled with level of dry matter between 30 and 35%. Thus, the addition of urea in the maize and silage come to increase the nutritional value of the silage. When urea is added in the confection of elephant grass (*Pennisetum purpurium* Schum), in which it presents low content of dry matter, from 15 to 20%, according to REZENDE et al. (2008), it may occur volatilization of ammonia.

The benefits of the use of urea (low unit cost per protein, containing between 42 and 45% of N), as silage additive, according to MATOS (2008) and FREITAS et al. (2002), is in the facility of obtaining, management in the application of this product and the production of ammonia (NH_3) in the presence of urease (enzyme which catalyses the hydrolysis of the urea into carbon dioxide and ammonia), due to the partial transformation of urea into ammonia in the fermentation of the silage. Ammonia has antimicrobial action, inhibiting the development of yeasts and molds, which consequently reduces the production of ethanol (or ethyl alcohol, CH_3CH_2OH), generating lower losses on dry matter and soluble carbohydrates (SCHMIDT, 2006), besides promoting stabilization of the ensiled matter and stimulating the lactic fermentation.

The use of urea as source of ammonia has showed its viability, being employed in alfalfa hay (*Medicago sativa* L.) with high humidity (FREITAS et al., 2002) since, in the presence of humidity and under the action of the urease existing in the plant and in the microorganisms, it suffers hydrolysis and produce molecules of NH_3 and one of CO_2, besides demonstrating control over the populations of fungi and yeasts. The use of urea as additive in silages is directed in the transformation of urea in ammonia, which reacts with water, consequently forming ammonium hydroxide (NH_4OH), causing an elevation of the pH and acting over the development of undesirable microorganisms (KUNG JR. et al., 2003).

The addition of urea (0.5%) according to PEREIRA et al. (2007), contributes with the elevation of the average contents of pH, increase in the content of ammoniacal nitrogen/total nitrogen ($N\text{-}NH_3/NT$) and elevation on the contents of crude protein in the silages. SANTOS et al. (2006), when studying the chemical composition of the sugarcane and of the silages with different additives in two cutting ages found values of crude protein in the dry matter superior for the treatment silage of sugarcane with 11 months more 1% of urea (14.4 against 10.5% for 24 months), being justified this value by the addition of nitrogen of the urea to sugarcane.

In a research about the quality of sorghum silages with additives, VIEIRA et al. (2004) noticed that the addition of urea (0.5%) in the silage increases the content of crude protein in the average of 40% in relation to the control silage (10.5 versus 7.4%). In the same work it was found contents superior of fiber in neutral detergent (55.9%) in silages with addition of urea (0.5%) or urea (0.5%) plus $CaCO_3$ (0.5%) (55.7%) in relation to control silages (52.1%), in which the authors relate the negative effect of urea in the development and action of bacteria degraders of the fiber portion of the forage (fibrolytic bacteria).

In evaluation of the effect of additives in the control of alcoholic fermentation and of the losses in sugarcane silages, PEDROSO et al. (2006b) verified the effectiveness of the treatment containing urea at 1% over the reduction of the production of alcohol resulting in silages with content similar to ethanol (19.3%), corresponding to the reduction in average of 19% in relation to the control (22.7%). However, the higher level of urea (1%) resulted in higher pH (4.5) and also higher gas loss during the ensilage (17.2% of the DM).

ANDRADE and MELOTTI (2004), when researching the effect of treatments over the quality of the silage of elephant grass, concluded the non recommendation of the inclusion of urea in elephant grass silage, which presented high content of humidity due to larger losses of dry matter (11.0 against 6.8% on the control treatment) and reduction of the digestibility of silage associated to high levels of humidity and presenting significant levels of acetic acid (1.81 against 0.30% for the control), since the inclusion of urea (0.5%) affected the fermentative process, since its alkalinizing action prevent the reduction of pH, favoring the development of undesirable bacteria.

PORTO et al. (2006), in a study about the fractions of the cellular wall and the digestibility "in vitro" of the dry matter (DIVDM) of different genotypes of sunflower (*Helianthus annuus* L.), emphasize that urea (0.5%) did not promote changes in the evaluated qualities (compounds of the cellular wall: fiber in neutral detergent, fiber in acid detergent, cellulose, hemicelluloses, lignin and DIVDM) and discarded the use of urea (0.5%) and other treatments (0.5% of calcium carbonate, 0.5% of urea plus 0.5% of calcium carbonate and bacterial inoculants) in the increasing of the improvements on the quality of sunflower silage.

When evaluating the effects of the chemical and biological additives in the ensilage of sugarcane under ruminal parameters and degradability of the DM and fiber fractions, SCHMIDT et al. (2007b) verified higher ruminal concentration of the propionic (21.7%) and butyric (12.1%) acid in silages treated with urea (0.5%), being related to the higher content of crude protein and ammoniacal nitrogen of these silages to the ruminal microbial growth.

ROSSI JUNIOR and SCHOGOR (2006) in evaluation about the degradability "in situ" of ensiled sugarcane with urea and maize in different proportions, verified in the treatment containing 1% of urea, higher values for effective degradability (45.2 versus 38.2%) and potential degradability (56.4 against 52.1%) in relation to the control treatment.

Summarizing, silages treated with urea present higher values of pH and appropriated levels of lactic acid, due to the buffering power of the ammonia over the acetic fermentation, besides delaying eventual secondary fermentations after opening the silo.

According to the literature, the most employed dose of urea is from 5 to 10 kg of urea (0.5 to 1%) per ton of fresh forage, having the necessity of a uniform distribution. It must be considered that urea increases the amount of nitrogen compounds favoring the development of the ruminal microorganisms, however the animals must be increasingly adapted to the consumption of the silage treated with urea to avoid eventual problems with intoxication of the ruminants.

Calcium carbonate ($CaCO_3$)

$CaCO_3$ is a result of the reaction between the calcium oxide (CaO) with carbon dioxide (CO_2). Its processing is performed trough the extraction of a mineral constituted by calcite. The separation is developed trough the flotation (SERRANA, 2002), resulting in purified calcium.

The use of $CaCO_3$ in silage has been studied as a form to control the fermentation and improve the quality of the sorghum silage (PEREIRA et al., 2007) and serving as a source of calcium to cultures deficient of this nutrient (PORTO et al., 2006).

PEREIRA et al. (2007) evaluated the employment of additives in sorghum silages and observed that the application of $CaCO_3$ (0.5%) resulted in superior values of pH for all the days of silo opening in relation to the control treatment, emphasizing the buffering effect of the additive. In the same work it was reported values of soluble carbohydrate in silages treated with $CaCO_3$ (0.5%), which presented similarities in all the days of the silo opening (from 0.15 to 1.85%) with exception of the 3rd day (0.22%), evidencing the fastest consumption of the soluble carbohydrates in the first three days of silo opening.

PORTO et al. (2006) verified that the $CaCO_3$ (0.5%) behaved as a redactor agent (providing electrons so that other substance was reduced) in the fermentative process for one of the genotypes evaluated, being found concentration of 8.2% of lignin in the first day of silo opening and consequently reduction to 6.3% in the 56th day. For the parameter DIVDM, $CaCO_3$ did not provide changes in the contents (from 45.2 to 52.5% of the DM), when compared to the control silages in practically all days of silo opening.

VIEIRA et al. (2004) concluded that the use of $CaCO_3$ (0.5%) as additive in sorghum silage presented characteristics similar to the control, since $CaCO_3$ do not chance the content of cellulose (22.9 x 22.6%) and crude protein (7.3 x 7.4%).

Concerning the calcium oxide (CaO) or quicklime, BALIEIRO NETO et al. (2007) emphasize that possibly it may have reducing power over the constituents of the cellular wall by alcalin hydrolysis and ads in the preservation of soluble nutrients, since it inhibits the development of yeasts that act over the ensiled forage, reducing the loss of the nutritive value during the ensilage and after he opening of the silo. By contrast, NETO et al. (2005) when studying the post-opening of the sugarcane silage with doses of calcium oxide, verified that the treatment containing CaO at 1.5% of the weight "in natura", reduced the losses of DM in 53% and provided increase in the aerobic stability, when compared to the control. However, it can be seen the lack of scientific work about the calcium oxide to investigate the characteristics described in this paragraph.

The consulted literatures recommend that the dose of calcium carbonate employed is from 5 to 10 kg (0.5 to 1%) per ton of fresh forage, with the necessity of a uniform distribution to optimize the chemical reaction. The use of $CaCO_3$ improves the palatability of the volume and favors the production of lactic acid, despite being unfavorable in the reduction of the pH and elevating the contents of ammoniacal nitrogen.

Sodium benzoate (C_6H_5COONa)

Sodium benzoate is one of the main bateriostatic agents used in the industries of food and beverage (MAKENI CHEMICALS, 2004b), not only for its excellent efficacy, but also by its easiness in the application. The sodium benzoate is characterized for being a white powder, grainy or crystalline, odorless or with wick balsamic odor, sweet flavor and lightly astringent.

The employment of sodium benzoate in silage is related to the reducing effect in the concentration of ethanol, inhibition of the development of yeasts and conservation of soluble carbohydrates (PEDROSO, 2003). SCHMIDT et al. (2007a) evaluated different chemical and biological additives in sugarcane and observed in silages which received the addition of sodium benzoate (0.1%) that they present higher effectiveness in preserving the content of soluble carbohydrates in silages. Meanwhile, the addition of sodium benzoate promoted lower coefficients of digestibility for the fractions FDN (47%) and FDA (40%), besides resulting in higher numeric value of consumption of dry matter (7.7 kg day^{-1}), however, without statistic significance.

According to SIQUEIRA et al. (2007a) in a study about losses of silage treated with chemical and biological aditives, it was found lower pH ranges (5.8 before the ensilage and 3.6 after opening the silo) in sugarcane silages treated with sodium benzoarte (0.1%), showing inhibitor effect over the metabolism of yeasts, determining that the species which act during the aerobic exposition were more sensible to sodium benzoate than the fermentative species.

Superior value of dry matter (35.4%) was found by PEDROSO et al. (2006a) in sugarcane silages containing sodium benzoate (0.1%) and higher animal yield, which present food conversion (7.63 kg DM kg^{-1} live weight) in relation to animals fed with silages treated with other additives (9.37 8.63 and 7.73 DM kg^{-1} of live weight to the control treatments, urea and bacterial inoculant, respectively).

SIQUEIRA et al. (2007b) in work performed about the association between chemical and bacterial additives in the ensilage of sugarcane, found values of DIVDM of 4.2% in silages treated only with sodium benzoate (0.1%) in relation to the control treatment. This result was justified by the occurrence of degradation and solubilization of the hemicellulose, increasing the value of DIVDM (68.2against 54.4% for the control before and 61.1 against 39.4% to the control after the silo opening).

SCHMIDT et al. (2007b) verified lower relation acetic acid/propionic acid (3.02) for the treatment used with sodium benzoate (0.1%) when evaluating ruminal parameters and degradability of the dry matter and the fiber fractions of the silages of sugarcane.

The research performed by PEDROSO (2003) in silages treated with different concentrations of sodium benzoate (0.05%, 0.1% and 0.2%) did not find reduction in the concentration of ethanol and total loss of DM, in the DIVDM (7.2%), due to an increase in the values of FDN (7%) and the loss of effluents were accented (15.2 kg t^{-1}) and higher than the control.

According to the consulted literature, the dose of sodium benzoate more recommended was 1 kg per each ton of green matter (0.1%). The available form of sodium benzoate is of soluble granules, which facilitates its manipulation on the moment of use, but there is the necessity of the uniform distribution of the product.

Sodium pyrosulfite ($Na_2S_2O_5$)

Sodium pyrosulfite is also called sodium metabisulfite and among its main uses it is noteworthy the use as chemical, in the production of pharmaceutical products and in the preservation of food, sterilizer and antioxidant/preservative. It is found on the market in the form of a white powder.

Sodium pyrosulfite is characterized for having bactericide action and acts in the restriction of the cellular respiration of the ensiled material, due to the liberation of sulfur dioxide (SO_2), contributing with the formation of an anaerobic environment proper to the action of the bacteria producer of lactic acid (EVANGELISTA and LIMA, 1999). It presents formation of irritant gases in its handling, which can difficult the work of ensilage and mainly the compaction of the forage.

According to LIZIERE and NASCIMENTO JÚNIOR (1989) the applied doses of sodium pyrosulfite are of 2 to 3 liters per tone of green matter (2 to 3%).

Sodium hydroxide (NaOH)

Sodium hydroxide, also known as caustic soda, highly corrosive, is used in the industry of manufacture of paper, tissues, detergents, food and biodiesel. For SIQUEIRA et al. (2007a), the sodium hydroxide, when added to silage, presents capacity of buffering, since it acts as additive in aqueous solution, dissociating in ion sodium (Na^+) and in hydroxyl (OH), which has affinity to combine with the H^+ of the medium and inhibit the changes of pH.

Sodium hydroxide is used as additive to facilitate the digestibility of the FDN, chance the fermentation, which is basically alcoholic to the lactic fermentation, consequently increasing the initial pH, which later would stimulate the action of lactic acid bacteria. The use of sodium hydroxide in sugarcane reduces the constitutes of the cellular wall and increases the value of the DIVDM (PIRES et al., 2006; VALERIANO et al., 2007).

SIQUEIRA et al. (2007b) observed that the silage of sugarcane treated with sodium hydroxide (1.0%) provided higher value of DIVDM (68.2% before the ensilage and 61.1% after the opening of the silo), due to the fast occurrence of alkaline hydrolyze over the fiber.

ANDRADE et al. (2001) in work performed over the nutritive value of sugarcane, treated with sodium hydroxide and increased with ground corn ears, concluded that the treatment with sodium hydroxide (1.0%) degraded the fiber (14.43 g $kg^{0.75}$ of insoluble fiber in neutral detergent versus 21.7 g $kg^{0.75}$ for cane + NaOH + 120 kg of ground corn ears) and contributed with increase in the digestibility (66.6 against 60.2% for cane + NaOH + 120 kg of ground corn ears).

SIQUEIRA et al. (2007a) in research about losses of sugarcane silage treated with chemical and bacterial additives, observed that the treatment containing 1.0% of sodium hydroxide resulted in silage with pH superior to the control (4.6 against 3.6), lower losses by gas (7.4 against 16.4% of the DM), or effluents (3.7 versus 75.9 kg t^{-1} of green matter) and minimized the quantitative losses during the fermentation (85.4 against 71.6% for the recovery of the DM).

PIRES et al. (2006) when studying the treatment of sodium hydroxide under four doses (0, 2.5, 5 and 7.5% of the DM) in sugarcane bagasse during 1, 3, 5 and 7 days, did not verify effect of the time over the contents of FDN, FDA, lignin, but it was possible to observe the effect of the doses to the parameters FDN (97.4 for 90%), FDA (81 for 76%) and lignin (15.5 for 13%), which proved the fast acting of the sodium hydroxide.

The sodium hydroxide was one of the most efficient substances in the treatment of volumes of low quality (REIS and RODRIGUES, 1994), however, there were some limits, as high content of sodium in the diets and the possible contamination of the environment. TEIXEIRA et al. (2007) also reported about precautions in the use of the sodium hydroxide, since besides soil contamination, due to the increase of the urine excretion, which eliminates the excess of ingested sodium, there is also the effect of the dilution over the population of microorganisms, due to the intense ingestion of water, resulting in lower fiber degradation, increase of the speed of food passage, causing a decrease in the time of retention of the rumen.

The consulted literature recommends that the dose of sodium hydroxide applied is from 10 to 15 kg (1 to 1.5%) per ton of fresh forage, having the necessity of a uniform distribution to optimize the chemical reaction.

Formic acid (CH_2O_2)

Formic acid is a colorless corrosive liquid, with penetrating odor, is presented as the simplest member of the series of the carboxylic acid, and it may behave as acid and/or reducing agent, depending on the conditions of the reactions (MAKENI CHEMICALS, 2004a), being employed in the chemical, pharmaceutical and textile industry.

When employed in silages, present dehydrator, bactericide (LIZIERE e NASCIMENTO JÚNIOR, 1989), and preservative effect due to an increase in the hydrogen ion concentration of the medium (EVANGELISTA e LIMA, 1999), promoting fast initial reduction of the pH (RUIZ e MUNARI, 1992), consequently inhibiting undesirable fermentation.

It has important actions over microorganisms and fermentation of the forage as most elevated levels of residual sugars and ethanol, management in the mildening of the temperature, reduced content of ammonia, low pH and insignificant concentrations of acetic and butyric acid (EVANGELISTA and LIMA, 1999).

ÍTAVO et al. (2000), when evaluating additives in the conservation of orange bagasse (*Citrus aurantium* L.) in the form of silage, verified that the formic acid (10%) promoted higher dehydration, higher value to content of dry matter, lower values of crude protein, higher values to DIVDM and presented immediate effect after the application in reducing the pH to 3.5. Concerning DM, they suggested that the formic acid may have produced more effluent and, consequently, it occurred losses of DM, or probably, of water, since the formic acid has dehydrator effect over the humid material. To pH, they emphasize the occurrence of fermentation of the soluble carbohydrates of the orange bagasse, enriching the medium with products from the fermentation, as lactic acid, or, probably, the formic acid, which besides being a strong acid, has also selective bactericide activity. Therefore, it may happen decrease of the pH, without increase of lactic acid.

According to EVANGELISTA and LIMA (1999), the most appropriate dose of formic acid to be used in silages, is from 5 to 6 liters per ton of green matter (0.5 to 0.6%), solved in water with proportion of 1:1.

Formol (HCO_2)

Formol is found over solutions from 37 to 45% of formaldehyde, as a colorless liquid or gas, with strong odor and at the same time irritating. It was wide employment with industrial aims, which goes from the manufactory of synthetic rubber, in the textile industry, to the manufactory of fertilizers and agricultural fungicides.

It presents some factors which contribute with its employment as additive in silages, being noteworthy the bacteriostatic action, contributing with the reduction of the secondary fermentation and it also aids in the insolubility of proteins untouchable by microorganisms in the silage and in the animal rumen (EVANGELISTA and LIMA, 1999). With the appliance of formol, the proteins absorbed in the abomasum and small intestine, which ends in liberation of aminoacids, avoiding thus that proteins are degraded with higher losses of nitrogen in the form of ammonia.

Researches performed in Brazil indicate that the best results obtained in silage were with doses of formol between 4 and 6 liters per ton (0.4 to 0.6%) of green matter. For EVANGELISTA and LIMA (1999), inferior doses to those already mentioned did not present efficiency and difficult the desired fermentation and high doses result in low ranges of digestion.

Cares to manipulate formol are indispensible, since it is a toxic product when inhaled and by the contact with the skin, with a necessity of use of an equipment of individual protection (EIP).

Mixtures of formol with formic acid

The objective to ally formol with formic acid is to aggregate the protector effect of the proteins with formol with the acidifying and bactericide action of the formic acid, since formol is not considered an ideal additive (EVANGELISTA e LIMA, 1999), because since it cannot contribute with a desirable fermentation in high levels, it reduces the consumption of the silage. Thus, allying formol with formic acid, enables the use of lower doses of formol, which contributes not to damage the consumption and the digestion at the same time, acting on the protection of proteins.

There are not conclusive data yet about the mixtures of formol and formic acid indicating the best proportions and doses to be used. In the level of experimentation, it is noteworthy the solution "Viher", which is a product composed by 70% of formol (38 to 40% of formaldehyde), 26% of formic acid (85% of purity) and 4% of water (EVANGELISTA and LIMA, 1999) and applied almost completely in silages of elephant grass, in the doses from 2 to 5 liters (0.2 to 0.5%) per ton of ensiled green mass (LIZIERE and NASCIMENTO JÚNIOR, 1989).

Final considerations

According to the exposed data referent to each preservative chemical additive it is evidenced that various alternatives of benefits to the conservation of distinct forage species in the form of silage. Only the use of these additives does not contribute to the significant increase of the quality of the ensiled forage, but serves to the maintenance of the quality and reduction of possible losses coming from an undesirable fermentation.

Cares must be observed during the process of ensilage, as the correct mixture of the additive in the silage, since thus, the exploitation of its properties is more efficient, resulting in silage of good quality. It must be respected the recommended dose and the proper attention in the product manipulation, since some inhibitor additives present risk to the human health, having thus the necessity of use of protection equipment.

The use or not of a preservative chemical additive do not dismiss the necessary cares of implantation and conduction of the harvest, of determined forage to be ensiled, i.e., the quality of the silage is directly related to the species and/or cultivated genotype, soil fertility, cultural treats, point of ensilage, compaction, and silo seal, since only the additive does not correspond to a considerable increase in quality of the produced silage.

The appliance of chemical additives inhibitors of the development of microorganisms is justified in critical situations as material with low content of dry matter and/or low content of soluble carbohydrates, difficulties in the compaction of the ensiled matter, and in deficient seal since it results in high percentage of oxygen inside the silo.

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