Aluminium sulphate as an improved alternative for dairy slurry acidification during storage

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Abstract

Acidification has been used to minimize ammonia (NH_3) emissions by biochemical changes on slurry composition [1] and have been studied previously by using sulphuric (H_2SO_4) and nitric acid (HNO_3) [2]. Acidification is a common practice in The Netherlands and Denmark [3, 4] by addition of H_2SO_4, but strong concerns with acid hazards [5] have limited the implementation in many countries as Portugal.

The main objective of this study was to compare two approaches for slurry acidification. In the first approach, acidification was performed only once at the beginning of the storage period to pH 3.5. Two initial pH values were considered in the second approach where acidification was performed to pH 3.5 and pH 5 at the beginning of the experiment and acid was added along in order to maintain those initial pH values of pH 3.5 and pH 5. In both approaches fresh slurry was weekly added to simulate real conditions,

Three additives, sulphuric acid [H_2SO_4], acetic acid [CH_3COOH] and aluminium sulphate [$Al_2(SO_4)_3$] were used to lower pH of a dairy slurry with an initial pH of 6.8, leading to 9 different treatments. NH_3 emissions and pH evolution were followed during 45 days. The evolution of carbon (C), nitrogen (N) and phosphorus (P), total content and their speciation was also studied.

Airtight glass jars of 5 litters were used and plastic recipients with 100 ml of H_3PO_4 (0.1 M) were employed to trap ammonia emissions.

Slurry acidification at both pH 3.5 and pH 5 allowed maintaining NH_3 emissions at trace levels < 5 mg N-NH_4 kg slurry^{-1} over the 45 days while the non-acidified slurry showed NH_3 emissions of 17 mg N-NH_4 kg slurry^{-1} (Table 1).

The amount of additive used varies widely with the strategy performed. The amount of added acid used to kept constant pH at 3.5 was the double than the amount used when initial pH 3.5 was allowed to rise.

When acidifying to pH 5, the pH evolution rapidly reached values of pH 6 in a period of 1 week, requiring the addition of extra acid to maintain initial values. When acidifying to pH 3.5 with acetic acid or aluminium sulphate without extra acid addition, pH values were lower than 4.3 at the end of the experimental period but pH 6 was reached at day 20 when acidifying with sulphuric acid.

Table 1. Characteristics of treated and raw dairy slurry with the different treatments and acid requirements

Treatment Approach	Acid type	Average pH	Cumulated NH_3 (mg Kg slurry^{-1})	Acid amount (g or mL Kg slurry^{-1})	Acid Equiv. (g Kg slurry^{-1})
Constant pH 5	H_2SO_4	5.5	1.53	4.2	0.09
	CH_3COOH	5.7	4.83	11.1	0.18
	$Al_2(SO_4)_3$	5.6	0.94	12.7	0.11
Constant pH 3.5	H_2SO_4	3.9	0.32	7.7	0.16
	CH_3COOH	3.7	0.34	118.7	1.98
	$Al_2(SO_4)_3$	3.8	0.15	54.1	0.47
Raised pH 3.5	H_2SO_4	5.2	2.40	4.3	0.09
	CH_3COOH	3.9	0.27	66.7	1.11
	$Al_2(SO_4)_3$	3.9	0.24	35.1	0.31
Raw Slurry	No Acid	7.3	16.54	-	-

When decreasing to an initial pH of 3.5, the behaviour was similar than when maintaining constant pH 3.5 in case of acetic acid and aluminium sulphate; nevertheless, for sulphuric acid it was necessary to acidify further, due to the quick increase of pH and consequent NH_3 emission. That leads to think that both, amount of additive to use and pH evolution should be taken into consideration when comparing different treatments.

The amount of aluminium sulphate employed at pH 3.5 was 3 times higher than with sulphuric acid. Nevertheless, the final pH differed from values of pH 3.9 when using aluminium sulphate to pH 5.2 when using sulphuric acid.

The same evolution occurred when keeping a constant pH at 3.5. Therefore, a repeated addition is needed to correct pH when using sulphuric acid, unlike what occurs when using acetic acid or aluminium sulphate.

Being the goal the maintenance of a low pH over a long storage period using the minimum amount of acid and/or labour, aluminium sulphate may be a viable alternative to sulphuric acid since the amount of aluminium sulphate employed to maintain a constant pH value of 5.0 was similar to the amount of sulphuric acid with similar pH evolution.

References

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