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A SIMPLE SYSTEM FOR STUDING THE FERMENTATION DYNAMICS OF SILAGES

JEDNOSTAVAN SISTEM ZA ISPITIVANJE FERMENTACIONE DINAMIKE U SILAŽI

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ABSTRACT

Ensiling is a preservation of moist forage crops based on an anaerobic solid-state fermentation. Different types of mini-silos have been used for laboratory examination of fermentation dynamics in silage. Suitability of these mini-silos is dependent on preventing air from getting into silage, as the presence of air can lead to undesirable microbiological reactions. In this study, whole crop maize was ensiled, with and without bacterial inoculants, in a simple system consisting of polypropylene (PP) containers with special water valve, which prevented air from entering the container while fermentation gases could freely pass out. The containers were opened on the 15th and 50th day and the samples were taken for determination of total mould and yeast count and total bacteria count. After 50 days, the silage was in good condition and there were no significant weight losses. The silage examination system proposed in this study is simple, economical and prevents air penetration into the silage.

Key words: *silage, fermentation, simple system, mini-silo.*

REZIME

Siliranje je metod konzerviranja biljnog materijala baziran na anaerobnoj fermentaciji, pri kojoj mikroorganizmi sintetišu organske kiseline koje konzervišu biljku kako bi se očuvale nutritivne materije. Različiti tipovi mini silosa (test tube, staklene tegle, metalne konzerve, plastične vreće) su do sada korišćeni za laboratorijsko ispitivanje fermentacione dinamike u silaži. Pogodnost ovih mini silosa zavisi pre svega od efikasnosti sprečavanja ulaska vazduha u silažni materijal. Prisustvo vazduha u silaži može da dovede do neželjenih mikrobioloških procesa, a time do razgradnje hranljivih materija.U ovom radu silirana je cela biljka kukuruza, sa i bez dodatka bakterijskog inokulanta, u jednostavnom sistemu za ispitivanje silaže. Sistem se sastojao od polipropilen (PP) posude, zapremine oko 2,5 dm^3, sa poklopcem na koji je postavljen specijalan ventil sa vodenim punjenjem, čija je uloga da onemogući da vazduh prodre u unutrašnjost posude, a da pri tome gasoviti produkti fermentacije mogu nesmetano da izlaze iz posude. Kontejneri su podeljeni u dve grupe: u jednu grupu je dodat komercijalni inokulant (Bonsilage Mais) u obliku heterofermentativnih i homofermentativnih bakterija mlečne kiseline, dok je druga grupa bila kontrolna. Kontejneri su otvarani 15. i 50. dana fermentacije, i u uzorcima su određivani ukupan broj kvasaca i plesni i ukupan broj bakterija. Posle 50 dana silaža je bila u dobrom stanju i nije bilo značajnih gubitaka mase. Sistem za ispitivanje silaže predložen u ovom radu je jednostavan, ekonomičan i u onemogućava pristup vazduha silaži u toku ispitivanja.

Ključne reči: *silaža, fermentacija, jednostavan sistem, mini-silos.*

INTRODUCTION

Forage crops are the staple ingredients of dietary rations fed to ruminant animals. They provide the animal with a large source of dietary fibre, critical for normal rumen function and its associated micro-environment (*Driehius and Oude Elferink, 2000*). The preservation of forage crops into a fermented feedstuff known as silage (ensiling process) has been an important practice in agriculture, especially in the dairy and beef cattle industries, where an increase in silage production has been documented since the early 1950s (*Bolsen and Laytimi, 1987*).

Ensiling is a preservation method for moist forage crops. It is based on solid-state lactic acid fermentation under anaerobic conditions, whereby lactic acid bacteria (LAB) convert water soluble sugars into organic acids, mainly lactic acid. As a result of this, the pH decreases and fresh crop is preserved. Air is detrimental to silage because it enables plant respiration and the activity of aerobic spoilage microorganisms such as yeasts and moulds. Therefore, many practices applied during ensiling, storage and feeding are intended to exclude air from silage (*Woolford, 1990*). There are three primary reasons why silage-making is important. First, it allows conservation of forage during times of harsh weather conditions, like extreme cold or drought, when it is not possible to cultivate forage crops. Secondly, it serves as means of saving surpluses harvested during the growing season. Lastly, it allows animals the access to forage crops that are difficult to graze (*Driehius and Oude Elferink, 2000*).

While most dry matter losses, which occur during storage, are due to aerobic conditions, most quality changes occur during fermentation. The crucial step of fermentation may be aided by bacterial inoculants. Inoculants are initially inactive organisms which, when added to silage, become active and can help in breaking down the plant sugars. Benefits of inoculants can include: reduced temperatures in the silo, reduced dry matter and energy losses while in storage, reduced protein solubilisation, longer bunk life, i.e., increased aerobic stability and better animal performance (*Buckmaster and Lundmark, 2009*).

It is possible to ensile almost any plant material including plant by-products. The most important crops for ensiling worldwide are whole-crop corn, alfalfa and various grasses (*Wilkins et al., 1999*).

Silage research addresses the various agronomical, biochemical, microbiological, nutritional and engineering aspects of

the process. As poor quality silage has lower nutritional value, and is often rejected by animals, much research has been focused on studying the ensiling process and the factors affecting it in order to gain better control and higher quality of the preserved feed (*Woolford, 1984; McDonald et al., 1991; Weinberg, Z. G., 1994*).

To evaluate numerous experimental variables and their interactions, involving different silage types, under controlled conditions, small-scale mini-silos are necessary. The entire contents of laboratory silos can be weighed, processed and analyzed accurately. This can only be done under the assumption that the fermentation process is reasonably similar to that taking place in field-scale silos (*Cherney and Cherney, 2003*). A survey of the limited number of studies directly comparing fermentation in field-scale and small-scale silos resulted in the conclusion that forage in both silo types did undergo similar fermentation (*Meiske et al., 1975*). Experimental silos enable experimental variables to be scaled down from field scale to experimental units and that allows multiple treatments and replications (*Cherney et al., 2004*). However, utilization of the mini-silos poses many problems of experimental technique, i.e., silages in mini-silos differ from commercial silages in their degree of consolidation and their gas exchange and heat transfer properties (*Cullison, A. E., 1948; Weinberg, Z. G., 1994*).

Over the past years, scientists have attempted to use various types of miniature silos in an effort to overcome some of the limitations of the field-scale silos for silage research purposes. Containers such as test tubes (*Allen, 1937a*), glass jars (Garber and Odland, 1927; Autrey, 1947), glass cylinders (*Archibald, 1946*), metal cans (*Nevens, 1933*) and small concrete and wooden structures (*Neidig, 1918; Allen, 1937a; Allen, 1937b*) have been used as miniature silos with varying degrees of success. In general, the suitability of such containers has depended largely on the degree to which air was excluded from silage material. However, no completely satisfactory method for the exclusion of air was reported by the above workers and varying degrees of spoilage were experienced in most instances (*Cullison, A. E., 1948*).

MATERIAL AND METHODS

Mini-silo developed in this study (Fig. 1) consisted of polypropylene (PP) container with the volume of approximately 2.5 dm^3.

Fig. 1. Mini-silo for silage study

In the centre of the cover of the container, a hole was made and a rubber seal, with special plastic valve, was put in the hole (Fig. 2 and 3). The valve was filled with water and it prevented air penetration into the silage, while silage fermentation gas products could freely pass out, thus ensuring anaerobic conditions. In Figures 2 and 3, two types of water valves, with the same role and effect are shown.

Fig. 2. Cover of the container with rubber seal and water-valve

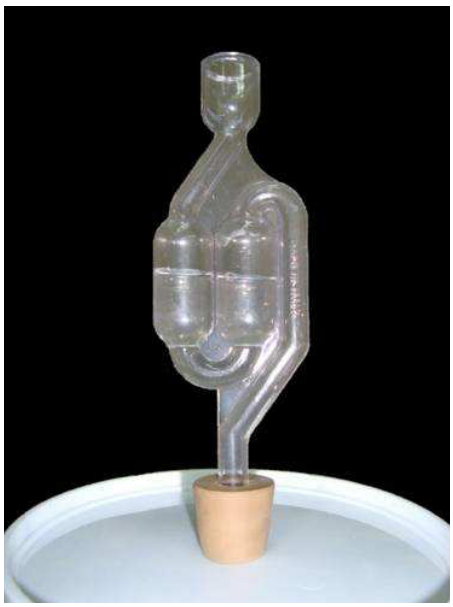

Fig. 3. Cover of the container with rubber seal and water-valve

For testing purposes, maize was ensiled using the developed mini-silo. Whole crop maize, harvested in season 2009, was chopped by a regular silage chopper at nominal particle length of approximately 5 mm. Fresh material was divided in two parts of 50 kg each. One part was spread in thin layer and sprayed with the solution of commercial bacterial inoculants ("Bonsilage Mais", Schaumann, Austria) in concentration according to manufacturer's specification. The other part of the material was used as control. "Bonsilage Mais" is a combination of hetero- (Lactobacillus buchneri) and homo-fermentative (Lactobacillus plantarum and Lactobacillus pentosaceus) lactic bacteria specially designed for maize silages.

Material was manually compacted into PP containers. The purpose of compaction was to minimize the presence of oxygen and ensure fast initiation of anaerobic conditions. The mass of the material in containers was 1.45 ± 0.3 kg and dry matter content of material was 37%. Containers were divided in two groups. Each group consisted of three containers with bacterial inoculants and three control containers without bacteria. The containers were stored in dark room at the temperature of 20 ± 3ºC. The first group of containers was opened on the 15th day and the second group on the 50th day. The samples for determination of total yeast and mould count and total bacteria count were taken.

RESULTS AND DISCUSSION

The results of determination of total yeast and mould count (TYMC) are presented in Table 1.

Table 1. Total yeast and mould count (TYMC) per gram of silage

	Sample number	Control samples	Samples with bacterial inoculant
The 15th day	1	4.0×10^5	8.0×10^6
	2	1.5×10^7	3.0×10^7
	3	8.0×10^5	1.0×10^6
	Mean	5.4×10^6	1.3×10^7
The 50th day	1	5.0×10^7	1.0×10^7
	2	2.5×10^7	8.0×10^6
	3	3.5×10^7	4.0×10^6
	Mean	3.7×10^7	7.3×10^6

The results in Table 1 show that TYMC in the samples with bacterial inoculants on the 15th day was 2.5 times higher than in control samples. But after 50 days, the results were different. In control samples, TYMC increased approximately 7 times and in samples with bacterial inoculants TYMC decreased around two times when compared to the 15th day. The comparison of samples with and without bacterial inoculants on the 50th day showed that TYMC in control samples was five times higher. This is probably due to more intense transformation of simple monosaccharides into acids in the samples with bacterial inoculants. Therefore, the better effect of conservation was achieved and the growth of yeasts and moulds was suppressed.

CONCLUSION

The system for silage studies proposed in this paper is simple, economical, easy to handle and it favourably prevents air penetration into the silage. The combination of PP containers and special water valves has been successfully applied in ensiling the whole crop maize. The total number of yeasts and moulds in the silage samples with bacterial inoculants decreased approximately twice on the 50th day, in comparison with the 15th day, and it was five times lower than in control samples. The results of this investigation showed that proposed system is suitable for laboratory examination of ensiling dynamics. PP mini-silos are easy to handle and water valve is effective in preventing air from entering the silo and in releasing gaseous products of fermentation.

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