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Effect of Different Absorbents on Fermentation Quality of Wet Potato Pulp

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Abstract: The objective of this experiment was to determine the fermentation quality of wet Potato Pulp (PP) treated with different absorbents. The absorbents were three agricultural by-products, dry Rice Straw (RS), dry Corn Stovers (CS) and dry Bean straw with Pods (BP). Four different ingredient combinations were investigated: 100% PP (Control), 80% PP+20% RS (RSP), 80% PP+20% CS (CSP) and 80% PP+20% BP (BPP). The laboratory bags were kept in the room, then were opened on 0, 3, 7, 10 and 50 days after ensiling for fermentation quality and chemical analysis, respectively. There was 110.52 mL kg^{-1} silage effluent production in the control while the absorbent treatments had no effluent losses. The Dry Matter (DM) loss was higher in the control (21.22% DM) than all the absorbent treatments (RSP, CSP and BPP) and the differences were significant ($p<0.05$). For all silages, there was a fast and large reduction in pH from the 3rd day of ensiling to <4.2. After ensiling, the pH value in all silages attained <4.00. The absorbents inhibited the break down of silage protein and the ammonia nitrogen (NH_3-N) content of absorbents addition silage significantly ($p<0.05$) lower than the control after 50 days of ensiling. Compared with the control, only the treatment RSP resulted in higher ($p<0.05$) lactic acid concentration. The acetic acid content in the absorbent treatments were ($p<0.05$) lower than that of the control silage. All the absorbent silages had a higher quality Fleig point than the control silage ($p<0.05$). These results indicated that adding the absorbent to potato pulp silage could prevent the effluent losses and reduced the silage DM loss during the ensiling and improved the fermentation quality.

Key words: Absorbent, fermentation quality, potato pulp, silage

INTRODUCTION

Potato pulp, one of the agricultural waster products that are not efficiently utilized obtained in high quantities during starch production in Northeast of China. About >80 million tons of potatoes were produced in China in 2009 (National Bureau Statistics of China, 2010). Although, <10% of these potatoes are processed in the potato starch industry, there would be nearly 5 million tons of pulp are generated each year (National Bureau Statistics of China, 2010).

It was reported that potato pulp has high nutritional value (Mayer and Hillebrandt, 1997) and it is rich in pectin thus dehydrated potato pulp is used in ruminant diets (Nicholson *et al*., 1964; Dickey *et al*., 1971). Additionally it is low in nitrogen and has similar characteristics with roughages. Usage of wet potato pulp has some disadvantages such as its production depends on season, low in dry matter content (8-20%) related with processing systems and high in sugar content cause spoiling, therefore it is used in animal feeding after dehydrating or ensiling processes. But, dehydrating is not feasible because the amount of pulp to be treated is too high for such a process to be cost-effective when a bulk product is made. Consequently, ensilage is the most convenient way to conserve nutritive values of feeds. Potato pulp silage has become a ruminant feed as a diet supplement (Sugimoto *et al*., 2009; Zunong *et al*., 2009). Although, the pulp can be ensiled with or without silage additives or bacterial inoculants (Okine *et al*., 2005; Okine, 2007; Oshita *et al*., 2007; Xue *et al*., 2011), much cost would be wasted on transporting water rather than nutrients. Other hand, ensiling of high moisture materials meant for ruminant livestock feeding involves difficulties not only in minimizing losses of silage nutrients but also in drainage through effluent with the attendant environmental consequences (Fransen and Strubi, 1998). Effluent losses are a main problem during high moisture ensilage. Adding absorbent to pulp silage could eliminate the problem. Additionally, absorbents (chopped barley straw, sugar potato pulp, straws, corn stover, hay, bean pods, cereal grains and some other dry roughage) have been successful added to various high moisture forages at ensiling to reduce DM losses and improve nutritive

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value (Jones *et al*., 1990; Ferris and Mayne, 1994; Khorvash *et al*., 2006). And, it also could be a cost-effective way in avoiding liquid loss in the silo (Alibes *et al*., 1984).

There were few studies have however, investigated the addition of dry absorbents like rice straw, corn stover and bean straw which were abundant in China in ensiling. Not only could the by-product be utilized as a source of nutrients for ruminants but using them to replace imported commercial feedstuffs could save energy in transportation and possibly reduce the environmental impact of burning or burying them as landfill. Furthermore, preparing total mixed rations silage is one practice whereby agriculture by-products are stored and utilized as animal feeds and has been reported to also improve the aerobic stability of by-product silage (Nishino *et al*., 2004).

The research was conducted to study the effect of different effluent absorbents on fermentation characteristic of wet potato pulp.

MATERIALS AND METHODS

Ensiling: The absorbers (dry rice straw, dry corn stovers and dry bean straw with pods) were from the Jiusan Farm (Heihe, China) and fresh potato pulp, obtained from the local Potato Industry Corporation was used in the study. All the absorbers were chopped into 2-3 cm using a crop chopper. The following experimental silages were made: wet potato pulp with no additive (Control) with absorbent in the form of dry rice straw amounts of 20% forage (RSP) with dry corn stovers in the amounts of 20% forage (CSP) with 20% forage of dry Bean straw with Pods (BPP). And approximately 1 kg from every treatment was weighed into the plastic bag (Polyethylene; 400 by 500 mm) and all the bags were sealed with a vacuum sealer and stored indoors for 50 days at ambient temperature about 18±2°C. Three bags per treatment were randomly opened on days 0, 3, 7, 10 and 50 for chemical analysis, respectively.

Chemical analysis: All the materials were dried at 65°C and analyzed for DM according to AOAC (1990) procedures. Nitrogen (N) content was measured by the Kjeldahl Method (AOAC, 1990). The CP was calculated as N×6.25. The Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) values were analyzed according to the procedures of Van Soest *et al.* (1991) using the Ankom System (Ankom 220 fiber analyzer; Ankom) with heat-stable α-amylase. Water-Soluble Carbohydrate (WSC) concentration was measured by the Colorimetric Method (DuBois *et al*., 1956). Starch was determined using the procedure of Okine *et al.* (2005). Pectin was determined by the HCl extraction method of Phatak *et al.* (1988). Both fresh and silage juice were extracted by blending 10 g forage (wet basis) in 90 mL of distilled water for 5 min and filtered the slurry through four layers of cheesecloth (Xing *et al*., 2009). Then, the filtrate was used for pH, Ammonia-N, lactic acid and VFA determination. The pH was directly measured using a pH meter (Sartorius Basic pH Meter, Germany). The ammonia-N (NH_3-N) concentration was determined by ammonia-sensing electrode (Expandable Ion Analyzer EA 940, Orion, USA). Samples for VFA analysis were prepared as described by Li and Meng (2006). The concentrations of a Volatile Fatty Acid (VFA) were analyzed by gas-liquid chromatography (GC 2010, Tokyo, Japan) equipped with a flame-ionization detector and a FFAP capillary column (HP-INNOWAX, 30 m×0.250 mm×0.25 um) while the lactic acid was determined by high-performance liquid chromatograph (Waters 600, Tokyo, Japan) following the procedure of Muck and Dickerson (1988). All chemical analyses were carried out in triplicate and expressed on a dry weight basis except DM content (% fresh matter) and NH_3-N (% Total Nitrogen (TN)). The Fleig points of the silages were calculated by the following equation by Kilic:

$$\text{Fleig points} = 220 + (2\times M\%-15)-40\times pH$$

(Values between 85 and 100 indicate very good quality, 60 and 80 good quality, 55 and 60 moderate quality, 25 and 40 satisfying quality and <20, worthless).

Statistical analysis: The data from the experiments were analyzed by one-way ANOVA with the GLM procedure of SAS (1999). If the variances were significant, differences between mean values were ascertained by using Duncan's multiple range test method. Standards error of means was calculated from the residual mean square in the analysis of variance.

RESULTS AND DISCUSSION

Chemical composition prior to ensiling: Chemical composition of potato pulp and absorbents is shown in Table 1. Dry matter content of fresh potato pulp determined in the present study (11.29% FM, Table 1) was compatible with the findings reported by Kryvoruchko *et al.* (2009). Potato pulp was characterized

Table 1: Chemical composition (DM %) of the materials

Items	DM	CP	NDF	ADF	WSC	Starch	Pectin
Potato pulp (FM %)	11.29	12.55	41.41	26.16	5.67	17.20	26.62
RS	84.54	3.91	71.58	39.75	4.64	1.36	ND
CS	87.25	4.47	76.62	41.82	3.49	1.35	ND
BP	89.13	4.74	72.93	50.71	1.05	1.43	ND

RS: Dry Rice Straw; CS: Dry Corn Stovers; BP: Dry Bean straw with Pods; ND: No Detected by pectin content, up to 26.62% DM which is a good energy feed for ruminants. The wet potato pulp contained 12.55, 41.41, 26.16, 17.20 and 5.67% DM as CP, NDF, ADF, starch and WSC, respectively. The chemical compositions were different from some studies. It is natural that chemical composition is changeable depending on the processing system and components of mixture.

It is known that there are at least three characteristics of forage materials necessary to make silage good (Wilkinson, 2005). Therefore, the main constraint to potato pulp silage was its low dry matter content. The relationship between the DM content for silage making and effluent production has been studied by earlier studies (Castle and Watson, 1973). The average minimum recommended DM content for ensiling was about 30% (Bastiman, 1976) which would produce no effluent or negligible effluent. In this study in order to ensure successful silage with minimal effluent production, the 20% addition of effluent absorbents may help to make silage better.

The pH and lactic acid content during the ensiling time: Silage pH and the lactic acid concentration are affected during the ensiling time (Fig. 1 and 2). For all silages, there was a quick and large reduction in pH in the 1st 3 days of

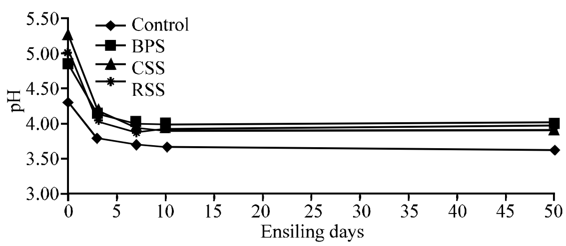

Fig. 1: The changes of pH during the ensiling time (Control: the wet pulp without any additive, RSS: the wet pulp with 20% Dry Rice Straw; CSS: the wet pulp with 20% Corn Stovers, BPS: the wet pulp with 20% Bean straw with Pods)

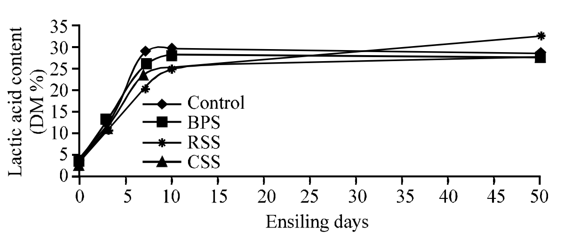

Fig. 2: The changes of lactic acid content during ensiling time (Control: the wet pulp without any additive, RSS: the wet pulp with 20% dry Rice Straw; CSS: the wet pulp with 20% Corn Stovers, BPS: the wet pulp with 20% Bean straw with Pods)

ensiling to below to 4.2 (Fig. 1). After 3 days the pH of silages decreased gradually till the 10th day and then all silages were stable till the 50th day of ensilage. The concentration of lactic acid increased rapidly between days 0-10 post-ensiling for all silages (Fig. 2). After the 10th day, the lactic acid content of all silages was increased lowly until the 50th day. From the two figures, it was presented there was a common trend in the fermentation pattern of the potato pulp silage irrespective of the absorbents used. The pH reduced while the lactic acid content increased during the ensiling.

Chemical composition after 50 days silages: Chemical composition of potato pulp-absorbent silages is shown in Table 2. The control silage had much effluent production at the bottom of the plastic bag, up to 110.52 mL kg^{-1} while the silages with absorbents had no effluent losses. It was because adding nature of fibrous absorbents with high moisture silage could reduce the water retention capacity, since fibrous materials hold water differently (Robertson and Eastwood, 1980). Mean while Sauter *et al*. (1985) presented mixtures of potato coproducts and straw substantially reduce effluent losses and ensile well based on fermentation end products. The control silage was characterized by the highest content of DM loss (21.22% DM). The DM loss concentrations in RSS, CSS and BPS silages were 8.88, 14.14 and 9.24% DM, respectively. Addition of absorbents in high moisture silage could reduce the DM loss, therefore, improving the nutritive value. The result was supported by Ozkul *et al*. (2011) who presented the addition of 9% bran to vegetable wasters significantly improved the silage in view of both dry matter content and nutritive value and also presented addition of some dry absorbents could prevent the effluent losses. Various straw additions significantly increased the DM content in all silage groups compared to the control ($p<0.05$) which was supported by Brzoska *et al*. (2000a, b). In addition, the inclusion of the absorbents to the pulp silage resulted in a significant ($p<0.05$) increase in NDF and ADF content

Table 2: Chemical composition (DM %) of ensiled potato pulp after 50 days of ensiling

	Silages				
Composition	Control	RSS	CSS	BPS	SEM
Effluent (mL kg^{-1})	110.52	0.00	0.00	0.00	0.014
DM	8.89^{d}	26.97^{b}	26.00^{c}	27.69^{a}	0.049
DM loss	23.03^{a}	8.89^{c}	14.13^{b}	9.25^{c}	0.556
CP	12.60^{a}	6.60^{c}	7.45^{b}	7.66^{b}	0.114
NDF	42.12^{d}	60.54^{c}	65.52^{a}	62.32^{b}	0.218
ADF	26.15^{c}	36.22^{b}	37.18^{b}	42.43^{a}	0.572

$^{a-d}$Row means common superscripts do not differ ($p>0.05$); SEM: Standard Error Mean; Control: The wet pulp without any additive, RSS: The wet pulp with 20% dry Rice Straw; CSS: The wet pulp with 20% Corn Stovers; BPS: The wet pulp with 20% Bean straw with pods

Table 3: Fermentation characteristic of ensiled potato pulp after 60 days of ensiling

	Treatments				
Items	Control	RSS	CSS	BPS	SEM
pH	3.62[c]	3.97[a]	3.90[b]	4.00[a]	0.006
NH_3-N (TN %)	2.50[a]	1.86[c]	2.15[b]	1.71[d]	0.031
Lactic acid (DM %)	2.83[b]	3.22[a]	2.73[b]	2.74[b]	0.089
Acetic acid (DM %)	0.59[a]	0.54[b]	0.42[c]	0.55[b]	0.013
Propionic acid (DM %)	0.07[a]	0.04[b]	0.04[b]	0.04[b]	0.003
LA/AA	4.77[c]	5.96[b]	7.04[a]	5.01[c]	0.239
Fleig point	77.98[c]	101.57[a]	100.87[a]	99.07[b]	0.264

[a-d]Row means common superscripts do not differ (p>0.05); SEM: Standard Error Mean; Control: The wet pulp without any additive, RSS: The wet pulp with 20% dry Rice Straw; CSS: The wet pulp with 20% Corn Stovers; BPS: The wet pulp with 20% Bean straw with Pods

and decrease protein content of the feedstuff compared with that of the control silage which was the same results as Brzoska *et al*. (2000a, b) who found ensiling with effluent absorbents had a significant effect on the chemical composition of silages. In fact, it was accepted that the fiber increased and the protein decreased with the straw addition.

Fermentation quality: Fermentation quality of 50 days silages is presented in Table 3. The control silage had the lowest pH value (3.62) which was higher than the value reported by Okine *et al*. (2005). The silages treated with RS (3.97), CS (3.90) and BP (4.00) had a higher pH than the control silage and the difference ($p<0.05$) was significant. There are several reasons why the control had a lower pH value. First it may have been a high level of water soluble carbohydrate in the control. The second reason may have been a high level of soluble protein in the control which can degrade rapidly and yield ammonia. The third reason may have been the low buffering capacity of the pulp silage. The absorbent treatments reduced the NH_3-N concentration and lower than the control group ($p<0.05$). The LA content in the control was 2.83% DM which higher than the results (2.46% DM) of Okine *et al*. (2007). The maximum Lactic Acid (LA) content (3.22% DM) was in RSP silage which was higher than that of the control and the other two absorbent silages ($p<0.05$). The silages with high LA concentrations were reported to have high nutrient density, more delicious and odorous; therefore, they had higher intake potential (Meneses *et al*., 2007). The LA contents of all groups were more than the value (2%) estimated for good quality silages. The pulp silage with absorbents had a lower acetic acid content compared to the control ($p<0.05$). The acetic acid content of all silages were between 0.3-0.6% which was the same value estimated for good quality silages. There was no butyric acid detected in any silage. It was clear that the use of straws as absorbent of effluents significantly decreased the acetic and propionic acid contents of silages (Brzoska *et al*., 2000a, b). As can be seen from Table 3, inclusion absorbents (RS, CS and BP) to the potato pulp silages made the proportion LA/AA higher than the control silage ($p<0.05$) except the silage BPP. The absorbent silages (RSP, CSP and BPP) had the high quality Fleig points (101.57, 100.87 and 99.07) while the control silage was in low quality Fleig points, only 77.98. But all silages were in good quality. Therefore, in this study, the addition of effluent absorbents at ensiling consistently reduced acetic and propionic acid concentration and made silage good, similar to the findings of Fazaeli and Mahdavi (1996) and Denek and Can (2006).

CONCLUSION

As a result of the study, it was very clearly seen that the pulp silage without any additive was concluded as an alternative roughage source for ruminants due to its high pectin, low NDF, ADF contents. However, absorbent addition to the fresh pulp would result in even better quality silage in view of both dry matter and nutrient contents. These results also suggested that addition dry absorbents with high moisture material could effectively prevented the effluent production during ensiling and environmental pollution.

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