Different Composition of *Indigofera zolingeriana* and Corn Stover Mix on Silage Quality and Fermentation Characteristic

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ABSTRACT
Agricultural by-products utilization is one of the solutions for feed shortage problem. Agricultural by-products have high potential to be used for feed, but its utilization is limited by the low nutrient quality. Silage is a type of by-product utilization that can increase the nutrient quality. Adding good quality forage to silage may augment the nutrient content and quality of silage. This study aimed to analyse the quality and characteristics of different composition percentages of corn stover (CS) and *Indigofera zolingeriana* (IZ) mix silage. The complete randomized design was applied in this research with four treatments consisting of T1 (90% CS + 10% milled corn), T2 (80% CS + 10% IZ + 10% milled corn), T3 (70% CS + 20% IZ + 10% milled corn), and T4 (50% CS + 40% IZ + 10% milled corn). The variables observed were pH level, dry matter, crude protein content, and Fleigh score. The results show that 10%, 20% and 40% *Indigofera zolingeriana* addition in silage yield high DM content (30,04±0,80, 30,85±2,00 and 33,03±0,99 respectfully) and increase CP content (2,87±0,04, 3,20±0,19 and 3,77±0,16 respectfully), and Fleigh score 150,5±0,9, 138,7±10,6 and 120,4±4,9 respectfully.

Keywords: *Quality, Characteristic, corn, Indigofera zolingeriana, silage.*

1. INTRODUCTION

Good quality forage is a key factor in maintaining ruminant husbandry, because forage is the main feed of ruminants. Agriculture by products utilization poses as a solution to the shortage of forage sustainability. Despite its potential utilization, agriculture by products possesses relatively low quality nutrients. Corn agriculture by products, such as corn stoves, is characterized by its perishable quality, thus technologies in processing is needed to improve the quality and storage time. One of the technologies that can be applied to corn stovers utilization as ruminant feed is silage.

The quality and nutritional contents of silage are determined by many factors, such as the plant used for silage; plant phase and dry matter content of crop; microbial involvement in fermentation process; and additive utilization. High quality forage addition to silage may improve silage's quality and nutrient contents. *Indigofera zolingeriana* is legume class forage that produces high quality and quantity of ruminant feed. This legume contains 27.9% crude protein, 15.25% crude fibre, 0.22% calcium, and 0.18% phosphorus content (dry matter); and may tolerate draught, swamp, or high salinity-land [1]. The high protein (Nitrogen) content in the forage used for silage may inflict high pH level due to base characteristic of N which in return will affect the buffering capacity of silage.

2. MATERIALS AND METHODS

The materials used in this research were corn stovers (CS) and *Indigofera zolingeriana* leaves (IZ). CS and IZ were chopped into 2-3 cm length, and then were left in room temperature for 24 hours to reduce the water content. The CS and IZ were then mixed based on the treatments compositions. Ensilage processes were done by putting the mixture in to silos and pressed to ensure anaerobic environment. The silos were layered in adhesive tape to ensure the anaerobic state during the ensilage process and they were kept for 21 days in a non-direct sunlit-room.

The research was designed based on Complete Randomized Design, using four replications for each treatment. The data obtained were tabulated and analysed using variance analysis. If the treatment had a significant effect, it would be tested for difference using Duncan Multiple Range Test (DMRT) post-test [2]. The observed parameters were: Silage pH, obtained by blending 5 g of silage sample on 50 ml distilled water; Dry matter content (DM), obtained through proximate procedures; Crude protein content (CP), obtained through proximate procedures; and *Fleigh* score (FS), calculated using the formula:

FS = 220 + [(2 × DM (%)) – 15] – (40 × pH) [3]

3. RESULTS AND DISCUSSION

Silage's chemical characteristics are acted as crucial indicator for its quality during ensilage process [4]. The characteristics of silage from this research are presented in table 2.

3.1 Silage pH

pH value is an important indicator for the success of ensilage process which signifies the fermentation of silage [5]. Analysis of variance shows highly significant difference between treatments ($p<0.01$) on pH value. Treatment T3 (70% CS + 20% IZ + 10% CF) shows the highest pH value (3.77) and treatment T1 (90% CS + 10% CF) has the lowest pH value (2.47). The pH values obtained in this research are consistent with good quality silage that ranges from 3.8 to 4.8 [6]. It might be due to quite low protein content of forage used for silage, with Indigofera posed as the main protein source, but the usage in the silage formulas is no more than 40%.

The result would be different if all of the forages used to make silage contain high crude protein content which would impact the buffering capacity of silage and in return would slower the pH reduction so the acidic environment would be difficult to obtain [7]. Fresh forage with high buffering capacity might need more acid to reduce the pH level for ensilage process [8]. The buffering capacity of treatment T3 is higher than T1 due to the IZ composition. Buffering capacity is one of the inhibiting factors for decreasing pH level during ensilage process due to amino and peptides groups [9]. The treatments comprised of IZ show higher buffering capacity than those without IZ. High buffering capacity is in consequence of the high crude protein (N) content in forage. The value of buffering capacity could not be evaluated, but it might be detected from NH_3 percentage produced during ensilage process. The high pH level might create ideal environment for spoilage bacteria to grow [10].

3.2 Dry Matter Content

The dry matter contents of forage before ensilaging are essential factor in determining silage quality. After the fermentation process, silage would reflect the nutritional contents of its materials [4]. The analysis results show that different composition percentages of CS and IZ silage significantly affect dry matter content ($p<0.01$). Dry matter content significantly increases

Table 1. Dry Matter and Crude Protein Content of Silage Material

Material	Dry Matter Content (%)	Crude Protein Content (%)
Corn Stover	24.38	7.50
Indigofera zolingeriana	20.78	27.60
Corn Flour	87.36	7.58

Table 2. Silage Nutrition Contents and Fleigh Score

Variable	T1	T2	T3	T4
pH	$2.47±0.10^a$	$2.87±0.04^b$	$3.20±0.19^c$	$3.37±0.16^d$
Dry Matter (%)	$27.43±0.45^a$	$30.04±0.80^b$	$30.85±2.00^b$	$33.03±0.99^c$
Crude Protein (%)	$10.35±2.10^a$	$12.52±0.50^b$	$13.14±0.90^b$	$17.38±1.10^c$
Fleigh Score	$160.90±3.40^a$	$150.50±0.90^a$	$138.70±10.60^b$	$120.40±4.90^c$

Different superscripts in the same line indicate significant difference between treatments ($p<0.05$).

T1 : 90% Corn Stover (CS) + 10% Corn Flour (CF)
T2 : 80% CS + 10% *Indigofera zolingeriana* (IZ) + 10% CF
T3 : 70% CS + 20% IZ + 10% CF
T4 : 50% CS + 40% IZ + 10% CF

from T1 to T4. The highest dry matter content is seen on T4 (33.03%) and the lowest is on T1 (27.43%). The results indicate that Indigofera addition in silage increases the dry matter content of silage. The difference in dry matter content of silage materials is affected by the different material percentages and in return would impact the pH level of silage [11].

The dry matter contents of CS and IZ combination silage are in accordance with CZ and up to 50% *Gliricidia sepium* combination silage which range from 27.28% to 34.16% [11]. Furthermore, ground corn addition results in the increase of dry matter content recovery of corn stovers. It also helps in maintaining nutritional contents in corn stover and results in the increasing dry matter recovery [12]. The high dry matter content indicates that the ensilage process is able to maintain the nutritional contents of forage and the additive material is acted as soluble carbohydrate source to increase dry matter content, to help accelerate the fermentation, and to maintain or to increase the preserved feed nutrition [13] [14]. The stable DM content in the range of 35-36% is considered to be influenced by the pH level of silage which is classified as an ideal pH so that the ensilage process will occur normally [15].

Carbohydrates and protein availability in silage materials hold an important role for lactic acid bacterial proliferation as the energy source and carbon frame [16]. During ensilage, the microorganisms included in fermentation process actively degrade the cellulose and hemicellulose components. Meanwhile, the other bacteria, particularly the lactic acid bacteria convert simple sugar to be organic acids (acetic acid, lactic acid, propionate acid, and butyrate acid) during the ensilage process. It results in more digestible end product compared to unfermented forages. The organic acids produced also helps in degrading the fiber components, particularly cellulose and hemicellulose [17].

3.3 Crude Protein Content

Statistical analysis results show that different CS and IZ combination silage significantly increase the crude protein content of silage from T1 to T4 ($p<0.01$). The highest crude protein content is detected in treatment T4 (17.38%) and the lowest is on treatment T1 (10.35%). The indigofera leaves addition up to 40% in silage is proven to significantly increase silage's crude protein content. Indigofera leaves high protein content is the main cause of the high crude protein content in the silage produced. Fresh legumes contain high crude protein that causes its higher buffering capacity than fresh forages or maize [8].

During ensilage process, the lactic acid bacteria in the forage utilize the forage as energy souce to produce organic acids such particularly lactid acid and results in the degradation of forage's protein content [18]. The materials protein content is broken down into amino acids and polypeptides which would later be degraded into nitrogen-ammonia ($N\text{-}NH_3$), volatile fatty acid (VFA), and CO_2. This condition would intensively continue if the oxygen supply is sufficient [19]. The legume naturally contains *Clostridium sp* and fungus more than lactic acid bacteria, and contains more crude protein content than cerealia plants such as corn [10]. Silage's ammonia (NH_3) is produced in silage due to *Clostridium sp* or other spoilage bacteria activities [20]. This *Clostridium* bacterium hold the most dominant role in secondary fermentation which converse lactic acid into butyric acid, also in protein, peptides, and amino acid degradation to amine and ammonia. The ammonia is produced from amine compounds which are released due to bacterial activity in degrading proteins.

3.4 Fleigh Score

Fleigh scores of CS and IZ combination treatments silage in this research are significantly different by statistical analysis ($p<0.01$). Treatment T1 shows the highest Fleigh score of 160.9 and treatment T4 has the lowest Fleigh score of 120.4. The increase of Indigofera leaves percentage in silage reduces silage Fleigh score. Low Fleigh score is a result of high pH level and dry matter content in silage. Fresh forage with high buffering capacity requires more acid to reduce pH compared to low-buffering capacity forage, fresh grass, or corn stovers [8].

Fleigh score increases with the increase of dry matter content and the decrease of pH level. The high dry matter content indicates that ensilage process is able to preserve the silage materials, while the low pH indicates that the ensilage process runs appropriately. Minimum biomass loss, low pH level, aroma and structure of silage indicate that ensilage process runs effectifely and it holds suffecient recovery capacity [13]. Good Fleigh score is characterized by high dry matter content and low pH level in silage. Maintaining high dry matter content is an indicator for good ensilage process preservative function; meanwhile low pH level is indicator for appropriate fermentation process [21].

Although the addition of Indigofera decreases the silage Fleigh scores, the result scores are still relativelly high (from 120.4 to 160.9). Fleigh score is categorized as excellent if it is more than 100. Others reported Fleigh scores of 87.2±0.1; 106.9±0.1; 99.7±0.1; and 102.5±0.1 as excellent [22]. This research's Fleigh scores are slightly higher than those of silage made of *Pennisetum purpureum-Acacia villosa* in combination with rice bran and *Lactobacillus plantarum* addition on 102.92±21.34 to 124.37±18.84 [23]. Generally, the Fleigh scores of silage in this research is categorized as excellent.

4. CONCLUSION

Up to 40% *Indigofera zolingeriana* leaves addition in corn stovers silage produces good quality silage which can maintain sufficient pH level, high dry matter content, and has excellent Fleigh score.

AUTHORS' CONTRIBUTIONS

Widhi Kurniawan designed and helped in writing the draft; Nina Ayu Lestari conducted the research and wrote the draft, Purnaning Dhian Isnaeni translated and edited the draft; and Natsir Sandiah guided the research progress.

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