The Impact of Substituting Corn Silage with Cactus Cladodes Silage on Growth Performance and Digestibility in Sheep Rations

Hanim A. El-Sheikh1; F. M. Abo-Donia1 and U. A. Nayel 2

1Agriculture By-product Utilization Research Department, Animal Production Research Institute (APRI), Giza, Egypt.
2Animal Production Department, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt.

ABSTRACT

Evaluation of co-ensiling Opuntia ficus indica with corn stover on the performance of twenty-seven Barki male lambs was investigated. The three experimental diets were R1 (control): 60% concentrate feed mixture (CFM) +10% rice straw + 30% corn silage; R2: 60% concentrate feed mixture (CFM) +10% rice straw + 15% corn silage (CS) +15% cactus cladodes silage (CCS); and R3: 60% concentrate feed mixture (CFM) +10% rice straw + 30% CCS, which were all iso-nitrogenous (13% CP) and iso-energetic (2.9 Mcal of ME kg-1 DM). Lambs fed R2 had a better (P ≤ 0.05) final weight and daily weight gain than lambs fed R3. There were no significant differences (P > 0.05) in the total protein, globulin, or liver enzyme levels. The OM, CP, CF, NFE, and ADF digestibility of were the same for all the tested diets. Group R3 had the lowest (P ≤ 0.05) digestion coefficient value of NDF (59.65%). Group R2 had the highest (P ≤ 0.05) calculated microbial protein values (18.31%). Total digestible nutrients (TDN) (55.81%) and digestible crude protein (DCP) (8.04%) in group R3 were significantly less than those in each of the other two groups. Thus, it may be stated that the silage of the cactus cladodes could be employed as a partial substitute for corn silage in livestock ration in arid, limited-resources farming situations to enhance growth performance and digestibility.

Keywords: Cactus cladodes silage, sheep, performance.

INTRODUCTION

Conventional feedstuff production is recognized as challenging in semi-arid environments due to cycles in dry conditions. Therefore, it is important to search for feasible, readily available feed resources, while not directly necessary for human nutrition, could be commercially considered an important part of farm animals’ diets. (Qelurem et al., 2007).

Opuntia (Opuntia ficus-indica L. Mill) is a plant that is often grown in semi-arid regions. It has lately become one of the most important fodder sources for farm animals (Tegegne et al., 2007 and Costa et al., 2009) due to its remarkable ability to survive in severe drought circumstances in all drylands around the world (Nefzaoui and Ben Salem, 2002). Also, plenty of fresh cladodes become available when plants are harvested in order to enhance fruit yield and quality (Zeeman, 2005).

There is a chance to use the massive amounts produced annually as plant material for cattle feed (De Waal et al., 2007), whereas Opuntia cultivation and usage as pasture is one of the low-cost and highly efficient choices for adapting to climate change, according to Ben Salem et al., 2004). In dry and semi-arid regions, where water resources are scarce, Nefzaoui and Ben Salem (2002) discovered that cactus silage can decrease ruminant water intake and reduce competition between humans and animals for water. In accordance with Mahouachi et al. (2012), the CC is a widely used energetic component in dry regions because of its good palatable qualities, high yield of freshly harvested biomass, relative availability, low cost, and ease of cultivation (De Kock, 2001). The cactus pear has low levels of crude protein (4.20 to 6.20%) and dry matter (10 to 13%), which prevents it from being recommended as the only meal in animal feed.

Additionally, Opuntia ficus indica cladodes lack nutritional balance due to its low content of crude protein, fiber, phosphorus, and sodium (Souza et al., 2009). As stated by Ben Salem et al (2004), cactus cladodes exhibit excellent dry matter digestibility, high water usage efficiency, and high moisture (around 900 g/kg) as total digestible nutrients and non-fiber carbohydrate (NFC) contents. Whenever consumed alone, due to its high water content (Souza et al., 2009 and Santos et al., 2001) and low physically effective neutral detergent fiber (NDF) which may restrict their use.

Ensiling is an efficient, simple preservation technique known to acidify biomass. As a result, it prevents the growth of bacteria that cause spoilage, guaranteeing the long-term preservation of moist forages (McDonald et al. 1991). Ensilage from cactus cladodes would enhance its use and give farmers an alternative choice for preserving feed that is high in water and energy. It might have more dry matter if it were ensiled with dry roughages such as dried corn stover or wheat straw (Ferreira et al., 2012), making it beneficial for ruminant feeding purposes. So, ensiling high-moisture cactus cladodes with dried roughage should therefore increase the feed’s dry matter content while improving the shortfalls in the used ingredients that have been identified. So, in order to increase the use of cactus as animal feed, research is required to develop feed ingredients that can be combined with cactus.

This research was conducted with the aim of studying the effect of replacing corn silage with various levels of cactus (Opuntia ficus indica) cladodes silage on the nutritional digestibility, feeding value, fermentation characteristics, and performance of growing Barki lamb.
MATERIALS AND METHODS

According to the cooperation protocol between the Animal Production Department of Menoufia University's Faculty of Agriculture and the Agriculture By-Product Utilization Research Department, Dokki, Giza governorate, Egypt (Reference No. 2429.22.2019), this study was carried out. Ethical approval

The present work has been conducted following the guidelines of the ethical committee of the Faculty of Agriculture at Menoufia University.

Silage preparation
The corn stalks with about 30% DM used in the preparation of corn silage (CS), which was used as a reference in this experiment, were obtained from wholesalers in Shibin Elkom City, Menoufia Governorate, during the harvest season of locally farmers. Green corn stalks that have been mechanically chopped at 2- to 5-cm lengths. On a dry matter basis, the corn silage comprised 94.31% fresh chopped corn stalks, 5.03% sugar cane molasses, and 0.66% urea.

The two and three-year-old Opuntia ficus indica cladodes (leaves) employed to produce the cactus pear cladode silage (CCS) originated on a farm in Sadat City, Menoufia Governorate. In terms of dry matter (DM), the cactus cladode silage (CCS) was formed up of 75.45% cactus cladodes, 18.86% corn stalk, 5.03% sugar cane molasses, and 0.66% urea as a nitrogen source. A sharp knife was used to cut these cladodes into 20 mm square pieces. While keeping the optimal silage humidity for each type of silage, the urea solution and sugar cane molasses were subsequently spread between the layers of silage at a depth of 25 cm. According to the findings from the laboratory, these ratios were determined with the goal of having 312.26 and 318.09 g DM kg−1 for CS and CCS, respectively. The chopped (3-5 cm) cladodes and the (2-5 cm) corn stalk were mixed separately with the molasses and urea solution, then placed in six identical 200-liter plastic bags in plastic drums, tightly packed and airtight sealed. For gathering data, the experimental period lasted 90 days. Mould detection and lactic acid bacteria counting were also conducted.

According to Moore and Undersander (2002), relative feed value (RFV) was obtained, and Fleig points (FP) were estimated as the physical analysis using the formula presented by Kamarloyi and Yamsri (2008), based on the pH values and DM content of the silage samples, as follows:

\[
\text{Fleig point} = 220 + (2 \times \% \text{ Dry Matter - 15}) - 40 \times \text{pH}
\]

Laboratory analysis:
The chemical composition of different feedstuffs is displayed in Table 1. When the ensiling period ended (60 days), three sub-samples (from each container) of each silage kind of cactus cladode silage (CCS) and corn silage (CS) were taken for chemical analysis from each silage type. Samples of the fresh material were taken, and the silos were opened to examine their chemical composition. These samples (feedstuffs, residuals, and feces) were pre-dried in a forced-air oven at 55 °C for 72 hours, ground in a Wiley mill with a 1-mm sieve, and after that kept in plastic containers. Chemical analyses of feedstuffs and feces were completed following the AOAC. (1995). In order to determine the nitrogen-free extract (NFE), the summation percentages of the CP, CF, EE, and Ash concentrations were subtracted from one hundred. The Van Soest et al. (1991) procedures were used to determine neutral detergent fiber (NDF) and acid detergent fiber (ADF). Using the techniques described by Van Soest et al. (1991), the NDF and ADF were determined. Without adjusting for the N content of NDF, the non-fiber carbohydrate (NFC) is determined by difference according to Calzamiglia et al. (2002):

\[
\text{NFC} = \text{OM} - (\text{NDF} + \text{EE} + \text{CP})
\]

Following formula of Moran (2005), the TDN of silages was calculated:

\[
\text{TDN} \% = 5.31 + 0.412 \text{ CP}\% + 0.249 \text{ CF}\% + 1.444 \text{ EE}\% + 0.937 \text{ NFE}\%
\]

For the purpose of determining the fermentation profiles (pH, total VFA concentration, and ammonia nitrogen (NH3-N)), 20 g of corn silage and cladodes silage were individually homogenized with 180 mL of sterile water for 10 minutes in the blender, followed by filtration using double layers of cheesecloth. Then, in 100 mL of each sample, fermentation profile measurements were carried out. Silage pH can be immediately measured by using a digital pH meter. Ammonia-N (NH3-N) concentration was calculated based on Weatherburn (1967) descriptions. Total volatile fatty acids (TVFAs) were determined using the steam distillation method described in Warner (1964). The molar proportions of SCFA’s were established by HPLC (column: Shodex RS Pak KC811; Showa Denko K.K., Kawasaki, Japan; detector: DAD, 210 nm, SPD20A; Shimadzu Co., Ltd., Kyoto, Japan; eluent: 3 mmol L−1 HClO4, 1.0 mL min−1; temperature: 50 °C). The lactic acid concentration was determined by the methods of James and Gardner. (1995).

The microbial count was determined according to Zhang et al. (2014). According to Difco (1984), total fungal counts were calculated at 60-day silages. According to Masama et al. (1997), digestible organic matter fermented in the runen (DOMR) was considered to be digestible organic matter multiplied by 0.65. Then, it was determined that the microbial protein output was 32 g N/kg DOMR.

Four animals from each group had a sample of blood taken from the jugular vein at the end of the experiment at 8:00 a.m. The coagulated blood samples were centrifuged at 3000 rpm for 20 minutes to obtain the blood serum. Blood serum was evaluated by calorimetric analysis following the manufacturer’s instructions for commercial kits (Bio Diagnostic, Giza, Egypt) for total protein (Armstrong and Carr, 1964), albumin (Doumas et al., 1977), globulin (calculated by subtracting serum albumin concentration from corresponding total protein concentration), and the activity of AST and ALT aminotransferases (Reitman and Frankel, 1957), using the spectrophotometer at 550 nm wavelength.

Management of the feeding trial
A growth trial for 27 Barki male lambs was carried out applying a completely random design, which was divided into three similar groups (nine lambs per group). Animals were 7 months of age with an average body weight of 20.47 kg, which was recorded at the beginning of the experiment and biweekly through the feeding experimental period.

Lambs were fed on tree isonitrogenous (13% CP) and iso-energetic (2.9 Mcal of ME kg−1 of dry matter) diets, which were created in accordance with requirements (NRC, 2001). They had access to water and rations at all times throughout the experiment. Daily meals were provided in two portions at 9:00 a.m. and 4:00 p.m. As shown in Table 1, animals were fed 60% concentrate feed mixture (CFM) for growth as instructed by the NRC (2001) and rice straw (RS) and silage at levels of 10% and 30%, respectively. The
animals in the control group (R1) were fed a standard diet and were given corn silage as the type of silage. With a 50% and 100% substitution of corn silage, respectively, cactus cladode silage (CCS) was used in the second (R2) and third (R3) groups (Table 1). According to variations in body weight, the level of dietary requirements was modified. Dry matter (DM) and total digestible nutrients (TDN) were determined and reported as absolute values (g/h/d) for daily feed intake. The following equation was used to get the feed conversion ratio (FCR):

\[ FCR = \text{average daily dry matter intake} / \text{average daily gain} \]

**Digestibility Trial**

Following the growth experiment, a 5-day digestion experiment was carried out on twelve animals (4 lambs/experimental diet; 39.27±2.43 kg) as a collection period to evaluate the nutritional value and digestibility of all experimental rations. During the 5-day collecting period, each animal was housed separately in a metabolic cage that measured 1.6 x 0.53 meters and was fed the three meals described before following the NRC (2001). Daily portions were offered, and refusals were recorded daily if they were noticed. The amount of daily excreted feces per animal was recorded, mixed, and 10% of the represented samples were extracted and dried for 48 hours at 70°C. After being processed through a 1 mm sieve on a Wiley mill grinder, feed, and fecal subsamples were stored for further analysis.

According to Masama et al. (1997), digestible organic matter fermented in the rumen (DOMR) was expected to be equal digestible organic matter multiplied by 0.65. Then it was determined that the microbial protein produced was 32 g N/kg DOMR.

**Statistical Analysis**

The data were analyzed by SAS's generalized linear model procedure (2002). The difference between means was statistically measured for significance at (P<0.05) according to Duncan’s test (1955). The following model was assumed:

\[ Y_{ij} = \mu + T_i + e_{ij} \]

Where: \( Y_{ij} \) is the parameter under analysis, \( \mu \) is the overall mean, \( T_i \) is the effect due to treatment, and it is the random term, it is considered to be distributed independently and normally.

**RESULTS AND DISCUSSION**

**Chemical composition of tested silages and experimental rations**

Table 1 illustrates the chemical composition of the tested silages and the calculated experimental rations. The dry matter values were nearly identical in both of the investigated silage kinds. The chemical analysis in this study revealed that the high content of organic matter in CS (93.26%) is compared to CCS (89.95%). These results were similar to those published by Çürek and Özen (2004). The high Ash content of the cactus utilized, which has previously been documented elsewhere (Stintzing and Carle, 2005), may cause the silage’s higher ash values. This could be a benefit when silage is added to animals fed low-quality roughages that are lacking in minerals. The protein content in CS was 8.75%, while it was 7.22% in CCS. The EE content of both tested types of silage was almost similar, which was in line with the 2.33% estimate provided by Çürek and Özen (2001). In contrast to the CS content of NFE (54.11%), the CCS content of NFE was higher (65.77%).

Regarding the CCS and CS contents of NDF, they were 29.14% and 47.18%, respectively. In terms of total digestible nutrients (TDN), CS and CCS contained 69.62% and 76.39%, respectively. The reason for these findings may be that CCS had more non-fiber carbohydrates (NFC) (51.79%) than CS (35.29%). The rations designed for the present investigation were planned to be comparable in terms of their protein percentages, which ranged from 13.02% in ration R3 to 13.48% in R1, and their energy contents (TDN), which were 76.232, 77.248, and 73.527 in R1, R2, and R3, respectively. While CF, NDF, and ADF values were lower in R2 and R3 than in R1 ration. The average ADF and NFC concentrations of CCS are significantly greater than those that Mokoboki et al. (2016) observed. The climate, the age of the cladodes, and variety are just a few factors that could be responsible for the difference.

**Table 1. Proportion of ingredients and chemical composition of feed ingredients and experimental rations (% of DM).**

<table>
<thead>
<tr>
<th>Item</th>
<th>CS*</th>
<th>CCS**</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn silage, CS</td>
<td>30</td>
<td>15</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cactus cladode silage, CCS</td>
<td>00</td>
<td>15</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice straw, RS</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentrate feed mixture, CFM***</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Chemical composition (%)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Dry matter, DM</th>
<th>Organic matter, OM</th>
<th>Crude protein, CP</th>
<th>Crude fiber, CF</th>
<th>Ether extract, EE</th>
<th>Ash</th>
<th>Non-fiber carbohydrate, NFC</th>
<th>Total digestible nutrients, TDN %</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>32.32</td>
<td>93.26</td>
<td>8.75</td>
<td>28.36</td>
<td>2.04</td>
<td>6.74</td>
<td>35.29</td>
<td>69.62</td>
</tr>
<tr>
<td>R2</td>
<td>31.41</td>
<td>94.22</td>
<td>7.22</td>
<td>35.05</td>
<td>1.49</td>
<td>6.24</td>
<td>36.58</td>
<td>73.52</td>
</tr>
<tr>
<td>R3</td>
<td>60.84</td>
<td>86.67</td>
<td>13.02</td>
<td>17.73</td>
<td>2.42</td>
<td>6.28</td>
<td>37.64</td>
<td>76.39</td>
</tr>
</tbody>
</table>

**Concentrate feed mixture (CFM, %) consists of:**

- yellow corn, 52%;
- cotton seed meal, 17.0%;
- soybean meal, 10.0%;
- wheat bran, 18.0%;
- limestone, 1.7%;
- common salt, 1.0%;
- mineral and vitamin mixture, 0.3%;
- CS: cactus silage; **CCS: cactus cladode silage**

**Fermentation characteristics of tested silages**

Table 2 illustrates the values for different fermentation parameters of the investigated silage. The fermented silage decreased pH values, ammonia nitrogen (NH3-N), acetate, and propionate slightly in the silage made with cactus cladodes (CCS) as compared with the silage made with corn stalks (CS), which indeed showed effective preservation. According to reports from Vasta et al. (2008) and Gusha et al. (2013), the low pH of the silages may be caused by highly fermentable soluble sugars in cactus cladodes.

Additionally, McDonald et al. (2002) reported that the rumen pH is lowered by the fast fermentation of starch into volatile fatty acids. To achieve good quality and well-preserved silage, Abo-Donia et al. (2022) recommend that high-quality silages have pH values of 3.5–4.5. The lactic acid value of the present study was highest (5.77%) in CCS and lowest (5.68%) in CS, which were greater than those obtained by Çürek and Özen (2004), who examined the silage of young and old cladodes of cactus pear and observed average amounts of 2.59% and 3.20% lactic acid, respectively.

The acetic acid (AA) content was highest (1.93%) in the CS, followed by the CCS (1.86%). These values are
similar to those discovered by Çürek and Özen (2004) when comparing cactus pear silages, young cladodes silages, and mature cladodes silages, which were around 1.53 and 1.52% AA in DM. A small quantity of acetic acid in silage may be useful, because it inhibits yeasts, leading to increased aerobic stability (Kung Junior et al. 2018). Also, the concentration of propionic acid was 0.13 and 0.11% for CS and CCS, respectively, and that is considered optimum by Roth and Undersander (1995), who claim that silages with propionic acid levels less than 0.50% are well-fermented.

This study found similar values in the two experimental silages, with NH3-N values of 2.66 and 2.63% in the CS and CCS, respectively. Because the NH3-N levels in the current study were less than the 10% suggested by Mokoboki et al. (2016), there was no excessive protein breakdown.

The levels of lactic acid, VFAs, and A/P ratio recorded the highest levels with the CCS but were comparable to the levels of CS. Lactic acid bacteria populations slightly increase in CCS (6.94 log CFU/g fresh matter) compared to CS (6.87 log CFU/g fresh matter), and this has led to an increase in the amount of lactic acid produced in CCS compared to CS. According to Teegagne et al. (2007), cactus is high in water, NFC and has high concentrations of pectin, all of which contribute to fast fermentation rates and a quick release of soluble sugars, which are then effectively utilized by the microbial groups, mainly LAB. The findings presented here are in line with those stated by Abo-Donia et al. (2022), who claim that good silage conditions promote the quick growth of LAB and prevent mold from penetrating the silage at 45 days.

However, the values of Flieg’s score in CS and CCS were 112.84 and 112.63, respectively, which indicates good quality silage with the two experimental kinds of silage. The Flieg points value for silages in the current study is higher than those observed by Saracieca et al. (2016) with corn silage (103.02 %) and El-sheikh et al. (2020) with corn silage (98.04%). High NFE levels may be responsible for cactus silages' excellent quality generally despite their high ash content (Çürek and Özen 2004).

Table 2. Fermentation quality of tested silages stored for 60 days.

<table>
<thead>
<tr>
<th>Item</th>
<th>Corn silage (CS)</th>
<th>Cactus Cladosodes silage (CCS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>3.92</td>
<td>3.88</td>
</tr>
<tr>
<td>NH3-N (g/100g DM)</td>
<td>2.66</td>
<td>2.63</td>
</tr>
<tr>
<td>TVFA s % of DM</td>
<td>1.37</td>
<td>1.43</td>
</tr>
<tr>
<td>Lactate(g/100 g DM)</td>
<td>5.68</td>
<td>5.77</td>
</tr>
<tr>
<td>Acetate(g/100 g DM)</td>
<td>1.93</td>
<td>1.86</td>
</tr>
<tr>
<td>Propanone, g/100 g DM</td>
<td>0.13</td>
<td>0.11</td>
</tr>
<tr>
<td>A/P</td>
<td>14.85</td>
<td>16.91</td>
</tr>
</tbody>
</table>

Fermentation patterns

Microbial counts (log10 cfu g⁻¹) after 60 days (fresh matter)
Youat 5.31 | 5.29
Molds 2.49       | 2.41
Aerobic bacteria 7.44        | 7.32
Lactic acid bacteria 6.87       | 6.94
Flieg’s score 112.84        | 112.63

Growth performance traits

Results of the dry matter intake (DMI), initial weight (IW), final weight (FW), weight gain (WG), daily weight gain (DWG), and feed conversion ratio (FCR) of growing Barki lambs given the experimental rations are shown in Table 3.

Data demonstrated that the R2 group had significantly (P < 0.05) higher dry matter intake (DMI) than the other studied groups. This may be explained by the fact that, generally, cacti are highly palatable (Nefzaoui and Ben Salem, 2002). Additionally, the mucilage makes the feed particles stick to the CC steading particle selection, reducing the time needed to feed (Ferreira et al., 2012; Siqueira et al., 2018).

Also, the greater observed DM intake (1330.80 g/day) for R2 may be attributed to the high NFC content of this ration (37.64 %), corroborating the results of Siqueira et al. (2019) with goats and sheep (Siqueira et al. 2019). While the rations with a lower proportion of NFC were R1 (35.18%) and R3 (35.05%), presenting, consequently, a lower DMI (1156.20 and 1100.65 g/day, respectively). Due to the high degradability of the soluble carbohydrates included in CCS, which enhances the digestion rate of these compounds, it may explain why DMI rose when CS was replaced with CCS (Siqueira et al., 2018).

The rations for lambs that contained various amounts of cactus cladodes silage (R2 and R3) did not significantly (P > 0.05) alter based on initial weight and the feed conversion ratio (FCR). The feed conversion ratio (FCR) was generally high, with lambs fed on R2 recording the highest levels (P < 0.05), which reflects the weight gain throughout the course of the trial. In contrast, when compared to lambs fed R3, lambs fed R2 observed higher (P < 0.05) final weight, weight gain, and daily weight gain. The daily weight gain (DWG) in group R2 was 236.78 g/day, which is close to the value of the DWG recorded by Lopes et al. (2015) in sheep with an average daily gain of 251 g/day when the animals were fed with spineless cactus. The values of the feed conversion ratio (FCR) did not change significantly (P > 0.05) between the various experimental treatments.

Table 3. Growth performance traits of Barki lambs fed the experimental rations through the 90-day experiment phase.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>SE</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter intake, DMI (g/d)</td>
<td>1156.20</td>
<td>1330.80</td>
<td>1100.65</td>
<td>34.84</td>
<td>0.0014*</td>
</tr>
<tr>
<td>Initial Weight, IW (Kg)</td>
<td>20.56</td>
<td>20.52</td>
<td>20.32</td>
<td>0.42</td>
<td>0.9122</td>
</tr>
<tr>
<td>Final Weight, FW (Kg)</td>
<td>39.01</td>
<td>41.83</td>
<td>36.98</td>
<td>0.94</td>
<td>0.0113*</td>
</tr>
<tr>
<td>Weight Gain, WG (Kg)</td>
<td>18.45</td>
<td>21.31</td>
<td>16.66</td>
<td>1.09</td>
<td>0.0329</td>
</tr>
<tr>
<td>Daily Weight Gain, DWG (g)</td>
<td>260.00</td>
<td>286.78</td>
<td>185.11</td>
<td>12.14</td>
<td>0.0029</td>
</tr>
<tr>
<td>Feed Conversion ratio, FCR</td>
<td>5.64</td>
<td>5.62</td>
<td>5.94</td>
<td>0.43</td>
<td>0.0390</td>
</tr>
</tbody>
</table>

| Means, within row, with different superscripts are significantly different (N=non-significant, *p<0.05, **p<0.01) |

Blood biochemical parameters

Blood metabolites and biochemical measurements of Barki lambs provided with the tested diets are shown in Table 4. The total protein, globulin, and liver enzyme concentrations, including both ALT and AST levels, did not change significantly (P > 0.05) when any of the treatments were given to the animals. While the group of lambs fed the R2 ration had the significantly (P < 0.05) highest albumin value (4.51), followed by the R3 group (3.26), and finally, the R1 group (3.88). The same values of blood proteins were reviewed by Rahman et al. (2018) and El-Malky et al. (2019), who found that the average blood total protein level for Barki ranged from 6.07 to 7.59 g/dl.

Additionally, it was noted by El-Bassiony (2016) that the average blood total protein level in Barki ewes was 6.80±0.13 g/dl. So, according to Silva et al. (2023), these enzymatic indicators do not indicate liver damage.
Item & R1 & R2 & R3 & SE & Pr>F \\
--- & --- & --- & --- & --- & --- \\
Total Protein (TP, g/dl) & 7.03 & 7.98 & 6.24 & 0.60 & 0.1690*NS \\
Albumin (g/dl) & 3.88b & 4.51a & 3.26b & 0.32 & 0.0533* \\
Globulin (g/dl) & 3.15 & 3.47 & 2.98 & 0.36 & 0.6319*NS \\
ALT (U/L) & 27.12 & 25.69 & 28.48 & 1.20 & 0.2988*NS \\
AST (U/L) & 70.11 & 67.94 & 72.41 & 1.96 & 0.3091*NS \\

*NS means, within row, different superscripts are significantly different (N=non-significant, *p<0.05). 

** Digestibility coefficients and nutritive value 

In Table 5, the digestibility coefficients of lambs given the experimental meals are shown. There were no variations that were significant (P > 0.05), in the digestion parameters of OM, CP, CF, NFE, and ADF in all of the examined diets. These OM digestibility values fell within the same range (60 to 70%) as those Nefzaoui and Ben Salem (2002) reported for Opuntia cladodes. In comparison to group 3, group 2 had a significantly (P ≤ 0.05) better DM digestibility coefficient, which fell in the range of 60–65%, as reported by Ben Salem et al. (1994), with higher DM digestibility values for Opuntia cladodes.

According to Rezende et al. (2020), the increase in DM digestibility was influenced by both the drop in the low digestible fraction (NDF) and the rise in the high digestible fraction (NFC). While the R1 group's fat digestibility coefficient (78.54%) was significantly (P ≤ 0.05) greater than the R3 group's (72.34%).

The least significant (P ≤ 0.05) digestion coefficient value of NDF was 59.65% in group 3 compared to the rest of the two treatments (R1 and R2). Whereas the lower NDF digestibility observed for R3 is related to the low concentration of NDF and ADF (37.72 and 24.16%, respectively) in this ration compared to the other experimental rations (Siqueira et al., 2019).

<table>
<thead>
<tr>
<th>Item</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>SE</th>
<th>Pr&gt;F</th>
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</thead>
<tbody>
<tr>
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<td>65.10a</td>
<td>59.24b</td>
<td>1.12</td>
<td>0.0158*</td>
</tr>
<tr>
<td>OM</td>
<td>64.61</td>
<td>66.16</td>
<td>60.21</td>
<td>2.05</td>
<td>0.1608*NS</td>
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<tr>
<td>CP</td>
<td>64.32</td>
<td>66.52</td>
<td>61.81</td>
<td>1.35</td>
<td>0.0980*</td>
</tr>
<tr>
<td>CF</td>
<td>63.94</td>
<td>60.97</td>
<td>58.18</td>
<td>1.74</td>
<td>0.1194*NS</td>
</tr>
<tr>
<td>EE</td>
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<td>76.39b</td>
<td>72.34b</td>
<td>1.53</td>
<td>0.0518*</td>
</tr>
<tr>
<td>NFE</td>
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<td>67.68</td>
<td>60.78</td>
<td>2.02</td>
<td>0.1067*</td>
</tr>
<tr>
<td>NDF</td>
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<td>62.05b</td>
<td>59.65b</td>
<td>1.24</td>
<td>0.0181*</td>
</tr>
<tr>
<td>ADF</td>
<td>59.47</td>
<td>55.18</td>
<td>53.06</td>
<td>1.77</td>
<td>0.0808*NS</td>
</tr>
</tbody>
</table>

Nutritive value (%): 

<table>
<thead>
<tr>
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<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>SE</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestion coefficients (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>62.05b</td>
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</tr>
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</table>

**NS means, within row, different superscripts are significantly different (*p<0.05, **p<0.01, ***p<0.001). 

Nefzaoui and Ben Salem (1996) reported that a spineless supply considerably reduced the effective degradability of DM and NDF in the diet. This suggested that the rumen's cellulosic activity had been impaired. Because of the massive quantity of soluble carbohydrates in cactus pads' decreasing effect on rumen cellulosic bacteria, increasing the amount of cactus in a diet reduces fiber digestibility. However, on the other hand, Siqueira et al. (2018) found that while adding cactus cladodes lowers ruminal pH, it does not do so to the extent that it restricts or inhibits NDF digestion.

Consequently, less value for nutritive value as total digestible nutrients (TDN) (55.81%) and digestible crude protein (DCP) (8.04%) in group R3 in a comparison with the other two treatments (R1 and R2). The calculated microbial protein values were significantly higher in group R2 (18.31%), then in group R1 (15.53%), and finally in group R3 (13.78%). However, as nitrogen and fermentable carbohydrates were introduced, along with probably more essential nutrients, the microbial protein supply increased (Toleran and Sundstol, 2000).

CONCLUSION

It was found that producing silage by combining cactus cladodes with low-quality roughage increased the amount of dry matter and nitrogen in the finished product. The lower gut's microbial protein flow is increased when cactus cladodes (Opuntia ficus indica) silage partially replaces corn silage, improving the availability of amino acids needed for maintenance, growth, and production. In farming areas with scarce resources and dry climates, these silages could be used as a partial substitution for corn silage in the diet of livestock to improve growth performance and digestibility.

REFERENCES


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تنوير استبدأ سيلاج الذرة بسيلاج الواح التين الشوكى على أداء النمو وقابلية الهضم في علاج الأذان

هانم عبد الرحمن الشيخ، 2000 ولى محمد أبو ندي، 1 وأسامة بالوعل نائل

1 اسمبحث استنتاج المخلفات الزراعية، مركز بحث الإنتاج الحيواني (APIR)، مركز البحث الزراعى، الجيزة، مصر

المنخفض

تم إجراء هذه الدراسة على 27 نرو وحصان البري، دراسة تأثير استخدام سيلاج الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica) على درجة التأثير في معدلات التأثير وراء فواكه الإكليل. كان النباتات ثلاثية (Opuntia ficus-indica) (R1) تكون من نباتات سهيلة (Opuntia ficus-indica) (R2) (10% من محتوى الامائات الفاكهة) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) لسلالة الذرة سيلاج الواح التين الشوكى (Opuntia ficus-indica Mill) (R3) (3% من محتوى الامائات الفاكهة (R3) L