Journal of Animal and Poultry Production

Journal homepage & Available online at: www.jappmu.journals.ekb.eg

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

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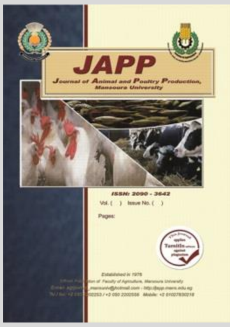

ABSTRACT

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 ($P \leq 0.05$) 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 ($P \leq 0.05$) digestion coefficient value of NDF (59.65%). Group R2 had the highest ($P \leq 0.05$) 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.

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DOI: 10.21608/jappmu.2023.229940.1086

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 Kamarloiy and Yansari (2008), based on the pH values and DM content of the silage samples, as follows:

Fleig point = 220 + (2 x% Dry Matter - 15) - 40 x 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 Calsamiglia et al. (2002):

NFC = OM – (NDF + EE + CP).

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

TDN (%)=5.31+0.412 CP%+0.249 CF%+1.444 EE%+0.937 NFE%

For the purpose of determining the fermentation profiles (pH, total VFA concentration, and ammonia nitrogen (NH_3-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 (NH_3-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 rumen (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 iso-nitrogenous (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= average daily dry matter intake / 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 70ºC. 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 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:

$$Yij=\mu+Ti+eij$$

Where: Yij is the parameter under analysis, µ is the overall mean, Ti 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%) as 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 w ere 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 NDF 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).

Item	CS*	CCS**	R1	R2	R3
Corn silage, CS			30	15	0
Cactus cladode silage, CCS			00	15	30
Rice straw, RS			10	10	10
Concentrate feed mixture, CFM***			60	60	60
Total			100	100	100
Chemical composition (%)					
Dry matter, DM	32.32	31.41	69.84	69.70	69.56
Organic matter, OM	93.26	89.95	94.22	93.72	88.17
Crude protein, CP	8.75	7.22	13.48	13.25	13.02
Crude fiber, CF	28.36	15.07	16.73	14.73	12.74
Ether extract, EE	2.04	1.89	2.42	2.40	2.38
Ash	6.74	10.05	5.78	6.28	11.83
Nitrogen-free extract, NFE	54.11	65.77	61.59	63.34	60.03
Neutral detergent fiber, NDF	47.18	29.14	43.13	40.42	37.72
Acid detergent fiber, ADF	27.44	20.18	26.33	25.25	24.16
Non-fiber carbohydrate, NFC	35.29	51.70	35.18	37.64	35.05
Total digestible nutrients, TDN %	69.62	76.39	76.232	77.248	73.527

*****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: corn 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 (NH_3-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 NH_3-N values of 2.66 and 2.63 % in the CS and CCS, respectively. Because the NH_3-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 Tegegne *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 Fleig points value for silages in the current study is higher than those observed by Saricicek *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.

Item	Corn silage (CS)	Cactus Cladodes silage (CCS)
Fermentation patterns		
pH	3.92	3.88
NH_3-N (g/100g DM)	2.66	2.63
TVFA s % of DM	1.37	1.43
Lactate,(g/100 g DM)	5.68	5.77
Acetate (g/100 g DM)	1.93	1.86
Propionate, g/100 g DM	0.13	0.11
A/P	14.85	16.91
Microbial counts (log10 cfu g^{-1}) after 60 days (fresh matter)		
Yeast	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 ($P \leq 0.05$) 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 ($P \leq 0.05$) 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 experimentation phase.

Treatment	R1	R2	R3	SE	Pr>F
Dry matter intake, DMI (g/d)	1156.20^{b}	1330.80^{a}	1100.65^{b}	34.84	0.0014**
Initial Weight, IW (Kg)	20.56	20.52	20.32	0.42	0.9122^{Ns}
Final Weight, FW (Kg)	39.01^{ab}	41.83^{a}	36.98^{b}	0.94	0.0113*
Weight Gain, WG (Kg)	18.45^{ab}	21.31^{a}	16.66^{b}	1.09	0.0329*
Daily Weight Gain, DWG (g)	205.00^{ab}	236.78^{a}	185.11^{b}	12.14	0.0329*
Feed Conversion ratio, FCR	5.64	5.62	5.94	0.43	0.8390^{Ns}

$^{a-b.}$ Means, within row, with different superscripts are significantly different (Ns=non-significant, *=p<.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 ($P \leq 0.05$) 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±0.13g/dl. So, according to Silva *et al.* (2023), these enzymatic indicators do not indicate liver damage.

Table 4. Blood metabolites and biochemical investigations of Barki lambs fed on the tested rations (Mean ± SE).

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)	3.88ab	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	0.3091Ns

a-b. means, within row, different superscripts are significantly different (Ns=non-significant, *=p<.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 5. Nutrient digestion coefficients and nutritive value of Barki sheep fed the experimental rations.

Item	R1	R2	R3	SE	Pr>F
	Digestion coefficients, %				
DM	62.05ab	65.10a	59.24b	1.12	0.0158*
OM	64.61	66.16	60.21	2.05	0.1608 Ns
CP	64.32	66.52	61.81	1.35	0.0980 Ns
CF	63.94	60.97	58.18	1.74	0.1194 Ns
EE	78.54a	76.39ab	72.34b	1.53	0.0518*
NFE	64.15	67.68	60.78	2.02	0.1067 Ns
NDF	65.92a	62.05ab	59.65c	1.24	0.0181*
ADF	59.47	55.18	53.06	1.77	0.0808Ns
	Nutritive value (%)				
TDN	63.15a	64.78a	55.81b	1.42	0.0036**
DCP	8.67a	8.81a	8.04b	0.17	0.0319*
DOMFR	485.56b	572.29a	430.75c	14.48	<.0001***
Microbial protein	15.53b	18.31a	13.78c	0.45	<.0001***

a-b-c Means, within row, with different superscripts are significantly different (*=p<.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 cellulolytic activity had been impaired. Because of the massive quantity of soluble carbohydrates in cactus pads' decreasing effect on rumen cellulolytic 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.

Significantly 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 (Tolera 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

Abo-Donia, F. M; M. M. El-Shora; W. A. Riad; N. B. Elgamal, and W. A. El-Hamady (2022). Improve the nutritional value and utilization of rice straw via an ensiling process with different energy sources and nitrogen enrichment. J. Appl. Anim. Res. 50 (1): 333-341 https: // doi. org / 10. 1080 / 09712119. 2022. 2076685.

AOAC (1995) Official Methods of Analysis. 14th Edition, Association of Official Analytical Chemists, Washington DC.

Armstrong, W.D. and C.W. Carr (1964). Physiological Chemistry Laboratory Directions. (3rded.). Burges Publishing Co., Minneapolis, Minnesota.

Ben Salem, H., Nefzaoui A. and Ben Salem L (2004). Spineless cactus (Opuntia ficus indica f. inermis) and oldman saltbush (Atriplex nummularia L.) as alternative supplements for growing Barbarine lambs given straw-based diets. In: Small Ruminant Research, 51, p. 65-73.

BenSalem, H., Nefzaoui, A. and Abdouli, H. (1994). Palatab ility of shrubs and fodder trees measured on sheep and dromedaries. 1. Methodological approach. Animal Feed Science and Technology 46:143–153.

Calsamiglia, S; M.D. Stern and J.L. Firkins (1995). Effect of protein source on nitrogen metabolism in continuous culture and intestinal digestion, *in vitro*. J. Anim. Sci., 73:1819

Costa, R.C; E.M.B. Filho; A.N. Medeiros; P.E.N. Givisiez; R.C.R.E. Queiroga and A.A.S. Melo (2009). Effects of increasing levels of cactus pear (*Opuntia ficus-indica* L. Miller) in the diet of dairy goats and its contribution as a water source. *Small Rumin. Res.*, 82: 65–65.

Çürek, M and N. Özen (2001). Feed value of Cactus and cactus silage. Turk. J. Vet Anim Sci. 28: 633-639.

Çürek, M. and N. Özen (2004). Feed value of cactus and cactus silage. Turk. J. Vet. Anim. Sci. 28, 633–639.

De Kock, G.C (2001). The use of opuntia as a fodder source in arid areas of Southern Africa. In: Mondragón-Jacobo, C., Pérez-González, S. (Eds.), pp. 101–105. Cactus (*Opuntia* spp.) as forage, FAO Plant protection and production paper 169, pp. 146.

De Waal, H.O., H. Fouche and J. Potgieter (2007). Turksvye as voerbron vir herkouers. Opuntia – the Cinderella feed source? Bonsmara SA 2007, pp. 48-53.

Difco, M. (1984). Dehydrated Culture Media Regents for Microbiology, 10th edition, Difco Laboratories Incorporated Detroit, Michigan, USA. pp. 689-691.

Doumas, B.T., W. Waston and H.H. Biggs (1977). Albumin standards and the measurements of Serum albumin with Bromocresol Green. Clinical Chemistry Acta 31: 87-96.

Duncan, D.B. (1955) Multiple Range and Multiple F-Test. Biometrics, 11, 1-5.

El-Bassiony, M.F (2016). Impact of increasing twinning rate in Barki ewes on milk yield, milk composition, and lamb's performance up to weaning. Australian Journal of Basic and Applied Sciences, 10(18):365- 376. Available at: http://www.ajbasweb.com/old/ajbas/2016/December/365-376.pdf.

El-Malky, O. M; T.H. Mostafa; N.H. Ibrahim; F.E. Younis; A.M. Abd El-Salaam and H.A. Tag El–Din (2019). Comparison between the productive and reproductive performance of Barki and Ossimi ewes under Egyptian conditions. Egyptian Journal of Sheep & Goat Sciences, 14(1): 61 – 82. DOI: http://dx.doi.org/10.1590/S1516-35982012000700030.

El-Sheikh, Hanim. A**;** F. M. Abo-Donia**;** T. H. El-Sawah**;** M. A. El-Shora**;** G. E. El-Emam and A. M. A. Fayed (2020). Using an unconventional energy source to make silages and their impact on silage quality and performance of lactating cows. Int. J. Dairy Sci., 15: 142-151. http://dx.doi.org/10.3923/ijds.2020.142.151

Ferreira, M.A., S.V.Bispo; R.R. Rocha Filho; S.A. Urbano; C.T.F. Costa (2012). The use of cactus as forage for dairy cows in semi-arid regions of Brazil. In: Petr Kon- valina. (Org.), Organic Farming and Food Production. InTech, South Bohemia.

Gusha, j; s. Katsande; p.i. zvinorova and s. Ncube (2013). The nutritional composition and acceptability of cacti (*opuntia ficus indica*)-legume mixed silage. Online journal of animal and feed research volume 3, issue 2: 116-120.

James, W. B., and D.L. Gardner. (1995). Learning styles: Implications for distance learning. New Directions for Adult and Continuing Education, 1995(67), 19–31. doi:10.1002/ace.36719956705.

Kamarloiy, M and A. T. Yansari (2008). Effect of microbial inoculants on the nutritive value of corn silage for beef cattle. Pakistan J Biol Sci, 11(11), 1137-1141. DOI: 10.3923/pjbs.2008.1137.1141.

Kung Junior, L; R.D. Shaver; R.j. Grant and R.J. Schmidt, R. J. (2018). Silage review: Interpretation of chemical, microbial, and organoleptic components of silages. *J. Dairy Sci.* 101, 4020–4033.

Lopes LD, De Souza Lima AO, Taketani RG, Darias P, Da Silva LRF, Romagnoli EM, Mendes R. (2015). Exploring the sheep rumen microbiome for carbohydrate-active enzymes. *Antonie Van Leeuwenhoek.* ;108(1):15–30. doi: 10.1007/s10482-015-0459-6.

Mahouachi, M; N. Atti, and H. Hajji (2012). Use of Spineless Cactus (*Opuntia ficus indica f. inermis*) for Dairy Goats and Growing Kids: Impacts on Milk Production, Kid's Growth, and Meat Quality. The Scientific World Journal Volume 2012, Article ID 321567, 4 pages doi:10.1100/2012/321567.

Masama, E; J.H. Topps; N.T. Ngongoni and B. Maasdorp (1997). Effects of supplementation with foliage from tree legumes Acacia angustissima, Cajanas cajan, Calliandra calothysus, and Leuceana leucocephala on intake, digestibility and nitrogen metabolism of sheep given maize stover ad. lib. Animal Feed Science Technology. 69: 233-240.

McDonald, P; R.A. Edwards; J.F.D. Greenhalgh and C.A. Morgan (2002). Animal nutrition. 6. ed. Essex. Pearson Education Limited.

McDonald, P; A.R. Henderson; S.J.E. Heron (1991). The Biochemistry of Silage, 2nd Ed. Chalcombe Publications, UK.

Mokoboki, K; N. Sebola and G. Matlabe (2016). Effects of molasses levels and growing conditions on nutritive value and fermentation quality of Opuntia cladodes silage. journal of Animal and Plant Sciences, 2016. Vol.28, Issue 3: 4488-4495 Publication date 1/05/2016, http://www.m.elewa.org/JAPS; ISSN 2071-7024.

Moran, J. (2005) Tropical dairy farming: feeding management for small holder dairy farmer in the humid tropics, pp. 27–39. Collingwood, Australia: Landlinks Press.

Moore, J.E and J. D. Undersander. (2002). Relative Forage Quality: A proposal for replacement for Relative Feed Value. Proceedings National Forage Testing Association.

Nefzaoui, A and H. Ben Salem (2002). Strategic fodder and efficient tool to combat desertification in the Wana region. Cactus as forage. FAO Plant production and protection paper 169.

Nefzaoui, A. and H. Ben Salem (1996). Nutritive value of diets based on spineless cactus (*Opuntia ficus-indica var. inermis)* and Atriplex (*Atriplex nummularia).* In: Native and Exotic Fodder Shrubs in Arid and Semi-Arid Zones, Regional Training Workshop, Tunisia.

NRC (National Research Council). (2001). Nutrient requirements of dairy cattle (7th ed.). National Academies Press. Washington, DC, USA, 381 pp. DOI: https://doi.org/10.17226/9825.

Qelurem, O.I.; A.G. Ngi and I.A. Andrew (2007). Phytonutrients in citrus fruit peel meal and nutritional implications for livestock production. LRRD.eprints. Kfupm, edu.sa/ view /year/ 2007.htmi.

Rahman, M.D.K; S. Islam; j. Ferdous; Md. H. Uddin; M.B. Hossain; M.M. Hassan and A. Islam (2018). Determination of hematological and serum biochemical reference values for indigenous sheep (Ovies aries) in Dhaka and Chittagong Districts of Bangladesh. Veterinary World, 11: 1089- 1093. DOI: https://dx.doi. org/10.14202%2Fvetworld.2018.1089-1093.

Reitman, S. and S. Frankel (1957) A Colorimetric Method for the Determination of Serum Glutamic Oxalacetic and Glutamic Pyruvic Transaminases. American Journal of Clinical Pathology, 28, 56-63.

Rezende, F. M; S.C. Antônia; M.C. Véras; M. C. B. Siqueira; Maria. G. Conceição; Camilla. L. Lima; Marina. P. Almeida; R. E. Mora-Luna; Maria L. M. W. Neves; Carolina. C. F. Monteiro; M. A. Ferreira (2020). Nutritional effects of using cactus cladodes (Opuntia stricta Haw Haw) to replace sorghum silage in sheep diet. Tropical Animal Health and Production (2020) 52:1875–1880. https://doi.org/10.1007/s11250-020-02213-w.

Roth, G.W. and D. Undersander. (1995). Corn silage Production and Feeding. NCR Publicate. 574, Am. Soc. Agron., Mandison, WI, USA

Santos, D.C and S.G. Albuquerque (2001). *Opuntia* as fodder in the semi-arid northeast Brazil, in Mondragon-Jacobo, C., Perez-Gonzalez, S. (Eds.), Cactus (*Opuntia* spp.) as Forage, Plant Production, and Protection Paper, vol. 169. FAO, Rome, Italy, pp. 130–133.

Saricicek, B. Z; B.Yildirim; Z. Kocabas; E. O. Demir. (2016). Effect of Storage Time on Nutrient Composition and Quality Parameters of Corn Silage. Turkish Journal of Agriculture - Food Science and Technology, 4(11): 934-939.

Silva, T.G.P; L.A. Lopes; F.F.R. de Carvalho; P.C. Soares; A. Guim; V.A. Silva Júnior and Â.M.V. Batista (2023). Blood biochemical parameters of lambs fed diets containing cactus cladodes. Arq. Bras. Med. Vet. Zootec., v.75, n.1, p.48-60.http://dx.doi.org/ 10.1590/ 1678-4162-12833.

Siqueira, M.C.B; M.A. Ferreira; J.P.I.S. Monnerat; J.L. Silva and C.T.F. Costa (2018). Nutritional Performance and Metabolic Characteristics of Cattle Fed Spineless Cactus 20, 13–22.

Siqueira, T. D. Q; J. P. I. d. Monnerat; J. C. C. Chagas; M. G. da Conceição; M. C. B. de Siqueira; Th. B. L. Viana and M. d. Ferreira (2019). Cactus cladodes associated with urea and sugarcane bagasse: an alternative to conserved feed in semi-arid regions. Tropical Animal Health and Production (2019) 51:1975–1980 https://doi.org/ 10.1007/ s11250-019-01895-1

Souza, E.J; A. Guim, A; M. Batista; K.L. Santos; J.R. Silva; N.A.P. Morais and A.F. Mustafa (2009). Effects of soybean hull inclusion on intake, total tract nutrient utilization, and ruminal fermentation of goats fed spineless cactus (*Opuntia ficus-indica Mill*) based diets. Small Rumin. Res. 85 (1), 63–69.

Stintzing, F. C and R. Carle (2005). ReviewCactus stems (Opuntiaspp): A review on their chemistry, technology, and uses. Mol. Nutr. Food Res. 2005,49, 175–194DOI 10.1002/mnfr.200400071.

Statistical Analysis System (SAS) Institute (2002) SAS/STAT User's Guide. Version 8, 6th Edition, SAS Institute, Cary, 112.

Tegegne, F; C. Kijora and K.J. Peters (2007). Study on the optimal level of cactus pear (*Opuntia ficus-indica*) supplementation to sheep and its contribution as a source of water. Small Rumin. Res., 72: 157–164.

Tolera, A and F. Sundstøl (2000). Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stages of maturity 1. Feed intake, digestibility, and body weight change. Anim. Feed Sci. Technol., 85 (3/4): 239-257

Van Soest, P.J; Robertson, J.B and B.A. Lewis (1991). Methods of Dietary Fiber, Neutral Detergent Fiber and Non-Starch Polysaccharides in Relation to Animal Nutrition. J. of Dairy Sci., 74, 3583-3597. http://dx.doi.org/ 10.3168/jds.S0022-0302(91)78551-2.

Vasta, V.; S. Abidi; H. Ben Salem; A. Nefzaoui and A. Priolo (2008). Effects of the supplementation of olive cake and cactus pad silage on sheep intramuscular fatty acid composition. Options Méditerranéennes, Series A, No. 78.

Warner, A.C.I (1964). Production of volatile fatty acids in the rumen, methods of measurement. Nutri. Abst. Rev., 34: 339-352.

Weatherburn, M. W (1967). Enzymic method for urea in urine. Anal. Chem, 39, 971-974. https://doi/10.1021/ ac60252a045.

Zeeman, D.C. (2005). Evaluation of sun-dried Opuntia ficus indica var. Algerian cladodes in sheep diets. Thesis. Dept. of Anim., Wildlife and Grassland Sciences, Univ. of Free State.

Zhang X; J. Zhao and Du X. (2014). Barcoded pyrosequencing analysis of the bacterial community of *Daqu* for light-flavour Chinese liquor. *Lett. Appl. Microbiol.* 58 549–555. 10.1111/lam.12225.

تأثير إستبدال سيلاج الذرة بسيلاج الواح التين الشوكى على أداء النمو وقابلية الهضم في علائق الأغنام

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الملخص

تم اجراء هذة الدراسة على ٢٧ من ذكور الحملان البرقى لدراسة تأثير استبدال سيلاج الذرة بسيلاج الواح التين الشوكى (*Opuntia ficus indica*) مع حطب الذرة الجاف المنخفض القيمة الغذائية على درجة المأكول من المادة الجافة ومعاملات الهضم واداء النمو. بحيث كانت العلائق المختبرة مكونة من عليقة التحكم (R1) تتكون من تركيبة اساسية وهى ٦٠% من مخلوط من العلف المركز و١٠% قش ارز + ٣٠% سيلاج الذرة فقط (CS)، العليقة المختبرة الثانية (R2) تتكون من نفس R1 بحيث يكون السيلاج ١٥% سيلاج ذرة (CS) +١٥% سيلاج الواح التين الشوكى (CCS) واخيرا العليقة المختبرة الثالثة R3 تتكون من نفس العليقة باستبدال كامل لسيلاج الذرة بسيلاج الواح التين الشوكى (CCS) (٣٠%) بحيث تكون جميع العلائق متساوية فى محتواها من البروتين (١٣%) ومتساوية فى الطاقة الممثله (ME) (٢,٩ ميجا كالورى) لكل كجم مادة جافة. اظهرت النتائج ان حجم المأكول (DMI) فى المجموعة التانية R2 كان اكبر معنويا مقارنة بباقى العلائق. كان للمجموعة R2 قيم اعلى معنويا فى الوزن النهائى و معدل الزيادة اليومية فى الوزن مقارنة بالمجموعة R3. بالنسبة لقيم سيرم الدم من كلا من البروتين الكلى والجلوبيولين وانزيمات الكبد (ALT and AST) لم يظهر فروق معنوية فيما بين جميع العلائق المختبرة. وايضا لم يظهر اى فروقات معنوية بين قيم هضم كلا من OM و CP و CF وNFE وADF لكن قيمة معامل هضم NDF كانت اقل بصورة معنوية فى المجموعة R3 (٥٩,٦٥%) مقارنة بالمجموعة R1 وR2. كانت الفروق معنوية بين جميع المجموعات المختبرة فى قيم البروتين الميكروبى حيث كانت ١٥,٥٣% فى R1 وكانت ١٨,٣١% فى R2 وكانت ١٣,٧٨% فى R3. كانت القيمة الغذائية فى صورة قيم TDN و البروتين الخام المهضوم (DCP) فى المجموعة R3 اقل معنويا مقارنة بباقى المعاملات المختبرة. من خلال تلك النتائج يمكن استنتاج انه يمكن استخدام سيلاج التين الشوكى كاإستبدال جزئى لسيلاج الذرة فى علائق الاغنام تحت الظروف القاحله والمحدودة الموارد من اجل تحسين اداء النمو والهضم.