15 *Egypt. J. Vet. Sci.* **Vol. 56,** No. 1, pp. 139-148 (2025)

Egyptian Journal of Veterinary Sciences

https://ejvs.journals.ekb.eg/

Impact of Substituting Corn Silage by Orange Pulp Silage on The Productive Performance and Economic Efficiency of Baladi Crossbred Calves

Mohammed H. Bakr, Aya M. Rabie* and Wafaa M.A. Ghoneem

Animal Production Department, Faculty of Agriculture, Cairo University, 12613, Giza, Egypt.

Abstract

THIS research aimed to assess the impact of corn silage (CS) replacement with orange pulp silage (OPS) at different levels (0, 50, and 100% on dry matter basis) in beef cattle rations. Thirty crossbred calves (240±3 kg average live body weight (LBW); 8 month of age) were divided into three equal groups (n=10 for each). The animals in control group (R1) were fed a CS-based ration without any replacement, while CS was replaced by OPS at level of 50% in R2 and 100% in R3. The silage quality, Feed intake (FI), digestibility of nutrients, average daily gain (ADG) and the feed economic efficiency (FEE) were measured. Results noted that the fermentation characteristics for CS and OPS were within the normal standards for an excellent silage quality. Digestion coefficients of ether extract, neutral detergent fiber, acid detergent fiber, cellulose and hemicellulose were noted to be higher for R1 comparing to R2 and R3, while an increase in organic matter, crude protein, nitrogen free extract was detected for R2, as well as total digestible nutrients and digestible crude protein compared to other groups. However, R3 group showed the least values for nutrients' digestibility compared to R1 and R2. Animals in R2 group showed improve in feed conversion ratio, higher ADG and FEE compared to R1 and R3. It can be concluded that inclusion of OPS with CS (1:1) in beef cattle ration is considered an effective strategy to maximize farm profitability, enhancing animal growth performance and nutrients digestibility.

Keywords: Average daily gain, digestibility, feed intake, Silage characteristics.

Introduction

In 2023, the Egyptian population has grown by twice in the last 20 years [1], which boosted the agricultural demand to meet the food needs. Subsequently, this leads researchers to continue investigating how to increase plant and animal production to achieve food security. Furthermore, the expansion in animal production requires increasing the feed supply in sufficient and high-quality amounts, bearing in mind the price and availability of feed resources that are not directly in competition with the human diet [2]. Based on the above trends, food demand will increase going forward by 2050, the number of grains consumed for human and animal feed will increase by 43% compared with the present [3]. The difference between available and required amounts of animal feeds (i.e., feed gap) in Egypt is estimated to be as much as annually, the total digestible nutrients (TDN) amounting to 4.2 million tons [4]. It worth mentioning that feeding cost could exceed 75% of the variable cost of animal production projects, with most ingredients imported from abroad at high prices [5]. Ruminants can benefit from feeding by-products of the food and agriculture industries in achieving two important aims: reducing their reliance on grains and filling nutritional gaps [6]. Therefore, using agro-industrial by-products (such as, tomato peel, beet pulp, molasses, orange pulp… etc.) as alternatives of feed ingredients would be a suitable strategy to decrease feeding cost and maximize the income and profits for livestock holders [7].

Citrus by-products are fed to ruminants in many forms such as dried citrus pulp, citrus molasses, and citrus silage [8]. Orange pulp is by-product obtained from the orange juice operation and containing of

*Corresponding author: Aya M Rabie، E-mail: ayamohamed24153@Gmail.com. Tel.:00201115434246
(Received 08/01/2024, accepted 02/04/2024)
DOI: 10.21608/EJVS.2024.260528.1774

orange peel, pulp, and seeds, [9]. According to Grizotto et al. [10], it contains beneficial nutritional like a high energy content, a considerable Fiber content, and a good palatability. Orange pulp is readily available as a low-cost by-product of the orange industry [11].

Due to low cost, high nutritive value, and inherent antimicrobial effects, citrus by-products (including orange pulp) were investigated in many ruminant species either as fresh, silage or dried forms [12].

Lashkari et al. [13] indicated that replacing maize and lucerne in rations of growing lambs with citrus pulp at levels of 57 and 55.1%, did not affect the digestibility of DM, while it had a quadratic effect on OM and CP digestibility. Moreover, the same authors concluded that citrus pulp inclusion promoted NDF digestibility. So, feeds high in easily digestible cell walls, such orange pulp, have a positive impact on starch concentrations and generally provide a more hospitable ruminal environment for cellulolytic bacteria [14]. Likewise, [15] reported a non-significant difference overall the nutrients digestibility in cattle when corn was replaced with citrus pulp by 100%. According to [12], lactating cows fed diets containing dried orange pulp (DOP) under stressful heat conditions showed an improvement in daily milk yield. Additionally, feeding moderate amounts of orange peel and pulp to dairy cows in excessively hot weather had a positive impact on the appetite of lactating cows [16]. As well as vitamin C can act as a protective antioxidant or anti-heat stress agent [12]. Otherwise, replacement of corn silage by orange by products silage at 50% or 100% had positively affected all nutrient digestion coefficients of Barki Ewes [17]. In parallel, [18,19] recorded that OM, DM, CP and CF digestibility were increased when citrus pulp silage was included in beef feeding. In the same trend, rations contained orange pulp silage (OPS) recorded high nutritive values, which may be related to the high nutrients' digestibility [20,21,22]. Papi et al. [23] examined the impact of replacing OPS at 50% and 100% of maize silage on the economic efficiency and growth performance of lamb diets and daily gain risen to a noticeable value. Improvements were also seen in feed conversion, feed intake. According to the findings, lambs fed OPS had lower feed costs per kg of growth than lambs fed maize silage, and economic efficiency improved because of reduced daily feeding cost.

Therefore, the current study aimed to assess the silage quality of orange pulp, and to investigate the effect of replacing the corn silage with orange pulp silage in growing calves' rations on growth performance, digestibility of nutrients, nutritive value and economic efficiency.

Material and Methods

The The field experiment of this study was carried out at Bonita Cattle Farm (Cairo-Alexandria Desert Road Kilo 58, Giza, Egypt). The chemical analysis of feed ingredients and feces was conducted at the laboratories of the Animal Nutrition Branch (Animal Production Department) and Cairo University Research Park (CURP) at the Faculty of Agriculture, Cairo University, Egypt. This experiment was conducted for 15 weeks (3 weeks for adaptation and 12 weeks as the experimental period). The first three weeks are considered the adaptation period for animals; in the first week, the two experimental groups (R2 and R3) were fed TMR containing 25% OPS as a partial substitute for CS; in the second week, animals in R2 and R3 were fed TMR containing 50% OPS as a partial substitute for CS. In the third week, animals in R3 were fed TMR containing 100% OPS as a complete substitute for CS.

Experimental animals and feeding management:

Thirty local crossbred (Friesians x Baladi) calves (n = 30; 240±3 kg average live body weight; average age 8 months) were selected and divided into three groups (ten animals each) according to their weight. The three groups received the same quantity and quality of the concentrate feed mixture (CFM) and rice straw (RS); however, the differences among the groups were in the partial or complete replacement of corn silage (CS) by orange pulp silage (OPS) according to the DM in the silage. The control group (R1) fed 59%CFM +15% RS +26% CS + 0% OPS; animals in the second group (R2; 50% OPS) were fed 59%CFM +15% RS + 13% CS + 13% OPS; animals in the third group (R3; 100% OPS) were fed 59%CFM+15%RS+0%CS+26%OPS.

calves were given the concentration feed mixture (CFM), corn silage, rice straw, and orang pulp silage three times a day at 6.00 am, 2.00 pm, and 10.00 pm. In Table 1, the CFM formulation appears. NRC [24] states that the offered feeds were evaluated to ensure they met the nutritional needs of calves. During the trial, the animals were kept in an open-house system. Throughout the day, there was always free water to drink.

TABLE 1. Formulation of the experimental concentrate feed mixture.

Feed ingredients	kg/ton
Yellow corn	400
Beet pulp	100
Soybean meal (47%)	90
Sunflower meal (36%)	30
Wheat bran	335
Limestone	18
Sodium chloride	10
Sodium bicarbonate	10
Magnesium Oxide	2
Anti-toxin	1
di-calcium phosphate	1
Vitamin and mineral mixture*	3
Total	1000

* Each 3 kg vitamins and minerals mixture contain: Vit A 4800000 IU; Vit D3 1000000 IU; Vit E 28000 mg; Zinc 100000 mg; Manganese 80000 mg; Iron 75000 mg; Copper 30000 mg; Iodine 750 mg; Cobalt 200 mg; Selenium 300 mg; Calcium bicarbonate up to 3 kg. (Produce d by Multi vita company for animal nutrition, 6 October City, Egypt, Feb. 2021).

The animals' weight were every 30 days, and the average daily gain (ADG) was calculated by the difference between two values. The quantity of TMR was recalculated every month according to the average live body weight.

Preparation and characteristics corn and orange pulp silages

Corn silage is manufactured by El Amira Feed Company (Cairo Alexandria Desert Road, El Amria-Behira Governate). Orange pulp materials were obtained from a commercial fruit juice factory in the Borg Al-Arab region, Alexandria Governate, Egypt. The product was ensiled into an approximately 1-meter-high stack for 60 days. The mixture was compacted in the bunker using a tractor, and air was kept out by covering it with tires and a 180-micron plastic sheet. In order to provide anaerobic fermentation conditions and protect silage from being exposed to solar radiation, it was also covered with soil. A layer of rice straw was put under the orange pulp as an absorbent to decrease the moisture content of the orange pulp. It was ensiled together without mixing with chopped rice straw to avoid decreasing the nutritive value of orange silage. Then the silo was opened for feeding, the samples were taken for chemical analysis, and determined the silage quality. The pH silage value was estimated using the Orion Research model 201/digital pH meter, while Total Volatile fatty acids (TVFAs) and ammonia nitrogen (NH_3-N) concentrations were estimated according to the methods of Warner [25] and Bergen et al. [26]. The Flieg point was calculated to evaluate the quality of silage using the following formula: FP = {220 + (2 x dry matter % -15) - 40 x pH}, according to [27] formulas follow: Zero to 20 (bad), 21 to 40 (average), 41 to 60 (relatively good), 61 to 80 (good), and 81 Up to 100 (excellent).

Digestion trial

Fecal samples were collected for three consecutive days and conducted to determine nutritive value and nutrients' digestibility as digestible CP (DCP) and total digestible nutrients (TDN). Fecal samples were collected from the rectum of each animal before feeding twice a day, at 10 am and 3 pm, in the last week of the experiment. Acid Insoluble Ash (AIA) was used as an internal marker to estimate fecal output and nutrients' digestibility according to [28] equation, while TDN was calculated according to the formula of [29], as follows:

TDN% = [digestible CF, % + digestible NFE, % + (digestible EE, % *2.25) + digestible CP, %]

$$\text{Dry matter digestibility} = [1 - (\frac{\text{Marker\% in feed}}{\text{Marker\% in feces}})] *100$$

$$\text{Nutrient digestibility} = [1 - (\frac{\text{Nutrient\% in feces}}{\text{Nutrient\% in feed}} * \frac{\text{Marker\% in feed}}{\text{Marker\% in feces}})] *100$$

Chemical composition of feedstuffs and feces

The proximate analyses of feeds and feces were conducted following [30] methodology to determine organic matter (OM), dry matter (DM), ether extract (EE), crude protein (CP), crude fiber (CF), and ash contents. Nitrogen-free extract (NFE) was estimated by the difference. Fiber fractions as acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) were analyzed according to [31]. By calculations, cellulose content was estimated as the difference between ADL and ADF, and hemicellulose as the difference between NDF and ADF.

Economic evaluation

Based on the results of the experiment, we calculated the relationship between feed costs and gain. Using the equation below, the costs associated with each kilogram of increase in body weight are calculated as follows:

The feed cost (L.E /1Kg gain) =

$$\frac{\text{total feed cost (L.E/ head/ day)}}{\text{Average daily live body wight (kg).}}$$

The ingredient costs according to 2021 prices were 4500 LE per Ton for CFM, 1200 LE per Ton for corn silage, 300 LE per Ton for orange pulp silage, and 800 LE per Ton for rice straw, Price of 1Kg body wight 58.

Economic efficiency = [total gain price x 100] / total gain cost.

Statistical analysis

An analysis of the data was conducted using the general liner formula of SPSS V19. The analysis was carried out using a one-way ANOVA for the following data model:

$Yij = \mu + Rij + Eij$

Where: μ = overall mean.

Yij; Rij = treatment effect.

Eij = experimental error.

Based on [32] Multiple Range Test, we separated the means based on their differences.

Results and Discussion

Chemical composition of feeds and experimental rations

As shown in Table 2, OM, CP and EE contents of CS and OPS are almost the same. The observed values for DM were 29.79% and 20% for CS and OPS, respectively. These results were very close to those reported by [33] who mentioned that DM, OM and CP contents of OPS to be about 19.24, 95.04 and 7.86%, respectively. in the same trend, [34,35] who recorded OM and CP content in CS at 92,6% and 8,15 %, respectively. Regarding CF and EE contents, they accounted for 26.36 and 4.24% for CS and 18.64 and 4.07% for OPS, respectively. The values of CF and EE in OPS was in agreement with [20] who showed that their contents in OPS were 17.96 and 3.73%, in the same order. Our findings for DM, CP and CF were noticed to be lower than those observed by [19] who recorded their values to be 38.90, 8.72, and 28.56%, respectively.

TABLE 2. Chemical composition (% DM basis) of concentrate feed mixture (CFM), corn silage (CS), orange pulp silage (OPS), and rice straw (RS)

Item	CFM	CS	OPS	RS
DM	90.44	29.79	20.00	89.64
OM	91.27	93.21	94.42	82.78
CP	15.37	8.00	8.22	3.58
EE	9.86	4.24	4.07	1.48
CF	10.78	26.36	18.64	38.4
Ash	8.73	6.79	5.58	17.22
NFE	55.26	54.61	63.49	39.32
NDF	21.89	41.30	34.60	72.30
ADF	10.16	29.45	22.89	37.53
ADL	3.21	4.83	5.06	7.81
Hemi cellulose	11.73	11.85	11.71	34.77
Cellulose	6.95	24.62	17.83	29.72

DM: dry matter,CP: crude protein, OM: organic matter,CF: crude fibre , EE: ether extract, NFE: nitrogen free extract ,ADL: acid detergent lignin , ADF: acid detergent fibre, NDF: neutral detergent fibre. Concentrate feed mixture (CFM), corn silage(CS), orange pulp silage(OPS), rice straw(RS).

The NDF and ADF values for CS were higher than those for OPS (41.3 and 29.45% vs. 34.6 and 22.89%, respectively). in the same trend, [36] who recorded NDF and ADF content in OPS at 33,96%, and 23.81%, respectively.

Hemicellulose content in OPS was similar to that of CS (11.71 vs. 11.85%). The current result was near to that noted by [19] who recorded10.15-10.8% hemicellulose in OPS. On contrary, the cellulose content of CS was higher than its content in OPS

(24.62 vs. 17.83%). The present result was in agreement with [37] who showed cellulose content in OPS being 18.5%.

Regarding the experimental rations as given in Table 3, CP values were approximately equal, being 11.69, 11.71, and 11.74% for R1, R2, and R3, respectively. The CF contents ranged from 16.97 to18.97%. values of NDF and ADF fell between 32.76–34.5% and 17.58–19.28%, respectively.

TABLE 3. Calculated chemical composition of the experimental rations fed calves

Item	Experimental rations (DM basis)		
	R1	R2	R3
DM	74.55	73.28	72.01
OM	90.50	90.66	90.82
CP	11.69	11.71	11.74
EE	7.14	7.12	7.10
CF	18.97	17.97	16.97
Ash	9.50	9.34	9.18
NFE	52.70	53.85	55.01
NDF	34.50	33.63	32.76
ADF	19.28	18.43	17.58
ADL	4.32	4.35	4.38
Hemi cellulose	15.22	15.20	15.18
Cellulose	14.96	14.08	13.19

DM: dry matter, CP: crude protein, OM: organic matter, CF: crude fibre , EE: ether extract, NFE: nitrogen free extract ,ADL: acid detergent lignin , ADF: acid detergent fibre, NDF: neutral detergent fibre, R1: 26% corn silage+ 59% CFM+15% rice straw , R2 : 13% orange pulp silage+ 13% corn silage+ 59% CFM+15% rice straw, R3: 26% orange pulp silage + 59% CFM + 15% rice straw.

The experimental rations, values of OM, CP, EE, ADL, hemicellulose were approximately equal, by increasing the replacement levels of OPS, this is due to the similar nutritional content of OPS and CS in these nutrients. However, values of NFE a higher by increasing the replacement levels of OPS, that because the content of these nutrients in OPS were higher than those recorded for CS. Whereas, values of CF, DM, Ash, ADF, NDF and cellulose lower by increasing the replacement levels of OPS, that because its decreased contents in OPS compared to CS values.

Silage fermentation characteristics

The fermentation characteristics, given in Table 4, stated the success of silage processing according to the general quality standers. The OPS had a good odor and color, and there were no signs of rotting or mold. The pH values in OPS and CS were observed to be 3.4 and 4.0, respectively. In the same context, [37,38] noted that the pH value of OPS ranged from 3.0 to 3.8; these values were within the normal range for high-quality silage as recorded by [39]. Moreover, flige point (FP) for CS and OPS accounted for 104.97 and 85.4, which were in agreement with Ülger et al. [40]. Depending on the FP value, an excellent silage quality was determined in the two kinds of silages, that indicates a similarity in the fermentation properties in both.

TABLE 4. Fermentation characteristics and quality of corn silage and orange pulp silage

Item	CS	OPS
PH	3.99	3.4
TOA, % of DM	6.04	8.16
TVFA, % of DM	1.39	1.78
NH3-N, % of DM	0.02	0.04
FP	104.97	85.40
Quality	excellent	excellent

Corn silage (CS), Orange pulp silage (OPS), Total organic acids (TOA), Total volatile fatty acids (TVFA), Flige point (FP)

The present study demonstrates that total organic acid concentration of CS was lower than that of OPS, being 6.04 and 8.16%, respectively; which appears to be close to that obtained by Chavan et al.[40]. Total volatile fatty acid (TVFA) concentration in both types of silages (CS and OPS) was within the normal range (1.39 to 1.78) for excellent-quality silage, which point out to an acceptable silage fermentation. In parallel, low values for NH3-N (0.02 to 0.04% of DM) of the two kinds of silage were noted in this study; also, these results are in accordance with those evaluated by [41].

Effect of replacing CS by OPS on nutrients digestibility and nutritive value of the experimental rations

The effect of replacing CS with OPS at different levels (R2, 50%–R3, 100%) on nutrient digestibility and nutritive values of the experimental rations are given in **Table 5**. Dry matter digestibility for R2 and R3 were 70.98 and 69.45%, respectively. These results were Similary, Shdaifat et al. [18] who used diets that contained 30% OPS + 70% CFM and 45% OPS + 55% CFM and showed that the DM digestibility values for the experimental rations were 71.27 and 69.94. Otherwise, [42] fed OPS at 10, 15, and 20% of TMR and found that the DM digestibility values were decreased (from 72 to 67.5%) by increasing the inclusion level of OPS.

The values of OM digestibility in the current study with R2 and R3 were 74.60 and 72.99, respectively. These results were in the same line with [43] who showed that the OM digestibility values for (10–30%) OPS containing rations were (74.91 to 76.02%).

The digestibility of CP in R2 was higher than R1 and R3, being 69.8 vs. 66.7 and 65.4%, respectively. These results were in agreement with those noticed by [44], as they estimated the CP digestibility at 66 to 69%. It worth mentioning that incorporation of OPS into ruminant diets had a positive effect on N supply to the intestine by creating favourable conditions inside the rumen [12]. No significant differences were detected in CF digestibility among all the experimental rations (R1, R2 and R3; $p>0.05$). However, the CF digestibility was recorded within a range of 61 to 66 % by [43,45].

TABLE 5. Nutrients digestibility and nutritive values of the experimental rations

Item	Experimental rations (DM basis)			±SEM	P-value
	R1	R2	R3		
Nutrients digestibility, %					
DM	70.47^{a}	70.98^{a}	69.45^{b}	0.24	0.001
OM	73.79^{b}	74.60^{a}	72.99^{c}	0.24	0.001
CP	66.66^{b}	69.76^{a}	65.39^{c}	0.76	<0.001
EE	89.95^{a}	88.95^{b}	85.20^{c}	0.73	<0.001
CF	73.68	73.50	73.25	0.10	0.275
NFE	73.23^{b}	74.12^{a}	72.92^{b}	0.19	0.002
NDF	61.39^{a}	54.70^{b}	51.92^{c}	1.41	<0.001
ADF	62.51^{a}	57.20^{b}	52.63^{c}	1.42	<0.001
Hemicellulose	59.97^{a}	51.67^{b}	51.10^{c}	1.43	<0.001
Cellulose	68.79^{a}	66.32^{b}	60.80^{c}	1.18	<0.001
Nutritive values (%)					
TDN	74.81^{b}	75.54^{a}	73.83^{c}	0.26	0.002
DCP	7.79^{b}	8.17^{a}	7.68^{b}	0.09	0.036

DM: dry matter, CP: crude protein, OM: organic matter, CF: crude fibre, EE: ether extract, NFE: nitrogen free extract , ADF: acid detergent fibre, NDF: neutral detergent fibre,TDN: total digestible nutrients,DCP: digestible crude protein, R1: 26% corn silage+ 59% CFM+15% rice straw, R2: 13% orange pulp silage+ 13% corn silage+ 59% CFM+15% rice straw, R3: 26% orange pulp silage + 59% CFM + 15% rice straw, a b c, Means within rows followed by different superscripts are significantly different at ($P < 0.05$), SEM - standard error of the mean

EE digestibility was significantly different ($p<0.05$) for the experimental rations, being higher for R1 and R2, followed by R3 (89.95, 88.95, and 85.20%, respectively). In contrast to the previous data, [17,42] recorded lower values for EE digestibility (from 62 to 76.40%) when OPS included in rations.

The NFE digestibility was significantly ($p<0.05$) affected by feeding the experimental rations. (R2) had a value of NFE digestibility that was significantly higher than R3 (74.12 vs. 72.92%), while the difference between R1 and R3 were approximately equal ($p>0.05$). on

The NDF digestibility was significantly ($p<0.05$) higher in R1 than R2 or R3 (61.39 vs. 54.70, and 51.92, respectively), which was similar to [46] results, who stated that NDF digestibility at 54.5 and 56 % in rations containing 30 and 45% of OPS. On the other hand, [19] noted that NDF digestibility can reach 66.50% for ruminant diets containing 50–100% OPS.

Likewise, the digestibility of ADF, cellulose, and hemicellulose were significantly ($p<0.05$) decreased with the implication of OPS in rations (R2 and R3) compared to R1, Orange by-products are rich in pectin, generally have a positive effect on the ruminant environment, but the decrease in fiber digestibility may be associated with the high lignin content of OPS [47].

The nutritive value of experimental rations, as TDN, was significantly different among groups ($p<0.05$), where R2 recorded the highest value compared to R1 and R3 (75.54% vs. 74.81 and 73.83%, respectively; $p<0.05$). Similarly, the highest DCP value was observed with R2 in a comparison to R1 and R3, being 8.17, 7.79 and 7.68%, respectively ($p<0.05$), however, difference between R1 and R3 was not significant.

Effect of replacing CS by OPS on feed intake, growth performance and economic efficiency

Feed intake, average daily gain (ADG), feed conversion, and economic efficiency of the experimental rations are presented in **Table 6**. Total dry matter intake (DMI) was approximately equal for all groups (R3, R2, and R1, being 9.17, 9.16, and 9.15 kg DMI, respectively). These results were in the same context, [19], as they observed non-significant difference in the feed intake of diets including 20 and 40% OPS. On the other hand, [20] assessed DMI in beef cattle fed diets with different replacement levels of CS by OPS and observed a linear increase in DM intake with increasing the OPS substitution level.

TABLE 6. Feed intake, growth performance and economic efficiency of calves fed the experimental rations

Item	Experimental rations			±SEM	*P*-value
	R1	R2	R3		
Initial live body weight, Kg	243.00	237.50	241.17	1.04	-
Final live body weight, Kg	356.00	357.00	341.83	2.54	<0.001
Total body weight gain, Kg	113.00^{b}	119.50^{a}	100.67^{c}	2.90	0.001
Average daily weight gain (kg/h/d)	0.94^{a}	1.00^{a}	0.84^{b}	0.027	0.008
Feed intake Kg/ day					
concentrate feed mixture (CFM)	6	6	6	-	-
corn silage (CS)	8	4	0	-	-
orange pulp silage (OPS)	0	6	12	-	-
rice straw (RS)	1.5	1.5	1.5	-	-
Total feed intake, Kg/h/d.	15.50	17.50	19.50	-	-
Total DMI/h/d	9.15	9.16	9.17	-	-
Feed conversion ratio (kg DMI/ kg gain)	9.73^{b}	9.16^{c}	10.92^{a}	0.26	<0.001
Economic efficiency					
TMR Price ((LE/kg)	2.44	1.99	1.63	-	-
Total Feed cost (LE/h/d)	37.82	34.83	31.79	-	-
Feed cost (LE)/1Kg gain	40.23	34.83	37.85	-	-
Relative economic efficiency (REE) (%) / 1kg gain	100%	87%	94%	-	-
Daily gain income (LE/h)	54.52	58.00	48.72	-	-
Income (LE/h/d)	16.70	23.17	16.93	-	-
REE (%)/h/d	100%	137%	100%	-	-

R1: 26% corn silage+ 59% CFM+15% rice straw, R2: 13% orange pulp silage+ 13% corn silage+ 59% CFM+15% rice straw, R3: 26% orange pulp silage + 59% CFM + 15% rice straw, Price of 1 ton CFM= 4500 LE Price of 1 ton CS = 1200 LE; Price of 1 ton OS = 300 LE and Price of 1 ton RS = 800 LE; Market price of 1 kg live body weight in (2021) = 58LE, REE(%) / 1kg gain: The cost of feed intake for produce one kg gain per calve in each group relative to the control group cost *100.Daily gain income (LE/h): Average daily gain ,Income (LE/h/d): Daily gain income (LE/h) - Total Feed cost (LE/h/d). REE (%) h/d: Income (LE/h/d) in each group relative to the control group *100. SEM : standard error of the mean, a,b,c Means within rows followed by different superscripts are significantly different at (P < 0.05).

In the current study, a non-significant increase in ADG for R2 was noted, while a significant ($p<0.05$) decrease was reported for R3 compared to the control (0.94, 1.00 and 0.84 kg/day for R1, R2 and R3, respectively). These results might be related to the higher digestibility for R2 followed by R1 and then R3. Regarding the economic efficiency, the present data are in harmony with those obtained by [48] when they used dried orange pulp as alternative energy source by 50% replacing corn grains to achieve lower cost of feeding.

The best feed conversion was reported for R2 followed by R1 and then R3 (9.16, 9.73 and 10.92, respectively). The improvement in feed conversion could be attributed to improvements in both nutrient digestibility and nutritive values. In the same context, [23] evaluated the replacement of CS by OPS in lamb rations, and found an improvement in feed efficiency, decreased daily feeding costs, and consequently improved relative economic efficiency.

Although ADG was reported as the lowest for R3 (0.84 kg/day) compared to R1 (0.94 kg/day) and R2 (1.00 kg/day), the feed cost for one kg ADG was lowered by 6%, likewise, it was reduced by 13% in R2 compared to the control. Furthermore, the estimated daily income was enhanced by 37% for R2 compared to the control, while there was not any negative effect on the daily income noted for R3.

Conclusions

Under our study conditions, the fermentation characteristics for corn and orange pulp silages (i.e., pH, total organic acids, total VFAs, NH_3–N and flige point) were within the normal standards for an excellent silage quality, reflecting the well-made silages. Over all nutrient's digestibility, replacing corn silage by 100% orange pulp silage in R3 showed the least values comparing to R1 and R2. Otherwise, digestion coefficients of EE, NDF, ADF, hemicellulose and cellulose found to be higher for the control group (R1) comparing to R2 and R3. Replacing corn silage by 50% orange pulp silage (R2), led to an increase of OM, CP, NFE digestibility as well as TDN and DCP in a comparison with other groups. Moreover, animals in R2 expressed a higher ADG, better feed conversion and economic efficiency compared to control and 100% replacement groups. Therefore, the current study suggests that using of orange pulp silage and corn silage mixture (50:50) is recommended regarding nutrient digestibility and animal performance, considered an effective strategy to reduce the feed cost and maximize farm profitability in addition to presenting an ecological service by applying the circular bioeconomy approach.

Conflicts of interest

Authors do not have any conflicts of interest to declare**.**

Ethical approval

The present study was performed according to the protocol of the Institutional Animal Care and Use Committee, Cairo University (IACUC) (Approval No: CU/II/F/18/22).

Acknowledgments

The authors wish to thank Bonita Cattle Farm for supporting and providing the experimental animals as well as the facilities for this work.

References

1. Worldometers, Egypt Population (LIVE). (2023) Available at: https://www.worldometers.info/world-population/egypt-population/
2. Sharif, M., Ashraf, M. S., Mushtaq, N., Nawaz, H., Mustafa, M. I., Ahmad, F., Younas, M. and Javaid, A. Influence of varying levels of dried citrus pulp on nutrient intake, growth performance and economic efficiency in lambs. *Journal of Applied Animal Research*, **46** (1), 264-268(2018)
3. FAO., The future of food and agriculture: Trends and challenges. (2023) Available at: https://www.fao.org/3/i6583e/i6583e.pdf
4. Shoukery, M.M. The possibility of using some unconventional feed resources as a source of energy and protein in feeding livestock. *Egyptian J. Nutrition and Feeds,* **22**(2), special issue, 1(2019)
5. Wang, C., G. L. Gao, J. X., Huang, K. S., Zhang, H., Zhong, H. W., Wang, J., Su, M. and Xie, Q. G. Wang. Nutritive value of dry citrus pulp and its effect on performance in geese from 35 to 70 days of age. *The Journal of Applied Poultry Research,* **26** (2), 253–259(2017).
6. Santos, G.T.; Lima, L.S.; Schogor, A.L. B.; Romero, J.V.; De Marchi, F.E.; Grande, P.A.; Santos, N.W.; Santos, F.S. and Kazama, R. Citrus pulp as a dietary source of antioxidants for lactating holstein cows fed highly polyunsaturated fatty acid diets. *Asian Australas. J. Anim. Sci.,* **27** (8),1104-1113(2014).
7. López M.C., Estellés F., Moya V.J. and Fernández C. Use of dry citrus pulp or soybean hulls as a replacement for corn grain in energy and nitrogen partitioning, methane emissions, and milk performance in lactating Murciano-Granadina goats. *J. Dairy Sci.*, **97**, 7821-7832(2014).
8. Bakr, M.H. Citrus pulp as an innovative feed ingredient in ruminant nutrition. A review. *Egyptian J. Anim. Prod.,* **57**, 73-80(2020)

9. Üçok, S., Aybek, A. & Yıldız, K. Determination of biogas values of apple and peach wastes experimentally. 1st *International Mediterranean Science and Engineering Congress* (IMSEC 2016), October 26-28, Adana, Turkey, pp. 437-444(2016)

10. Grizotto, R. K.; Bueno, A. P. A.; Campos, A. F.; Siqueira, G. R. and Modesto, R. T. Citrus pulp pellets as an additive for orange bagasse silage. *Boletim de Indústria Animal,* **74**,17-26(2017).

11. Aghsaghali, A.M. and N. Maheri-Sis. Nutritive value of some agro-industrial by -products for ruminants - a review. *World Journal of Zoology*, **3** (2), 40-46(2008).

12. Allam, S.M., El-Bedawy, T.M., Bakr, M.H. and Mahmoud, A.E.M.. Effect of feeding dried orange pulp to lactating dairy cows on nutrients digestibility, blood constituents, plasma antioxidant biomarker and pathogenic fecal bacteria. *Pakistan J, Zool*., **52** (1), 79-86 (2020).

13. Lashkari, S., Taghizadeh, A., Paya, H. and Jensen, S.K. Growth performance, nutrient digestibility and blood parameters of fattening lambs fed diet replacing corn with orange pulp. *Spanish J. Agric. Res*., **15**, 1-6 (2017).

14. Gobindram, M.N.N.E., Bognanno, M., Luciano, G., Avondo, M., Piccione, G. and Biondi, L. The effects of barley replacement by dehydrated citrus pulp on feed intake, performance, feeding behaviour and serum metabolic indicators in lambs. *Anim. Prod. Sci*., **57**, 133-140 (2017)

15. Gilaverte, S., Susin, I., Pires, A.V., Ferreira, E.M., Mendes, C.Q., Gentil, R.S. and Rodrigues, G.H. Digestibilidade da dieta, parâmetros ruminais e desempenho de ovinos Santa Inês alimentados com polpa cítrica peletizada e resíduo úmido de cervejaria. Rev. *Bras. Zootec*., **40**, 639-647 (2011).

16. Carmo, C.A., Batistel, F., de Souza, J., Martinez, J.C., Correa, P., Pedroso, A.M. and Santos, F.A.P. Starch levels on performance, milk composition and energy balance of lactating dairy cows. *Trop. Anim. Health and Prod*., **47**, 179-184 (2015).

17. Khattab, A. R., Elwakeel, A. M., Sadek, W. M. A., Saber, E. A., Zedan, A. H. & Eissa, M. M. Effect of Replacing Maize Silage with Orange by-product Silage on Rumen Fermentation and Performance of Barki Ewes. In *Anim. Prod*., **59**, (2),61-67 (2022).

18. Shdaifat, M. M., Al-Baraka, F. S.., Kanana, A.Q. and Obeidatb, B.S. The effect of feeding agricultural by-products on performance of lactating Awass ewe. *Small Ruminant Research*, **113**, 11–14 (2013).

19. Mahrous, A. A., Karkoutli, A. S., El-Tahan, A. A. H., Hafez, Y. H., Abu El-Alla, A. A. and Moussa, S. K. Replacement corn silage by orange waste silage in barkiram lambs rations. *Egyptian J. Nutrition and Feeds*, **22**(2), 111-119 (2019).

20. Abdel Gawad, A.A., Mahmoud, A.E.M. and Al Slibi, Y.H.. Response of growing bulls fed ration containing different levels of citrus pulp. *World Appl. Sci. J*., **28**(10),1475-1480 (2013)

21. Etman, K. E. I., Shahin, G. F., El-Tahan, A. A. and Sayed, S. K. Studies on feeding allowances during different growth periods for crossed Friesian heifers. *Egyptian J. Nutrition and Feeds,* **9** (2), 19-35 (2007).

22. Mostafa, M. R. M., Safaa, S.B. Mehany, , Abd ELAzim, N. and Soheir Latif, J. Effect of using three varieties of sorghum bicolor stover silages on performance of growing and fattening lambs. *Egyptian J. Nutrition and Feeds*, **13** (2), 271-283 (2010).

23. Papi, N., Fazaeli, H., & Alimohamadi, S. J., Use of total mixed ration citrus pulp silage as a new feeding strategy for growing lambs. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, **123**(1), 31–38. (2022) https://doi.org/10.17170/kobra-202201195570

24. NRC: National Research Council., Nutrient Requirements of Dairy Cattle, 7th rev. ed. *National Academy Press, Washington*, DC, USA (2001)

25. Warner, A. C. I., Production of volatile fatty acids in the rumen, methods of measurements. *Nutr. abstr. and Rev*., **34**, 339-410 (1964)

26. Bergen, W. G., Cach, E. H. and Henderson, H. E. Changes in nitrogenous compounds of the whole corn plant during ensiling and subsequent effects on dry matter intake by sheep. *J. Animals. Sci*., **39**,629-637 (1974).

27. Akyildiz. A.R. Feed Science and Technology. *Agricultural Faculty Publications*, Ankara University, Publication no **895**. Ankara, Turkey, 974. (1986)

28. van Keulen, J.V. and Young, B.A., Evaluation of acid insoluble ash as a natural marker in ruminant digestibility studies. *J. Anim. Sci*., **44**,282-290 (1977)

29. McDonald, P.; R.A. Edwards and J. F. D. Greenhalgh, *Animal Nutrition* (5th edition). Oliver and Boyd Publisher (1995)

30. AOAC, Official methods of analysis, 21st edn. *AOAC International*, (2019) Gaithersburg, MD, USA

31. Van Soest, P. J.; J.D. Robertson and B. A. Lewis, Methods for dietary fibre, neutral detergent fiber and non–starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, **74**,3583-3597 (1991).

32. Duncan, D.B. Multiple range, and multiple F-test. Biometrics, **11**, 1-42(1955). https://doi. org/10.2307/3001478.

33. Özkan, Ç.Ö., Kaya E., Ülger, İ., Güven, İ. and Kamalak, A., Effect of species on nutritive value and methane production of citrus pulps for ruminants. *Hayv.Üret*., **58**, 8-12 (2017)

34. Hamed, M.G., Mohamed, E., Ahmed, A. E., Ahmed, A.G., Mohamed, F.A. and Mohamed, M.E. Evaluating the Rations Containing of Corn, Triticale and Oat Silages on the Growth Performance and Semen Quality of Ram Lambs. *Egyptian Journal of Veterinary Sciences,* **54**(Special issue) (*The Scientific Conference of Kafr Elsheikh University (One World.. One Health, 5th- 8th October 2022*), 261-272 (2023).

35. Srour, A. A., Said, A. M., Nabil, M. E. and Mahmoud, M. B. Productive Performance of Lactating Buffaloes Fed Different Types of Silages During Summer Period. *Egyptian Journal of Veterinary Sciences.* **54**(Special

issue) (*The Scientific Conference of Kafr Elsheikh University (One World..One Health, 5th- 8th October 2022*), 157-165 (2023).

36. Paya, H., Taghizadeh, A. and Lashkari, S. Effects of Lacto- bacillus plantarum and hydrolytic enzymes on fermentation and ruminal degradability of orange pulp silage. *J. Bio. Sci. Biotechnol*., **4**, 349-357 (2015)

37. El-Zaiat, H. M., El-Wakeel, E. S. A., Saber, A. M., Khattab, A. R. and Sallam, S. M. Influence of Replacement Levels of Orange Waste Silage on Intake, Nutrient Digestion, Ruminal Fermentation and Milk Yield in Barki Goats. *Annals of Animal Science*, **22**(1), 283–303 (2022) https://doi.org/10.2478/aoas-2021-0028

38. Grizotto, R.K., Siqueira, G.R., Campos, A.F., Modesto, R.T. and Resende, F.D. de. Fermentative parameters and aerobic stability of orange peel silage with pelleted citrus pulp. *Revista Brasileira de Zootecnia*, **49**, e20190265, (2020). DOI: https://doi.org/10.37496/rbz4920190265.

39. Srour, A. A., Said, A. M., Nabil, M. E. and Mahmoud, M. B. Performance of Lactating Buffaloes as Affected by Partial Substation of Berseem by Maize and Maize Teosinte Hybrid Silage During Winter Season in Egypt. *Egyptian Journal of Veterinary Sciences.* (special issue), No.7 105-113(2022)

40. Ülger, I., Beyzi, S. B., Kaliber, M. and Konca, Y. Chemical, nutritive, fermentation profile and gas production of citrus pulp silages, alone or combined with maize silage. *South African Journal of Animal Science*, **50**(1), 161–169(2020) https://doi.org/10.4314/sajas.v50i1.17

41. Chavan, P., Singh, A. K. and Kaur, G. Recent progress in the utilization of industrial waste and by-products of citrus fruits: A review. In *Journal of Food Process Engineering,* **41**(8). Blackwell Publishing Inc. (2018) https://doi.org/10.1111/jfpe.12895

42. Dağtekin, M., Aybek, A., Üçok, S. and Beyaz, A. The effect of adding corn silage at different ratios to orange and tangerine wastes on biogas production efficiency. *Tarim. Bilimleri. Dergisi*, **24**(4), 531–538(2018) https://doi.org/10.15832/ankutbd.347918

43. Ali, M. M., Abdel-Rahman, K. M. and Nayel, U. A. Use of Tomato Pomace and/or orange pulp supplemented corn silage for *animal feeding. In Agric. Res.,* **40**(3), 643-654 (2015). http://www.mujar.net.

44. Williams, S.R.O., Chaves, A.V., Deighton, M.H., Jacobs, J.L., Hannah, M.C., Ribaux, B.E. and Moate, P.J. Influence of feeding supplements of almond hulls and ensiled citrus pulp on the milk production, milk composition, and methane emissions of dairy cows. *J. Dairy Sci.,* **101**, 2072-2083(2018)

45. Kordi, M. and Naserian, A. A. Influence of wheat bran as a silage additive on chemical composition, in situ degradability and in vitro gas production of citrus pulp silage. *African Journal of Biotechnology*, **11**, 12669-12674 (2012)

46. Lashkari, S., Taghizadeh, A., Seifdavati, J. and Salem, A.Z.M. Qualitative characteristics, microbial populations and nutritive values of orange pulp ensiled with nitrogen supple mentation. *Slovak. J. Anim. Sci.,* **47**, 90-99 (2014).

47. Kordi, M., Naserian, A. A., Valizadeh, R. and Tahmasebi, A. M. Effect of different levels of sugar beet pulp on chemical composition, fermentational properties, textitin situ degradability and textitin vitro gas production of citrus pulp silage. *Iranian Journal Ruminant Research*, **2**(1), 17–32 (2014).

48. Andrade, W.R., Pires, A.J.V. and Jesus, M.O. de. Citrus co-products in ruminants feeds: a review. *Iranian Journal of Applied Animal Science*, **10**, 191-202(2020).

49. Allam, S.M., Abou-Ward, G.A., Tawila, M.A., Ali, M.A., Al-Hosseiny H.M., Sayed, S.K. and ElNaggar, S.I. Nutritional and economical impact of using dried orange pulp as energy source in growing lambs rations. *Egyptian J. Nutri. Feeds*, **14**,337-347. (2011).

تأثير استبدال سيلاج الذرة بسيلاج البرتقال على الأداء الإنتاجي والكفاءة الاقتصادية للعجول الهجينة البلدية

محمد حسن بكر ، اية محمد ربيع و وفاء مصطفى على غنيم
قسم الانتاج الحيوانى - كلية الزراعة - جامعة القاهرة - الجيزة - مصر.

كان الغرض من هذا البحث هو تقييم تأثير استبدال سيلاج الذرة (CS) بسيلاج لب البرتقال (OPS) بمستويات مختلفة (0، 50، و100٪ كمادة جافة) في حصص العجول. تم تقسيم ثلاثين عجلاً هجيناً (240 ± 3 كجم متوسط وزن الجسم، متوسط العمر 8 أشهر) إلى ثلاث مجموعات، عشرة حيوانات لكل مجموعة، على أساس الوزن. تم تغذية الحيوانات في المجموعة المقارنة (R1) بحصة أساسها CS دون أي بديل، في حين تم استبدال CS بـ OPS بمستوى 50% في المجموعة الثانية (R2) و100% في المجموعة الثالثة (R3). تم قياس استهلاك العلف، وهضم العناصر الغذائية، ومتوسط الكسب اليومي (ADG) والكفاءة الاقتصادية. أشارت النتائج إلى ان خصائص التخمير لـ CS و OPS كانت ضمن النطاق الطبيعي للحصول على جودة سيلاج ممتازة.. لوحظ أن معاملات هضم EE وADF وNDF والسليلوز والهيميسيلولوز أعلى بالنسبة لمجموعة التحكم (R1) مقارنة بـ R2 وR3، في حين تم الكشف عن زيادة في قابلية هضم OM وCP وNFE بالنسبة لـ R2، وكذلك TDN و DCP مقارنة بالمجموعات الأخرى. ومع ذلك، أظهر R3 أقل القيم لهضم العناصر الغذائية مقارنة بـ R1 وR2. أظهرت الحيوانات في R2 تحسينات في تحويل العلف، وارتفاع ADG والكفاءة الاقتصادية مقارنة بالتحكم وR3. يمكن أن نستنتج أن إدراج OPS كخليط (1:1) مع CS في حصص العجول يعتبر استراتيجية فعالة لتعظيم ربحية المزرعة عن طريق تقليل تكلفة العلف وتعزيز أداء نمو الحيوان وهضم مغذيات العلف.

الكلمات الدالة: متوسط الكسب اليومي، الهضم، تناول العلف، خصائص السيلاج.