EFFECT OF REPLACING MAIZE SILAGE WITH ORANGE BY-PRODUCT SILAGE ON RUMEN FERMENTATION AND PERFORMANCE OF BARKI EWES

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SUMMARY

The study was performed to evaluate the effect of partial or complete replacement of maize silage (MS) with orange by-product silage (OBPS) on feed intake, nutritive value, digestibility, milk production and composition, of Barki ewes. Thirty-two Barki ewes (3-5 years old and live body weight 41±0.29kg) were divided into three equal groups; the 1st group (control) was fed concentrate mixture and MS (G1), the 2nd and 3rd groups were fed the concentrate mixture and replaced MS with 50% OBPS (G2) or 100% OBPS (G3). The forage concentrate ratio in all groups was 50%:50%. The results indicated that the lowest dry matter intake (DMI, g/h/d) was recorded in control group followed by G2, while G3 recorded the highest value. The NH3-N concentration was significantly decreased (P<0.05) due to partial replacement of MS by OBPS. Also, an opposite relationship was a served between NH3-N concentration values and the microbial protein content values, over all dietary treatments. While concentrations of total volatile fatty acids (TVF's) were significantly increased (P<0.05) with G2 and G3 compared to G1. The replacement of maize silage by orange by-products silage at 50% or 100% in G2 and G3, respectively showed significanteffect on all nutrient digestibility coefficients compared with G1. The overall daily milk yield, and milk constituents percentage of fat, protein, lactose, solids not-fat (SNF) and total solids were improved (P<0.05) due to partial or total substitution of maize silage by OBPS compared to the control group. The average body weight of lambs at the 10th week of age was 13.31, 14.58, and 14.94 kg for the G1, G2, and G3, respectively. The measured blood parameters show slight differences except cholesterol and triglyceride that were significantly decreased with G2 and G3 vs. G1. It can be concluded from the data of the current study that the OBPS can be fed to ewes and have positive effects on the feed conversion, milk production, and performance of newborn lambs without any adverse on blood parameters this is of particular value in the north-western coast where sheep are fed on reduced roughage feed due to lack conventional sources of roughage resulting in increased cost of feeding compared to economic return from harboring small ruminants.

Keywords: Orange silage, nutrient digestibility, blood parameters, economic return

INTRODUCTION

Oranges represent around 30% of the total Egyptian fruit production and 65 % of citrus production. Egypt Maintains its Position as the World Leading Orange Exporter ahead of South Africa, United States, EU, Turkey, and Australia (USDA/FAS, 2020). Total planted area of oranges stands at 168,000 hectares (403,200 feddan) producing (3.4 MMT), according to the USDA official estimate. Sixty percent of the total area planted with oranges is located in the reclaimed lands. An increase in local consumption is attributed to the high quality of oranges, preferred taste, and low prices compared to other fruits that have made oranges the favorite fruit consumed by Egyptians. Increased consumption of fresh oranges by consumers grow by 4.4 percent (2020/21) as a result of the COVID-19 pandemic due to its high content of vitamin C (USDA/FAS, 2020).

Citrus fruits are principally consumed by humans as fresh fruit or processed juice, either fresh chilled or concentrated. After juice is extracted from the fruit, there remains a residue comprised of peel (flavedo and albedo), pulp (juice sac residue), rag (membranes and cores) and seeds. These components, either individually or in various combinations, are the source materials from, which citrus by-product feedstuff (BPF) are produced (Sinclair, 1984; Ensminger *et al*., 1990). The main citrus BPF from citrus processing are fresh citrus pulp which is the whole residue after extraction of juice, representing between 492 and 692 g/kg of fresh citrus fruit with 300–350 g/kg dry matter (DM)/kg pulp (Martınez-Pascual and Fernandez-Carmona, 1980).

The aim of this work was to evaluate the effect of replacing completely, or partially, maize silage with orange by-product silage, on milk production and composition of Barki ewes in the suckling period then reflect that on changing body weight of their newborn lambs. Investigate the effects on digestion coefficients and some blood parameters of Barki rams.

MATERIALS AND METHODS

The feed material of the study was the by-product of the orange, which results from the preservation industry processes of washing and extraction of the segments, after which the peel remains as the main constituent.

Thirty-two Barki ewes (3-5 years old ABW 48±0.29kg) from the herd of Animal Production Research Station, Borg El Arab, which belongs to Animal Production Research Institute, Agricultural Research Center, Egypt. Ewes, we're used in the study. They were in the post-partum stage, and were divided into 3 equal groups (8 in each). The experimental period continued till weaning (60 days of lambing). Changes in live body weights were recorded bi weekly, and individually, for all the new born lambs. The ewes were fed for one week as a transitional period on the same rations before the start of the experiment. All groups were fed on restricted amount of concentrate feed mixture (CFM) to cover 50% of CP requirements according to NRC (1981), plus were given roughages *ad lib*. The experimental groups were fed as follows: G1: CFM+ 100% maize silage (MS), G2: CFM + (50% MS) +50% citrus by-product silage (OBPS) and G3: CFM+ 100% OBPS. The restricted rations were offered in two equal meals at 8 a.m. and at 3 p.m. Water was available at all times.

The concentrate feed mixture (CFM) contained; undecorticated cotton seed meal (23%), yellow maize (43%), wheat bran (22%), soybean meal (6%), molasses (2.5%), limestone (2%), common salt (1%) and minerals (0.5%). The chemical analysis of the feed ingredients is presented in Table (1).

Table 1. Chemical analysis of feed ingredients and tested rations (% as DM basis)

Item	DM	CF	CP	EE	NFE
Concentrate feed mixture (CFM)	91.20	15.93	14.03	3.31	59.88
Maize Silage (MS)	30.00	29.10	9.00	3.09	49.71
Citrus By-product Silage (OBPS)	34.89	28.00	8.80	2.93	44.50
Rice straw, (RS)	90.31	37.85	3.45	1.15	38.98
Chemical analysis of experimental rations					
Tested ration 1, (G1)	60.60	22.52	11.52	3.20	54.80
Tested ration 2, (G2)	61.82	22.24	11.49	3.16	53.49
Tested ration 3, (G3)	63.05	21.97	11.46	3.12	52.19

G1: CFM+ 100% maize silage (MS),G2: CFM + (50% MS) +50% citrus by-product silage (OBPS), G3: CFM+ 100% OBPS.

In the last week of the experiment, feces samples were collected daily for seven successive days from three Barki rams (average body weight 55 kg) for every tested group. Representative samples of the fresh feces were dried and ground then mixed and kept for chemical analysis and estimation of nutrient digestibility. Chemical analysis of feed ingredients and feces was carried out according to A.O.A.C. (2000).

Ruminal fluid samples were collected using stomach tube at 4 hrs post feeding from 3 Barki rams at the end of metabolic trial then filtered through three layers of gauze without squeezing and directed for the determination of pH value by a digital pH-meter (ORION RESEARCH, model 20). Whereas, ruminal ammonia-N (NH3-N) concentration was determined according to Conway (1957). The concentration of total VFA's was determined by steam distillation method as described by Warner (1964). The microbial protein synthesis was measured by sodium tungestate method according to Shultz and Shultz (1970).

The newborn lambs were isolated from mothers for 8 hrs and milk samples were collected. Kids were weighed before and after suckling their mothers for milk yield determination (Ashmawy, 1980). Milk samples (100 ml) were collected biweekly for each group during the suckling period. Milk samples were analyzed for contents of total solids, protein, fat content, SNF and lactose by using Lactoscan (Milko-Scan 133B). Ash content was determined as reported in A.O.A.C (2000). While, somatic cell count determined by using Fossmatic 5000, Country).

At the end of the experimental periods, blood samples were collected 4-hours post-feeding from the jugular vein of 4 ewes in each group,. The whole blood samples were directly analyzed hematologically. Other samples were centrifuged at 4000 rpm for 20 min and divided into two parts, one for enzymes activity determination, while the other was frozen at -20°C till the biochemical analysis. Commercial kits were used for all colorimetric biochemical determinations.

Data were statistically analyzed by the least square's methods described by Likelihood program of SAS (2003).

RESULTS AND DISCUSSION

The different silages had a good physical characteristics expressed as natural color and pleasant aroma as well as a good fermentative quality. pH values were all in normal range of a good silage quality, being 3.80 and 4.10 for orange by product silage and maze silage, respectively as shown in Table (2). The same trend was observed with acetic acid concentration, where orange by product silage had the lowest concentration of acetic acid 2.38 vs 2.5% for maize silage. In this respect, butyric acid concentration recorded 0.23, 0.32 and 0.36% for different types of silages, respectively. Obtained values are considered were good indicators for good quality silage product. Ammonia-N concentration

showed same trend as butyric acid concentration. Martinez Pascual and Fernandez Carmona (1978) reported that the mean values of rumen pH for citrus pulp silage ranged from 3.2 to 3.6., which in agreement with the results presented for ensiled whole oranges by Volanis *et al*. (2004) and Volanis *et al.* (2006) with citrus pulp mixture silage.

Observation of ewes behavior toward various treatments including eating refusals or other problems while consuming the silage.

The impression was that orange by-product silage was palatable, possibly due to its pleasant odor. Based on behavioral observation of the ewes, diet ingredients appeared to be more palatable according to the percentage of orange by-product as following order G3 followed by G2, while G1 recorded the lowest total dray mater intake (1234, 1226, and 1222 g/h/d, respectively) as shown in Table (3). The same trend was observed by Volanis *et al*., (2006) using sixty-six ewes of the Sfakian dairy sheep breed to study the effects of feeding citrus pulp silage mixture on milk yield and milk composition.

Table 2. Mean values of different quality parameters of maize and orange by-products silages

Item	MS	OBPS
pH	4.10±0.21	3.62±0.15
Lactic acid, % of DM	4.15±1.39	4.35±1.26
Acetic acid, % of DM	2.50±1.04	2.38±1.07
Proponic acid, % of DM)	0.19±0.23	0.29±0.18
Butyric acid, % of DM	0.08±0.04	0.05±0.03

MS= Maize Silage OBPS= Orange by-product Silage

Table 3. Feed intake of lactating ewe fed on experimental rations as dry matter basis

Item	G1	G2	G3
No. of ewe	8	8	8
Average BW, kg	40.88	41	41.12
CFM	623	613	642
MS	599	270	0
OBPS	0	343	592
Total DMI, g/h/d	1222	1226	1234
DMI g/w0.75	75.57	75.68	75.99
CPI	140.8	140.9	141.4
Roughage : Concentrate ratio	49:51	50:50	48:52

Data on some ruminal liquor parameters of Barki rams fed the experimental treatments are presented in (Table 4). Differences among treatments respecting all parameters were not significant at zero sampling time, while at 4hrs post-feeding, ammonia-N concentration of G2 was lower ($P<0.05$) than G1control group and insignificant than G3. While concentrations of TVF's 4 hrs post feeding were higher ($P<0.05$) with the two tested rations (G2 and G3) than that of control group (G1). In that regard,Ben-Ghedalia *et al*., 1989; Flackowsky *et al*., 1993 and Volanis *et al*. (2006) showed that the presence of citrus by-products improves the utilization of dietary fibrous fractions, possibly due to its positive effects on rumen microflora activity.

The results presented in Table (5) showed that ewes fed G3 recorded the highest digestion coefficients of DM, OM, CP, CF, EE, NFE and nutritive values as TDN and DCPfollowed by G2 compared with G1maize-silage based diet (G1). The replacement of maize silage by orange by-products silage at 50% or 100% in G2 and G3 had significantly affected all nutrient digestibility coefficients compared with maize-silage based diet(G1). These results were in agreement with Mahrous *et al*. (2019); Shdaifat *et al*. (2013); and Gholizadeh and Naserian. (2010) who reported that DM, OM, CP and CF digestibility were increased when dried citrus pulp substitute for starchy feeds. In the same line, Gawad *et al*. (2013) reported that the high values of TDN and DCP of ration contained orange waste silage may be attributed to the associative effect of highest nutrients digestibility. These results are in agreement with those obtained by Taie *et al*. (1998); Etman *et al*. (2007) and Mostafa *et al*. (2010).

Table 4. Rumen parameters of Barki rams as affected by fed orange by-products silage

Item	hr.	G1	G2	G3	±SE
Rumen pH	0	7.03	7.05	6.98	0.06
	4	6.45	6.49	6.53	0.05
Ammonia-N (mg/100ml)	0	16.90	17.00	17.08	0.30
	4	23.10a	21.90b	22.11ab	0.25
TVFA's (mEq/100ml)	0	8.85	9.05	9.00	0.15
	4	11.71b	12.92a	12.69a	22

a-b Means in the same row with different superscript differ significantly at P<0.05.

Table . Digestion coefficients and nutritive values of experimental rations

Items	G1	G2	G3	±SE
Digestibility coefficients%:				
DM	64.32b	64.75a	65.54a	0.47
OM	60.43b	62.20a	63.70a	0.05
CP	66.43b	67.43a	68.77a	0. 80
CF	63.02b	64.90a	66.36a	0.50
EE	73.30b	74.64a	75.50a	0.59
NFE	64.00b	65.10a	66.50a	0.14
Nutritive value %:				
TDN	60.00b	62.10b	63.30a	0.33
DCP	7.30b	7.55a	9.15a	0.01

a-b Means in the same row with different superscript differ significantly at P<0.05.

The average daily milk production and percentage of milk components are presented in Table (6). The overall daily milk yield of ewes in the G1 maize silage (537g) was significantly low compared to the orange by-product silages G2 and G3 (565 and 603 g, respectively). The percentage of fat and protein were lower (P<0.05) in G1control (3.36 and 4.01 %, respectively) than the orange by-product silages-based diets (G2 and G3; 3.42, 4.37 and 3.59, 4.51%, respectively). In the same line, the milk components of lactose, TS, SNF and ash were recorded. The two treated diets (G2 and G3) showed decline (P<0.05) in somatic cell count compared to the maize silage-based diet.

The favorable effect of citrus pulp silage on milk yield, after the ewes were adapted to the experimental diets, may be explained by the fact that citrus by-products contain easily digestible cell walls (Madrid *et al*., 1997).

Figure (1) summarized the body weight changes of newborn lambs during the experimental period (suckling). At the beginning (one week postpartum), the average live body weight of lambs fed on milk production from ewes fed the tested rations was 3.56±0.06 kg. After 10 weeks, i.e., at the end of the experiment, the average body weight for lambs was 13.31, 14.58, and 14.94 kg for the G1, G2, and G3, respectively, these differences were due to the increase in milk production from ewes accompanied by increases in protein yield of both OBPS groups, respectively as shown in Table (6).

Table 6. Effect of type of silage on milk yield and composition of lactating ewes

Items	G1	G2	G3	±SE
Average daily milk production, g	537b	565a	603a	7.21
Fat, %	3.36b	3.42a	3.59a	0.08
Protein, %	4.01b	4.37a	4.51a	0.15
Lactose, %	4.00b	5.03a	5.11a	0.06
Total Solid, %	12.16b	13.64a	14.07a	0.13
Solids nonfat (SNF), %	8.80b	10.22a	10.48a	0.22
Ash, %	0.79b	0.82a	0.86a	0.03
Somatic cell count (SCC) × 103	410a	391b	315c	3.27

a-b Means in the same row with different superscript differ significantly at P<0.05.

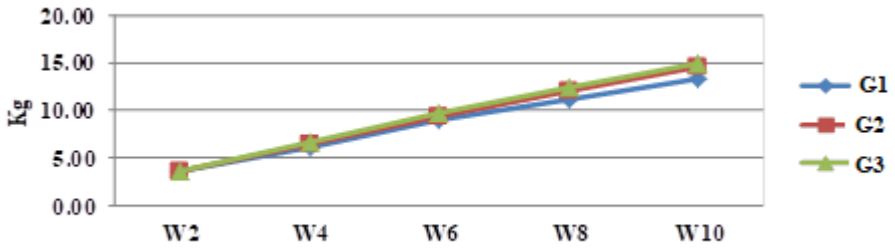

Figure 1. Body weight change of Barki lambs during suckling period.

The data in Table (7), showed that some blood parameters were affected the types of silage that were fed. The presented results indicated that insignificant (P>0.05) differences among the different experimental treatments on RBC's, glucose, total protein, albumin, and globulin. While, cholesterol and triglyceride were significantly decreased with 50% and 100% replacement of MS with OBPS (G2 and G3, respectively). The lowest values were recorded with G3 compared with G1 (79.40 and 84.07 vs. 91.30 and 96.65 mg/100ml, respectively). This positive response may be due to presence of antioxidant's capacity and concentration in OPBS as reported by Allam*et al*. (2011). All blood serum parameters were found to be within the normal range as reported by Eissa *et al*., (2016), Gholizadeh and Naserian (2010) and Sadek *et al*. (2020).

Data in Table (8) indicates that the economic efficiency (EE) was better with G3 followed by G2 compared with G1, in terms of growth performance of the offspring in relation to treatments. Feed conversion tended to decrease with maize silage vs. OBPS, which may be due to reduced voluntary feed intake (as shown in Table 3) accompanied by a significant decrease in TDN and DCP in the ewes that were fed G1 (Table 5). A slight increase in economic efficiency was detected between G2 and G3 (0.14 and 0.15%, respectively). In this respect, Omer and Tawila (2009) concluded that replacements of corn grains by citrus by- production in goat's ration improved feed efficiency and decreased daily feeding cost, and consequently improved relative economic efficiency. Similarly, Mahrous *et al*. (2019) found that all rations containing citrus by-product silage recorded the best feed conversion values compared with corn silage in growing Barki lambs.

Table 7. Some blood parameters of Barki ewes as affected by orange by-products as silage

Items	G1	G2	G3	±SE
Red blood cells (RBC's) ×106ul	10.63	10.56	10.87	0.11
Glucose mg/100ml	46.26	46.65	46.18	0.93
Total Protein g/100ml	7.13	7.21	7.18	0.09
Albumin g/100ml	3.86	4.01	3.92	0.22
Globulin g/100ml	3.27	3.20	3.26	0.04
Triglycerides mg/100ml	91.30a	83.17b	79.40b	2.91
Cholesterol mg/100ml	96.65a	86.20b	84.07b	2.86

a-b Means in the same row with different superscript differ significantly at P<0.05.

Table 8. Economic efficiency (%) of using orange by-products as silage in sheep rations

Item	G1	G2	G3
Feed intake, g/day			
CFM	678	667	698
MS	1018	459	-
OBPS	-	567	978
Total feed intake, as feed	1696	1692	1676
Daily body gain, g/d	173	195	205
Price of total feed intake (h/d), L.E	4.98	4.92	4.87
Price of daily body gain (g/d), L.E	10.38	11.7	12.3
Net profit (h/d), L.E	5.40	6.78	7.43
Economic efficiency %	0.11	0.14	0.15

CONCLUSION

The results of the present study showed that the orange by-products silage had a positive and valuable impact on both farm animals' productivity and the environment, especially in the north-western coast of Egypt. Therefore, the availability of orange silage as a good alternative feed source depended on the excellence of this region in the production and manufacturing of citrus fruits, which reduces the feeding cost and increases the economic return from herds of small ruminants.

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تأثير إستبدال سيلاج الذرة بسيلاج البرتقال على تخمرات الكرش وأداء الأغنام البرقى

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تم إجراء هذا البحث لتقييم تأثير الإستبدال كليًا أو جزئيًا لسيلاج الذرة بسيلاج البرتقال على إنتاج اللبن وتكوينه ، والماكول ، والقيمة الغذائية ، ومعاملات الهضم ، والأداء الانتاجى لأغنام البرقى عند تغذيتها على علائق تحتوى 100%سيلاج ذرة أو خليط مع 50%سيلاج البرتقال أو 100٪ سيلاج البرتقال. كانت نسبة بين العلف الخشن والمركزفي كل المجموعات 50٪: 50٪. أشارت النتائج إلى أن اقل مأكول كمادة جافة (جم / راس /يوم)مج1 ثم مج2 بينما مج3 سجلت اعلى قيمة. أظهرت عينات سائل الكرش عندالساعة 4 بعد التغذية انخفاضًا معنويًا في تركيز نتروجين امونيا الكرش لمعاملات البرتقال مج2 ومج3 مقارنة مج1 دون اختلاف معنوى بين مج2و مج3 ، مع ملاحظة وجود علاقة عكسية بين قيم تركيزنتروجين امونيا الكرش وقيم محتوى البروتين الميكروبي في جميع المعاملات. بينما ارتفع بشكل معنوى التركيز الكلى للاحماض الدهنية الطيارة فى مج2 و مج3 مقارنة مج1. ادى الاستبدال الجزئى او الكلى لسيلاج الذرة بسيلاج البرتقال مج2و مج3 على التوالي الى زيادة معنوية فى جميع معاملات هضم مقارنة مع مج1. كان إنتاج اللبن اليومي للنعاج مج1 أقل مقارنة بالمعاملات مج2 ومج3. حدث انخفض معنوى فى نسبة دهن اللبن والبروتين في مج1 مقارنة مع مج2 و مج3. متوسط وزن الجسم للحملان 13.31 ، 14.58، 14.94كجم لكل من مج1 ومج2 و مج3 على التوالي. كما أظهرت قياسات الدم اختلافات طفيفة بين المعاملات باستثناء الكوليسترول والدهون الثلاثية التى انخفضت بشكل معنوى مع مج2 و مج3 مقارنة مج1، بيما كانت جميع المستويات ضمن المعدل الطبيعى.

أظهرت نتائج الدراسة أن علف البرتقال كان له تأثير قيم سواء على إنتاجية حيوانات المزرعة أو البيئة ، خاصة في الساحل الشمالي الغربي لمصر. لذلك ، فإن توفر علف البرتقال كمصدر علف بديل جيد يعتمد على تميز هذه المنطقة في إنتاج وتصنيع ثمار الحمضيات ، مما يقلل من تكلفة التغذية ويزيد من العائد الاقتصادي من إيواء المجترات الصغيرة.