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Effect of Kinnow Mandarin (*Citrus Nobilis Lour* × *Citrus Deliciosa Tenora*) Fruit Waste Silage on Nutrient Intake, Digestibility and Performance of Goat Bucks

Bilal Ahmad Malla[1*], Ankur Rastogi[2], Ramesh Kumar Sharma[2], Ishfaq Ahmad[2], Hujaz Tariq[1] and Javid Farooq[2]

[1]Division of Dairy Cattle Nutrition, National Dairy Research Institute, Karnal, Haryana, INDIA
[2]Division of Animal Nutrition, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Jammu and Kashmir, INDIA

[*]Corresponding author: BA Malla; Email: bilal.ahmad368@gmail.com

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ABSTRACT

The objective of this study was to evaluate the effect of the feeding Kinnow mandarin fruit waste (KMW) silage viś-a- viś oat silage on nutrient intake, nutrient digestibility, utilization and general performance of adult male goats. Twelve local adult male goats were randomly allotted into two equal groups namely oat silage (OS) and Kinnow silage (KS) group. Animals were offered weighed quantities of respective silage (Oat silage to OS and KMW silage to KS) on *ad lib*. Silage intake (g/d), DM intake (DMI), digestible DMI, digestible organic matter (OMI) and digestible CP intake was comparable (P>0.05) among the two dietary groups. The per cent digestibility of all the analysed nutrients was analogous (P>0.05) in both the groups irrespective of the diet. Total digestible nutrient (TDN) intake (g/d) of goats kept on KMW silage was significantly (P<0.05) higher than OS group animals. Balance of nitrogen and phosphorus was positive in both the groups without any significant (P>0.05) difference between dietary groups. There was no significant difference in analysed blood bio-chemicals and serum enzymes level between different periods and groups, suggesting general well-being of goats. On the basis of results of present study, it can be concluded adult male goats can be maintained on the silage of Kinnow waste without affecting nutrient intake, utilization and general performance of animals.

Keywords: Citrus fruit waste, Energy supplement, Goats, Kinnow silage, oat silage

A major constraint to increasing livestock productivity in developing countries is the scarcity and fluctuating quantity and quality of the year-round supply of conventional feeds (Bakshi and Wadhwa, 2007). Fruit processing industry provides juice, concentrate, or canned fruit and wastes including pulp, peel, rag, and seeds. After extracting juice, the moist pulp, comprises about 44 to 50% of the original fruit weight (Widmer *et al*., 2010). This waste (amounting to several tons per day in a medium-sized processing plant) causes many economic and environmental problems because of its fermentability (Tripodo *et al*., 2004). These residues are rich in soluble sugars, organic acids, fiber and have high digestibility potential (Jetana *et al*., 2009; Migwi *et al*., 2001) but are poor in nitrogen (Caro *et al*., 1990). Furthermore, because of its high water content (about 86%) it is difficult to dry them and high content of organic matter makes diffcult to dispose them (Crupi *et al*., 2001). Citrus pulp is a valuable edible material that includes a wide range of energy nutrients for rumen microorganisms (Miron *et al*., 2002; Scerra *et al*., 2001). Citrus fruit by-product contains a relatively large amount of pectin and soluble carbohydrates, and can be used in animal feeding either fresh or after ensilage or dehydration (Karabulut *et al*., 2007). Citrus pulp has been previously used as a high energy feed in rations of growing and lactating cattle (Solomon *et al*., 2000; Miron *et al*., 2001).

'Kinnow,' a hybrid between king and willow mandarins (Citrus nobilis Lour x Citrus deliciosa Tenora) is one of the important citrus fruit crops in Northern Indian States (Sharma *et al*., 2007). In India Kinnow is being grown in many states like Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Haryana and Utter Pradesh. Jammu and Kashmir produces 19070 MT of citrus fruit (NHB, 2010), majority of which is produced in Jammu Division and out of which a considerable share is that of Kinnow-mandarins. Because citrus pulp has high moisture content (80%), it is bulky and therefore, it is difficult to store or transport it. Ensiling of citrus by-product is a simple procedure and can be easily performed by the farmer in all weather conditions. The silage produced has a good fruity smell and is efficiently consumed by the animals. This study was carried out to evaluate the effect of Kinnow Mandarin fruit waste (KMW) silage on nutrient intake, digestibility, balance of nutrients and blood biochemicals in bucks.

MATERIALS AND METHODS

Animals and diets

Twelve non-descript local adult male goats of about 15-18 months age and body weight of about 23kg were randomly allotted on body weight basis following independent t test into two equal groups (n = 6)= namely 'Oat silage (OS)' and 'Kinnow silage (KS)' kept under uniform management conditions. This was approved by Institutional Animals Ethical Committee (IAEC). The goats in OS and KS group were fed oat and Kinnow waste silage on *ad lib*. The composition of respective silages offered is given in table 1. To cater for skewed calcium: phosphorus ratio of KMW, disodium hydrogen orthophosphate was added @ 2.5 g/kg at the time of ensiling. Animals were adapted to the experimental diets for period of one week. The animals were fed twice daily 08:00 and 17:00 h with free-access to water. Feed offered and refusals were recorded daily before the addition of fresh feed and dry matter content was determined to calculate individual feed intakes (DMI). After 21 days of feeding, a metabolic trial of 7 days duration was conducted. The animals were given 3 days as an adaption period to crates followed by 4 days for sample collection. Faeces were collected, weighed, sampled (10%), composited, dried (55°C), ground, and then stored for later analyses. Urine was collected in plastic buckets 50 ml of sulphuric acid solution (containing 5 ml of concentrated sulphuric acid in 50 ml of distilled water), to keep the final pH below 3, Sub-sampled 20 ml was stored at −20 °C for the estimation. Samples of the offered and refused feed and dried faeces obtained from the digestibility study were analyzed for dry matter, organic matter, crude protein, neutral detergent fiber and acid detergent fiber to calculate nutrient digestibility. Digestibility was calculated as the difference between the average nutrient intake and nutrient excreation in faeces. Balance of phosphorus and nitrogen was determined by difference between average intake and excreation via faeces and urine.

Table 1. Chemical composition (%) of Oat silage and KMW silage

Attributes*	Oat silage	KMW silage
Moisture	73.00 ± 0.29	75.00 ± 0.23
Organic matter	92.50 ± 0.29	95.50± 0.29
Crude protein	8.20 ± 0.18	8.07± 0.10
Ether extract	3.00 ± 0.01	4.90± 0.21
Total ash	7.50 ± 0.29	5.50 ± 0.29
Neutral detergent fibre	53.00 ± 0.93	33.00 ± 0.58
Acid detergent fibre	33.00 ± 0.29	22.00 ± 0.35
Calcium	2.23 ± 0.09	2.06 ± 0.06
Phosphorus	1.21 ± 0.06	0.95 ± 0.01
pH	4.14 ± 0.06	3.80 ± 0.02
Lactic acid (% DM)	6.23 ± 1.08	8.14 ± 1.12
NH_3 - N (% Total N)	4.2 ± 0.30	3.3 ± 0.45
Water soluble carbohydrates (% DM)	2.73 ± 0.35	1.86 ± 0.30

*Expressed on dry matter basis except moisture

Analytical methods

Obtained samples of dietary ingredients, and refused feed were analyzed procedures of AOAC (1995) for dry matter (DM; 105°C in a forced-air oven for 24 h; method 967.03), organic matter (OM; weight loss upon ashing at 550°C for 8 h; method 942.05), nitrogen (N; Kjeldahl procedure; method 976.06), ether extract (EE; Soxhlet procedure, method 920.29), Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Van Soest *et al.* (1991). Samples of the offered and refused feed and dried faeces from digestibility study were analyzed for dry matter, organic matter, nitrogen, neutral detergent fiber and acid detergent fiber to calculate nutrient digestibility. Urine samples were analyzed for nitrogen, calcium and phosphorus content. Blood samples were collected before feeding at interval of 10 days for estimation of haemoglobin, blood biochemical's and enzymes. Haemoglobin was estimated by Drabkins method. Blood biochemical's and serum enzymes were estimated by using diagnostic kits from the Erba Mannheim Gmbh, Mumbai, Maharashtra, *India*.

Statistical analysis

Statistical analysis of data was done using one way ANOVA (Snedecor and Cocharan 1994) under independent t test scheme and the means having significant difference were ranked as per Duncan's multiple range test (Duncan, 1955). The data were processed as per SPSS software for Windows Release to compare the target parameters.

RESULTS AND DISCUSSION

Feed intake

Effect of feeding KMW silage and oat silage on feed intake and plane of nutrition in goats is presented in Table 2.

The dry matter intake (DMI, g/d) was comparable (P>0.05) among the two dietary groups. Although, organic matter intake [OMI (g/d)] was significantly (P<0.01) higher in KS group as compared to that OS group, but when expressed as gram per Kg metabolic body weight (g/kg $W^{0.75}$), it was found comparable (P>0.05) between the two groups. Bueno *et al.* (2002) reported feed intake as 3.31% live weight (LW) and 71.6 g dry matter /$LW^{0.75}$ in Saanen kids on feeding dried citrus pulp, which is higher than found in our study. The cause may be due to the fact that dried citrus pulp (DCP) was used as 100% replacement of corn rather than as single feed in our study. But the intake in this study was sufficient for mantainence of animals as indicated by body weight (Table 2).

Feeding of citrus waste in cross-bred rams did not affect (P>0.05) total DM intake of tropical grass hay plus supplemental silage (Riestra *et al*., 2014). The organic matter intake [OMI (g/d)] was significantly (P<0.01) higher in KS group, which was expected owing to the fact that organic matter content (% DM) was also significantly (P<0.01) higher in KMW silage. Volanis *et al*. (2006) found that Citrus pulp silage can be fed to ewes without any negative effects on the performance of the dairy ewes. The digestible DMI, digestible OMI and digestible CP intake (g/d) was comparable between the experimental animals. However TDN intake (g/d) of goats kept on KMW silage was significantly (P<0.05) higher than OS group, but when expressed as g/kg $W^{0.75}$, it was found analogous between both groups, irrespective of the diet. Saiyed *et al.* (2003) reported that feeding of mango seed kernels in goat concentrate mixture reduced the cost of feeding without

Table 2. Effect of feeding KMW silage on feed intake and plane of nutrition

Attributes	Groups	
	OS	KS
Initial body weight (kg)	22.56±2.44	22.9±1.91
Metabolic body size (kg $W^{0.75}$)	10.33±0.29	10.54 ± 0.24
Final body weight (Kg)	22.52±2.14	23.14±1.83
Dry matter intake (g/d)	561.33± 3.87	572.88± 5.66
% live weight	2.50 ± 0.08	2.49 ± 0.09
g/kg $W^{0.75}$	54.53 ± 1.46	54.52 ± 1.74
Organic matter intake (g/d)	519.23 ± 3.58^a	541.38 ± 5.34^b
% live weight	2.32 ± 0.08	2.35 ± 0.09
g/kg $W^{0.75}$	50.44 ± 1.35	51.52 ± 1.65
Digestible DM (g/d)	344.86 ± 10.65	366.99 ± 13.78
g/kg $W^{0.75}$	33.48± 1.30	34.89 ± 1.53
Digestible OM (g/d)	322.22 ± 10.26	353.64 ± 11.69
g/kg $W^{0.75}$	31.29 ± 1.28	33.62 ± 1.37
Digestible CP (g/d)	30.00 ± 0.96	29.80 ± 1.51
g/kg $W^{0.75}$	2.91 ± 0.09	2.83 ± 0.18
TDN (g/d)	377.20 ± 13.43	425.06 ± 16.11
g/kg $W^{0.75}$	36.52± 0.93	40.45 ± 1.97
ME (Mcal/day)	1.36±0.04^a	1.53±0.06^b
Nutrient density		
TDN %	67.19 ± 2.33	74.16 ± 2.52
DCP %	5.35 ± 0.19	5.20 ± 0.25
ME (Mcal/kg diet)	2.41±0.08^a	2.67±0.09^b

Superscripts in a row differ P < 0.05.

any negative effect on performance of animals. Nutrient density of KMW and oat silage was found comparable in terms of per cent total digestible nutrients (TDN) and per cent digestible CP. Although the daily nutrient intake in terms of digestible DMI and digestible OMI were comparable between both the test groups, significantly (P<0.01) higher NFE and EE concentration in KMW silage translated into significantly (P>0.05) higher TDN intake (g/d) in diet. Feeding of ensiled sliced oranges had no negative effects on the performance of ewes (Volanis, 2004). Supplementation of citrus pulp could increase rumen fermentation rate, improve utilization of non-protein nitrogen through stimulation of microbial protein synthesis, and increase ruminal acetate to propionate ratio without depressing ruminal pH (Broderick *et al*., 2002). Citrus pulp has ability to mantain the rumen pH compared with other by-products high in starch and rapid rumen fermentation, which reduce rumen pH and as a result, diminish cellulytic activity (Barrios- Urdaneta *et al*., 2003).

Nutrient digestibility

The nutrient digestibility of experimental goats fed respective silage is given in Table 3.

Table 3. Effect of feeding KMW silage on nutrient digestibility

Attributes	Groups	
	OS	KS
DM	61.40 ± 1.65	64.04 ± 2.23
OM	62.04 ± 1.75	65.31± 1.99
CP	65.25 ± 2.41	64.48 ± 3.19
EE	62.54 ± 3.66	64.16 ± 4.84
NDF	59.08 ± 4.42	62.51 ± 4.16
ADF	56.10 ± 4.51	60.38 ± 5.10

The per cent digestibility of all the analysed nutrients was analogous (P>0.05) in both the groups irrespective of the diet. The digestibility of nutrients in Kinnow silage group was higher than found by Sruamsiri and Silman,(2009), in ensiled mango fruit waste, which may be due to inclusion of rice straw during ensiling. The inclusion of citrus waste had no significant effect on DM and CP digestibility (Reistra *et al*., 2014). The digestibility coefficients (%) are in the range as reported by Shrewab *et al.* (2010) for citrus pulp silage in Barki rams. The per cent digestibility of various nutrients observed in KS group for KMW silage are lower than the values observed for diets based on citrus pulp as reported by previous workers (Barrios-Urdaneta *et al*., 2003; Bueno *et al*., 2002). This may be because of the fact that the Kinnow peel was also a part of the KMW used in the present study and as peel is more fibrous than pulp, it is obvious that its inclusion will have negative effect over digestibility values. Several studies examined digestibility of citrus pulp and concluded that citrus pulp promotes digestion of all nutrients, including fiber from feedstuffs that have elevated lignin contents (Bampidis and Robinson 2006; Macedo *et al*., 2007; Pereira *et al*., 2008). The digestibility values obtained with respect to oats silage are in agreement with Medhi *et al.* (2010). Comparable (P>0.05) digestibility values for all nutrients in both dietary groups are suggestive of the fact that nutrient utilization from KMW is comparable to any good quality fodder like oat.

The fermented feedstuff have better digestibility, may be due to different microorganisms and their enzymes (McDonald *et al*., 2011). Goats fed with lemon pulp has digestibility of 66.5 and 68.5 %, for NDF and ADF which is nearly similar to our results (Madrid *et al*., 1996). Fegeros *et al.* (1995) reported that digestibility of crude protein in citrus pulp is around 85% of that in corn. Orange peel and pulp and other citrus fruits contain essential oils (e.g., limonene) that are toxic to bacteria and exhibit antioxidant effects in host animal. Orange peel and pulp reduced populations of E. Coli O157:H7 and Salmonella in gastrointestinal tract of cattle thus may improve health and reduce food borne pathogens (Callaway *et al*., 2011). Freeze dried citrus pulp (FDCP) increased dry matter digestibility (DMD) and organic matter digestibility (OMD) likely due to the soluble solids in FDCP, which would be rapidly digested (Nam *et al*., 2009). Pereira and González, (2004) stated that the byproduct obtained from juice industries is a better source of digestible fiber than dry forages due to their high and low contents of pectin and lignin, respectively. Macedo *et al*. (2007) substituted 0, 25, 50 and 75% of sorghum silage with fresh orange pulp (FOP) in diets for sheep and found a quadratic increase in DM, CP and NDF apparent digestibility, and a linear increase in DM, OM and CP intake with increasing FOP level. Additionally, they concluded that the presence of FOP in diets for fattening lambs resulted in greater

DM and nutrient intake which promoted better apparent digestibility compared to diets with sorghum silage.

Nitrogen and Phosphorus balance

The nitrogen and phosphorus intake, excretion and balance data is presented in Table 4 .

Table 4. Effect of feeding KMW silage on nitrogen and phosphorus balance

Attributes	OS	KS
Nitrogen balance		
Nitrogen intake g/d	7.36 ± 0.05	7.39 ± 0.07
Nitrogen excretion (g/d)		
Faeces	2.55 ± 0.19	2.62 ± 0.24
Urine	1.70 ± 0.08	1.80 ± 0.16
Total	4.26± 0.16	4.43 ± 0.16
Nitrogen balance (g/d)	3.09 ± 0.13	2.95 ± 0.14
Nitrogen Retention		
% of Intake	42.10 ± 1.97	40.03 ± 1.98
% of absorbed	64.42 ± 1.67	62.25 ± 2.21
Phosphorous balance		
Phosphorous intake (g/d)	5.50 ± 0.03	5.44 ± 0.05
Phosphorous excretion (g/d)		
Faeces	3.86 ± 0.13	3.95 ± 0.13
Urine	0.78 ± 0.06	0.77 ± 0.05
Total	4.64 ± 0.16	4.72 ± 0.15
Phosphorous balance (g/d)	0.85 ± 0.16	0.71 ± 0.17
Phosphorous Retention		
% of Intake	15.52 ± 3.03	13.10 ± 3.17
% of absorbed	50.01 ± 6.31	44.91 ± 7.47

Mean daily nitrogen and phosphorus intake (g/d), excretion in faeces (g/d) and urine (g/d), total excretion (g/d) and net balance (g/d) were similar (P>0.05) among both the dietary groups. There was also no significant (P>0.05) difference between mean retention of nitrogen and phosphorus (expressed as percentage of intake and percentage of absorbed), irrespective of the diets. Both the groups showed positive balance without any significant difference between the two groups. Retention also did not vary significantly between the two groups.

Citrus pulp has been reported to be rich source of calcium and poor source of phosphorus, with a highly skewed Ca:P ratio (Bampidis and Robinson, 2006; Kour, 2012). However, in our study KMW was fortified with phosphorus through disodium hydrogen orthophosphate addition (@ 2.5 g/kg on fresh basis) at the time of filling of silo, the calcium:phosphorus ratio was corrected. Thus, in contrast to Kour (2012), there was no significant difference in calcium and phosphorus intake, excretion and balance with both experimental groups showing positive calcium and phosphorus balance.

Blood biochemical profile

Effect of feeding Kinnow silage and oat silage on periodic observation of levels of blood bio-chemicals and serum enzymes is presented in Table 5.

Table 5. Effect of feeding KMW silage on blood bio-chemicals and serum enzymes

Parameter	OS	KS
Haemoglobin (g dl^{-1})	9.07± 0.06	8.97± 0.09
Total Serum Protein (g dl^{-1})	6.94 ± 0.06	7.06 ± 0.05
Serum Albumin (g dl^{-1})	3.00 ± 0.07	2.89± 0.07
Serum Globulin (g dl^{-1})	3.93 ± 0.09	4.17 ± 0.08
Serum A:G Ratio	0.78 ± 0.03	0.70 ± 0.02
Blood Urea Nitrogen (mg dl^{-1})	17.46± 0.56	18.40 ± 0.61
Serum AST (IU L^{-1})	165.59 ± 7.67	163.60 ± 6.41
Serum ALT (IU L^{-1})	33.06 ± 1.00	35.16 ± 1.00
Serum ALP (IU L^{-1})	101.26 ± 2.39	100.12 ± 2.00

The mean haemoglobin levels (g/dl), total serum protein, mean serum albumin, mean serum globulin. A:G ratio, blood urea nitrogen (BUN), Mean serum aspartate aminotransferase (AST), Mean serum alanine transaminase (ALT), Mean alkaline phosphatase (ALP) level showed no significant (P>0.05) difference between the periods as well as between the dietary. Citrus pulp silage had no significant effect was on serum biochemical in cow (Shwerab *et al*., 2010). Blood serum total protein, albumin, globulin, urea concentrations were not significantly affected by feeding dried citrus pulp in dairy cows (Belibasakis, 1996). The activity of AST and ALT is an indicator of damage to liver and muscles (Silanikove *et al*., 1996). The comparable level of AST and ALT irrespective of dietary treatments observed in this study reflects that there is no adverse effect of KMW silage feeding on liver, kidney and muscles mass. This also suggests that the energy and protein intake of animals was sufficient to maintain body weight and to prevent muscle breakdown. The previous report of improper calcium: phosphorus ratio in KMW (Kour, 2012) warranted that a parameter needs to be included in the study to observe the bone health. Serum ALP level was monitored to serve this purpose. ALP activity is an indicator of liver functioning and bone health. Comparable (P>0.05) ALP levels in both groups and across the periods indicate that there was no negative effect of KMW silage feeding on liver and bone health.

CONCLUSION

In tropics and sub-tropics where natural pasture and crop residues form an entire diet, unconventional feed resource is economical and productive. Thus, it is imperative to include untapped unconventional feed resources as stock feed. This study indicates that KMW silage can be fed to goat bucks without any negative effects on intake, digestibility and performance . KMW is cheap, easily available and ensiling can reduce the potential threat of KMWs as an environment pollutant and also provides Kinnow mandarin silage as a non-conventional feed for small ruminants.

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