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Nutrient intake, nitrogen balance and growth performance in buffalo calves fed citrus pulp as a concentrate source

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The study was planned to investigate the effects of dried citrus pulp on nutrient intake, digestibility, nitrogen balance, blood metabolites, growth performance and economics in *Nilli Ravi* buffalo calves. Twenty buffalo male calves of 18 to 24 months of age having 200 to 250 kg body weight were used in a randomized complete block design. Four iso-caloric and iso-nitrogenous diets containing 5, 10, 15 and 20% dried citrus pulp were formulated. The experiment lasted for adaptation period while last five days of each month served as collection period. Feed was offered *ad libitum* twice a day. Animals were weighed fortnightly before morning feeding to assess their growth performance. The results showed non-significant effects of various levels of dried citrus pulp on nutrient intake and digestibility. Nitrogen metabolism was also remained unaltered among the treatments. There were non-significant differences in weight gain and blood metabolites in calves fed various levels of dried citrus pulp. However, a linear reduction in price per kg diet was observed as the level of dried citrus pulp was increased from 5 to 20% in the diet. The study showed that dried citrus pulp can be used successfully up to 20% in the diet of calves without any ill effect on feed intake, digestibility and growth performance.

Key words: Buffalo calves, citrus pulp, economics, growth performance.

INTRODUCTION

Citrus pulp is one of the major agro-industrial by-products. It is solid residue lefts after squeezing the juice of fresh citrus fruits. It comprises 60 to 65% peels, 0 to 10% seeds and 30 to 35% pulp segments. Fresh citrus pulp has 19.7% dry matter (DM) (Agshaghali and Maheri, 2008). It has high moisture and sugar contents (Rihani, 1991). Properly preserved citrus pulp can be used in the diet of ruminants throughout the year without any chemical change (Caparra et al., 2007). There are two methods for its preservation, that is, ensiling and drying. Drying reduces the moisture content of citrus pulp from 80 to 11% (Grant, 2007). Dried citrus pulp contains 85.5,

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Table 1. Ingredients and chemical composition of experimental diets for calves.

Ingredients	Diets[1]			
	LDCP	MDCP	HDCP	VHDCP
Dried citrus pulp	5	10	15	20
Maize	6	2	1	1
Wheat bran	4	3	1	1
Rice Polishing	3	2	0	0
Sunflower meal (CP 32%)	6	7	7	4
Canola meal (CP 30%)	6	6	7	10
Cotton seed cake	7	7	7	3
Molasses	10	10	9	8
Urea	1	1	1	1
Mineral Mix	2	2	2	2
Corn silage	30	30	30	30
Wheat straw	20	20	20	20
Total	100	100	100	100
Chemical composition (%)				
Dry matter	72.96	73.12	73.39	73.59
Crude protein	14.09	14.03	14.03	14.00
Metabolizeable energy (Mcal/kg)	2.46	2.45	2.45	2.50
Neutral detergent fibre	40.33	40.80	40.68	39.55
Acid detergent fibre	24.30	25.03	25.43	25.64

[1]LDCP, MDCP, HDCP and VHDCP indicates 5, 10, 15 and 20% inclusion level of dried citrus pulp in diets, respectively.

92.8, 6.9, 24.2 and 22.2% of DM, organic matter (OM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF), respectively (NRC, 2001).

Dried citrus pulp has greater importance in tropical areas where low to medium quality forages are the common feedstuffs (Villarreal et al., 2006). It is rich in energy content approximately 1.66 Mcal of net energy/kg of DM (Fegeros et al., 1995) and contains 120 to 400 g sugar and less than 10 g starch per kg of DM (Hall, 2000). It also has 250 g pectin contents per kg of DM which are approximately 98% digestible (Arthington et al., 2002). Ruminal bacteria can easily degrade the pectin content of dried citrus pulp (Sunvold et al., 1995). It can be used as an alternate energy source in ruminants' diet (Caparra et al., 2007). Dried citrus pulp can be used as a cereal substitute in concentrate for ruminant feed (Bampidis et al., 2006; Villarreal et al., 2006). Its incorporation in the diet enhances fiber digestion and microbial protein synthesis (Gado et al., 2009). As citrus pulp is high in fiber contents, it produces large amount of saliva that act as a buffer (Faria et al., 2008) that increases fiber digestion. Addition of dried citrus pulp in the diet of ruminants reduces urinary N excretion due to increased microbial growth (NRC, 2000). Caparra et al. (2005) stated that its supplementation in lambs' diet did not affect average daily gain and live body weight. The dried citrus pulp also improves feed intake and economic efficiency (Caparra et al., 2007). It results in better growth performance and feed intake in growing kids (Bueno et al., 2002).

Limited data are available regarding the use of dried citrus pulp as an energy source in *Nilli Ravi* buffalo calves. So, the present study has been planned to evaluate the effects of dried citrus pulp as an energy source on nutrient intake, digestibility, nitrogen metabolism, blood parameters, growth performance and economics in *Nilli Ravi* buffalo calves.

MATERIALS AND METHODS

Citrus pulp was collected from juice extraction unit "Citro Pak. Ltd., Sargodha". After receiving the pulp, it was scattered on a polythene sheet for sun drying at Agronomy Farm, University of Agriculture, Faisalabad. Polythene sheets were spread to prevent the soil contamination. After drying, samples were taken and analyzed for DM, OM and nitrogen (AOAC, 1990), NDF and ADF (Van Soest et al., 1991). Four isocaloric and isonitrogenous diets containing 5, 10, 15, and 20% dried citrus pulp were formulated and represented as low dried citrus pulp (LDCP), medium dried citrus pulp (MDCP), high dried citrus pulp (HDCP) and very high dried citrus pulp (VHDCP), respectively (Table 1).

Twenty *Nilli Ravi* buffalo male calves of 18 to 24 months of age having 200 to 250 kg weight were used to conduct the trial at

Table 2. Chemical composition of dried citrus pulp.

Nutrients (%)	Percentage (DM basis)
Dry matter	90.21
Organic matter	94.40
Crude protein	6.56
Metabolizeable energy (Mcal/kg)	3.06
Neutral detergent fiber NDF	21.19
Acid detergent fiber ADF	14.61
Ash	5.37

Buffalo Research Institute, Pattoki, according to approved protocol for research projects by the University Ethics Committee. These calves were weighed at day zero (initial body weight was 204.8 to 206.4 kg) before morning feeding. Calves were randomly divided into four blocks, 5 animals in each block. The experiment lasted for 80 days where first 21 days were taken as adaptation period while last five days of each month served as collection period. Calves were fed *ad libitum* twice a day. Feed intake was recorded daily. Fresh water availability was ensured round the clock. Animals were weighed fortnightly before the morning feeding.

During the collection period, digestibility of DM, CP, NDF and ADF were determined using total collection method. Fecal samples were collected daily, weighed, mixed thoroughly and 20% were sampled and dried at 55°C. At the end of each collection period, dried fecal samples were composited and 10% of these were taken for analysis. Samples of feed and feces were taken and ground to pass through a 2 mm screen and analyzed for DM and CP (AOAC, 1990), while NDF and ADF were analyzed using method described by Van Soest et al. (1991).

Two calves were selected randomly from each group for blood collection. Blood samples were collected six hours after the last feeding. Ten milliliters of blood was extracted from jugular vein and transferred to vacutainer. Serum was extracted by centrifuging it at 3500 rpm. Blood urea nitrogen was determined according to the method prescribed by Bull et al. (1991). Blood glucose was determined by using crescent diagnostic glucose enzymatic colorimetric god-pap method (Trinder, 1969). Nitrogen balance was calculated by the equation described by NRC (2001). Cost incurred on each diet was also calculated to determine the economics of feeding.

The data collected for nutrient intake, digestibility, nitrogen metabolism, blood metabolites, growth performance and economics were statistically analyzed using General Linear Model procedure of SPSS (SPSS 10.0.1., 1999) and means were compared by Duncan's Multiple Range Test (Steel et al., 1997).

RESULTS

Chemical composition

Chemical analysis of dried citrus pulp revealed that it contained 90.21% DM, 94.40% OM, 6.56% CP, 3056 kcal/kg ME, 21% NDF, 14% ADF, and 5.37% ash (Table 2).

Nutrient intake

The DM intake was not significantly affected. It was 8.00, 8.14, 8.29 and 8.30 kg/day in calves fed LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 3). The CP intake also remained unaltered. It was 1.09, 1.17, 1.19 and 1.19 kg/day in calves fed LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 4). Similarly, a non-significant difference (P>0.05) was observed on NDF and ADF intakes in buffalo calves fed various levels of dried citrus pulp.

Nutrient digestibility

There were non-significant effects of different levels of dried citrus pulp on DM digestibility in buffalo male calves. It was 66.70, 65.38, 65.30 and 65.17% in calves fed LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 3). Similarly, the CP digestibility was also non-significant (P>0.05) among different treatments. It was 69.81, 69.63, 69.14 and 69.01% in calves offered LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 3). NDF and ADF digestibility also remained unaltered across the treatments (Table 3).

Nitrogen metabolism

Various levels of dried citrus pulp in the diet had non-significant effect on nitrogen intake. It was 174.46, 187.15, 190.34 and 190.44 g/day when the calves were fed LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 4). Fecal and urinary nitrogen excretion remained unchanged (P>0.05) across treatments. Nitrogen retention also remained unaffected by dietary treatments (Table 4).

Blood metabolites

Dried citrus pulp had non-significant effects on blood urea in *Nilli Ravi* calves. Blood urea nitrogen also remained unaffected. It was 26.33, 25.97, 25.03 and 25.01 mg/dl in calves fed LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 5). Blood glucose also remained unaltered. It was 53.79, 53.93, 54.41 and 54.88 mg/dl in calves fed LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 5).

Table 3. Effects of varying levels of dried citrus pulp on nutrient intake and digestibility in buffalo calves.

Parameter	Diets[1]				SEM[2]
	LDCP	MDCP	HDCP	VHDCP	
Dry matter					
Intake(kg)	8.0	8.14	8.29	8.30	0.168
Digestibility (%)	66.70	65.38	65.30	65.17	0.602
Crude protein					
Intake(kg)	1.09	1.17	1.19	1.19	0.026
Digestibility (%)	69.81	69.63	69.14	69.01	0.550
Neutral detergent fibre					
Intake(kg)	2.64	2.78	2.84	2.84	0.058
Digestibility (%)	54.60	54.13	53.03	52.52	0.774
Acid detergent fibre					
Intake(kg)	1.44	1.47	1.49	1.49	0.029
Digestibility (%)	47.58	46.16	45.95	45.13	0.910

[1]LDCP, MDCP, HDCP and VHDCP indicates 5, 10, 15 and 20% inclusion level of dried citrus pulp in diet. [2]Standard error mean (P>0.05).

Table 4. Effects of varying levels of dried citrus pulp on nitrogen balance in buffalo calves.

Item (g/day)	Diets[1]				SEM[2]
	LDCP	MDCP	HDCP	VHDCP	
Nitrogen intake	174.46	187.15	190.34	190.44	1.348
Nitrogen in feces	52.83	56.61	58.68	58.99	0.615
Nitrogen in urine	103.99	109.21	107.63	103.81	0.468
Nitrogen retention (%)	10.11	11.40	12.62	14.51	0.299

[1]LDCP, MDCP, HDCP and VHDCP indicates 5, 10, 15 and 20% inclusion level of dried citrus pulp in diet. [2]Standard error mean (P>0.05).

Table 5. Effects of varying levels of dried citrus pulp on blood metabolites in buffalo calves.

Blood metabolites (mg/DL)	Diets[1]				SEM[2]
	LDCP	MDCP	HDCP	VHDCP	
Blood urea	46.83	46.58	46.14	45.89	0.212
Blood urea nitrogen	26.33	25.97	25.03	25.01	0.669
Blood glucose	53.79	53.93	54.41	54.88	0.495

[1]LDCP, MDCP, HDCP and VHDCP indicates 5, 10, 15 and 20% inclusion level of dried citrus pulp in diet. [2]Standard error mean (P>0.05).

Growth performance and gain to feed ratio

Body weight gain also remained unaffected (P>0.05) across treatments. Average body weight gain was 38.80, 39.60, 40.00 and 40.40 kg when calves were fed LDCP, MDCP, HDCP and VHDCP diets, respectively (Table 6). A non-significant (P>0.05) effect was observed on gain to feed ratio among the treatments (Table 6).

Economics

Price per kg of diet was reduced by increasing the level of dried citrus pulp. It was 24.19, 23.40, 22.98 and 22.10

Table 6. Effects of varying levels of dried citrus pulp on weight gain and economics inbuffalo calves.

Weight (kg)	Diets[1]				SEM[2]
	LDCP	MDCP	HDCP	VHDCP	
Initial	206.2	206.4	204.8	206.4	3.384
Final	245.0	246.0	244.8	246.8	5.029
Weight gain	38.8	39.6	40.0	40.4	2.331
Avg. Daily gain(g)	517.3	528.0	533.3	538.7	38.845
Feed price (Rs./kg)	24.19	23.40	22.98	22.10	-
Gain to feed ratio	0.12	0.12	0.11	0.11	0.007
Price/kg weight (Rs.)	208.63	201.51	199.97	196.73	10.716

[1]LDCP, MDCP, HDCP and VHDCP indicates 5, 10, 15 and 20% inclusion level of dried citrus pulp in diet. [2]Standard error mean (P>0.05).

Rs. for LDCP, MDCP, HDCP and VHDCP diets, respectively. Price was maximum for LDCP and minimum for VHDCP diet (Table 1).

DISCUSSION

Chemical composition

Chemical composition of dried citrus pulp in this study is in consistent with Abdullah and Sharif (2014), who observed 90.63, 94.57, 6.32, 20.68 and 14.32% DM, OM, CP, NDF and ADF, respectively. Ibrahim et al. (2011) also observed 94.98, 6.40 and 5.02% OM, CP and ash contents, respectively. Similar results were observed by Watanabe et al. (2010) who reported that dried citrus pulp contained 89.10, 6.35, 18.85 and 14.32% f or DM, CP, NDF and ADF, respectively. Contrary to this study, Kour et al. (2014) observed that dried citrus pulp contained 92.05% DM, 7.6% CP, 26.35% NDF and 19.5% ADF. Hernandez et al. (2012) also noticed higher CP (7.6%) and lower ash (3.9%) contents. Variations in chemical composition of citrus pulp might be due to the difference in soil properties used for growing citrus (Lambert et al., 2008) or juice extraction method, which affects chemical composition of citrus pulp (Arthington et al., 2002).

Nutrient intake

Our findings are in accordance with Gobindram et al. (2015) who reported that feed intake was remained unaltered in lambs fed 35% dried citrus pulp in concentrates. Santos et al. (2014) also stated non-significant effect on feed intake using various levels of dried citrus pulp in diet. In accordance to our findings, Gilaverte et al. (2011) observed that nutrient intake of Santa ines sheep was not significantly affected by replacing corn by dried citrus pulp. However, Gawad et al. (2013) reported significant differences in nutrient intake with an increase in dried citrus pulp level. Crosswhite et al. (2013) observed higher DM intake in animals by replacing corn with dried citrus pulp. The reason for increased intake might be likeness of animals for dried citrus pulp due to its specific smell and taste. Another reason might be better palatability of the citrus pulp (Franzolin et al., 2010).

Nutrient digestibility

Lack of effect in our study was in accordance with Gawad et al. (2013) who reported that DM, OM and CP digestibility remained unaffected by various levels of dried citrus pulp. Ahooei et al. (2011) stated that supplementation of dried citrus pulp in the diet had non-significant effect on nutrient digestibility. Gilaverte et al. (2011) also noticed that nutrients digestibility remained unaffected in sheep when corn was replaced by dried citrus pulp. Contrary to our findings, Nam et al. (2009) reported that nutrient digestibility was higher in dried citrus pulp based diet than control. Macedo et al. (2007) found higher digestibility when levels of dried citrus pulp were increased in ruminant rations. Miron et al. (2002) pointed out increase in digestibility when dried citrus pulp was increased (9.6 to 20.7% of dietary DM) in dairy cows diet. This might be due to total soluble solids and neutral detergent soluble carbohydrates in dried citrus pulp that would be rapidly digested in the rumen (Nam et al., 2009).

Nitrogen metabolism

Results of our studies are in agreement with Peixoto et al. (2015) who found non-significant differences of various levels of dried citrus pulp on ammonia nitrogen. This ammonia nitrogen is necessary to promote growth of fiber degrading bacteria which use ammonia nitrogen as nitrogen source, resulting in improved fiber digestion. Williams et al. (1987) also observed lack of effect of dried

citrus pulp on nitrogen retention in calves. Chen et al. (1981) stated that dried citrus pulp did not affect nitrogen retention in lambs. This might be due to its non-significant effect on intake and digestibility.

Blood metabolites

Various inclusion levels of dried citrus pulp had non-significant effect on blood metabolites in buffalo calves. Our results are in agreement with Ahooei et al. (2011) who reported non-significant effect of dried citrus pulp on blood urea nitrogen in male fattening calves. Similarly, Belibasakis and Tsirgogianni (1996) also found that blood urea nitrogen remained unaltered in dairy cows fed dried citrus pulp based diets. Findings of our study are similar with Oni et al. (2008) who reported that blood glucose remained unaltered by various levels of dried citrus pulp in West African dwarf goats. Broderick et al. (2002) found lack of effect on blood glucose in cows fed dried citrus pulp based diets. Lack of effect of DCP on blood glucose might be attributed to non-significant intake and digestibility of DCP based diets.

Growth performance and gain to feed ratio

Non-significant effect of dried citrus pulp on weight gain in the present study was supported by Gawad et al. (2013). Santos et al. (2014) also stated that weight gain remained unaltered by different levels of dried citrus pulp. Caparra et al. (2007) found non-significant differences of dried citrus pulp on weight gain in lambs. Scerra et al. (2001) also revealed lack of effect on live body weights of lambs fed dried citrus pulp based diets. This might be attributed to similarity in chemical composition of diet fed to the animals.

Contrary to this study, Bueno et al. (2002) revealed a better growth performance in Saanen kids fed diet having 46% dried citrus pulp. Similarly, Miron et al. (2002) found that there was a higher weight gain in cows fed total mixed ration having 21% dried citrus pulp than those offered total mixed ration having 10% dried citrus pulp. Aregheore (2000) stated better daily live weight gain in sheep and goats fed dried citrus pulp based diets. The reason for higher weight gain might be attributed to more feed consumption by the animals with an increased level of dried citrus pulp (Williams et al., 1987).

Economics

Results of our study are in accordance with Gholizadeh and Naserian (2010) who reported that dried citrus pulp reduced the feeding cost. Oni et al. (2008) noticed that feed cost was decreased when barley grains were replaced with dried citrus pulp in the diet of Saanen kids. Caparra et al. (2007) stated that using dried citrus pulp as concentrate energy source is very economical in diets of lambs. Macedo et al. (2007) also found a reduction in feed prices when citrus pulp replaced sorghum silage as concentrate energy source. Similarly, Broderick et al. (2002) stated that dried citrus pulp is very efficient to minimize feed cost in goat rations. The reason might be that citrus pulp is a waste industrial by-product with excellent nutritional profile for ruminants which is cheaper than cereal grains, resulting in preparing an economical ration (Naserian et al., 2009).

Conclusion

The study showed that dried citrus pulp can be used successfully up to 20% in the diet of calves without any ill effect on feed intake, digestibility and growth performance. It also helps in cost effective ration formulation.

Conflict of interests

The authors have not declared any conflict of interest.

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