Journal of Animal and Veterinary Advances 10 (14): 1811-1816, 2011
ISSN: 1680-5593

Effects of Different Levels of Dried Citrus Pulp and Urea on Performance of Fattening Male Calves

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Abstract: To evaluate the effect of different levels of Dried Citrus Pulp (DCP) and urea on performance of fattening male calves, twenty Brown Swiss male calves (192.15±30 kg live weight and 196.3±24 days age) were housed in individual tie stalls and randomly allocated to four experimental diets as follows: without urea and DCP (control), 12% DCP+0% urea, 0% DCP+0.65% urea and 12% DCP+0.65% urea. The experimental diets consisted of 35% forage (corn silage) and 65% concentrate. The length of the trail was 100 days (15 days for adaptation and 85 days for experimental period). Data showed that experimental diets had significant effect on nutrients apparent digestibility ($p<0.05$). The dry matter and crude protein digestibility of diet four was higher than other diets. According to the results, the experimental diets had no significant effect on dry matter intake, average daily gain and feed to gain ratio ($p>0.05$). There was no significant difference in rumen pH but rumen $N\text{-}NH_3$ was significantly differ between treatments ($p<0.05$). Calves were fed diet three significantly had the highest rumen $N\text{-}NH_3$. Ruminating, eating and chewing of calves had no significant difference between treatments ($p>0.05$). Blood metabolites (glucose, triglyceride, urea nitrogen) were not significantly affected by experimental diets approximately 2 h after feeding. The experimental diets had no significant effect on carcass and liver weight ($p>0.05$). It seems that including of dried citrus pulp supplemented urea in the fattening male calves ration can improve dry matter intake, feed conversion ratio, average daily gain and increase nutrients apparent digestibility of Brown Swiss male calves.

Key words: Dried citrus pulp, feedstuff, performance, urea, experimental period, Iran

INTRODUCTION

Ruminant feeding systems based on locally available by-product feedstuffs are often a practical alternative because the rumen microbial ecosystem can utilize by-product feedstuffs which often contain high levels of structural fiber to meet their nutrient requirements for maintenance, growth, reproduction and production (Bampidis and Robinson, 2006). The main citrus by-product feedstuffs from citrus processing are fresh citrus pulp which is the whole residue after extraction of juice, representing between 492 and 692 g kg^{-1} of fresh citrus fruit with 600-650 g Dry Matter (DM) kg^{-1} peel, 300-350 g kg^{-1} pulp and 0-100 g kg^{-1} seeds (Pascual and Carmona, 1980) and Dried Citrus Pulp (DCP) which is formed by shedding, liming, pressing and drying the peel, pulp and seed residues to about 80 g kg^{-1} moisture and citrus meal and fines which is formed and separated during the drying process. Hydration can affect bulk density by causing swelling of the feed matrix due to absorption of water and so, hydration rate is important in determining the effective bulk density in the rumen. As bulk density before feeding, hydration rate and effective bulk density are potentially important factors impacting feed intake of Total Mixed Rations (TMR) due to rumen fill (Kammel, 1991). DCP contains relatively large amounts of pectins and soluble carbohydrates and very limited amounts of available N (Bampidis and Robinson, 2006). Taiwo *et al*. (1995) suggested that the N content of citrus pulp can be enhanced by trapping excess ammonia generated from such as urea treated barley straw. Net microbial N synthesis, absorption, retention and microbial efficiency were higher for diets that contained DCP ammoniated with urea versus diets supplemented with urea or DCP ammoniated with ammonium hydroxide while the source of supplemental non-protein N did not

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influence OM digestion (Rihani *et al*., 1993). Bampidis and Robinson (2006) reviewed the effect of citrus by-products on performance of growing ruminants summarized from several sources. Overall, results suggested that substitution of corn and wheat grains with citrus by-product feedstuffs results in equal growth of ruminants. However due to little information regarding substitution of barely with citrus pulp, the experiment was designed.

MATERIALS AND METHODS

The experiment was conducted in dairy farm of high education center of Jihad-e-Agriculture of Khorasan-e-Razavi province, Iran. Twenty Brown Swiss male calves (192.15±30 kg initial live weight and 196.3±24 days old) were used in this experiment. Calves were individually identified with ear tags and received vaccination against *Pasteurella hemolytica* and were treated to eliminate intestinal parasites. The calves were weighed before feeding on two consecutive days immediately before the treatments were imposed. Calves were randomly assigned to one of four diets and individually offered the experimental diets for 85 days. Calves were allowed 2 weaks to acclimate to the tie stalls furnished with individual feeders and automatic drinkers before starting the feeding trial.

The trial was a 2×2 factorial design with 4 dietary groups: without urea and DCP (control), 12% DCP+0% urea, 0% DCP+0.65% urea and 12% DCP+ 0.65% urea. Diets were formulated based on beef NRC (1996) requirements (Table 1). The diets were consisted of 35% forage (corn silage) and 65% concentrate (Dry Matter (DM) basis). Dietary composition for all diets was the same (Table 2). Diets offered twice daily at 06:00 and 18:00 h. Animals were fed *ad libitum* and were given sufficient quantities to allow a daily refusal of approximately 50 g kg^{-1} intake. Samples of the total mixed diet for each treatment were collected weekly throughout the fattening period. These samples were frozen at 20°C until analysis. Feed samples were ground to pass a 2 mm screen in a Wiley mill and thoroughly mixed until the sample appeared homogenous. Weekly samples were pooled on an equal-weight basis to form a monthly sample. The calves were weighed every 3 weeks throughout the trial (after a 12 h fast by removing feed) and amount of diet offered was adjusted based upon their live weights. Feed intake, daily weight gain and feed efficiency were calculated. Amount of feed offered to each calf was recorded and refusals were collected and weighed daily in order to determine feed intake. Feeds and faeces of each calf were collected for 5 days and sampled at the end of the fattening period to determine nutrients apparent digestibility. Blood samples of calves were collected approximately 3 h after feeding during the trial in EDTA-coated tubes and immediately centrifuged to obtain the plasma fraction and then determined contents of plasma glucose, triglyceride, urea nitrogen and cholesterol. Rumen liquid samples were taken approximately 2 h after feeding by stomach tube then pH was determined immediately (Greisingerelectronics, GPHR 1400 A, Swiss). One sample of rumen liquid was strained through two layers of cheese cloth and was acidified with 10 cc of HCl solution(50% v/v) for ammonium-N analysis. Fluid samples were placed on ice for transport to the laboratory where they were frozen until analyzed for ammonia concentrations. During the trial chewing activity of calves for 24 h was measured by method of direct observation every 5 min for 24 h. The length of ruminating and eating time was considered as chewing activity.

For nutrient analysis, samples were dried at 60°C for 48 h in a forced-air oven (Memmert 854, Germany Schwabch) and then ground through the 2 mm screen of a Wiley mill. The samples were ashed at 600°C in an electric furnace (Hotspot gallen kamp, England) to determine OM content (AOAC, 2000). Fiber fractions

Table 1: Ingredient composition (DM%) of the diets used in the experiment

	Urea (0%)		Urea (0.65%)	
Items	DCP 0%	DCP 12%	DCP 0%	DCP12%
Corn silage	35.00	35.00	35.00	35.00
Dried citrus pulp	0.00	12.00	0.00	12.00
Barely grain	26.20	14.20	26.20	14.20
Corn grain	9.20	9.20	9.20	9.20
Wheat bran	3.70	1.75	6.10	6.50
Beet sugar pulp	0.00	0.00	5.00	0.00
Canola meal	11.50	12.70	7.50	10.00
Cottonseed meal	11.50	12.70	7.50	10.00
Calcium carbonate	1.35	0.90	1.30	0.90
Urea	0.00	0.00	0.65	0.65
Salt	0.25	0.25	0.25	0.25
Vit. and min. premix	0.50	0.50	0.50	0.50
Sodium bicarbonate	0.65	0.65	0.65	0.65
Magnesium oxide	0.20	0.20	0.20	0.20

Table 2: Chemical composition of diets used for fattening calves (on DM basis)

	Urea (0%)		Urea (0.65%)	
Items	DCP (0%)	DCP (12%)	DCP (0%)	DCP (12%)
Metabolizable energy (Mcal kg^{-1} DM)	2.66	2.66	2.65	2.65
Crude protein (%)	15.50	15.60	15.80	15.70
NDF[1] (%)	30.50	30.90	31.10	31.20
ADF[2] (%)	17.20	18.20	17.60	18.00
NFC[3] (%)	46.00	45.30	45.50	45.00
Ether extract (%)	3.10	3.10	3.10	3.20
Ash (%)	6.70	6.80	6.60	6.70
Calcium (%)	0.80	0.80	0.80	0.80
Phosphorus (%)	0.50	0.50	0.50	0.50

[1]NDF: Neutral Detergent Fiber; [2]ADF: Acid Detergent Fiber; [3]NFC: Non-Fiber Carbohydrate

(NDF and ADF) were determined as described by Van Soest *et al*. (1991). Analysis of CP was performed using Kjedahl method on the Technicon nitrogen analyzer (AOAC, 2000). In this trial, nutrients apparent digestibility was measured using fecal collection. At the end of study, the calves were slaughtered at a commercial slaughterhouse. Dressing percentage was calculated as a ratio of hot carcass weight to the live weight obtained in the slaughterhouse.

Statistical analysis was carried out using the GLM procedure of SAS 9.1 (SAS institute Inc., Cary, NC). The following model was used:

$$y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + \varepsilon_{ijk}$$

Where:

y_{ijk} = The dependent variable
μ = The overall mean
A_i = The effect of level i of dried citrus pulp (i = 1, 2)
B_j = The effect of level j of urea (j = 1, 2)
$(AB)_{ij}$ = The effect of the interaction of factor A and factor B
ε_{ijk} = Residual error

RESULTS AND DISCUSSION

The effects of experimental diets on Dry Matter Intake (DMI) of fattening male calves are shown in Table 3. Results showed that differences between diets on DMI were not significant (p>0.05). Numerically, calves were fed diets with urea (diets 3 and 4) DMI increased than diets 1 and 2. Lanza reported that partial or total substitution of corn or barely grain by DCP in the concentrate fed to Friesian dairy cattle had no effect on intake of the ration. Diets effects on daily weight gain (kg) of fattening male calves were not significant (p>0.05; Table 3). According to the results the daily weight gains were greater for animals fed the diets containing urea (diets 3 and 4) compared to the diets without urea (diets 1 and 2). Feed Conversion Ratio (FCR) of animals did not significantly affected by the experimental diets (p>0.05). The diets had no significant effect on carcass efficiency of animals (p>0.05; Table 3). Numerically, the carcass efficiency of animals receiving diets without DCP (diets 1 and 3) was greater than animals fed the diets containing DCP (diets 2 and 4). Hadjipanayiotou and Louka (1976) studied the nutritional value of DCP as a barley grain replacement in calf fattening diets. They found that daily weight gain, feed intake, FCR and dressing proportion were similar among diets.

The researchers concluded that replacement of barley grain with DCP had no adverse effect on growth and that the nutritive value of DCP approached that of barley grain. Vijchulata *et al*. (1980) showed that effects of DCP as a replacement for corn grain on performance and carcass characteristics of steers and reported that body weight gain, FCR and dressing proportion were not affected by energy source.

These results suggest that DCP when properly fed is a similar energy source to corn grain for cattle. Henrique *et al*. (1998) studied the effects of replacing corn grain with DCP in diets containing various concentrate levels on performance and carcass characteristics of 28 young bulls. In the low concentrate TMR, corn grain or DCP was incorporated at 70 g kg^{-1} DM of the concentrate and in diets with a high concentrate level, corn or DCP was incorporated at 650 g kg^{-1} DM. No differences occurred between diets in BW gain, DMI or FCR but performance of bulls fed corn in the high concentrate diet was better from that of bulls fed DCP. Overall, results suggest that substitution of corn, wheat and barely grains with citrus by-product feedstuffs results in equal growth of ruminants.

The nutrients apparent digestibility of diets is shown in Table 3. Significant differences observe between diets (p<0.05). Dry Matter (DM) digestibility in diets containing urea (69.42 and 70.67 for diets 3 and 4, respectively) was significantly greater then diets without urea (65.45 and 63.99 for diets 1 and 2, respectively). However, DCP had no significant effect on DM digestibility. Similarly, the same results were obtained for Crude Protein (CP) digestibility which existence of urea in the diets resulted in higher CP digestibility. Ben-Ghedalia *et al*. (1989) studied effects of a pectin-rich (DCP based) diet on quantitative aspects of digestion in sheep in comparison to a starch-rich (barley grain based plus a small proportion of DCP) diet. DM was equally digestible in both diets but CP was more digestible in the starch-rich diet and

Table 3: Effects of experimental diets on performance of fattening male calves

	Urea (0%)		Urea (0.65%)			p-value		
Items	DCP (0%)	DCP (12%)	DCP (0%)	DCP (12%)	SE	U[1]	C[2]	U×C
DMI (kg day^{-1})	7.07	6.96	7.28	7.28	0.82	0.78	0.91	0.98
Daily weight gain (kg)	1.49	1.45	1.51	1.54	0.13	0.66	0.97	0.10
Feed conversion	4.72	4.76	4.75	4.68	0.30	0.88	0.99	0.79
Carcass efficiency (%)	55.22	51.99	53.93	52.69	1.43	0.43	0.62	0.73
DM digestibility (%)	65.45^{bc}	63.99^{c}	69.42^{ab}	70.67^{a}	1.13	<0.01	0.93	0.25
CP digestibility (%)	63.65^{b}	63.02^{b}	68.67^{ab}	74.59^{a}	1.61	<0.01	0.42	0.25

*Within a row, means for nutritional treatment differ (p<0.05); U[1]: Urea p value, C[2]: Citrus pulp p-value

NDF was more digestible in the pectin-rich diet. In the experiment, digestibility coefficients of pectin uronic acid, fructose and glucose residues were high in both diets, their digestion being essentially complete in the forestomachs. They concluded that DCP even at a high dietary proportion, creates favorable conditions for cellulolysis in the rumen and has a positive effect on N supply to the intestine. Barrios-Urdaneta *et al.* (2003) examined effects of supplementation with various proportions of barley grain or Dried Orange Pulp (DOP) on digestion of ammonia-treated straw by sheep. Rates of DM and NDF degradation and DM and OM digestibility coefficients were unchanged as the DOP proportion in the diet increased.

Overall, results suggest similar citrus by-product feedstuffs digestibility among ruminant species. Supplementation of forages with citrus by-product feedstuff that are rich in pectin usually has a less negative effect on the rumen environment than supplementation with starch-or sugar-rich feeds. Citrus by-product feedstuffs contain a variety of energy substrates for ruminal microbes including soluble carbohydrates. When citrus by-product feedstuffs substituted for starchy feeds, DM digestibility coefficients tend to remain unaffected while CP digestibility decreases. Lanza reported that decreased digestibility of CP in some DCP diets may be due to high temperatures of dehydration (i.e., >140°C). Citrus by-product feedstuffs improve utilization of dietary fibrous fractions, possibly due to positive effects on rumen microflora.

Rumen pH did not differ between diets ($p>0.05$; Table 4). Animals fed diets containing DCP had greater pH (numerically) compared to other diets. These results agreement with McCullough and Sisk (1972) who studied rumen fermentation characteristics of steers fed concentrates containing DCP at 150 and 250 g kg^{-1} DM along with either corn or wheat silage. They found that ruminal pH as well as acetic, propionic and butyric acid molar proportions were similar for the diets.

In contrast, Schaibly and Wing (1974) found that ruminal pH declined with increasing DCP at levels up to 820 g kg^{-1} DM. There were significant differences between diets for rumen N-NH_3 concentration ($p<0.05$). Animals fed diet containing 0.65% urea and 0% DCP had the highest rumen N-NH_3 concentration compared to others (16.99 vs. 8.42, 8.39 and 10.86). It is clearly shown that animals received diets containing urea had higher rumen N-NH_3 concentration than those which received diets without urea. Pinzon and Wing (1976) also studied effects of DCP as a replacement for corn grain in high urea rations for steers on ruminal fermentation. Increasing DCP reduced rumen pH values to 6.61. Rumen ammonia N was not affected by diets (mean = 956 mgL^{-1}).

Overall results suggest that citrus by-product feedstuffs, as high pectin energy sources, cause little or no decline of rumen pH, increase the molar proportion of acetic acid and decrease the molar proportion of propionic acid, resulting in an increased acetate/propionate ratio.

The effects of different levels of DCP and urea on blood metabolites of fattening male calves are shown in Table 4. According to the results, there wasn't any significant difference between diets ($p>0.05$). Bhattacharya and Harb (1973) reported in lambs fed corn and DCP in proportions of 600:0, 400:200, 200:400 and 0:600 g kg^{-1}, blood glucose (706.5 mg L^{-1}), blood VFA (3.25 mequiv./l) and rumen pH (6.65) did not differ among diets. Belibasakis and Tsirgogianni (1996) evaluated effects of dietary inclusion of DCP on blood serum metabolites with 20 cows fed to one of two TMR, containing either DCP at 200 g kg^{-1} DM and concentrate at 300 g kg^{-1} DM or dried beet pulp 150 g kg^{-1} DM, ground corn grain 80 g kg^{-1} DM and concentrate 270 g kg^{-1} DM, plus corn silage at 500 g kg^{-1} DM. There were no differences in blood serum concentrations of glucose, total protein, albumin, globulin, urea, triglycerides, phospholipids, Na, K, Ca, P, Mg and Cl. Additionally, serum concentrations of cholesterol were higher (2350 mg L^{-1} versus 2230 mg L^{-1}) when cows were fed the diet containing DCP.

Table 5 shows the chewing activity of fattening male calves. Eating activity differ between diets ($p<0.05$), the highest and lowest eating time were related to T_4 and T_1, respectively (237 min day^{-1} vs. 171 min day^{-}). [1] Ruminating and chewing time did not differ between diets ($p>0.05$). The difference between plant Cell Wall (CW) or total fiber in an agronomic context and NDF or structural fiber in an animal feeding context is important with most

Table 4: Effects of experimental diets on pH and blood metabolites of fattening male calves

	Urea (0%)		Urea (0.65%)			p-value		
Items	DCP (0%)	DCP (12%)	DCP (0%)	DCP (12%)	SE	U^1	C^2	U×C
Rumen pH	6.10	6.32	6.10	6.14	0.10	0.39	0.22	0.42
N-NH_3 (mg dL^{-1})	8.42[b]	8.39[b]	16.99[a]	10.86[ab]	1.93	0.01	0.13	0.13
Glucose (mg dL^{-1})	83.60	88.00	80.00	77.80	2.61	0.01	0.68	0.22
Triglyceride (mg dL^{-1})	8.40	7.40	7.40	8.80	1.42	0.18	0.18	0.68
Urea nitrogen (mg dL^{-1})	12.60	10.80	14.20	12.00	0.90	0.14	0.04	0.83
Cholesterol (mg dL^{-1})	101.40	121.40	93.40	125.60	8.23	0.82	<0.01	0.47

*Within a row, means for nutritional treatment differ ($p<0.05$); U^1: Urea p value, C^2: Citrus pulp p-value

Table 5: Effects of experimental diets on chewing activity of fattening male calves

	Urea (0%)		Urea (0.65%)			p-value		
Items (min day^{-1})	DCP (0%)	DCP (12%)	DCP (0%)	DCP (12%)	SE	U[1]	C[2]	U×C
Eating	171^{b}	200^{ab}	205^{ab}	237^{a}	0.03	0.03	0.54	0.92
Ruminating	395	385	337	382	27.88	0.29	0.54	0.34
Chewing	566	585	542	619	29.93	0.87	0.13	0.35

*Within a row, means for nutritional treatment differ ($p<0.05$); U[1]: Urea p value, C[2]: Citrus pulp p value

citrus by-product feedstuffs because of their high content of pectin which is a part of CW but not part of NDF. The NDF level of citrus pulp is intermediate between that of most concentrates and forages. Welch and Smith (1971) studied effects of citrus pulp on rumination activity and found that rumination time for DCP fed rams was lower compared to those fed a chopped mixed hay (0.16 min g^{-1} vs. 0.34 min g^{-1} DM consumption) but similar relative to cell wall constituents at 0.56 min g^{-1} vs. 0.50 min g^{-1} CW consumption.

Similarly, rumination time for DCP fed cattle was lower vs. those fed a long mixed hay (0.041 min g^{-1} vs. 0.072 min g^{-1} DM consumption) but similar with regard to CW (0.154 min g^{-1} vs. 0.109 min g^{-1} CW consumption). Sudweeks (1977) studied effects of the DCP, corn grain and soybean mill feed at concentrate levels of 100, 400 and 700 g kg^{-1} DM on chewing time of steers. Chewing time was not affected by concentrate type but it was reduced with each increase in concentrate level (713, 490 and 387 min day^{-1}, respectively).

CONCLUSION

The results of DCP and urea in the diets of fattening male calves can improve dry matter intake, daily weight gain and feed conversion ratio of Brown Swiss male calves. Also, nutrients apparent digestibility of diets can be increased by diets. Rumen pH and blood metabolites did not differ between diets.

ACKNOWLEDGEMENT

The researchers gratefully acknowledge the support by the High Education Center of Khorasan Razavi Jihad Agriculture, Department of Animal Science.

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