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The Effects of Replacing Dried Citrus Pulp with Barley Grain on the Performance of Iranian Saanen Kids

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Abstract: This study was conducted to evaluate the effect of replacing barley with Dried Citrus Pulp (DCP) on the performance of growing kids. About 12 female Iranian Saanen weaned kids aged 88±3 days with live weight 7±0.7 kg were used in a completely randomized design. Kids were housed in individual metabolic cages. There were 3 treatments (n = 4 kids per treatment). The dietary treatments were T_1, 30% lucerne with 70% concentrate supplement; T_2 and T_3, 7 and 14% of barley grain in supplements were replaced with DCP, respectively. Daily intake was determined. The growth of animals was monitored every 15 days. Rumen fluid was collected by stomach tube and pH measured. Blood samples were collected from each animal at the end of experiment via jugular vein, 2 h after morning feeding. Significant difference ($p<0.05$) occurred for DMI, average daily gain, feed efficiency, rumen fluid pH and Blood Urea Nitrogen (BUN). DMI and daily gain decreased with increasing DCP. In contrast, feed efficiency, rumen pH and BUN increased. Apparent digestibility of DM, NDF, ADF, CP and N-balance did not differ between treatments ($p<0.05$). No differences observe between treatments for body measurements ($p>0.05$). It was concluded that DCP in ration of growing kids is not able to support requirements like starch sources but citrus pulp could be incorporated into ruminant ration.

Key words: Citrus pulp, barley, digestibility, goats, performance, Iran

INTRODUCTION

Dried Citrus Pulp (DCP) is the main by-product from the citrus-processing industry that is used as a feedstuff for ruminants Grasser *et al.* (1995). The DCP is a mixture of peel, inside portions and culled fruits of the citrus family (e.g., orange, lemons and grapefruit). Citrus pulp is composed of approximately 250 g pectins kg dry matter Arthington *et al.* (2002). Additionally, this feed stuff contains between 120 and 400 g of sugars and <10 g starch kg DM. Pectins are highly digested in rumen over 980 g kg DM (Titgemeyer *et al.*, 1992; Hall *et al.*, 1998; Arthington *et al.*, 2002). Neutral Detergent Fiber (NDF) content is 230 g kg DM (NRC, 1996) with a digestibility of 780-840 g kg DM (Miron *et al.*, 2002).

The nutrient content of DCP is influenced by several factors including source of fruit and type of processing. Use of citrus pulp has been associated with positive effects on ruminal fermentation Pinzon and Wing, 1976, fiber digestion (Miron *et al.*, 2001) and microbial protein synthesis (Ariza *et al.*, 2001). Positive effects have been reported in dairy cattle (Van Horn *et al.*, 1975) and in small ruminants (Fegeros *et al.*, 1995; Aregheore, 2000). Citrus pulp has been studied as an alternative energy source replacing some grain in concentrate diets. Due to its high energetic content, it can be used as barley replacement in the diets of ruminants. Barley is the main energy sources of the concentrate mixture and alternatives to its replace-contribute to a decrease in the cost of animal origin products. Barley contains readily fermentable carbohydrate which produces lactates in the rumen, leading to a drop in pH and reduce fiber digestibility.

Growing kids need a diet with high energy concentration to obtain high weight gains and reach mating weight earlier. The DCP has a high concentration of pectin in its composition which leads to a fast degradation in rumen releasing energy for a rapid microbial growth. Since pectinis considered soluble fiber, its fermentation produces lesser lactate than starch (Hall *et al.*, 1998) and creates better rumen conditions for fiber fermentation. Its high level of potential degradable dry matter (Silva *et al.*, 1997) provides a high TDN content (74-83%) (De Peters *et al.*, 1997). The objective of this study was to evaluate the performance of growing kids and apparent digestibility coefficients of diets with increasing levels of replacement of barley by dried citrus pulp.

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MATERIALS AND METHODS

The experiment was carried out at Ferdowsi University of Mashhad, Iran. Twelve female Iranian Saanen weaned kids aged 88±3 days with live weight 7±0.7 kg were used in a completely randomized design. Each kid was confined in a separate digestion and metabolism crate (1.3×0.5 m) during the entire experiment. The kids were allowed a 14 days adjustment period in the crates, prior to starting the experiment. Kids were divided into three blocks of four kids each according to body weight. Three rations were randomly assigned to the kids of each block. Period of trial consisted of 60 days.

The growth and body measurement were monitored every 15 days. Wet citrus pulp was collected from a local citrus canning factory. The entire pulp including seeds and peels after extraction of juice was dried at a temperature of about 90°C. The ingredient composition of the concentrate and chemical composition of feed is shown in Table 1 and 2. There were 3 treatments (n = 4 kids/treatment). The dietary treatments were T_1, 30% lucerne with 70% concentrate supplement; T_2 and T_3, 7 and 14% of barley grain in supplements were replaced with dried citrus pulp, respectively.

Animals were fed twice daily. Water was available to kids. Daily intake was determined. Feed samples were collected at each feeding and composited for later analysis. During the last 7 days of collection period, feces, urine and refused feed were also collected. Feed, refusals and fecal samples were analyzed for DM (48 h at 60°C) and ash (4 h at 550°C). Nitrogen content was determined using the Kjeldhal method. Neutral detergent fiber content and acid detergent fiber content of samples was determined according to the method of Van Soest *et al.* (1991).

Apparent Digestibility Coefficient (ADC) and Nitrogen Balance (NB) were determined as described by Schneider and Flatt (1975). Rumen fluid was collected by stomach tube, strained through two layers of cheese cloth and acidified with 10 mL of HCl solution (50%, vol/vol) for ammonia-H analysis. The pH of rumen was determined immediately (Metrohm, 691). Citrus pulp, feed and feces were analyzed for proximate components and urine nitrogen was determined by AOAC (2000) methods.

Blood samples were collected from each animal at the end of experiment via jugular vein 2 h after morning feeding and later centrifuged at 3000× g for 10 min. Plasmas obtained were stored at -20°C for later analysis. Urine from am and pm collections was mixed by kids, weighed and acidified with concentrated sulfuric acid. Aliquots of blended, acidified urine were frozen at -15°C for subsequent analysis. Statistical analyses were performed using the MIXED method of SAS. The model included the diet (levels of replacement of barley for DCP), initial live weight and experimental error.

Table 1: Ingredients composition (%) used in concentrate mixture

	Treatments		
Ingredients (%)	T_1	T_2	T_3
Citrus pulp	0.0	7.00	14.00
Barley grain	14.0	7.00	0.00
Corn grain	48.0	48.00	48.00
Soybean meal	13.0	13.90	14.80
Canola meal	10.0	10.00	10.00
Sugar beet pulp	7.0	6.10	5.20
Wheat barn	7.0	7.00	7.00
Limstone	0.7	0.70	0.70
Mineral mix[a]	0.3	0.30	0.30

Composition by kg of product: Ca, 100 g; P, 80 g; Mg, 7.5 g; Na, 202 g; S, 10 g; Zn, 4000 mg; Fe, 1500 mg, Mn, 1000 mg

Table 2: Chemical composition of feed

	Treatments[1]		
Composition (% DM)	T_1	T_2	T_3
DM	88.50	88.29	88.03
CP	16.50	16.80	16.80
NDF	18.60	18.50	18.40
ADF	8.70	9.60	10.00
NFC	58.60	58.00	58.00
EE	3.50	3.60	3.70
ME (Mcal kg^{-1})	3.23	3.23	3.23
NEg (Mcal kg^{-1})	1.37	1.36	1.36
Ca	0.70	0.70	0.70
P	0.60	0.60	0.60

[1]The treatments were, T_1= 0, T_2 = 7 and T_3 = 14% DCP, respectively

RESULTS AND DISCUSSION

The effect of treatments on Dry Matter Intake (DMI) is shown in Table 3. Difference between treatments on DMI was significant ($p<0.05$). DMI decreased with increasing DCP (849, 835 and 793 g day^{-1} for T_1, T_2 and T_3, respectively). The intake of a ration fed to Awasi lambs containing DCP was reported to be the same as that containing corn grain at up to 400 g DCP kg^{-1} DM but declined at higher levels Bhattacharya and Harb (1973). The replacement of corn by dehydrated citrus pulp leading to an improvement in DM intake at the replacement level of around 40% Bueno *et al.* (2002).

Lanza (1984) reported that Partial or total substitution of corn or barley grain by Dried Orange Pulp (DOP) or Dried Lemon Pulp (DLP) in the concentrates fed to Friesian dairy cattle had no effects on intake of the ration. Volanis *et al.* (2004) reported that ensiled sliced oranges at 309 g kg^{-1} DM of the TMR was palatable to lactating dairy sheep, possibly due to its pleasant to dour while Migwi *et al.* (2001) suggested that the level of citrus pulp, ensiled with wheat straw and poultry litter in the ration of sheep should be maintained between 150 and 200 g kg^{-1} DM to avoid depressed intake that may arise with higher

Table 3: Effects of replacing barley with DCP on performance of kids

Variables	Treatments[1] T_1	T_2	T_3	SE
DMI (g day^{-1})	849.00^a	835.00^b	763.00^c	10.22
Daily gain (g day^{-1})	198.00^a	186.00^b	167.00^c	0.26
Feed efficiency	4.20^a	4.56^b	4.78^c	0.24
Apparent digestibility (%)				
DM	78.44	78.95	78.31	0.60
NDF	58.48	59.87	60.93	0.49
ADF	50.50	51.41	52.46	0.74
CP	74.38	73.51	72.49	0.86
NB	3.86	3.57	3.68	0.03

[1]The treatments were, T_1 = 0, T_2 = 7 and T_3 = 14% DCP, respectively

citrus pulp levels, presumably due to low palatability. Decreasing DMI in this present experiment may be due to low palatability of DCP, processing of DCP, differences in ruminal development.

Treatments effects on daily gain (g day^{-1}) were significant ($p<0.05$). The daily live-weight gains were greater for kids fed the T_1 compare to T_2 and T_3 (198, 186 and 167 g day^{-1}, respectively). Feed efficiency did differ between treatments ($p<0.05$) increased with increasing DCP (4.20, 4.56 and 4.78, respectively). Pascual and Carmona (1980) reported that the BW gain and feed conversion ratio were not affected up to 300 g kg^{-1} DM of DCP in the diet but the animal response was poorer with higher DCP feeding levels. Bueno *et al.* (2002) evaluated effects of replacing corn grain with DCP (0, 33, 66 and 100% DM) on performance of Saanen kids and reported that the BW was not affected by DCP incorporation in to the concentrates. The researchers concluded that replacing about 400 g kg^{-1} DM of corn grain by DCP resulted in the best performance of growing kids. Decreasing live weight gain and feed efficiency at this present study presumably due to decreasing DMI and low palatability of DCP. The digestibility coefficients of diets are shown in Table 3. No difference observe between treatments ($p>0.05$) but digestibility of DM, NDF and ADF tended to be greater for kids fed the DCP.

The increase on the digestibility of these fractions seems to be associated with the low lignin content of DCP. The Crude Protein (CP) digestibility was not changed by the replacement of DCP ($p>0.05$). Bueno *et al.* (2002) reported that with increasing levels of DCP, apparent digestibility of DM had a quadratic effect while apparent digestibility of NDF and ADF increased linearly. Bhattacharya and Harb (1973) studied DCP as a replacement for corn grain in Awasi lambs. Corn and DCP were fed to lambs in proportions of 600:0, 400:200, 200:400 and 0:600 g kg^{-1}. The DM digestibility was similar among treatments but CP digestibility was lower at the highest DCP that digestibility of ADF increased but that of DM

Table 4: Effects of treatments on pH, blood metabolites and body measurments

Variables	Treatments[1] T_1	T_2	T_3	SE
pH	6.28^a	6.41^b	6.62^c	0.004
BUN (mg dL^{-1})	30.00^a	31.00^b	35.00^c	0.060
Glucose (mg dL^{-1})	51.00	51.00	52.00	0.070
Body measurments (cm)				
Body length	60.52	59.82	59.01	1.580
Wither hight	53.74	53.46	53.19	0.980
Heart girth	61.85	61.50	60.80	1.210
Circumference of Fore phalanges	7.50	7.39	7.38	0.370
Circumference of Hind phalanges	7.96	7.68	7.55	0.520
Hip-Pin interval	18.95	18.75	18.67	0.560

[1]The treatments were, T_1 = 0, T_2 = 7 and T_3 = 14 % DCP, respectively

and CP tended to decrease with increasing levels of DCP. N-balance did not different between treatments ($p>0.05$). The value was high for T_1 compare to T_2 and T_3 (0.37, 0.36 and 0.35, respectively). Results agreement with Bueno *et al.* (2002).

Rumen pH did differ between treatments ($p<0.05$; Table 4) and increased with increasing DCP. Kids fed the T_3 had the highest pH compare to T_1 (6.62 vs. 6.28). Result agreement with Wing *et al.* (1988). In contrast, Schaibly and Wing (1974) found that ruminal pH declined with increasing DCP at levels up to 820 g kg^{-1} DM. Pinzon and Wing (1976) also studied effects of DCP as a replacement for corn grain in high urea rations for steers on ruminal fermentation. Corn and DCP were fed to steers in proportions of 600:0, 390:190, 180:380 and 0:550 g kg^{-1}. Increasing DCP reduced rumen pH values to 6.61.

Increasing rumen pH at this present study may be due to increase the molar proportion of acetic acid and decrease the molar proportion of propionic acid resulting in an increased acetate/propionate ratio. Effect of replacing barley with DCP on Blood Urea Nitrogen (BUN) of kids was significant ($p<0.05$; Table 4). BUN increased with increasing DCP (30, 31 and 35 mg dL^{-1}, respectively). Pinzon and Wing (1976) reported that urea BUN decreased with increasing DCP suggesting increased N utilization. This controversy could possibly be attributed to the nature of starch and its fermentation pattern, composition and physical form of starter and type of hay used in this study. No difference observes between treatments for blood glucose ($p>0.05$; Table 4). Treatments effects on body measurements were not significant ($p>0.05$; Table 4).

CONCLUSION

The replacement of barley by DCP in ration of growing kids is not able to support requirements like starch sources but citrus pulp could be incorporated into

ruminant ration. DMI and feed efficiency decreased with increasing DCP. Digestibility of nutrients and body dimensions did not differ between treatments.

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