JOURNAL OF ANIMAL SCIENCE ADVANCES

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J Anim Sci Adv 2013, 3(8): 386-391

Online version is available on: www.grjournals.com

ISSN: 2251-7219

Original Article

Nitrogen Balance and Blood Metabolites of Llama (*Lama Glama*) Fed Barley Hay Supplemented with Alfalfa and Quinoa Straw in Bolivia

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Abstract

Eight male llamas (190±21.2 kg BW; 3 yrs old) were housed in metabolism crates. The diet treatments fed were barley hay (B), barley hay plus 20% quinoa straw (BQ), and barley hay plus 20% alfalfa hay (BA). The treatments were fed in random order, once daily with water provided ad libitum. Treatment periods were 14 d, with d 1 to 7 for diet adjustment and d 8 to 14 for N data collection. Blood samples were collected on d 14 to determine plasma metabolite concentrations. Dry matter intake was not different between the treatments 824, 1247 and 1196 g/d for B, BA and BQ. Nitrogen intake was 8.01, 21.44 and 13.42 g/d ($P<0.05$) for B, BA and BQ, respectively. Fecal N was highest for BA (6.41 g/d), but was only different from B (3.97 g/d; $P<0.05$). Urine N excretion as a percent of total was lowest for BQ (35.7%) and highest for B (60.8%; $P<0.05$). Nitrogen retained was -2.9, 9.7 and 4.9 g/d for B, BA and BQ ($P<0.05$). Dry matter digestibility was not different between treatments (63 to 66%), while N digestibility was different ($P<0.05$) across all three treatments; 47, 70 and 59% for B, BA and BQ. Plasma glucose NEFA, triglycerides, total plasma and creatinine were not different across treatments. These data demonstrate that feeding quinoa straw is a good supplement for camelids to increasing CP intake in-place of higher quality forage supplements, like alfalfa, that can be used for other higher producing livestock like dairy cows.

Keywords: Llama, blood metabolites, nitrogen balance, quinoa.

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Received on: 19 Jul 2013
Revised on: 20 Jul 2013
Accepted on: 29 Jul 2013
Online Published on: 26 Aug 2013

Introduction

Llamas (*Lama glama*) are native to the high plains of the Andean ranges of Peru, Bolivia and Chile. The high plains or Altiplano rests at 4,267 m above sea level. The climate is cold and dry, thus vegetation is sparse and low in quality. Natives rely on llamas as pack animals, for their meat and milk, and their valuable wool. During the eight to nine month dry season the llamas are typically grazed on pastures that consist of low shrubs and over grazed native grasses. Barley hay (*Hordeum vulgare*) is typically grown as an animal feed for the dry season. Other forage crops include alfalfa (*Mendicago sativa*). These forage crops are harvested by hand and fed during periods where grazing is limited (dry season from June to October). Barley hay is stacked at the time of harvest, while alfalfa is usually harvested as needed and fed.

A native crop of the Andes, quinoa (*Chenopodium quinoa*), is a pseudo grain that is drought, salt, and frost-resistant and thrives in poor soils and high altitudes where few plants do well (Burgener, 1992; Coulter, 1990). The quinoa plant ranges in height from 0.7 to 2.0 meters with seeds at the top that are 1.8 to 2.6 mm wide and conically shaped (Coulter, 1990). Bolivian's have grown quinoa grain for thousands of years as a major human food source, important for its exceptionally high levels of essential or limiting amino acids, and its protein quality (Coulter, 1990). A by-product of the grain harvesting is the straw (dried stocks and leaves) which the majority of the time is stacked and burned or fed to livestock (Shams, 2011). Considering the quinoa's wide usage and growth, the use of quinoa straw as a diet supplementation for animals has not been looked at scientifically at the nutrition level.

The objectives of this experiment were to demonstrate the efficacy of quinoa straw supplementation for improving nutrient intake of llamas and to characterize the blood metabolites in male llamas fed barley hay supplemented with quinoa straw or alfalfa hay.

Materials and Methods

Animals

This study was conducted at the Benson Agriculture and Food Institute research station in Letanias, Bolivia (~4085 m elevation). Eight intact male llamas (190±21.2 kg BW; 3 yrs old) were divided into two replicate groups of four and housed in metabolism crates. Prior to placing in the crates the llamas were sheared to a uniform 1 cm length. The animals were allowed to become accustomed (acclimation period) to the metabolism crates for two weeks prior to initiating the experiment.

Thirty days prior to being put in the metabolism crates, and during the two-week acclimation period, the llamas were fed barley hay. The llamas were fed ad libitum once daily throughout the experiment and water was available ad libitum.

Treatments

The experimental design administered forage treatments randomly to two repetitions of four animals in each. Quinoa straw was collected from the same source and consisted of the quinoa plant residue (dried stocks and leaves) material leftover from the grain harvest. Alfalfa was harvested from the same field and sun dried for two-weeks prior to the experiments initiation. Barley hay was harvested from the same field and stored in a stack until ground and fed. Three treatments consisted of barley hay (B), barley hay plus 20% quinoa straw (BQ), and barley hay plus 20% alfalfa hay (BA). The forages were each ground to 5 cm length using a motorized grinder and a 2cm screen. The treatment diets were mixed for the entire experimental replication to assure uniformity throughout the replication. There was no significant variation noted between the replication diets. Chemical composition of the three forages is presented in Table 1. Treatment periods were for 14 days where d 1 to d 7 were for treatment acclimation. Samples were collected on d 8 through d 14.

Table 1: Forage composition[a].

Component	Barley	Alfalfa	Quinoa
CP	6.1	23.5	10.4
NDF	58.5	41.0	48.7
ADF	30.0	28.7	27.5
Ash	6.6	10.3	12.8
Ca	0.20	1.52	0.66
P	0.18	0.26	0.14

[a]Forage composition was determined by wet chemistry procedures and are expressed as a percent of DM.

Nitrogen Balance

Feed intake and refusal was determined during d 8 to d14 of each treatment period, along with feed samples and total feed refusals. Feces were collected via a fecal bag connected to a harness attached to the animal. Daily fecal output was measured and dried. Treatment feces were composited for each animal. Feed, feed refusal and fecal samples were dried at 60º C then ground through a Wiley Mill (Arthur A. Thomas Co., Philidelphia, PA) with a 1mm screen. Urine was collected via a funnel into a collection reservoir containing 50 ml of 6N HCl to bring the urine below a pH of 3.0. Daily urine output was measured and the treatment samples composited. An aliquot of each treatment was taken and frozen for future analysis. Nitrogen of feed, fecal and urine were determined using a combustion gas analyzer (LECO, St. Joseph, MI).

Blood Metabolites

On d 14, blood samples were collected at 30 min intervals over a 6-h period via indwelling jugular venous catheters (Micro-Renathane®, Braintree Scientific, Braintree, MA). Plasma was obtained by centrifugation at 2400 g for twenty min, aliquotted and frozen at -20° C for later analysis. Plasma samples were analyzed for glucose, urea N and creatinine using a NOVA 16 blood chemistry analyzer (Nova Biomedical, Waltham, MA). Non-esterified fatty acids (NEFA) were determined using a NEFA-C kit (#990-75401, Wako Chemical USA Inc., VA). Plasma total plasma protein, albumin, were determined using analysis kits (TECO Diagnostics, Anaheim, CA).

Statistical Analysis

Analysis of variance was determined using PROC GLM (SAS, Inst., Cary, NC) to compare main effects of repetition, treatment and the interaction. Repetition was not significant and was removed from the analysis. Data are expressed as least square means for the treatment effect at a level of significance of $P<0.05$.

Results

Dry matter intake (Table 2) was not different between treatments. Numerically, the B intake was 300 to 400 g/d less than BA or BQ. Nitrogen intake was significantly different ($P<0.007$) as we expected due to the incorporation of the higher protein dense supplements. Dry matter digestibility was not different across the three treatments.

Table 2: Effects of feeding barley hay and barley hay supplemented with alfalfa or quinoa straw on whole-body N utilization in llamas.

	Forage			
	B	BA	BQ	SEM
DM intake, g/d	824	1247	1196	160
N intake, g/d	8.01[a]	21.44[b]	13.42[a]	2.08
Fecal N, g/d	3.97[a]	6.41[b]	5.42[ab]	0.82
Urine N, g/d	6.50[a]	5.38[ab]	3.14[b]	1.03
Urine as a % of total, %	60.8[a]	44.5[ab]	35.7[b]	7.17
N retained, g/d	-2.86[a]	9.66[b]	4.86[b]	2.31
DM digestibility	62.7	65.2	65.8	1.93
N digestability	46.7[c]	69.8[a]	58.6[b]	2.65

[abc]Means with differing superscript are different at P<0.05.

Nitrogen Utilization

Feed intake was determined during d 8 to d14 of each treatment period, where feed samples and total feed refusals were collected for analysis. Feces were collected via a fecal bag connected to a harness attached to the animal. Daily fecal output was measured and composited for each animal. Nitrogen retained was significantly different (P<0.005) between the treatments, as was digestibility of N for the three treatments (P<0.01).

Blood Metabolites

The blood metabolite data are presented in Table 3. Total plasma protein was not different across the treatments, but albumin was lower (P<0.05) for BA than for B and BQ treatments. Urea N concentration was higher (P<0.05) for BA (9.5 mmol/l) and B (8.2 mmol/l) than BQ (6.4 mmol/l). Creatinine, glucose, NEFA and triglyceride concentrations were not affected by supplementation.

Table 3: Effects of barley hay (B), barley hay supplemented with 20% alfalfa (BA) or barley hay supplemented 20% quinoa straw (BQ) on plasma metabolite concentrations in llamas.

	Forage			
	B	**BA**	**BQ**	**SEM**
Total Plasma Protein, g/l	67.6	63.6	63.7	3.75
Albumin, g/l	37.1[ab]	34.2[a]	38.2[b]	1.13
Urea N, mmol/l	8.2[ab]	9.5[a]	6.4[b]	0.86
Creatinine, µmol/l	238.7	229.8	229.8	16.8
Glucose, mmol/l	10.9	8.6	9.4	0.76
NEFA, mmol/l	506	485	486	57
Triglyceride, µmol/l	40.8	40.1	41.8	2.4

[abc]Means with differing superscript are different at P<0.05.

Discussion

In an effort to address camelid nutrition issues for South American camelid producers, our goal was to see if a normally discarded grain by-product, quinoa staw, could be used to increase nutrient intake. Quinoa straw, which is usually burned, is a relatively stocky material that will require grinding or chopping in some way to make it more eatable for the animal. Use of the quinoa straw for feeding llamas will allow higher CP forages such as alfalfa to be used to supplement higher producing livestock such as dairy cows or other lactating animals. The llamas in this experiment did not exhibit a palatability issue when supplemented with the quinoa straw. Nitrogen intake did increase 67.5% with the 20% quinoa straw supplementation. Davies et al., (2007b) did show a similar pattern for DM intake as we found for B and BA, with B intake being about 25% less than BA. Barley hay alone has a palatability issue that seems to be overcome when alfalfa or quinoa straw is added.

Dry matter digestibility was similar to Davies et al., (2007b), but was 10% higher than llamas fed similar B and BA diets in the USA (Davies et al., 2007a) with DM intake for both diets about 400 g/d

more. The NDF and ADF fractions were lower for the diets in this study compared to those reported by Davies et al., (2007a) and may account for the higher digestibility. Another factor could be the altitude effect on digestion efficiency reported by Vallenes and Stevens (1971). The DM intake for BQ was welcome and demonstrated that the quinoa straw could be added at the 20% level without affecting intake.

Plasma glucose, NEFA and triglycerides concentrations were not different between the three diets indicating energy was not a limiting factor contributing to the responses observed.

The fecal N excretion pattern is as expected following N intake. Nitrogen digestibility increased 23% for BA over B and 12% for BQ. We expect the BA N digestibility to be higher because of the N intake being higher than B, but because the quinoa was in a dried straw form, we did not expect BQ N to be more digestible than B. Our assumption was that because the straw was made up primarily of stock material the N would be bound in the lignified matrix and be unavailable. This was not the case.

Urine N excretion was lower for BQ than B ($P<0.05$). When expressed as a percent of total N excreted (UN%T), urine N was similar with BQ, less than B ($P<0.05$). The UN%T determined in our llamas for B was similar to those reported by Davies et al., (2007). The BA UN%T was 15% less than they reported. Marini and Van Amburgh (2005) found that approximately 90% of urine N excreted is urea N in growing Holstein heifers Nitrogen recycling is an important facet of camelid nitrogen nutrition a period. Mossa et al., (1994) showed that camels recycle 94% of urea, while sheep and goats recycle 75 and 79% respectively. This high urea recycling was also noted in llamas by Engelhardt et al., (1978). Mousa et al., (1994) concluded that an increase in dietary protein intake and an increase in NH_3 in the rumen may down regulate urea uptake from the blood into the rumen. This would result in an increase in blood urea and urine N excretion. Nitrogen retained was negative for B accompanied by the highest urine N excreted (60.8% or total N excreted), indicative of protein catabolism. These values for BA, where N retained is positive and urine N excreted is not different form B shows that BA protein intake was above requirement and excess dietary protein was being catabolized. When compared to B and BA, BQ has a positive N retention, the lowest urine N excretion (36% of total N excreted) and the lowest plasma urea N, leading us to assume that the supplementation of quinoa straw was adequate to meet the protein requirement for the llamas in this study and under these conditions.

Conclusion

We have demonstrated that quinoa straw can effectively be used as a supplement to increase CP density in camelid diets with no adverse palatability issues. The use of this typically discarded feed stuff allows the producer to gain more from their quinoa production by benefiting alpaca nutrition and use other supplements, such as alfalfa, for production animals that require higher quality forages.

Acknowledgements

We appreciate the assistance of Laural Tegland, Laura Moore and Carla Coaquira for assistance in sample collection and data analysis. Financial assistance provided by the Benson Agriculture and Food Institute, Salt Lake City, UT 84150.

References

Burgener KW (1992). Mineral, Protein and Amino Acid Analysis of Quinoa Accession. Brigham Young University.

Coulter L, Lorenz K (1990). Quinoa-composition, nutrition value, food applications. Lebens. Wiss. Technol., 23: 203.

Davies HL, Robinson TF, Roeder BL, Sharp ME, Johnston NP, Christensen AC, Schaalje GB (2007a). Digestibility, nitrogen balance, and blood metabolites in llama (Lama glama) an dalpaca (Lama pacos) fed barely or barley alfalfa diets. Small Rumin Res., 73: 1-7.

Davies HL, Robinson TF, Roeder BL, Sharp ME, Johnston NP, Christensen AC (2007b). Plasma metabolites and nitrogen balance in Lama glama associated with forage quality at altitude. Small Rum. Res., 69: 1-9.

Engelhardt WV, Hinderer S, Wipper E (1978). Factors affecting the endogenous urea-N secretion and utilization in the gastrointestinal tract. In: Ruminant Digestion and Food Evaluation. (eds) Osbourn DF, Beever DE, Thomson DJ. Agricultural Research Council. London., pp 4.1-4.2.

Marini JC, ME Van Amburgh (2005). Partition of nitrogen excretion in urine and the feces of Holstein replacement

heifers. J. Dairy Sci., 88: 1778-1784.
Mousa HM, Abbas AM, Lechner M, Doll Wv, Engelhardt (1994). J Camel Pract. Res., 1: 122-124.
San Martin F, Bryant FC (1989). Nutrition of domestic South American llamas and alpacas. Sm. Rum. Res., 2: 191-216.
Shams A (2011). Combat degradation in rain fed areas by introducing new drought tolerant crops in Egypt. Int. J. Water Resources and Arid Environ., 1: 318-325.
Vallenes A, Stevens CE (1971). Volatile fatty acid concentration and pH of llama and guanaco forestomach digesta. Cornell Vet., 61: 239-252.