Effects of *Morinda Citrifolia* (Noni) Pulp on Growth Performance and Stress Responses of Growing Cattle

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Story in Brief

The pulp of *Morinda citrifolia* (Noni), a Tahitian plant known to reduce stress and improve immunity in lab rats, was fed to growing cattle. Thirty crossbred beef calves (578 lb) were limit-fed diets that were top-dressed with 0, 1, or 2% Noni pulp for 28 d. Every 4 d, cattle were weighed, bled, and assessed for subjective and objective excitability scores. Average daily gain increased linearly ($P = 0.03$) as the percentage of Noni in the diet increased from 0 to 2%. Cattle tended to gain more efficiently, as the feed to gain ratio decreased linearly ($P = 0.08$), with increasing Noni addition. Noni-fed cattle also were healthier, as indicated by the decreasing concentration of white blood cells in the blood with increased Noni concentration (linear; $P = 0.01$). Control cattle had similar serum cortisol concentrations to those fed Noni pulp ($P = 0.22$). Exit velocity, as well as subjective pen and chute excitability scores, also was not affected ($P \geq 0.05$) by the addition of Noni to the diet. Therefore, we concluded that Noni has the potential to improve growth in growing cattle.

Introduction

Morinda citrifolia, more commonly known as the Noni plant, is a medicinal evergreen found in tropical areas, specifically the islands of Polynesia. The native peoples of the islands have used the roots, stems, bark, leaves, flowers, and fruit of the Noni plants as medicine as well as a source for food, juices, and dyes. Commercially, Noni juice is marketed as an alternative herbal remedy for several illnesses in humans including cancer, arthritis, diabetes, ulcers, and depression. Furthermore, Noni products are endorsed by several well-known equestrians as supplements for performance horses competing in physically grueling events, and research indicates that Noni extract has an analgesic effect on rats.

Improving the reaction of cattle to stress factors has the potential to decrease the percentage of cattle that develop the dark-cutting condition. Caused by the depletion of glycogen antemortem, this condition costs the beef industry $132 to $170 million/year. In addition to the obvious cost of dark-cutting beef, the expense of excitable cattle also is evident in non-quantifiable measures. In the feeding and processing facility, calm cattle are less likely to cause worker injuries or bruises to their pen-mates. Cattle with calm temperament scores had greater ADG than cattle with more excitable temperaments (Voisinet et al., 1997b), and excitable cattle have been shown to produce steaks with higher Warner-Bratzler shear force values, indicating tougher beef (Voisinet et al., 1997a; King et al., 2005).

The objective of this study was to determine the effects of feeding the pulp from *Morinda citrifolia* on feeder cattle temperament scores, production traits, and stress indicators in the blood.

Experimental Procedures

Thirty crossbred beef calves (6 steers and 24 heifers, Brangus cross dams with Charolais sires) were obtained from a local cattle producer. Cattle were transported to the facility and allowed to adapt to the feeding pens and diet for 2 wk before the start of the study. On d –2, calves were weighed (578 ± 10.6 lb), then blocked by gender and body weight (BW; 5 blocks). Calves within a block were assigned randomly to pens (2 calves/pen, 3 pens/block). Treatments were assigned randomly within blocks to pens. The 3 treatments were no supplemental Noni, or 1 or 2% feed intake (as fed basis) of Noni. Noni was analyzed to contain 8.3% DM, and 8.5% CP, 0.63% fat, 21% NDF, 18% ADF, and 15.4% ash (DM basis). Cattle were fed 2.75% of their initial BW (Table 1). Therefore, the doses of Noni were 0, 0.0275, and 0.055% of initial BW. Calves were fed a grain mix (75% of intake) at approximately 0900, and the appropriate amount of Noni was top-dressed onto this feed each morning. At approximately 1400, hay was fed (25% of intake). Calves were housed in 12 ft × 98 ft pens with a 10-ft concrete feedbunk in the front of each pen. Calves had ad libitum access to water.

Calves were sampled every 4 d for the 28-d study. At 0800 each sampling day, calves were moved by pen to the working facility. Beginning at the easternmost pen, 2 observers opened the rear gate. Observers did not enter the pen with the calves, but instead walked on the outside of the east side of the pen. Observers walked quietly past the calves, and without consulting one another, each observer recorded a pen score for each calf (Table 2). Observers moved into that pen (behind the calves) and moved calves to the crowding pen and alley system in the working facility barn (approximately 430 ft). After each pen was caught in the crowding pen, observers returned to the barn and consistently repeated the process until all 15 pens had been moved.

Upon arrival at the working facility, calves were moved as quickly and quietly as possible through the alley; excessive noise, etc. was discouraged. When put on the scale before the chute, individual calves were scored (chute score, Table 2) within 1 min; 2 people made these observations without consulting each other. After the chute score was assigned, BW was recorded. Calves were caught in the chute and blood collected via jugular venipuncture. Blood was collected in a plain glass vacuum tube for serum cortisol. On d

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0, 4, 8, 12, 20, and 28 a vacuum tube containing EDTA (ethylenediaminetetraacetic acid) for differential and total blood cell counts also was collected. Before exiting the chute, a bar was placed in close proximity to the rear of the calf so that it could not back up. Exit velocity of the calf was measured electronically (Polaris Wireless Timer; FarmTek, Inc.; Wylie, Texas) over a 6 ft distance beginning 6 ft in front of the head gate.

Blood samples were stored on ice prior to centrifugation at 2,100 × g for 20 min for separation of serum. Serum was stored frozen until used to analyze for cortisol concentrations by radioimmunoassay (DPC, Los Angeles, Calif.), with intra- and interassay CV of 2 and 9.1%, respectively. An automated system (Hemavet 1500, CDC Technologies Inc., Oxford, Conn.) was used for determination of the total and differential cell counts, hematocrit, and hemoglobin. Samples were analyzed within 24 h of collection.

Data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, N.C.). Pen means were used for all analyses. The model for the performance data included dietary treatment as a fixed effect and BW block as a random effect. Contrast statements were used to test the linear and quadratic effects of Noni addition. Prior to statistical analyses, observations from both observers were averaged to obtain pen and chute scores. Blood data, exit velocities, and pen and chute scores were analyzed using the repeated statement with a SP (POW) covariance structure and pen as the subject. The model included BW block, treatment, day, and the day by treatment interaction as fixed effects.

Results and Discussion

Noni-supplemented diets increased ADG linearly ($P = 0.03$) as the percentage of Noni-pulp in the diet increased from 0 to 2% (Table 3). The efficiency of gain also improved linearly ($P = 0.08$) with increased Noni levels in the diets (Table 3). Although the effects of Noni pulp on gain in cattle have not been previously researched, cattle with calmer temperaments have been shown to have greater ADG (Voisinet et al., 1997b), and Noni juice has been shown to have calming effects on other mammalian species (Wang et al., 2002). The addition of Noni pulp was applied as a top-dressing, thus the caloric intake of the diets was potentially not balanced between treatments. The digestibility of the Noni pulp is unknown. However, assuming that Noni is completely digestible, the additional calories provided by the Noni pulp would not have been great enough to account for the differences observed in weight gain.

The addition of Noni pulp to the diets did not cause refusal of the diets as evidenced by the similarities in feed intake ($P = 0.54$) among the treatments. Because the cattle were offered a fixed amount of feed (2.75% of BW), it is not known how Noni might affect ad libitum feed intake.

The concentration of white blood cells decreased linearly ($P = 0.01$) with the inclusion of Noni in the diet (Table 4). Furthermore, there was a quadratic relationship between monocytes and Noni dose ($P = 0.0004$) with the cattle fed 1% Noni having the largest percentage of monocytes. The relationship of Noni dose and eosinophils also was quadratic with a similar pattern ($P = 0.01$). No time × treatment interactions existed for total white blood cells or percentage of neutrophils, lymphocytes, monocytes, and eosinophils. There was a time × treatment interaction ($P < 0.01$) only for the percentage of basophils (Figure 1). Cattle supplemented with 2% Noni pulp had a large increase in the percentage of basophils on d 4 and 8 with no differences between the treatments on d 12 or later. The biological significance of this observation is unknown. The addition of Noni pulp did not affect the neutrophil to lymphocyte ratio, red blood cell counts, hemoglobin concentration, or hematocrit. Wang et al. (2002) noted the antibacterial and immunological activities of Noni plant extracts, but specific effects of Noni products on white blood cell counts in cattle have not been previously studied. The neutrophil to lymphocyte ratio has been used as an indicator of stress in cattle, with the ratio increasing in a stressed animal.

Noni pulp treatments did not affect serum cortisol ($P = 0.22$) concentrations at any time during the study (Figure 2). No previous research has been conducted on the effects of Noni products on cortisol concentrations in cattle. King et al. (2005) found numerical, but no statistical differences in cortisol concentrations between calm and excitable yearling-fed and calf-fed steers after the cattle had been on feed. In our study, there was variability between days ($P < 0.0001$) in serum cortisol concentrations, but no consistent trend could be identified.

Exit velocity also is used as a measure of excitability and has been correlated to gain and tenderness when measured in young cattle not exposed to human contact (Falkenberg et al., 2005; King et al., 2005). Nevertheless, adding Noni to the diet did not affect ($P > 0.05$) exit velocity scores (Figure 3), nor did time on feed and exposure to handling, as exit velocity times did not change ($P > 0.05$) with time. Falkenberg et al. (2005) found that exit velocity scores in yearling-fed cattle were not related to gain. This was in contrast to the present study, as the cattle were young and unexposed to human contact and the exit velocity scores did not improve with time.

Objective pen and chute scores were not affected ($P > 0.05$) by the inclusion of Noni pulp in the diet (Figure 4). Although there was no interaction ($P > 0.05$) between day of sampling and Noni pulp treatment, both pen and chute score decreased ($P < 0.0001$) with time, indicating that the cattle became calmer as the study progressed. No previous research has been conducted with Noni products in cattle, but rats have shown much calmer, less stressed demeanors when fed Noni (Wang et al., 2002). When Noni juice was supplemented in the drinking water for rats at 5, 10, and 20% for 10 d, animals were more tolerant than controls of antimony potassium tartrate-induced pain in a dose-dependent manner (Wang et al., 2002). In a separate study, female rats with Noni supplemented at 10 and 20% in their drinking water for 7 d were less reactive to hot-plate induced pain than control rats (Wang et al., 2002). Moreover, Younos et al. (1990) found that, in addition to being more pain tolerant, rats fed aqueous extracts from the roots of Morinda citrifolia showed less locomotor activity than controls in several tests. These researchers linked the sedative effect of Noni to its central analgesic effect.

In conclusion, cattle supplemented with Noni had greater gains and gained more efficiently than controls. The improvement in growth may be attributed to improved immune function. Noni-fed cattle were healthier, indicated by lower white blood cell concentrations. The effects of Noni juice on stress factors were not observed in stress and excitability measures such as neutrophil to lymphocyte ratio, serum cortisol, exit velocity, or subjective pen and chute scores.

Implications

This study should be the first of many investigating the effects of *Morinda citrifolia* (Noni) on large, domestic mammals. Further studies should examine the effects of Noni on grass-fed cattle in cow-calf and stocker operations, feedlot cattle, as well as various levels of pork production. Noni may have the potential to decrease the incidence of dark cutters in beef and the pale, soft, and exudative condition in pork.

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Table 1. Composition of diet (as fed basis).

Ingredient	%
Bermudagrass hay	25
Corn	47.92
Soybean meal	5.6
Wheat midds	15
Molasses	3.75
Fat	1
Salt, white	0.3
Limestone	1.35
Vitamin premix[a]	0.05
Trace mineral premix[b]	0.03
Rumensin[c]	+

[a]Premix contained 1,710,000 IU vitamin A, 343,000 IU vitamin D, and 11,600 IU vitamin E/lb.
[b]Premix contained 12% Zn, 8% Mn, 4% Cu, 500 ppm Co, 2,000 ppm I, and 600 ppm Se.
[c]Provided 11.25 mg of monensin/lb of diet.

Table 2. Description of criteria used to assign behavior scores.

Item	Score	Description
Pen scores	1	Walks slowly, can be approached slowly, not excited by humans
	2	Runs along fences, stands in corner if humans stay away
	3	Runs along fences, head up and will run if humans come closer, stops before hitting gates and fences, avoids humans
	4	Runs, stays in back of group, head high and very aware of humans, may run into fences and gates
	5	Excited, runs into fences, runs over anything in its path
Chute scores	1	Calm – no movement
	2	Restless shifting
	3	Squirming, occasional shaking of weigh box
	4	Continuous vigorous movement and shaking of weigh box
	5	Criteria for a score of 4, plus rearing, twisting, or violently struggling

Table 3. Growth performance, feed intake, and feed to gain ratio of calves supplemented with Noni[a].

	Noni, % of diet (as fed)				*P* value	
Item	0	1	2	SE	Linear	Quadratic
Initial BW, lb	569	563	570	25.6	0.92	0.49
Final BW, lb	609	608	625	29.6	0.18	0.34
ADG, lb	1.42	1.60	1.95	0.194	0.03	0.61
Daily feed intake, lb	15.9	15.9	15.8	0.69	0.54	0.89
F/G	12.0	10.8	8.2	1.38	0.08	0.71

[a]Noni is the pulp of *Morinda citrifolia*, a Tahitian plant.

Table 4. Blood cell counts, hemoglobin, and hematocrit of calves supplemented with Noni[a].

	Noni, % of diet (as fed)				*P* value	
Item	0	1	2	SE	Linear	Quadratic
White blood cells, 1,000/µL	13.2	11.1	10.6	0.53	0.01	0.27
Neutrophils, %	35.4	34.7	36.9	1.8	0.59	0.54
Lymphocytes, %	54.7	52.5	54.2	1.7	0.84	0.37
Monocytes, %	5.6	7.0	5.4	0.21	0.51	0.0004
Eosinophils, %	3.9	5.2	3.2	0.37	0.19	0.01
Neutrophil:lymphocyte ratio	0.68	0.68	0.71	0.053	0.73	0.82
Red blood cells, 1,000,000/µL	10.8	10.7	10.3	0.22	0.14	0.49
Hemoglobin, g/dL	12.1	12.3	11.5	0.33	0.24	0.30
Hematocrit, %	41.2	42.3	39.7	1.05	0.34	0.20

[a]Noni is the pulp of *Morinda citrifolia*, a Tahitian plant.

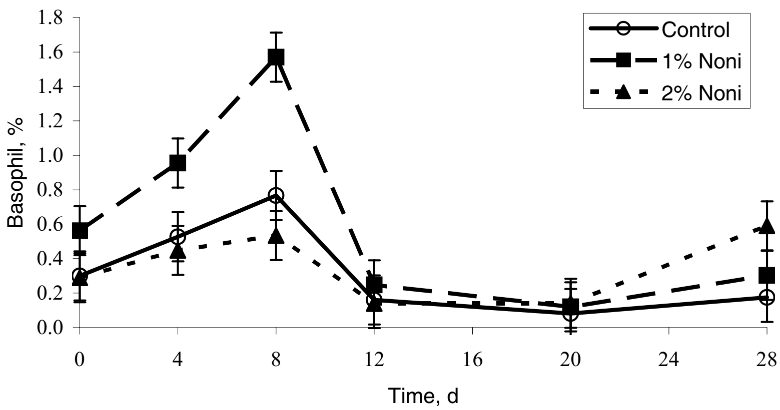

Fig. 1. Effect of supplemental Noni on percentage of basophils in whole blood (treatment, *P* = 0.02; day, *P* < 0.001, treatment × day, *P* = 0.01)

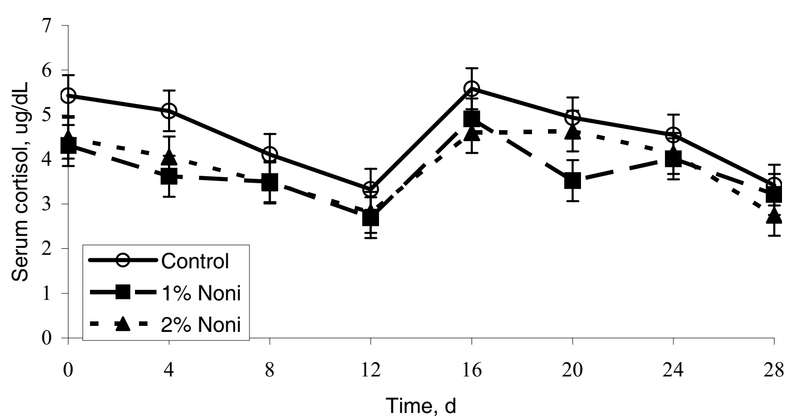

Fig. 2. Effect of supplemental Noni on serum cortisol concentrations (treatment, *P* = 0.22; day, *P* < 0.0001; treatment × day, *P* = 0.18).

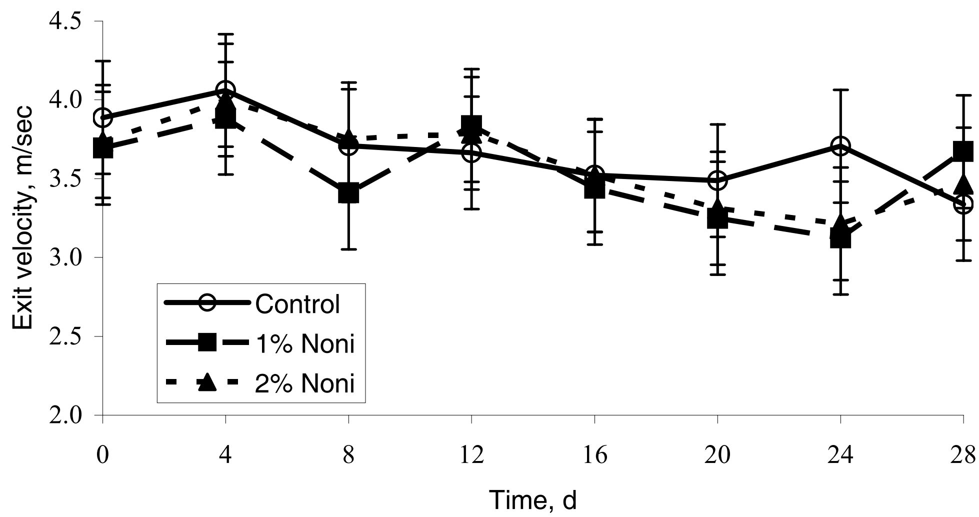

Fig. 3. Effect of supplemental Noni on chute exit velocity (treatment, *P* = 0.92; day, *P* = 0.21; treatment × day, *P* = 0.93).

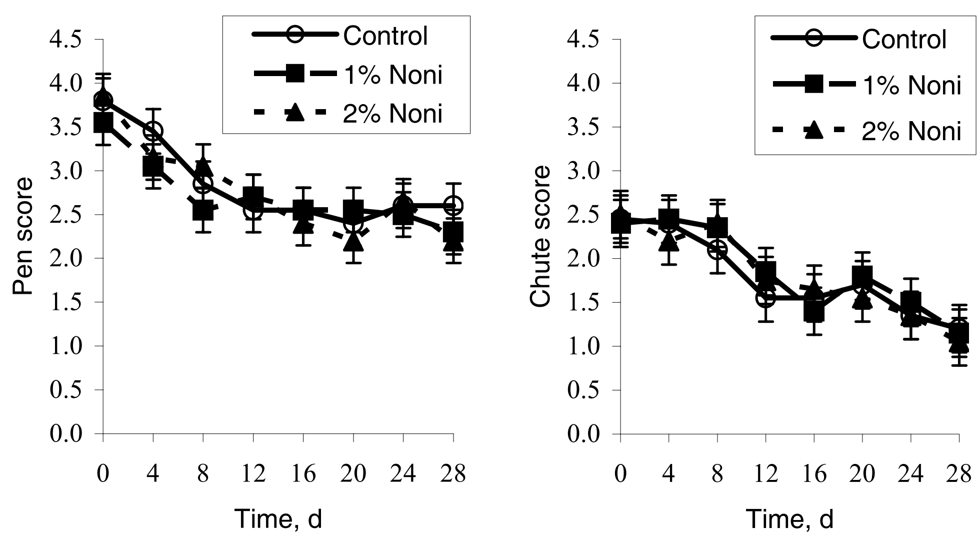

Fig. 4. Effect of supplemental Noni on pen and chute scores (treatment, *P* ≥ 0.81; day, *P* < 0.0001; treatment × day, *P* ≥ 0.80)