DEVELOPING SUSTAINABLE DIETS FOR RABBITS: EFFECT OF SWEET POTATO FORAGE ON GROWTH AND FEEDING TRAITS

Garza M.T.[1], Lukefahr S.D.[1*], Schuster G.L.[2], McCuistion K.C.[1]

[1] Dept. of Animal, Rangeland and Wildlife Sciences and [2] Dept. of Agriculture, Agribusiness, and Environmental Sciences, MSC 228, Texas A&M University, Kingsville, TX 78363, USA
[*]Corresponding author: s-lukefahr@tamuk.edu

ABSTRACT

The objective of this two-year investigation was to develop a sustainable feeding system involving diets for growing rabbits based on sweet potato (SP) forage (leaves with vines) with limited commercial feed or energy supplements that could potentially benefit smallholder families. Diets evaluated in 2010 consisted of: 1) commercial pellets, 2) 24-hr wilted SP forage plus half of the commercial pellets consumed by control animals on the previous day, and 3) 24-hr wilted SP forage with crimped oats. In 2011, diets were: 1) commercial pellets, 2) 24-hr wilted SP forage with crimped oats, and 3) SP hay made by exposing harvested forage in a drying room or in open sunlight for approx. 4 d with crimped oats. Forage was offered to rabbits on an *ad libitum* basis. Diets were evaluated based rabbit performance. The duration of the 2010 and 2011 studies were 35 and 28 d. Breed types were crossbred and New Zealand White (NZW). The 2010 study involved 54 NZW and crossbred rabbits from 15 litters with initial age ranging from 51 to 57 d. The 2011 study involved 45 NZW and crossbred rabbits from 12 litters with initial age ranging from 54 to 56 d. All pens contained three rabbits of the same breed type but different litters. A mixed-model was used to analyze growth and feeding traits that included the source of litter as random blocks. Chemical analyses revealed that DM varied for commercial pellets, SP wilted and hay as forage, and crimped oats at 92.9, 14.5, 48.0, and 92.8%, respectively. Leaves from SP had numerically higher CP (32.5 *vs.* 17.7%) but lower gross energy (3.45 *vs.* 4.34 mcal/kg) than commercial pellets. Also, the NDF value was lower for SP leaves than pellets (16.0 *vs.* 38.3%), but ADF and ADL values were numerically similar. The Ash content of SP leaves was higher than for pellets (15.5 *vs.* 9.6%). In both years, initial BW means were similar ($P>0.05$) across diets. Mean ADG was more rapid and final BW was heavier for controls than for forage fed groups ($P<0.0001$). For pen traits in 2010, controls consumed an average of 96.9 g/d of pellets, while the wilted SP with 50% pellets group consumed an average of 48.2 g/d of pellets ($P<0.05$). The average rabbit DM intake of wilted SP forage with 50% pellets and without pellets was 17.5 and 26.5 g/d, respectively ($P<0.05$). In 2011, average rabbit DM intake was highest ($P<0.05$) for pellets and lowest for wilted SP and intermediate for SP hay. In 2010, no differences were detected ($P>0.05$) among diets for gross feed efficiency. However, for the 2011study, gross feed efficiency was significantly different among all three diets. In conclusion, despite superior growth performance of controls fed commercial pellets, the cost of SP forage was considerably lower (economic analyses not reported in this paper) and growth performance was satisfactory, which warrants further investigation.

Key words: Rabbits, forages, growth, sweet potato, sustainability.

INTRODUCTION

In recent years, the precarious global economy, rising food and fuel prices, and the deteriorating environment have dramatically redirected lines of agricultural research that have been felt even by rabbit scientists. Terms such as appropriate technology, sustainability, organic, green, and stewardship have become mere buzz words due to their overuse in popular and scientific literature. Nonetheless, rabbit research in southeast Asia by Doan Thi Gang et al. (2006) and Nguyen Van Thu and Nguyen Thi Kim Dong (2008) have studied the feeding of sweet potato (SP) forage with rice bran to growing rabbits, which has shown considerable promise as a sustainable and low-cost diet for increasing farmer

profits. SP forage is inexpensive to produce when grown in family gardens or plots. In addition, SP leaves contain about 30% CP, which exceeds the 16% CP requirement for growing rabbits (NRC, 1977).

The work of this paper represents three years of research involving the feeding of SP forage to growing rabbits in the summer season. Results of the first year involved the comparison of three SP varieties (White Triumph, Centennial, and Georgia Jet) based on both adaptive characteristics and rabbit performance (Lukefahr et al., 2010). The objective of this paper is to present results from the second and third years of research that aimed at developing a sustainable, low-cost feeding system for growing rabbits based on SP forage with potential benefits to small-scale, limited-resource families.

MATERIALS AND METHODS

Study site, forage plots, diets, and animals

The study area (27˚ 36' N, 97˚ 57' W) is considered semi-arid and sub-tropical during the summer season. Plots of sweet potato (SP) forage were established in April of 2010 and 2011 at the Agricultural Farm of Texas A&M University-Kingsville (TAMUK). The Centennial commercial variety of SP was purchased as transplants (slips) from Willhite Seed Inc., Poolville, TX. The plot areas were 12 X 12 and 9.1 X 30.5 m^2 in 2010 and 2011. An approx. 30.5 cm slip spacing existed between plants and rows. All cultural practices, including irrigation and fertilization, were made according to commercial production protocols. At maturity, plots were hand-harvested. SP forage consisted of leaves with vines that were collected and sun dried for 24 h and offered *ad libitum* to growing rabbits. Diets evaluated in 2010 consisted of: 1) commercial pellets fed *ad libitum*, 2) 24-hr wilted SP forage plus half of the commercial pellets consumed by control animals on the previous day, and 3) 24-hr wilted SP forage with crimped oats (35 g/rabbit/d). In 2011, diets were: 1) commercial pellets fed *ad libitum*, 2) 24-hr wilted SP forage with crimped oats, and 3) SP hay made by exposing harvested forage in a drying room or in open sunlight for approx. 4 d with crimped oats. The length of the feeding period (following a 7-d adaptation period to diets) was 35 and 28 d for 2010 and 2011 studies, respectively. SP forage was fed in commercial aluminum feeders (Bass Equipment Co., Monett, MO) mounted to the front of the pen. Rabbits had access to water at all times *via* automatic water valves. Trace-mineralized blocks (Lixit Corporation, Napa, CA) were made available to all forage fed pens of rabbits. The control group was a commercial pelleted diet (Nutrena Rabbit Pellets, Cargill-Nutrena Feeds Division, Minneapolis, MN), formulated to meet nutrient requirements (NRC, 1977). Samples of pellets, SP forage, and crimped oats were collected and analyzed for chemical composition by Proximate Analysis (AOAC, 1990).

At the TAMUK Rabbit Research Unit, weaned rabbits were randomly allocated into commercial pens (dimensions of 76.2 x 76.2 x 45.0 cm). Breed types were crossbred (a composite of over eight breeds) and New Zealand White (NZW). Pens contained three rabbits. In 2010, random samples of three rabbits from each of twelve crossbred litters, six rabbits from one crossbred litter, and six rabbits from each of two NZW litters were made for a total of 54 rabbits (six pens per diet) with initial age ranging from 51 to 57 d. For the three litters of six littermates, two were randomly assigned to the same diet but to different pens. Twelve out of eighteen pens contained one NZW rabbit. In 2011, random samples of three rabbits from each of six crossbred litters, six rabbits from three crossbred litters, and three rabbits from three NZW litters were made for a total of 45 rabbits (five pens per diet) with initial age ranging from 54 to 56 d. To balance litter effects across diets and pens, rabbits were randomized with the restriction that only one or two littermates were assigned to the same diet, but no littermates were assigned to the same pen.

Traits measured and statistical analysis

Both experiments were initiated in June. Individual BW was recorded weekly over the experimental feeding periods. Daily DM feed intake and 24-h refuse weights of pellets, forage, and crimped oats were recorded daily and summed weekly. Gross feed conversion ratio (total DM feed intake/total weight gains) was calculated for each pen. Data were subjected to analysis of variance using Mixed

Model procedures (SAS, 2003). For BW traits, the model consisted of fixed effects of breed-type, diet, and breed-type X diet interaction, whereas random effects were the nested effect of the litter within breed-type, random litter within breed-type X diet interaction, and random error. The random litter source was used as the appropriate error line for testing the breed-type source, and the litter within breed-type X diet interaction source was used as the appropriate error line for testing the diet and breed-type X diet interaction sources. To justify our model, it is well documented that litter is a major source of variation for growth traits in rabbits. While randomly distributing litters across treatments generally balances for this effect, adding it to the model may also improve experimental precision and reduce the probability of Type II error. For pen traits in 2010 – pellet and forage DM intake and gross feed efficiency - the model was a one-factor analysis with sources of fixed diet and random pen within diet as error. For pen traits in 2011, the model was a two-factor analysis with sources of fixed diet, breed, and diet X breed interaction and random pen within diet X breed subclasses as error. It should be noted that because there was only one pen of NZW rabbits for each diet, error consisted entirely from records of crossbred pens. In all models, random effects were assumed to be normally and independently distributed. Least-squares means were tested for significance at the $P<0.05$ probability level using the method of Tukey-Kramer.

RESULTS AND DISCUSSION

In 2010 and 2011, during the experimental period, mean outside maximum temperature approached or exceeded 40 °C and mean minimum humidity was 80%, typical of tropical conditions. Chemical analyses revealed that DM varied for commercial pellets, SP wilted and hay as forage, and crimped oats at 92.9, 14.5, 48.0, and 92.8%, respectively. Leaves from SP had numerically higher CP (32.5 *vs.* 17.7%) but lower gross energy (3.45 *vs.* 4.34 mcal/kg) than commercial pellets. Also, the NDF value was lower for SP leaves than pellets (16.0 *vs.* 38.3%), but ADF and ADL values were numerically similar. The Ash content of SP leaves was higher than for pellets (15.5 *vs.* 9.6%). Present values on chemical composition of SP leaves and vines are in general agreement with numerous literature reports.

Individual growth and pen feed utilization performances

There were no cases of disease or mortality in both experiments. Least-squares diet means for growth and feed utilization traits are shown in Tables 1 and 2. For initial BW means, there were no differences ($P>0.05$) across diets for both years. Final BW means were heavier ($P<0.0001$) for pellet-fed controls than for forage fed groups in both years. In 2010, ADG performance of controls were superior, while pens fed wilted SP forage without pellets had inferior growth performance ($P<0.05$). The wilted SP with 50% pellets group was intermediate and significantly different from the other two diet groups (Table 1).

Table 1: Least-squares diet means and SE for growth and feed utilizations traits in 2010[a]

Trait	Pellets *ad libitum*	SP + 50% pellets	SP +35 g oats/day	SE	P
Initial weight, g	1226	1203	1222	62.6	0.8251
Final weight, g	2146[c]	1875[b]	1761[b]	68.0	<0.0001
ADG, g/d	26.5[d]	19.1[c]	15.4[b]	1.05	<0.0001
Pellets intake/fryer (DM), g/d	96.9[c]	48.2[b]	-	2.19	<0.0001
Forage intake/fryer (DM), g/d	-	17.5[b]	26.5[c]	0.13	<0.0001
Gross feed efficiency	3.88	3.75	4.26	0.18	0.1355

In 2011, the ADG mean of controls was significantly different from both forage-fed groups. Nonetheless, the growth rates in both forage-fed groups exceeded 20 g/d which is considered satisfactory for tropical environments (Table 2). Studies conducted in Vietnam have shown that ADG performance was 15.8 g/d in one experiment (Nguyen Van Thu and Nguyen Thi Kim Dong, 2008), but ranged from 20.2 to 21.3 g/d in three other experiments (Doan Thi Gang et al., 2006; Le Thi Lan

Phuong, 2008; Nguyen Kien Cuong et al., 2008), the latter reports being more consistent with our results in 2011 (Table 2).

Table 2: Least-squares diet means and SE for growth and feed utilization traits in 2011[a]

Trait	Pellets *ad libitum*	Wilted SP + oats	SP hay + oats	SE	P
Initial weight, g	1505	1519	1525	47.8	0.8140
Final weight, g	2457[c]	2298[b]	2287[b]	53.9	0.0009
ADG, g/d	25.2[c]	21.0[b]	20.6[b]	0.85	<0.0001
Feed intake/fryer (DM), g/d	105.0[d]	53.6[b]	74.8[c]	1.17	<0.0001
Gross feed efficiency	4.46[d]	2.77[b]	3.97[c]	0.14	<0.0001

[a] Diets were commercial pellets (control), 24-h wilted sweet potato (SP) forage, and SP hay forage. Pens of rabbits given forage were fed 35 g of crimped oats per animal per day.
[bcd] Means with different letters in the same row differ significantly (P<0.05) from Tukey-Kramer test.

For pen traits in 2010, controls consumed an average of 96.9 g/d of pellets, while the wilted SP with 50% pellets group consumed an average of 48.2 g/d of pellets (P<0.05; Table 1). The average rabbit DM intake of wilted SP forage with 50% pellets and without pellets was 17.5 and 26.5 g/d, respectively (P<0.05). In 2011, average rabbit DM intake was highest (P<0.05) for pellets and lowest for wilted SP and intermediate for SP hay. It is interesting to note that while more feed was consumed by rabbits in SP hay *vs.* wilted group, there was no difference in mean ADG performance. In 2010, no differences were detected (P>0.05) among diets for gross feed efficiency. However, for the 2011study, gross feed efficiency was significantly different among all three diets. Paradoxically, gross feed efficiency was numerically better for the pellets *vs.* the SP wilted group in 2010, but for 2011 the reverse trend was observed between the same two diets, suggesting diet by year interaction. If true, the nature for this interaction is unknown. Our values for gross efficiency are consistent with lower values ranging from 3.91 to 7.69 from studies conducted in Vietnam involving feeding of SP forage (Doan Thi Gang et al., 2006; Nguyen Kien Cuong et al., 2008; Nguyen Van Thu and Nguyen Thi Kim Dong, 2008).

CONCLUSIONS

Under ideal conditions, to sustain a small-scale rabbit enterprise, families provide labor to cultivate and harvest plots of sweet potatoes and procure agricultural and(or) cereal grain by-products as on-farm energy supplements, being functionally integrated to produce fertilizer from composting animal and plant “wastes”. Herein, the only real cost may be the purchase of sweet potato slips and a limited quantity of cereal grain by-products from the marketplace. In conclusion, based on present encouraging results, further research is needed involving the feeding of only sweet potato forage with an energy supplement, such as crimped oats or rice bran, or even SP tubers themselves. Another useful study would involve the feeding of a similar forage diet to breeding does with litters. In the face of the global economic crisis, diminishing fossil fuel supplies, global warming, and rising societal concerns of feeding cereal grains to livestock, it is all-the-more important for scientists to develop complete livestock diets using local feedstuffs from on-farm resources that include family garden and(or) forage plots.

ACKNOWLEDGEMENTS

The authors express their gratitude to Katelyn Curry, Avan Guerra, David Johnson, Lauren Lambert, and Ruby Saldana for their assistance in forage harvesting and feeding and other data collection activities. This research was supported by a grant through the University Research Awards program at TAMUK. The authors express their gratitude to Katelyn Curry, Rita Flores, Avan Guerra, Michelle Honeycutt, Zachary Hubert, David Johnson, Lauren Lambert, Richard Rosa, Ruby Saldana, and Jackie Zradicka for their assistance in forage harvesting and feeding and other data collection activities and laboratory analysis of feed samples.

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