SELF-SUSTAINING RABBIT PROJECTS : A PILOT STUDY INVOLVING FEEDING OF SWEET POTATO FORAGE

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Summary

The objective of a pilot study was to develop a sustainable feeding system involving diets for growing rabbits based on sweet potato (SP) forage with limited commercial feed that could be of potential benefit to small-scale farmers. Three commercial varieties of SP: White Triumph (WT), Centennial (Cen), and Georgia Jet (GJ), were evaluated based on chemical composition and rabbit performance. Thirty-six crossbred rabbits were randomly assigned to pens as replicates with each pen containing three rabbits, which were fed for 28 days on either a commercial pelleted diet (control) or wilted SP leaves with vines (offered *ad libitum*) with 50% pellets (consumed by controls on the previous day) and 35 g of crimped oats per rabbit per day. Individual growth traits were analyzed according to a statistical model that consisted of effects of litter as a random block, fixed diet, random pen nested within diet, and random within-pen error. Proximate analyses revealed that both SP leaves and vines had numerically higher CP but lower gross energy than commercial pellets. NDF and ADF values were higher for pellets compared to SP leaves. However, NDF values were more similar between pellets and SP vines, although ADF values were somewhat lower for pellets compared to SP vines. ADL was numerically lower for pellets compared to SP leaves. Initial body weights (BW) were similar across diets (P=0.8194). Final BW means were not statistically different between controls and Cen, whereas differences existed (P<0.05) between controls and WT and GJ forage groups. Diet means for ADG were not significantly different. Forage intake of pens was lower (P<0.001) for WT compared to Cen and GJ varieties; however, Cen and GJ varieties had poorer gross feed efficiency than controls, while no difference existed between WT and controls. Although mean live pre-harvest weights varied (P=0.0424) by diet, dressing percentages and emptied digestive tract and cecum percentages were similar across diets. Abdominal fat percentages were numerical lower for forage fed rabbits compared to controls. In conclusion, further research is needed involving the feeding of only SP forage with an energy supplement.

Key words: Rabbits, Forages, Growth, Sustainability, Tropical agriculture.

Introduction

On the occasion of the 8th World Rabbit Congress, Lukefahr (2004) presented a paper on broad aspects of developing sustainable rabbit projects. More recently, papers have been published (Lukefahr, 2007a,b) on stages of rabbit project development and strategies for designing sustainable small- and medium-scale rabbit enterprises. However, according to numerous literature reports, and in the experiences of the author, perhaps the greatest constraint to project success is diet quality. To develop truly sustainable rabbit projects, it is imperative that farmers utilize on-farm, high quality feed resources. Lebas (1983) reported that for small-scale operations, farmers can sustain rabbits from wild or cultivated plants, weeds or forbs, shrubs, and garden and kitchen refuse. Also, Cheeke (1986) stated that rabbits can be sustained on diets comprised entirely of forages and agricultural by-products.

Raising meat rabbits using locally grown forages can be a sustainable goal for family food production. Moreover, due to the worsening global economy, many Americans are now planting gardens, and there is a growing demand for rabbit breeding stock. In fact, during World War II, a record rabbit population existed in the U.S. because much of the domestic beef and pork supplies were exported to support our troops (Templeton, 1968). Many families combined their "victory garden" with raising rabbits to produce enough food to eat. Traditionally in Europe, rabbits are largely fed forages from plots and garden "wastes" (e.g., husks, leaves, peelings, roots, and vines). The manure is recycled as compost as inexpensive fertilizer for the family garden. Also, global consumer interest is rapidly growing in both natural and organic food products.

Recent innovative studies (Doan Thi Gang et al., 2006; Nguyen Van Thu and Nguyen Thi Kim Dong, 2008) conducted in Vietnam, involving the feeding of sweet potato forage and rice bran as an energy supplement to growing rabbits, have shown considerable promise. The impetus for this research has been the spread of Asian Bird Flu and rising costs of imported cereal grains, negatively impacting the poultry industry. Sweet potato forage is inexpensive, being grown in family backyards (even in city limits). Also, sweet potato leaves contain about 30% crude protein; growing rabbits require only 16% crude protein (NRC, 1977).

The objective of this paper is to present results on a sustainable and integrated feeding system involving diets for growing rabbits based on sweet potato forage with limited commercial feed that could be of potential benefit to small-scale, limited-resource farmers.

Materials and Methods

Study Site, Forage Plots, and Animals

The study area (27˚ 36' N, 97˚ 57' W) is considered semi-arid and subtropical. Plots of sweet potato forage were established in April of 2009 at the Kika de le Garza - Plant Materials Center, which is adjacent to the Agricultural Farm of Texas A&M University-Kingsville (TAMUK). Three commercial varieties of sweet potato (White Triumph, Centennial, and Georgia Jet) were purchased as transplants (slips) from Willhite Seed Inc., Poolville, TX. Varieties have a 90-day maturation period. Plot length was 8 rows by 200 feet (60.96 m) for a total of 15,680 slips per acre (0.405 ha) at 12 inch (30.5 cm) slip spacing. All cultural practices, including irrigation and fertilization, were made according to commercial production protocols. Plots were maintained for foliage production. At maturity, plots were hand-harvested. Leaves with vines were collected and sun dried for 24 h and offered *ad libitum* to growing rabbits. Samples of pellets and sweet potato leaves with vines 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 cages (dimensions of 76.2 x 76.2 x 45.0 cm). Each of the three sweet potato varieties was evaluated based on performance of rabbits in three cages as replications with each cage containing three rabbits. A control group consisted of three cages of rabbits receiving only a commercial pelleted diet fed *ad libitum* (Nutrena Rabbit Pellets, Cargill-Nutrena Feeds Division, Minneapolis, MN), formulated to meet nutrient requirements (NRC, 1977). The original study design was to offer rabbits an *ad libitum* supply of sweet potato forage with 35 g/head/d of crimped oats as an energy supplement. However, before initiating the study, due to a severe drought with high ambient temperatures, it became evident that yields of sweet potato forage may be quite limited, and so the decision was made to provide 50% of the quantity of commercial pellets as consumed by pens of control animals on the previous day. Sweet potato forage was fed in commercial aluminum feeders mounted to the front of the cage. Rabbits had access to water at all times *via* automatic water valves. Trace-mineralized salt blocks were made available to all forage fed groups of rabbits.

The study involved thirty-six crossbred rabbits from six litters that were obtained from a local commercial breeder. Age ranged from 52 to 54 d. Six rabbits were randomly sampled per litter. Mean BW was 1,299 g (range of 1,024 to 1,616 g). To balance litter effects across diets and pens, rabbits were randomized with the restriction that only two littermates were assigned to the same diet, and that no littermates were assigned to the same pen.

Traits Measured

The experiment was initiated on June 12, 2009, following a 7-d adaptation period to diets. Daily intake and 24-h refuse weights of pellets and forage were recorded daily and summed weekly. Individual BW was recorded weekly. On week three of the experiment, mean BW first exceeded 1,800 g (4 pound minimum market weight). It was then decided to terminate the study one week later (July 10, 2009). Gross feed conversion ratio in pens was calculated over the total 28-d experimental feeding period. Carcass data (n=12) were collected with one rabbit being randomly sampled from each pen; however, randomization was restricted to two rabbits from each of six litters but with littermates being fed different diets. Following a 24-h fast of feed, rabbits were euthanized by sudden blunt force to the skull, resulting in sudden loss of consciousness (JAVMA, 1986). Carcass traits included: pre-harvest body and hot carcass weights, and dressing and pelvic fat percentages. The European style of processing carcasses was used with hot carcass weight including esophagus, head, heart, kidneys, liver, lungs, trachea, and thymus (Blasco and Ouhayoun, 1993).

Statistical Analyses

The experimental design was a Split-Plot with four diets, three cages per diet (replicates) as experimental error, and three rabbits per cage (sampling error). Data were subjected to ANOVA using MIXED model procedures (SAS, 2003). Individual growth traits were analyzed according to random litter, fixed diet, random pen nested within diet, and random within-pen error. Random effects were assumed to be NID. Carcass trait data were similarly analyzed, except random pen within diet source was eliminated. In preliminary analyses, it was observed that R^2 values were considerably higher in models when growth and carcass data were blocked for the random litter source (despite the loss of error df), accounting for some genetic and common environmental effects. It was assumed that there was no litter x diet interaction. For pen traits – pellet and forage intake and gross feed efficiency - the model was comprised of only fixed diet and random pen within diet as error. Least squares means were tested for significance at the $P<0.05$ probability level using Tukey's method.

Results and Discussion

Nutrient Composition of Experimental Diets

Typical of tropical conditions, during the 28-d experimental period, mean outside maximum temperature was 37.1 °C (range of 33.9 and 41.1 °C), mean maximum humidity was 92% (range of 84 to 100%), and mean maximum wind speed was 33.8 km/h (range of 25.7 to 45.1 km/h) (http://www.wunderground.com/history/airport/KNQI/DailyHistory.html).

In preliminary analyses, it was determined that for mean, 28-d DM content of forage (24-h wilted weight divided by fresh harvest weight) neither the effects of sweet potato variety, week of forage collection, or variety x week interaction were statistically important. Results for chemical composition of commercial pellets and sweet potato forage varieties are provided in Table 1. Proximate analyses revealed that both sweet potato leaves and vines had numerically higher CP but lower gross energy than commercial pellets. NDF and ADF values were numerically higher for pellets compared to sweet potato leaves. However, NDF values were more similar between pellets and sweet potato vines, although ADF values were somewhat lower for pellets compared to sweet potato vines. ADL was numerically lower for pellets compared to sweet potato leaves. Also, leaves compared to vines had numerically higher CP, gross energy, and ADL, and lower NDF and ADF values. Present values on chemical composition of sweet potato leaves and vines are in general agreement with numerous literature reports.

Table 1 : Chemical composition of commercial pellets and sweet potato forage (% DM)

		Sweet potato forage variety					
Item	Pellets	White Triumph		Centennial		Georgia Jet	
DM[a]	91.5	76.8		74.3		78.7	
		Leaves	Vines	Leaves	Vines	Leaves	Vines
Crude protein	17.7	31.3	21.5	32.3	25.0	31.9	22.2
Gross energy, mcal/kg	4.34	3.47	3.01	3.45	3.09	3.51	3.20
NDF	32.4	21.7	30.4	19.8	29.5	23.0	28.9
ADF	18.9	15.4	24.1	13.7	23.9	13.9	23.3
ADL	4.97	6.35	4.85	5.39	3.11	5.27	3.12
Ash	10.4	18.2	17.7	20.8	17.4	18.6	16.8

[a]For commercial pellets, DM was determined by Proximate Analysis. For sweet potato forage, DM was based on weight of wilted forage (leaves with vines) following 24 h of post-harvest sun drying. Wilted forage was fed directly to experimental rabbits.

Individual Growth and Carcass and Pen Feed Utilization Performances

Least squares diet means for growth, feed utilization, and carcass traits are shown in Table 2.

For initial body weight means, there were no differences across diets (P>0.05). Also, there were no cases of disease or mortality in the experiment. For ADG, although Tukey's method detected no significant differences among diet means, a contrast comparison was made that revealed that controls, on average, achieved more rapid gains by 2.5±1.1 g/d (P=0.0453) versus the combined gains of experimental forage fed rabbits. 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 present results. However, these studies did not involve a standard commercial diet as a control because such diets are not available. There was no statistical difference between control rabbits and those fed Centennial forage (along with restricted pellets and crimped oats) for mean final body weight (2169 vs. 2054 g), although rabbits fed White Triumph and Georgia Jet were significantly lighter than controls.

Table 2 : Generalized least squares diet means (SE) for growth, feed utilization, and carcass traits

	Control	Sweet potato forage variety[c]					
Item	Commercial pellets	White Triumph	Centennial	Georgia Jet	SE	R^2	P-value
Initial weight, g	1311	1269	1333	1284	63	0.74	0.8194
Daily gain, g/d	22.6	20.7	20.5	19.2	1.04	0.46	0.0382
Final weight, g	2169 [b]	1971[a]	2054[ab]	1952[a]	72	0.70	0.0569
Pellet intake per rabbit, g	108.5[b]	53.1[a]	53.1[a]	53.1[a]	0.78	1.00	<0.0001
Forage intake, g/d[d]		56.8[a]	69.9[b]	68.0[b]	1.3	0.91	0.0008
Gross feed efficiency[d]	0.208[b]	0.187[ab]	0.166[a]	0.161[a]	0.0069	0.79	0.0045
Pre-harvest live weight (LW, g)	2117[ab]	1756[a]	2208[b]	1947[ab]	79	0.95	0.0424
Carcass weight, g[e]	1417	1184	1438	1284	55	0.92	0.0850
Dressing %[e]	67.0	67.2	65.2	66.0	0.63	0.94	0.1126
Emptied digestive tract, % LW	14.4	13.4	14.6	14.4	0.80	0.73	0.7089
Emptied cecum, % LW	6.10	5.75	6.30	6.05	0.52	0.81	0.8709
Abdominal fat, % LW	1.08	0.62	0.39	0.36	0.21	0.84	0.2229

[a,b]Least squares means in rows with different letters are different at P<0.05.

[c]Diets: Control was 100% commercial pellets. Experimental diets involved one of three varieties of sweet potato forage (fed *ad libitum*), including 50% pellets consumed by control animals on the previous day and 35 g/rabbit/d of crimped oats as an energy supplement.

[d]Forage intake consisted of weight of wilted sweet potato forage (leaves with vines) following 24-h of sun drying, expressed on a per rabbit basis, whereas gross feed efficiency was calculated for control pens as total body weight gains divided by total pellet intake, whereas for forage-fed pens was calculated as total body weight gains divided by total pellet plus total wilted forage intake.

[e]Hot carcass weight including esophagus, head, heart, kidneys, liver, lungs, trachea, and thymus, whereas dressing percent was calculated as hot carcass divided by live pre-harvest live weight, times 100.

For pen traits, controls consumed an average of 108.5 g/d of pellets, while forage fed rabbits consumed an average of 53.1 g/d of pellets (Table 2). Also, the 35 g of crimped oats fed per rabbit per day was always consumed within 24 h. Daily forage intake was lowest ($P<0.05$) for pens receiving White Triumph compared to Centennial and Georgia Jet (56.8, 69.9, and 68.0 g/d, respectively). As stated previously, a severe drought likely limited sweet potato forage growth. On some days as it was observed that forage feeders were empty for pens receiving White Triumph. However, forage biomass was not measured in plots. Of relevance, Goldy and Wendzel (2007) reported significantly lower yields in tuber production of White Triumph compared to Centennial, whereas Centennial had significantly lower yields than the Georgia Jet variety. Nguyen Kien Cuong et al. (2008) reported that when sweet potato forage was fed as the sole diet to growing rabbits, average daily DM intake was 85.9 g/d. Gross feed efficiency was similar between control rabbits and those fed White Triumph forage with restricted pellets and crimped oats (0.208 vs. 0.187), although rabbits fed Centennial and Georgia Jet had significantly poorer feed efficiency than controls. Our values for gross efficiency are consistent with values ranging from 0.130 to 0.256 from studies conducted in Vietnam involving feeding of sweet potato forage (Doan Thi Gang et al., 2006; Nguyen Kien Cuong et al., 2008; Nguyen Van Thu and Nguyen Thi Kim Dong, 2008).

Prior to harvest, mean live weights only differed ($P<0.05$) between rabbits fed White Triumph and Centennial forage, whereby the latter group had numerically heavier mean live weights than controls (Table 2). Mean carcass weights tended to vary across diets ($P=0.0850$), presumably due to our small sample size. For dressing percentage and emptied digestive tract and cecum percentages of live weight, statistical differences were not detected among diet means, which were numerically similar. Nguyen Van Thu and Nguyen Thi Kim Dong (2008) observed that growing rabbits fed only sweet potato forage with 30 g of paddy rice per head/d had a dressing percentage of 47.0%: however, no description was provided of how this trait was measured. From the same report, the cecum weight percentage of live weight was calculated at 8.8%, somewhat higher than present values for forage fed groups. Lastly, abdominal fat percentage (an indicator of physiological maturity) was numerically higher for controls, although statistical differences were not detected. Although Tukey's procedure did not reveal significant differences among diet means, a contrast comparison was made that showed that controls, on average, tended (P=0.078) to have more abdominal fat by 0.62±23% compared to experimental forage fed rabbits.

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. 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 family garden and(or) forage plots.

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