

## Chapter 7

### Sweetpotato Roots Silage for Efficient Feeding of Weaner and Finishing Pigs in China

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#### Abstract

Tests were conducted to analyze the nutritional value, as pig feed, of sweetpotato roots ensiled with various special additives and to assess the feeding efficiency of sweetpotato silage as pig feed. Machine-grated sweetpotato roots were ensiled with varying proportions of special additives A, B, C, 10% grain stillage, and 20% wheat bran. Nutrients (crude protein, true protein, crude fiber, crude fat, crude ash, calcium and phosphorus) were measured at 0, 2, 4, 6, 9, 12 and 25 weeks of ensiling. It was found that nutritional value of sweetpotato silage did not differ significantly over time except for fat content and pH value. The presence of bacteria disappeared after 12 weeks of ensiling. Amino acid content and other nutrients of the sweetpotato ensiled for more than 9 weeks was superior in comparison to fresh sweetpotato. Using Cheng Fengqin's simple sensory judgment of silage feed quality, the sweetpotato silage mixed with 0.32g, 0.5g, 0.5g, 10g, 20g of special additives A, B, C, with 10% grain stillage and 20% wheat bran, passed for grade B.

Pig-feeding test was done on weaner and finishing pigs.<sup>2</sup> Four feeds with varying proportions of sweetpotato silage to total feed were compared: 0%, 20%, 40% and 60% sweetpotato silage. Daily weight gain was 581g for 0%, 613g for 20%, 579g for 40% and 618g for 60% for a period of 115 days of weaner-finishing pigs. However, the differences were not as significant as were the increases in the proportion of sweetpotato silage to total feed. The most important finding was that growth rates could be increased with sweetpotato silage. Also, it can be stored for up to six months without spoilage. Storage of fresh sweetpotato tubers causes decay that could be harmful to the environment. Moreover, the storage problem and the abundance of sweetpotato roots has led to massive feeding of pigs. The resulting feed wastage has subsequently lead to nutrient losses.

Another pig-feeding trial examined how much sweetpotato silage should be incorporated in the diet to maximize growth and economic efficiency. The greatest efficiency for weaner pigs (20-60 kg live weight per pig) and finishing pigs (60-90 kg liveweight per pig) were both observed at the combination of 20% of sweetpotato silage + 80% basal diet.

**Key words** : sweetpotato silage, nutritive value, economic efficiency

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<sup>2</sup> Weaner pigs are young pigs that have already been weaned. They are defined here as pigs with live weight between 20 and 60 kg. Finishing pigs are adult pigs between 60 kg and 90 kg live weight.

## Introduction

Sweetpotato is one of the four food crops grown in the southwest areas of China. Its use as an animal feed is gaining acceptability due to its abundance and easy cultivation. In 1996, production of sweetpotato roots in Sichuan (including Chongqing) was 5.2 million tons (dry weight), constituting 21 percent of total sweetpotato root production in China. In addition, fresh sweetpotato vine production totaled 60 million tons. Sweetpotato is very popular in Chongqing especially in the Three Gorge areas (Wanxian, Fuling and Qianjiang) along the Yangtze River.

It has been a traditional practice of farmers to store excess sweetpotato roots in cellars after harvest for future use as animal feed. The sweetpotato roots are used fresh or cooked to feed animals in subsistence farming systems. It is often mixed with other cereal feed ingredients, such as corn. This simple and rough processing of roots for animal feed causes problems. The roots that are stored for a long time suffer major losses due to decay or rotting. To minimize losses, farmers tend to feed large quantities of sweetpotato tubers to animals causing feed wastage and hence, nutrient losses. In order to overcome these problems, an attempt was made to investigate the processing of sweetpotato roots into silage with the addition of special additives and to assess the efficiency of use of the silage as feeds to weaner-finishing pigs. The development of sweetpotato silage technology that will address storage problems and produce feeds that boost hog performance is envisioned to increase the utilization of abundant sweetpotato, leading to the development of the sweetpotato industry.

## Materials and Methods

### *Test 1. Nutrient preservation test on sweetpotato silage*

The silage test was conducted for about six months and ended on November 10, 2000. Four hundred kilograms of fresh sweetpotato were washed clean and machine-grated. This was mixed with special additives A, B, C, 10% grain stillage and 20% wheat bran before being put in double-layer plastic bags, sealed and stored. The silage trial was tested on eight groups as shown in Table 1. A two-kg sample was taken from each treatment for chemical analysis on the first day of sealing and on the 2<sup>nd</sup>, 4<sup>th</sup>, 6<sup>th</sup>, 9<sup>th</sup>, 12<sup>th</sup> and 25<sup>th</sup> weeks thereafter during the ensiling process.

To determine the amount of nutrients lost in the ensiling process, analysis of the following indices was carried out: amount of microorganisms, pH, crude protein, true protein, crude fiber, crude fat, crude ash, calcium (Ca) and phosphorus (P). In addition, Cheng Fengqin's simple method of sensory judgment in determining silage feed quality (Table 2) was used in grading the sweetpotato silage. This method uses the experimenter's judgment on the color and flavor of the sweetpotato silage.

### *Test 2. Feed value assessment of sweetpotato silage for weaner-finishing pigs*

Based on the most appropriate sweetpotato silage-basal feed ratio determined in Test 1 done on November 10, 2000, a feeding test for weaner-finishing pigs was

conducted from March 29, 2001 to July 23, 2001.

**Test design.** Sixty-four castrated piglets of Landrace × Rongchang crosses of the same weight ( $\pm 15$ kg) were selected for the feeding test. The 64 piglets were randomly divided into four groups. Each group of 16 piglets was further divided into four to form four replicates per pen. During the first week of the preliminary trial period, all piglets were dog-eared, dewormed and vaccinated. The piglets were re-grouped and weighed before the feeding trial to ensure that there was no significant differences in the weights of the piglets per group and per pen. Four treatment groups were formed, based on the proportion of sweetpotato silage in the pigs' diet (0%, 20%, 40% and 60%) as indicated in Table 3.

**Feeding trial and feeding system.** During the feeding trial, each group of four pigs received a basal diet feed formula to make the diet nutrient consistent. The mix of these ingredients was based on the weight of the pigs. Tables 4 and 5 indicates the basal feed formulas for 20-60 kg weaner pigs and for 60-90 kg finishing pigs, respectively. The pig pens were cleaned twice a day and high temperatures were prevented. The basal diet feed supplements for the weaner and finishing pigs (Tables 4 and 5) were mixed with the sweetpotato silage at varying ratios (Table 3). Each group of pigs was fed *ad libitum* daily and drinking water was made freely accessible to the pigs.

**Data collection and analysis.** The pigs were weighed at the end of the two phases of feed tests: one at the end of the weaner phase (20-60 kg) and the second at the end of the finishing phase (60 to 90 kg). At the end of each phase, the empty body weight of pigs was obtained after 12 hours of feed restriction. The daily feed intake of each group of pigs was recorded. The total amount and value of feeds consumed for each phase was recorded to calculate the costs of total feed consumed and gain in weight per kilogram of feed consumed. The daily gain, daily intake and feed conversion rate (F/g) were calculated.

## **Results and Discussion**

### *Test I. Nutrient preservation test on sweetpotato silage*

The changes in nutrient content of the sweetpotato silage over time (0, 2, 4, 6, 9, 12 and 25 weeks of silage) are shown in Table 6. Within each group, crude protein, crude fiber, crude ash, calcium, and phosphorus contents did not differ significantly over time. However, the fat content of sweetpotato silage generally increased while pH generally decreased through time. No microorganisms were detected after 12 weeks of ensilage and pH value was below 4.2. This is an indication that fermentation ceases after 12 weeks of ensilage. Based on Cheng Fengqin's simple sensory judgment of silage feed quality, the sweetpotato silage in the 8<sup>th</sup> group with 0.32g, 0.5g, 0.5g, 10g, 20g of special additives A, B, C, 10% grain stillage<sup>3</sup> and 20% wheat bran added to 68.68g of sweetpotato was graded "B". The result of the analysis of nutrient composition of sweetpotato silage from the 8<sup>th</sup> group at the 9<sup>th</sup> week of ensilage is

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<sup>3</sup> Stillage is the grains and liquid effluent remaining after distillation.

shown in Table 7. The table also shows how it compares with the nutrient composition of fresh sweetpotato. A conversion of the fresh sweetpotato silage into air-dried basis is known: two kilograms of fresh sweetpotato silage amounts to one kilogram of air-dried sweetpotato silage. Due to supplements of wheat bran, grain stillage and special additives before fermentation, nutrient contents of sweetpotato silage such as dry matter, crude protein, true protein, crude fat, crude fiber, crude ash, total P and amino acid remarkably increased.

#### *Test 2. Feed value assessment of sweetpotato silage for weaner-finishing pigs*

Table 8 shows the results of sweetpotato silage feeding test in weaner–finishing pigs. The daily weight gains (579g to 618g) of the pigs over 115 days of the feeding test were not significantly different across the four treatments of increasing ratios of sweetpotato silage in the pig’s feed. Daily intake of concentrates declined from 1.92 to 1.02 kg while intake of sweetpotato silage (air-dry matter basis) rose from 0 to 1.5 kg as the proportion of sweetpotato silage is increased. An important finding was that sweetpotato root silage could boost pig growth, while ensiling effectively resolves the sweetpotato roots storage problem. The feed conversion ratio (FCR) of concentrates decreased from 3.31 to 1.65 but the FCR of sweetpotato silage on a dry matter basis substantially increased by almost 2.5. The second group of pigs with feeding treatment of 80% basal diet+20% sweetpotato silage had the least cost (4.475 Yuan grain feed cost per kg) or was the most cost-effective while the first group of pigs fed with 100% basal diet was the least cost-effective with a gain feed cost (4.658 Yuan grain feed cost per kg). Economic efficiency of Group 2 pigs could still be increased by 3.92%.

A closer examination of the results in each of the phases suggests that there were no significant differences in daily weight gain in weaner pigs (a range of 53g) and finishing pigs (a range of 80g) but a substantial difference in the gain in feed cost per kg unit could be observed. Lowest levels of gain in feed cost per kg of 4.196 and 4.909 in the weaner phase and finishing phase, respectively, were obtained in Group 2. These subsequently gave an economic efficiencies of 0.76% for weaner pigs, and 7.82% for finishing pigs.

## **Conclusion**

Feeding fresh or cooked sweetpotato roots to pigs offers a good opportunity to convert an abundant and easy-to-cultivate crop into a high-value commodity such as pork. However, the simple and rough processing of sweetpotato roots as animal feeds causes major losses to farmers as they feed large quantities of sweetpotato roots to animals to avoid decay or rotting in storage. Consequently, feed wastage nutrient losses result. The sweetpotato silage technology offers a solution to this problem. The nutrients - dry matter, crude protein, true protein, crude fat, crude fiber, crude ash, total P and amino acids - of sweetpotato silage mixed with wheat bran, grain stillage and special additives greatly increased even before fermentation. Over time, the fat content of sweetpotato silage also generally increased, while pH decreased. Other nutrients did not show significant differences. The fermentation ceases after 12 weeks of ensiling as bacteria was not detected. The wine flavor, brown color and pH value of less than 4.2

are indications that the sweetpotato silage is of grade B feed quality.

When mixed with special additives, even small amounts of sweet potato silage (20% of the total feed) can achieve good hog growth. It seems that in both weaner and finishing pigs it is most cost-effective to feed pigs with 20% proportion of sweet potato silage. The proportion of sweet potato silage in pigs diet could be increased to as much as 60% without affecting its palatability. In addition, it could be stored for over 6 months without spoilage and not pollute the environment. Most importantly, local farmers' income would increase and women and children have the opportunity for employment.

Table 1. Composition of the sweetpotato silage mixtures in grams

Additive	Group							
	1	2	3	4	5	6	7	8
A		0.32			0.32	0.32		0.32
B			0.5		0.50		0.5	0.50
C	0.5	0.50	0.5	0.5	0.50	0.50	0.5	0.50
10% grain stillage				10.0		10.00	10.0	10.00
20% wheat bran	20.0	20.00	20.0	20.0	20.00	20.00	20.0	20.00
Sweetpotato	79.5	79.18	79.0	69.5	78.68	69.18	69.0	68.68

Table 2. Simple sensory judgment of silage feed quality

Grade	Color	Flavor	pH
A	Golden yellow	Favorable sweet and sour	3.6 - 3.8
	Olive		
B	Brown yellow	Light bitter among sweet and sour	3.9 - 4.2
C	Dark brown	Strong bitter	4.2 - 4.5
	Black brown		
D	Ammonia, decay		> 4.6
	Deep green		

Based on Cheng Fengqin's sensory method.

Table 3. Feeding treatment design of sweetpotato silage for pigs

Group	Number of Heads	Number of Pens	Treatment
1	16	4	100% basal diet + 0% sweetpotato silage
2	16	4	80% basal diet +20% sweetpotato silage
3	16	4	60% basal diet +40% sweetpotato silage
4	16	4	40% basal diet +60% sweetpotato silage

Table 4. Basal diet formula for weaner pigs (from 20 to 60 kg per pig)

Feed Ingredient	Group			
	Basal diet (100%)	Basal diet (80%)	Basal diet (60%)	Basal diet (40%)
Corn	63.00	63.00	59.80	63.37
Wheat bran	13.10	11.00	11.30	
Soybean meal	10.60	9.20	6.80	8.50
Rapeseed meal	6.00	7.50	10.00	9.50
Vitamin	0.02	0.025	0.033	0.05
Lysine	0.08	0.18	0.33	0.58
Calcium meal	0.70	1.00	1.40	2.10
Calcium bicarbonate	0.84	0.90	0.90	1.30
Salt	0.30	0.40	0.50	0.80
Whole soybean	5.00	6.30	8.30	12.50
Total energy	100.04	100.025	100.043	100.00
Pig digest energy (Mcal/kg)	3.10	3.12	3.15	3.18
Crude protein (%)	16.00	16.36	16.96	18.16
Crude fat (%)	3.67	3.81	4.04	4.42
Ca (%)	0.60	0.70	0.87	1.22
Total P (%)	0.50	0.51	0.52	0.55
Effective P (%)	0.24	0.24	0.25	0.31
Lysine (%)	0.75	0.86	1.05	1.43
Methionine (%)	0.22	0.23	0.24	0.25
M + cystine (%)	0.51	0.52	0.54	0.56
Threonine (%)	0.61	0.62	0.64	0.68
Tryptophan	0.20	0.20	0.20	0.20
Arginine	1.01	1.02	1.03	1.11

Table 5. Basal diet formula for finishing pigs (from 60 to 90 kg per pig)

Feed Ingredient	Group			
	Basal diet (100%)	Basal diet (80%)	Basal diet (60%)	Basal diet (40%)
Corn	62.30	66.50	73.20	77.51
Wheat bran	22.52	16.60	6.48	
Soybean meal	3.30	2.00	0.50	12.50
Rapeseed meal	10.00	12.50	16.70	5.20
Lysine	0.18	0.28	0.44	0.59
Vitamin	0.01	0.013	0.017	0.025
Calcium meal	1.00	1.20	1.50	2.40
Salt	0.30	0.40	0.50	0.80
High Cu	0.40	0.52	0.68	1.00
Total	100.01	100.013	100.017	100.025
Digest energy (Mcal/kg)	3.10	3.11	3.13	3.18
Crude protein (%)	14.00	14.00	14.20	14.71
Crude fat (%)	3.17	3.11	3.00	2.87
Ca (%)	0.50	0.58	0.71	0.96
Total P (%)	0.42	0.40	0.36	0.30
Effective P (%)	0.12	0.12	0.11	0.09
Lysine (%)	0.63	0.71	0.85	1.13
Methionine (%)	0.21	0.22	0.23	0.20
M + cystine (%)	0.48	0.49	0.51	0.46
Threonine (%)	0.52	0.52	0.53	0.55
Tryptophan	0.17	0.17	0.16	0.17
Arginine	0.79	0.76	0.72	0.86

Table 6. Nutritive composition of sweet potato silage over time (% dry matter)

Item	Week/ Group	Fresh Sweet- potato	Sweetpotato Silage							
			1	2	3	4	5	6	7	8
Color		Ginger yellow	Ginger yellow	Ginger yellow	Ginger yellow	Brown yellow	Ginger yellow	Brown yellow	Brown yellow	Brown yellow
Flavor		light	light	light	ammonia	Wine	light	wine	wine	wine
R-water	0	69.89	58.72	59.78	59.94	54.66	62.00	54.69	53.33	49.45
	2		58.88	60.11	59.18	55.54	60.63	55.81	55.21	54.75
	4		60.28	60.65	63.70	55.91	60.80	55.51	54.64	53.96
	6		60.48	65.02	61.23	52.19	60.59	52.22	53.63	54.47
	9		61.46	62.67	62.54	58.43	60.13	56.28	53.75	56.49
	12		59.31	60.31	60.23	57.40	59.20	55.76	51.27	55.42
	25		58.47	59.08	56.86	56.38	56.12	53.24	50.72	55.65
C-Water	0	6.28	6.31	5.86	6.57	5.52	6.26	6.05	5.51	5.32
	2		4.94	5.23	4.82	4.74	4.90	4.64	4.86	4.57
	4		5.01	4.64	4.46	4.13	5.05	4.42	3.96	4.14
	6		10.67	9.89	9.97	8.99	10.52	9.17	9.04	8.84
	9		5.26	4.50	5.20	4.97	5.80	4.37	4.07	4.33
	12		9.10	9.10	9.65	8.51	8.91	8.23	7.87	8.15
	25		10.55	11.34	10.86	10.60	11.06	9.75	9.24	10.35
T-water	0	71.78	61.33	62.13	62.57	57.16	64.38	57.43	55.91	52.14
	2		60.91	62.20	61.15	57.65	62.56	57.86	57.38	56.82
	4		62.27	62.48	65.32	57.73	62.78	57.48	56.44	55.87
	6		64.69	68.48	65.10	56.49	64.73	56.61	57.82	58.49
	9		63.49	64.35	64.49	60.49	62.44	58.19	55.63	58.37
	12		63.01	63.92	64.07	61.02	62.83	59.40	55.11	59.05
	25		62.85	63.72	61.55	61.00	60.97	57.80	55.28	60.24
Crude Protein	0	4.64	9.30	12.75	14.45	13.12	10.67	12.09	15.66	18.17
	2		9.33	12.77	14.50	13.44	11.04	12.90	16.29	15.93
	4		9.59	12.58	16.43	13.46	11.27	13.39	15.83	17.21
	6		10.24	12.43	15.04	13.42	11.18	12.82	15.89	15.97
	9		10.31	14.37	16.33	13.41	11.43	13.33	16.05	17.06
	12		9.12	12.97	15.22	12.34	10.30	12.29	14.78	16.42
	25		9.63	12.85	13.91	13.00	12.05	11.01	14.60	16.90
Crude Fat	0	0.69	1.17	1.36	1.17	1.83	1.19	1.80	1.77	2.42
	2		1.35	1.39	1.41	2.27	1.40	2.01	2.00	2.26
	4		1.60	1.45	1.65	2.52	1.52	2.28	2.24	2.42
	6		1.80	1.89	2.12	2.70	1.79	2.58	2.52	2.61
	9		1.77	1.84	2.07	2.71	1.79	2.57	2.42	2.52
	12		1.73	1.66	1.93	2.89	2.06	2.53	2.62	2.75
	25		2.63	2.65	2.50	3.45	2.46	3.89	3.36	3.10

Table 6. (continued)

Item	Week/ Group	Fresh Sweet- potato	Sweet Potato Silage							
			1	2	3	4	5	6	7	8
Color		Ginger yellow	Ginger yellow	Ginger yellow	Ginger yellow	Brown yellow	Ginger yellow	Brown yellow	Brown yellow	Brown yellow
Flavor		light	light	light	ammonia	Wine	light	wine	wine	wine
Crude	0	3.04	4.94	5.18	6.43	10.69	5.49	10.75	10.45	12.04
Fiber	2		4.97	5.42	6.77	11.34	5.53	11.43	10.93	11.74
	4		5.59	5.52	6.60	11.16	5.79	12.03	11.35	12.73
	6		5.46	5.47	6.26	11.98	5.68	11.45	11.29	11.65
	9		5.51	5.57	6.58	10.92	5.88	11.30	10.95	12.75
	12		5.26	5.17	6.25	10.72	5.58	10.76	10.55	10.51
	25		5.33	5.36	7.17	12.00	5.87	11.77	11.80	12.57
Crude	0	2.49	2.97	4.12	3.60	5.42	4.33	6.10	5.31	6.76
Ash	2		3.01	4.13	3.69	5.57	4.43	6.31	5.55	6.33
	4		3.15	4.21	4.32	5.86	4.56	6.35	5.65	6.67
	6		3.27	4.24	3.90	5.69	4.44	6.10	5.45	6.23
	9		3.20	4.26	4.04	5.99	4.36	6.38	5.64	6.38
	12		3.18	4.29	4.01	6.03	4.49	6.48	5.42	6.78
	25		3.15	4.35	3.70	5.95	4.10	6.29	5.43	6.84
Ca	0	0.21	0.21	0.20	0.21	0.22	0.22	0.20	0.20	0.19
	2		0.21	0.20	0.21	0.21	0.21	0.22	0.22	0.21
	4		0.20	0.21	0.21	0.22	0.22	0.24	0.24	0.22
	6		0.21	0.21	0.21	0.20	0.22	0.23	0.22	0.21
	9		0.21	0.20	0.21	0.21	0.22	0.22	0.22	0.21
	12		0.21	0.22	0.21	0.21	0.22	0.23	0.22	0.21
	25		0.22	0.21	0.22	0.22	0.24	0.23	0.23	0.22
Total P	0	0.12	0.41	0.44	0.49	0.52	0.42	0.48	0.49	0.53
	2		0.40	0.41	0.46	0.51	0.41	0.50	0.47	0.52
	4		0.41	0.43	0.48	0.49	0.42	0.49	0.48	0.50
	6		0.41	0.42	0.47	0.51	0.41	0.48	0.48	0.52
	9		0.40	0.42	0.47	0.51	0.41	0.48	0.47	0.51
	12		0.41	0.43	0.49	0.54	0.44	0.49	0.48	0.52
	25		0.42	0.45	0.50	0.54	0.44	0.51	0.50	0.55
pH	2		4.13	4.13	4.24	4.33	4.18	4.46	4.43	4.38
	4		4.13	4.14	4.22	4.15	4.16	4.19	4.18	4.25
	9		4.09	4.11	4.16	4.11	4.09	4.11	4.09	4.24
	12		3.98	4.00	4.09	4.09	4.02	4.06	4.07	4.17
	25		3.75	3.78	3.86	3.88	3.71	3.86	3.89	4.05
Bacterium	4		18.00	17.1	24.75	27.90	22.95	195.25	28.80	143.95
(million/g)	9		111.20	87.6	17.60	25.70	22.50	17.60	15.80	13.50
	12		0.00	0.00	167.00	0.00	158.00	0.00	0.00	0.00
	25		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7. Comparison of nutrient composition of fresh sweetpotato and sweet potato silage<sup>1</sup>

Nutrient	Sweetpotato fresh	Sweetpotato silage	Nutrient	Sweetpotato fresh	Sweetpotato silage
Dry matter	28.22	43.40	Aspartic acid	0.30	0.747
Crude protein	4.64	16.34	Leucine	0.12	0.682
True protein	3.83	9.30	Serine	0.10	0.424
Crude fat	0.69	2.37	Glutamic acid	0.23	1.961
Crude fiber	3.04	12.17	Proline	0.18	0.740
Crude ash	2.49	6.69	Glycine	0.09	0.463
Calcium	0.21	0.20	Alanine	0.12	0.694
Phosphorus	0.12	0.49	Cystine	0.14	0.050
Lysine	0.11	0.446	Tyrasine	0.11	0.235
Methionine	0.06	0.123	Phenylalanine	0.11	0.413
Threonine	0.09	0.390	Histidine	0.04	0.593
Isoleucine	0.11	0.332	Oxyproline		0.479
Arginine	0.14	0.446			

<sup>1</sup> Samples were taken at 9<sup>th</sup> week of ensiling.

Table 8. The effect of sweetpotato silage on pig performance

March 29 - June 8 70 days		Initial weight	Final weight	Daily intake			Daily gain (grams)	Feed Conversion Ratio (FCR)			Gain cost Y/kg	Relative gain cost	
Concen- trate	Sweetpotato silage			total	Concen- trate	Sweetpotato silage		Total					
	fresh					dry			fresh	dry			
1. Control	15.60± 0.88	57.55± 3.46	1.741	0	0	1.741	599	2.905	0.000	0	2.905	4.228	100.00
2. 20%	15.60± 0.82	58.73± 5.52	1.544	0.772	0.386	1.930	616	2.506	1.253	0.626	3.132	4.196	99.24
3. 40%	15.60± 0.80	55.04± 3.95	1.206	1.608	0.804	2.010	563	2.140	2.853	1.427	3.567	4.335	102.53
4. 60%	15.60± 0.81	55.54± 5.68	0.878	2.634	1.317	2.195	571	1.538	4.615	2.307	3.846	4.321	102.20

  

June 8 - July 23 45days		Initial weight	Final weight	Daily intake			Daily gain (grams)	Feed Conversion Ratio (FCR)			Gain cost Y/kg	Relative gain cost	
Concen- trate	Sweetpotato silage			total	Concen- trate	Sweetpotato silage		Total					
	fresh					dry			fresh	dry			
1. Control	57.55± 3.46	82.39± 4.65	2.295	0	0	2.295	562	4.084	0	0	4.084	5.325	100.00
2. 20%	58.73± 5.52	86.10± 4.28	2.001	1.000	0.500	2.501	618	3.237	1.619	0.809	4.046	4.909	92.18
3. 40%	55.04± 3.95	82.20± 7.31	1.591	2.122	1.061	2.652	568	2.803	3.737	1.868	4.671	5.225	98.12
4. 60%	55.54± 5.68	86.63± 6.83	1.198	3.594	1.797	2.995	642	1.866	5.599	2.799	4.665	4.951	92.98

  

March 29 -July23 115 days		Initial weight	Final weight	Daily intake			Daily gain (grams)	Feed Conversion Ratio (FCR)			Gain cost Y/kg	Relative gain cost	
Concen- trate	Sweetpotato silage			total	Concen- trate	Sweetpotato silage		Total					
	fresh					dry			fresh	dry			
1. Control	15.60± 0.88	82.39± 4.65	1.927	0	0	1.927	581	3.317	0	0	3.317	4.658	100.00
2. 20%	15.60± 0.82	86.10± 4.28	1.712	0.856	0.428	2.140	613	2.792	1.396	0.698	3.489	4.475	96.08
3. 40%	15.60± 0.80	82.20± 7.31	1.391	1.855	0.927	2.318	579	2.404	3.205	1.602	4.006	4.684	100.56
4. 60%	15.60± 0.81	86.63± 6.83	1.023	3.070	1.535	2.559	618	1.657	4.971	2.486	4.143	4.568	98.08