THE USE OF DRY CASSAVA ROOTS AND SILAGE FROM LEAVES FOR PIG FEEDING IN YUNNAN PROVINCE OF CHINA

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ABSTRACT

Since 1990 we have undertaken a large number of experiments and conducted research on the development and use of cassava roots and leaves as animal feed resources, in order to explore the possibility of substituting cassava-based feeds for those of grain, thus saving grain for human consumption that was previously used for feeding animals. We have conducted chemical analyses to determine the nutrient composition of cassava roots and leaves, conducted animal feeding trials using cassava, and experimented with the substitution of cassava-powder for maize in raising animals and fish, as well as the feeding of pigs with silage of cassava leaves. The results are very satisfactory.

At present we have introduced 32 improved varieties of cassava and we have set up a 200 ha production base for selection and multiplication of these varieties.

Use of cassava in animal feeds now accounts for 32.2% of total output of cassava in Yunnan province. The cassava cultivated area increased from 2,453 ha in 1988 (five counties) to 14,000 ha in 1998, resulting in a production increase of 6.5 times compared with the output in 1988. This has removed some of the competition between people and animals for grain, and promoted the development of animal husbandry in Honghe district.

INTRODUCTION

With the rapid development of the animal husbandry industry in Honghe district, there is more and more demand for animal feed, especially high energy feed from grains. But grain crop production can not meet the ever increasing demand for animal feed. Since 1990 we have conducted many experiments and have researched the possible use of cassava-based feed stuff in order to explore the possibility of substituting cassava for grain-based feeds. This would eliminate the existing competition between people and animals for grain crops. We have conducted chemical analyses to determine the nutrient composition of cassava roots and leaves, experimented with the use of cassava dry root powder to feed livestock, poultry and fish, and the use of cassava leaf silage to feed pigs. The results indicate that it is possible to substitute cassava roots and leaves for grain-based feeds.

For that reason we have introduced a series of improved varieties of cassava, such as Hainan 124 (SC124), Hainan 205 (SC205) and Nanzhi-188. In Yunnan the area planted with cassava was only 2,450 ha in 1988, but increased to 14,000 ha in 1998, a 5.7 times increase over the past ten years; production of dry cassava chips increased from 5,520 tonnes in 1988 to 36,200 tonnes in 1998.

The development and application of cassava feed resources have become an important measure to promote the development of animal husbandry in Honghe district. More then 140 million pigs were slaughtered in 1998. The slaughter rate reached 72%, an increase in number of 163% over the last ten years. The consumption of meat increased to an average of 37.8 kg per person, an increase of 425% over the last ten years. The total value of animal products reached 7.4 billion Yuan (RMB), an increase of 7 billion Yuan over the last ten years. The development and application of cassava-based feed resources

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helped alleviate the poverty of people living in mountainous areas. Farmers have greatly benefitted from cassava planting. The development of animal husbandry now meets the market needs for livestock and poultry products.

We have substituted dry cassava powder for maize in different proportions as an energy source in feed used for fattening pigs and the results are very satisfactory. Governments at all levels have paid attention to these experiments. The local government has put cassava planting as a feed resource into the grain crop development plan. Meanwhile, improved varieties of cassava were introduced and a 200 ha cassava varietal improvement area was set up. This would meet the needs of farmers for improved cassava. In 1998 about 65% of the total cassava cultivated area was planted with improved varieties. The Fudian Feed Processing Factory, under the Animal Husbandry and Veterinary Station of Honghe district, has researched and produced animal feeds based on cassava, and these enriched feed rations were well received by farmers when they were sold in the market. The project on the development and use of cassava-based feed resources has become a part of the Ninth 5-year National Economic Plan. In order to speed up the application and development of cassava feed resources in Honghe district, the governments and various departments involved at different levels have invested more than 7 million Yuan to support this project since 1994. A plan for the development of cassava has been drawn up and local governments, enterprises, collectives and farmers have been encouraged to develop cassava production.

It has been reported that the metabolizable energy (ME) of one kg of fresh cassava roots is about 3.6 MJ (0.860 Mcal), or 12.5 (2.99 Mcal) per kg dry powder (Kayouli and Lee, 1999), which is equivalent to about 12,900 Mcal per ha. For other crops this is: taro 3.3 MJ/kg fresh matter, sweetpotato 4.1 MJ and cassava leaves 1.1 MJ/kg fresh matter. Crude protein production is 16 g/kg dry cassava root powder and 235 g/kg dry leaf powder. Cassava starch consists mainly of carbohydrate ($C_6H_{12}O_6$), of which 80% is starch and 20% sugars. Two of the main constituents of starch are starch sugar and colloidal starch. Starch sugar is a linear polymer while colloidal starch is a branched polymer, which is more easily digested and absorbed by animals. It has been shown that feed grains in compound animal feeds can be replaced by cassava.

The nutrient composition of dry cassava roots is as follows:
Dry matter (DM): 87.0%; Gross energy (GE): 4.00 Mcal/kg; Digestable energy (DE): 3.50 Mcal/kg; Metabolizable energy (ME): 3.33 Mcal/kg; Crude protein (CP): 3.8%; Ether extractable (EE): 0.2%; Crude fibre (CF): 2.8%; Nitrogen-free extractable metabolic energy (NFE): 78.4%. The digestibility rate is: CP 68%, EE 23%, CF 76% and NFE 99%. **Tables 1** and **2** show the ash content of dry cassava root powder and the amino acid composition of protein in cassava roots, respectively.

EXPERIMENTS ON THE USE OF CASSAVA ROOTS AND LEAVES

1. Replacing Maize with Cassava Powder to Feed Fattening Pigs

The daily nutrient levels of the feed rations for fattening pigs are shown in **Table 3**.

Table 1. The ash content (mg/kg) of dry cassava roots.

	Parenchyma	Cortex
K_2O	41.58	14.70
P_2O_5	15.09	2.45
CaO	10.64	6.62
MgO	7.35	3.32
Na_2O	1.28	0.95
Fe_2O_3	0.66	2.45
SO_3	3.73	1.71
CO_2	0.91	2.51
SiO_2	0.94	10.94[1)]
SiO_2	7.15	52.58[2)]
Cl+	2.75	1.41

[1)]dissolved in Na_2O solution
[2)]not dissolved in Na_2O solution

Table 2. The amino acid composition of protein in cassava roots

Amino acid	mg/g of N	mg/100 g of roots
ILE	175	46
LEU	247	64
LYS	259	67
MET	83	22
CYS	90	23
PHE	156	21
TYR	100	26
THR	165	43
TRY	72	19
VAL	209	54
ARG	683	178
HIS	129	34
ALA	235	61
ASP	406	11
GLY	106	42
GLU	1009	262
SER	172	45
PRO	284	53

Table 3. The effect of replacing cassava powder for maize in feed rations for fattening pigs on the daily nutrient levels of feed.

Body weight of 20-35 kg	Experimental rations				
	1	2	3	4	Check
DE (Mcal/kg)	3.10	3.10	3.06	3.04	3.11
CP (%)	16.00	16.00	14.79	14.39	16.00
CF (%)	4.72	4.60	5.14	5.14	4.14
CA (%)	0.56	0.56	0.61	0.64	0.58
P (%)	0.46	0.46	0.43	0.41	0.46
LYS (%)	0.69	0.71	0.62	0.60	0.67
MET+CYS (%)	0.38	0.36	0.38	0.37	0.46
THR (%)	0.57	0.57	0.53	0.51	0.60
ILE (%)	0.64	0.63	0.55	0.53	0.62

Body weight of 35-60 kg					
	1	2	3	4	Check
DE (Mcal/kg)	3.10	3.10	3.04	3.02	3.10
CP (%)	14.02	14.01	12.89	12.47	14.15
CF (%)	4.35	4.18	4.75	4.75	4.75
CA (%)	0.65	0.66	0.72	0.73	0.67
0.54	0.54	0.52	0.55	0.54	0.59
LYS (%)	0.61	0.62	0.54	0.54	0.59
MET+CYS (%)	0.39	0.37	0.34	0.31	0.41
THR (%)	0.50	0.49	0.46	0.44	0.53
ILE (%)	0.54	0.55	0.48	0.46	0.55

Body weight of 60-90 kg					
	1	2	3	4	Check
DE (Mcal/kg)	3.10	3.10	3.04	3.02	3.10
CP (%)	13.01	13.02	11.80	11.35	13.03
CF (%)	4.30	4.19	4.74	4.74	4.74
CA (%)	0.65	0.67	0.65	0.66	0.61
P (%)	0.51	0.49	0.53	0.56	0.57
LYS (%)	0.54	0.55	0.47	0.45	0.52
MET+CYS (%)	0.36	0.36	0.32	0.30	0.40
THR (%)	0.47	0.47	0.43	0.41	0.50
ILE (%)	0.50	0.50	0.43	0.41	0.50

An experiment was conducted using 50 fattening pigs fed with two different rations: one is to replace 28.5 and 39.8% of maize with dry cassava powder in the daily ration; the other is to replace 60 and 80% of maize in the daily ration with dry cassava powder. We set up four groups and one check: each group consisted of 10 piglets. The check groups used basic feeds. The nutritional levels of feeds for groups 3 and 4 are slightly lower than those of groups 1 and 2. The experimental period was 87 days. The results are shown in **Table 4**.

Table 4. Results obtained in fattening of pigs using four experimental feed rations and a check treatment (see Table 3).

	Experimental rations				
	1	2	3	4	Check
Daily gain (gm)	723	740	681	701	681
Feed intake (kg)	2.66	2.69	2.68	2.78	2.69
Feed conversion rate[1])	3.17	3.66	3.97	3.92	3.95
Maize consumption (kg/kg gain)	0.68	0.34	0.77	0.38	1.93
Cost (Yuan/kg gain)	2.80	2.69	2.85	2.68	3.25
Benefit (Yuan/kg gain)	1.20	1.30	1.15	1.32	0.75

[1)]Feed conversion rate=kg of feed needed to produce 1 kg of body weight

Another experiment was conducted using 72 cross-bred piglets and replacing maize by cassava in ten farmer's families at Jinhe Town of Jinpin County. **Table 5** shows the daily nutrient levels in the feed rations of fattening pigs at three levels of body weight, and **Table 6** the daily feed composition and nutrient levels of four types of feed. The results are shown in **Table 7**.

Table 5. Nutrient concentration of daily feed rations of fattening pigs at three levels of body weight in experiments conducted with ten farmers in Jinhe town, Jinpin county, Yunnan, China.

	Weight 15-35 kg		Weight 35-60 kg		Weight over 60 kg	
	Experim. ration	Check	Experim. ration	Check	Experim. ration	Check
DE (Mcal/kg)	3.17	3.05	3.13	3.11	3.10	3.10
CP (%)	13.34	16.00	11.84	14.39	9.71	10.34
Ca (%)	1.11	1.09	0.91	0.90	0.72	0.71
P (%)	0.62	0.70	0.57	0.66	0.51	0.53
LYS (%)	0.63	0.73	0.55	0.64	0.43	0.46
MET+CYS (%)	0.39	0.52	0.35	0.48	0.28	0.32
THR (%)	0.48	0.61	0.42	0.54	0.32	0.35
CF (%)	5.92	5.50	7.18	0.76	8.54	8.44

Table 6. Composition (%) of daily feed rations using four types of feed tested by ten farmers for fattening pigs in Jinhe town, Jinpin county, Yunnan, China.

Feed	Weight 15-35 kg		Weight 35-60 kg		Weight over 60 kg	
	Experim. ration	Check	Experim. ration	Check	Experim. ration	Check
Concentrate[1)]	25	25	20	20	15	15
Maize	13	65	13	65	13	65
Cassava powder	52	-	52	-	52	-
Chaff	10	10	15	15	20	20

[1)]Concentrate produced by the Animal Husbandry and Veterinary Station of Honghe district.

Table 7. Results obtained in fattening pigs using two feed rations by ten farmers in Jinhe town, Jinpin county, Yunnan, China.

Items	Total number of piglets	Age at start of experim. (months)	Starting weight (kg)	Days of experim.	Final weight (kg)	Daily gain (kg)	Net income Yuan/pig	Feed conversion rate[1)]
Exp. groups	36	3	23.3	174	107.2	0.46	99.62	3.8
Check	36	3	22.7	179	101.9	0.44	63.68	3.9

[1)]Feed conversion rate = kg of feed needed to produce 1 kg of body weight.

2. Fattening Beef Cattle with Cassava Powder

The Animal Husbandry Bureau of Honghe district has conducted an experiment on fattening beef cattle of 10-24 months age using a certain amount of ammoniated molasses and ammoniated rice straw and adding 500 g cassava powder each day for each head of cattle. The experimental period was 87 days. The cattle gained 104 g per day more than using conventional feeds. The digestibility of cassava was CP 69%, EE 51%, CF 53%, and NFE 90%.

3. The Use of Cassava Powder to Raise Chickens

Reports from the Mengzhi Experimental Chicken Farm shows that if 173% of cassava powder was added to the feed, the body weight of chickens can be up to 2 kg after 49 days of feeding chickens; the CP was 3%, EE 10%, CF 4% and ME 76.3% higher than the check group.

4. The Use of Cassava Leaves as a Protein Source

Table 8 shows that dry cassava leaves have about 27% (some up to 38.6%) protein. Each hectare of cassava can produce annually about 2 tonnes of protein in the leaves, in which ß -carotene is 53 mg/100 g, and xanthophyl 92 mg/100 g. The leaves are high in amino acids except for methionine, which is below the critical value (**Table 9**). The amino acids in cassava leaf protein are richer than in soybean cake, oilcake and fish meal (**Tables**

10 and **11**). Sixty percent of protein can be extracted of which 90% is digestible. The crude fiber and ash contents in cassava leaves is very low (**Table 8**). Leaves can be easily mixed and combined with dry cassava powder without decreasing the digestion rate. Thus, cassava leaf protein can be a good ingredient in animal feeds.

Table 8. Nutrient compositions (%) of dry cassava and sweetpotato leaves and rice bran.

Items	Water	Crude protein	Crude fibre	Crude fat	NFE	Ash
Dry cassava leaves	9.02	27.50	12.28	11.81	31.79	5.38
Dry sweetpotato vine	11.50	9.60	24.00	3.90	43.60	8.50
Rice bran and broken rice	11.29	7.01	30.81	6.11	30.77	14.61
Rice bran	10.50	10.80	11.50	11.70	45.00	9.20

Table 9. Amino acid contents of dry cassava leaves (mg/100 g).

ASP	2002.91	CYS	107.85	PHE	992.33
THR	803.99	VAL	1108.40	LYS	824.24
SER	915.38	MET	196.44	NH3	435.55
GLU	3126.21	ILE	855.26	HIS	860.05
GLY	939.41	LEU	1623.15	ARG	532.33
ALA	1099.18	TYR	520.07	PRO	1096.28

[1)]Total amount: 18,059 mg/100 g.

Table 10. Protein (%) and amino acid (mg/100 g) content of dry cassava leaves in comparison with fodder grass, maize and soybean.

	Cassava leaves	Cassava leaves with petioles	Fodder grass	Maize	Soybean
CP	27.50	20.30	12.60	11.90	45.70
ARG	5.21	3.89	6.10	-	7.41
CYS	1.18	0.98	0.51	5.64	1.52
HIS	2.47	2.32	2.54	2.82	2.39
ILE	4.12	4.40	4.32	3.45	5.45
LEU	10.00	8.75	8.64	7.55	6.97
LYS	7.11	5.89	1.02	4.82	6.32
MET	1.45	1.83	1.86	1.36	1.52
PHE	3.87	4.37	5.42	5.82	4.79
THR	4.70	5.70	4.41	4.73	4.14
TRY	1.07	1.24	-	-	1.30
VAL	6.18	8.43	6.27	5.18	5.23

Table 11. The amino acid content (g/100 g) of protein in dry cassava leaves, soybean cake, oil cake and fish meal.

	Cassava leaf-protein	Soybean cake	Oil cake	Fish meal
ISO	3.17	2.43	1.01	3.23
LEU	5.89	3.49	1.88	5.42
LYS	4.26	3.06	1.34	5.81
MET	1.48	0.72	0.46	2.05
CYS	0.90	0.84	0.48	0.92
PHE	3.92	2.52	1.65	2.89
TYR	2.83	1.91	0.95	2.32
THR	3.27	2.15	1.06	3.18
VAL	4.10	2.64	1.40	3.82
ARG	4.36	3.57	3.40	4.60
HIS	1.51	1.28	0.79	1.93
GLS	3.64	2.24	1.33	5.35

5. Processing and Use of Cassava Leaves

We have used two types of technologies for feed processing; i.e. using the leaves only or the leaves with petioles for producing either dry powder or silage. Farmers did not use cassava leaves for feeding animals before because of the toxic levels of hydrocyanic acid that can poison pigs. Ensiling can solve this problem and maintain the nutrient composition (**Table 12**) increase microbial protein and improve the taste.

Table 12. Nutrient composition (%) of cassava leaf silage (on DM basis).

Water	Crude protein	Crude fat	Crude fibre	Ash	NEF	Ca	P
74.0	12.04	7.79	21.94	9.32	36.61	2.08	0.17

The ensiling process

There are two steps in making leaf silage:

Step 1: Reduction in the respiration rate of leaves

Leaf cells do not die immediately after picking but continue to respire; this will consume sugar:

$$C_6H_{12}O_6+6O_2 \rightarrow 6CO_2+6H_2O+ATP+calories$$

Sugar in the cells is oxidized during leaf respiration, releasing ATP and heat. To produce 676 cal will consume 180 g of sugar. Oxygen is an important factor in leaf respiration; so, putting the fresh leaves into containers and sealing up the containers to reduce respiration is essential. If the heat can not be released, the temperature inside will go up to 76^{o}C which will produce a lot of aerobic bacteria and fungi, which makes the silage musty, can poison the animals and cause female animals to abort. Reducing respiration and lowering the temperature are very important. The way to do this is:

a. cut the leaves into pieces of about 2-5 cm
b. pack tighty in plastic bags or containers
c. seal these tightly

Step 2. Fermentation

Silage that is tightly sealed up produces three kinds of acids by anaerobic bacteria: lactic acid ($CH_3CH(OH)COOH$), acetic acid (CH_3COOH) and butanoic acid ($CH_3CH_2CH_2COOH$); of these lactic acid is the best one. Good ensiling produces ethanol and lactic acid by lactic acid bacteria which exists in leaves. It has been shown that one leaf contains between 100 and 1000 lactic acid bacteria. One kilogram of dry-matter contains 80 grams of acid in good quality silage. The more lactic acid, the lower the pH, and the less other bacteria. The multiplication of lactic acid bacteria is controlled by the amount of acid formed, which tends to reach a stable state after which the silage can be kept for a long time.

The control of water content is very important in silage making. According to common practice the most suitable water content is between 70% and 75% (not less than 55%). More water will cause the sugar and colloidal-matter in plant liquid to be diluted, which will damage the lactic acid bacteria and cause silage to be putrid. On the other hand, the air remaining inside the container will allow harmful microorganisms to multiply, resulting in bad silage. To avoid this, add dry feed such as rice bran. This is an effective method to avoid losing nutrients, control the moisture content and improve the quality of silage.

The formula for adding dry feed is as follows:

$$M = \frac{A-B}{C-D} \times 100, \text{ where}$$

M = amount of material to be added (per 100 kg), A = moisture content of material, B = desired moisture content of silage, C = fresh feed moisture requirement, D = dry feed moisture content.

The visual quality evaluation of silage is shown in **Table 13**, while the digestibility is shown in **Table 14**, and the amount of cassava leaf silage that can be fed to various animals is shown in **Table 15**.

CONCLUSIONS

The results of these and other experiments have shown that compound feed made from dry cassava roots and leaf silage has an advantage over maize with respect to taste, daily gain, feed conversion rate, and economic returns. Maize can be partially or

completely replaced by cassava to feed various livestock and poultry. Cassava leaf silage has enormous value and can compensate for the lack of protein in cassava root powder, in order to meet the needs of animals for feed during winter and spring.

Cassava roots and leaves contain hydrocyanic acid, but this will be reduced to non-toxic levels by either drying or ensiling. We have not examined the amount of hydrocyanic acid because of lack of facilities, but no poisoning has occurred in veterinary clinical practice. No carcass of livestock and poultry examined by the Veterinary Health Department has shown any signs of toxins. Test results are included in the documentary records.

Table 13. The visual quality evaluation of silage.

	Very good	Good	Poor
Color	Green, yellow-green, Same as primary color	Yell-brown or dark brown	Black, brown or dark green
Smell	With strong smell	With irritating smell, light fragrant	Smelly or musty
Structure	Moist, tight; leaves keep their original shape; easy to be separated; not sticking to hands	Parts of leaves keep original shape; soft and loose; sticks slightly to hands	Putrid, pasty state; sticky or dry blocky structure; vein dim

Table 14. The digestibility of cassava leaf silage in various animals.

Animals	Digestibility (%)	
	Silage	Dry fodder
Cattle and sheep	75-85	55-60
Horses	50-60	30-40
Pigs	40-50	18-20

Table 15. The amount of cassava leaf silage[1)] that can be fed to different animals.

	Daily ration
Cattle	(kg/100 kg of body weight)
- milkcows	5-7
- fattening cattle	4-5
- draft cattle	4-5
- breeding bulls	1.5-2
Sheep (or goat)	(kg/animal)
- ewe	3-6
- strong sheep	2-4
- fattening sheep	3-6
Pigs	(kg/animal)
- barren sows	2-4
- pregnant sows	1-2
- suckling sows	3-6
- fattening pigs	3-5

[1)]mixed with rice bran and cassava root meal

REFERENCES

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