Straw as a Fattening Basal Diet for Cattle in China

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Introduction

China covers about 9.6 million square kilometers (one fifteenth of the world) and has a total population of about 1.3 billion inhabitants (one fourth of the world). Its economy is changing rapidly from a centrally planned to a market oriented system. This leads to tremendous adjustments the results of which are difficult to predict at the present time and still more difficult to foresee in the medium or long term.

Animal production

Animal production in China has followed these changes:

Table 1 Human and Animal populations in China (in million)

Year	1960	1970	1980	1990	1994
Human	658	816	981	1135	1187
Pig	82	172	319	352	393
Poultry	530	620	875	2000	2600
Cattle	49	57	52	79	90
Sheep	61	79	102	113	111
Goats	51	60	80	98	105
Equines	8	19	22	26	26

Source FAO, 1995

Pig populations have considerably increased from 1960 to 1980 and to a lesser extent since 1980. On the contrary, cattle population has been relatively stable from 1960 to 1980 and has increased by 73% from 1980 to 1994. However, both pig and poultry production are still predominant in China and the very high monogastric population puts a strong pressure on the priority for feed.

Pig meat production increased enormously from 1960 to 1980. At that time it constituted 80% of total meat, and beef only 1.8%. Since the year 1978, it has been the policy of the government that the consumption of other types of meat should increase at the expense of pork (Guo Tingshuang et al. 1993). As a result of this, the production of other meats has grown considerably (see table 2). In 1994 the share of pig-meat was reduced to 77%, whilst beef, still relatively low, reached 5.3% of total meat consumed. Poultry meat production also significantly increased. Milk production is relatively low to requirements, although it is increasing at a high rate.

Ruminant Feed Resources

Cattle and sheep are traditionally raised in the Northern grasslands which cover about 290 million hectares (3 times the total cultivated area in China).

Table 2 Animal production in China (Million tonnes)

Products		1960	1970	1980	1990	1994
Meat	Pork	1370	5635	11341	22811	32650
	Beef	43	122	235	1100	2250
	Mutton/ Goat meat	100	210	450	1068	1550
	Poultry	622	855	1360	3160	5870
Fresh Milk		600	640	1141	4157	5300
Eggs		1200	1500	2240	6357	9800

Source FAO, 1995

Table 3 Main crop residues available in China (in million tonnes)

Straws and stovers		Other residues	
Rice straw	187.9	Soybean haulm	15.0
Wheat straw	109.3	Peanut haulm	6.6
Corn stover	155.2	Rape stalk	20.9
Sorghum/ Millet stover	16.6	Potato/ Sweet potato vine	24.4
		Sugar cane top	14.4
Total:	**469.0**	Total:	**81.3**

Source Adapted from Guo Tingshuang and Yang Zhenhai, 1994

The interest of Chinese government in developing better use of crop residues is not new. As early as the end of the 1950's some work was done on calcium hydroxide treatment of wheat straw, using 75 kg of lime (CaO) and 3 tonnes of water for each tonne of straw. During the same period ensilage of chopped fresh corn stover was also studied (Zhang Ziyi et al. 1959: cited by XiongYiqiang 1988). This technology was then encouraged resulting in 5.5 million tonnes of fresh maize stover ensiled in 1984. In the 60's and 70's much efforts were devoted to biological treatment with fungi and yeasts in fermentation of crop residues, but with little success. Sodium hydroxyde was also used in the late 70's using the Danish Taarup-805. A Chinese machine was then designed, but this method was never adopted on a large scale. Ammonium carbonate (NH_4HCO_3) one of the most common fertilizers in China has been used to treat straw to improve it's digestibility on a limited scale at the rate of 1 O-l 5% of the straw. The first national conference on ammoniation of wheat straw was held in 1983. Positive results were reported in beef and dairy cattle (XiongYiqiang 1988). In North China where the winter temperatures are very low (- 30°C) work has been done on ammoniation in an insulated oven made of metal or of bricks and heated by electricity. One hundred and twenty ovens were built in 1991 (Xu Dingren et al 1991).

First Phase: The TCP Project

The situation at the start of the project

At the request of the government of the People's Republic of China, FAO sent two consultants in November 1987. Their task was to review the feed resources availability, and to evaluate the present extent of, and opportunities for, straw treatment (Orskov 1987). They also had to study the existing ruminant production systems and trade situation and to prepare a project proposal to pave the way for large scale beef production stratification in the country (Chirgwin 1987). Efforts were concentrated in the two provinces of Hebei and Henan in the cropping area.

At that time, the main product of cattle was draught power, followed by beef and milk was of little importance. A very large proportion of the ruminant diet consisted of untreated crop residues. However, a large amount of straw was unused, the availability of straw was estimated between 12 and 15 t/head/year. The accumulated straw was sometimes used for cornposting but in most cases it was burnt, causing air pollution.

Cattle fattening was done when calves reached 2-3 years, on high concentrate diets largely based on maize grain, wheat bran and cottonseed meal for a period of 3-4 months.

Some straw treatment had already taken place on a limited scale in these regions. In Hebei, anhydrous ammonia contained in tanks or bottles (of 200 kg) was used at the rate of 3% of straw (although there was no metering devise). In Henan mainly urea was used, also at the rate of 3% of straw dry matter only and with 60kg water/100 kg straw. Cattle fed on treated straw were supplemented with 1 kg/d of maize grain. Liveweight gain was in the range of 200-500 g/d (Orskov 1987).

At the start of the project, the price of urea/ ammonia was more than twice the price of anhydrous ammonia.

Objective of the TCP project

The first phase started in March 1989 with the FAO funded TCP (Technical Cooperation Programme) project: TCP/CPR/8858: "Evaluating and upgrading of straw and stovers for meat production in Hebei and Henan provinces". These two provinces are located in the eastern central plains of China. The objective was to provide initial assistance in implementing straw treatment technology pending a large-scale development programme. It aimed at:

- establishing liquid ammonia treatment in Hebei province, using tanks or bottles containing from 15 to 200 kg of anhydrous ammonia
- supporting urea/ammonia treatment of straw for

Table 4 Degradation rate of straw at different time intervals (%):

		Degradation rate (%) of straw in the rumen at different time intervals (hours)					
Region	Treatment	8	16	24	48	72	96
Hebei (sheep)	Untreated	13.0	21.0	26.7	35.0	43.8	47.3
	NH_3 Treated	21.5	30.7	36.8	54.0	65.0	69.4
Henan (cattle)	Untreated	17.0	26.0	32.7	44.1	48.9	50.8
	Urea treated	23.7	32.6	40.0	55.6	64.7	70.1

Source Orskov, 1990

cattle fattening in Henan province- supporting two established feed evaluation laboratories
- supplying the minimum necessary equipment

through training courses, feeding trials, on-farm-demonstrations and fellowships for technicians.

Technical and economical results

The effect of degradation of ammonia treatment on the rumen degradation characteristics was evaluated on sheep with 3% NH, (Hebei) and on cattle with 5% urea (Henan). Table 4 shows that treatments were very effective in both cases.

Thirty two yellow beef cattle (12 to 18 months old) were used to measure the effect of treatments and fed on 3% ammonia (Hebei) or 5% urea (Henan) treated straw and two levels of concentrate (75% wheat bran and 25% cottonseed meal)

The treatment was very effective in terms of weight gain as well as profitability (Table 5). Both the response in liveweight gain to ammoniation and to levels of concentrate were highly significant ($P<0.01$).

Average performances of cattle fattened in the two provinces during the period of this project are summarized in Table 6. Results were extremely encouraging both from a technical and economic view point and provided a good base for the following development project.

In addition the project had permitted the appropriate equipment of two feed evaluation laboratories and the training of several hundred farmers and technicians in the new technology.

The only problems encountered were with the anhydrous ammonia treatment. Farmers did not calculate the exact amount of straw to be treated and there was no metering device for liquid ammonia on the market, so dosing of ammonia for the corresponding amount of straw was not accurate. However, more serious concern was raised on the safety precautions which were not properly observed in the handling of the ammonia gas. It was finally recommended that no further ammonia treatment be made in Hebei province until these problems were solved. In conclusion the most rapidly adopted technology was the urea/ammo-

Table 5 Summarized results of animal performance trials (4 animals per group):

Treatment		Concentrate allowance, kg/day	Initial weight, kg	Daily gain, g/day	Straw intake, kg/day	Feed conversion, kg feed/kg gain	Cost of f kg gai yuan
Hebei	Untreated straw	0.5	186.8	110	4.3	44.3	5.00
		1.0	194.3	240	3.9	20.6	3.38
	Treated straw	0.5	197.5	485	4.8	10.8	1.82
		1.0	213.4	660	4.3	8.0	1.74
Henan	Untreated straw	0.5	198.6	160	4.96	34.1	-
		1.0	200.3	209	4.92	28.3	
	Treated straw	0.5	199.6	354	5.92	18.1	
		1.0	199.5	504	5.94	13.8	

Source Orskov, 1990

Table 6 Average performances of cattle receiving either untreated or ammonia treated straw in Hebei and Henan provinces

Treatment	Liveweight gain, (g/d)	Feed conversion, (kg feed/kg gain)	Feed cost, (yuan/kg LW gain)
Untreated straw	180	32.1	3.93
Ammoniated straw	500	13.1	2.20

Source Orskov, 1990

nia treatment since it needed little investment and infrastructure and did not present any safety problems (Sundstol 1990).

Second Phase: The UNDP Development Project

Objective of the project

The immediate objective of this project was to evolve a technically suitable beef production system and determine its economic viability under local conditions. It started during the last trimester of 1990. It soon became clear that it was no longer possible to consider the beef fattening operation as a discrete activity, unrelated to to the other aspects of the farm. A farming system approach was proposed for this second phase which took into account the inter-dependence of crops (cereals and cotton) and cattle, with the maintenance of soil fertility on which the crop depends (Dolberg and Finlayson 199 1).

Technical results

Comparison of urea and NH, treatments

Given the difficulties encountered with anhydrous ammonia in the Hebei province and the success in Henan with urea, a trial was undertaken to compare the effects of urea and NH, treatments on degradability of straw in the rumen and on animal performances.

There was a clear advantage in anhydrous ammonia treatment for the improvement of straw degradation in the rumen and for growth rate of cattle. However the response to the supplement was the dominant response (Table 7). The logistic and safety problems were not

Table 7 Comparisons of urea and NH_3 *treatments*

	Degradation in the rumen at 48 hours, % (1)	Initial Weight, Kg	ADG, g/day (8 animals in each group)		ADG, g/day (90 day
			1.5 kg CSM (42 days)	2.5 kg CSM (48 days)	
3% NH_3	54.5	162	360	510	440
5% urea	46.5	162	333	470	406

(1) Untreated straw degradation at 48 hours was 38.4 %.
Source: Dolberg (1992)

Table 8 Effect of cottonseed meal supplementation level on performances of animal fed ad libitum on NH_3 treated straw in Hebei (there were 10 animals/group)

CSM, kg/day	0	0.25	0.5	1.5	2.0	2.5
No of animals	10	10	10	10	10	10
Initial weight, kg	137	159	183	192	175	19
Final weight, kg	143	193	231	263	250	27
ADG, g/day	63	370	529	781	829	89
DM intake, % LW						
Straw	2.7	2.5	2.3	2.0	1.8	1.7
CSM	0.0	0.1	0.2	0.5	0.8	0.9
FCR, kg feed/kg gain	60	12	10	7	7	7

Source Dolberg, (1992)

solved, the farmers themselves gave their preference to urea treatment. One more reason was the flexibility of this technology. The farmer can treat his straw with urea at the most convenient time for him, without depending on an external organization, and he can also treat small quantities at any one time. At the end of the project more than 90% of the farmers treating straw had adopted the urea treatment. Ammonia treatment could be more convenient for large farms where labour is scarce and more expensive.

Importance of the protein supplementation

The role of protein supplementation when feeding ruminants on unbalanced feeds such as straw is of utmost importance and has been well defined by Preston and Leng (1987). However, as protein supplement availability is usually limited and very costly, it was necessary to determine the optimum economic level of cottonseed meal to use in the diet.

For this purpose, trials were carried out in Hebei (with 3% NH_3) and in Henan (with 5% urea). Results are shown respectively in Tables 8 and 9. In both trials the growth rate increased with the level of cottonseed meal, although there was an inflexion in the response curve at between 1.5-2 kg levels. At increasing level there was a substitution of straw by cottonseed meal.

On-farm demonstrations

Four counties were selected for on-farm demonstration trials where fattening animals were regularly weighed. Three hundred fanners in 12 villages with 1027 animals under their management were involved. The supplementation was made 1 to 2 kg of a mixture of 75% cottonseed meal and 25% of corn, or of cottonseed meal alone. Average daily gain was about 640 g/day.

On the basis of data generated by the project, it was concluded that with treated crop residues as a

Table 9 Effect of cottonseed meal supplementation level on performances of animal fed ad libitum on urea treated straw in Henan

CSM, kg/day	0	1	2	3	4
No of animals	8	8	8	8	8
Initial weight, kg	182	183	183	183	183
Final weight, kg	205	237	242	258	262
ADG, g/day	250	600	655	845	883
DM intake, % LW					
Straw	2.6	2.5	2.1	1.9	1.3
CSM	0.0	0.4	0.8	1.2	1.6
FCR, kg feed/kg gain	20	10	10	8	7

Source Dolberg, (1992)

Table 10 Effect of level of cottonseed meal (CSM) supplement on financial returns from using urea treated straw in Henan

CSM, kg/day	0	1	2	3	4
ADG, g/day	236	639	786	841	861
Gross income, Y/hd	1710	1710	1710	1710	1710
Total cost, Y/hd	1620	1154	1176	1259	1338
Feed cost, Y/hd	663	386	428	517	598
Profit, Y/hd	90	556	534	451	282
Profit, Y/day	0.08	1.31	1.56	1.40	0.90
Break-even gain, g/day	144	218	300	394	530
Break-even CSM, Y/kg	-	1.71	1.18	0.87	0.62
Fattening period, mths	38	14	11.4	10.7	10.4

basal diet and a supplement of 1.5 ± 0.5 kg cottonseed meal, an average daily gain of between 600-700 g, can be achieved with local yellow cattle under small farmer management.

Zoukhou in Henan province, was selected as a national training centre. It received 3 16 groups and more than 3200 visitors from all over China. This considerably helped the dissemination of the technology throughoutthe whole country.

Economics

Profitability analysis was made on the basis of an initial weight of 180 kg and a final weight of 350 kg for all level of supplements (Table 10) using the Henan trial data. The break-even daily gain is the growth rate required to cover variable costs (mainly feed). Break-even CSM is the price of the cottonseed meal which would result in zero profit (Finlayson 1993).

The level of supplement at which maximum growth occurs is about 4 kg/day; the the level at which maximum profit occurs is between 1 and 2 kg/day. It is also apparent that maximum profit per day is reached at a different different level (about 1 kg/day) than maximum profit per head (about 2 kg/day). Therefore, a farmer who wants a maximum turn-over will use more supplement than the one who wants maximum profit per head. When the cost of supplement increases, it will be less advantageous to use higher levels.

Reasons for Success

The results of the project have largely overtaken the most optimistic expectations. Farmers have been very enthusiastic about the proposed technology, particularly urea treatment of straw. The region in which the project has been sited, has been transformed into one of the main beef producing areas, surpassing the traditonal grazing areas of Mongolia (Guo Tingshuang et al 1993). Moreover, the technology has spread over the whole country. Uptake, from 1985 to 1993, is indicated in Table 11. The figures are impressive even for such a large country.

The main reasons for such success have been discussed by Dolberg and Finlayson (1995). They considered the following:

- the huge availability of crop residues, on the farm, for which no sustainable alternative uses existed the relative shortage of other feed resources such as pastures and the need to reserve grain for human consumption and monogastric animal production.

  the relative low cost of the local protein supplement (cottonseed meal)

  the development of an appropriate technology (urea treatment) easy for the small fanner to learn and to apply, and which presented no risks

  the relevance and the profitability of the proposed production system and its demonstration at the farm level

  the strong support from the government which took the form of trained technical assistance at the village level, ready availability of credit at concessional interest rates through the Agricultural Bank, supply of urea at a subsidized price at the start of the project, political and institutional support at all administrative levels from the village to the national government.

- the technical assistance from by international organizations (FAO, UNDP) which provided qualified experts, in-service and external training and a minimum of essential equipment.

Next steps should be the use of treated straw for dairy cattle and small ruminants, and the extension of the technology to sub-tropical and tropical areas where rice straw is predominant.

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Table 11 Uptake of the straw treatment technology in China

Year	1985	1986	1987	1988	1989	1990	1991	1992	19 3
No of Farmers (1,000)	-	-	-	-	-	-	-	2.200	3.
Treated straw (million tonnes)	0.003	0.042	0.148	1.480	1.830	2.570	3.870	6.000	11.

Source Ministry of Agriculture

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