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China looks to sorghum for ethanol (Part 2)

China's sweet sorghum bio-ethanol program can have a sizeable impact on expanding the nation's feedstuffs availabilities as well as providing ethanol to blend with gasoline.

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No sorghum grain

There is considerable demand for sorghum grain to be fed directly to livestock rather than using it for bio-ethanol as well as other uses such as distilling it for alcoholic beverages. The destination and usage depends on economic variables as well as government and industry policies. Consequently, an analysis of the impact on the bio-ethanol program is an appropriate scenario to evaluate.

The base scenario for sweet sorghum grain in the study was set at 80% of production being used in the bio-ethanol program and feeding all of the residue to animals, half as WDG and half as DDG. The alternative scenario for 2030 evaluated was that none of the grain be used for bio-ethanol. The result is that bio-ethanol production would be reduced from 8.0 million to 6.29 million tons because the amount of land required to produce 8.0 million tons would exceed the maximum land available.

The ME availabilities without distillers grain co-products would lead to the program's impact falling from 2.10% of arable land crop equivalency to 1.85% -- a 12% decline. CP availabilities from sweet sorghum would decline 37% as a proportion of arable land equivalencies, from 1.56 to 0.98%.

Energy availabilities over the base period gap would decline only slightly, from 37% in the base scenario to 36% with no grain used for bio-ethanol -- a drop of 3%. Distillers grains are very high in protein, with the result that China's CP deficit would expand from 31% in the base scenario to 34% -- a difference of 10%. Offsetting the effects somewhat is what the nation would gain to the extent that the grain itself was fed to animals. That event is not calculated.

The conclusion is that the decision about the extent to which sweet sorghum grain should be used for bio-ethanol or allowed to be sold on the open market is a serious one that requires considerable economic and policy analysis. A 10% change in CP availabilities is akin to the nation requiring an additional 10% of protein equivalency imports.

Feedstuffs supply, usage

Per capita consumption of poultry meat, cow milk and fish and seafood is projected to grow dramatically through the projection period (Table 1). Global warming will continue to cast a pall over the outlook on agricultural growing conditions, leading to the conclusion that from China's viewpoint, prudence about food security is warranted.

The poultry industry will continue to develop into large-scale units in the more favorable geographic areas for production and nearer to sources of feedstuffs.

Milk is a very bulky commodity, so its production will be concentrated near urban centers. DDG can be included in diets of all animals and fish, so there is a ready market for that product from the bio-ethanol industry. The stover residue can become a dietary mainstay for cattle and small ruminants, so those classes of animals are very important in considering policy options.

Per capita consumption of beef is expected to double during 2000-30 -- from 4 to 8 kg. It could grow even more, perhaps to 10 or even 12 kg, depending on relative prices and dietary changes, with substantial effects on protein-based feedstuffs and oilseed imports.

Animal production

Animal productivity is still relatively low in China despite dramatic improvement since the country opened in 1978. The rapid economic growth and changes in land tenure regulations will be accompanied by continual adoption of production technologies. One of the best indicators is that meat production per head of inventory will be at or near those of economically developed countries by 2030 (Table 2).

The impact from technological adoption and restructuring China's rural economy will be so dramatic that the number of pigs, poultry and milk cows is projected to be about the same in 2030 as in 2000 despite growth in population and per capita consumption of their products (Table 3; Simpson, 2003, 2004 and 2006).

Cattle, sheep and goats are a focal point for government planners and policy-makers from the perspective of the sweet sorghum bio-ethanol program as they are ruminants and thus are adapted to consuming the stover residue.

Sheep and goats, collectively called small ruminants, are projected to account for about 7% of ME and CP consumed by all animals and fish in 2030 compared with 8% in 2000 (Table 4). The number of small ruminants is projected to grow from 280 million head in the base period to 309 million in 2030, a 10% increase. Large farms to accommodate them during dry seasons, droughts, winter and for fattening to slaughter would be very beneficial to improving their productivity, for enhanced food security and to improve producer livelihoods by rural restructuring. The areas around the bio-ethanol refineries would be ideal for such a project.

Cattle traditionally used for work purposes are being replaced by machinery. However, total cattle numbers are actually increasing as beef-type animals replace draft-oriented ones due to growth in beef consumption. There were 104 million head of cattle (including dairy cattle for beef) in 2000, and a 25% increase is projected to 2030, at which time inventory is calculated to be 130 million head (Table 3). That projection is based on 8 kg of beef consumed per capita. Proportionately more cattle would be required if per capita consumption were greater.

Draft/beef cattle consumed 353 billion Mcal in 2000 and are projected to require 613 billion Mcal in 2030, a 74% increase. Protein requirements will grow 64%. These very large increases in demand for feedstuffs provide ample opportunities to fatten cattle around bio-ethanol refineries.

The massive amounts of stover residue are ideal feedstuffs for ruminants and fit in especially well with the type of feeding systems Chinese cuisine demands. That residue is bulky, and transport costs are high, dictating that most of it be consumed close to the refineries. In addition, the most cost- and energy-effective way to utilize the distillers grains is via WDG.

Table 4 amply demonstrates the importance of draft/beef cattle to sweet sorghum policy options. Beef cattle accounted for 22% of all ME and 21% of CP requirements by animals and pond-raised fish in 2000. The proportions for draft/beef cattle in 2030 are projected to increase to 27% for ME and 22% for CP. In contrast, the proportions of ME and CP for pigs, which have been the largest consumer of feedstuffs, are projected to decline from 42 and 35%, respectively, in 2000, to 39 and 31%, respectively, in 2030.

Sources of animal feedstuffs

Nutrition, including the type of feedstuffs, is central to understanding the extent to which China can react to the great increases projected in livestock commodity and fish production and to meet changes in demand for them.

Energy availabilities are calculated to have been 1.18 trillion Mcal of feedstuffs in 2000, and 42% of that was derived from principal crop sources such as grains. That proportion will increase to 55% by 2030 as the industry and economy mature, still leaving 45% from other sources. In 2000, 39% of protein was produced from principal crop sources such as grains and oilseeds, and it will only reach 42% in 2030 unless there is a substantial reallocation in crop makeup. This finding has major policy implications.

NCFR is a major source of both energy and protein for animal feeds (36% of ME and 26% of CP production in 2000). They are nearly as important as principal crops, from which 42 and 39% of total energy and protein were derived in 2000 (Table 5).

Crop residues and silage are, without a doubt, the key to understanding China's potential to meet its growth in animal and fish production. They will continue to be an important source of animal feedstuffs for the next two decades even though their proportions of total ME and CP will decline to 26 and 22%. Principal crops are projected to increase to 55 and 42% (Table 5) as crop breeding improvements lead to a higher proportion of grain within the plant.

Draft and beef cattle consume most NCFR, and this feedstuffs category explains why China will be able to feed its rapidly growing cattle numbers without resorting to substantial grain imports. Crop residues include vines, straw and stover, a part of which is simply waste that is burned in the field after harvest, plowed back into the ground, used in other activities such as making paper or used by farmers for cooking and heating. The rest is fed to animals, primarily ruminants. In 2000, 34% of all residues were fed to animals, and estimates are that it will reach 38% by 2010 primarily as a result of government programs (Tingshuang, Sanchez and Peiyu, 2002).

An important part of China's animal policy has been to increase use of both untreated and treated residues. China embarked on a crop residue improvement program in the mid-1980s, and the Food & Agriculture Organization and U.N. Development Program provided considerable financial and technical assistance from 1987. By 2000, 13 prefectures and 380 counties had programs, including demonstration sites.

Projections of total tonnage fed reveal the emphasis that continues to be placed on the program, one of the most important in rural China. Thus, it can easily be seen that the sweet sorghum bio-ethanol program fits very well into current government policy.

Conclusions, policy implications

China is in a very enviable position based on the nutrition-oriented analyses presented in this article.

Policy options abound when considered within the milieu of human diets, animals as users of the co-product feedstuffs generated from sweet sorghum and other bio-ethanol raw materials, international trade, the bio-ethanol program itself, the impact on arable land crop production alternatives and restructuring the rural economy as the nation develops economically.

The sweet sorghum bio-ethanol project and its many facets will clearly have a substantial impact on development of the rural economy. It can be concluded that the program analyzed in the study presented, plus the use of other biomass raw materials, have great potential to help China in its quest for continued food security as well as a non-petroleum source of gasoline.

The analysis presented dramatically shows the benefits from the crushed stover residue grains of bio-ethanol production and the need for careful policy development to capture them.

Fifty-three percent of bio-ethanol is projected to be from sweet sorghum in 2030, and the co-products are a significant addition to crops from arable land. This analysis only focuses on sweet sorghum. However, co-products from other sources will also provide significant amounts of energy and protein in animal feedstuffs.

Optimization of general agricultural policy as part of rural restructuring is perhaps the foremost part of the many options available. Substantial use of the sweet sorghum bio-ethanol co-products as animal feedstuffs in coordination with the program for treating NCFR from crops to improve their quality will allow considerable flexibility in cropping patterns.

For example, the abundance of surplus ME means crops could possibly be shifted from energy-oriented ones like corn to protein-rich ones such as soybeans. Stover from corn and straw from other crops fed to livestock are currently the major reason for a surplus of energy. As an energy-based surplus grows, NCFR could be diverted to other uses such as fuel for homes or industry (like the energy to produce bio-ethanol) to make particle board or paper. It could also be left in the fields to improve soil quality. That, in turn, would open the way for expanded no-till agriculture, improving soil fertility and a fuel (gasoline and diesel) cost-saving technique in which the land is not tilled as the seeds are just drilled directly into the ground.

Additional implications are that planners of China's biotechnology program should carefully consider emphasizing protein enhancement in crops rather than increasing energy content. That would have major implications on trade balances. Another benefit is that marginal arable land such as areas with growing water shortages could be converted into sweet sorghum production or forests, grasslands or parkland. It also would help to reduce the impact from cropland lost through urbanization.

Policy questions abound, such as who should own the distillation plants, animal farms and feedlots near the plants and the use of cooperatives rather than individual owners and operators.

The stover residue also has multiple potential outputs, such as paper or particle board rather than animal feed. That leads to the question of the extent to which food security is more important than manufacturing. Economics -- costs and benefits of production, marketing and use as well as social analyses -- have not been covered in this study and are needed for rational evaluation of policy and its implementation.

Overall, China's policy options related to its bio-ethanol program are quite pleasant ones compared to many others on economic development issues. Clearly, the sweet sorghum program also has great relevance for the U.S. and other countries struggling with development of their own bio-ethanol programs.

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1. Per capita meat and fish supply in China (kg), 2000-30

	2000	**2010**	**2030**
Beef and veal	4	6	8
Pork	33	34	38
Mutton and goat	2	2	2
Poultry	10	14	21
Fresh fish and seafood	25	30	34
Total meat, fish and seafood	74	86	103
Cow milk	7	18	40
Eggs, hen	15	16	17

Source: **Simpson, modeling results.**

2. China's production per head of inventory (kg/head), economy robust, 1984-86 to 2030

Species	**1984-86**	**1989-91**	**1994-96**	**Avg 99-01**	**2010**	**2020**	**2030**
Sheep	3	5	8	11	11	12	13
Goats	5	5	6	9	9	9	10
Cattle	6	15	31	48	60	75	84
Buffalo	6	8	12	16	16	18	19
Pigs	54	67	81	95	103	130	145
Poultry	1	2	2	3	4	6	7

Source: **Historical data from FAO Datastats. Projections from Simpson, modeling.**

3. China's livestock inventory (1,000 head), economy robust, 1984-86 to 2030							
Species	**1984-86**	**1989-91**	**1994-96**	**1999-2001**	**2010**	**2020**	**2030**
Non-bovine work animals							
Asses	9,942	11,128	10,853	9,906	7,466	4,021	1,151
Camels	542	470	360	330	242	197	157
Horses	10,956	10,338	10,025	8,889	6,236	5,095	4,382
Mules	4,785	5,417	5,480	4,647	2,822	1,876	1,017
Total non-bovine	26,225	27,353	26,718	23,772	16,765	11,190	6,708
Cattle							
Milk cows	1,680	2,821	3,945	4,934	7,489	8,629	8,984
Draft/beef	41,659	55,051	69,099	98,869	117,685	115,411	120,629
Total cattle	43,339	57,872	73,044	103,803	125,173	124,040	129,613
Buffalo	19,571	21,412	23,030	22,681	19,704	14,530	6,732
Total buffalo	62,910	79,284	96,074	126,484	144,877	138,571	136,345
Total large animals	89,135	106,637	122,792	150,256	161,643	149,761	143,053
Sheep	96,108	112,299	118,919	130,539	145,976	150,188	144,213
Goats	64,521	95,615	126,431	149,245	166,467	168,157	164,808•
Total small ruminants	160,629	207,914	245,350	279,784	312,443	318,345	309,021
Commercial pigs			154,134	204,371	298,879	348,665	
Backyard pigs			286,248	249,787	99,626	34,483	
Total pigs	319,078	360,543	408,782	440,382	454,158	398,505	383,149
Total poultry, mil. birds	1,586	2,558	3,914	4,410	4,770	4,545	4,199
Source: **Historical data from FAO Datastats. Projections from Simpson, modeling.**							

4. ME and CP requirements by species groups in China, economy robust, 1999-2001 to 2030						
	-Total requirements-		**-% increase-**		**-Species proportion-**	
	ME	**CP**	**ME**	**CP**	**ME**	**CP**
Species	**(Mil. Mcal)**	**(1,000 mt)**	**-Avg. 1999-2001-**		**(%)**	**(%)**
Draft/beef cattle	352,933	14,074			22.4	20.6
Other large animals	132,571	5,324			8.4	7.8
Total large animals	485,503	19,398			30.8	28.4
Small ruminants	124,315	5,678			7.9	8.3
Pigs	660,159	23,534			41.9	34.5
Poultry	154,003	8,182			9.8	12.0
Fish, fresh water	151,631	11,463			9.6	16.8
Total	1,575,612	68,254			100.0	100.0
	-2030-					
Draft/beef cattle	612,892	23,292	74	65	27.2	22.1
Other large animals	121,936	5,815	-8	9	5.4	5.5
Total large animals	734,828	29,106	51	50	32.6	27.6
Small ruminants	151,293	6,941	22	22	6.7	6.6
Pigs	888,348	33,008	35	40	39.4	31.3
Poultry	304,413	20,105	98	146	13.5	19.1
Fish, fresh water	175,407	16,205	16	41	7.8	15.4
Total	2,254,289	105,365	43	54	100.0	100.0
Source: **Simpson modeling.**						

5. Total ME and CP produced by source type in China, economy robust, 2000-30				
Item	**2000**	**2010**	**2020**	**2030**
ME, %				
Byproducts	9	9	9	10
Non-conventional	36	35	30	26
Grassland	13	11	10	9
Principal crop	42	45	51	55
Total	100	100	100	100
CP, %				
Byproducts	25	25	27	29
Non-conventional	26	27	24	22
Grassland	10	9	8	8
Principal crop	39	39	40	42
Total	100	100	100	100
Source: **Simpson modeling.**				