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FOOD & FERTILIZER TECHNOLOGY CENTER

FEED GRAIN SUBSTITUTES AND NON-CONVENTIONAL FEEDSTUFFS FOR POULTRY AND LIVESTOCK IN JAPAN

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FOREWORD

The rapid development of Japan's livestock industry has resulted in the massive and growing import of feedstuffs. At present, more than 90% of the concentrates fed to livestock in Japan are imported. At the same time, Japan's farmers are trying to cope with a surplus of rice and other staple foods. To increase the level of self-sufficiency and to diversify the system of agricultural production, livestock scientists in Japan are working to increase the use of locally produced feedstuffs. This Bulletin describes recent research in Japan aimed at expanding the range of domestic resources used for commercial feed concentrates.

One important feed is the by-products from polishing food grains and milling flour. The Bulletin describes the special wheat bran with a high flour content produced by mills in Japan, where the rate of bran production is government controlled to meet the demand. Rice is also used as a feed grain, in spite of the high production costs. The production of high-protein yeast from petroleum for use as a feed is also described, together with the problems which have discouraged its widespread adoption.

Among the new feed grain crops grown in Japan is a new variety of naked barley with a very high protein and lysine content. Because the grain is dark in color, it is more suited for use as a feed than in human food. Finally, the Bulletin discusses the use of by-products from food processing as feed. Japan has been extremely successful in making use of these resources, and 70% of the by-products produced by the food processing industry are now being used for livestock feed.

The paper on which this Bulletin is based was first presented by its author at an international seminar on *"Feed Grain Substitutes and Non-conventional Feedstuffs for Livestock and Poultry in Asia"*, held in the Philippines on November 13-18 1989 and sponsored by FFTC and SEARCA (SEMEO Regional Center for Graduate Study and Research in Agriculture), Los Baños, Philippines.

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(Chinese Abstract)

摘　　要

在日本一種新興發展具有高蛋白質裸大麥爲相當具有希望的穀類飼料。在目前經濟條件下，不能生產水稻或由石油碳氫化物中提煉出單細胞蛋白質做爲飼料之用。目前約 70%食品加工業副產品可做爲飼料，這些副產品乾燥成本却爲發展的主要限制因子。

(Japanese Abstract)

摘　　要

日本の畜産業は輸入した濃厚飼料によって支えられている。從って飼料の効率的利用と新飼料資源の開發，副產物の高度な利用は重要な研究課題である。

日本では普通のフスマよりも小麥粉含量の多い特殊フスマが政府の管理の下で飼料用に製造されている。

米の飼料價値はトウモロコシと同等といえるが生產コストが高いため現實には使われていない。

微生物蛋白質の飼料價値の研究は行われたが、安全性に對する不安から消費者に受け入れられなかったことと經濟性から、微生物蛋白質の飼料化は實用化されなかった。

高蛋白質の大麥の新品種は榮養價値は高く飼料穀物として可能性はあるが、生產費が高く現實には利用されていない。

食品工業の副產物の70%は家畜の飼料として利用されている。大量に生產されて乾燥した副產物はよく利用されているのに對して、小規模に生產される水分の多い副產物は輸送費用が高いこと、乾燥費用が高いことによって、あまり利用されていない。水分の多い副產物をより多く利用するには貯藏，輸送，乾燥の費用を低くするための研究が必要である。

(Korean Abstract)

초　　록

현재 일본에서는 특수하게 제조된 밀기울을 사료로 생산하고 있으며, 새로이 개발된 고단백 정맥한 쌀보리는 사료용 곡류로 인정을 받고 있다. 현재의 경제여건상 사료용 쌀의 생산 및 식유에서 추출한 단세포성 단백질의 생산은 실용성이 없다. 현재 식품가공산업에서 얻어지는 부산물의 70%가 가축사료로 이용되고 있다. 이때 이 부산물의 건조비용이 주요한 제한요소로 되어 있다.

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ABSTRACT

Specially prepared wheat bran with a high flour content is now being produced as feed in Japan, while a newly developed high-protein naked barley is a promising feed grain. Under current economic conditions, neither the production of rice as a feed grain nor the production of single cell protein from petroleum hydrocarbon is practicable. At present, 70% of the by-products from the food processing industry are being used as animal feed. The cost of drying these by-products is a major limiting factor.

INTRODUCTION

In 1987, 3.5 million mt of meat, 7.4 million mt of milk, and 2.4 million mt of eggs were produced in Japan (Statistics and Information Division, MAFF, 1989b). This level of production was supplemented by imported animal products to supply the annual *per capita* consumption of 24 kg of meat, 68 kg of dairy products, and 16 kg of eggs (Table 1).

The self-sufficiency ratio for meat, dairy products and eggs is 75, 78 and 99% respectively *(ibid)*. This self-sufficiency level is higher than for feed grains, only 31% of which are produced domestically, and also soybean and oil and fat, of which only 6% and 32%, respectively, are produced in Japan. The fact is, Japan's animal production depends mostly on imported feed grains (Table 2). To achieve the present livestock production level, Japan uses, 22.3 million mt of concentrates and 6.0 million mt of total digestible nutrients (TDN) from roughage. More than 90% of concentrates are imported.

If Japan's level of self-sufficiency in animal products is calculated on the basis of the amount of imported feed, it is as low as 27%.

The amount of grain imported by Japan accounted for 13% of that available on the world market in 1988, including 16.6 million mt of corn, 3.7 million mt of sorghum, and 4.8 million mt of soybeans (Statistics and Information Division, MAFF, 1989a). Besides these feed grains, the

Table 1. Animal Production in Japan, 1987

	No. head (millions)	Domestic production (1000 mt)	Imported livestock products (1000 mt)	Self-sufficiency level (%)	Supply *per capita* (kg)
Dairy cattle	2.05	7,427	1,733	78	68
Beef cattle	2.65	568	319	64	4.6
Pigs	11.4	1,591	415	80	10.7
Broilers	155.2	1,440	217	88	9.8
Layers	135.2	2,378	36	99	15.7

Source: Pocket Statistics of Agriculture, Forestry and Fisheries, 1989

Table 2. Import and domestic production of major feeds into Japan, 1988

Concentrates	Imports (1000 mt)	Domestic production (1000 mt)
Corn (total)	16,602	1
(for feed use)	11,776	
Sorghum	3,738	0
Wheat	1,184	864
Barley	1,284	351
Rye + Oats	323	6
Soybean	4,797	287
Soybean meal	500	
Alfalfa meal	288	
Hay + Hay cubes	1,408	
Beet pulp	680	220
Straw	114	11,000

Source: Monthly Statistics of Agriculture, Forestry and Fisheries

amount of imported roughages has been increasing in recent years.

The Japanese animal industry has developed on the basis of imported feed, and is thus vulnerable to changes in international economic conditions, such as the production level in overseas countries or the currency exchange rate. As a result, the efficient use of imported feedstuffs, the development of new feed resources, and the optimum use of by-products, are the most important objectives for further development of the livestock industry in Japan.

SPECIAL WHEAT BRAN

The by-products of food grain polishing or flouring are important feedstuffs in Japan. The demand for wheat bran has increased with the development of animal production in Japan, while the demand for wheat flour has remained unchanged. To meet the increased demand for wheat bran, the Government plans to increase the production of bran while decreasing that of flour. Since 1933, a special wheat bran with a high flour content has been produced in Japan under the supervision of the government. While only 22-25% of wheat bran can be produced from wheat grain using the standard method, a special processing technique can be used to give 40-60% bran. This special bran, called "Tokushyu fusuma", is now produced in 128 licensed factories, for which the Government controls the standard of the materials, production levels, prices and marketing. The bran production rate fluctuates between 40 and 60%, depending on the demand. In 1988, the rate was 50%, and 530 thousand mt of special wheat bran were produced, 90% of which was used for cattle, 8% for swine and 2% for poultry. The nutrient content of this special wheat bran, compared to ordinary wheat bran and rice bran, is shown in Table 3.

RICE AS A FEED GRAIN

Given the Japanese situation, in which 90% of feed grains are imported, it is not surprising that a small amount of surplus rice is sometimes used as animal feed. Rice is Japan's staple food, and until self-sufficiency was achieved, only broken rice and immature rice were used as animal feed. The annual production of rice started to exceed the demand from the mid 1960's, and in 1970 the Government introduced a new policy to restrict the production of rice. Under this policy, programs to produce upland crops in rice fields, and studies on the nutritive value of rice and the production of rice suitable for animal feed, were initiated.

The production of rice for feed is favored by the climate, which is suitable for this crop and also makes direct use of farmers' advanced technical skills in rice production, together with the existing irrigation system and farm machinery. For the security of Japan's food supply, it s important to

Table 3. Chemical composition and nutrient content of special wheat bran and other brans

		Special wheat bran	Ordinary wheat bran	Rice bran	Extracted rice bran
Moisture	%	13.3	13.0	12.0	13.1
Crude protein	%	14.0	15.4	14.8	17.7
Crude fat	%	2.9	4.1	18.5	1.9
N-free extract	%	62.9	53.4	38.2	47.1
Crude fiber	%	4.2	9.1	7.7	8.5
Acid detergent fiber	%	4.8	12.5	-	11.5
Crude ash	%	2.7	5.0	8.8	11.7
TDN catttle	%	75.9	62.9	80.5	55.9
TDN swine	%	68.5	58.9	75.5	52.4
ME poultry	kcal/g	2.26	1.94	2.79	1.65

Source: Standard Tables of Feed Composition in Japan, 1987
TDN: Total Digestible Nutrients
ME: Metabolizable energy

maintain rice fields so that they can be used at any time to produce rice for human food if necessary.

The Italian rice variety "Arbolio", the Korean variety "Miliyang", and several other varieties have been tested by agronomists in breeding a new variety for use in livestock feed. Selected varieties, all of which are hybrids of Indica rice, can give yields as high as 8-10 mt/ha, about 1.5 times higher than the average yield from Japonica varieties.

A series of feeding experiments using rough rice were carried out for chicks, swine and cattle (Japan Scientific Feed Association, 1978). Feeding experiments with layer starters showed that chicks fed with rough rice which had been finely ground and passed through a 3 mm mesh sieve had better feed efficiency than chicks fed coarsely ground rice, while separation of the husk was not observed in finely ground rice. The nutritive value of the rice was not increased by steam flaking, popping or cooking it.

In an experiment using layers, hens were fed one of four experimental iso-energy and iso-protein feeds which contained rough rice at a rate of 0, 35, 50 and 60%. No significant differences were observed in egg production, egg weight, feed intake, viability and body weight gain during the experiment, except that there was a decrease in the intensity of the yolk color proportional to the amount of rough rice in the feed.

An eight-week experiment using broiler chicks also fed them a diet containing rough rice at a rate of 0, 35, 50 or 60%. During the first four weeks, feed with a 20% crude protein (CP) content and 2.79 kcal/g metabolizable energy (ME) was used, while subsequently feed with 16% CP and 2.99 kcal/g ME was used. The results, shown in Table 4, indicated that the growth of chicks fed on rice was superior to those fed the control corn diet. No significant differences were detected in growth, feed intake or feed requirements among the three groups that received the rice based diet. It was observed that the intensity of the yellow color of the leg skin decreased in proportion to the level of rice in the diet. This suggests that it is necessary to adjust the energy, protein and pigment level in the feed when yellow corn is replaced by rice grain in poultry diets.

In a feeding experiment using fattening pigs, 64 hybrid pigs 75 days old were fed diets containing rice for 15 weeks. The experimental feeds, were mainly composed of corn, rice and soybean meal: total digestible nutrients (TDN), were adjusted to 70% using rice bran, wheat bran and yellow grease. Finely ground rough rice was included, at a rate of 0, 35, 50 and 65%. The crude protein content of the feed was adjusted to 15% for the first eight weeks, and 13% for the final seven weeks.

While the growth, feed requirements and dressing percentage of the pigs fed a rice based diet were better than those given the control feed, no significant difference was observed between the

Table 4. Broiler finisher feeds and performance

Feed		0% rice	35% rice	50% rice	60% rice
Corn	%	71.65	35.71	20.43	9.65
Rough rice	%	0	35.0	50.0	60.5
Soybean meal	%	11.9	15.0	16.3	17.2
Defatted rice bran	%	8.7	3.7	1.5	0
Yellow grease	%	2.0	4.9	6.1	7.0
Fishmeal	%	3.0	3.0	3.0	3.0
Ca carbonate	%	1.36	1.07	0.95	0.86
Ca phosphate	%	0	0.23	0.33	0.4
Minerals	%	0.45	0.45	0.45	0.45
Additives	%	0.94	0.94	0.94	0.94
Crude protein	%	16	16	16	16
Metabolizable energy	kcal/g	2.99	2.99	2.99	2.99
Average daily gain	kg	2.000^{a}	2.189^{b}	2.231^{b}	2.201^{b}
Feed intake	kg	4.887^{a}	5.148^{b}	5.148^{b}	5.038^{ab}
Feed/Gain		2.45^{a}	2.36^{ab}	2.31^{b}	2.29^{b}
Raising rate	%	96.5	95.5	89.5	92.8
Leg color*		5.08	3.38	1.48	<1

Source: Japan Scientific Feed Association 1978
* Roche color fan number
Different subscripts differ significantly at a 5% level

Table 5. Performance of swine fed rough rice

Feed		0% rice	35% rice	50% rice	65% rice
0-15 gain	kg	68.1^{a}	79.1^{b}	79.6^{b}	81.1^{b}
Feed intake	kg	253.5	271.1	263.4	264.1
Feed/Gain		3.75^{a}	3.43^{b}	3.32^{b}	3.27^{b}
Dressing	%	64.7^{a}	67.5^{ab}	67.6^{b}	67.9^{b}
Back fat	cm	2.53	2.93	2.83	2.88

Source: Japan Scientific Feed Association, 1978
Different superscripts differ significantly at 5% level

experimental groups which received different levels of rice. These results indicate that the nutritive value of rice is as high as that of corn or sorghum, and that the palatability of rice is higher than that of corn.

The nutritive value of rice compared to corn is shown in Table 6. The crude protein content of dehulled rice was 1% lower than that of corn, while the energy content of the two grains was the same. The nutrient content of rough rice was about 20% lower than that of dehulled rice, due to the weight of the low-nutrient hull.

It would seem that from the nutritional point of view, rice appears to be as satisfactory a feed grain for livestock as corn. The problem is whether rice used for feed can be produced at a cost comparable to that of imported feed grains, under current economic conditions in Japan. The production cost of rice used for feed is estimated to be US$600/mt, which is much higher than the price of

Table 6. Nutrient content of rice and corn

		Brown rice		Rough rice		Corn
		STFC*	Arbolio**	STFC*	Arbolio**	STFC*
Moisture	%	13.8	14.2	13.7	14.0	13.5
Crude protein	%	7.9	8.1	8.9	7.1	8.8
Crude fat	%	2.3	2.1	2.2	1.9	3.9
NFE	%	73.7	74.3	61.2	65.0	70.7
Crude fiber	%	0.9	0.9	8.6	7.0	1.9
Crude ash	%	1.4	1.4	5.4	5.0	1.2
TDN cattle	%	81.3		66.3		79.9
TDN swine	%	82.5		63.4		80.7
ME poultry	kcal	3.29	3.35	2.64	2.85	3.27

* STFC: Standard Tables of Feed Composition in Japan, 1987
** Arbolio: An Italian Variety, details from Yamazaki *et al.* 1988

imported corn (US$286/mt). However, although it may not be economical to use rice as feed in Japan, it may be possible to produce rice as a feed grain in other Asian countries where the climate is more suitable for this crop.

THE PRODUCTION OF SINGLE CELL PROTEIN IN JAPAN

The production of high-protein yeast (Single Cell Protein, or SCP) from petroleum hydrocarbon has been seen as an attractive proposition for the production of protein feed. Because the source material does not compete with other food products, the factory production system is independent of weather conditions or land area.

In the years since industrial mass-production technology was established by several companies in the end of the 1960's, several studies on the use of this yeast as animal feed have been carried out, most of them during the 1970's.

Studies of hydrocarbon yeasts showed that the protein content and amino acid balance of yeast varied with the strains of yeast used, while the level of the essential amino acids, methionine, arginine and phenylalanine was relatively low (Tajima *et al.* 1971). The metabolizable energy content ranged from 2.5 to 3.4 kcal/g (Kosaka *et al.* 1972). These values are higher than those for soybean meal, but lower than those for fish meal.

The results of a feeding experiment over six consecutive generations in laying hens which received feed containing hydrocarbon yeast at a rate of 15% did not reveal any abnormalities considered to be caused by the yeast in egg production, viability, body weight at maturity, or fertility (Yoshida *et al.* 1975). Hatchability was not affected, and no deformities in the offspring or chronic toxic symptoms were observed (Fujiwara *et al.* 1975). In the sensory test, there was no difference between the taste of the meat and eggs from hens which received hydrocarbon yeast in their feed, and those from hens fed the control corn diet (Yoshida 1974).

Although these series of experiments confirmed the nutritive value and safety of hydrocarbon yeast, many consumers were still concerned about the safety of feeds of petroleum origin. In particular, they worried about the possibility of contamination of feed by the toxic substances contained in petroleum, such as carcinogenic cyclic compounds, and possible mutation of microorganisms during processing leading to the production of substances harmful to animals. They were also concerned about the lack of adequate controls to ensure the safety of yeast in terms of both feed and food.

The companies which had developed the production system lost interest in the production of hydrocarbon yeast, due to the oil crisis of 1974 and consumers' strong rejection of petroleum protein. Changes in the economic situation in 1974 made the production of yeast from oil, all of which was imported, unprofitable in Japan. Production was eventually discontinued, and the technology developed in Japan was little used in other countries.

The production of bacterial cell protein from methanol, which is chemically synthesized from natural gas, was also developed. However its use

as feed was discontinued when lesions were found in the livers of hens fed a large amount of this bacterial cell protein for only one week (Ando *et al.* 1983).

Currently in Japan, torula yeasts produced from sulfite pulp waste water, beer yeast and bread yeast, are being used as feed.

NEW HIGH-PROTEIN NAKED BARLEY

A new variety of naked barley with a high protein and lysine content has been developed at the Shikoku National Agricultural Experiment Station. It was bred by crossing a Highproly variety with a Japanese variety with early maturity and high yield (Kato *et al.* 1987). Due to the dark color of its grain, this new variety of naked barley was found to be more suitable for use as an animal feed than for human food.

Although the yield (4 mt/ha) of high-protein naked barley is lower than that of ordinary naked barley (4.8 mt/ha), the protein yield is higher. The yield of crude protein of the new barley was 0.668 mt/ha, compared to 0.604 mt/ha for common naked barley. A reduction of the level of soybean meal used in feed could thus be obtained, by replacing corn with high-protein naked barley (HPNB).

The nutritive value of HPNB was determined (Hijikuro *et al.* 1986), in order to make efficient use of it as a livestock feed. The feed composition is shown in Table 7, together with that of the ordinary naked barley variety "Nanpuhadaka", and figures from the Japanese standard feed composition tables.

The crude protein content of HPNB ranged from 14 to 17%, and was higher than that of the ordinary naked barley variety (11-13%). While there was no difference in the fat, fiber, and ash content between HPNB and the common varieties, the nitrogen free extract (NFE) level was lower in HPNB. The nutrient content of HPNB varied according to the year of production. The essential amino acid content was higher in HPNB than in the ordinary variety (Table 8). The availability of amino acids of HPNB was determined using the true metabolizable energy assay (Yamazaki *et al.* 1988).

All the amino acids determined in HPNB showed a higher availability compared to those found in the normal variety. The availability of lysine in HPNB ranged from 80 to 87%, and was also higher than that of the ordinary variety (68%), although weather conditions during the growing season affected the amino acid availability in the HPNB.

These results demonstrate that the quantity of available essential amino acids supplied by HPNB is 1.5 to 2.0 times higher than those from ordinary naked barley.

In a 14-day feeding experiment, seven-day-old layer chicks were fed a diet with various levels of HPNB (Hijikuro *et al.* 1986. The amino acid composition and availability of the experimental feeds used are shown in Table 9, and the results of

Table 7. Nutritive value of naked barley

		High-protein naked barley 1982*	Naked barley var. Nanpuhadaka**	Naked barley STFC***
Moisture	%	10.1	11.4	12.3
Crude protein	%	15.8	9.7	10.3
Crude fat	%	2.6	2.4	1.9
NFE	%	68.0	73.1	71.8
Crude fiber	%	1.2	1.3	1.7
Crude ash	%	2.3	2.1	2.0
ME	kcal/g	2.72	2.68	2.71

* 1982: produced in 1982
** Nanpuhadaka: the variety most commonly cultivated in Japan
*** STFC: Standard Tables of Feed Composition in Japan, 1987

Table 8. Amino acid composition of two barley varieties, and availability of their amino acids to chickens

		High-protein naked barley		Common naked barley		
				"Nanpuhadaka"		STFC
		Content	Availability	Cont.	Avail.	Content
Crude protein	%	15.8		9.7		10.3
Arginine	%	0.78	91.1	0.49	77.4	0.51
Glycine	%	0.64	88.4	0.43	73.7	0.41
Histidine	%	0.33	91.5	0.21	80.1	0.22
Ileusine	%	0.61	87.5	0.35	68.9	0.34
Leucine	%	1.10	89.9	0.66	75.2	0.71
Lysine	%	0.62	87.3	0.35	68.1	0.38
Methionine	%	0.31	87.5	0.18	71.1	0.16
Cystine	%	0.27	85.2	0.22	73.6	-
Phen.	%	0.89	90.1	0.46	71.7	0.51
Tyrosine	%	0.48	87.0	0.30	73.1	0.32
Threonine	%	0.53	83.1	0.35	66.6	0.36
Tryptophan	%	0.19	88.9	0.11	75.1	-
Valine	%	0.81	87.7	0.50	72.6	0.50
Serine	%	0.63	86.9	0.41	71.2	0.42

Source: Yamazaki *et al.* 1988
STFC: Standard Tables of Feed Composition in Japan, 1987

Table 9. Composition of experimental feed containing HPNB

		Corn	Ordinary naked barley		HPNB	
Corn	%	60	-	33	-	35
Common naked barley	%	-	66	33	-	-
HPNB	%	-	-	-	75	35
Soybean meal	%	23.0	19.0	22.0	10.5	18.0
Fish meal	%	5.0	5.0	5.0	5.0	5.0
Def. rice bran	%	6.5	0.6	0.6	0.6	0.6
Soybean oil	%	-	4.0	1.0	3.5	1.0
Alfalfa meal	%	3.0	3.0	3.0	3.0	3.0
Minerals + Vitamins	%	2.5	2.4	2.4	2.4	2.4
Crude protein	%	20.3	19.7	20.4	19.1	19.5
ME	kcal/g	2.78	2.83	2.79	2.74	2.82

Source: Hijikuro *et al.* 1986

the feeding experiment are given in Table 10. A significant decrease in growth and feed efficiency was observed when all the corn (i.e. 75%) in the standard feed was replaced by HPNB. However, when only half the corn (i.e. 35%) was replaced by HPNB, the performance of chicks was not significantly different from those given the standard feed.

Since the addition of 0.1% cellulase to barley feed improves the metabolizable energy of the feed, the supplemented feed gave better body weight gain and feed efficiency (Table 10).

The amount of barley used as feed in Japan amounted to 1.31 million mt in 1988. Of this, about 0.4 million mt were produced domestically.

Table 10. Effect of adding cellulase to naked barley feed on the performance of layer chicks

Feed		Corn	33% Naked barley	33% Naked barley	75% HPNB	75% HPNB	35% HPNB	35% HPNB
Cellulase supplement			–	+	–	+	–	+
Average gain*	(g)	166.2[c]	152.0[ab]	161.4[bc]	139.6[a]	155.6[bc]	154.5[bc]	163.4[bc]
Feed intake*	(g)	316.2	313.7	299.2	310.9	298.5	304.4	313.0
Gain/Feed		52.6[de]	48.4[b]	54.0[e]	44.9[a]	52.1[cd]	50.8[c]	52.2[cd]
ME	kcal/g	2.78[a]	2.83[b]	3.05[e]	2.74[a]	3.00[de]	2.82[b]	2.89[c]

* During the experimental period
Source: Hijikuro *et al.* 1986
Different superscripts differ significantly at 5% level

The domestic production of naked barley, (0.29 million mt), is now low, but that of HPNB is likely to increase. The estimated production cost of HPNB is US$1,190/mt, which is about eight times higher than the price of imported barley. The increased use of HPNB depends mainly on the cost of production, but also on government policy and trends in the international trade in feed gains.

FOOD PROCESSING BY-PRODUCTS USED FOR FEED

A survey carried out in 1988 by the Central Animal Husbandry Association (1989) showed that the amount of feed which could potentially be obtained from by-products of food processing in Japan was approximately 8.824 million mt, or 1.72 million mt if this is converted into total digestible nutrients (TDN). This amount is equivalent to 7.1% of the total TDN required for animal production in Japan. Of these 1.72 million mt, 1.19 million mt, (about 70%), are actually used as animal feed. Of the 8.824 million mt of by-products produced by the food industry each year, two-thirds originate from beet sugar, broiler processing, potato starch, corn starch, soybean curd ('tofu'), beer and cane sugar production.

The by-products are used mainly on dairy farms. It has been estimated that the average lactating cow in Japan can consume 500 kg of beet pulp, 315 kg of brewers' grain, 133 kg of tofu waste, 35 kg of starch waste, 18 kg of soy sauce cake and 150 kg of miscellaneous by-products as feed in one year.

Mass-produced and dried by-products are frequently used as feed, including corn gluten feed, corn gluten meal, beet pulp, feather meal, wastes from bamboo shoot and sweet corn canneries, broiler processing by-products, brewers' by-products, distillers' by-products, tofu waste and orange juice pulp. However, little use is made of sake cake (a by-product of Japanese rice wine production), bagasse, peach cannery wastes or tuna cannery wastes. While the use of dried by-products is increasing, the use of wet by-products such as juice pulp, tofu cake, potato starch waste and beer waste is decreasing. The main by-products from food processing used for feed in Japan are shown in Table 11.

The more intensive use of agricultural and food processing by-products as animal feed in Japan is being promoted, both to intensify the use of domestically produced and imported resources, and to reduce environmental pollution. In many cases, the high moisture level, vulnerability to rot, and high fiber content of these waste products restrict their use as animal feed. However once they are dried, most of them can be mixed into swine or poultry feed, or used as a cattle feed.

The development of an economically viable system for recovering valuable feed components from wet waste products, and the production of condensed dried and solidified by-products, is essential for the wide use of by-products in a wide range of animal feeds. Generally, efficient use of by-products is made when food processing is on a large scale, since the total use of resources is planned from the beginning. When food processing is on a small scale, however, the use of by-products as an animal feed is one of the main methods of treating waste products.

One of the main constraints to the more extensive use of by-products is the difficulty of securing a constant supply throughout the year.

Table 11. By-products used in formula feeds in Japan, 1988

Unit: 1000 mt

	Cattle	Swine	Poultry
Wheat bran	503.2	97.6	75.6
Rice bran	68.5	23.6	58.3
Defatted rice bran	96.7	50.7	106.7
Corn gluten feed	384.7	37.4	133.5
Corn gluten meal	5.5	0.7	220.2
Screened pellets	124.5	2.4	6.1
Soluble fish by-products	1.0	+	50.8
Bone meal	-	106.9	354.1
Feather meal	-	0.3	51.1
Whey powder	2.2	11.1	-

Source: Monthly Statistics of Agriculture, Forestry and Fisheries

The supply of these by-products is unstable, as a result of the seasonal harvest of farm products or the seasonal production of the main product such as beer. This means that a large volume of by-products becomes available at one particular time when there may be too large a supply for processing by the facilities available.

By-products dehydrated by centrifugation can be dried using the waste heat of the factory, which reduces the cost of drying and increases the value of the material. In most cases, the price at which the by-products are sold does not cover the processing cost. In extreme cases, by-products are delivered at a reduced charge to farms by the food processor, or money is paid to farmers to encourage their use of the by-products.

If wet wastes are dehydrated to a moisture content of 70% or less, silage can be produced satisfactorily by mixing other dry feeds at ensilaging. This process requires silo facilities, a considerable labor input, and changes in the feeding system. At present, the efficient use as feed or wet by-products that rot readily is threatened by an increase in drying and transportation costs. On the

Table 12. By-products from the food industry in Japan, 1988

By-product	Production (1000 mt)	Amount used as feed (%)	Moisture content (%)	Selling price dry US$*/mt	Selling price wet US$*/mt
Orange pulp	210	87	85	21-93	0
Fish scrap	76	50			
Brewery grain	670	94	74	71-180	
Distillers' grain					
(whiskey) soluble	380	84	76	0.07	
(rice wine) soluble	378	19	95		
Corn starch	785	75	10	89-643	
Potato starch	1,045	70	92		0
Soy sauce cake	86	64	27	1.5-57	
Tofu cake	672	90	84	61	
Beet pulp	1,209	100	82	11-18	
Bagasse	540	-	-	fuel	
Poultry scrap	179	98			7-43
Bread crumbs	44	55	3-38	0-286	

Source: Central Animal Husbandry Association, 1989
*1 US$ = 140 Yen

other hand, the extensive use of by-products is being promoted due to the high costs of waste disposal. The costs of storage, transportation and drying must be reduced, if we are to achieve a more efficient use of by-products, and an equilibrium between production and demand of by-products from food processing.

REFERENCES

Agriculture, Forestry and Fisheries Research Council Secretariat, Ministry of Agriculture Forestry & Fisheries 1987. *Standard Tables of Feed Composition in Japan, 1987.*

Ando, M., M. Yamazaki, D. Kubota and K. Kameoka. 1983. *Liver lesion in laying hens fed diets containing some dried microbial (Bacteria) cells.* Bulletin of the National Institute of Animal Industry 41: 29.

Central Animal Husbandry Association. 1989. *Report of the Project for Promotion of Efficient Use of Available Feed Resources in 1988.*

Fujiwara, W., T. Horiuchi, T. Taniguchi, I. Inoue, S. Sakurai, M. Tokuoka, K. Yamanaka and H. Kurahara. 1975. Histological examination of chickens fed with yeast grown on n-paraffin. *Japanese Poultry Science* 12: 127.

Hijikuro, S., M. Takemasa and M. Yamazaki. 1986. Nutritive value of new variety of high-protein naked barley and its improvement by cellulase supplementation. *Japanese Poultry Science* 23: 326.

Japan Scientific Feed Association. 1978. *Report of the Experiments on the Use of Rough Rice as Animal Feed.*

Kato, I., T. Katayama, H. Seko, R. Yoshikawa and T. Tsutsumi. 1987. Breeding for high protein, high lysine naked barley parental line No. 1. *Bulletin of the Shikoku National Agricultural Experiment Station* 49: 1.

Kosaka K., H. Hoshii and M. Yoshida. 1972. Available energy of yeast grown on various carbon sources by growing chicken. *Japanese Poultry Science* 9: 159.

Statistics and Information Division, Ministry of Agriculture, Forestry and Fisheries. June. 1989a. *Monthly Statistics of Agriculture, Forestry and Fisheries.*

Statistics and Information Division, Ministry of Agriculture, Forestry and Fisheries. 1989b. *Pocket Statistics of Agriculture, Forestry and Fisheries.*

Tajima, M., K. Totsuka, H. Kinoshita, K. Shoji and K. Aso. 1971. Amino acid supplementation of hydrocarbon yeast chick diet. *Japanese Poultry Science* 8: 217.

Yamazaki, M. and K. Kaku. 1988. Chemical Composition, Metabolizable Energy Value and Available Amino Acid Composition of Feedstuffs for Poultry in Japan. *Memoirs of the National Institute of Animal Industry, No. 1.*

Yoshida, M. 1974. Note on the flavor of the egg and meat of the hens fed yeast grown on n-paraffin. *Japanese Poultry Science* 11: 217.

Yoshida, M., M. Tada, H. Bansho, M. Matsushima, K. Koba, M. Iino and I. Umeda. 1975. Effect of hydrocarbon yeast as dietary protein source on reproducibility of breeding hens. *Japanese Poultry Science* 12: 83.

DISCUSSION

Q. (I.G. Lumanta)
In Table 4, do your figures for rough rice include the hull? (Yes, they do). When you used 65% of rough rice in the diets of fattening pigs, did you observe that their fat was soft at slaughtering?

A. No, we did not observe this.

Comment: (Boonlom Cheva-Isarakul)
Did the high crude fiber content of rough rice cause any problems? I note that your data indicate an increase in feed intake and a higher average daily gain, giving a better feed conversion ratio with higher levels of rough rice. Experiments in Thailand which studied the effect of feeding rough rice to poultry found that that there was a higher feed intake but the average daily gain decreased, so that there was a decline in the feed conversion ratio.

A. The crude fiber content of brown rice is 0.9%, while that of rough rice is 8.6%. In our experiments, we adjusted the diets to ensure that they had the same protein and energy levels, but we did not consider the crude fiber content of the feedstuff to be a problem.

Q. (C.M. Collado)
In Table 4, I note that your experimental diets were isocaloric and isonitrogenous, and yet the treatment with 60% rice gives better broiler performance, with a higher weight gain and feed conversion ratio. Is this due solely to the higher level of rice in the diet? If so, why does rice give a better weight gain and feed conversion ratio?

A. We were trying to find the optimum level of rice, but in fact when a high level of rice was used, it was necessary to add a coloring agent, although this may not have much nutritional effect. The isocaloric diet was based on the calculated energy content, and the calculated energy value for rice may not have been exact; possibly we underestimated it. If the actual value is higher, a higher level of rice in the diet would give a better result, in terms of animal performance.

Comment: (C.M. Colado)
I suggest that the better performance with a higher level of rice may have been because the content of yellow grease and soybean meal was also increased, giving a higher fat content and amino acid content. We know that a higher fat content in the diet, especially for non-ruminants, always tends to improve animal performance.

A. In an experiment of this kind, feed formulations are usually based on the Japanese Feeding Standards. In these, the minimum level is very clear but the highest level is not much considered. We perhaps needs to calculate again the energy and protein content of diets when rice is used in feeding trials, to adjust the nutritional value of the total feed.

Comment: (H.H. Hsieh)
As Dr. Collado pointed out, there is an extra calory input when yellow grease is added to the high-fiber diet. Although the diet is meant to be isocaloric, the cumulative effect of different components of the diet need to be taken into account. There is also evidence of increased mortality when poultry are fed a high-fiber diet, as shown by the raising rate in Table 4, which may partly account for the difference.

Q. (D.H. Chung)
The new high-protein naked barley has a high lysine content, and the grain has a dark color. Is a dark color the indicator of a high lysine content?

A. I'm not sure. I was given these results by a barley breeder at the Shikoku Experiment Station, but I don't know whether a dark grain color indicates a high protein content. The variety has been released only very recently by the National Resources Genetic Bank.

Q. (K.J. Shin)
I have two questions. Firstly, Table 2 shows that Japan imports 10% of the total straw used in feed. However, 80% of the rice straw produced in Japan is used for feed. What kind of straw is imported, and why do you import it?

Secondly, Table 12 shows that the selling price for dehydrated orange pulp can be as low as US$20/mt, and yet the cost of drying it is US$28/mt. Is this difference paid by the government or the company?

A. A certain amount of rice straw is imported because of the price – imported straw is cheaper. The harvesting machinery now used in Japan chops the straw and spreads it over the field, while the traditional cutting system is not used much any more. This makes the cost of collection higher, so that it is cheaper to import rice straw from Thailand or mainland China.

No government compensation is paid to cover the difference between the cost of drying the orange pulp and the price received for it. The cost is borne by the company, and is a big problem for this kind of company.

Q. (I.G. Lumanta)
To what extent is defatted rice bran used in Japan?

A. More than 80% of the rice bran used for feed is defatted, because in Japan the oil extracted from bran is used for cooking. Grain processing centers now routinely process the bran and extract the fat. Furthermore, whole rice bran cannot be stored for very long.

Comment: (I.G. Lumanta)
If 80% of the rice bran used is defatted, there must be many studies on the use of defatted bran.

A. No, defatted bran is a traditional feedstuff in Japan which has been used for many years, and there is little interest in doing research on it.

Q. (I.G. Lumanta)
In the Philippines, waste rice hull is a major problem. Is there any way of improving its quality as a substitute or non-conventional feed?

A. Steaming may improve the nutritional value of the hull, but it is expensive, and after treatment the nutritional value is still fairly low. We do not find it economical to include rice hull in feed, and in fact we have the same problem with waste rice hull in Japan as you do in the Philippines.

Q. During the feed trials using rough rice for broilers, at what age were the broilers begun on the diet for the finishing stage? Was it when they reached a certain age or a certain weight?

A. They began receiving the diet when they reached four weeks of age. Up until that point, they were given starter feed. They were raised until they reached seven to eight weeks.

Q. (A.L. Gerpacio)
What percentage of petroleum yeast was used in the livestock diet? Did it have any deleterious effect on animal performance?

A. No, at this level of 15% of the diet, no ill effects were seen. Higher levels of yeast than this were used in the experiments, but we found that if higher levels were used, the energy etc. content of the diet had to be adjusted. In practice, 15% yeast was found to be the optimum level in the feed.

Comment: (A.L. Gerpacio)
We have used yeast in broiler diets, although this was not hydrocarbons but coconut yeast and yeast from whey. We found that above a 10% level there was a high uric acid level which produced weakness of the legs and other symptoms similar to those of gout in humans.

Q. (R.G. Zamora)
Was the variety of rough rice used in the Japanese experiments different from the Philippine rough rice? Does Japanese rice have a higher nutritive value?

A. No, there should be no difference in digestibility. Until now, all rice varieties used in experiments were Japonica/Indica hybrids, or foreign rice varieties imported from abroad which give higher yields per hectare.

Q. (R.G. Zamora)
Your Table 1 shows that you import ten times more whole soybean than soybean meal. Is whole soybean used as a feed in Japan?

A. We produce a great deal of soybean meal from whole soybeans in Japan, because we use soybean oil as a cooking oil. There is a also great deal of other soybean processing. We also import the soybean meal itself. We don't usually utilize the whole soybean as feed: whether we use the whole grain or separate it into meal and oil depends on current prices.