17. PRESENT STATUS OF THE RESEARCH IN ANIMAL NUTRITION IN JAPAN

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The population of domestic animals in Japan is; 1.8 million of dairy cattle, 1.8 million of beef cattle, 7 million of swine and 150 million of poultry.

In order to meet the requirements by these animals, feed demand has increased remarkably, and now, 20 million tons of concentrate and 10 million tons of roughage are being consumed annually. At present, about 80% of concentrate is imported from or originated in foreign countries such as U.S.A., Thailand, Argentina, Australia and so on. Moreover, even some roughages, such as alfalfa meal, and alfalfa hay cube, are imported from U.S.A.

As a result of the above mentioned situation in feed supply and demand, nutritional researches in Japan are focused on improving the utilization of feed nutrients.

Generally speaking, the research on animal nutrition can be divided into two, the basic work and the applied one. The former may be defined as "nutrition physiology" which deals with the function of nutrient utilization and metabolism of various nutrients. The latter is concerned with feeding methods and so on.

Now, I should like to explain the main researches performed in Japan. Although the limit of time does not allow me the detailed explanation, I do hope this will be of some help for you to understand the situation in the research work in Japan.

Ruminant Nutrition

A lot of works have been performed to clarify the rumen function, such as the studies on the rumen development, rumen fermentation, nutrition absorbtion, rumen microbiology and so on.

First of all, I will introduce the works of Prof. Kandatsu and his colleagues carried out mainly at Tokyo University. They have established the technique to cultivate the rumen protozoa, and found that protozoa metabolize the feed protein and excrete some kinds of amino acids and ammonia into the rumen liquor. Moreover, it was found that the protozoa eat rumen bacteria, so that the protozoa improve protein quality. As you know, protozoa protein is more digestible and of higher quality than bacterial protein.

Also, they found that the protozoa can utilize intact starch instead of soluble sugars of low molecular weight. They are now challenging the elucidation of the real function of protozoa in the rumen, that is, they have started the work, using the defaunated ruminants, to clarify whether the existence of protozoa in the rumen has a favorable influence on the efficiency of feed utilization or not.

The Tohoku University group has established the small rumen technique, making a blank sack made of rumen wall by the surgical operation. Using this technique, they clarified what kinds of substances can be absorbed. According to them, fatty acids, ammonia and some minerals are directly absorbed through the rumen wall, but some of amino acids are not absorbed.

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In another experiment, they succeeded in raising goat with volatile fatty acids, that is, they removed the rumen content completely through the rumen fistula, and then infused dried fish meal, volatile fatty acids, minerals and vitamins through the fistula. By this method, they were able to keep the goat alive for a long period.

During these trials, they found that ruminant survive consuming volatile fatty acids as only energy source. They also reported that the absorption rate of each volatile acid is almost equal. This is the point which does not agree with the results of some workers that the velocity of absorption of each acid from the rumen differs to some extent.

I have investigated the extent of the role of the rumen in ruminant digestion, using the goats surgically separated forestomach. According to my experiment, it was shown that most of the digestible carbohydrates (that is, nitrogen free extracts and crude fiber) are absorbed from the rumen. And, as for crude protein, the absorption ratio differs according to the level of protein intake. Thus, the relation between the level of protein in feed and the absorption ratio is shown in the following equation,

$$Y=2.90X-29.28$$

where Y is the protein absorption ratio in the rumen (%)
X is the crude protein content in the feed (%)

The research in calf nutrition was accelerated by the early weaning method. Until 1950, there were only 700~800 thousand of dairy cattle in Japan. But, thereafter the population increased rapidly. Before 1950, the calves were raised by conventional method, that is, the whole milk was given until 3 month-old and then skim-milk was given until 6 month-old, total amounts of whole milk and skim-milk being over 600 kg. By this method, the calves grew well indeed, but the cost of raising was fairly high. Therefore, farmers tried to reduce the amount of milk but the growth of the calves was not satisfactory.

In order to overcome such an undesirable situation, the early weaning method was developed by Dr. Morimoto with the invention of the new type of milk replacer and calf starter.

In the effort to develope the early weaning method, many researches have been carried out concerning the development of rumen function, feed utilization, determination of the optimum growth and so on.

At the same time, more grasslands were developed in various parts of Japan, and the calves raised on pasture have become common. This stimulated the nutritional studies of grazing cattle, especially the elucidation of growth delay during the grazing season. This period coincided with the period when the Cornell and Tennessee groups were studying the influence of growth rate on the life productivity of dairy cattle.

In spite of much effort of the researchers, the optimum growth rate of dairy cattle during grazing was undetermined, but many people believe that the figure proposed by Japanese Holstein Association, that is, 0.74 kg daily gain, is too high to raise cattle under grazing condition. They think that more than 0.5 kg daily gain is satisfactory.

Together with these studies, the work on the compensative growth was carried out, and it was found that the growth delay during grazing can be recovered during the succeeding barn feeding.

On the other hand, as the rearing cost of the dairy bull calves had become comparatively cheep due to the invention of the new type of milk replacer and calf starter, the studies on dairy beef production were started.

At present, the dairy beef production has amounted to one-third of total beef production in Japan.

Various fattening systems of dairy beef cattle have been established. However, researches are in progress on the relationship between fattening method and meat quality, liver abscess, rumen parakeratosis, urinary calculi and so on.

Researches on the beef cattle are similar to those of dairy beef cattle except for creep feeding. Calves of Japanese native beef cattle are marketed at 6~8 months old weighing over 200 kg. Such a body weight cannot be attained without the aid of creep feeding due to the low milking ability of their dams.

A lot of studies concerning protein and mineral metabolism have been performed by many workers. Especially for mineral metabolism, we remember that the Kyoto University group found that cobalt deficiency was the main reason for the "Kuwazu" disease. "Kuwaze" means in Japanese, to lose appetite or not to eat. This disease had attacked Japanese native cattle in a local district in Chugoku. The cattle suffering from this disease lost appetite and finally fell dead.

Recently, it was reported that grass tetany-like disease occurred in some districts in Japan not only in the animals on grassland but also in those not grazing. This

Table 1. Daily nutrient requirements of dairy cattle

		DCP. (kg)	TDN. (kg)	Ca (g)	P (g)	Carotene (mg)
Normal growth of dairy heifers						
Body weight	kg 350	0. 41	4. 47	13	12	32
	450	0. 43	4. 97	12	12	40
	550	0. 45	5. 47	12	12	48
Maintenance of mature cows						
Body weight	kg 350	0. 23	3. 02	8	8	48
	400	0. 25	3. 34	9	9	54
	450	0. 27	3. 65	10	10	60
	500	0. 29	3. 95	11	11	66
	550	0. 31	4. 25	12	12	72
	600	0. 33	4. 53	13	13	78
	650	0. 35	4. 81	14	14	84
	700	0. 37	5. 09	15	15	90
Reproduction (add to maintenance during last 2 to 3 months)						
		0. 27	2. 70	12	7	30
Lactation (add maintenance for each kg of milk)						
Milk fat percentage	% 3. 0	0. 043	0. 280	2. 2	1. 6	—
	3. 5	0. 045	0. 305	2. 2	1. 6	—
	4. 0	0. 047	0. 330	2. 2	1. 6	—
	4. 5	0. 050	0. 355	2. 2	1. 6	—
	5. 0	0. 053	0. 380	2. 2	1. 6	—
	5. 5	0. 056	0. 405	2. 2	1. 6	—
	6. 0	0. 059	0. 430	2. 2	1. 6	—

Table 2. Daily nutrient requirement of beef cattle

Average daily gain / Body Weight	0.4 kg		0.6 kg		0.8 kg		1.0 kg		1.2 kg		1.4 kg		Ca	P	Carotene
	DCP.	TDN.	DCP.	TDN.	DCP.	TDN.	DCP.	TDN.	DCP.	TDN.	DCP.	TDN.	(g)	(g)	(mg)
Growing and finishing steers															
150	0.30	2.21	0.30	2.27	0.31	2.33	0.31	2.39	0.32	2.45	0.32	2.51	16	13	15
200	0.38	3.19	0.39	3.27	0.39	3.35	0.40	3.42	0.40	3.49	0.41	3.56	16	14	20
250	0.46	4.02	0.46	4.12	0.47	4.20	0.47	4.28	0.48	4.37	0.48	4.46	17	14	25
300	0.55	4.62	0.56	4.71	0.56	4.80	0.57	4.90	0.57	4.98	0.58	5.07	17	15	30
350	0.61	5.11	0.62	5.21	0.62	5.30	0.63	5.39	0.63	5.49	0.64	5.58	17	16	35
400	0.68	5.62	0.68	5.71	0.69	5.80	0.69	5.89	0.70	5.98	0.70	6.07	18	17	40
450	0.74	6.05	0.74	6.15	0.75	6.25	0.75	6.35	0.76	6.45	0.76	6.55	18	18	45
500	0.80	6.50	0.81	6.60	0.81	6.70	0.82	6.80	0.82	6.90	0.83	7.00	18	18	50
Finishing heifer and cows															
350			0.36	4.47	0.41	5.07	0.47	5.67	0.52	6.27	0.58	6.87	24	21	35
400			0.44	4.98	0.51	5.66	0.58	6.33	0.66	7.01	0.73	7.69	25	22	40
450			0.51	5.48	0.61	6.24	0.70	6.99	0.79	7.75	0.88	8.50	25	22	45
500			0.59	5.97	0.70	6.80	0.81	7.64	0.92	8.47	1.03	9.30	25	22	50
550			0.67	6.47	0.80	7.37	0.92	8.28	1.05	9.19	1.18	10.10	26	23	55
600			0.74	6.95	0.89	7.93	1.04	8.92	1.19	9.90	1.33	10.89	26	24	60

disease may be due to the deficiency of magnesium, and now some researchers are studying on Mg metabolism in order to clarify the cause of this disease.

Speaking of the other researches, I can point out the following subjects; nitrate poisoning, urea utilization, preparation of complete ration, feeding method with minimum amount of roughage, feeding of silage as a sole roughage and so on.

Finally, I should like to talk about feeding standards of dairy and beef cattles. About 15 years ago, the research on the establishment of the feeding standard for dairy cattle in Japan was started in cooperation with many national and local research organizations sponsered by Japanese National Research Council of Agriculture and Forestry.

Table 1 and Table 2 show the feeding standards for dairy and beef cattle established by the above works. As you know, these standards have many deficient parts which are going to be revised in the near future.

During these researches, the respiration chamber was built at the National Institute of Animal Industry. At the same time, the stalls for digestion trials were constructed in several experiment stations. Since that time, much progress has been made in the energy metabolism and nitrogen balance studies for cattle.

Swine Nutrition

Population of research workers for swine nutrition is rather small for the numbers of pigs kept in Japan. I think this trend is not only for Japan but also for all over the world. I don't know the reason, but I hope many people concerned animal industry should pay attention to this fact and make effort to increase the researches in this field.

Now, the research in swine nutrition in Japan was encouraged by the studies for the establishment of the feeding standard for swine and those for the preparation

Table 2. Daily nutrien requirement of beef cattle (Continued from Page 166)

Body weigt	DPC. (kg)	TDN. (kg)	Air dry matter (13% moisture)	Ca (g)	P (g)	Carotene (mg)
Maintenance of mature cows						
350	0.20	2.54	5.7	8	8	35
400	0.22	2.80	6.3	9	9	40
450	0.24	3.06	6.9	10	10	45
500	0.26	3.31	7.5	11	11	50
550	0.28	3.56	8.0	12	12	55
600	0.30	3.80	8.5	13	13	60
Maintenance and prengnancy (1st 2～3 months of gestation)						
400	0.41	4.69	10.3	16	15	75
450	0.43	4.96	10.3	16	15	80
500	0.36	4.26	10.3	16	15	85
Cows nursing calves, first 2～3 months postpartum						
450	0.64	6.02	12.4	24	20	60
Normal growth of beef heifers						
50	— (0.27)	— (1.36)	— (1.2)	— (5)	— (4)	— (5)
75	0.03 (0.28)	0.25 (1.45)	0.4 (1.4)	— (8)	— (6)	— (7)
100	0.08 (0.30)	0.59 (1.66)	0.9 (1.8)	4 (10)	2 (8)	— (10)
125	0.15 (0.34)	1.05 (1.99)	1.6 (2.4)	6 (12)	6 (11)	— (13)
150	0.23 (0.40)	1.62 (2.43)	2.5 (2.8)	7 (12)	7 (11)	— (15)
175	0.35 (0.49)	2.32 (3.00)	3.6 (4.1)	9 (13)	8 (12)	— (17)
200	0.38	2.92	6.1	13	12	21
250	0.40	3.33	7.1	14	13	26
300	0.41	3.71	8.1	15	14	32
350	0.42	4.05	8.8	16	15	37
400	0.42	4.31	9.4	16	15	42

Figures in parentheses show the amount of real requirement including the milk sucked by calves.

of artificial milk for baby pigs.

Table 3 shows the feeding standard for swine established recently in Japan.

Researches for the feeding standard for sow and for the pigs of large breed such as large Yorkshires and Landrace in growing-finishing stage are now under way with the cooperation of many prefectural research stations.

During the research for the feeding standard, it was established to apply the index method for digestion trial with swine using Cr_2O_3 as indicator. As the result, the digestion trial with swine has become easier than before. Thus the digestibilities of many feedstuffs were determined.

Further, it was indicated that the feedstuffs commonly used in Japan are deficient in lysine, the first limiting amino acid, as the results of many growing-finishing trials. Therefore, at present, 0.05% of lysine is usually supplemented to the commercial formula feed for growing-finishing stage.

Table 3. Nutrient requirements of growing-finishing pigs
— Percentage in feed or gram per kilogram of feed —

		Liveweight 20 to 50 kg		Liveweight 50 to 90 kg	
Percentage of total feed to liveweight	%	6.5	4.4	4.4	3.8
DCP (digestible crude protein)	%	11.5		9.5	
TDN (total digestible nutrients)	%	67.0		67.0	
DE (digestible energy)	%	2,950		2,950	
Calcium	%	0.60		0.50	
Phosphorus	%	0.60		0.50	
Salt (NaCl)	%	0.50		0.50	
Vitamin A	IU	1,300		1,300	
Vitamin D	IU	160		130	
Thiamine	mg	1.1		1.1	
Riboflavin	mg	2.6		2.2	
Pantothenic acid	mg	11		10	
Niacin	mg	13		11	
Vitamin B_6	mg	1.1		—	
Choline	mg	880		—	
Vitamin B_{12}	mcg	11		11	

Notes: 1. DE was calculated on the assumption that 1 kilogram of TDN has 4,400 kcal of DE, and the conversion rate has confirmed the reliability in this study.
2. Requirements of vitamins have been quoted from provisional Japanese Feeding Standard (Morimoto).

During the work to develop the artificial milk, it was found that the digestive fluid of a baby pig is deficient in the activity of pepsin. Therefore, pepsin is added to the artificial milk in order to improve the digestibility of protein.

There are also some works on iron copper metabolism in connection with the prevention of anemia in pigs.

Recently, the study on the relation between embryo death and nutritional level was started, and it was clarified that embryo death occurred when high energy ration is given at the early stage of pregnancy.

Poultry Nutrition:

The feeding standards for laying hen and broiler have been established by the research group in our Institute at Chiba with the aid of many workers in the prefectural experiment stations. The standards are shown in Table 4.

Most farmers in Japan used to believe that diet containing more than 20% protein was necessary for the laying hen of high productivity. However, as the result of the establishment of the feeding standard, diets containing 16% protein and 66% TDN are now being used. Thus the results of the research work have contributed to the economy of practical poultry industry.

Further, in order to establish low cost feeding system, many experiments are still being carried out such as phase feeding, restricted feeding so on.

Studies on egg shell quality have shown that the thickness of egg shell should be in the range of 0.3~0.35 mm in order to have durability in handling and trans-

Table 4. Recommended dietary level of nutrients for Japanese chickens

Nutrients		Layer				Broiler	
		0–4 wks	4–10 wks	10–20 wks	Layer	0–4 wks	>4 wks
Crude protein	%	20	16.5	14.5	16	20*	16*
Total digestible nutrients	%	68	68	64	66	68*	73*
Calucium	%	0.83	0.75	0.5	2.75	0.8	0.8
Phosphorus	%	0.6	0.6	0.45	0.75**	0.6	0.5
Sodium chloride	%	0.5	0.5		0.3	0.5	0.5
Manganese	mg/kg	55					
Methionine+cystine	%	0.7				0.7	
Vitamin A	iu/kg	2650			4400		
Vitamin D	icu/kg	200			500		
Thiamine	mg/kg	2.5				1.8	
Riboflavin	〃	5.5			2.2	7.2	
Pantothenic acid	〃	9.3			4.6		
Nicotinic acid	〃	29				37	
Pyridoxine	〃	6.7			2.9	2.9	
Biotine	μg/kg	90					
Folic acid	〃	550			24		
Vitamin B_{12}	〃	9					
Choline	g/kg	1.3				1.3	

* Figures recommended on the economical basis.
** For caged layer. 0.6% may be satisfactory for layer on floor.

portation. If it is less than 0.26 mm, eggs are apt to break or crack. According to the results of the experiments, the diet which produces the eggs of desirable quality should contain more than 2.75% calcium and 0.75% phosphorus.

As for the influence of the environmental temperature, it was found that egg shell tends to be thinner if the hens are kept at higher temperature.

The environmental temperature also affects the performance of hens. The experiments with white Leghon layers showed that, when they were kept at higher than 30°C, feed intake decreased and, while egg production was not affected, egg weight reduced by 2~3 g per egg. It should be noted, however, that the response of the hen to the environmental temperature may differ from breed to breed.

In our Institute at Chiba, it was also demonstrated that the fat content of meat decreased when the broiler was fed high-protein low-calorie diet, while low-protein high-calorie diet produced carcasses with more fat.

Artificial anus technique established at our Institute has made it possible to separate completely the feces and urine of a bird, and this has promoted the metabolism studies with poultry to a great extent.

Dr. Tasaki and his colleagues of Nagoya University have been doing a lot of experiments in poultry nutrition including energy, amino acids and mineral metabolism.

Discussion

Tim Bhannasiri, Thailand: 1) Why do you recommend the 16% protein ration to the layer while the farmer in Japan believes that diet containing more than 20%

protein is necessary?

2) Concerning the temperature effect in layer, you indicated that when they were kept at higher than 30°C, the egg production was not affected. Would you kind to give more explanation about this how you over come this problem, please.

Answer: 1) Very few farmers still believe the diet should contain more than 20% protein. But almost all agree with our opinion, the important thing is that the diet containing 16% protein should also contain ample amount of energy, 66% TDN or 2.7 K cal. ME is suitable.

2) The experiment performed at air conditioning room, 30°C, 60% humidity, for more than 2 months. The result conditions differ from that of trial room. Especially, the humidity is higher and egg productivity decreases about 5–10% in Japan. Present, the suitable method is not found out in ordinary poultry barn.

S. B. Dhanapala, Sri Lanka: On page 7, you refer to experiments carried out on phase feeding and restricted feeding of poultry. Could you kindly explain some of these experiments?

Answer: I will explain briefly about phase feeding and restricted feeding. Conventional feeding is the method to raise poultry to gain optimum growth or production at any period, but phase feeding and restricted feeding are adopted to gain the most economical benefit for all over their production life. Usually, phase feeding is adopted to laying hen, to fit the nutritional level to their productivity, that is, the nutritional level during the 6 months after the begining of laying goes up and then goes down. In the restricted feeding, the amount of feed given during the growing period was restricted in order to prevent the over fastening.

B. K. Soni, India (Comment): The question of percentage of protein (20 to 16%) in layer ration has been raised. Should not the emphasis be on protein energy ratio rather than absolute figure of percentage of protein in ration of laying hen.

Similarly statement has been made that at temp. higher than 30°C, although feed intake was decreased, the egg production was not affected. Actually the egg number might have remained constant but the "egg mass" would have decreased.