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JAPANESE FEEDING STANDARDS

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Introduction

The number of horses bred in Japan decreased sharply from over 1.5 million in the past to approximately 100,000 today. The situation in Japan, where over half of the horses being bred are light breed horses, is unlike that in any other country in the world. Many of the light breed horses (Thoroughbreds and Anglo-Arab horses) are being produced for use as racehorses. The 8,000 to 9,000 horses that are registered for breeding annually are the main source of racehorses.

Until now, there have been almost no textbooks dealing with the nutrition of horses written in Japanese, to say nothing of a feeding standard for horses designed specifically for Japan. Consequently, horse breeders who were eager to learn more about this subject had to utilize the NRC, but the majority of breeders were forced to rely on their experience and intuition. Furthermore, Japanese horse racing was closed to the rest of the world for many years, but with its recent internationalization the number of foreign-bred horses taking part in horse races in Japan is on the rise. This prompted those in the industry to think about the need to improve the ability and physical strength of racehorses born and raised in Japan. The consensus was that, in order to accomplish this goal, scientific breeding and training methods that reflect actual conditions in Japan must be actively introduced. The Japanese Feeding Standard for Horses was drafted as part of that initiative. In Japan, however, the number of universities and research institutions conducting research on horses is very small, so there was a dearth of research data on horses. Thus, foreign literature, including the NRC, was referred to when drafting the Japanese Feeding Standard. The first light breed horse feeding standard in Japan was published in 1998.

Basic Principles Behind Drafting of the Feeding Standard

Priority was given to the following principles when drafting the Japanese Feeding Standard for Horses:

1. Prepare a standard growth table in order to properly evaluate growth rates, which are said to be closely associated with the onset of bone diseases in growing horses.
2. Enhance instructions related to factors that affect nutritional requirements and feeding-related matters that require attention, using values obtained under average Japanese breeding conditions as the nutritional requirements.
3. Indicate nutritional requirements for nursing foals based on the results of experiments related to milk intake and changes in milk composition.

4. Enhance instructions regarding feeding management during grazing, because grazing is an important part of raising horses.
5. For performance horses, requirements are to be based on average nutritional intake by racehorses and information cited in the literature, because there are large individual differences in the amount of exercise performed by adult horses.
6. Indicate the procedure for determining feed amounts by adding a chapter entitled "How to Use the Japanese Feeding Standard."

Standard Growth

Based on the results of a growth study conducted in Japan (investigated in Hokkaido Prefecture where approximately 90% of Japanese light breed horses are produced), a standard growth table was included in the Feeding Standard. Shown in the standard growth table (Table 1) are body weight, withers height, heart girth and cannon bone circumference.

Table 1. Standard growth of Thoroughbreds in Japan.

	Male		Female		Daily gain (kg/day)
	Mean	Normal range	Mean	Normal range	
at birth					
BW (kg)	57	50-64	57	50-64	1.33
1 month					
BW (kg)	97	89-105	97	89-105	
WH (cm)	110	108-112	110	108-112	
HG (cm)	101	98-104	101	98-104	
CC (cm)	13.1	12.7-13.4	13.1	12.7-13.4	1.15
3 months					
BW (kg)	166	152-180	166	152-180	
WH (cm)	123	121-125	123	121-125	
HG (cm)	122	118-126	122	118-126	
CC (cm)	14.9	14.6-15.2	14.6	14.3-14.9	1.00
5 months					
BW (kg)	225	203-247	225	203-247	
WH (cm)	132	130-134	131	129-133	
HG (cm)	136	131-141	136	131-141	
CC (cm)	16.0	15.5-16.5	15.6	15.1-16.1	0.80-0.85
7 months					
BW (kg)	275	250-300	267	242-292	
WH (cm)	137	134-140	136	133-139	
HG (cm)	146	141-151	146	141-151	
CC (cm)	16.9	16.5-17.3	16.6	16.2-17.0	0.60-0.80
9 months					
BW (kg)	310	285-335	301	276-326	
WH (cm)	141	138-144	140	137-143	
HG (cm)	153	148-158	153	148-158	
CC (cm)	17.6	17.1-18.1	17.2	16.7-17.7	
11 months					
BW (kg)	335	309-361	328	302-354	
WH (cm)	144	142-146	143	141-145	
HG (cm)	158	154-162	158	154-162	0.40-0.50 [1]
CC (cm)	18.2	17.7-18.7	17.8	17.3-18.3	

13 months					
BW (kg)	364	344-384	364	344-384	
WH (cm)	148	146-150	146	144-148	
HG (cm)	163	159-167	163	159-167	
CC (cm)	18.5	18.0-19.0	18.1	17.6-18.6	0.40-0.70 [2]
15 months					
BW (kg)	408	379-437	408	379-437	
WH (cm)	151	148-154	149	146-152	
HG (cm)	168	162-174	168	162-174	
CC (cm)	18.8	18.4-19.2	18.3	17.9-18.7	
17 months					
BW (kg)	421	396-446	413	390-436	
WH (cm)	153	150-156	153	150-156	
HG (cm)	170	166-174	170	166-174	
CC (cm)	19.0	18.4-19.6	18.5	18.0-19.0	
19 months					0.10-0.30
BW (kg)	439	415-463	429	405-453	
WH (cm)	154	151-157	154	151-157	
HG (cm)	173	169-177	173	169-177	
CC (cm)	19.3	18.7-19.9	18.7	18.2-19.2	
27 months					
BW (kg)	451	425-477	433	410-456	
WH (cm)	159	156-162	158	155-161	
HG (cm)	175	171-179	174	170-178	
CC (cm)	19.5	19.0-20.0	18.8	18.3-19.3	

The following abbreviations were used : BW, body weight; WH, withers height; HG, heart girth; CC, cannon bone circumference.
1) Growth rate is slow in winter.
2) Growth rate is rapid in summer.

Nutrient Requirement of Horses

Daily nutrient requirements of horses in Japan are shown in Table 2 and digestible energy (DE) requirements compared with NRC are shown in Table 3.

Table 2. Daily nutrient requirements of horses.

Horse	Body weight -kg-	Daily Gain kg/day-	Digestible Energy Mcal/day- (Mcal/kg)	Crude Protein -g- (%)	Lysine -g- (%)	Ca -g- (%)	P -g- (%)	Mg -g- (%)	Vitamin A -1,000IU- (1,000IU/kg)
Growing horses									
Nursing foal [Nutrient intake from mare s milk]									
2 months	130	1.15	8 [7.9]	330 [300]		23 [12]	13 [8]	3.4 [0.6]	
4 months	195	1.00	9 [5.9]	430 [220]		25 [7]	14 [5]	4.2 [0.3]	
Yearling long yearling									
10 months	315	0.45	17.5 (2.50)	780 (11.2)	34 (0.49)	27 (0.39)	15 (0.22)	5.3 (0.08)	14 (2)
15 months	405	0.40	20.5 (2.30)	920 (10.3)	39 (0.44)	29 (0.33)	16 (0.18)	6.6 (0.07)	18 (2)
22 months (in training)	450	0.20	26.5 (2.65)	1,120 (11.2)	45 (0.45)	34 (0.34)	19 (0.19)	9.9 (0.10)	20 (2)
Mature horses									
Racehorses	455-475	-	27-35 (2.70)	1,300 (11.2)	46 (0.40)	40 (0.34)	29 (0.25)	15.1 (0.13)	22 (1.9)

Mare									
Late gestation	640	0.50	25 (1.80)	1,100 (7.7)	38 (0.27)	47 (0.33)	36 (0.26)	12.0 (0.08)	38 (2.7)
Early lactating	570		31 (2.40)	1,600 (12.5)	57 (0.45)	61 (0.48)	41 (0.32)	12.2 (0.10)	34 (2.7)
Late lactating	570		28 (2.20)	1,200 (9.4)	42 (0.33)	42 (0.33)	26 (0.20)	9.8 (0.08)	34 (2.7)

1) Values in parentheses show nutrient concentrations in total diets on dry matter basis.
2) Body weight and daily gain are based on the standard growth of Thoroughbreds in Japan (Table 1).
3) Requirements of crude protein, lysine, Ca, P, Mg and Vitamin A are referred to NRC (1989).
4) Values in racehorses are based on data obtained under Japanese conditions.

Table 3. DE requirement compared with Japanese Feeding Standard for Horses and NRC (1989).

Month of age	DE requirement (Mcal/day)		
		NRC	
	Japanese Feeding Standard	500 kg mature weight	600 kg mature weight
6		15.0	17.0
10	17.5		
12		18.9	22.7
15			
daytime grazing	20.5		
longtime grazing	30.5		
18		19.8	23.9
22			
in training	26.5		
24			
in training		26.3	32.3

A. Digestible Energy Requirements

1. Nursing Foals

Digestible energy (DE) requirements for two- and four-month-old foals were indicated. The standard body weights were 130 kg and 195 kg, respectively. Maintenance DE requirements were calculated using the following formula (Pagan and Hintz, 1986), and 10% was added to correct for exercise.

Maintenance DE (Mcal DE/day) = 0.975 + 0.021 x body weight (kg)

Next, the amount of digestible energy required to increase body mass (daily gain, or DG, is 1.15 kg/day and 1.00 kg/day, respectively) was sought using the body composition of foals and how efficiently they utilize energy from protein and fat reserves. Digestible energy requirements, 8 Mcal/day for two-month-old and 9 Mcal/day for four-month-old foals, were calculated by combining the above results.

Meanwhile, the milk intake of foals was set at 16 kg/day at two months of age and 12 kg/day at four months of age from the results of trials to estimate milk yield. Gross energy (GE) was calculated from the milk composition at each stage (Table 5). As the digestibility of milk was set at 100%, the digestible energy amounts from milk are 7.9 Mcal/day and 5.9 Mcal/day, respectively. Therefore, two-month-old foals can obtain almost all their required energy from milk, but the energy from milk alone is insufficient for four-month-old foals.

2. Growing Horses

Two to three month feeding and digestibility trials were conducted for 10-month-old horses (assuming winter when grazing is the mainstay of management, but horses cannot be expected to consume enough forage), 15-month-old horses (assuming summer when grazing is the mainstay of management and horses are expected to consume a substantial amount of forage) and 22-month-old horses (assuming winter when horses are in training). Digestible energy requirements for each stage were examined from the results of the trials. It was found that at all three stages DG increased at a regular rate when the amount of digestible energy consumed increased. From these regression equations, the DG appeared to be appropriate at each stage, namely 0.45 kg/day at 10 months old, 0.40 kg/day at 15 months old and 0.20 kg/day at 22 months old (Table 1). Digestible energy requirements were 17.7 (17.5 in requirement table) Mcal/day at 10 months old, 20.5 Mcal/day at 15 months old and 26.7 (26.5 in requirement table) Mcal/day at 22 months old. The digestible energy requirement of 15-month-old horses is for horses that graze only during the day (0830-1530 h, 7 hours). The digestible energy requirement of 15-month-old horses that graze from afternoon until the next morning (1530-0830 h, 17 hours) is 30.5 Mcal/day. Eighty percent or more of this requirement, however, can be consumed by grazing if the vegetation conditions are satisfactory.

3. Racehorses

Large individual differences in the amount of exercise undertaken were observed and there were many areas that were unclear, so the digestible energy requirement was set at 27-35 Mcal/day using the results of feed intake surveys.

4. Mares

Digestible energy requirements for late gestation, early and late lactation were indicated. Mean body weight at each stage was 640 kg, 570 kg and 570 kg, respectively. Using the results of feeding trials in Hokkaido, where late gestation is from winter to early spring, the digestible energy requirement for horses in late gestation was set at 25 Mcal/day. With the daily milk yields in early and late lactation set at 16 kg and 12 kg, respectively, the digestible

energy amounts required for lactation are 12.7 Mcal/day and 9.5 Mcal/day, respectively, when the digestible energy required to produce 1 kg of milk, 792 kcal, is totaled. The maintenance requirement of a horse weighing 570 kg as determined using an NRC formula, 18.5 Mcal/day, was added, leaving a digestible energy requirement of 31 Mcal/day for early lactation and 28 Mcal/day for late lactation.

B. Protein Requirements

1. Nursing Foals

   The protein requirements of nursing foals are not necessarily clear. It is surmised from experience that the requirements of one- or two-month-old foals are met by the protein contained in the dam's milk, but in four-month-old foals the protein in the milk alone may not be sufficient. Assuming that the amount of digestible protein required to maintain two-month-old foals is 0.6 g/day per 1 kg of body weight and that protein makes up approximately 22% of their increase in body weight, the protein requirement of foals is 330 g/day (130 kg x 0.6 g/kg + 1,150 g x 0.22). Meanwhile, protein intake from milk is estimated to be approximately 300 g (16 kg/day x 1.9%) in two-month-old foals, and since the digestibility of the protein in the mother's milk is high, the protein from the milk alone is considered to be nearly sufficient in two-month-old foals. In four-month-old foals, however, the amount of protein provided from milk is approximately 220 g/day (12 kg/day x 1.8%), presumably leaving a deficiency of about 200 g.

2. Growing Horses

   Protein requirements were calculated by multiplying the digestible energy requirements for 10-, 15- and 22-month-old horses by the coefficient in the formula for calculating protein requirements indicated in the NRC. The protein requirements were 780 g/day (45 x 17.5), 920 g/day (45 x 20.5) and 1,120 g/day (42 x 26.5) for 10-, 15- and 22-month-old horses, respectively.

3. Racehorses

   The protein requirement was set at 1,300 g/day based on the requirements (1,312 g/day for intense working horses with a body weight of 500 kg) indicated in the NRC. The problem of overfeeding protein in racehorses is addressed later in this presentation.

4. Mares

   According to the NRC, the protein requirement is found by multiplying the digestible energy requirement (Mcal/day) by 44. This formula was adopted and the protein requirement was set at 1,100 g/day (25 x 44). In addition, according to the NRC, the protein requirements of early (body weight of 500

kg) and late (body weight of 600 kg) lactating mares are 50 and 43 times the digestible energy requirement, respectively, so the protein requirements were set at 1,600 g/day (31 x 50) and 1,200 g/day (28 x 43), respectively.

C. Mineral Requirements

Calcium. Calcium requirements were calculated based on an endogenous loss (for maintenance) of 0.02 g/kg BW/day, 16 g required per 1 kg increase in body weight and an absorption efficiency of 50%. For instance, in the case of a growing 15-month-old horse (body weight 405 kg, DG 0.40), a calcium requirement of 29 g ((8.1 + 6.4)/0.5) was calculated based on an endogenous loss of 8.1 g and allowing 6.4 g for the increase in body weight. In the case of an early lactating mare (body weight 570 kg), a requirement of 61 g ((11.4 + 19.2)/0.5) was calculated based on an endogenous loss of 11.4 g and secretion into the milk of 19.2 g (milk yield of 16 kg x calcium concentration of 0.12%). Additionally, the calcium requirement for growing horses in training was sought in the same manner as that in the NRC: (calcium required for horses not in training) x (DE required for horses in training/DE required for horses not in training).

Phosphorus. Phosphorus requirements were calculated based on an endogenous loss (for maintenance) of 10 mg/kg BW/day, 8 g required per 1 kg increase in body weight and an absorption efficiency of 45%. For instance, in the case of a growing 10-month-old horse (body weight 315 kg, DG 0.45), a phosphorus requirement of 15 g ((3.15 + 3.6)/0.45) was calculated based on an endogenous excretion volume of 3.15 g and providing 3.6 g for the increase in body weight. In the case of a late lactating mare (body weight 570 kg), a requirement of 26 g ((5.7 + 6)/0.45) was calculated based on an endogenous loss of 5.7 g and secretion into the milk of 6 g (milk yield of 12 kg x phosphorus concentration of 0.05%). Additionally, the phosphorus requirement for growing horses in training was sought in the same manner as that in the NRC: (phosphorus required for horses not in training) x (DE required for horses in training/DE required for horses not in training).

Magnesium. Magnesium requirements were calculated based on an endogenous loss (for maintenance) of 6 mg/kgBW/day, 1.25 g required per 1 kg increase in body weight and an absorption efficiency of 40%.

Other minerals. For sodium, potassium, sulfur, iron, manganese, copper, zinc, selenium, iodine and cobalt, the requirements indicated in the NRC have been adopted. However, in the section entitled “How to Use the Feeding Standard,” a

note recommends 25-30 mg of copper and 100-120 mg of zinc be added per kg of feed in growing horses.

D. Vitamin Requirements

Vitamin A. The formula indicated in the NRC has been adopted: 60 IU/kg BW/day for mares and 45 IU/kg BW/day for other horses.

Other vitamins. For vitamins D and E, thiamin and riboflavin, the requirements indicated in the NRC have been adopted.

Feeding Management and Feeding-Related Matters that Require Attention

This chapter includes matters related to feeding management that require attention at each stage of a horse's life. For instance, the section on mares discusses how to evaluate body condition scores, the importance of mineral supplementation in the last stages of gestation and the increase in requirements during lactation. The section on foals discusses the importance of ingesting colostrum, suckling behavior, the necessity and precautions of creep feeding and other matters. The section on growing horses discusses how to manage pastures, the advantages of extended grazing, the importance of preventing excessive weight gain during training, the importance of supplying minerals and other matters. The section on racehorses explains problems associated with giving horses too much concentrated feed, the utility of adding oils and fats to the diet, the importance of maintaining the proper balance of calcium and phosphorus, the importance of replenishing electrolytes and other matters.

Expected feed consumption by horses in Japan is shown in Table 4.

Table 4. Expected feed consumption by horses in Japan (% body weight)*.

	Forage	Concentrate	Total
Mature			
Maintenance	1.5 2.0	0 0.5	1.5 2.0
Mares, late gestation	1.2 2.0	0.5 0.8	1.7 2.2
Mares, early lactation	1.5 2.5	0.8 1.5	2.5 3.0
Mares, late lactation	1.5 2.0	0.5 1.0	2.0 2.5
Working horses			
Light moderate work	1.0 2.0	0.5 1.5	1.5 2.5
Intense work	1.0 2.0	1.0 2.0	2.5 3.5
Young horses			
Nursing foal, 3-5 months	0.5 2.0	0.5 1.5	1.5 3.0
10 months	1.5 2.0	0.8 1.3	2.0 3.0
15 months	1.0 1.5	0.5 1.0	2.0 2.5
22 months (in training)	1.5 2.5	1.0 1.5	2.5 3.5

* Air-dry feed (about 90% DM)

How to Use the Feeding Standard for Horses

This section indicates the procedure for setting feed menus for growing horses and mares using nutritional requirement and feed composition tables.

Reference Materials

Tables of feed composition. These were prepared based on feed composition tables already published for domestic animals in Japan, and values in the feed composition tables listed in the NRC for feeds given to Japanese horses, or feeds that could possibly be given to them.

Characteristics of feeds used for horses. Lists nutritional features of each type of feed and how to use them.

Composition of milk in Thoroughbreds. Includes a milk composition table (Table 5) for mares bred under average Japanese breeding conditions. The state of changes accompanying the weekly course after gestation was nearly the same as that indicated in the NRC, but concentrations of fat, magnesium and calcium tended to be somewhat lower.

Growth of other breeds. Average body weight, withers height, heart girth and cannon bone circumference at different stages of growth are indicated for both light Hokkaido native horses and the heavy breed horses Breton and Percheron.

References. Literature and data referred to in the Japanese Feeding Standard for Horses are listed.

Conclusion

The environment in which horses are produced and raised in Japan is not necessarily ideal. Japan is a small country, the humidity is high and the weather is often unseasonable. The acidity of the soil is high and it lacks available minerals, because almost all organic soil in Japan is covered with volcanic soils. Consequently, it is difficult to cultivate quality grass. In such an environment, it is necessary to manage the feeding of horses based on scientific evidence in order to produce and raise "strong horses." However, there are a limited number of textbooks written in Japanese that could serve as a bible for those raising horses and there was no feeding standard that Japan could call its own, so it was imperative that one be prepared quickly.

In order to complete a feeding standard in a short period of time, it was necessary to make it possible to use many formulas for calculating requirements

adopted by the NRC. Since the basis of many of those formulas is body weight and digestible energy amounts, we sought the appropriate growth for horses being raised in Japan and the digestible energy requirements at each stage of a horse's life.

Horses in Japan also are affected by developmental orthopedic disease (DOD) such as osteochondrosis or epiphysitis, and potential problems related to nutrition and growth had been pointed out, so the demonstration of standard (appropriate) growth in Japan was very significant. Foals with a body weight higher than 100 kg at one month of age subsequently grow more and are more susceptible to DOD. Also, nursing foals with a lower-than-standard body weight that suddenly grow in their second year require attention.

The mainstay of feeding weanlings is grazing, which is greatly affected by seasonal change. In the latter half of this stage, training fitted to each horse is performed, so it is difficult to feed horses the exact required digestible energy. In addition, the amount of digestible energy given to horses must be raised or lowered as necessary. This is true for mares and racehorses. Therefore, those managers or trainers must have knowledge of nutrition in order to be able to give each horse the appropriate feed. One of the roles of the Japanese Feeding Standard for Horses is to supply them with that knowledge. The Japanese Feeding Standard for Horses was prepared based on the above strategy, but there are still many inadequacies, so a series of revisions will likely be required in the future.

Table 5. Composition of milk in Thoroughbreds (as liquid basis).

Time After Foaling	Total solids (%)	Energy (kcal/100g)	Protein (%)	Lactose (%)	Fat (%)	Ca (%)	P (%)	Mg (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)
0 day (colostrum)	19.1	103.1	12.3	4.0	1.5	0.08	0.07	340	1.1	7.1	1.7
1 week	10.5	52.5	2.7	6.2	1.3	0.12	0.08	90	0.6	2.5	1.3
7 week	10.1	49.3	1.9	6.6	1.3	0.08	0.05	40	0.4	2.3	1.1
17 week	10.2	49.5	1.8	6.8	1.3	0.06	0.04	20	0.3	2.1	0.9


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