略　　号
畜試研報
Bull. Nat. Inst.
Anim. Ind.

ISSN : 0077-488X
CODEN : CSKKAQ

Bulletin of
National Institute of Animal Industry

No. 56
March 1996

畜産試験場研究報告

第 56 号

平成 8 年 3 月

農林水産省
畜　産　試　験　場
茨城県茎崎町

National Institute of Animal Industry
(Ministry of Agriculture, Forestry & Fisheries)
Ibaraki, Japan

場長	松川　　正
企画連絡室長	古谷　　修
育種部長	三上仁志
繁殖部長	假屋堯由
生理部長	竹下　　潔
栄養部長	阿部　　亮
飼養技術部長	田中彰治
加工部長	中井博康

Tadashi **MATSUKAWA**
Director-General, National Institute of Animal Industry

Shu **FURUYA**
Director, Research Planning and Co-ordination Division

Hitoshi **MIKAMI**
Director, Department of Animal Breeding and Genetics

Takayoshi **KARIYA**
Director, Department of Animal Reproduction

Kiyoshi **TAKESHITA**
Director, Department of Animal Physology

Akira **ABE**
Director, Department of Animal Nutrition

Shoji **TANAKA**
Director, Department of Feeding and Management

Hiroyasu **NAKAI**
Director, Department of Animal Products

畜産試験場研究報告　第56号　目次

（平成８年３月）

BULLETIN OF NATIONAL INSTITUTE OF ANIMAL INDUSTRY
No.56 (1996. 3)
CONTENTS

Comparison of Near Infrared Reflectance Spectroscopy-Book Value System with Conventional Laboratory System for Feeding Management of Dairy Cattle

Agung PURNOMOADI*, Masahiro AMARI, and Akira ABE
(Department of Animal Nutrition)

This study was done in comparison of two feeding calculation systems for farms, and carried out to 87 feedstuffs from nine farms raising at Hokkaido (5) and Tochigi prefecture (4).These two systems were, (1) system A : Conventional method, which is feeding calculation by using the data result of chemical analysis, and (2) system B : NIRS-book value system, which is using the combination of predicted data by NIRS method for forage, Feed Tables data for concentrate, and manufacture label composition data for commercial formula feeds.

The comparison was done for chemical components, organic cell contents (OCC), organic cell Wall (OCW), acid detergent fiber (ADF), crude protein (CP) and total digestible nutrients (TDN). Especially for forage, the OCW fraction divided into high digestible fraction (Oa), and low digestible fraction (Ob).

The results show that for forages NIRS data has a high precision for feeding calculation using for OCC and OCW, and relatively good for CP. The TDN results are found better although they were affected by big differences of Oa which is used in prediction equation in both systems. This tendency is observed similar in alfalfa, but the differences in OCC and OCW of corn silage are found higher than grass.

Regarding to the total supply of chemical composition and TDN in comparison between system A and B, the range and average of absolute differences from individual farms found that OCC is lying in 0.1～1.9 kg (0.6 kg), OCW in 0.1～1.5 kg (0.4 kg), ADF in 0.0～0.6 kg (0.3 kg), CP in 0.2～1.5 kg (0.3 kg), and TDN in 0.0～0.3 kg (0.1 kg). Based on TDN supply, system B observed has an availability and reliability enough to calculate the feeding of dairy cattle in farm.

1. INTRODUCTION

Near infrared reflectance spectroscopy (NIRS) analytical method has been widely studied to predict nutritive value of feedstuff. Since NORRIS[1] published his successful experiment using NIRS to the forages, many studies using the same analysis have been carried out in many different feedstuffs. Almost all experiments conducted conclude that NIRS method has an ability and reliability in predicting nutrient contents in feed. Not only it is an undestructive, and unlaborious method, but also it does not use chemical reagents. This makes the NIRS method applicable for big farms. In future, this method may have a good prospect in relation to optimization of feeding management for the development of animal industry.

Practically, feeding calculation in farms use the fixed data from feeds tables by only determining dry matter content of each feedstuff. This tables represent the averaged value of same feeds from whole countries. Therefore the differences of composition influenced of origin will

平成7年5月18日受付

* Tokyo University of Agriculture

possibly observed between areas. NIRS seems have an ability to more precisely predict the feed composition due to the benefits as previously described.

The fundamental feature of NIRS method is its powerful statistical program in the connected computer, which allows to calculate valuable peaks of absorbed wavelength from samples being measured. A linear regression is the most widely used program in which the precision can be determined in the magnitude of regression and standard error values. Data taken for such statistical analysis in the program are usually from numerous samples. Therefore, the nutritive value of each sample observed using the NIRS method may differ from a 'real' value observed on the basis of individually chemically analyzed samples.

The aim of this study is to determine nutritive contents of a feed ration based on the NIRS and those from chemically analyzed data.

2. MATERIALS AND METHODS

2.1. Materials

Eighty seven feedstuffs collected from 9 dairy farms were used in this study. Five farms are located at Hokkaido and the others are at Tochigi prefecture. Composition of feed ingredients and dry matter (DM) of the feedstuff from each farm is presented in Table 1.

2.2. Methods

Two systems to evaluate nutritive value of each feedstuff were used in this study. (1)system A was based only on the conventional laboratory analysis and defined as a conventional value, (2) system B was based on either (a) nutritive value of forages predicted using the NIRS method ; or (b) nutritive values of concentrate taken from Standard Tables of Feed Composition in Japan (1987)[2] for crude protein (CP), acid detergent fiber (ADF) and its organic matter, while organic cell wall (OCW) taken from Japanese Feeding Standard for Dairy Cattle (1994)[3], or (c) nutritive values taken from commercial feed composition supplied by manufacturer. Point (b) and (c) was termed as 'book value'.

In case of concentrate, feed organic matter was divided into two fractions of organic cell contents (OCC) and organic cell wall (OCW). For forage, the OCW was further divided into two fractions, namely : organic a fraction (Oa) which is highly digestible and organic b fraction (Ob) which is lowly digestible. Other nutritive values determined for both feedstuffs were CP, ADF and TDN. The OCC, OCW, Oa and Ob were analyzed by enzymatic analysis[4], while CP and ADF were determined by Kjeldahl and detergent methods[5] respectively.

TDN contents of forages were calculated by following equations from the results of enzymatic analysis[7].

$$\text{TDN (for grass)} = 1.111(\text{OCC} - \text{Oa}) - 0.605\ \text{Ob} - 18.8$$

$$\text{TDN (for alfalfa)} = 0.428\ \text{OCC} + 0.379\ \text{Oa} + 34.3$$

$$\text{TDN (for corn silage)} = 0.545\ \text{OCC} + 1.413\ \text{Oa} - 26.4$$

In contrast, TDN contents of concentrates were calculated using the book value. TDN and ADF content of commercial feeds were uniformly to be 85.2% and 8.1% in dry matter base[6] for both systems of A and B respectively.

NIRS analysis of forages in system B, was obtained using Nireco FQA-51 A, and calibration set sample from National Institute of Animal Industry, Japan. The calibration set samples used were 126 forages, including grass hay, rice straw, and alfalfa ; 120 grass silages ; and 142 corn silages as previously reported[7].

Table 1 Composition of feed ingredients of 9 dairy farms and dry matter (kg/d) to a dairy cow

Farm	Forage	supply	Concentrate	supply	Commercial feed supply
A-1	*(30 kg milk/day): ratio F : Ct : Cm = 12.3 : 4.2 : 7.0*				
	Timothy silage	6.0	Beetpulp	0.8	A : 7.0
	Orchard grass hay	4.1	Corn	3.4	
	Alfalfa cube	2.2			
A-2	*(40 kg milk/day): ratio F : Ct : Cm = 12.7 : 8.6 : 7.0*				
	Timothy silage	6.0	Beetpulp	3.4	A : 7.0
	Orchard grass hay	4.1	Cotton seed	0.9	
	Alfalfa cube	2.6	Corn	3.4	
			Soybean	0.9	
A-3	*(50 kg milk/day): ratio F : Ct : Cm = 14.0 : 8.7 : 8.7*				
	Timothy silage	6.0	Beetpulp	1.7	A : 8.7
	Orchard grass hay	4.1	Cotton seed	0.9	
	Alfalfa cube	3.9	Soybean	1.8	
			Corn	4.3	
B	*ratio F : Ct : Cm = 8.7 : 2.6 : 14.1*				
	Corn silage	3.5	Beetpulp	2.6	B : 14.1
	Timothy hay	3.5			
	Alfalfa cube	1.7			
C	*ratio F : Ct : Cm = 14.3 : 4.7 : 14.1*				
	Corn silage	6.1	Wheat bran	0.9	C : 14.1
	IRG silage	8.2	Beetpulp	2.1	
			Rolled Barley	1.7	
D	*ratio F : Ct : Cm = 9.9 : 7.0 : 4.4*				
	Timothy hay	2.8	Tofu cake	2.1	D-a : 2.2
	Alfalfa hay	2.7	Wheat bran	0.8	D-b : 2.2
	Rice straw	4.4	Rolled barley	0.8	
			Rolled corn	0.8	
			Heated Soybean	0.8	
			Cotton seed	0.4	
			Beetpulp	1.3	
E	*ratio F : Ct : Cm = 6.5 : 15.0 : 0.8*				
	Alfalfa cube	0.9	Tofu cake	8.4	E : 0.8
	Timothy hay	2.8	Rolled Barley	1.5	
	Rice straw	2.8	Rolled Soybean	0.5	
			Wheat bran	1.2	
			Rolled Corn	0.8	
			Cotton seed	0.9	
			Beetpulp	1.2	
			molasses	0.5	

Table 1 continued

F	*ratio F : Ct : Cm = 10.5 : 1.8 : 11.2*				
	Corn silage	3.1	Beetpulp	1.8	F : 11.2
	IRG	silage	2.6		
	Alfalfa hay	2.5			
	Oat hay	0.9			
	Alfalfa cube	1.4			
G	*ratio F : Ct : Cm = 8.5 : 5.4 : 9.1*				
	IRG silage	2.3	Beetpulp	2.8	G-a : 7.3
	Alfalfa cube	3.0	Cotton seed	0.5	G-b : 1.8
	Oat hay	3.2	Rolled Corn	1.1	
			Rolled Barley 0.5		
			Rolled Soybean	0.5	
H	*ratio F : Ct : Cm = 10.9 : 14.9 : 0*				
	Sudan hay	3.6	Beetpulp	4.3	
	Bermuda grass straw	0.6	Rolled Corn	5.5	
	Alfalfa hay	1.2	Barley	1.2	
	Timothy hay	1.2	Heated Soybean	1.8	
	Alfalfa cube	4.3	Soybean meal	[illegible]	
			Cotton seed	0.5	
			Corn gluten-mill	0.3	
			Fish meal	0.4	
I	*ratio F : Ct : Cm = 8.4 : 7.0 : 1.3*				
	Corn silage	3.4	Beetpulp	2.5	I : 1.3
	Alfalfa hay	3.7	Rolled Barley	1.3	
	Oat hay	1.3	Rolled Corn	0.6	
			Soybean meal	0.3	
			Heated Soybean	0.4	
			Brewers grain	0.6	
			Cotton seed	1.0	
			Fish meal	0.3	

Note: farm A to E located in Hokkaido, farm F to I located in Tochigi prefecture;
IRG = Italian ryegrass; F: forage; Ct: concentrate; Cm: commercial feed

3. RESULTS AND DISCUSSION

As presented in Table 1, concentrate, including commercial feed, is the main feed given in all farms under investigation. Concentrate contains rich protein and starch which are required for milk production. Across the farms, components in the concentrate used were apparently similar. In most cases, the limitedly available concentrate is compensated with the increase of commercial feed. Especially for the commercial feed, DM from concentrate in the Hokkaido farms is higher than that in the Tochigi ones. Three main forages mostly used in all farms are grasses in the form of hay or silage in various species, alfalfa and corn silage. In two cases, farms D and E, rice straw was added in the forage supply.

3.1. Forages

The chemical composition and TDN contents of grasses, based on the systems A and B, were

Table 2 Comparison of system A and B for chemical composition and TDN-grass*[1]

Feeds (farm)	OCC		OCW		Oa		Ob		ADF		CP		TDN	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Timothy silage (A)	26.4	17.3	66.9	70.2	7.4	12.7	59.5	57.5	41.3	41.9	8.1	9.9	54.7	49.3
Orchad grass hay (A)	23.2	27.3	65.5	63.2	17.2	15.3	48.3	49.9	37.6	35.4	8.8	9.7	55.3	57.5
Timothy hay (B)	22.9	25.7	72.9	67.7	12.1	7.4	60.8	60.3	44.1	41.3	8.0	9.4	56.9	54.5
IRG silage (C)	33.0	33.4	56.8	54.3	17.1	13.4	39.7	40.9	34.0	33.1	15.1	15.7	60.9	57.9
Timothy hay (D)	16.0	19.8	77.3	71.7	13.1	8.7	64.2	63.0	42.4	43.6	8.0	8.4	52.4	51.0
Rice straw (D)	16.4	17.2	71.0	72.4	10.9	13.9	60.1	58.5	39.4	41.7	3.8	3.7	49.9	51.1
Timothy hay (E)	21.4	23.7	72.1	68.4	14.1	12.3	58.0	56.1	41.0	38.1	9.5	9.9	55.7	55.1
Rice straw (E)	16.5	17.9	69.1	72.5	11.9	17.7	57.2	54.8	39.9	41.7	4.7	4.5	43.4	53.9
IRG silage (F)	31.2	31.5	60.0	58.0	16.3	14.3	43.7	43.7	38.3	34.7	10.7	12.2	60.4	58.5
Oat hay (F)	26.2	28.6	65.6	62.5	9.5	7.9	56.1	54.6	37.1	37.9	7.8	8.9	54.8	54.8
IRG silage (G)	31.2	31.3	58.9	57.1	20.0	15.6	38.9	41.5	34.3	33.4	14.1	14.2	61.6	58.4
Oat hay (G)	24.9	24.5	66.2	65.4	9.4	5.6	56.8	59.8	36.6	38.4	8.3	9.0	53.7	50.5
Timothy hay (H)	20.5	23.6	72.9	68.9	13.7	12.2	59.2	56.7	43.4	41.1	6.9	7.6	55.6	55.3
Bermuda grass straw (H)	24.0	23.8	65.7	66.3	7.8	3.8	57.8	62.5	36.7	39.4	7.9	9.1	51.5	48.7
Sudan grass hay (H)	29.5	29.6	61.6	59.9	13.0	10.8	46.6	49.1	37.6	35.6	10.6	11.3	58.8	55.8
Oat hay (I)	27.7	26.9	63.8	62.5	13.6	10.2	50.2	52.3	37.9	26.2	10.4	11.1	57.5	54.1
Average	24.4	25.1	66.6	65.1	13.1	11.4	53.6	53.7	38.9	37.7	8.9	9.7	55.2	54.2

*[1] A, B: Calculation using system A, B (see Materials and Methods); IRG: Italian ryegrass.

presented in Table 2. In average, the value of each chemical composition as well as TDN was similar and there was a tendency that the values observed using system B is lower than those observed using system A.

In enzymatic fractions, an unexpected result was found in the case of timothy silage. The value of OCC in farm A was 9.1% higher in the system A than B. This is significantly above the average differences of OCC values observed in other grasses which ranged from 0.1% to 4.1%. In the case of OCW, the difference of values observed in system A and B was also higher than those of other grasses. In farm B, D, E, and H the differences were 5.2%, 5.6%, 3.7%, and 4.0% respectively. In contrast, the differences observed in other grasses varied from 0.6% to 3.4%. In all farms, in the case of Oa and Ob, the range (and average) of differences between two systems were 1.5%-5.8% (3.5%) and 0.0%-4.7% (1.9%), respectively.

In ADF, one unexpected result was found. Difference of the value between system A and B ranged from 0.6%-3.6% for all cases, but 11.7% for oat hay in farm I. For CP, slight difference of the values between two systems was observed, ranging from 0.1% to 1.8% with an average value of 0.8%. Based on the formula used, TDN was unavoidably affected by differences in each constituent. The range of differences for the TDN between two systems was considerably wide, from 0% to 10.5%. However, only two wide differences were found, 5.4% in timothy silage used in farm A and 10.5% in rice straw used in farm E. Differences in the others were lower than 5%.

Chemical composition and TDN percentage of alfalfa in systems A and B were shown in Table 3. Regardless to the forms of alfalfa given to animals, averaged differences of nutritive value between two systems are 2.9%, 2.3%, 1.6% and 4.2% for OCC, OCW, CP and TDN respectively.

Table 3 Comparison of system A and B for chemical composition and TDN-alfalfa*)

Feeds (farm)	OCC		OCW		Oa		Ob		ADF		CP		TDN	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Alfalfa cube (AB)	38.0	40.4	49.7	49.7	6.9	13.9	42.8	35.8	37.3	28.2	21.6	24.8	53.2	56.9
Alfalfa hay (D)	41.7	45.8	47.9	48.7	5.4	14.0	42.5	34.7	33.8	27.9	23.4	24.1	59.2	68.6
Alfalfa cube (E)	39.5	45.5	47.9	49.1	9.1	2.5	38.7	46.6	31.6	29.1	16.8	20.6	58.6	62.7
Alfalfa hay (F)	30.4	30.6	60.4	63.0	10.3	8.7	50.1	54.3	47.7	36.7	12.9	13.9	51.2	50.7
Alfalfa cube (FGH)	39.1	38.1	49.3	55.8	11.8	7.8	37.5	48.0	37.1	31.4	18.3	18.8	55.5	53.6
Alfalfa (H)	42.1	47.3	46.9	44.9	6.6	14.9	40.2	30.0	32.9	27.4	22.7	24.2	54.8	60.2
Alfalfa hay (I)	43.4	45.1	45.3	48.1	6.1	14.9	39.1	33.2	29.8	29.4	26.9	26.3	55.2	59.2
Average	39.2	41.8	49.6	51.3	8.0	11.0	41.6	40.4	35.7	30.0	20.4	21.8	55.4	55.8

*) see Table 2.

Table 4 Comparison of system A and B for chemical composition and TDN-corn silage*)

Farm	OCC		OCW		Oa		Ob		ADF		CP		TDN	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
B	39.6	42.7	53.9	50.3	11.2	6.6	42.7	43.7	31.7	29.2	8.8	8.1	63.8	65.5
C	50.3	57.8	43.5	37.3	7.8	3.4	35.7	33.9	23.4	23.2	8.0	8.0	64.8	68.9
F	42.7	49.5	51.1	46.5	11.6	8.5	39.7	38.0	32.9	27.8	9.6	7.9	66.1	69.8
I	49.3	42.9	46.2	52.7	5.7	9.1	40.5	43.6	25.1	31.2	7.3	7.0	61.3	57.8
Average	45.5	48.2	48.7	46.7	9.1	6.9	39.7	39.8	28.3	27.9	8.4	7.8	64.0	65.5

*) see Table 2.

Table 5 Comparison of system A and B for chemical composition and TDN-beetpulp*)

Farm	OCC		OCW		ADF		CP		TDN
	A	B	A	B	A	B	A	B	A/B
A	25.4	22.1	70.4	72.1	28.0	26.3	10.4	12.6	74.6
B	28.0	22.1	65.1	72.1	25.9	26.3	9.7	12.6	74.6
C	26.9	22.1	66.5	72.1	26.5	26.3	8.9	12.6	74.6
D	23.8	22.1	71.8	72.1	28.6	26.3	10.0	12.6	74.6
E	25.9	22.1	67.6	72.1	26.9	26.3	10.2	12.6	74.6
F	25.3	22.1	67.4	72.1	26.8	26.3	10.3	12.6	74.6
G	27.5	22.1	65.6	72.1	26.1	26.3	10.0	12.6	74.6
H	27.0	22.1	65.7	72.1	26.1	26.3	7.2	12.6	74.6
I	23.4	22.1	69.2	72.1	27.5	26.3	8.5	12.6	74.6
Average	25.9	22.1	67.7	72.1	26.9	26.3	9.5	12.6	74.6

*) see Table 2.

In contrast, the averaged differences for Oa, Ob and ADF were 6.4%, 7.6% and 5.7% respectively, all of which were higher than 5%. All the differences observed were in favor of system B, except for Ob and ADF.

Results of evaluation for corn silage, as presented in Table 4, shows that the averaged differences between two systems in the enzymatic fractions were 6.0%, 5.2%, 3.9% and 1.9% for OCC,

Table 6 Comparison of system A and B for chemical composition and TDN-Soybean and its derivatives*[)]

Feeds (farm)	OCC		OCW		ADF		CP		TDN
	A	B	A	B	A	B	A	B	A/B
Soybean (A)	68.9	77.0	25.8	17.5	12.4	8.3	42.3	41.4	103
Soybean (E)	64.7	77.0	29.9	17.5	14.3	8.3	39.0	41.7	107
Heated Soybean (D)	71.3	77.2	23.1	17.5	11.1	8.3	40.3	41.9	106
Heated Soybean (I)	65.6	77.2	29.0	17.5	13.9	8.3	41.7	41.9	106
Average	67.6	77.1	27.0	17.5	12.9	8.3	42.0	41.7	106
Soybean meal (G)	74.2	68.9	18.7	24.4	7.4	8.9	51.4	52.2	86.8
Soybean meal (H)	64.7	68.9	29.9	24.4	16.2	8.9	49.8	52.2	86.8
Soybean meal (I)	69.2	68.9	23.8	24.4	8.7	8.9	51.0	52.2	86.8
Average	69.4	68.9	24.1	24.4	10.8	8.9	50.7	52.2	86.8
Tofu cake (D)	34.2	46.9	62.4	48.5	21.3	18.4	23.5	28.7	94.1
Tofu cake (E)	42.4	46.9	52.2	48.5	22.1	18.4	22.9	28.7	94.1
Average	38.3	46.9	57.3	48.5	21.7	18.4	23.2	28.7	94.1

* see Table 2.

Table 7 Comparison of system A and B for chemical composition and TDN-Wheat and Barley*[)]

Feeds (farm)	OCC		OCW		ADF		CP		TDN
	A	B	A	B	A	B	A	B	A/B
Wheat bran (C)	68.7	53.5	27.8	40.8	7.9	14.4	16.3	17.7	72.3
Wheat bran (D)	50.9	53.5	42.9	40.8	13.9	14.4	18.1	17.7	72.3
Wheat bran (E)	50.2	53.5	43.7	40.8	14.1	14.4	18.0	17.7	72.3
Average	56.6	53.5	38.1	40.8	12.0	14.4	17.5	17.7	72.3
Barley (H)	80.6	79.9	16.9	17.5	6.6	6.6	12.2	12.0	84.1
Rolled Barley (C)	72.8	79.9	24.9	17.5	6.7	6.6	12.8	12.0	84.1
Rolled Barley (D)	69.7	79.9	27.1	17.5	10.0	6.6	14.7	12.0	84.1
Rolled Barley (E)	70.7	79.9	25.8	17.5	10.0	6.6	11.8	12.0	84.1
Rolled Barley (G)	77.3	79.9	20.1	17.5	7.4	6.6	12.5	12.0	84.1
Rolled Barley (I)	75.7	79.9	21.5	17.5	6.9	6.6	12.8	12.0	84.1
Average	74.5	79.9	22.7	17.5	7.9	6.6	12.8	12.0	84.1

*[)] see Table 2.

OCW, Oa, and Ob respectively. For ADF, CP and TDN the differences were 3.5%, 0.7% and 3.2% respectively. This result clearly showed that the nutritive values for CP and Ob were well predicted by system B. Unfortunately this figure was only represented in 4 farms.

3.2. Concentrate

As mentioned in the materials and methods, system B used in this evaluation was only based on the book value. This means that nutritive values used in the system B for the evaluation for each feedstuff are the same.

Table 8 Comparison of system A and B for chemical composition and TDN-Corn*[1]

Feeds (farm)	OCC		OCW		ADF		CP		TDN
	A	B	A	B	A	B	A	B	A/B
Corn (A)	87.9	88.0	10.8	10.6	2.5	3.8	9.2	10.2	92.3
Rolled corn (D)	83.9	88.0	14.6	10.6	2.8	3.8	9.4	10.2	92.3
Rolled corn (E)	85.9	88.0	12.6	10.6	3.5	3.8	9.4	10.2	92.3
Rolled corn (G)	86.6	88.0	12.0	10.6	2.6	3.8	9.5	10.2	92.3
Rolled corn (H)	87.2	88.0	11.3	10.6	3.4	3.8	9.4	10.2	92.3
Rolled corn (I)	89.1	88.0	9.4	10.6	2.3	3.8	9.6	10.2	92.3
Average	86.8	88.0	11.8	10.6	2.9	3.8	9.4	10.2	92.3

*[1] see Table 2.

Table 9 Comparison of system A and B for chemical composition and TDN-commercial feeds*.

Farm	OCC		OCW		ADF	CP		TDN
	A	B	A	B	A B	A	B	A B
A	73.2	77.0	18.8	20.1	8.1	19.2	20.0	85.2
B	70.9	77.0	21.1	20.1	8.1	23.0	20.0	85.2
C	59.5	77.0	32.5	20.1	8.1	29.5	20.0	85.2
D (a)	73.4	77.0	18.6	20.1	8.1	21.0	20.0	85.2
D (b)	73.8	77.0	18.2	20.1	8.1	19.2	20.0	85.2
E	70.7	77.0	21.3	20.1	8.1	33.5	20.0	85.2
F	67.5	77.0	24.5	20.1	8.1	22.6	20.0	85.2
G (a)	68.8	77.0	23.2	20.1	8.1	19.4	20.0	85.2
G (b)	73.8	77.0	18.2	20.1	8.1	13.1	20.0	85.2
I	77.3	77.0	14.7	20.1	8.1	16.3	20.0	85.2
Average	70.9	77.0	21.1	20.1	8.1	21.7	20.0	85.2

*[1] see Table 2.

In evaluating beetpulp used in all farms, results observed for chemical composition under system A were compared with the value in the book value. As shown in Table 5, the averaged differences in all chemical constituents were 3.8%, 4.4%, 0.8%, and 3.1% for OCC, OCW, ADF, and CP respectively. TDN was not evaluated in this comparison, because this value was taken from the book value for both systems. In general, nutritive values calculated from system A were higher than those from system B for OCC and ADF, but they were lower for OCW and CP.

Chemical compositions and TDN for soybean and its derivatives was presented in Table 6. In general, the value of enzymatic fraction and ADF observed using two systems were significantly different. However, this was not the case for CP, except in tofu cake which might be caused by different processing conducted to the soybeans.

Chemical compositions and TDN contents of wheat bran and barley were presented in Table 7. For wheat bran, the averaged differences of the two systems in the ADF and CP contents were 2.4% and 0.7%, respectively. Similar results were observed for barley in which averaged differences were 1.3% and 0.9% for ADF and CP respectively.

Table 10 Nutrient supply (kgDM/day) resulted from calculation based on system A and B-parts of forage*[1]

Farm	OCC supply			OCW supply			ADF supply			CP supply			TDN supply		
	A	B	|A-B|	A	B	|A-B|	A	B	|A-B|	A	B	|A-B|	A	B	|A-B|
A-1	3.4	3.0	0.4	7.8	7.9	0.1	4.8	4.6	0.2	1.3	1.5	0.2	6.7	6.6	0.1
A-2	3.5	3.2	0.3	8.0	8.1	0.1	5.0	4.7	0.3	1.4	1.6	0.2	6.9	6.8	0.1
A-3	4.0	3.8	0.2	8.7	8.8	0.1	5.5	5.1	0.4	1.7	2.0	0.3	7.6	7.6	0.0
B	2.8	3.1	0.3	5.3	5.0	0.3	3.3	2.9	0.4	1.0	1.0	0.0	5.2	5.3	0.1
C	5.8	6.3	0.5	7.3	6.7	0.6	4.2	4.1	0.1	1.7	1.8	0.1	8.9	9.0	0.1
D	2.3	2.5	0.2	6.6	6.5	0.1	3.8	3.8	0.0	1.0	1.0	0.0	5.2	5.5	0.3
E	1.4	1.6	0.2	4.3	4.3	0.0	2.5	2.5	0.0	0.5	0.6	0.1	3.3	3.6	0.3
F	3.7	3.9	0.2	5.9	5.9	0.0	4.1	3.5	0.6	1.2	1.3	0.1	6.1	6.2	0.1
G	2.7	2.6	0.1	5.0	5.1	0.1	3.1	2.9	0.2	1.1	1.2	0.1	4.8	4.6	0.2
H	3.6	3.8	0.2	6.2	6.3	0.1	4.1	3.7	0.4	1.7	1.7	0.0	6.1	6.0	0.1
I	3.6	3.5	0.1	4.1	4.4	0.3	2.4	2.5	0.1	1.4	1.4	0.0	4.9	4.9	0.0
Average	3.4	3.4	0.2	6.3	6.3	0.2	3.9	3.7	0.2	1.3	1.4	0.1	6.0	6.0	0.1

*[1] see Table 2; |A-B| : the value of absolute differences between system A and B.

An extremely different result on nutritive values of wheat bran observed for the OCC and OCW was found only in the farm C. The difference between systems A and B was 15.2% and 13.0% for OCC and OCW respectively, which are significantly higher than differences observed in the farms D and E. These were, in average, 3.0% and 2.5% for OCC and OCW respectively. This situation may be explained for the Japan's case. In this country, wheat bran are normally produced as by-products from the wheat flour manufacturing. This is classified into two, including high and low recoveries of flour. Wheat bran used in the farm C is considered from the low recovery of flour.

Averaged differences between two systems than previous values were found in the contents of OCC and OCW for rolled barley in 6 farms. The difference was 5.6% and 5.4% for OCC and OCW respectively. The high differences in these two enzymatic fractions may be due to ignorance of the values of the different forms in the rolled barley used. Disappointingly, the values of this feedstuff according to their forms are not specifically classified in the book value.

As expected, the difference between two systems was considerably low. Presented in Table 8, the averaged differences of the chemical composition for corn were 1.5%, 1.6%,1.0% and 0.8% for OCC, OCW, ADF and CP respectively.

Table 9 shows the chemical composition of commercial feeds. The commercial feeds distributed for animal industries in Japan varied greatly. The differences between the two systems are shown for the contents of OCC, OCW, and CP. The averaged differences are 6.2%, 3.4%, 4.2% for OCC, OCW and CP respectively. However, if the farms were considered individually, high difference between two systems was only found in farm C for all constituents and in farm E for CP. The differences in the farm C were 17.5%, 12.4% and 9.5% for OCC, OCW and CP respectively, while for CP in the farm E was 13.5%. The differences observed in CP showed that system A was higher than system B.

Table 10 shows the total nutrient supply (kg/d) from forage based on system A and B. The averaged differences between system A and B are 0.2 kg for OCC, OCW and ADF. In addition,

Table 11 Nutrient supply (kg DM/d) resulted from calculation based on system A and B whole feed of total ration*)

Farm	Total supply	OCC			OCW			ADF			CP			TDN		
		A	B	A-B	A	B	A-B	A	B	A-B	A	B	A-B	A	B	A-B
A-1	23.5	11.7	11.6	0.1	10.1	10.3	0.2	5.7	5.5	0.2	3.2	3.4	0.2	16.4	16.3	0.1
A-2	28.3	13.5	13.4	0.1	12.8	12.9	0.1	7.0	6.7	0.3	4.1	4.4	0.3	20.3	20.1	0.2
A-3	31.5	16.2	16.4	0.2	12.9	13.0	0.1	7.3	6.9	0.4	5.1	5.3	0.2	22.9	22.8	0.1
B	25.4	13.6	14.5	0.9	10.0	9.7	0.3	5.1	4.8	0.3	4.5	4.2	0.3	19.1	19.2	0.1
C	33.1	13.4	15.3	1.9	12.2	10.7	1.5	5.7	5.6	0.1	4.8	4.1	0.7	20.1	20.1	0.0
D	21.3	8.9	9.8	0.9	10.6	10.1	0.5	5.4	5.3	0.1	3.3	3.1	0.2	15.0	15.3	0.3
E	22.3	8.8	9.9	1.1	11.3	10.8	0.5	5.5	5.0	0.5	3.7	2.2	1.5	16.8	17.1	0.3
F	23.5	11.7	12.9	1.2	9.9	9.4	0.5	5.5	4.8	0.6	3.9	3.7	0.2	17.0	17.1	0.1
G	23.0	11.8	12.2	0.4	9.4	9.5	0.1	4.8	4.7	0.1	3.5	3.9	0.4	17.0	16.7	0.3
H	25.8	12.8	13.0	0.2	10.9	11.1	0.2	6.0	5.5	0.5	4.4	4.8	0.4	19.1	19.0	0.1
I	16.7	7.9	7.8	0.1	7.5	7.7	0.2	3.9	3.9	0.0	2.7	3.0	0.3	11.5	11.5	0.0
Average	11.9	12.4	0.6	10.7	10.5	0.4	5.6	5.3	0.3	3.9	3.8	0.3	17.7	17.7	0.1	

* see Table 10.

the difference between two systems for CP and TDN is the same, being 0.1 kg. Because of small difference between two systems, data predicted using NIRS is applicable for calculation of the ration.

3.3. Total supply in all farms and its effect on milk production

Table 11 shows the nutrient supply (kg/d) of total rations based on system A and B. The mean of each constituent supply was 0.6 kg, 0.4 kg, 0.3 kg, 0.4 kg and 0.1 kg for OCC, OCW, ADF, CP and TDN respectively. Those which have more than 0.5 kg for each constituent were farms B, C, D, E and F for OCC ; farms C, D, E, and F for OCW ; farms E, F and H for ADF ; as well farms C and E for CP. However, these figures were not found for TDN.

Based on TDN values, there was no difference in farms C and I. The important thing in this result was that higher proportion of forage than concentrate in ration was offered in both farms. In contrast, larger differences, 0.3 kg, were found in farms D and E. One possible explanation for this result is that high quantity of tofu cake was served as a feed ingredients. As described previously, this difference affected the total supply (see Table 6).

Satter and Roffler[8] outlined the allocation of metabolizable protein (MP) for maintenance and for milk production, and stated that MP is equal to about 75% of CP when low protein rations are fed. Assuming that milk contains 3% true protein and the efficiency with which MP is utilized for milk production and body weight gain is 60%, the synthesis of 1 kg of milk will require 50 g of MP. The averaged differences of CP total supply between the systems on parts of ration and its conversion to milk production were shown in Table 12.

The forage contribution shows that only farm A has a big difference (3.2-4.1 kg milk/d). This might be caused by timothy silage offered in large amount. Slightly lower difference were found in farms B and H (1.2 kg milk/d) which tend to be affected by timothy hay and bermuda grass straw (see Table 2).These three kinds of forages, as shown in Table 2, were those which were poorly predicted in the system B.

Table 12 Crude protein supply contributed from forages, concentrates, commercial feed, its differences between two systems and its conversion to milk production (kg/d)*

Farm	Forage			milk differ	Concentrate			milk differ	Commercial			milk differ	Total supply			milk differ
	A	B	|A-B|		A	B	|A-B|		A	B	|A-B|		A	B	|A-B|	
A-1	1.3	1.5	0.21	3.2	0.4	0.5	0.05	0.8	1.5	1.4	0.07	1.0	3.2	3.4	0.20	3.0
A-2	1.4	1.6	0.23	3.4	1.3	1.3	0.09	1.3	1.5	1.4	0.07	1.0	4.1	4.4	0.24	3.7
A-3	1.7	2.0	0.27	4.1	1.6	1.6	0.05	0.7	1.8	1.7	0.09	1.3	5.1	5.3	0.23	3.5
B	1.0	1.0	0.08	1.2	0.3	0.3	0.08	1.1	1.0	1.0	0.07	1.1	4.5	4.2	0.30	4.5
C	1.7	1.8	0.05	0.7	0.5	0.6	0.13	2.0	2.6	1.7	0.83	12.4	4.8	4.1	0.70	10.5
D	1.0	1.0	0.03	0.4	1.4	1.2	0.18	2.7	0.9	0.9	0.00	0.1	3.3	3.1	0.16	2.4
E	0.5	0.6	0.04	0.6	2.9	1.4	1.47	22.0	0.3	0.2	0.11	1.6	3.7	2.2	1.53	23.0
F	1.2	1.3	0.03	0.4	0.2	0.2	0.04	0.6	2.5	2.2	0.29	4.4	3.9	3.7	0.22	3.3
G	1.1	1.2	0.04	0.6	0.7	0.9	0.18	2.7	1.7	1.8	0.17	2.5	3.5	3.9	0.39	5.6
H	1.7	1.7	0.08	1.2	3.2	3.1	0.14	2.1	—	—	—	—	4.4	4.8	0.39	5.8
I	1.4	1.4	0.02	0.3	1.3	1.4	0.16	2.4	0.2	0.3	0.05	0.7	2.7	3.0	0.30	4.6
Total	14.1	15.1	1.08	16.2	13.5	12.5	2.56	38.5	13.8	12.7	1.74	26.1	43.3	42.1	4.67	70.0
Average	1.3	1.4	0.10	1.5	1.2	1.1	0.23	3.5	1.3	1.2	0.17	2.6	3.9	3.8	0.42	6.4

* see Table 10; milk conversion refers to Satter and Roffler

In the concentrate contribution, the extremely big difference was observed in farm E (22 kg milk/d). Referring to Table 1, in the farm E, tofu cake was given in a large amount in the ration (8.4 kg/d which is around 38% of total DM supply). As already presented in Table 6, the significant difference between two systems is influenced by the value of tofu cake. The same situation was apparently found in the farm D. In another case, farms G and I whose differences were 2.7 kg milk/d and 2.4 kg milk/d respectively may be caused by the utilization of either rolled or heated concentrate. These processes have an effect on protein.

The results of conversion to milk production contributed from commercial feed were observed extremely big differences in farm C and F by 12.4 kg milk/d and 4.4 kg milk/d respectively. These were resulted from a significant difference in CP values determined using two systems (see Table 9). Moreover in these farms, commercial feed is offered in a large quantity (see Table 1). Since system B is lower than system A, it means that if system B was used as a standard calculation it would oversupply CP to animals. Thus, although this system is still applicable in feeding calculation, the more valid data reported from the manufacturers is needed.

Protein intake is not the only factor affecting milk production. An interaction between dietary protein and dietary energy is more important[10]. It is well known that the sources of dietary protein differ in the affecting the ability to convert feed into milk production. Fish meal protein was found to be better than plant protein in supporting such ability due to low degradability in the rumen[3]. Further, the response of lactating cow to increasing levels of protein in the diet obey the law of diminishing returns. Each successive increment to the ration causes a progressively smaller response. In advancing lactation the energy balance increases and the protein requirement will decrease. An excess of protein in the diet will compensate for shortage of energy and vice versa. Thus, the differences of CP intake do not automatically cause differences in milk yield.

Commercial feed should be more importantly considered as the main source of protein for milk production than concentrate and forages. This argument is caused by the fact that commercial feed has high escape protein (called as 'by-pass' protein) which is available for absorption. The differences resulted from forages can be ignored in affecting milk production. Supply of forages tends to be used as a main source of energy for maintenance and production.

Commercial feed was found better than concentrate source in term of the averaged difference of milk production. The differences resulted from concentrate and commercial feed were 3.5 kg milk/d and 2.6 kg milk/d, respectively. But by eliminating farm E (in concentrate) and farm C (in commercial feed), it was observed similar by 1.65 and 1.52 kg milk/d, respectively.

Consider to TDN supply, it needs 0.31 kg TDN to produce 1 kg milk containing 3.5% milk fat[3]. The averaged differences of TDN total supply was 0.1 kg. It means that the milk production has only about 0.3 kg/d differences. As mentioned in materials and methods, TDN for forage was calculated using prediction equations, and for concentrate was cited from the book value in both systems. Thus the differences of TDN value were only influenced by forages. Though some differences were observed in individual forage, total supply shows no differences between the two calculation systems. These results support that NIRS predicted data of forage is applicable for feeding calculation.

4. CONCLUSION

Results investigated in this study suggested that: (1) NIRS predicted data of forages are applicable for farm feeding calculation; (2) The conventional data should be used if one kind of concentrate is altered in a large quantity; or (3) the more accurate information about chemical composition of commercial feed from manufacturer is needed.

REFERENCES

1) Norris, K. H., R. F. Barnes, J. E. Moore and J. H. Shenk: Predicting Forage Quality by Near Infrared Reflectance Spectroscopy, *J. Anim. Sci.*, **43**, 889-897, 1976

2) Agriculture, Forestry and Fisheries Research Council Secretariat, Ministry of Agriculture, Forestry and Fisheries: Standard Tables of Feed Composition in Japan (1987), Central Association of Livestock Industry, Tokyo, 1987

3) Agriculture, Forestry and Fisheries Research Council Secretariat, Ministry of Agriculture, Forestry and Fisheries: Japanese Feeding Standard for Dairy Cattle (1994), Central Association of Livestock Industry, Tokyo, 1994

4) Abe, A., S. Horii and K. Kameoka: Application of Enzymatic Analysis with Glucoamylase, Pronase, and Cellulase to Various Feed for Cattle, *J. Anim. Sci.* **48**, 1483-1489, 1979

5) Morimoto H.: Dobutsu eiyo shikenho (Experimental Method of Animal Nutrition), Yokendo, Tokyo, 280, 1971

6) Abe, A., M. Shinoda, K. Iwasaki, F. Sato, T. Suda and B. Takahashi: Assessment of Total Digestible Nutrients (TDN) of Hays from Its Chemical Composition. *Jap. J. Zootech. Sci.*, **50**, 12-19, 1985

7) Japanese Grassland Society: Soshiryo no hinshitsu hyoka guide book (Guide Book for Forage Evaluation), 1994

8) Amari M., A. Abe, R. Tano, S. Masaki, S. Serizawa and T. Koga: Prediction of Chemical Composition and Nutritive Value of Forages by Near Infrared Reflectance Spectroscopy, 1. Prediction of chemical composition. *J. Japan Grassl. Sci.*, **33**, 219-226, 1987

9) SATTER, L. D., and R. E. ROFFLER: Influence of Nitrogen and Carbohydrate Inputs on Rumen Fermentation, *in*: W. HARESIGN and D. J. A. COLE (Editors), Recent Developments in Ruminant Nutrition, Butterworths, London, 135, 1981

10) KAUFMANN, W. and H. HAGEMEISTER: Composition of Milk, *in*: H.O. GRAVERT (Editor), World Animal Science, C Production-system Approach, 3 Dairy-Cattle Production, Elsevier, 136, 1987

11) BONDY, A. A.: Animal Nutrition, John Wiley & Sons Ltd, Chichester, 463-466, 1987

乳牛の飼料給与診断における近赤外分析・飼料成分表の栄養評価システムと化学分析法との比較

Agung PURNOMOADI*・甘利　雅拡・阿部　亮

(畜産試験場栄養部)

摘　要

栃木県と北海道の酪農家9戸について，その給与飼料内容を調査し，併せて飼料(87)点の採取を行った。飼料の栄養価評価について次の2つの方法で比較し，飼料給与診断のための手法を検討した。

システムA：すべての飼料成分を室内分析で行う。TDNについては，牧乾草，サイレージはTDN推定式で算出し，穀類，油粕類，ヌカ類，製造粕類，市販配合飼料等のいわゆる濃厚飼料は日本標準飼料成分表あるいは日本飼養標準・乳牛のデータを用いる。

システムB：牧乾草，サイレージについては近赤外分析により成分の測定を行い，それ以外の飼料は日本標準飼料成分表あるいは日本飼養標準・乳牛のデータを用いる。

対象とした分析項目および栄養価は細胞内容物質(OCC)，総繊維(OCW)，酸性デタージェント繊維(ADF)，粗蛋白質および可消化養分総量(TDN)であり，サイレージと乾草については高消化性繊維(Oa)と低消化性繊維(Ob)も測定した。

近赤外分析と室内分析の比較ではイネ科草の場合，OCC，OCWの含量については比較的満足すべき結果であり，粗蛋白質では近赤外分析によりかなり精度よく測定された。しかし，Oa含量については両法の差に大きい値のものが散見されたが，TDNの含量では両者は比較的近い値を示した。この傾向はアルファルファの場合にも同様に認められたが，トウモロコシサイレージの場合には，OCC，OCWの両法間の差が牧草よりも大きい値となった。

給与飼料全体の成分およびTDNについてシステムAで評価した給与量をシステムBと比較して，その差と差の平均値をみると，OCCでは0.1-1.9 kg(平均値0.6 kg)，OCWでは0.1-1.5 kg(同0.4 kg)，ADFでは0.0-0.6 kg(同0.3 kg)，粗蛋白質では，0.2-1.5 kg(同0.3 kg)，そしてTDNでは0.0-0.3 kg(同0.1 kg)であった。このことから，TDN給与量の評価について，システムBは乳牛栄養の飼料給与診断の場面で十分に使用に耐えるものと判断された。

---

* 東京農業大学