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An Investigation on the Shortest Ruminal Incubation Time in Calculating Effective Rumen Degradability of Nutrients in Solvent Extracted Sunflower Seed Meal

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Abstract: The purpose of this study is to investigate the possibilities of calculating Effective Degradability of Dry Matter (EDDM), organic matter (EDO) and crude protein (EDP) by means of the shortest ruminal incubation time. After calculating EDP, EDO and EDDM using 4-72 h ruminal incubation time, the relationship between them and degradability of Dry Matter (DMD), Organic Matter (OMD) and Crude Protein (CPD) measured at 4, 8, 16, 24, 48 and 72 h was investigated by applying simple linear regression analysis. The determination coefficient indicated that 93.9 of variation in EDP for 0.02 h^{-1} can be adequately explained by CPD measured at the end of 48 h of ruminal incubation ($p<0.01$). The results indicated that EDP for outflow rate of 0.05 and 0.08 h^{-1} would be estimated from the CPD measured at 8 h. Moreover, the calculated determination coefficients were 91.7 and 94.6% for outflow rates of 0.05 and 0.08 h^{-1}, respectively, which confirmed that EDO can accurately be calculated by means of the 8th h measurements of OMD ($p<0.01$). The results also shown that 90% of variation in EDDM, which is a satisfactory amount, can be elucidated by the DMD measurements of 16th h, which states that EDDM for the outflow rate of 0.02 h^{-1} can be estimated from the DMD measurements taken at the end of 16 h ($p<0.01$). The determination coefficients were calculated as 92.7 and 97.9% for outflow rates of 0.05 and 0.08 h^{-1}, respectively, indicating that EDDM for 0.05 and 0.08 h^{-1} would be predicted from the DMD measured at the end of 8 h incubation time.

Key words: Sunflower seed meal, dry matter, organic matter, crude protein, effective rumen degradability, regression analysis

INTRODUCTION

Obtaining desirable animal yield depends on providing required nutrients in suitable proportions. Barley, wheat, rye, maize and oat are commonly used grain feeds to provide energy requirements of ruminants. In addition to energy, the other nutrients, such as protein, vitamin and mineral should sufficiently be supplied. To use vegetable protein sources to supply these needs is the most common and economic. The meals produced from soybean, sunflower and cotton etc. are the most important vegetable protein sources except the forages.

In study, there are limited studies exhibiting the usefulness of sunflower meal as vegetable protein source in animal diet. However, Lardy and Anderson (2002) reported that sunflower meal is biologically and economically very useful vegetable protein source for the growing and finishing cattle. In like manner, they also stated that sunflower meal can also be used as an additional effective protein source and that it can be utilized as a degradable protein source in lower quality forage and high corn finishing rations. The degradability can be influenced by the high amount of fiber in it. Nevertheless, ruminants are tolerable to high amount of fiber than the other races (Lardy and Anderson, 2002).

There are misuses of meals in ruminant diet due to the lack of information on the feed value. The lack of information on the feed value causes to use wrong forage with unsuitable grain feed not to arrange forage and concentrate feed ratio correctly and to consume these grain feeds more than necessary, which is the main reason for the economic losses. To prevent the losses, concentrate feeds should be used in balance in ruminant diet, which depends on the information on the feed value.

To gain information on the feed value, Dacron or polyester bag technique, which can also be expressed as

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in sacco or *in situ* rumen degradability technique, was achieved (Quin *et al*., 1938) and developed (Orskov and McDonald, 1979). This technique determines ruminal degradation losses in either dry or organic matter of feeds in certain time points (Bhargava and Orskov, 1987; Orskov *et al*., 1980; Kempton, 1980). This technique can also be performed to observe amount of by-pass protein, protein in rumen, cellulose degradability and degradation degree. Metabolic energy value can be calculated using organic matter degradability rate at the end of 48 h (Bhargava and Orskov, 1987).

In study to use 12-72 h ruminal incubation time, depending on the type of feed and animal race, during which maximum degradability rate is achieved is recommended to calculate the effective degradability of protein, organic matter and dry matter (Orskov *et al*., 1980).

The long ruminal incubation time causes economical lose, harm to animal and time loses due to the complexity of the polyester bag technique. Therefore in study, there are studies investigating possibility of using reduced incubation time in calculating accurate effective degradability of protein, organic matter and dry matter.

Mathis *et al*. (2001) compared the estimates of effective degradability of protein using 2, 8 and 96 h with 2-single time-point enzyme assays. They stated that average ED values obtained from the both 48 and 4 h enzyme assays explained 87 and 88% of variation observed in average effective degradability values from *in situ* technique, respectively.

Olaissen *et al*. (2003) examined, whether it is possible to calculate the effective degradability of dry matter and protein using minimal number of ruminal incubation time. They reported that bilinear regression models, based on two (4 and 24 h) and three (2, 8 and 24 h) incubation time, gave similar effective degradability estimates as calculated from 7 or 8 incubation times for outflow rate of 0.06 h^{-1}.

Umucalilar *et al*. (2002) inspected the relationship between effective degradability of dry matter calculated from 0, 2, 4, 8, 16, 24 and 48 h incubation times and the in vitro gas production at 6, 24 and 48 h for the outflow rate of 0.05 h^{-1}. According to the results, they obtained, it was reported that EDDM might be predicted from *in vitro* gas production. Therefore, they recommended that the gas production parameters might be used in regression equation.

In the above-mentioned studies, the relationship between the effective degradability calculated from 6-9 incubation times according to the reference method and the effective degradability obtained from *in vitro* techniques in which much shorter period was taken into consideration was investigated to give answer to the question as to whether effective degradability of nutrients could be estimated from reduced time points.

This study was undertaken to investigate the relationship between EDP, EDDM and EDO calculated according to the reference method for the outflow rate of 0.02, 0.05 and 0.08 h^{-1} as recommended in Agricultural and Food Research Council (Yan and Agnew, 2004) and degradability of Crude Protein (CPD), Organic Matter (OMD) and Dry Matter (DMD) at the certain ruminal incubation time. In this way, it was examined whether it is possible to calculate Effective Degradability of Dry Matter (EDDM), organic matter (EDO) and crude protein (EDP) by means of the shortest ruminal incubation time.

MATERIALS AND METHODS

Animals and diet: Three mature Anatolia Merinos rams, being 3 years of age and 82 kg live body weight, which have ruminal cannulas were used in this experiment. During the experiment, the amount of feed to be given to the animals was determined by multiplying maintenance by 1.25 (Bhargava and Orskov, 1987). Therefore, animals were fed with 878 g compound feed, 304 g alfalfa hay and 250 g wheat straw 2 times a day (at 9 O'clock in the morning and at 5 O'clock in the evening). The diet is organized as 40% of the ration of forage feed and 60% of concentrate feed. Chemical composition of the concentrate feed, alfalfa hay and wheat straw and ingredients of the compound feed are given in Table 1.

Experimental feedstuffs: Solvent Extracted Sunflower Seed Meal (SSM) used in this study was provided from five different feed factories. Chemical composition of them and supplements were determined according to the procedures described by AOAC (2003). Chemical composition of the feeds is presented in Table 2.

***In situ* method:** *In situ* bags were made of polyester Dacron with an aperture of 45 μm. Dimensions of each bag were 9×14 cm. Approximately, 5 g of grain sample was weighed into each bag. Bags containing each 5 different feed samples were suspended for each time points, which are 4, 8, 16, 24, 48 and 72 h through the ruminal fistulas. Bags containing the feed samples were introduced into the rumen 2 h after the morning meal and were consistently withdrawn at the scheduled times. Six measurements were made for each grain at each time point (3 rams × 2 bags). At the end of the incubation, bags were removed from the rumen, washed with water and then squeezed until the runoff was clear. After that the bags were dried at 65°C for 48 h and weighed. At the end of

Table 1: Nutrient compositions of the experimental diet (%) and ingredients of the compound feed (%)

Components	Compound feed	Alfalfa hay	Wheat straw
Experimental diet (%)			
Dry matter	89.81	91.72	92.89
Crude protein	11.22	15.16	3.63
Crude fiber	5.21	35.95	40.00
Ether extract	2.09	0.95	0.80
Crude ash	7.65	11.07	4.75
Metabolizable energy (kcal kg^{-1})	2700.00	2200.00	1485.00
Ca	1.50	1.40	0.16
P	0.75	0.20	0.05
Feeds			%
Ingredients of the compound feed (%)			
Barley			60.34
Tapioka			9.50
Maize			18.42
SSM			6.35
$CaCO_3$			2.54
DCP			2.15
Salt			0.50
Vitamin mix*			0.10
Mineral mix**			0.10

*Contains 18000 IU Vitamin A, 3000000 IU Vitamin D_3, 30.000 mg Vitamin E, 5000 mg Vitamin B_1 per kg of premix; **Contains 100000 mg niasin, 50000 mg Mn, 50000 mg Fe, 50000 mg Zn, 150 mg Co, 800 mg I, 150 mg Se per kg of premix

Table 2: Chemical composition of SSM samples

		DM (%)						
Feeds	DM (%)	CP	CF	EE	CA	OM	NFE	NDF
SSM1	91.41	29.78	27.75	1.90	7.81	92.19	32.75	46.14
SSM2	91.10	42.39	17.29	2.20	7.50	92.51	30.64	36.80
SSM3	93.55	38.24	18.31	2.34	7.14	92.86	33.97	32.33
SSM4	92.92	37.19	16.88	1.89	7.05	92.95	36.99	34.61
SSM5	92.27	33.65	23.93	1.12	7.08	92.92	34.23	44.09

DM: Dry Matter, CP: Crude Protein, CF: Crude Fiber, CA: Crude Ash, EE: Ether Extract, OM: Organic Matter, NFE: Nitrogen Free Extract, NDF: Neutral Detergent Fiber

each incubation period, the required data were observed to calculate dry matter, organic matter and crude protein losses (Bhargava and Orskov, 1987; Orskov *et al*., 1980; Nocek, 1988).

DMD, OMD and CPD of feed samples were determined (Bhargava and Orskov, 1987). Rumen degradability characteristics were calculated by means of equation (McDonald, 1981):

$$P = a + b\,(1-e^{-ct})$$

Where,

P = DMD, OMD and CPD in ith incubation period
a = Water-soluble extracted Dry Matter (DM), Organic Matter (OM) or Crude Protein (CP)
b = Potentially degradable DM, OM or CP
c = Fractional rumen degradation rate per hour of b
t = Incubation period (h)

EDDM, EDO and EDP of feed samples were computed using equation (McDonald, 1981):

$$Pe = a+bc/(c+k)\; e^{-(c+k)t}$$

Where,

Pe = EDDM, EDO and EDP
k = Rumen outflow rate (k-value is 8% for high producing dairy cows, 5% for beef cows, sheep, goat and low producing dairy cows, 2% for weaning cows) (Bhargava and Orskov, 1987)

The rumen degradability characteristics of feed samples were calculated by using Neway computer program (McDonald, 1981).

Statistical analysis: After calculating EDP, EDO and EDDM by means of 4-72 h ruminal incubation time, the relationship between DMD, OMD and CPD measured at 4, 8, 16, 24, 48 and 72 h and the calculated effective degradability was investigated applying simple linear regression analysis to select the best and shortest ruminal incubation time to calculated the EDP, EDO and EDDM.

Regression analysis provides information on the relationship between independent, being nutrients degradability and dependent variables, being effective degradability of nutrients. It also provides information on variation in dependent variables explained by independent variables (Neter *et al*., 1989; Draper and Smith, 1998). All analysis were performed by using MINITAB 15.1 statistical package.

RESULTS AND DISCUSSION

The results of regression analysis applied to the CPD and EDP are given in Table 3. As shown in Table 3, the strongest relationship was attained between EDP and CPD measured at the end of 48 h incubation time when outflow rate was 0.02 h^{-1}. The determination coefficient indicated that 93.9 of variation in EDP can be adequately explained by CPD measured at the end of 48 h of ruminal incubation ($p<0.01$).

However, the results of the analysis exhibited that while the outflow rate was increasing, the EDP had stronger relationship with the CPD measured in a far shorter incubation time. The calculated regression coefficient indicated that there was a mean effective protein degradability increase of 0.743% with a unit increase of protein degradability measured at 8 h ruminal incubation time for the outflow rate of 0.05 h^{-1}. The calculated determination coefficients, being 96.6%, confirmed that an adequate amount of variation in EDP can be explained by CPD measured at 8 h ruminal incubation time owing to the fact that it was statistically significant ($p<0.01$). The similar result was also obtained for the relationship between EDP and CPD for the outflow

Table 3: The results of regression analysis for CPD and EDP of ATK

Outflow rate	Time (h)	Regression equation	R^2 (%)	$F_{(1, 13)}$	p-value
0.02 h^{-1}	04	EDP2 = 46.8 + 0.663 CPD4	80.8	54.86	<0.01
	08	EDP2 = 43.8 + 0.560 CPD8	88.0	95.31	<0.01
	16	EDP2 = 34.1 + 0.617 CPD16	85.6	77.11	<0.01
	24	EDP2 = 17.0 + 0.771 CPD24	90.8	128.40	<0.01
	48	EDP2 = -15.0 + 1.06 CPD48	93.9	199.01	<0.01
	72	EDP2 = -34.1 + 1.18 CPD72	81.1	55.93	<0.01
0.05 h^{-1}	04	EDP5 = 25.1 + 0.883 CPD4	89.4	109.48	<0.01
	08	EDP5 = 21.2 + 0.743 CPD8	96.6	372.02	<0.01
	16	EDP5 = 9.70 + 0.794 CPD16	88.5	99.69	<0.01
	24	EDP5 = -10.9 + 0.973 CPD24	90.2	119.77	<0.01
	48	EDP5 = -46.0 + 1.27 CPD48	84.3	69.62	<0.01
	72	EDP5 = -61.0 + 1.33 CPD72	63.9	23.06	<0.01
0.08 h^{-1}	04	EDP8 = 14.6 + 0.973 CPD4	94.6	229.32	<0.01
	08	EDP8 = 11.1 + 0.803 CPD8	98.5	836.33	<0.01
	16	EDP8 = 0.76 + 0.823 CPD16	82.8	62.38	<0.01
	24	EDP8 = -20.4 + 1.00 CPD24	83.8	67.36	<0.01
	48	EDP8 = -55.7 + 1.30 CPD48	77.1	43.71	<0.01
	72	EDP8 = -70.0 + 1.35 CPD72	57.4	17.55	<0.01

rate of 0.08 h^{-1} owing to the fact that the determination coefficient confirmed that 98.5% of variation in EDP can be explained by the CPD measured at the 8th h of incubation time ($p<0.01$) (Table 3).

The calculated regression equations and the regression lines, which were calculated for the relationship between EDP and CPD for outflow rates of 0.02, 0.05 and 0.08 h^{-1}, respectively are given in Fig. 1. As shown in Fig. 1, the strongest relationships between EDP and CDP measured at the end of 8 h incubation time were achieved for the outflow rates of 0.05 and 0.08 h^{-1}. This indicates that EDP for outflow rate of 0.05 and 0.08 h^{-1} would be estimated from the CPD measured at 8 h.

The results of regression analyses obtained for the EDO and OMD pointed out that if outflow rate equals to 0.02 h^{-1}, OMD measurements taken at the end of 16th h of incubation time is enough to estimate the EDO. This is because the determination coefficient, being 94.6% and statistically significant ($p<0.01$), clarifying that an adequate amount of variation was explained by the 16th h measurements of OMD (Table 4). Moreover, the calculated determination coefficients were 91.7 and 94.6% for outflow rates of 0.05 and 0.08 h^{-1}, respectively, which confirmed that EDO can accurately be calculated by means of the 8th h measurements of OMD ($p<0.01$).

The calculated regression equations and the regression lines, which were calculated for the relationship between EDO and OMD for outflow rates of 0.02, 0.05 and 0.08 h^{-1}, respectively are given in Fig. 2. As seen in Fig. 2, the strongest relationship between EDO and OMD measured at the end of 8 h incubation time was determined for the outflow rates of 0.08 h^{-1}.

Regarding effective degradability of dry matter, the results of regression analysis emphasized that EDDM was strongly correlated with the DMD measured at the 16th h of ruminal incubation time when the outflow rate equals to

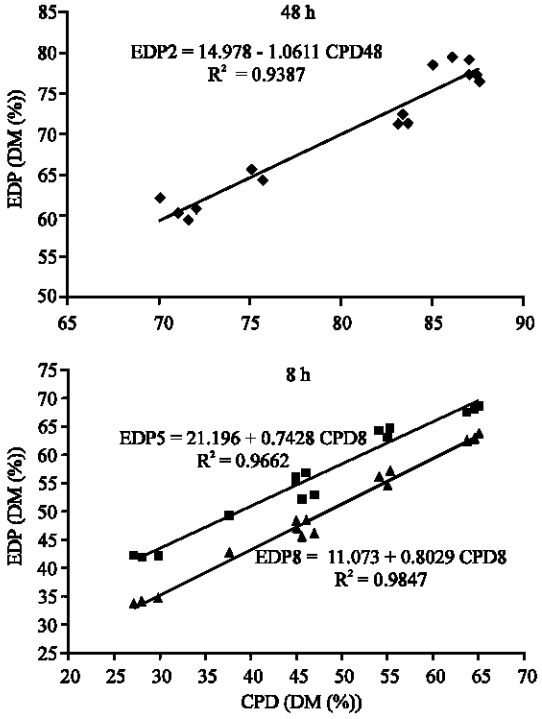

Fig. 1: Effective degradability of crude protein

0.02 h^{-1} (Table 5). The calculated regression coefficient indicated that a mean increase of 0.669% in EDDM was achieved with a unit increment in DMD at the 16th h. In addition, it was highlighted that 90% of variation in EDDM, which is a satisfactory amount, can be elucidated by the DMD measurements of 16th h, which states that EDDM for the outflow rate of 0.02 h^{-1} can be estimated from the DMD measurements taken at the end of 16 h ($p<0.01$).

The results also confirmed that an increase in outflow rate resulted in faster degradability of nutrients owing to

Table 4: The results of regression analysis for OMD and EDO of ATK

Outflow rate	Time (h)	Regression equation	R^2 (%)	$F_{(1, 13)}$	p-value
0.02 h^{-1}	04	EDO2 = 34.2 + 0.672 OMD4	53.0	14.67	<0.01
	08	EDO2 = 37.2 + 0.473 OMD8	73.0	35.11	<0.01
	16	EDO2 = 21.6 + 0.711 OMD16	94.6	229.96	<0.01
	24	EDO2 = 45.4 + 0.216 OMD24	12.4	1.84	>0.05
	48	EDO2 = 7.53 + 0.779 OMD48	76.3	41.92	<0.01
	72	EDO2 = -3.48 + 0.875 OMD72	75.3	39.72	<0.01
0.05 h^{-1}	04	EDO5 = 14.5 + 0.981 OMD4	79.0	48.94	<0.01
	08	EDO5 = 21.4 + 0.628 OMD8	90.1	118.45	<0.01
	16	EDO5 = 6.14 + 0.836 OMD16	91.7	143.92	<0.01
	24	EDO5 = 30.9 + 0.313 OMD24	18.3	2.90	>0.05
	48	EDO5 = -1.7 + 0.778 OMD48	53.4	14.88	<0.01
	72	EDO5 = -9.9 + 0.834 OMD72	48.0	11.98	<0.01
0.08 h^{-1}	04	EDO8 = 6.86 + 1.07 OMD4	88.5	99.60	<0.01
	08	EDO8 = 15.3 + 0.662 OMD8	94.6	229.82	<0.01
	16	EDO8 = 2.21 + 0.819 OMD16	83.3	64.79	<0.01
	24	EDO8 = 25.2 + 0.330 OMD24	19.2	3.09	>0.05
	48	EDO8 = -0.7 + 0.687 OMD48	39.4	8.44	<0.05
	72	EDO8 = -7.7 + 0.732 OMD72	34.9	6.98	<0.05

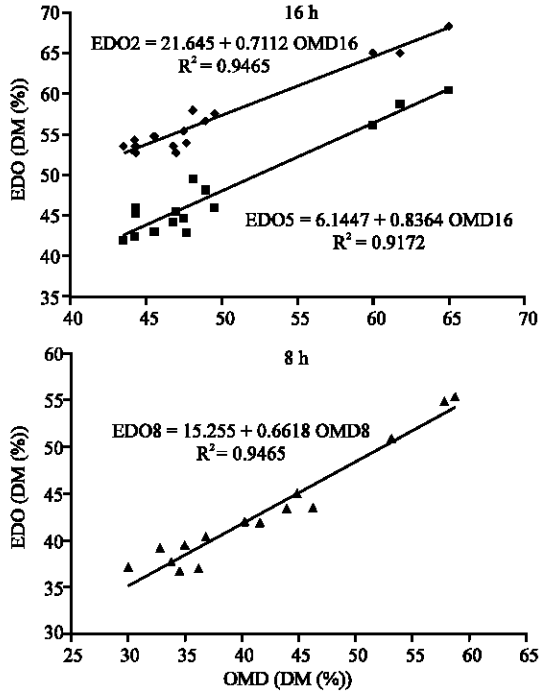

Fig. 2: Effective degradability of organic matter

the fact that EDDM was most strongly related to the DMD measured at the end of 8 h incubation time for the outflow rates of 0.05 and 0.08 h^{-1} (Table 5). While, a 92.7% of variation in EDDM was explained by the DMD measurements taken at the end of 8 h incubation time, DMD measurements taken at the end of 8 h incubation time explicated a 97.9% of variation in EDDM. The regression coefficients calculated for outflow rates of 0.05 and 0.08 h^{-1} were very close to each other, indicating that approximately 0.6% increment in EDDM occurred with a unit increase in DMD measured at the end of 8 h period.

The calculated regression equations and the regression lines, which were calculated for the relationship between EDDM and DMD for outflow rates of 0.02, 0.05 and 0.08 h^{-1}, respectively are given in Fig. 3. As shown in Fig. 3, the strongest relationships between EDDM and DMD measured at the end of 8 h incubation time were attained for the outflow rates of 0.05 and 0.08 h^{-1}.

The findings of this study emphasized that EDP, EDO and EDDM for the outflow rate of 0.08 h^{-1} can be estimated by means the CPD, OMD and DMD measurements at the end of 8 h ruminal incubation time, respectively. These results were in accordance with the studies corroborating that the effective degradability of nutrients can be calculated from the shorter period measurements gained from different techniques. For example, it was stated that the average ED values obtained from the both 48 and 4 h enzyme assays explained 87 and 88% of variation observed in average effective degradability of protein in different forages using 2, 8 and 96 h from in situ technique, respectively (Mathis *et al*., 2001). It was also investigated whether it is possible to calculate the effective degradability of dry matter and protein in different concentrate feeds using minimal number of ruminal incubation time and reported that bilinear regression models, based on two (4 and 24 h) and three (2, 8 and 24 h) incubation time, gave similar effective degradability estimates as calculated from seven or eight incubation times for outflow rate of 0.06 h^{-1} (Olaissen *et al*., 2001).

In addition, Umucalilar *et al*. (2002) expressed that the effective degradability of dry matter in grain feeds calculated from 0, 2, 4, 8, 16, 24 and 48 h incubation times may be predicted from the in vitro gas production at 6, 24 and 48 h for the outflow rate of 0.05 h^{-1}. According to the results, they obtained, it was reported that EDDM might

Table 5: The results of regression analysis for DMD and EDDMD of ATK

Outflow rate	Time (h)	Regression equation	R^2 (%)	$F_{(1, 13)}$	p-value
0.02 h^{-1}	04	EDDM2 = 35.5 + 0.641 DMD4	45.7	10.94	<0.01
	08	EDDM2 = 37.7 + 0.439 DMD8	73.8	36.62	<0.01
	16	EDDM2 = 23.4 + 0.669 DMD16	90.0	117.15	<0.01
	24	EDDM2 = 20.3 + 0.647 DMD24	86.6	83.86	<0.01
	48	EDDM2 = 12.2 + 0.689 DMD48	63.6	22.76	<0.01
	72	EDDM2 = -5.78 + 0.884 DMD72	76.1	41.41	<0.01
0.05 h^{-1}	04	EDDM5 = 14.8 + 1.00 DMD4	74.4	37.69	<0.01
	08	EDDM5 = 21.3 + 0.603 DMD8	92.7	165.51	<0.01
	16	EDDM5 = 5.90 + 0.827 DMD16	91.5	139.41	<0.01
	24	EDDM5 = 1.70 + 0.805 DMD24	89.5	110.62	<0.01
	48	EDDM5 = 6.3 + 0.618 DMD48	34.2	6.75	<0.05
	72	EDDM5 = -13.0 + 0.839 DMD72	45.7	10.95	<0.01
0.08 h^{-1}	04	EDDM8 = 6.33 + 1.12 DMD4	87.2	88.59	<0.01
	08	EDDM8 = 14.9 + 0.637 DMD8	97.9	602.29	<0.01
	16	EDDM8 = 1.92 + 0.802 DMD16	81.3	56.62	<0.01
	24	EDDM8 = -2.19 + 0.782 DMD24	79.7	51.13	<0.01
	48	EDDM8 = 8.7 + 0.495 DMD48	20.7	3.40	>0.05
	72	EDDM8 = -9.9 + 0.718 DMD72	31.7	6.03	<0.05

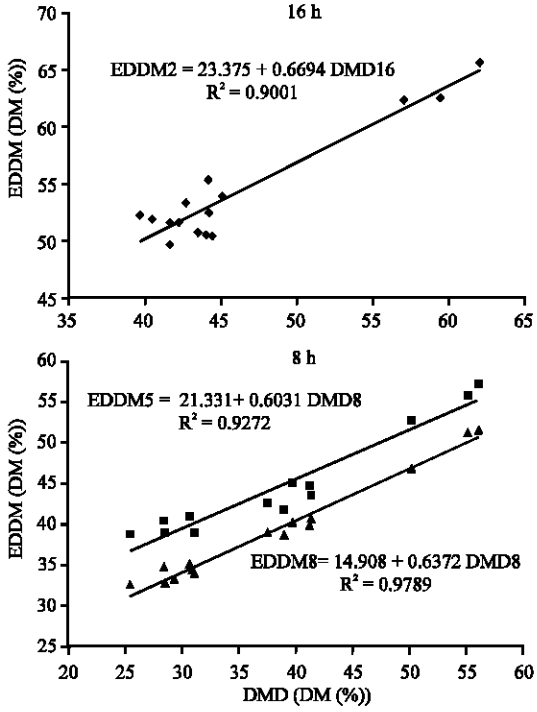

Fig. 3: Effective degradability of dry matter

be predicted from *in vitro* gas production. Therefore, they recommended that the gas production parameters might be used in regression equation.

CONCLUSION

In practice, the model developed by Orskov *et al.* (1980) is accepted as the reference model to predict accurate effective degradability of nutrients. However, this model requires 12-72 h ruminal incubation time, depending on the type of feed and animal race, during which maximum degradability rate is achieved is recommended to calculate the effective degradability of protein, organic matter and dry matter. The long ruminal incubation time causes economical lose, harm to animal and time loses due to the complexity of the polyester bag technique. In this study, the question as to whether, it is possible to predict EDP, EDO and EDDM using a single incubation time was scrutinized.

The findings of this study clarified that EDP for the outflow rate of 0.02 h^{-1} can be adequately explained by CPD measured at the end of 48 h of ruminal incubation ($p<0.01$). Moreover, the strongest relationship between EDP and CDP measured at the end of 8 h incubation time was obtained for the outflow rates of 0.05 and 0.08 h^{-1}. This indicates that EDP for outflow rate of 0.05 and 0.08 h^{-1} would be estimated from the CPD measured at 8 h.

Regarding EDO, the results of regression analysis obtained for the EDO and OMD pointed out that if outflow rate equals to 0.02 h^{-1}, OMD measurements taken at the end of 16th h of incubation time is enough to estimate the EDO owing to the fact that the determination coefficient, being 94.6% and statistically significant ($p<0.01$). Moreover, the calculated determination coefficients were 91.7 and 94.6% for outflow rates of 0.05 and 0.08 h^{-1}, respectively, which confirmed that EDO can accurately be calculated using the 8th h measurements of OMD ($p<0.01$).

The results of regression analysis indicated that 90% of variation in EDDM, which is a satisfactory amount can be elucidated by the DMD measurements of 16th h, which states that EDDM for the outflow rate of 0.02 h^{-1} can be estimated from the DMD measurements taken at the end of 16 h ($p<0.01$). In addition, the fact that the strongest relationship between EDDM and DMD measured at the end of 8 h incubation time was attained for the outflow rates of 0.05 and 0.08 h^{-1}, which confirmed that EDDM would be explained by DMD measured at the end of 8 h incubation time.

The linear models built in this study would be used to predict EDP, EDO and EDDM in solvent extracted sunflower seed meal. However, before using to predict effective degradability, the models should be validated using the data observed from other studies. If the validation tests show that the models are adequate to calculate EDP, EDO and EDDM in solvent extracted sunflower seed meal, the researcher should keep in mind that effective degradability of nutrients in solvent extracted sunflower seed meal would be calculated by means of the models built in this study.

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