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# Prediction Total Digestible Nutrient value of forage and feedstuffs from their chemical characteristics.

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## ABSTRACT

Total Digestible Nutrient Value of forage and concentrate and nutritional characteristics and develop a prediction equation using the chemical composition variables as predictors.
Nutrient chemical characteristics data were obtained from 278 forage and 87 feedstuffs.

The data included dry matter and organic matter, crude protein, ether extract, ash, fiber composition, and non-fiber Carbohydrate.
Stepwise regression was used to eliminate variables that did not influence variation in the model and used 0.05 as the critical level of probability.
Data were then randomly divided into two parts, two-thirds of the data was used to estimate Total Digestible Nutrient whereas the remaining part was used to validate the estimated Total Digestible Nutrient and was analyzed by multiple linear regressions.

Total Digestible Nutrient in forage was negatively correlated with Ether Extract, Acid Detergent Lignin, and Non-fibre Carbohydrate ($P<0.01$), but positively correlated with Crude Protein ($P<0.01$), ash, Neutral Detergent Fibre, and Acid Detergent Fiber.

Total Digestible Nutrient in feedstuffs was negatively correlated with NFC ($P<0.01$) but positively correlated with Neutral Detergent Fibre ($P<0.01$), Acid Detergent Lignin ($P<0.01$), Ether Extract ($P<0.01$), Crude Protein ($P<0.01$), ash, and Acid Detergent Fiber ($P<0.01$).

The prediction equation of TDN was:

Equation (1)

$TDN_{forage}$= 70.41- (0.546 * Non-fibre Carbohydrate) + (0.453 * Crude Protein) + (0.04* Ether Extract) ± error

Equation (2)

$TDN_{feedstuffs}$= 86.76 – (0.822 * Non-fibre Carbohydrate) + (0.291* Ether Exstract) ± error

The results show that the Total Digestible Nutrient content can be accurately estimated starting from the chemical composition.

**Keywords:** total digestible nutrient; forage; concentrate; feed analysis.

## INTRODUCTION

The available energy in feedstuff represents the largest proportion of the total cost of ruminant production. Furthermore, the improved nutrient utilization efficiency is strongly related to enhanced economic performance and reduced environmental impact of farms.

Provision of energy for livestock is performed through feedstuff and it substantially determines the production level. The main nutrients that contribute to energy are carbohydrates, lipids, and protein[1].

The energy present in feeds is called gross energy (GE) but it does not reflect to which extent the energy is available for animals. To overcome such weaknesses have been developed other energy measures that are digestible energy (DE), metabolizable energy (ME), and net energy (NE).

Another important measurement energy system has been developed: the total digestible nutrient (TDN); its value represents the utilizable energy content of a feedstuff, and it is calculated by[2] equations.

Traditionally, TDN is utilized as the base for estimating the NE content of feedstuff and diets.

For example, TDN levels of concentrates affect average daily gain (ADG) and intramuscular fat deposition of fattening cattle[3]. Therefore, it is an important factor in producing high-quality meat from steers[4]. Improving cow productivity over the past 25 years has also required increased nutrient requirements, making it difficult to meet the demands of high-yielding cows with grazing alone[5-6-7].

In Korea, studies have been undertaken on the shortening of the fattening period and appropriate age of slaughter to reduce feed costs and decrease the production of inedible fat[8-9]. Additionally, studies have been conducted about increasing the TDN level of concentrates to maintain the marbling score while shortening the fattening period have been[10-11]. The papers reported that increasing the TDN levels in concentrate has improved the dry matter (DM) digestibility, energy availability, ADG, and meat quality grade[12-13-14]; however, feeding excessively high TDN concentrate may lead to deposition of inedible fat and cause metabolic diseases[15].

The present study aimed to investigate the relationship between the chemical characteristics of forage and concentrate and develop a prediction equation using the chemical composition variables as predictors.

## MATERIALS AND METHODS

Nutrient chemical characteristics data were obtained from 278 forage and 87 feedstuffs.

The chemical compositions of the experimental feed were analyzed following the standard methods of the[16], neutral detergent fiber (NDF) and Lignin (ADL) were analyzed based on methods describe d by[17] and TDN was analyzed and evaluated following the method described by[2].

Non-fibre Carbohydrate (NFC) is calculated as OM-(NDF+EE+CP).

The chemical composition and nutritional value of the feedstuffs are shown in Table 1.

Table 1 – Summary (means ± standard deviation) of chemical composition (% DM) of forage (n=278) and feedstuffs (n=87) used in the database

| Parameter | Forage | Feedstuffs |
|---|---|---|
| | μ ± SD | μ ± SD |
| DM | 90.24 ± 6.93 | 91.08 ± 2.01 |
| OM | 84.68 ± 4.61 | 86.97 ± 4.77 |
| CP | 10.14 ± 4.28 | 27.55 ± 6.02 |
| EE | 2.07 ± 0.52 | 2.14 ± 0.49 |
| Ash | 8.64 ±2.81 | 4.11 ± 0.84 |
| NDF | 53.04 ± 7.70 | 20.16 ± 9.53 |
| ADL | 4.71 ± 2.18 | 4.03 ± 0.83 |
| NFC | 19.62 ± 7.64 | 37.13 ± 9.98 |
| TDN | 68.33 ± 6.53 | 53.05 ± 10.16 |

μ=means; SD=standard deviation; DM=Dry Matter; OM=Organic Matter; CP=Crude Protein; EE=Ether extracts; NDF=Neutral Detergent Fibre; ADL= Acid Detergent Lignin; NFC=Non-fibre Carbohydrate; TDN=Total Digestible Nutrient

Statistical analysis was performed using[18]. The data were analyzed by multiple linear regressions to evaluate the relationship between TDN and various predictor variables. Stepwise regression was used to eliminate variables that did not influence variation in the model and used 0.05 as the critical level of probability.
The correlation was performed between chemical composition and TDN for both forage and feedstuffs (Tables 2 and 3). The significance was indicated by * and ** for P<0.05, P<0.01, respectively.
Data were then randomly divided into two parts, two-thirds of the data was used to estimate TDN whereas the remaining data was used to validate the estimated TDN.
The standard error of prediction was used to judge the predictive ability of a calibration equation. Equation validation was conducted to assess the predictive ability of the selected calibration equation.
Validation entails the prediction of either an independent set of samples, i.e., from a different population than the calibration set, with known reference values, or removing a certain number of samples from the calibration set, and not using them in the calibration process.

## RESULTS AND DISCUSSION

The study found significant coefficients between forage chemical composition and nutrient digestibility, specifically for CP (0.993 with p<0.01) and NFC (-0.994 with p<0.01).
As far as feed is concerned, the correlation coefficients were significant for all parameters considered, except for dry matter.
The results were as follows: NDF (0.703 p<0.01); ADL (0464 p<0.01); NFC (-0.952 p<0.01); EE (0.657 p<0.01); CP (0.373 p<0.01); ADF (0.685 p<0.01).
Similar results were reported by[19].
High correlation values represent greater agreement but not necessarily greater accuracy for estimating the means.
In Table 2 we report the results of ANOVA for the regression model considered for predicting TDN in forage. Examination of the table shows the goodness of the forecast model chosen, as highlighted by the low value of the residue.

Table 2 - ANOVA for the regression model of forage

| Model | Sum of Squares | Mean Square | F | Sign. |
|---|---|---|---|---|
| Regression | 1102016.880 | 367338.960 | 11209.606 | 0.01 |
| Residue | 8815.134 | 32.770 | | |
| Total | 1110832.014 | | | |

Predictor: NSC, CP, EE; $R^2$=0.992; SE of the Estimate=5.72451

Using NFC, CP, EE may be predicted by the following equation (1):

$$TDN_{forage}=70.41-0.546NFC+0.453CP+0.04EE \pm error \quad (1)$$

Relatively similar coefficients between NFC and CP to estimated TDN in forage confirm the similarity of energetic values between starch and protein[20].

Values of estimated and observed TDN in forage were reported in Figure 1 and indicating the validity of the prediction equation.

In Table 3 we report the result of ANOVA for the regression model considered for predicting TDN in feedstuffs. Examination of the table shows the goodness of the forecast model chosen, as highlighted by the low value of the residue.

Table 3 - ANOVA for the regression model of feedstuffs

| Model | Sum of Squares | Mean Square | F | Sign. |
|---|---|---|---|---|
| Regression | 14484.606 | 7242.303 | 1537.248 | 0.01 |
| Residue | 395.742 | 4.711 | | |
| Total | 14880.348 | | | |

predictor: NFC, EE; $R^2$=0.987; SE of the Estimate=2.17053

Using NFC and EE may be predicted by the following equation (2):

$$TDN_{feedstuffs}=86.76-0.822NFC+0.291EE \pm error \quad (2)$$

These prediction equations were quite accurate as indicated by the high values of $R^2$. The non-significant correlation of TDN with NDF, for forage and the absence of this parameter in predictive equations may indicate a lower contribution to the energy available for livestock this may be related to the negative effect of NDF, particularly lignocellulose component, on ruminal degradation and total tract digestibility[21-22].

The low EE coefficient, in the prediction equation for both fodder and feedstuffs, is probably linked to the fact that lipids generate less energy than starch and proteins.

This result contrasts with what was reported by[23] in a study carried out on dairy calves.

Values of estimated and observed TDN in feedstuffs were reported in Figure 2, indicating the validity of the prediction equation.

In case you want to estimate the TDM content of a unifeed, as suggested by[24] it is necessary to know exactly the forage/feedstuffs ratio (F:f) to obtain the TDN value of the diet. For example, a unifeed with an Forage: feedstuffs ratio of 60:40, its TDN equation could be (3):

$$TDN_{unifeed} = (0.6\ TDM_{forage}) + (0.4\ TDM_{feedstuffs}) \quad (3)$$

## CONCLUSIONS

The impact of interactions between feed components on TDN is important, and the continuous need to deepen our understanding of energy and metabolism concepts is evident. Building upon this, the results of this preliminary study underscore that the TDN content, whether in forages or feedstuffs, can be precisely estimated based on the chemical composition of the diet-administered foods. This contribution to the field enhances our grasp of the intricate relationships between feed composition and TDN levels, empowering accurate predictions. These findings hold significance as they provide valuable insights for crafting optimal livestock diets, thereby enhancing both economic performance and environmental sustainability within agricultural enterprises.

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