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Artificial Neural Network Model to Predict Crude Protein and Crude Fiber from Physical Properties of Feedstuffs

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Abstract. The aim of this research was to build artificial neural networks model to predict crude protein and crude fiber content from physical properties of feedstuffs. The 91 data were obtained from <https://repository.ipb.ac.id> using keywords, e.g., sifat fisik and pakan. To reduce the dimensional of the data had been transformed. The independent variables consist of specific gravity (SG), bulk density (BD), compacted bulk density (CBD) and angle of repose (AoR). The dependent variable was crude protein (CP) and crude fiber (CF). Artificial neural networks (ANN) model built by R programming language 3.6.0 using library R-base and neuralnet. The correlation and accuracy used to compare predicted and actual. ANN model of crude fiber has an accuracy of 75.08% and Pearson's signification correlation (0.7529; P <0.01). ANN model of crude protein has an accuracy of 75.08% and Pearson's signification correlation (0.7529; P <0.01). The artificial neural networks model generally can perform better to predict crude protein and crude fiber from physical properties of feedstuffs.

Keywords: artificial neural networks model, crude fiber, crude protein, physical properties, feedstuffs.

1. Introduction

Fluctuate the database of several feedstuffs due to extreme environmental change, increasing of a large number of feedstuffs database (especially, in physical and chemical properties), and non-linear interaction on each parameter. They will become crowded and wasted if not be defined the knowledge in it. Using computation technique may proper for this due to these problems. Computation techniques, such response surface modelling and artificial neural networks, are used increasingly in feed science because they are the robust, accurate, and flexible technique for prediction analysis.[1] These techniques have been used for optimizing of antibacterial activity extraction process from *Hermetia illucens*. [2] Artificial neural networks have been used for the prediction of nutritional requirements of digestible lysine, methionine, and threonine in broiler chicks. [3] ANN has been developed as a model that mimics the nervous system. ANN is mainly used in solving difficult problems. [4] ANN properties for learning from database patterns make it a powerful program based



on incomplete domain compilation or compilation of partial inaccuracies or conflicting data.[4] The objective of this research was to build artificial neural networks model to predict crude protein and crude fiber content from physical properties of feedstuffs and validate it using correlation and accuracy value.

2. Materials and Methods

Collecting and Transforming Data

A total of 91 data were obtained from <https://repository.ipb.ac.id> database using keywords, e.g., *sifat fisik* and *pakan*. The data included specific gravity (SG), bulk density (BD), compacted bulk density (CBD), angle of repose (AoR), crude protein (CP), and crude fiber (CF). CP and CF converted in 100% dry matter (DM). The summary database is presented in **Table 1**.

Table 1. Summary database of physical properties, crude protein, and crude fiber of feedstuffs (n = 91).

Parameter	Feedstuffs		
Specific gravity (kg/m ³)	1.2427	±	0.2184
Bulk density (kg/m ³)	0.3950	±	0.1425
Compacted bulk density (kg/m ³)	0.5350	±	0.1336
Angle of repose (°)	36.7012	±	6.4289
Crude protein (%DM)	18.1645	±	10.0826
Crude fiber (%DM)	15.2704	±	9.1858

DM, dry matter.

Then, data was split into data train (75%, n = 69) and data test (25%, n = 22). After that, the data train and data test were normalize using minimum and maximum transformation. The data transformation formula is as follows.

$$x' = (x - \min(x)) \div (\max(x) - \min(x)),$$

where x = initial value; x' = transformed value; max(x) = maximum value; min(x) = minimum value.

Build, Fitting, and Validate Model

The artificial neural networks model was built on R-base 3.6.0 programming language and used "library(neuralnet)".[5, 6] Four input parameter consists of SG, BD, CBD, and AoR perform the ANN model. Four hidden layers (hly), which are hly1 (n = 40), hly2 (n = 15), hly3 (n = 9), and hly4 (n = 3) to build ANN model of predicted CP content of feedstuffs. While ANN model of predicted CF content of feedstuffs used three hidden layers, there are hly 1 (n = 3), hly2 (n = 15), and hly3 (n = 6). The four and three hidden layers of ANN model follows this formula,

$$CP(x) = w_0 + \sum_{l=0}^L w_l \cdot f \left(w_{0l} + \sum_{k=0}^K w_{kl} \cdot f \left(w_{0k} + \sum_{j=0}^J w_{jk} \cdot f \left(w_{0j} + \sum_{i=0}^I w_{ijk} \cdot x_i \right) \right) \right),$$

$$CF(x) = w_0 + \sum_{k=0}^K w_k \cdot f \left(w_{0k} + \sum_{j=0}^J w_{jk} \cdot f \left(w_{0j} + \sum_{i=0}^I w_{ijk} \cdot x_i \right) \right),$$

where w_0 denotes the intercept of the output neuron and w_{0l} the intercept of the 1th hidden neuron. Additionally, w_1 denotes the synaptic weight corresponding to the synapse starting at the 1th hidden neuron and leading to the output neuron, $w_1 = (w_{11}, \dots, w_{1n})$ the vector of all synaptic weights corresponding to the synapses leading to the 1th hidden neuron, and $x = (x_1, \dots, x_n)$ the vector of all covariates [6].

The fitting plot used to compare predicted and actual value. Validation of the ANN model has used Pearson correlation and accuracy value. Pearson correlation significance marked as ns, *, and ** for $P > 0.05$, $P < 0.05$, and $P < 0.01$, respectively.

3. Results and Discussion

Physical properties of feedstuffs, e.g, specific gravity, bulk density, compacted bulk density, and angle of repose can affect chemical properties, e.g, dry matter, organic matter, crude protein, crude fibre, and ether extract. Increase of specific gravity may increase quality of feedstuffs, especially crude protein and starch. Beside that lower specific gravity cause decrease feedstuffs and increase crude fibre content.

Table 2. Validation of artificial neural networks model of feedstuffs (n = 22).

Validation	Crude protein	Crude fiber
Accuracy	0.8315	0.7508
Correlation	0.7112**	0.7529**

ns, $P > 0.05$; *, $P < 0.05$; **, $P < 0.01$.

ANN model validation of crude protein and crude fiber using accuracy and Pearson's correlation values are present in **Table 3**. ANN model of crude protein has an accuracy of 83.15% in predicting the correct output. Pearson's significance correlation (0.7112; $P < 0.01$) of the crude protein ANN model, this states that there is a strong relationship between predictive value and actual value. ANN model of crude fiber has an accuracy of 75.08% in predicting the correct output. Pearson's signification correlation (0.7529; $P < 0.01$), this states that there is a strong relationship between predictive value and actual value.

ANN model of crude protein with four hidden layers (40, 15, 9, 3) has a positive correlation (Figure 1). Pearson correlation value, between predictions and actual 0.7112, this means there is a strong relationship between the two variables. This model can be used to estimate crude protein content of feedstuffs.

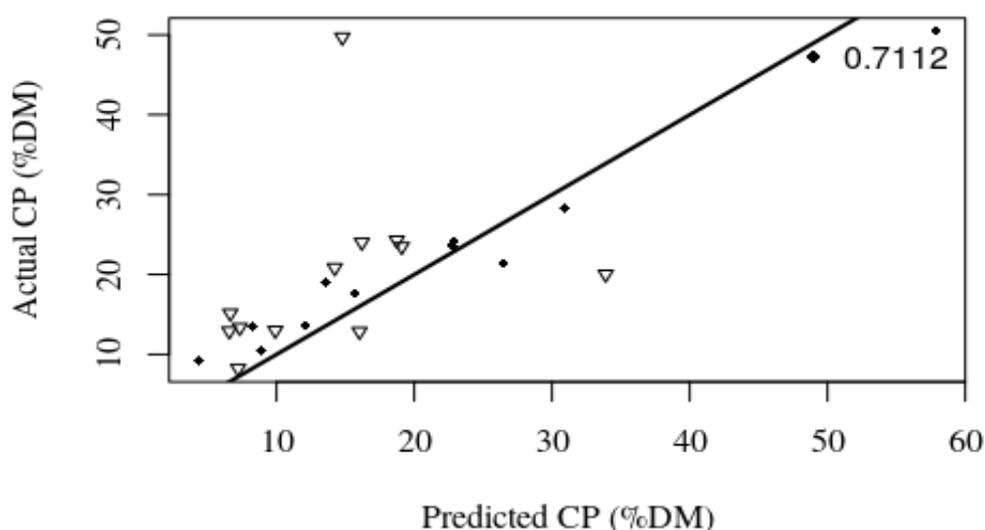


Figure 1. Plot between predicted (▽) and actual (◆) crude protein (CP) content of feedstuffs.

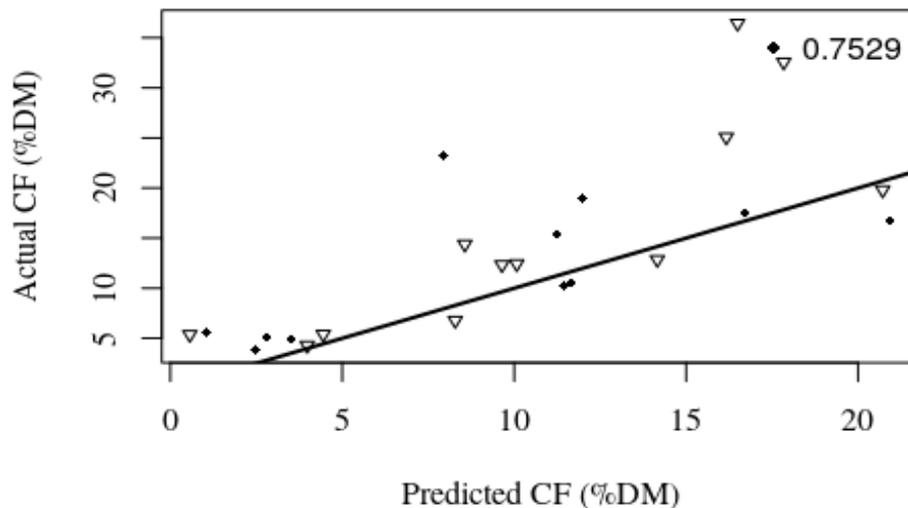


Figure 2. Plot between predicted (▽) and actual (◆) crude fiber (CF) content of feedstuffs.

ANN model of crude fiber with three hidden layers (3, 15, 6) has a positive correlation (**Figure 2**). Pearson correlation value, between predictions and actual 0.7529, this means there is a strong relationship between the two variables. This model can be used to estimate crude fiber content of feedstuffs.

4. Conclusions

The artificial neural networks model generally can perform better to predict crude protein and crude fiber from physical properties of feedstuffs.

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