Model test on the relationship feed energy and protein ratio to the production and quality of milk protein

R Hartanto*, M A C Jantra, S A B Santosa and A Purnomoadi
Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang 50275, Indonesia

*Corresponding author’s e-mail: rudyharta@gmail.com

Abstract. The purpose of this research was to find an appropriate relationship model between the feed energy and protein ratio with the amount of production and quality of milk proteins. This research was conducted at Getasan Sub-district, Semarang Regency, Central Java Province, Indonesia using 40 samples (Holstein Friesian cattle, lactation period II-III and lactation month 3-4). Data were analyzed using linear and quadratic regressions, to predict the production and quality of milk protein from feed energy and protein ratio that describe the diet. The significance of model was tested using analysis of variance. Coefficient of determination (R²), residual variance (RV) and root mean square prediction error (RMSPE) were reported for the developed equations as an indicator of the goodness of model fit. The results showed no relationship in milk protein (kg), milk casein (%), milk casein (kg) and milk urea N (mg/dl) as function of CP/TDN. The significant relationship was observed in milk production (L or kg) and milk protein (%) as function of CP/TDN, both in linear and quadratic models. In addition, a quadratic change in milk production (L) (P = 0.003), milk production (kg) (P = 0.003) and milk protein concentration (%) (P = 0.026) were observed with increase of CP/TDN. It can be concluded that quadratic equation was the good fitting model for this research, because quadratic equation has larger R², smaller RV and smaller RMSPE than those of linear equation. Keywords: feed energy and protein ratio, milk production, milk protein, regression

1. Introduction

Milk is a nutritious food that has high nutritive value, because it contains a plenty of nutritional substances and fulfills the needs of the human body. It is important for breeders to grow their dairy cows producing high quality and large amount of milk. The quality of milk is a reflection of the quality of feed given. The composition of nutrients present in animal feed will affect the production and composition of milk. High-performance lactation dairy cattle require adequate energy and protein intake to meet production needs in terms of both quality and quantity [1, 2, 3]. Protein feed has a very important role in the synthesis of milk components (protein, lactose and milk fat) [4]. Protein content in milk is one of important measurements of milk quality. INS stated that good fresh milk contains at least 2.8% protein [5].

The consumption of protein from the diet affects the amount of production and quality of milk proteins. Milk protein production is the result of multiplication of milk protein concentration with the amount of milk production [6]. There was a significant positive linear relationship between the consumption of crude diet protein and milk protein concentration, therefore higher consumption of
protein will cause higher milk protein content [4]. Dairy cows including livestock are efficient in the use of food energy into milk energy [2]. Because of the principle of dairy cattle production is energy storage in milk, the lack of energy in the ration will result in decreasing milk production [7]. Protein synthesis is also influenced by the energy content of feed, because the synthesis of milk protein cannot optimally occur unless adequate energy is provided in the body [1]. Therefore it is reasonable to suspect the relationship between the feed energy and protein ratio with the amount of production and quality of milk proteins. Until now there is no clear information about it. Based on these facts, this research will be conducted using a survey method at the farmer level to collect the data needed to find an appropriate relationship model between the feed energy and protein ratio with the amount of production and quality of milk proteins.

2. Materials and Methods

2.1. Database

This research was conducted at Getasan Sub-district, Semarang Regency, Central Java Province, Indonesia using 40 samples (Holstein Friesian cattle, lactation period II-III and lactation month 3-4). Purposive sampling was used to determine the location of farms that spread in 4 villages. The data were collected based on the amount of feeding, feed consumption and milk production for each cattle during 5 days. Feed samples were analyzed proximate to determine the content of feed ingredients which later to calculate the feed energy and protein ratio (CP/TDN) based on data of feed consumption. On the fifth day, 200 ml of milk samples from each cattle were obtained for the analysis of protein, casein and milk urea nitrogen (MUN) according to AOAC [8].

2.2. Statistical Analyses

Data were analyzed with regression analysis including linear and quadratic models using SPSS software. The feed energy and protein ratio was independent variable (X); the milk content of protein, casein and MUN were dependent variables (Y). Coefficient of determination (R²), P-value and Residual variance (RV) values were reported for the developed equations as an indicator of the goodness of model fit [9]. Mean square prediction error (MSPE) was also reported for the developed models and the evaluated extant models, calculated as:

$$\text{MSPE} = \frac{1}{n} \sum_{i=1}^{n} (O_i - P_i)^2$$

Where Oi is the observed value, and Pi is the predicted value. An estimate of the overall prediction error prediction by square root of the MSPE (RMSPE), expressed as a proportion of the observed mean [10].

3. Results

The equations of linear and quadratic models are shown in Table 1. P-value showed that the significant relationship was observed in milk production (L or kg) and milk protein quality (%) as a function of CP/TDN, on linear and quadratic model. Other relationships were not significant (P ≥ 0.082). Increased feed energy and protein ratio did not affect (P < 0.05) in a quadratic increase in milk production (L or kg) and in a quadratic decrease in milk protein quality (%).

4. Discussion
In our research, a quadratic model was the best model for prediction milk production and milk protein content as a function of CP/TDN ratio, because a quadratic model has shown larger $R^2$, smaller RV and smaller RMSPE than those of linear equation [9, 10], as shown in Table 1. In quadratic model for milk production, the cusp of the curve was on $X = 0.24$ and $Y = 13.84$ kg. Milk production has good correlation with consumption of the feed energy and protein ratio. The contents of energy and protein in ration have positive effect on milk production [1, 7]. The nutrient requirement of dairy cows increases with milk production, where high production of milk requires high energy and protein diets [3]. The utilization of nitrogen and energy in the rumen for milk production on dairy cows was influenced by the source of dietary crude protein (CP) and energy fed [2, 6]. In other studies, they reported that the balanced intake of energy and protein with rumen undegraded protein supplementation in early lactating dairy cows didn’t impact on milk production but may increase the amount of protein in the small intestine and finally could impact on milk protein concentration and production [6].

The ratio of protein and energy availability for milk production influenced milk protein production efficiency [11, 12]. Besides, the stage of lactation period and level of milk production also influenced it [6]. The low energy and high protein content in the ration caused low protein efficiency [13]. Although most research suggested that milk production is improved by increasing CP intake, and increasing energy intake increased both concentration and production of milk protein [14], the present research showed that only concentration of milk protein was influenced by CP/TDN and production of milk protein, milk casein and MUN were not affected. This can explain that decrease of concentration of milk protein and increase of milk production by increasing CP/TDN intake lead no no effect on production of protein, casein, MUN. In this quadratic model for concentration of milk protein, the turning point of the curve was on $X = 0.23$ and $Y = 1.50\%$.

5. Conclusions

Quadratic model can explain well the protein content and milk production as a function of CP/TDN. Especially, this analysis method in local farm has great merit to improve dairy milk production. Based on the result of research, it can be concluded that quadratic equation was the good fitting model for prediction milk production and milk protein content in this research, because of larger $R^2$, smaller RV and smaller RMSPE than those of linear equation.

Acknowledgments

This work was supported by the “Hibah Penelitian FPP UNDIP, No. 84/UN7.5.5/PP/2017” Faculty of Animal and Agricultural Sciences, Diponegoro University.

References

[1] Bath D L, Dickinson F N, Tucker H A and Appleman R D 1985 Dairy Cattle : Principles, Practices, Problem, Profits 3th Ed (Philadelphia: Lea Febiger)
[2] McDonald P, Edwards R A, Greenhalg J F D and Morgan C A 2011 Animal Nutrition 7th Ed (London: Prentice Hall Inc.)
[3] NRC 2001 Nutrient Requirements of Dairy Cattle 7th Ed (Washington D C: National Academic Science)
[4] Syafri A, Harjanti D W and Santoso S A B 2014 Animal Agriculture Journal 3(3): 450-456
[5] Indonesian National Standard 2011 INS No. 3141.1:2011 about Milk Fresh (Jakarta: National Standardization Agency of Indonesia)
[6] Widyobroto BP, Rochijan, Ismaya, Adiarto and Suranindyah Y Y 2016 J. Indonesian Trop. Anim. Agric.41(2):83-90
[7] Musnandar, E 2011 J. Penelitian Universitas Jambi Seri Sains 13(2): 53-58
[8] AOAC 2006 *Methods of Analyses* 16th Ed (Rockville: Publ, AOAC)  
[9] Gordeyase Mas I K, Hartanto R and Prastiwi W D 2007 *J. Pengembangan Peternakan Tropis.* 32(4): 285 – 292  
[10] Ellis J L, et al. 2009 *J. Anim. Sci.* 87: 1334-1345  
[11] Mahr-un-Nisa, Javaid A, Aasif Shahzad M and Sarwar M 2008 *Asian-Aust. J. Anim. Sci.* 21: 1303-1311  
[12] Santos F A P, Santos J E P, Theurer C B and Huber J T 1998 *J. Dairy Sci.* 81: 3182-3213  
[13] Widyobroto B P, Budhi S P S and Agus A 2010 *J. Indonesian Trop. Anim. Agric.* 35(1): 27-33  
[14] DePeters E J and Cant J P 1992 *J. Dairy Sci.* 75: 2043-2070
Table 1. Summary and evaluation of linear and quadratic equations developed

| Variable | Equation | P-Value | R     | R²   | RV   | RMSPE (%) |
|----------|----------|---------|-------|------|------|------------|
| Milk Production (L) (Y) and CP/TDN (X) | Linear: \( Y = 134.100 \ X - 15.456 \) | 0.001  | 0.518 | 0.268 | 4.778 | 22.713     |
|         | Quadratic: \( Y = 589.666 \ X - 1222.966 \ X^2 - 57.765 \) | 0.003  | 0.520 | 0.271 | 4.760 | 22.671     |
| Milk Production (Kg) (Y) and CP/TDN (X) | Linear: \( Y = 139.464 \ X - 16.074 \) | 0.001  | 0.518 | 0.268 | 5.168 | 22.713     |
|         | Quadratic: \( Y = 589.666 \ X - 1222.966 \ X^2 - 57.765 \) | 0.003  | 0.520 | 0.271 | 4.760 | 22.671     |
| Milk Protein (%) (Y) and CP/TDN (X) | Linear: \( Y = 9.038 - 35.862 \ X \) | 0.007  | 0.420 | 0.176 | 0.584 | 31.937     |
|         | Quadratic: \( Y = 15.961 X - 43.971 X^2 - 1.216 \) | 0.903  | 0.074 | 0.005 | 0.007 | 3.540      |
| Milk Protein (Kg) (Y) and CP/TDN (X) | Linear: \( Y = 0.305 - 0.418 \ X \) | 0.766  | 0.494 | 0.002 | 0.007 | 3.545      |
|         | Quadratic: \( Y = 15.961 X - 43.971 X^2 - 1.216 \) | 0.903  | 0.074 | 0.005 | 0.007 | 3.540      |
| Milk Casein (%) (Y) and CP/TDN (X) | Linear: \( Y = 1.300 + 0.137 \ X \) | 0.986  | 0.003 | 0.000 | 0.212 | 34.283     |
|         | Quadratic: \( Y = 15.961 X - 43.971 X^2 - 1.216 \) | 0.903  | 0.074 | 0.005 | 0.007 | 3.540      |
| Milk Casein (Kg) (Y) and CP/TDN (X) | Linear: \( Y = 1.583 X - 0.164 \) | 0.082  | 0.279 | 0.078 | 0.003 | 4.008      |
|         | Quadratic: \( Y = 30.100 X - 76.554 X^2 - 2.813 \) | 0.144  | 0.315 | 0.099 | 0.003 | 3.961      |
| Milk Urea N (mg/dl) (Y) and CP/TDN (X) | Linear: \( Y = 10.009 - 15.773 \ X \) | 0.339  | 0.155 | 0.024 | 0.982 | 13.833     |
|         | Quadratic: \( Y = 25.806 X - 111.617 X^2 + 6.148 \) | 0.636  | 0.156 | 0.024 | 0.982 | 13.832     |