Model test on the relationship crude fiber consumption to the production of milk fat on dairy cattle in Kudus Regency

Rudy Hartanto, Andhika Ragil Saputra, Eko Pangestu, Suranto Moch Sayuthi

Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang 50275, Indonesia

E-mail: rudyharta@gmail.com

Abstract. This research was completed at PT. Moeria, Kudus Regency, Central Java Province, Indonesia using 35 samples (Holstein Friesian cattle, lactation period II-III and lactation month 5-9). The observational method was used in this study. Data obtained were analyzed using linear and quadratic regressions, to predict the production and quality of milk fat from crude fiber (CF) consumption that describe the diet. Analysis of variance was used to test the significance of model, then used root mean square prediction error (RMSPE), residual variance (RV) and coefficient of determination (R²) to developed equations as an indicator of the goodness of model fit. The result showed that no relationship between milk fat concentration (%) with CF consumption as predictor. There were significant relationship on between milk production (kg); milk fat production (kg) with CF consumption as predictor, on linear and quadratic model. In addition, a quadratic change in milk production (kg) (P = 0.050) and milk fat production (kg) (P = 0.044) were observed with changed CF consumption; whereas the quadratic equation has smaller RV, smaller RMSPE and bigger R² than linear equation. It was concluded that the model fit for this research was quadratic equation.

1. Introduction

Kudus Regency is one of the big regency in Central Java Province, Indonesia. Production of milk in Central Java Province is around 98,860 ton/year or 11.67% of milk production in Indonesia, the third position after West Java Province and East Java Province [1]. The same with other place, milk production and milk quality including milk fat production was affected by the quality of feed given. Feed nutrient especially crude fiber has effect on production and quality of milk [2, 3]. In rumen, crude fiber as a part of carbohydrate will be degradation by rumen microbes to volatile fatty acids (acetate, propionate and butyrate) that is substrate for milk biosynthesis. Acetate is use for milk fat biosynthesis especially short chain fatty acids that around 50% of milk fat [4, 5, 6]. Forage is important for dairy cattle. Crude fiber from high quality grass have good digestibility, then feed with more crude fiber content will producing more proportion of acetate and butyrate. The grass intake will lead to produce more acetic acid and make the value of Acetate/Propionate ratio higher [7, 8, 9]. The ration with the low fiber will decrease fat milk. The increasing in milk production was in line with decreasing of milk fat concentration [10]. It is reasonable to suspect relationships between the crude fiber consumption with the production and quality of milk fat. Therefore this research will be conducted to find the model fit for those relationships.
2. Materials and methods

2.1. Database
This research was completed at PT Moeria, Kudus Regency, Central Java Province, Indonesia using 35 samples (Holstein Friesian cattle, lactation period II-III and lactation month 5-9). The observational method was used in this study. The data were collected for 7 days for each cattle, including the amount of feeding, feed consumption, milk production. Feed samples were analyzed proximate to determine the content of feed ingredients especially crude fiber to calculate crude fiber consumption [11]. On the 7th day, 200 ml of milk samples from each cattle were obtained for the analysis of density and milk fat concentration using Lactoscan. The production of milk fat was calculated from (concentration of milk fat) x (milk production) [12].

2.2. Statistical analyses
Data were analyzed with regression analysis including linear and quadratic models using SPSS software. The crude fiber consumption was independent variable (X); milk production and milk fat were dependent variables (Y). Analysis of variance was used to test the significance of model, then used root mean square prediction error (RMSPE), residual variance (RV) and coefficient of determination (R²) to developed equations as an indicator of the goodness of model fit [3]. RMSPE calculated as:

\[ \text{MSPE} = \sum_{i=1}^{n} (O_i - P_i)^2 / n \]

Where \( O_i \) is the observed value, and \( P_i \) is the predicted value. Square root of the MSPE (RMSPE) is an estimate of the overall prediction error prediction, then expressed as a proportion of the observed mean [13].

3. Results
The equations of linear and quadratic models are shown in table 1. P-value showed that the significant relationship (\( P \leq 0.05 \)) were found on between milk productions (kg); milk fat production (kg) with CF consumption (kg) as predictor, both on linear and quadratic model. In addition, the relationship between CF consumption and milk fat concentration (%) was not significant, both on linear and quadratic (\( P \geq 0.298 \)). Changed CF consumption (kg) was affected (\( P \leq 0.05 \)) in a quadratic increase on milk production (kg) and in a quadratic increase on milk fat production (kg).

4. Discussion
In this research, a quadratic model was the best model for prediction milk production and milk protein content by CF consumption, because has bigger R², smaller RV and RMSPE than linear equation [3, 13], shown in table 1. In quadratic model for milk production, the turning point of the curve was on \( X = 2.38 \) kg and \( Y = 6.68 \) kg. It’s mean that after CF consumption more than 2.38 kg will have positive effect on milk production. The feed consumption including CF consumption has positive effect on milk production, and the nutrient requirement of dairy cattle increases with milk production [6, 14]. Production and composition of milk varies with nutrients intake that is influenced by blood flow and utilization of nutrients by mammary gland [15].The ration with produce more high in acetate/propionate ratio will produce more high in milk production [12].

The CF consumption have not significant relationship with milk fat concentration, but significant with milk fat production on linier and quadratic. In this quadratic model, the turning point of the curve was on \( X = -1.05 \) kg and \( Y = -0.212 \) kg. It’s mean that if dairy cattle consume CF will have positive effect on milk fat production. This happens because acetate and butyrate from degradation CF in rumen by microbes is precursor for milk fat biosynthesis [4, 6].The milk fat production and milk fatty
acid profile responds rapidly and is very sensitive to changes in diet [14]. The increasing fiber digestibility is in line with increasing of acetate/propionate ratio or acetate production [16]. The ration with produce more high in acetate/propionate ratio will produce more high in production and quality of milk fat [12]. So that’s mean CF from high quality forage is very important in dairy cattle diet.

5. Conclusions
There are relationships between milk production and milk fat production with crude fiber consumption as predictor. The model fit was quadratic equation because has bigger $R^2$, smaller RV and RMSPE than linear equation.

References
[1] Pusat Data dan Sistem Informasi Pertanian 2016 Outlook Milk (Susu) (Jakarta: Indonesian Ministry of Agriculture)
[2] Bath D L, Dickinson F N, Tucker H A and Appleman R D 1985 Dairy Cattle : Principles, Practices, Problem, Profits 3rd Ed (Philadelphia: Lea Febiger)
[3] Hartanto R, Jantra MAC, Santosa SAB and Purnomoadi A 2018 IOP Conf. Ser.: Earth Environ. Sci. 102:012053
[4] Larson and Smith 1978 Lactation (New York: Academic Press)
[5] McDonald P, Edwards R A, Greenhalg J F D and Morgan C A 2011 Animal Nutrition 7th Ed (London: Prentice Hall Inc.)
[6] Schmidt GH, van Vleck LD and Hutjens MF 1988 Principles of Dairy Sciences 2nd Ed (New Jersey: Prentice Hall Inc.)
[7] Moran and Chamberlain 2017 Increasing Domestic Milk Production in Developing Countries (Clayton South: CSIRO Publishing)
[8] Suharlina, Astuti DA, Nahrowi, Jayanegara A and Abdullah L 2016 J. Indonesian Trop. Anim. Agric. 36(3):213-218
[9] Umar M, Arifin M and Purnomoadi A 2011 J. Indonesian Trop. Anim. Agric. 41(2):83-90
[10] AOAC 2006 Methods of Analyses 16th Ed (Rockville: Publ, AOAC)
[11] Poorkasegaran S and Yansari AT 2014 J. Anim. Sci. Biotechnol. 5:6.
[12] Ellis J L, et al. 2009 J. Anim. Sci. 87:1334-1345
[13] Schwendel BH, Wester TJ, More PCH, Tavendale MH et al. 2016 J. Dairy Sci.98:721–746
[14] Kume S and Tanabe S 1993 J. Dairy Sci. 76:1654-1660.
[15] Weimer PJ, Stevenson DM, Mertens DR and Hall MB 2011 Anim. Feed Sci. Technol. 169:68–78
Table 1. Summary and evaluation of linear and quadratic equations developed on relationship between CF consumption with milk production, milk fat concentration and milk fat production

| Variable | Equation | P-Value | R   | R²   | RV  | RMSPE (%) |
|----------|----------|---------|------|------|-----|-----------|
| Milk Production (Kg) (Y) and CF Consumption (X) | | | | | | |
| - Linear | Y = 8.224 X - 16.404 | 0.014 | 0.411 | 0.169 | 11.389 | 31.454 |
| - Quadratic | Y = -22.126 X + 4.643 X² + 33.040 | 0.050 | 0.414 | 0.171 | 11.358 | 31.410 |
| Milk Fat Concentration (%) (Y) and CF Consumption (X) | | | | | | |
| - Linear | Y = -0.616 X + 6.719 | 0.298 | 0.181 | 0.033 | 0.382 | 12.971 |
| - Quadratic | Y = 15.570 X - 2.476 X² - 19.650 | 0.399 | 0.236 | 0.056 | 0.373 | 12.816 |
| Milk Fat Production (Kg) (Y) and CF Consumption (X) | | | | | | |
| - Linear | Y = 0.318 X - 0.562 | 0.012 | 0.420 | 0.177 | 0.016 | 25.903 |
| - Quadratic | Y = 0.078 X + 0.037 X² - 0.171 | 0.044 | 0.421 | 0.178 | 0.016 | 25.903 |

* CF = Crude Fiber, R = Coefficient of Correlation, R² = Coefficient of Determination, RV = Residual Variance, RMSPE = Root Mean Square Prediction Error