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Short communication

The use of artificial neural network for modeling *in vitro* rumen methane production using the CNCPS carbohydrate fractions as dietary variables

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ABSTRACT

The objective of this trial was to investigate the suitability and accuracy of modeling the rumen methane production of mixed rations for cattle using artificial neural network (ANN). The three layer back propagation neural network (BP) which included the input, the hidden and the output layers, was used for modeling. Two datasets used in the trial were from Dong and Zhao (2013). The first dataset which contained the CH_4, CO_2 and total gas production and the Cornell Net Carbohydrate and Protein System (CNCPS) carbohydrate fractions of forty-five rations was for training the BP model and the second dataset which contained ten rations was for testing the BP model. The predicting performances of the BP models with different number of neurons in the hidden layer and different number of variables in the output layer were compared, and the effective BP models were established. Paired *t*-test showed that no difference was found between the observed and the predicted CH_4, CO_2 and total gas production based on the BP models ($p > 0.05$). Model performance analysis based on the test data showed the root mean square prediction errors (RMSPE%) were 3.89%, 2.95% and 4.23%, and the determination coefficients (r^2) between the observed and the predicted values were 0.95, 0.97 and 0.92 for CH_4, CO_2 and total gas, respectively. Testing of the BP models indicated that the *in vitro* CH_4, CO_2 and total gas production of mixed rations for cattle could be reliably and accurately predicted based on the CNCPS carbohydrate fractions using BP models. The BP models showed similar accuracy with the multiple regression model for predicting the CH_4 production and better accuracy for predicting the CO_2 and the total gas production than the multiple regression models.

1. Introduction

Anaerobic fermentation of dietary carbohydrates in the digestive tract of ruminants produces about 80 million tons of CH_4 annually which accounts for about 28% of anthropogenic emissions (Beauchemin et al., 2008). High-producing dairy cows produce up to 128 kg CH_4 and other cattle 53 kg CH_4 per head annually (IPCC, 2006). In recent years, there has been growing attention with regards to greenhouse gases for their potential effect on the global warming and climate change. Modeling and accurate predicting the CH_4 emission from enteric fermentation of ruminants are the basis to find strategies to mitigate the CH_4 emission and therefore become more and more important in the field of ruminant nutrition.

During past decades, quite a few types of models, including the linear regression models (Holter and Young, 1992; Moe and Tyrrell, 1979), the nonlinear regression models (Blaxter and Clapperton, 1965; Mills et al., 2003) and the dynamic mechanistic models (Dijkstra et al., 1992) *etc.*, were proposed for predicting the CH_4 production from ruminants. These models successfully modeled the CH_4 production from

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Table 1
The components of rations for modeling (%, air dry basis).

Ration no.	Corn	Soybean meal	Wheat bran	Cottonseed meal	Rapeseed meal	DDGS	Wheat middlings	Rice straw	Corn stover	Corn silage	Wheat straw	Millet straw	Chinese wildrye	Concentrate/ forage ratio
1	28.5	11.5	10.0	–	–	–	–	50	–	–	–	–	–	50:50
2	22.8	9.2	8.0	–	–	–	–	60	–	–	–	–	–	40:60
3	17.1	6.9	6.0	–	–	–	–	70	–	–	–	–	–	30:70
4	11.4	4.6	4.0	–	–	–	–	80	–	–	–	–	–	20:80
5	28.5	11.5	10.0	–	–	–	–	–	–	25	–	25	–	50:50
6	22.8	9.2	8.0	–	–	–	–	–	–	39	–	21	–	40:60
7	17.1	6.9	6.0	–	–	–	–	–	–	56	–	14	–	30:70
8	5.7	2.3	2.0	–	–	–	–	–	–	45	–	45	–	10:90
9	27.5	–	9.5	13.0	–	–	–	–	50	–	–	–	–	50:50
10	22.0	–	7.6	10.4	–	–	–	–	60	–	–	–	–	40:60
11	11.0	–	3.8	5.2	–	–	–	–	80	–	–	–	–	20:80
12	5.5	–	1.9	2.6	–	–	–	–	90	–	–	–	–	10:90
13	26.5	7.5	9.5	–	6.5	–	–	–	–	50	–	–	–	50:50
14	15.9	4.5	5.7	–	3.9	–	–	–	–	70	–	–	–	30:70
15	10.6	3.0	3.8	–	2.6	–	–	–	–	80	–	–	–	20:80
16	5.3	1.5	1.9	–	1.3	–	–	–	–	90	–	–	–	10:90
17	18.8	6.0	6.0	4.0	–	2.4	2.8	–	–	–	–	–	60	40:60
18	14.1	4.5	4.5	3.0	–	1.8	2.1	–	–	–	–	–	70	30:70
19	9.4	3.0	3.0	2.0	–	1.2	1.4	–	–	–	–	–	80	20:80
20	4.7	1.5	1.5	1.0	–	0.6	0.7	–	–	–	–	–	90	10:90
21	23.5	7.5	7.5	5.0	–	3.0	3.5	–	25	–	25	–	–	50:50
22	18.8	6.0	6.0	4.0	–	2.4	2.8	–	39	–	21	–	–	40:60
23	14.1	4.5	4.5	3.0	–	1.8	2.1	–	56	–	14	–	–	30:70
24	9.4	3.0	3.0	2.0	–	1.2	1.4	–	60	–	20	–	–	20:80
25	26.0	–	9.0	7.5	7.5	–	–	–	–	–	–	50	–	50:50
26	20.8	–	7.2	6.0	6.0	–	–	–	–	–	–	60	–	40:60
27	15.6	–	5.4	4.5	4.5	–	–	–	–	–	–	70	–	30:70
28	5.2	–	1.8	1.5	1.5	–	–	–	–	–	–	90	–	10:90
29	26.0	–	9.0	7.5	7.5	–	–	–	–	–	25	25	–	50:50
30	20.8	–	7.2	6.0	6.0	–	–	–	–	–	39	21	–	40:60
31	10.4	–	3.6	3.0	3.0	–	–	–	–	–	60	20	–	20:80
32	5.2	–	1.8	1.5	1.5	–	–	–	–	–	45	45	–	10:90
33	25.0	7.5	8.5	5.0	4.0	–	–	–	–	–	50	–	–	50:50
34	15.0	4.5	5.1	3.0	2.4	–	–	–	–	–	70	–	–	30:70
35	10.0	3.0	3.4	2.0	1.6	–	–	–	–	–	80	–	–	20:80
36	5.0	1.5	1.7	1.0	0.8	–	–	–	–	–	90	–	–	10:90
37	20.0	6.0	6.8	4.0	3.2	–	–	–	–	20	30	–	10	40:60
38	15.0	4.5	5.1	3.0	2.4	–	–	–	–	35	21	–	14	30:70
39	10.0	3.0	3.4	2.0	1.6	–	–	–	–	52	14	–	14	20:80
40	5.0	1.5	1.7	1.0	0.8	–	–	–	–	30	30	–	30	10:90
41	27.0	–	8.0	–	15.0	–	–	–	25	–	25	–	–	50:50
42	21.6	–	6.4	–	12.0	–	–	–	39	–	21	–	–	40:60
43	16.2	–	4.8	–	9.0	–	–	–	56	–	14	–	–	30:70
44	10.8	–	3.2	–	6.0	–	–	–	60	–	20	–	–	20:80
45	5.4	–	1.6	–	3.0	–	–	–	45	–	45	–	–	10:90

Dong and Zhao, 2013. DDGS refers to dried distiller's grains with solubles.