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Original article

Evaluation of some commercial dairy rations in terms of chemical composition, methane production, net energy and organic matter digestibility

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Summary. The aim of the present study was to evaluate some commercial dairy rations in terms of chemical composition, methane production, net energy for lactation (NE_L) and organic matter digestibility (OMD). There are considerable variations among total mixed rations (TMRs) used by farms, especially in terms of chemical composition. Crude protein (CP) contents of TMRs ranged from 9.83 to 14.32 %. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents of TMRs ranged from 22.79 to 32.32 % and 42.5 to 52.98 % respectively. There are significant differences among TMRs in terms of gas, methane production, NE_L and OMD. Gas production ranged from 82.25 to 97.25 ml. Gas production, NE_L and OMD for TMR 3, 6 and 8 was significantly higher than the others. Methane production (ml) for TMR 8 was significantly higher than that for TMR 7. As a conclusion, TMRs investigated in the current study are not well balanced to meet the nutritional requirements of lactating cows. Therefore, it is not likely that lactating cows fed with these TMR will not explain their genetic potential very well. Especially CP and NE_L of TMRs should be taken into consideration to improve efficiency in milk production of lactating cows in small farms in Turkey.

Key words: chemical composition, digestibility, methane production, net energy lactation, total mixed ration

Introduction

As most parts of the world, diet formulation of lactating cows are based on protein and energy requirements. The chemical compositions and energy contents of feed ingredients or TMRs used in lactating cow diets were not determined due to lack of analytic facilities in most of small dairy farms in Turkey. In addition, most of small dairy farms have no a qualified consulting nutritionist. As a result, in practice, formulating of well-balanced diets is very difficult in the most of small dairy farms. Preliminary investigation clearly showed that diets of lactating cows were not well balanced in Turkey due to lack of analytic facilities and qualified consulting nutritionist in most of small dairy farms. Recently the chemical composition and *in vitro* gas production technique were widely used for evaluation of uninvestigated forages (1-5). The *in vitro* gas production technique not only allows estimation of energy content but also allows methane production of feedstuffs. Recently methane production potentials of some commercial dairy rations and some feedstuffs were evaluated using *in vitro* gas production technique (1, 6). It is well known that methane is one of the most important greenhouse gases. The methane production from ruminant animal has a considerable contribution to the global worming during the fermentation. It was also reported that during the ruminal fermentation 2-12 % of dietary energy intake is lost as methane (7). Therefore, the aim of current experiment was to evaluate the diets of lactating cows in terms of chemical composition, NE_L, OMD and methane production.

Materials and methods

This experiment was conducted in the laboratory of Department of Animal Science, Faculty of Agriculture, University of Kahramanmaras Sutcu Imam, Kahramanmaras in Turkey. Studies performed using *in vitro* experimental model was approved by the Animal Experimentation Ethics Committee of University of Kahramanmaras Sutcu Imam, Faculty of Agriculture (Protocol No: 2018/01).

The ingredients of TMRs were collected from eight different farms in 2017 in Nigde Province of Turkey and mixed in the laboratory as exactly done in farm. The TMRs dried under the shadow at room temperature. Dried TMRs samples were milled to pass 1 mm screen and kept in airtight plastic bags for chemical analysis and *in vitro* gas production. Dry matter (DM), ash, CP and ether extract (EE) contents of TMRs were determined according to AOAC (8). Cell wall (NDF and ADF) contents of TMRs were determined according to method described by Van Soest and Wine (9) and Van Soest (10) respectively. Chemical analysis was carried out in triplicate. The chemical compositions of TMRs are given in Table 1.

The *in vitro* gas and methane production of TMR samples were determined using the *in vitro* gas production technique (11). Three Awassi lambs (approximately 50 kg average weight) were used as inocolum donor's animal for *in vitro* gas production trials. Lambs were fed with diet containing of alfalfa hay (800g) and barley (400g). Equal amount of rumen fluid was transferred into thermo flask before morning feeding and strained through four layered cheesecloths under flushing with CO_2. The rumen fluid and buffer solution were combined in the ratio 1:2 (V/V). 40 ml of buffered rumen fluid were transferred into syringes containing TMR samples (0.5 gram) in quadruplicate. 40 ml of buffered rumen fluid were transferred into four syringes without TMR samples to obtain the blanks. All syringes were incubated for 24 h in water bath maintained at 39 °C. The gas and methane production were detected from the syringes containing TMR samples to determine the net gas production at 24 h incubation. Net gas productions of TMR samples were obtained after correction for blank and hay standard (University of Hohenheim, Germany).

NE_L (MJ/kg DM) and OMD of TMR samples were estimated using equation of Menke and Steingass (11) as follows:

- NE_L (MJ/kg DM) = -0.22 + 0.1062GP+ 0.048CP +0.1329EE
- OMD (%) = 14.88 + 0.8893GP + 0.448CP +0.651 Ash
- Where GP = 24 h net gas production (ml/200 mg); CP = Crude protein (%), EE: Ether extract (%), ash content (%). NE_L was converted into kcal multiplying by 0.239

The methane contents of gas produced after 24 h incubation of TMR samples were determined using an infrared methane analyzer (Sensor Europe GmbH, Erkrath, Germany) (12).

Methane production (ml) = Total gas production for 24 h incubation (ml) X Percentage of Methane (%)

The effect of TMR on gas production, methane production, NE_L and OMD were determined using the one-way analysis of variance (ANOVA). Tukey's multiple range tests was employed to identify the significance between means. Mean differences were considered significant at $P<0.05$.

Results and discussion

There is considerable variation among TMRs in terms of feed ingredients and their levels in TMRs used for dairy cows in Nigde Province, Turkey. TMRs used in the current experiment contained up to 10 ingredients. The concentrate obtained from commercial feed companies used by the all farms, which is common practice in Turkey. In addition to the concentrates, the oat grain was used by one dairy farm. The concentrate level of TMRs ranged from 23.17 to 54.32 %. Wheat straw, corn silage and sugar beet pulp are the mainly used forages for TMRs. Alfalfa hay is used for only three dairy farms.

There is also considerable variation among TMRs in terms of chemical composition. CP contents of TMRs ranged from 9.83 to 14.32 % respectively. It is well known that CP requirements of lactating cows are considerable high due to milk production. NRC (13) suggested that lactating cows with an average 30.9 kg/d of milk production should be fed with a diet averaging 16.1 % of CP of DM with a range from 13.8 to 20.8 % of DM. As can be seen from Table 1, CP contents of TMRs 1, 3, 5, 6 and 7 did not fall into this range suggested by NRC (13). On the other side, CP contents of TMRs 2, 4 and 8 was close to lower and of this range suggested by NRC (13).

As can be seen from Table 1, ADF and NDF contents of TMRs ranged from 22.79 to 32.32 % and 42.5 to 52.98 % respectively. NRC (13) recommends a minimum of 17 to 21% of ADF, 25 to 35 % of NDF for lactating cows. It is unlikely that metabolic disorders such as low milk fat, off feed problems, acidosis and feet sore will occur in the farms involved in current study since ADF and NDF contents of all TMRs studied in the current experiment higher than NRC (13) recommendation. On the other hand, Allen (14) summarized 15 studies and showed a general decline in dry matter intake with increasing NDF concentrations in diets when diets exceeded 25 percent NDF. Therefore high level of NDF contents of TMRs used in the current experiment will results in depression of feed intake, thus reducing milk production.

Estimated NFC (Non Fibrous Carbohydrates) contents of TMRs ranged from 23.9to 34.1 %. Hoover and Stokes (15) regressed data from Nocek and Russell (16) and found that when dietary NFC was greater than 45 to 50 % or less than 25 to 30 %, milk production was decreased. As can be seen from Table 1, NFC contents of TMRs 1, 2, 5 and 7 were very close to lower end of this recommended range. The others except for TMR 3 was lower than the upper end of recommended end.

In vitro gas production, methane production, NE_L and OMD of TMRs are given in Table 2. There are significant differences among TMRs in *in vitro* gas, methane production, NE_L and OMD. Gas production ranged from 82.25 to 97.25 ml. Methane productions of most of TMRs studied in the current experiment was similar whereas methane production (ml) for TMR 8 was only significantly higher than that for

Table 1. Ingredient composition (%) of TMR fed lactating cows on selected dairy farms in Turkey, (as dry matter)

	TMRs							
Ingredients	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Wheat straw	33.44	33.14	-	20.37	40.3	15.49	19.31	21.73
Corn silage	14.85	10.09	10.4	18.26	17.58	15.54	4.25	-
Sugar beet pulp	11.57	6.91	-	8.39	8.87	15.18	3.09	18.52
Concentrate	40.13	42.61	51.49	44.82	33.25	41.3	23.17	54.32
Patato	-	7.24	7.21	-	-	-	-	-
Bean straw	-	-	30.9	-	-	-	-	-
Oat grain	-	-	-	8.15	-	-	-	-
Alfala hay	-	-	-	-	-	12.49	11.58	5.43
Barley straw	-	-	-	-	-	-	19.31	-
Corn stover	-	-	-	-	-	-	19.31	-
Total	100	100	100	100	100	100	100	100
Composition (% DM)								
DM	91.00	91.47	91.12	91.49	92.57	91.92	92.43	91.66
Ash	10.94	9.17	13.17	9.60	10.14	10.25	8.70	13.17
CP	10.06	14.32	12.41	14.08	9.83	12.78	10.38	13.95
ADF	29.5	28.11	22.79	23.78	30.4	26.09	32.32	23.82
NDF	51.56	50.17	38.06	43.10	52.98	48.46	55.27	42.5
EE	2.88	2.46	2.3	3.33	2.69	2.28	1.65	2.15
NFC	24.0	23.9	34.1	29.9	24.4	26.2	24.0	28.2

DM: Dry matter (% as feed), CP: Crude protein, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, EE: Ether extract, NFC= 100-(NDF+CP+EE+CA)

Table 2. Gas, methane production, net energy for lactation and organic matter digestibility of TMR fed lactating cows on selected dairy farms in Turkey

	TMRs									
Parameters	1	2	3	4	5	6	7	8	SEM	Sig.
GP(ml)	84.50^{b}	84.50^{b}	97.25^{a}	85.75^{b}	84.00^{b}	92.25^{a}	82.25^{b}	92.75^{a}	1.625	***
CH_4(ml)	12.71^{ab}	13.26^{ab}	13.39^{ab}	13.33^{ab}	12.43^{ab}	13.04^{ab}	11.88^{b}	13.74^{a}	0.473	***
CH_4(%)	15.04^{abc}	15.69^{a}	13.77^{c}	15.54^{ab}	14.80^{abc}	14.14^{bc}	14.46^{abc}	14.81^{abc}	0.440	***
NE_L	1012.0^{d}	1047.5^{cd}	1149^{a}	1084.7^{bc}	997.7^{de}	1102.7^{ab}	953.5^{e}	1117.0^{ab}	16.53	***
OMD	56.56^{cd}	57.33^{cd}	63.61^{a}	57.94^{c}	55.77^{de}	60.09^{b}	54.46^{e}	61.88^{ab}	0.578	***

*$^{a\,b\,cd}$ Row means with common superscripts do not differ (P<0.05); S.E.M. – standard error mean; Sig. – significance level; GP: Gas production (ml), CH_4 – Methane emission(ml or %), NE_L: Net energy for lactation (MJ /kg DM), OMD: Organic matter digestibility (%), , ***P<0.001.*

TMR 7. The gas and methane production of TMRs at 24 h incubation were considerably lower than those reported by Getachew *et al.* (1) who measured gas and methane production of seven TMR from selected dairies. The low gas production of TMRs in the current experiment might be associated with low NFC and high level of NDF and ADF, which ranged from 23.9 to 34.1%, 42.5 to 55.27 % and 22.79 to 32.32% respectively. NFC, NDF and ADF contents TMRs selected by Getachew *et al.* (1) ranged from 34.9 to 46.3, 25.0 to 31.5% and 18.3 to 24.6% respectively.

TMRs used in the current experiment were collected from small dairy farms without qualified consulting nutritionist. Therefore, it was expected that there would be considerable variations in chemical composition of TMRs, which was the case and the variation in chemical compositions of TMRs would affect the methane production. However, the type of TMR has a significant effect on methane emission but not great as much as expected. The methane production of TMRs ranged from 11.88 to 13.74 ml per 0.5 g incubated DM. Methane production is been affected by forage species and quality.

Table 3. Correlation coefficient (r) of relationship of chemical composition with gas, methane production and estimated parameters

	GP	CH_4	NE_L	OMD
Ash	0.828*	0.624^{NS}	0.714*	0.848**
CP	0.399^{NS}	0.828*	0.688^{NS}	0.538^{NS}
ADF	-0.808*	-0.906**	-0.965**	-0.890**
NDF	-0.830*	-0,840**	0.929**	0.904**
EE	-0.177^{NS}	0.302^{NS}	0.143^{NS}	-0.072^{NS}
NFC	0.791*	0.609^{NS}	0.812*	0.814*

*Ash (% of DM), CP – Crude protein (% of DM), ADF – Acid detergent fiber (% of DM), NDF – Neutral detergent fiber(% of DM), EE: Ether extract (% of DM), CT – Condensed tannin (% of DM), GP: Gas production (ml), CH_4 – Methane emission (ml), NE_L: Net energy for lactation (kcal /kg DM), OMD: Organic matter digestibility (%) NS: Not significant, ** P<0.01, *P<0.05*

Gas production, NE_L and OMD for TMRs 3, 6 and 8 was significantly higher than the others. As can be seen from Table 2, NE_L of TMRs ranged from 953.5 to 1149 kcal/kg DM. The recommendation of NRC (13) for NE_L ranged 1234 to 1640 kcal /kg DM for lactating cows with 10-30 kg milk production. Therefore, TMRs studied in the current study is not likely to meet the energy requirement of lactating cows since the NE_L of TMRs offered were lower than those suggested by NRC (13).

The cell wall contents of feedstuff are very important factors affecting the nutritive value of feedstuffs. As can be seen from Table 1, an increase in NDF and ADF of TMRS at the expense of NFC decreased the gas production, digestibility and NE_L value of TMRs since cell wall contents of TMRs are less fermentable than NFC contents of TMRs. As can be seen from Table 1, NFC contents of TMRs increased with increased level of concentrate. Concentrates are rich in NFC than that for forages. Therefore, cell wall structural elements contents are negatively correlated with nutritive value parameters such as gas production, digestibility and energy value of feedstuffs. As can be seen from Table 3, *in vitro* gas and methane production of TMRs were negatively correlated with NDF or ADF contents of TMRs.

It is well know that concentrate contains more fermentable substrate than forages. Therefore, the concentrate produces more gas and methane when fermented by rumen micro-organisms.

As can be seen from Table 3, NE_L and OMD decreased with increasing NDF or ADF contents of TMRs whereas NE_L and OMD increased with increasing NFC content. Therefore, TMRs studied in the current study should be supplemented with concentrate to increase NE_L contents.

Conclusion

All theTMRs investigated in the current study are not well balanced to meet the nutritional requirements of lactating cows. Therefore, it is not likely that lactating cows fed with these TMRs will not explain their genetic potential very well. Especially CP and NE_L of TMRs should be taken into consideration to improve efficiency in milk production of lactating cows in small farms in the Turkey and worldwide.

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