Effect of cell-wall nitrogen proportion on protein utilization by ruminant livestock: a meta-analysis across different experiments

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Abstract

Sustainability of animal production is dependent on the diet given to the animal. With regard to protein in diet, which is considered as the most important nutrient, ideally the compound can be maximally utilized by the animal and minimally excreted to the environment in order to contribute to the sustainable animal production concept. Different types of ingredients and processing of feed lead the variation of rumen degradability. Based on its degradability in the rumen, CP is divided into five fractions, namely A, B1, B2, B3 and C. Fraction A is non-protein nitrogen (NPN), which dissolved in buffer solution and can be used directly by rumen microbes. Fraction B1 is mostly available for microbial degradation in the rumen. Fraction B2 is degraded partially while the majority is escaped from rumen degradation. Fraction B3, known as neutral detergent insoluble crude protein (NDICP), is degraded slowly or even tend to by-pass in the rumen, so as to provide the amino acids that can be absorbed by the small intestine. Fraction C, known as acid detergent insoluble crude protein (ADICP), cannot be degraded by rumen microbes and thus cannot provide amino acids for ruminants. Taking into consideration of protein fractions in diet, this study is aimed to evaluate the effect of NDICP proportion in total CP on protein utilization in ruminants, particularly on the availability of protein to be absorbed in small intestine (metabolizable protein). This study is expected to contribute to nitrogen management for sustainable animal production.

Key words: nitrogen fraction; NDICP; ADICP; protein utilization; ruminant.

1. Introduction

Until now, experiment in Indonesia mostly still used crude protein (CP) as an indicator in ruminant diet. High crude protein in diet is believed to be of good quality diet because it can provide amino acids that are absorbed in the small intestine and contribute to the high productivity for ruminants. However, it may not be necessarily true because the crude protein is composed of several factions that will affect the rate and feedstuffs degradability in the rumen of ruminants. According Sniffen *et al.* (1992), protein is divided into five factions, namely A, B1, B2, B3 and C. Fraction A contains non-protein nitrogen available to microbes. Fraction B1 is rapidly, fraction B2 is intermediate, fraction B3 is slowly degradable fractions based on rates of protein

degradation in the rumen. Crude protein fraction B1 was estimated as true protein minus buffer insoluble protein, CP fraction B2 was estimated as a buffer insoluble protein minus neutral detergent insoluble crude protein (NDICP) and CP fraction B3 by subtracing the acid detergent insoluble crude protein (ADICP) of NDCIP. Fraction C was ADICP that can not be degraded at all.

Type of feed material such as wheat bran, maize fodder (Das *et al.* 2014), carrot, sweet potato (Zhao *et al.* 2004) and processing step such as the processing of non-ensiling and after ensiling (Mustafa *et al.* 2002) affect the protein fractionation, and will further affect the rate and rumen degradability in order to determine the availability of amino acids to be absorbed in the small intestine of ruminants. Overall, this will affect the productivity and sustainability of ruminant production.

So far, there were few studies which using statistical approach to meta-analyze the utilization of feed protein for ruminants. The present study used a statistical approach to evaluate the effect of NDICP proportion to total CP on various types of feedstuffs for protein utilization in ruminants.

2. Materials and Methods

2.1. Meta-data development

Database were designed based on the study in feed content such as CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), degradable crude protein, soluble crude protein, and NDICP on various indicators of protein utilization such as metabolizable protein (MP), rumen degradable protein (RDP), rumen undegradable protein (RUP), fraction A, *in vitro* dry matter digestibility (IVDMD), dietary utilizable protein (UTP), total true protein (TTP), fraction B1, fraction B2, fraction B3, fraction C, NPN, degradation rate and effective degradability. Total studies as many as 19 journal articles are presented on Table 1.

2.2. Statistical analysis

Data were analyzed by a statistical meta-analysis approach (Sauvant *et al.* 2008). Different studies were considered as fixed effects in the procedure GLM of SAS version 9.1 (SAS Institute Inc. 2008) and the proportion of NDICP also as as fixed factors. Data reported in different units of measurement were transformed into the same units. These studies using the following model:

$$Yij = B0 + B1Xij + eij$$

where,:

Yij = dependent variable
B0 = overall intercept from all studies (fixed effect)
B1 = linear regression coefficient of Yon X (fixed effect)
Xij = value of the continuous predictor variable (concentration ADICP and NDICP)
eij = the unexplained residual errors.

Table 1. Studies included in the meta-analysis of the effect of cell-wall nitrogen proportion on protein utilization by ruminant livestock

Study no.	Reference
1	Chrenkova *et al.* (2012)
2	Coblentz *et al.* (2010)
3	Das *et al.* (2014)
4	Kajikawa *et al.* (2012)
5	Karsli *et al.* (2005)
6	Mustafa *et al.* (2001)
7	Mustafa *et al.* (2002)
8	Mustafa *et al.* (2003)
9	Mustafa *et al.* (2003)
10	Pirmohammadi *et al.* (2006)
11	Seifdavati *et al.* (2012)
12	Yari *et al.* (2012)
13	Yari *et al.* (2014)
14	Yu *et al.* (2003)
15	Zhao *et al.* (2004)
16	Zhao *et al.* (2008)
17	Rezaei *et al.* (2009)
18	Robinson *et al.* (2004)

3. Result and Discussion

The NDICP is a fraction of CP in the NDF residue because after the extraction done, not all the nitrogen can be soluble (Licitra *et al.* 1966). Equations for linear regression of NDICP proportion are presented in Table 2.

Higher proportion of NDICP in feedstuffs decreased linearly MP ($P<0.05$) and tended to decrease protein degradation rate ($0.05<P<0.1$), however, tended to increase fraction C ($0.05<P<0.1$). All other parameters were insignificant on the influence of NDICP proportion. The NDICP is slowly degraded in the rumen and constitutes a major portion of the ruminal undegraded protein content (Sniffen *et al.* 1992; NRC 1996). This fraction can escape the rumen fermentation and supply the RUP requirement. Therefore the protein sources that are resistant to microbial degradation

in the rumen can provide a practical way to alter the amino acid profile of protein reaching the small intestine for digestion and absorption.

Table 2. Equations for linear regression of nitrogen cell wall, i.e. NDICP proportion (%CP) on protein utilization

Response variable		Variable estimates					
	n	Intercept	SE interce	*P* intercept	Slope	SE slope	*P* slope
MP (% CP)	9	58.03	7.17	<0.001	-0.34	0.16	0.050
RDP (% CP)	9	12.27	11.13	0.280	0.19	0.25	0.470
RUP (% CP)	16	20.27	11.73	0.090	0.22	0.27	0.420
Fraction A (% CP)	34	25.11	8.31	0.007	-0.27	0.19	0.170
Fraction B1 (% CP)	54	52.00	12.99	<0.001	-0.27	0.29	0.380
Fraction B2 (% CP)	54	40.89	6.91	<0.001	0.04	0.16	0.790
Fraction B3 (% CP)	49	13.01	17.94	0.480	-0.13	0.41	0.750
Fraction C (% CP)	49	34.69	15.23	0.030	0.67	0.35	0.066
NPN (% CP)	58	9.20	9.78	0.360	0.13	0.22	0.560
Degradation rate (% CP h^{-1})	17	36.86	11.83	0.005	-0.51	0.27	0.071
Effective Degradability (% CP)	17	33.69	11.49	0.008	-0.38	0.26	0.160

CP, crude protein; n, number of observation; MP, metabolizable protein; NDICP, neutral detergent insoluble crude protein; NPN, non-protein nitrogen; RDP, rumen degradable protein; RUP, rumen undegradable protein; SE, standard error.

The MP content of feeds is a better indicator of animal performances than the CP content (Das *et al.* 2014), although CP in the feedstuff is high. It is because crude protein which by pass into the rumen will be divided into several factions that may affect the degradability rate. Degradability rate of these protein fractions will affect the accuracy in predicting of animal performances because of the protein which degraded too fast will not provide the amino acids to be absorbed, so it can decrease animal performance.

4. Conclusion

The NDICP in feedstuffs is slowly degraded fraction in the rumen and negatively correlated with MP and protein degradation rate. Its presence increases the protein fraction that completely can not be utilized by ruminants. Therefore this component is

important to be measured and should be considered as a routine analysis in the laboratory related to animal feed and nutrition.

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