



Protein-Energy Synchronization Index of Various Energy Source of Feed Concentrate for Ruminants

(Indeks sinkronisasi protein-energi berbagai bahan pakan konsentrat sumber energi bagi ruminansia)

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ABSTRACT. The study aimed to determine the protein-energy synchronization (PES) index of the various energy source of feed concentrate *in vitro*, as a database for the preparation of ruminant rations based on the PES index. The research was conducted from May to August 2020. The research was carried out experimentally through three stages: proximate analysis, *in vitro* digestibility test, and index calculation. The materials used were rumen fluid of three Jawa Randu Goats, taken shortly after being slaughtered at Sokaraja Goat Slaughterhouse, and seven types of energy sources of feed concentrate. Each feedstuff was duplicated for 3 replications, then the digestibility data for organic matter and protein of each feedstuff were collected at the 2nd, 4th, 6th, 8th, 12th, 24th, and 48th hour by *in vitro* fermentation. The data collection results were then regressed and the results were included in the PES index equation. The variable measured was the PES synchronization index. The results showed that the PES index of rice bran was 0.54, rice polish 0.50, pollard 0.57, corn 0.87, dried cassava 0.94, dried cassava dreg 0.90, and bread flour 0.94. The study concluded that the energy source of feed concentrate are potential as the medium to the high category of PES index values in the preparation of ruminant rations, where corn, dried cassava, dried cassava dreg, and bread flour have a PES index in the high category, while rice bran, rice polish, and pollard in the medium category.

Keywords: concentrate, energy source, *in vitro*, and synchronization protein-energy index

ABSTRAK. Tujuan penelitian ini adalah menginventarisasi indeks sinkronisasi protein-energi (SPE) berbagai bahan pakan konsentrat sumber energi, sebagai basis data penyusunan ransum ruminansia berbasis indeks SPE secara *in vitro*. Penelitian dilaksanakan mulai bulan Mei hingga Agustus 2020. Penelitian dilaksanakan secara eksperimental melalui tiga tahap yaitu analisis proksimat, kecernaan *in vitro*, dan perhitungan indeks. Materi yang digunakan adalah cairan rumen 3 Kambing Jawa Randu yang diambil sesaat setelah disembelih di Rumah Potong Hewan Sokaraja, serta 7 jenis bahan pakan konsentrat sumber energi. Masing-masing bahan pakan diduplikasi sebanyak 3 ulangan, kemudian masing-masing diukur kecernaan bahan organik dan protein pada waktu fermentasi *in vitro* ke 2, 4, 6, 8, 12, 24 dan 48 jam. Data yang dikoleksi selanjutnya di uji regresi dan hasilnya dimasukkan dalam persamaan indeks SPE. Variabel yang diukur adalah indeks SPE. Hasil penelitian menunjukkan bahwa indeks SPE dedak sebesar 0,54, bekatul 0,50, pollard 0,57, jagung 0,87, gaplek 0,94, onggok kering 0,90 dan tepung roti 0,94. Penelitian menyimpulkan bahwa, konsentrat sumber energi memiliki potensi nilai indeks sinkronisasi protein-energi pada kategori sedang hingga tinggi dalam penyusunan ransum ruminansia. Jagung, gaplek, onggok kering dan tepung roti memiliki indeks sinkronisasi protein-energi pada kategori tinggi, sedangkan dedak, bekatul dan pollard pada kategori sedang.

Keywords: konsentrat, sumber energi, *in vitro*, dan indeks sinkronisasi protein-energi

INTRODUCTION

Ruminants are a polygastric whose main requirement for feed comes from fiber sources. The development of science in animal feed ingredients has proven the potential for supplementation of various types of concentrate, derived from agricultural waste or food processing waste to supporting ruminant productivity. The composition of concentrate in ruminant rations even reaches 40-90% of the total dry matter intake (DMI) requirement of the ruminant. Several types of energy source concentrate commonly used in

ruminant rations are rice bran, rice polish, pollard, cassava dreg, and so on.

The ration of ruminants must be formulated with a balance of protein and energy to improve the performance of microorganisms in the rumen. This kind of ration arrangement can be done by the protein-energy synchronization (PES) index. The concept of the PES index was first proposed by Sinclair *et al.* (1993). The PES index is described on a scale of 0-1, where a ration with a PES index close to 1, can supply energy and ammonia simultaneously (synchronous). Widyobroto *et al.* (2007) said that the balance of the availability of ammonia and energy in the rumen must run simultaneously. This is related to the level of degradation of protein and organic matter in supplying ammonia and energy in the

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rumen. Chumpawadee *et al.* (2006) explained that unequal (asynchronous) levels of energy supply and ammonia will result in losses. Energy is a limiting factor of ammonia use, the lower amount of energy can cause ammonia to be absorbed in the blood and converted into urea in the liver. A small portion of urea will be recycled and the rest will be wasted or even cause urea toxicity.

Chumpawadee *et al.* (2005) and Chumpawadee *et al.* (2006) proved that rations with a high PES index were able to increase fermentation activity, microbial protein synthesis (MPS), feed utilization, and digestibility in the rumen and thereby increasing body weight in brahman-local crossbred cattle. Cabrita *et al.* (2006) proved that PES in dairy cattle rations was able to maximize milk production. Kaswari (2004) expressed a contrasting opinion that the effect of PES on ruminant rations yielded mixed and inconsistent results. Therefore, an in-depth and continuous study is needed regarding the ration preparation based on the PES index, whether assessed through indexing, determining feed ingredient pairs, or other effects that have not been consistently proven.

The ration preparation based on the PES index is a technique that needs to be developed but requires information on the PES index of each feed ingredient. An inventory of the PES index for local feed ingredients needs to be done as a baseline that can be used similar to the proximate nutritional content in the preparation of rations (Ginting, 2005). The PES index was determined through a series of in vivo degradability tests, however, this technique was limited by the availability of fistulated ruminants. According to Silva *et al.* (2013) and Syamsi *et al.* (2017), the PES index can be determined in vitro. Syamsi *et al.* (2017), Walidi *et al.* (2017), and Syamsi *et al.* (2019) have succeeded in collecting the PES index of various local feed ingredients but in limited quantities. Kaswari *et al.* (2007) showed that microbial protein synthesis in the PES index experiment using in vivo techniques was not much different from in vitro, although the tendency was higher. It means that the PES index study information through in vitro techniques is needed to provide an overview of the results in vivo techniques. Therefore, this study aimed to determine the PES index of various energy sources concentrates by in vitro as a database of ruminant rations based on the PES index.

MATERIALS AND METHODS

This research was carried out experimentally through in vitro methods. The material used was rumen fluid from three Jawa Randu Goats taken at the Sokaraja Slaughterhouse, shortly after being slaughtered. The feed material used was seven types of energy source concentrate, i.e. corn, dried cassava, rice bran, rice polish, pollard, dried cassava dreg, and bread flour. The research was carried out in three stages: nutritional analysis, in vitro digestibility, and calculation of the protein-energy synchronization (PES) index. Each feedstuff was duplicated for three replications, then the digestibility data for organic matter and protein of each feedstuff were collected at the 2nd, 4th, 6th, 8th, 12th, 24th, and 48th hour by in vitro fermentation. The results of the data collection were then regressed and the results were included in the PES index equation.

Nutritional Analysis

Nutritional analysis of concentrate in determining moisture content, dry matter (DM), ash, organic matter (OM), crude protein (CP), extract ether (EE), crude fiber (CF), and nitrogen free extract (NFE) was using the proximate method developed by AOAC (2005). Moisture content and DM were determined by drying 2g of the sample in an oven at 105°C. The remaining weight was determined as DM, while the evaporated one or lost was determined as moisture content. The ash and OM content were determined by burning 2g of the sample in a furnace at 600°C. The remaining weight was ashes and the oxidized one was determined as OM. The protein content was determined by digestion of a 0.1g sample in a Kjeldahl tube, then the results were distilled and titrated.

The EE content was determined by dissolving 1g of the sample in a Soxhlet tube using acetone as a solvent. The CF content was determined by washing 1g of the sample using solvents sequentially, i.e. H₂SO₄ 0.3N, hot water, H₂SO₄ 0.3N, and acetone. The washing residue was burned in a furnace at a temperature of 600°C, the remaining weight was crude fiber. The NFE content was calculated by the formula = 100% - (ash + EE + CP + CF). Total digestible nutrient (TDN) levels were determined by the formula developed by Wardeh (1981), i.e., TDN = 40.2625 - 0.1379 CF + 1.1903 EE + 0.4228 NFE + 0.1969 CP.

Measurement of Protein and Organic Matter Digestibility

Digestibility measurements were carried out using the in vitro method developed by Silva *et al.* (2013). This method was applied using a 250 ml Erlenmeyer tube filled with 4g of the sample, 48 ml of McDougall's solution and 32 ml of rumen fluid. Erlenmeyer was then put into a shaker water bath with a temperature of 39°C. Erlenmeyer was supplied with CO₂ for 30 seconds, then covered with a ventilated rubber. The degradation of protein and organic matter (OM) was measured at 7 different times, at 2, 4, 6, 8, 12, 24, and 48 hours. The results of the degradation each time were then regressed to obtain the average degradation of g protein and kg OM per hour. This method was developed by Silva *et al.* (2013) from the method of Ørskov and McDonald (1979).

Protein-Energy Synchronization Index Calculating of Each Concentrate

The average degradation of g protein and Kg OM per hour for each concentrate then can be included in the formula for calculating the PES index. This formula was found by Hermon *et al.* (2008) and developed by Sinclair *et al.* (1993). The PES index formula is as follows:

$$\text{PES index} = \frac{20 - \sum_{1-24}^n \frac{\sqrt{\left(20 - \frac{N}{OM \text{ per hour}}\right)^2}}{24}}{20}$$

Note: 20: the optimal ratio assumption for microbial protein synthesis in local feed ingredients is 20 g N/Kg OM; 1-24: time; 24: time of day; n: observation time; N/OM per hour: the degradation rate ratio of protein between organic matter every hour.

Statistical Analysis

The results of the proximate analysis were discussed descriptively. The digestibility of

protein and organic matter of each concentrate was tested using regression analysis and the average degradation results were calculated in the protein-energy synchronization (PES) index formula. The results of the PES index calculation for each concentrate then were discussed descriptively.

RESULTS AND DISCUSSION

Nutritional Value

The energy sources concentrate are products generally produced from agricultural products or food processing. This feedstuffs are mostly grain-based and contain fermentable non-structural carbohydrates. The addition of energy sources concentrate in the ration is generally intended as a reinforcing agent. The use of this concentrate will increase energy supply quickly and can be immediately utilized in the MPS process (Hindratiningrum *et al.*, 2011 and Sitindaon, 2013). The potency of each concentrate can be determined from its nutritional content because each feed ingredient has different nutritional characteristics. The nutritional analysis of some energy source concentrate is shown in Table 1.

The nutritional analysis in Table 1 shows a quite diverse results for 7 types of energy source concentrate, but there is a similar trend in dry matter (DM), organic matter (OM), and ash. The DM content ranged between 85.54-89.01%, the OM content between 87.03-89.64%, and the ash between 10.36-13.53%. Hartadi *et al.* (2019) explained that when DM are burned, the OM will be oxidized and what remains is minerals in the form of ash. The OM levels presented in Table 1 indicate that each feed ingredient has a high OM content. The highest ash content was found in rice bran, which was 13.53%, while the lowest was in corn, which was 10.36%.

Table 1. The results of the nutritional analysis of some energy source concentrate

Feedstuff	DM (%)	OM (%DM)	Ash (%DM)	CP (%DM)	EE (%DM)	CF (%DM)	NFE (%DM)	TDN (%DM)
Corn	88.54	89.64	10.36	8.28	18.00	7.22	56.13	86.06
Dried cassava	85.89	87.03	12.97	2.91	15.02	5.57	63.53	84.81
Rice bran	85.54	86.47	13.53	10.78	20.07	23.70	31.92	76.50
Rice polish	89.01	88.15	11.85	11.50	21.01	21.24	34.40	79.15
Pollard	86.74	87.78	12.22	12.48	16.07	15.31	43.92	78.31
DCD	86.54	87.47	12.53	2.13	10.24	31.45	43.65	66.99
Bread flour	86.08	88.11	11.89	5.27	15.94	15.49	51.41	79.87

Note : DCD: dried cassava dreg; DM: dry matter, OM: organic matter, CP: crude protein, CF: crude fiber, NFE: nitrogen free extract, TDN: total digestible nutrient. TDN: calculated by the formula% TDN = 70.60 + 0.259 CP + 1.01 EE - 0.76CF + 0.0991 NFE (Sutardi, 2001)

Energy source concentrates are included in the fifth class code feedstuff which contains <18% crude fiber and <20% crude protein (Hartadi *et al.*, 2019). Based on this category, Table 1 shows the suitability of the protein content analysis results the seven types of feedstuff. The protein content of dried cassava was 2.13%, lower than the others, while pollard was 12.48%, higher among the others. The different results showed that the crude fiber of 3 feedstuffs was higher than others, i.e. the rice bran, rice polish, and dried cassava dreg (DCD), 23.70%, 21.24%, and 31.45% respectively. Rice bran consists of an outer layer of rice grains with some seed, while rice polish is an inner layer of rice grains including a small portion of starchy endosperm. The content of cellulose and hemicellulose in these two types of feedstuff is still very high, which causes the crude fiber analysis also high. The dried cassava dreg has a very high fiber, presumably due to the drying treatment, so that the fiber fraction is high.

The NFE is the composition of carbohydrates in feed, while total digestible nutrients (TDN) are a description of the total energy derived from feed (Amrullah *et al.*, 2015, and Hartadi *et al.*, 2019). The results showed that rice bran and rice polish had lower levels of the

NFE than the others, 31.92% and 34.40% respectively. This is because the contents of CP, EE, and CF of these two feedstuffs are relatively high compared to the others. The TDN content showed a high average for each feedstuff, which is above 50%. Corn and the dried cassava showed a high average compared to the others, 86.06% and 84.81% respectively. This is thought to be related to the starch content in the feed, the higher starch content, and the lower fiber content, the higher TDN.

Synchronization Protein-Energy Index

The protein-energy synchronization (PES) index is a description of the ability to supply ammonia from protein degradation and energy from the OM degradation of feedstuff. The index is represented by a numerical scale between 0-1. An index close to 1 describes a more harmonious (synchronous) condition in releasing ammonia and energy, and inversely if the scale is closer to 0. Based on the scale, the PES index 0-0.4 was the low category, 0.4-0.7 was the medium category and above 0.7 was high category (Sinclair *et al.*, 1993; Ginting, 2005; Syamsi *et al.*, 2017). The PES index results of several types of energy source concentrate are presented in Table 2.

Table 2. Protein-energy synchronization index of various energy source concentrate

Feedstuff	Protein degradation			OM degradation			PES index
	Equation	R ²	g/ hour	Equation	R ²	kg / hour	
Corn	$y = 0.285x - 0.0607$	0.98	13,6193	$y = 20.442x + 88.402$	0.98	1069.618	0.87
Dried cassava	$y = 0.13235x - 0.1577$	0.91	6.1951	$y = 5.7238x + 13.806$	0.91	288.5484	0.94
Rice bran	$y = 0.1167x - 0.0123$	0.93	5.5893	$y = 27.659x + 5.4102$	0.93	1333.0422	0.54
Rice polish	$y = 0.0994x + 0.5703$	0.98	4.2009	$y = 20.218x + 122.331$	0.98	1092.795	0.50
Pollard	$y = 0.1163x + 0.0049$	0.95	5.5873	$y = 15.019x + 540.85$	0.95	1261.762	0.57
DCD	$y = 0.2623x - 0.2756$	0.97	12.3148	$y = 17.466x - 9.5785$	0.97	833.5895	0.90
Bread flour	$y = 0.1161x + 1.8447$	0.97	7.4175	$y = 0.9578x + 330.56$	0.94	376.5344	0.94

Note: DCD: dried cassava dreg; OM: organic matter; R²: the coefficient of determination; PES: protein-energy synchronization

Table 2 shows the equations resulting from the degradation of g protein and kg OM at 2, 4, 6, 8, 12, 24, and 48 hours. The resulting equations are quite diverse but have a fairly high coefficient of determination, which is above 90% on average. The similar result was also proven by Syamsi *et al.* (2017), Walidi *et al.* (2017), and Syamsi *et al.* (2019). The differences of equations are related to differences in the content of protein and organic matter in each feedstuff, as well as differences in degradability that take place at each observation time. The equation was a linear regression obtained based on the accumulation of data, observed on protein or OM digestibility which

continues to increase from the beginning to the end of the observation time.

The average degradation of g protein/hour and kg OM/hour was then used as the basis for calculating the PES index for each concentrate. The results showed that rice bran, rice polish, and pollard were categorized in the moderate PES index, 0.54, 0.50, and 0.57 respectively. Corn, dried cassava, dried cassava dreg, and bread flour are categorized in the high SPE index category, 0.87, 0.94, 0.90, and 0.94 respectively. Walidi *et al.* (2017) stated that feedstuffs containing high starch content tend to have a higher index. Syamsi *et al.* (2019) further explained that feed ingredients with a high fiber fraction, complex

compound bonds, and the anti-nutritional compounds will cause the PES index to be lower.

Several previous studies have also obtained the PES index on various types of energy source concentrate. Kaswari *et al.* (2007) obtained the PES maize grain and wheat grain indexes, namely 0.59 and 0.56 respectively. Sani *et al.* (2016) obtained the PES index of rice bran 0.66, cassava dreg 0.11, pollard 0.89, and corn 0.53. Walid *et al.* (2017) obtained the PES index of rice bran 0.29, dried cassava 0.92, and pollard 0.42. The diversity of study results is due to differences in measurement techniques (in vitro or in sacco) and also the nutritional conditions of the feedstuffs used during the study. An in-depth study is crucial needed to obtain more complete and comprehensive information.

CONCLUSIONS

The study concluded that the energy source of concentrates are potential with the medium to the high category of PES index values in the preparation of ruminant rations, where corn, dried cassava, dried cassava waste, and bread flour are in the high category PES index, while rice bran, rice polish, and pollard are in the medium category.

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