OPEN ACCESS Advances in Animal and Veterinary Sciences

Research Article

The Potency of Traditional Market Vegetable Waste as Ruminant Feed in the Special Region of Yogyakarta

Muhsin Al Anas[1*], Himmatul Hasanah[2], Ali Agus[1]

[1]Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia; [2]Department of Biology Education, Faculty of Math and Science, Yogyakarta State University, Yogyakarta, Indonesia.

Abstract | The relatively high-volume of vegetable waste in the Special Region of Yogyakarta Province causes environmental problems. Although it contains high nutrients, vegetable waste potential as ruminant feed is yet optimally utilized due to the possible presence of heavy metals such as Pb, Cu, and Hg, which can reduce livestock productivity. This study aimed to determine the nutrients and heavy metals content of vegetable waste from 11 traditional markets in Yogyakarta. The results showed vegetable waste contains protein (>20%) and fiber (<30%). It was also noted that the heavy metal concentration is below the maximum tolerable limit for ruminant feed ingredients. The nutrient and heavy metal content showed no difference between Sleman District, Bantul District, and Jogja City. This study concludes that vegetable waste from traditional markets in the Special Region of Yogyakarta has prospective as ruminant feed due to its high nutrient content with a low level of heavy metal.

Keywords | Ruminant feed, Heavy metals, Nutrients, Vegetable waste, Yogyakarta

Received | May 14, 2021; **Accepted** | June 12, 2021; **Published** | July 28, 2021
***Correspondence** | Muhsin Al Anas, Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia; **Email:** muhsin_alanas@ugm.ac.id
Citation | Al Anas M, Hasanah H, Agus A (2021). The potency of traditional market vegetable waste as ruminant feed in the special region of yogyakarta. Adv. Anim. Vet. Sci. 9(9): 1416-1423.
DOI | http://dx.doi.org/10.17582/journal.aavs/2021/9.9.1416.1423
ISSN (Online) | 2307-8316; **ISSN (Print)** | 2309-3331

INTRODUCTION

The Special Region of Yogyakarta has a relatively high potential for vegetable waste due to the presence of many traditional markets as places for high-intensity vegetable transactions. Vegetables and fruit waste in traditional markets reaches 84% of total market waste (Cahyari and Sahroni, 2015). This waste was not optimally utilized and had an impact on environmental pollution. Processing vegetables and fruits waste into alternative feed can increase livestock productivity with low costs. Besides, it can reduce the pile of vegetable waste that pollutes the environment. The problem with vegetable waste as ruminant feed is the high heavy metal content. Heavy metals consumed by ruminants decrease rumen fermentation performance and feed digestibility. Heavy metals become enzyme inhibitors in the gastrointestinal tract cause feed degradation was not optimal. Inhibited nutrient utilization causes a decrease in livestock productivity (Yue et al., 2007; Mudhoo and Kumar, 2013; Marounek and Joch, 2014). Heavy metals such as Pb, Cu, and Cr in vegetables exceed the maximum limit (Zhou et al., 2016; Latif et al., 2018). Based on this description, this study aims to determine the potential and heavy metal contamination of traditional market vegetable waste in the Special Region of Yogyakarta.

MATERIALS AND METHODS

Samples collection

Vegetable waste samples were collected from 11 traditional markets in the Special Region of Yogyakarta. Three traditional markets in Sleman District include Demangan, Condong Catur, and Gamping, three traditional markets in Bantul District covering Piyungan, Barongan, and Bantul. Meanwhile, five traditional markets in Jogja City include Kranggan, Beringharjo, Kotagede, Prawirotaman, and Giwangan. From each traditional market, a total of ±12 kg of vegetable waste was collected at three different points as replications, with ±4 kg of the sample at each replication. Vegetable waste samples were stored in plastic bags for laboratory analysis.

Identify the type of vegetable waste

A total of 1-2 kg of collected vegetable waste was used for identification. Vegetable waste was separated based on the variety and weighed to get the percentage of each vegetable waste.

Vegetable waste drying

The unsorted vegetable waste sample (1 kg), divided into three parts and wrapped in a weighed paper bag. The wrapped samples were heated in a 55°C oven for 3-5 days to obtain air-dried samples. The dry waste samples were ground into powder using a Wiley 2 mm grinding machine. Vegetable waste samples were analyzed proximate (crude protein, crude fat, crude fiber, dry matter, and organic matter) using the AOAC (2005) and heavy metals (Pb, Cu, and Hg) through the atomic absorption spectroscopy (AAS) method (Hina et al., 2011).

Data analysis

Data were analyzed by one-way analysis of variance (ANOVA) with a completely randomized design, followed by Duncan's Multiple Range Test (DMRT) to determine the difference between mean values (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The potential of traditional market vegetable waste in the Special Region of Yogyakarta is presented in Table 1. The results showed that each traditional market in Sleman District, Bantul District, and Jogja City had high potential based on the vegetable variety. Each traditional market has an average of 12 types of vegetable waste and was dominating by vegetables such as cabbage, spinach, water spinach, mustard greens, Chinese cabbage, green beans, chayote, cucumber, carrots, tomatoes, long beans, and jackfruit peels. A variety of waste will have various types of nutrients and potential as ruminant feed. According to some researchers, vegetable waste such as carrots, cabbage, spinach, cauliflower, tomatoes, banana leaves, corn husks, onion peels, cassava leaves, taro, jackfruit, cucumbers, potatoes, pumpkins, leek, celery, lettuce, broccoli, bananas, oranges, grapes, melons, pears, and plums have the potential as feed for ruminants (Ezeldin et al., 2016; Wadhwa and Bakshi, 2013; Bakshi et al., 2016; Mahgoub et al., 2020).

There are many traditional markets in the Special Region of Yogyakarta. According to Statistics Indonesia (2019), the Special Region of Yogyakarta has 357 traditional markets. The number of traditional markets is due to the high people's preference for purchases in traditional markets. People choose vegetables at an affordable price. Vegetables were mostly produced in rural areas in the Special Region of Yogyakarta, which affected the variety of vegetables in traditional markets. Furthermore, the supply of vegetables also comes from other producer areas, such as Magelang and Boyolali, which have vegetable production centers.

The chemical composition analysis of traditional market vegetable waste in the Special Region of Yogyakarta is shown in Table 2. The chemical composition of traditional market vegetable waste in Sleman District, Bantul District, and Jogja City were no different ($P>0.05$). It was due to the high percentage of aste variety in each district almost same.

The chemical composition analysis showed that vegetable waste protein content reached 19%, and fiber lower than 30% would support livestock growth. The protein and the fiber content of vegetable waste are almost equivalent to elephant grass (*Pennisetum purpureum* S.) at 13.47-19.43% and 29.60-35.50% (Haryani et al., 2018), and Setaria grass (*Setaria sphacelata*) about 20.31-23.44% and 24.02-30.41% (Fitriana et al., 2017). According to Bakshi et al. (2016), vegetable waste is a good source of crude fiber and energy, especially for ruminants. Sheep requires about 9.8-16.7% protein (National Research Council, 1985), vegetable waste as an alternative feed can increase productivity at an economical cost. According to research by Retnani et al. (2014), the utilization of 100% vegetable waste as wafers feed-in sheep has the highest body weight gain and a final weight of 25.6% higher than conventional feed.

The result of the analysis of heavy metal content in vegetable waste is presented in Table 3. The results showed that the contamination of heavy metals Pb, Cu, and Hg in Sleman District, Bantul District, and Jogja City did not show a significant difference ($P>0.05$). Pb contamination in all traditional markets is below 0.01 mg/kg. The maximum level of Pb contamination in forage for feed is 10-50 mg/kg (Reis et al., 2010; Adamse et al., 2017). Pb contamination in vegetable waste was still lower than the maximum level of Pb feed contamination. The maximum Hg

Table 1: The potential of traditional market vegetable waste in the Sleman District, Special Region of Yogyakarta

No.	Market Name	Vegetable Type	Botanical Name	Total (g)	Percentage (%)
1.	Demangan	Basil leaves	Ocimum basilicum	1033	18.384%
		Jackfruit peels	Artocarpus heterophyllus	534	9.503%
		Grated coconut	Cocos nucifera	453	8.062%
		Papaya	Carica papaya	444	7.902%
		Cucumber	Cucumis sativus	393	6.994%
		Banana leaves	Musa paradisiaca	373	6.638%
		Water spinach	Ipomoea aquatica	345	6.140%
		Others		330	5.873%
		Spinach	Amaranthus spp.	279	4.965%
		Eggplant	Solanum melongena	263	4.681%
		Bamboo shoots	Dendrocalamus asper	235	4.182%
		Young jackfruit	Artocarpus heterophyllus	206	3.666%
		Mustard greens	parachinensis	170	3.025%
		Chinese cabbage	Brassica rapa subsp. pekinensis	144	2.563%
		Cabbage	Brassica oleracea	140	2.492%
		Ridge gourd	Luffa acutangula	107	1.904%
		Scallion	Allium fistulosum	42	0.747%
		Chayote	Sechium edule	34	0.605%
		Green beans	Phaseolus vulgaris	22	0.392%
		Celery	Apium graveolens	21	0.374%
		Long beans	*Vigna cylindrica* (L.)	18	0.320%
		Carrot	Daucus carota	12	0.214%
		Corn husk	Zea mays	8	0.142%
		Grape	Vitis vinifera	7	0.125%
		Cassava leaves	Manihot utilissima	6	0.107%
2.	Condong Catur	Chinese cabbage	Brassica rapa subsp. pekinensis	1755	34.574%
		Chayote	Sechium edule	1142	22.498%
		Cabbage	Brassica oleracea	670	13.199%
		Water spinach	Ipomea aquatica	606	11.939%
		Cassava leaves	Manihot utilissima	244	4.807%
		Mustard greens	parachinensis	242	4.768%
		Tomato	Solanum lycopersicum	157	3.093%
		Eggplant	Solanum melongena	135	2.660%
		Green beans	Phaseolus vulgaris	51	1.005%
		Spinach	*Amaranthus* spp.	35	0.690%
		Long beans	*Vigna cylindrica* (L.)	15	0.296%
		Scallion	Allium fistulosum	11	0.217%
		Onion peels	Allium cepa	9	0.177%
		Chili	Capsicum annuum	4	0.079%
3.	Gamping	Water spinach	Ipomea aquatica	1448	32.701%
		Spinach	*Amaranthus* spp.	627	14.160%
		Kenikir leaves	Cosmos caudatus	527	11.902%
		Cabbage	Brassica oleracea	384	8.672%

	Mustard greens	Brassica rapa subsp. parachinensis	362	8.175%
	Cucumber	Cucumis sativus	319	7.204%
	Carrot peels	Daucus carota	234	5.285%
	Guava	Syzygium aqueum	89	2.010%
	Pumpkin	Cucurbita moschata Durch	70	1.581%
	Eggplant	Solanum melongena	67	1.513%
	Others		64	1.445%
	Chayote	Sechium edule	53	1.197%
	Radish	Raphanus sativus	42	0.949%
	Long beans	*Vigna cylindrica* (L.)	42	0.949%
	Corn	Zea mays	31	0.700%
	Green beans	Phaseolus vulgaris	23	0.519%
	Scallion	Allium fistulosum	16	0.361%
	Chili	Capsicum annuum	15	0.339%
	Daun melinjo	Gnetum gnemon	8	0.181%
	Klutuk banana leaves	Musa balbisiana	5	0.113%
	Cassava leaves	Manihot utilissima	2	0.045%

Table 2: The potential of traditional market vegetable waste in the Bantul District, Special Region of Yogyakarta

No.	Market Name	Vegetable Type	Botanical Name	Total (g)	Percentage (%)
1.	Piyungan	Cabbage	Brassica oleracea	2338	58.877%
		Spinach	*Amaranthus* spp.	587	14.782%
		Mustard greens	Brassica rapa subsp. parachinensis	505	12.717%
		Bay leaves	Syzygium polyanthum	312	7.857%
		Bamboo shoots	Dendrocalamus asper	131	3.299%
		Bitter melon	Momordica charantia	98	2.468%
2.	Barongan	Cucumber	Cucumis sativus	958	19.740%
		Bitter melon	Momordica charantia	753	15.516%
		Cabbage	Brassica oleracea	689	14.197%
		Tomato	Solanum lycopersicum	560	11.539%
		Eggplant	Solanum melongena	261	5.378%
		Water spinach	Ipomea aquatica	257	5.296%
		Klutuk banana leaves	Musa balbisiana	235	4.842%
		Carrot	Daucus carota	180	3.709%
		Long beans	*Vigna cylindrica* (L.)	175	3.606%
		Scallion	Allium fistulosum	161	3.318%
		Cassava leaves	Manihot utilissima	143	2.947%
		Banana	Musa paradisiaca	138	2.844%
		Taro	Colocasia esculenta	112	2.308%
		Others		83	1.710%
		Celery	Apium graveolens	55	1.133%
		Cauliflower	Brassica oleracea var. Botrytis	44	0.907%
		Mustard greens	Brassica rapa subsp. parachinensis	44	0.907%

		Bay leaves	Syzygium polyanthum	5	0.103%
3.	Bantul	Cabbage	Brassica oleracea	1592	41.394%
		Carrot	Daucus carota	771	20.047%
		Long beans	*Vigna cylindrica* (L.)	495	12.871%
		Cauliflower	Brassica oleracea var. Botrytis	290	7.540%
		Mustard greens	Brassica rapa subsp. parachinensis	205	5.330%
		Scallion	Allium fistulosum	173	4.498%
		Water spinach	Ipomea aquatica	163	4.238%
		Potato	Solanum tuberosum	80	2.080%
		Green beans	Phaseolus vulgaris	35	0.910%
		Ridge gourd	Luffa acutangula	27	0.702%
		Eggplant	Solanum melongena	8	0.208%
		Chili	Capsicum annuum	7	0.182%

Table 3: The potential of traditional market vegetable waste in the Jogja City, Special Region of Yogyakarta

No.	Market Name	Vegetable Type	Botanical Name	Total (g)	Percentage (%)
1.	Kranggan	Green beans	Phaseolus vulgaris	1178	27.796%
		Red apple	Malus domestica	424	10.005%
		Long beans	*Vigna cylindrica* (L.)	348	8.211%
		Spinach	*Amaranthus* spp.	324	7.645%
		Chinese cabbage	Brassica rapa subsp. Pekinensis	287	6.772%
		Mustard greens	parachinensis	272	6.418%
		Cabbage	Brassica oleracea	269	6.347%
		Bamboo shoots	Dendrocalamus asper	219	5.168%
		Star fruit	Averrhoa carambola	179	4.224%
		Corn husk	Zea mays	162	3.823%
		Celery	Apium graveolens	144	3.398%
		Orange	Citrus reticulata	115	2.714%
		Carrot	Daucus carota	91	2.147%
		Scallion	Allium fistulosum	89	2.100%
		Banana	Musa paradisiaca	49	1.156%
		Eggplant	Solanum melongena	31	0.731%
		Tomato	Solanum lycopersicum	30	0.708%
		Chili	Capsicum annuum	12	0.283%
		Mangosteen peels	Garcinia mangostana	9	0.212%
		Rambutan peels	Nephelium lappaceum	6	0.142%
2.	Beringharjo	Mustard greens	Brassica rapa subsp. parachinensis	924	28.839%
		Cabbage	Brassica oleracea	907	28.308%
		Eggplant	Solanum melongena	322	10.050%
		Madeira vine	Anredera cordifolia	300	9.363%
		Scallion	Allium fistulosum	259	8.084%
		Celery	Apium graveolens	243	7.584%
		Carrot	Daucus carota	221	6.898%
		Parsley	Petroselinum crispum	28	0.874%
3.	Kotagede	Cabbage	Brassica oleracea	3222	74.774%

		Potato	Solanum tuberosum	339	7.867%
		Scallion	Allium fistulosum	308	7.148%
		Mustard greens	Brassica rapa subsp. parachinensis	148	3.435%
		Long beans	*Vigna cylindrica* (L.)	130	3.017%
		Bay leaves	Syzygium polyanthum	66	1.532%
		Celery	Apium graveolens	54	1.253%
		Others		32	0.993%
		Chili	Capsicum annuum	4	0.093%
		Klutuk banana leaves	Musa balbisiana	4	0.093%
		Carrot peels	Daucus carota	2	0.046%
4.	Prawirotaman	Sweet leaves	Sauropus androgynus	1619	37.827%
		Jackfruit peels	Artocarpus heterophyllus	783	18.294%
		Water spinach	Ipomea aquatica	530	12.383%
		Spinach	*Amaranthus* spp.	475	11.098%
		Cabbage	Brassica oleracea	435	10.164%
		Chayote	Sechium edule	136	3.178%
		Carrot	Daucus carota	102	2.383%
		Orange	Citrus reticulata	71	1.659%
		Banana peels	Musa paradisiaca	33	0.771%
		Kenikir leaves	Cosmos caudatus	26	0.607%
		Scallion	Allium fistulosum	24	0.561%
		Tomato	Solanum lycopersicum	19	0.444%
		Cassava leaves	Manihot utilissima	18	0.421%
		Bay leaves	Syzygium polyanthum	7	0.164%
		Green beans	Phaseolus vulgaris	2	0.047%
5.	Giwangan	Mustard greens	Brassica rapa subsp. parachinensis	3268	85.438%
		Tomato	Solanum lycopersicum	378	9.882%
		Eggplant	Solanum melongena	105	2.745%
		Corn husk	Zea mays	74	1.935%

Table 4: Chemical composition of traditional market vegetable waste in the Special Region of Yogyakarta (%)*

District	Dry Matter	Organic Matter	Crude Protein	Crude Fiber	Ether Extract	Total Digestible Nutrient
Sleman	93.19	19.43	19.03	20.66	2.13	63.00
Bantul	89.79	22.96	18.90	23.42	1.69	68.80
Jogja City	91.04	22.30	22.73	20.11	1.47	68.33
Average	91.06	21.81	19.98	21.76	1.75	67.09
SE	1.913	1.189	0.966	1.110	0.191	1.713
P-value	0.802	0.507	0.235	0.434	0.478	0.230

*dry weight

Table 5: The heavy metal content of traditional market vegetable waste in the Special Region of Yogyakarta (dry matter sample)

District	Lead (Pb, mg/kg)	Copper (Cu, mg/kg)	Mercury (Hg; µg/kg)
Bantul	<0.01	18.39	23.46
Sleman	<0.01	18.50	33.12
Jogja City	<0.01	12.54	14.52

Average	<0.01	16.84	25.41
SE	0.000	1.740	5.414
P-value	1.000	0.352	0.397

contamination in the feed is 0.1 mg/kg. The Hg content in vegetable waste is still lower than the contamination limit based on Adamse et al. (2017). The standard of Hg content in ruminant feed is 0.1 mg/kg. Hg contamination in vegetable waste is below the maximum contamination limit.

The heavy metals content in vegetables was affected by several factors, such as pesticides and herbicides application, fertilizers, air pollution, soil and irrigation water contaminated with waste, and poor handling during the distribution process (Onakpa et al., 2018; Ruzaidy and Amid, 2020). The problem of utilizing vegetable waste as feed is high heavy metals contamination causes risks to livestock. Heavy metals such as Pb, Cu, and Cr, contained in vegetables, exceed normal permissible limits. Heavy metals consumed by ruminants will reduce rumen fermentation performance and decrease feed digestibility. Heavy metals become enzyme inhibitors in the digestive tract caused less feed degradation. Low nutrient utilization decreased livestock productivity (Yue et al., 2007; Marounek and Joch, 2014).

The consumption of heavy metals through the feed can become a residue in meat and is dangerous if consumed by humans. Research by Sudiyono (2011) shows that cattle that consume heavy metals lead heavy metal contamination of meat to exceed the maximum limit, causing humans health problems. Sheep that grazing in landfill area contains heavy metals on lamb meat over the permissible limit (Rahayu et al., 2016). Consuming heavy metals causes damage to the brain, lungs, kidneys and liver function, blood composition, and other essential organs. Long-term exposure can lead to physical, muscular, and neurological degenerative processes that imitate diseases such as multiple sclerosis, Parkinson's disease, Alzheimer's disease, muscular dystrophy, hypertension, cancer, and may even cause death (Mudgal et al., 2010; Jaishankar et al., 2014) (Table 4 and 5).

CONCLUSION

Traditional market vegetable waste in the Special Region of Yogyakarta is potentially utilized as a ruminant feed based on the variety and chemical composition. Heavy metal contamination of Pb, Cu, and Hg in vegetable waste was still below the permissible limit for ruminant feed.

ACKNOWLEDGEMENTS

Laboratory of Nutritional Biochemistry, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTION

Muhsin Al Anas designed, performed the experiment and wrote the manuscript. Himmatul Hasanah collected the samples and analyzed the data. Ali Agus supervised all the study and revised the manuscript. All authors read and approved the final manuscript for publication.

REFERENCES

- Adamse P, van der Fels-Klerx HJ, de Jong J (2017). Arsenic, lead, cadmium and mercury in animal feed and feed materials; Trend analysis of monitoring results collected in the Netherlands. Wageningen. https://doi.org/10.18174/416680
- AOAC (2005). Official Methods of Analysis. 20th ed. Association of Official Analytical Chemists, Washington DC, USA.
- Bakshi MPS, Wadhwa M, Makkar HPS (2016). Waste to worth: Vegetable wastes as animal feed. CAB Rev. Perspect. Agric. Vet. Sci. Nutr. Nat. Resour. 11: 1 – 26. https://doi.org/10.1079/PAVSNNR201611012
- Cahyari K, Sahroni A (2015). Effect concentration of Chili pepper (*Capsicum annum* L.) and Tabasco pepper (*Capsicum frutescens* L.) on biogas production from organic waste. J. Bahan Alam Terbarukan 4: 8 – 15.
- Ezeldin I, Massaad O, Omer SA (2016). Evaluation of some vegetable wastes as feedstuff for ruminants. Int. J. Sci. Res. 5: 628 – 631. https://doi.org/10.21275/v5i3.NOV161789
- Fitriana PR, Akbarillah HT, Supratman JWR, Limun K, Fax BT (2017). Quality of the nutrition of *Setaria spacellata* grass harvested based on cutting intervals. J. Sain Peternak. Indonesia. 12: 444 – 453. https://doi.org/10.31186/jspi.id.12.4.444-453
- Gomez KA, Gomez AA (1984). Statistical Procedure for Agricultural Research. John Wiley and Sons, USA.
- Haryani H, Norlindawati AP, Norfadzrin F, Aswanimiyuni A, Azman A (2018). Yield and nutritive values of six Napier (*Pennisetum purpureum*) cultivars at different cutting age. Malaysian J. Vet. Res. 9: 6 – 12.
- Hina B, Rizwani GH, Naseem S (2011). Determination of toxic metals in some herbal drugs through atomic absorption spectroscopy. Pak. J. Pharm. Sci. 24: 353 – 358.
- Jaishankar M, Tseten T, Anbalagan N, Mathew BB, Beeregowda KN (2014). Toxicity, mechanism and health effects of some heavy metals. Interdiscip. Toxicol. 7: 60 – 72. https://doi.org/10.2478/intox-2014-0009
- Latif A, Bilal M, Asghar M, Azeem M, Ahmad MI, Abbas A, Ahmad MZ, Shahzad T (2018). Heavy metal accumulation

in vegetables and assessment of their potential health risk. J. Environ. Anal. Chem. 5: 1000234. https://doi.org/10.4172/2380-2391.1000234
- Mahgoub O, Kadim IT, Eltahir Y, Al-Lawatia S, Al-Ismail AM (2020). Nutritional value of vegetable wastes as livestock feed. Sultan Qaboos Univ. J. Sci. [SQUJS] 23: 78 – 84. https://doi.org/10.24200/squjs.vol23iss2pp78-84
- Marounek M, Joch M (2014). Effects of heavy metals and arsenate on the Ovine rumen fermentation in vitro. Agric. Trop. Subtrop. 47: 106 – 108. https://doi.org/10.2478/ats-2014-0014
- Mudgal V, Madaan N, Mudgal A, Singh RB, Mishra S (2010). Effect of toxic metals on human health. Open Nutraceuticals J. 3: 94– 99. https://doi.org/10.2174/187639600100301000 94
- Mudhoo A, Kumar S (2013). Effects of heavy metals as stress factors on anaerobic digestion processes and biogas production from biomass. Int. J. Environ. Sci. Technol. 10: 1383 – 1398. https://doi.org/10.1007/s13762-012-0167-y
- National Research Council (1985). Nutrient Requirements of Sheep. National Academy Press, Washington DC.
- Onakpa MM, Njan AA, Kalu OC (2018). A review of heavy metal contamination of food crops in Nigeria. Ann. Glob. Heal. 84: 488 – 494. https://doi.org/10.29024/aogh.2314
- Rahayu P, Munawaroh IS, Elok K (2016). Comparison of heavy metal residues on sheep that grazing in landfill area before and after elimination process. Pages 319–326 in Proceedings of International Seminar on Livestock Production and Veterinary Technology 2016. https://doi.org/10.14334/Proc.Intsem.LPVT-2016-p.319-326
- Reis LSLS, Pardo PE, Camargos AS, Oba E (2010). Mineral element and heavy metal poisoning in animals. J. Med. Med. Sci. 1: 560 – 579.
- Retnani Y, Saenab A, Taryati (2014). Vegetable waste as wafer feed for increasing productivity of sheep. Asian J. Anim. Sci. 8: 24 – 28. https://doi.org/10.3923/ajas.2014.24.28
- Ruzaidy NIM, Amid A (2020). Heavy metal contamination in vegetables and its detection: A review. Sci. Herit. J. 4: 01 – 05. https://doi.org/10.26480/gws.01.2020.01.05
- Statistics Indonesia (2019). Market and Trade Center Distribution By Classifications 2019. Available at https://www.bps.go.id/indicator/173/1875/1/sebaran-pasar-dan-pusat-perdagangan-menurut-klasifikasi.html (verified 2 February 2021).
- Sudiyono S (2011). Efforts of elimination of residual heavy metals in beef cattle from the waste disposal site locations with conventional maintenance. Sains Peternakan. 9(1): 1 – 7.
- Wadhwa, M., and S. P. M. Bakshi. 2013. Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value-added products (HPS Makkar, Ed.). FAO, Bangkok.
- Yue ZB, Yu HQ, Wang ZL (2007). Anaerobic digestion of cattail with rumen culture in the presence of heavy metals. Bioresour. Technol. 98: 781 – 786. https://doi.org/10.1016/j.biortech.2006.03.017
- Zhou H, Yang WT, Zhou X, Liu L, Gu JF, Wang WL, Zou JL, Tian T, Peng PQ, Liao BH (2016). Accumulation of heavy metals in vegetable species planted in contaminated soils and the health risk assessment. Int. J. Environ. Res. Public Health. 13: 289 – 300. https://doi.org/10.3390/ijerph13030289