International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 10, 2020
ISSN: 1475-7192

NUTRIENT POTENTIAL OF Coix Lachryma-Jobi L. AS RUMINANT FEED SOURCE IN EAST KALIMANTAN

[1]*Hamdi Mayulu, [2]Taufan Purwokusumaning Daru, [3]Suyadi, [4]Marry Christiyanto

ABSTRACT*--Increasing population and productivity are alternative policies that must be implemented comprehensively in East Kalimantan by applying the concept of feed forage budgeting. Utilization of superior forage through exploration of local resource to find new feed source is a necessity. The objective of this research was to determine the nutrient composition, dry matter digestibility (DMD) and organic matter digestibility (OMD) of Coix lachryma-jobi. This research was conducted at Laboratory of Animal Nutrient Science, Faculty of Animal Science and Agriculture, Diponegoro University, Semarang by using proximate analysis and in vitro method. The result showed that Coix lachryma-jobi contained of MC (13.27%); DM (86.73%); CP (8.10%); EE (0.89%); CF (21.29%) and ash (12.08%). The stem contained of MC (12.95%); DW (87.05%); CP (7.94%); EE (0.96%); CF (24.11%) and ash (11.26%). The bran contained of MC (11.53%); DM (88.47%); CP (12.55%); EE (6.40%); CF (60.78%) and ash (8.74%).The DMD of leaves was 59.56%; OMD of leaves was 38.22%; DMD of stem was 51.77% and OMD of stem was 34.41%. This showed that Coix lacryma-jobi L. is potential to be used for ruminant feed source especially for ration combined with other feed sources through the application of feed processing technology (hay, silage, amofer, complete feed). Effective biomass utilization could provide continue and sustainable feed source thus it can meet the needs of ruminant and give additional economic advantages.*

Keywords*--Potency, nutrient, Coix lachryma-jobi, feed, ruminant*

ABSTRAK--Peningkatan populasi dan produktivitas merupakan alternatif kebijakan yang harus dilaksanakan secara konprehensif di Kalimantan Timur dengan menerapakan konsep feed forage budgeting. Pemanfaatan hijauan unggul dengan upaya eksplorasi bahan pakan baru yang menjadi sumberdaya lokal merupakan keniscayaan. Penelitian bertujuan mengetahui komposisi nutrisi, kecernaan bahan kering (KcBK), dan bahan organik (KcBO) Coix lachryma-jobi. Penelitian dilaksanakan di Laboratorium Ilmu Nutrisi Ternak Fakultas Peternakan dan Pertanian Universitas Diponegoro Semarang, menggunakan metode analisis proksimat, dan in vitro. Hasil penelitian Coix lacryma-jobi L. menunjukkan bahwa daun memiliki KA (13,27%); BK (86,73%); PK (8,10%); LK (0,89%); SK (21,29%) dan abu (12,08%). Batang KA (12,95%); BK (87,05%); PK (7,94%); LK (0,96%); SK (24,11%) dan abu (11,26%). Dedak KA (11,53%); BK (88,47%); PK (12,55%); LK (6,40%); SK (60,78%) dan abu (8,74%). Kecernaan bahan kering daun 59,56%; KcBO daun 38,22%; KcBK batang 51,77% dan KcBO batang 34,41%.Coix lacryma-jobi L. memiliki potensi menjadi pakan ruminansia terutama sebagai pakan penyusun ransum dengan dikombinasi bahan pakan lain melalui aplikasi teknologi pengolahan (hay, silase, amofer, complete

[1] *Faculty of Agriculture, Mulawarman University, Campus Gunung Kelua, Samarinda 75119, East Kalimantan, Indonesia, mayoeloehsptno@yahoo.com

[2] Faculty of Agriculture, Mulawarman University, Campus Gunung Kelua, Samarinda 75119, East Kalimantan, Indonesia.

[3] Faculty of Agriculture, Mulawarman University, Campus Gunung Kelua, Samarinda 75119, East Kalimantan, Indonesia.

[4] Diponegoro University, Kampus drh. Soejono Koesoemowardoyo Semarang, Indonesia

Received: 27 Feb 2019 | Revised: 20 Mar 2019 | Accepted: 30 Apr 2020

feed). Pemanfaatan biomassa secara efektif mampu menyediakan bahan pakan yang kontinu, dan berkelanjutan sehingga kebutuhan pakan ruminansia dapat terpenuhi serta mampu memberikan tambahan manfaat secara ekonomi.

Kata kunci: Potensi, nutrisi, Coix lachryma-jobi, pakan, ruminansia

I. INTRODUCTION

World ruminant growth increases followed by the increasing demand of livestock product due to increasing population, increasing income and increasing urbanization (Getabalew and Alemneh, 2019). Ruminant has great potency in providing animal protein (beef) worldwide, about 75.5% contributes for global livestock biomass (Mayulu, 2019). A complex digestive system causes ruminant requires a variety of nutrients to support their productivity (Mikkelson, 2017). Feed is the basic factor in livestock business because it has large influence on livestock productivity (Mayulu, 2015) and an increasing population needs to be balanced with the availability of adequate and high-quality feed (Mayulu, 2019). Fluctuating seasons may impact on the sustainability of animal feed (Malalantang et al., 2019; Mayulu and Daru, 2019) especially in the dry season, so that the availability of forage fiber is expected to support ruminant production.

The carrying capacity of animal husbandry development area has an important role in providing feed resources (forages) which is in accordance with the direction of the development (Mayulu and Daru, 2019). Forage plants are considered as the main aspect of agroforestry because they are not only providing food security but also having impact on the increasing economic aspect (Dey and Mukherjee, 2015). Forage plants that are resistant to drought become an alternative choice in providing forages such as Coix lachryma-jobi L.

Jelai (Coix lachryma-jobi L.) is a tropical plant that has many seeds from Poaceae family (Nurmala, 2010; Jampeetong et al., 2013) and it is able to adapt in warm areas such as Asia, Africa and Asia - Mediterranean belt (Lu et al. , 2013). This plant is cultivated as a small seed crop (Irawanto et al., 2017; Fu et al., 2019). Other names for Coix lachryma-jobi L. in Indonesia are Hajeli; Jali (Nurmala, 2010), Japen, Jaten while in other countries it is called Adlay (Philippines), Job's tears (Australia), Mayuen (China) and Sila (Fiji) (Ruminta et al., 2017). The main product is seeds that can be consumed by humans as food and medicine (Yu et al., 2008; Lu et al., 2013) and by-products (leaves, stems) are used for animal feed (Irawanto et al., 2017). Utilization of Coix lachryma-jobi seeds is supported by complete nutritional content such as protein (16.2%), fat (4.65%) (Kim et al., 2004; Yang et al., 2013), carbohydrate (79.17%), amino acid, vitamin(B_1 330 mg %) (Kim et al., 2004), inorganic salt, diuretic, anti-inflammatory drug, anti-allergy (Chen et al., 2012) anti-cancer drug, analgesic (Li et al. , 2013), containing large amount of lipopolysaccharide (palmitic acid, stearic acid, octadecadienoic acid, oleic acid and linoleic acid) (Yu et al., 2008), oligosaccharides (free radical prevention) and antioxidant (Lu et al., 2013) .

Compared to other cereals, Coix lachryma-jobi L. has an advantage in terms of harvesting which can be harvested 2-3 times (Irawanto et al., 2017), thus by-products (bran) are higher. Sustainability in livestock production requires exploration of new locally available feed source because of the composition of the nutritional superiority (Malik et al., 2018), however the information reference is still limited. Exploration of feed source (Coix lachryma-jobi L.) that is less well known for ruminants is important to be studied so that research is expected to be able to promote and open opportunities for wider utilization by considering the potential for nutrition, anti-nutrition, pharmacology and nutraceuticals aspect.

II. MATERIAL AND METHOD

This research was conducted at Laboratory of Animal Husbandry Nutrient Science, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang. Material used in this research were: a) Coix lachryma-jobi L. plant; b) in vitro material such as: cattle rumen liquid, Mc Dougall solution (artificial saliva), pepsin-HCL solution as protein degradable enzyme, ice liquid (to stop fermentation process), whatman 41 filter paper and CO_2 gas.

Sample Preparation

Sample preparation (Coix lachryma-jobi L.) was conducted by physical treatment consisting of cutting, drying and milling to make sample in mesh size. Plant samples of Coix lachryma-jobi L., was obtained from agriculture field located in Samarinda City, East Kalimantan Province.

Proximate Analysis

Nutrient content of Coix lachryma-jobi L., was determined by using proximate analysis (AOAC, 1990). This analysis classifies the component of feed source based on chemical composition which contained of moisture content (MC), dry matter (DM), crude protein (CP), eter extract (EE), crude fiber (CF) and ash.

In vitro Analysis

In vitro analysis is one of biological analysis method which is used to determine the nutrient intake of feed source by livestock. This analysis was developed by Tilley and Terry, (1963). Parameters that can be obtained from this analysis were dry matter digestibility (DMD) and organic matter digestibility (OMD). In vitro method divides the analytical process into two stages i.e. fermentative digestion for 48 hours and enzymatic digestion for 48 hours (Tilley and Terry, 1963; Mabjeeshh et al., 2000; Makkar, 2004).

Calculation and Statistic Analysis

In vitro analysis of dry matter digestibility and organic matter digestibility was calculated with this following equation (Mayulu et al., 2018):

1. DMD equation:

$$\text{DMD}\ (\%) = \frac{\text{DM weight of the sample} - (\text{DM contained in residue} - \text{blanco})}{\text{DM weight of the sample}} \text{X } 100 \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

2. OMD equation:

$$\text{OMD}\ (\%) = \frac{\text{OM weight of the sample} - (\text{OM residue} - \text{blanco})}{\text{OM weight of the sample}} \text{X } 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Remarks:

DM sample = sample weight x % DM

DM residue = weight after oven-CP-filter paper

OM sample	= weight of DM sample x % OM
% OM	= 100% DM -(% ash contained in DM)
OM residue	= weight after oven – weight after kiln – filter paper
Blanco	= weight after oven – CP - filter paper

III. RESULT AND DISCUSSION

Characteristic of Coix lachryma-jobi L.

Coix lachryma-jobi L., is a grain plant (cereals), classified as monocotyledonae (Nurmala, 2010), tolerant to fungi and pest (insect) and can be grown on marginal land (Jampeetong et al., 2013). The cultivation of Coix lachryma-jobi L., in Indonesia is majorly done sporadically as a secondary crop with polyculture system on the house yard (Nurmala, 2010). Indonesia has four varieties of Jelai including 1) Agrotis or stone jelay (hard seeds and used as handicraft materials) such as stenocarpa stapf and monilifer Watt; 2) ma-yuen (Rom.) is widely used as food, 3) Palustris; and 4) Aquatica (growing in wet places such as lakes and swamps) (Nurmala, 2010; Khongjeamsiri et al., 2011). This following is the taxonomy of jelai (Nurmala, 2010).

Kingdom	:	Plantae
Division	:	Spermatophyta
Subdivision	:	Angiospermae
Class	:	Monocotyledoneae
Ordo	:	Poales
Family	:	Poaceae
Genus	:	Coix
Species	:	C. lacryma-jobi

Based on theseed characteristic,there are two types of Coix lacryma-jobi L., namely hard-shell Jelai (Coix lacryma-jobi var. stenocarpa stapf and Coix lacryma-jobi var. monilifer Watt) and soft-shell Jelai (Coix lacryma-jobi var. ma-yuen) (Chen et al., 2012). The hard-shell seed makes Coix lacryma-jobi var. stenocarpa stapf and Coix lacryma-jobi var. monilifer Watt is utilized for handicraft such as beads (ECHO Asia Seed Fact Sheet, 2013) while soft-shell seed is cultivated and utilized for crops, medicine (Li et al., 2013; Lu et al.,2013) and livestock feeds (Yang et al., 2013) including the leaves, stems and milling by-products (barn). The tree is 1-2 meters tall, male and female flower is located in different tree and female flower produces yellow, purple or brown grain (Nurmala, 2010).

Figure 1: Plant of Coixlacryma-jobi L., (Source: Yu et al., 2008).

Figure 2: Seed of Coix lacryma-jobi L., (Source: Liao et al., 2019).

Coix lacryma-jobi L., is classified as a short-day plant (Irawanto et al., 2017) quantitative, requires high temperature, abundant rainfall, fertile soil (ECHO Asia Seed Fact Sheet, 2013) and its growth is indeterminant (Nurmala, 2010) and can be harvested 2-3 times in one planting (Irawanto et al., 2017). Coix lacryma-jobi L., can be grown in highland and upland habitat, tolerant to cold temperature and acidic or basic soils (Irawanto et al., 2017). Optimum growth of Coix lacryma-jobi L., can occur when planted at the beginning of the rainy season (ECHO Asia Seed Fact Sheet, 2013). Plant can be harvested at 7-8 months of age with extensive and 5-6 months with intensive planting system (Irawanto et al., 2017).

According to Juhaeti (2015), the growth phaseis divided into four stages which include 1) germination (continued with the growing of leaves); 2) offspring formation (vegetative); 3) flower and seed formation (reproductive); and 4) seed maturation (harvest). The germination stage takes place within 1-2 weeks (Irawanto et al., 2017) and the vegetative stage occurs for four months prior flowering and pollination. Pollination occurs monoeciously, namely individual flower is male or female, but both sexes can be found on the same plant and pollinated by the wind, then the process of seed formation occurs for two months and the stalk starts to dry when most of the seeds are ripe (ECHO Asia Seed Fact Sheet, 2013).

The morphology of Coix lacryma-jobi L includes solid rounded rods with a pile, corkscrew, segmented, branched at the top, yellowish green and smooth (shiny) (Irawanto et al., 2017). Leaf is single type, downy leaf sheath, rough leaf surface, narrow lanceolate leaf blade with 20-50 cm length size and 1.5-4 cm wide, and prominent leaf midribs. Monoecious flowers namely male and female flowers can be found in the same plant. Fruit shapes a water droplet with size of 8 mm x 1.1 cm and glossy. The grains gather at the base of the leaves which are located on the stem of 3-6 cm long and consist of separated male and female. Male flower is oblong shaped with 6-10 mm in size, has three yellow stamens while female flower is rounded-shape, greenish in color and has a small hole at the top with two stigmas (ECHO Asia Seed Fact Sheet, 2013; Irawanto et al., 2017). The fruit is shaped like a water droplet, smooth, with size of 5-15 mm x 6-10 mm and shiny and turns brown or black when ripe (based on its variety). The planting distance of Coix lacryma-jobi L., is about 30 cm (12 inches), and separated in rows of 40-80 cm (16-32 inches) The most common pest attack is smut (Ustilago coicis), which can destroy the ovaries (ECHO Asia Seed Fact Sheet, 2013).

Potency of Coix Lacryma-jobi L., as Ruminant Feed

1. The Result of Proximate Analysis

The supply of quality feed throughout the year needs to be in place in order to increase ruminant population and productivity through comprehensive implementation of feed forage budgeting, utilization of superior forage and exploration of local feed potency (Mayulu et al., 2010). Forage acts as the major component of feed originating from grazing land (Mayulu et al., 2013; Dey and Mukherjee, 2015) or other sources (agricultural waste). Grass is used as the main feed of ruminants but can not be used to provide all nutrient needs of the ruminant (Mikkelson, 2017). Utilization of biomass such as Coix lacryma-jobi L., provides a good opportunity to supply feed at a lower price and is supported by innovation and technology (Mayulu and Suhardi, 2015) to increase its nutritional value (Mayulu et al., 2013)

Coix lacryma-jobi L., becomes an important minor cereal as feed material before corn becoming popular in South Asia (Fu et al.,2019). The production of Coix lacryma-jobi L., reaches to 3500 kg/ha (Liao et al., 2019) and produces green forage up to 34.6 ton/ha and dry material 6.9 ton/ha (ECHO Asia Seed Fact Sheet, 2013) while the green forage production of sorghum is 15-20 tone/ha (Sirappa, 2003). The production will keep continue to increasing so that it will also increasing of biomass, on the other hand it will also increases the economic sector of livestock farmers where they can earn more incomes by utilizing the biomass for livestock feed. The planting area is 73.000 ha to produce grain (whole seeds with shell) 0.22 Million tone (Fu et al., 2019). Physiologically, ruminant can consume feed derived from agricultural waste (Mayulu, 2019). The nutritional value of Coix lacryma-jobi L., by products varies greatly (Table 1). Based on the nutritional potency, it is considered that its crop can be utilized widely for ruminants in East Kalimantan Province.

The wide range of nutritional value contained in the crop offers more flexibility for livestock farmers and more complexity for nutritionist to utilize the biomass efficiently as it contains high crude fiber particularly on the grain (71.81%) and the barn (60.78%). The stems and the leaves of Coix lacryma-jobi L., tend to have similar characteristic with other crop`s by-products. The by-products of agricultural crops especially from cereals tend to have low nutrient, because the nutrient contained in stem and leaf transfers to the grain (Mayulu, 2019). The utilization of by-products derived from Coix lacryma-jobi L., can be given directly to livestock in fresh form similarly with utilization of corn by-products (Umiyasih and Wina, 2008).

One of efforts to optimize the utilization of leaves and stems of Coix lacryma-jobi L., is to process into preserved feed such as hay, silage (Umiyasih and Wina, 2008), ammoniation fermentation (amofer) (Mayulu and Suhardi, 2015), and complete feed (Mayulu et al., 2009). Those processing technologies can extend the shelf life of feed. Processing is very necessary in an effort to ensure continuity of feed (Umiyasih and Wina, 2008). Grain given to livestock roles as energy, protein, vitamin and mineral (Alijosius et al., 2016) so that they can be used as ingredients for concentrate compound (energy sources) (Amanzougarene et al., 2020). Based on the nutrient content (Table 1), Coix lacryma-jobi L., can be used for concentrate feed compound as an effort to optimally fulfill ruminants nutrition both for breeding and fattening (Mayulu et al., 2009). Proper processing of grains can increase the nutrients digestibility in the digestive tract of ruminants (Garcia et al., 2018).

Table 1: Nutrient Composition of Coix lacryma-jobi L.,on Each Plant Part

Nutrient	Plant Part			
	Grain*	Leaf	Stem	Barn
	……………………………………………………...……% …………………………………………………………			
Moisture Content	11.04	13.27	12.95	11.53
Dry Matter	88.96	86.73	87.05	88.47
Crude Protein	16.20	8.10	7.94	12.55
Eter Extract	5.18	0.89	0.96	6.40
Ash	1.38	12.08	11.26	8.74
Crude Fiber	71.81	21.29	24.11	60.78

Source: Proximate analysis result in Laboratory of Animal Husbandry Nutrient Science Laboratory, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang (2020).

*Kim et al. (2004); Nurmala, (2010).

Compared with others cereals crops which widely used for livestock (corn and sorghum), nutrient content of Coix lacryma-jobi L. shows variable result (Table 2). The grain of Coix lacryma-jobi L., contained DM (88.96%) which was almost equal to DM content of corn (89.00%) and sorghum (87.38%), but the leaves of Coixlacryma-jobi L., contained higher DM (86.73%) than corn (80.00%) and sorghum (30.42%). In term of CP, the leaves contained higher content than corn and sorghum i.e. 8.10%, 7.00% and 7.82%, respectively. Thus shows that barn of Coixlacryma-jobi L., can supply protein for ruminants (Fu et al., 2019). The stem of Coix lacryma-jobi L. had higher CP i.e. 7.94% and the stem of corn was 5.00%. The total nutrient content (DM, CP, EE, CF, Ash) of Coixlacryma-jobi L., had higher nutrient content compared with corn.

Table 2: Nutrient Composition of Coix lacryma-jobi L. Compared with Other Cereals

Nutrient	Coixlacryma-jobi L.				Corn				Sorghum			
	Grain	Leaf	Stem	Barn	Grain	Leaf	Stem	Barn	Stem	Leaf	Straw	Barn
	---%--											
Moisture Content	11.04	13.27	12.95	11.53	11.00	20.00	70.00	20.00	12.62	69.58	-	-
Dry Matter	88.96	86.73	87.05	88.47	89.00	80.00	30.00	80.00	87.38	30.42	-	-
Crude Protein	16.20	8.10	7.94	12.55	9.00	7.00	5.00	9.00	8.70	7.82	4.40	19.00
Crude Fiber	71.81	21.29	24.11	60.78	2.00	21.70	35.00	25.00	3.00	28.94	32.30	8.60

Eter Extract	5.18	0.89	0.96	6.40	4.20	2.32	1.30	2.40	2.50	2.60	1.60	4.90
Ash	1.38	12.08	11.26	8.74	2.00	13.77	7.00	7.00	2.8	11.43	8.90	2.02

Source: Proximate analysis result carried out in Animal Husbandry Nutrient Science Laboratory, Faculty of

Animal Husbandry andAgriculture, Diponegoro University, Semarang (2020);

Sirappa, (2003); Umiyasih and Wina, (2008); Kulamarva et al. (2009); Sariubang and Herniwati, (2011); Animal Nutrition, (2012); Suarni and Firmansyah, (2016); Wulandari et al. (2019); Amanzougarene et al. (2020).

2. Dry Matter and Organic Matter Digestibility

The nutrient quality of a feed stock is determined by nutrient composition and the utilization level by ruminant (digestibility) (Wild et al., 2019). Digestibility is the percentage of nutrient which can be digested by digestive track (Mayulu, 2014) and nutrient utilization by ruminants is greatly determined by the activity of microbe fermentation inside rumen (Wild et al., 2019).

Table 3: In Vitro Digestibility of Leaves and Stems of Coix lacryma-jobi L.

Plant Part	Digestibility	
	Dry Matter	Organic Matter
	-----------------------------------%-----------------------------------	
Leaves	59.56	38.22
Stems	51.77	34.41

The evaluation of in vitro digestibility on leaves and stems of Coix lacryma-jobi L., showed varied results (Table 3). Dry matter digestibility (DMD) of Coix lacryma-jobi L., stem produced a higher value (59.56%) compared to DMD of cornstalk (51%) (Umiyasih and Wina, 2008), but equivalent to DMD sorghum (49.5%-70%) (Kulamarva et al., 2009). High digestibility values indicate that more nutrients are absorbed by livestock (Mayulu, 2014). The organic matter digestibility (OMD) of Coix lacryma-jobi L., stem was 38.22%, but lower compared to OMD of sorghum which ranged between 74-81% (Heuze et al., 2015). The in vitro DMD of Coix lacryma-jobi L.,leaves produced 51.77%, and this value was higher compared to DMD of sorghum leaves (39.80%) but lower compared to corn leaves (58%) (Umiyasih and Wina, 2008).Coix lacryma-jobi L. had lower DMD. The OMD of Coix lacryma-jobi L., leaves reached 34.41%, thus based on these overall results Coix lacryma-jobi L., had relatively good digestibility so it is effectively used for ruminants (Alijosius et al., 2016) to be composed for feed ration.

IV. CONCLUSION

Based on the nutrient content, biomass that can be derived from Coix lacryma-jobi L., have a potential to be used for ruminant feed source in East Kalimantan especially for ration feed stock which combined with other feed stocks and supported with application of processing technology (hay, silage, amofer, complete feed). Biomass utilization can effectively supply continue and sustainable feed stock to meet with the ruminant's feed needs and able to generate additional economic benefits.

REFERENCE

1. Alijosius, S., G. J. Svirmickas, V. Kliseviciute, R. Gruzauskas, V. Sasyte, A. R. Stupeliene, A. Dauksiene, and J. Dailidaviciene. 2016 . The chemical composition of different barley varieties grown in Lithuania.Vet Med Zoot 73 (95): 9-13.
2. Amanzougarene, Z., S. Yuste and M. Fondevila. 2020. Fermentation pattern of several carbohydrate sources incubated in an in vitro semicontinuous system with inocula from ruminants given either forage or concentrate-based diets. Animals 10, 261:1-14.
3. Animal Nutrition Group. 2012. Nutritive value of commonly available feeds and fodder in India. National Dairy Development Board.
4. Association of Official Analytical Chemists (AOAC). 1990. Official Methods of Analysis. Association of Official Analytical Chemists. United States of America.
5. Chen, J. H., H. Y. Hsu, and W. Chiang. 2012.Allergic immune-regulatory effects of adlay bran on an OVA-immunized mice allergic model. Food and Chemical Toxicology 50: 3808-3813.
6. Dey, A., and A. Mukherjee. 2015. Tribal way of livestock husbandry: an ethnobotanical survey of Purulia District, India in search for fodder plants: neutraceutical and pharmaceutical relevance. Research Journal of Medicinal Plant 9 (3): 105-115.
7. ECHO Asia Seed Fact Sheet. 2013. Coix lacryma-jobi. [Download 30 March 2020]. Available at: http://www.plantnames.unimelb.edu. au/Sorting/Coix.html#lacrimajobi) -
8. Fu, Y. H., C. Yang, Q. Meng, F. Liu, G. Shen, M. Zhou, and M. Ao. 2019. Genetic diversity and structure of Coix Lacryma-Jobi L. from its world secondary diversity center, Southwest China. Hindawi International Journal of Genomics 2019: 1-9.
9. Garcia, U, A, G., L. Corona, F. C. Pineda, J. Balcells, O. C. Ortega, and M. G. Ronquillo. 2018. A comparison of processed sorghum grain using different digestion techniques. Journal Of Applied Animal Research 46 (1): 1-9.
10. Getabalew, M., and T. Alemneh. 2019. The application of biotechnology on livestock feed improvement. Arch Biomed Eng & Biotechnol 1(5): 1-7.
11. Heuze, V., G. Tran, S. G. Riverdin, D. Renaudeau, D. Bastianelli, and F. Lebas. 2015. Sorghum by product. Chapter. October 2015. [Download 23 Maret 2020]. Available at: http://www. feedipedia.org/node/752.
12. Irawanto, R., D. A. Lestari, and R. Hendrian. 2017. Jali (Coix lacryma-jobi L.): Seeds, germination, and its potential. Pros Sem Nas Masy Biodiv Indon 3(1): 147-153.
13. Jampeetong, A., D. Konnerup, N. Piwpuan, and H. Brix. 2013. Interactive effects of nitrogen form and pH on growth, morphology, N uptake and mineral contents of Coix lacryma-jobi L. Aquatic Botany 111:144-149.
14. Juhaeti, T. 2015. Jali (Coix lacryma-jobi L.; Poaceae) for food diversification: its productivity under various doses of fertilization. Berita Biologi 14(2): 163-168.

15. Khongjeamsiri, W., W. Wangcharoen, S. Pimpilai, and W. Daengprok. 2011. Development of Job's tears ice cream recipes with carrot juice and pumpkin paste. Maejo Int. J. Sci. Technol 5(3): 390-400.
16. Kim, S. O., S. J. Yun, B. Jung, E. H. Lee, D. H. Hahm, I. Shim, and H. J. Lee. 2004. Hypolipidemic effects of crude extract of adlay seed (Coix lachrymajobi var. mayuen) in obesity rat fed high fat diet : Relations of TNF-α and leptin mRNA expressions and serum lipid levels. Life Sciences 75 1391-1404.
17. Kulamarva, A. G., V. R. Sosle and G. S.V. Raghavan. 2009. Nutritional and rheological properties of sorghum. International Journal of Food Properties 12: 55-69.
18. Li, P. C., W. H. Tsai, and C. T. Chien. 2013. Dietary Monascus adlay supplements facilitate suppression of cigarette smoke-induced pulmonary endoplasmic reticulum stress, autophagy, apoptosis and emphysema-related PLGF in the rat. Food Chemistry 136:765-774.
19. Lu, X., W. Liu, J. Wu, M. Li, J. Wang, J. Wu, and C. Luo. 2013. A polysaccharide fraction of adlay seed (Coix lachryma-jobi L.) induces apoptosis in human non-small cell lung cancer A549 cells. Biochemical and Biophysical Research Communications 430:846-851.
20. Liao, Y. L., W.S. Lin, and S.Y. Chen. 2019. Taichung no. 5': A short plant height with high grain yield job's tears cultivar. Hortscience 54 (4):761-762.
21. Mabjeesh. S. J., M. Cohen, and A. Arieli. 2000. In vitro methods for measuring the dry metter digestibility of ruminant feedstuffs: comparison of methods and inoculum source. Journal of dairy science 83 (10): 2289-2294.
22. Makkar, H. P. S. 2004. Recent advances in the in vitro gas method for evaluation of nutritional quality of feed resources. Assessing Quality and Safety of Animal Feeds: 55-88.
23. Malalantang, S. S., L. Abdullah, P. D. M. H. Karti, I. G. Permana, and Nurmahmudi. 2019. Agronomy characteristics of several types of sorghum from radiation mutations as a ruminant animal feed provide. IOP Conf. Series: Earth and Environmental Science 399: 1-7.
24. Malik, T. A., S. S. Thakur, M. S. Mahesh, M. Mohini, T. K. Varun, and S. H. Mir. 2018. Pertinence of maize wet milling by-products in ruminant feeding-a review. International Journal of Livestock Research 8(9):1-11.
25. Mayulu, H., and T. P. Daru. 2019. Region based of animal husbandry development policy: a case study in East Kalimantan. Journal of Tropical AgriFood 2019 1(2): 49-60.
26. Mayulu, H. 2019. Technology in Ruminants Feeds (Teknologi pakan ruminansia). PT Raja Grafindo Persada. Depok.
27. Mayulu, H., N. R. Fauziah, M. I. Haris, M. Christiyanto, and Sunarso. 2018. Digestibility value and fermentation level of local feed-based ration for sheep. Animal Production, 20 (2):95-102.
28. Mayulu, H. 2015. Cattle Feed and Fattening Business Efficiency (Pakan sapi potong dan efisiensi usaha penggemukan). Unnes Press. Semarang.
29. Mayulu, H., and Suhardi. 2015. Nutrient potency of rice straw processed with amofer as cattle feed stuff in East Kalimantan. Internat. J. Sci. Eng 9(2):101-105.
30. Mayulu, H. 2014. The nutrient digestibility of locally sheep fed with amofer palm oil byproduct-based complete feed. Internat. J. Sci. Eng 7(2):106-111.
31. Mayulu, H., Sunarso, M. Christiyanto, and F. Ballo. 2013. Intake and digestibility of cattle's ration on complete feed based-on fermented ammonization rice straw with different protein level. Internat. J. Sci. Eng 4(2):86-91.

32. Mayulu, H., Sunarso, C. I. Sutrisno, and Sumarsono. 2010. Beef cattle development policy in Indonesia. Jurnal Litbang Pertanian 29 (1):34-41.
33. Mayulu, B. Suryanto, Sunarso, M. Christiyanto, F. I. Ballo and Refa'i. 2009. Feasibility of complete feed based on ammoniated fermented rice straw utilization on the beef cattle farming. J. Indon.Trop. Anim. Agric 34(1): 74-80.
34. Mikkelson, K. 2017. Feed options for ruminants in the tropics. ECHO Asia Notes.Thailand.
35. Nurmala, T. 2010. Potency and prospect on the development of Hanjeli Coix Lacryma-jobi L. as a fat-rich nutritious food to support food diversification towards independent food security (Potensi dan prospek pengembnagan Hanjeli Coix Lacryma-jobi L. sebagai pangan bergizi kaya lemak untuk mendukung diversifikasi pangan menuju ketahanan pangan mandiri).PANGAN 20 (1): 41-48.
36. Ruminta, Y. Yuwariah, and N. Sabrina. 2017. Response of growth and yields of Job's Tears (Coix lacryma- jobi L.) to row spacing and liquid complement fertilizer (Respon pertumbuhan dan hasil tanaman hanjeli (Coix lacryma- jobi L.) terhadap jarak tanam dan pupuk pelengkap cair). Jurnal Agrikultura 28 (2): 82-89.
37. Sariubang, M.,and Herniwati. 2011. Planting and production system of corn biomass as animal feed (Sistem pertanaman dan produksi biomas jagung sebagai pakan ternak). Cereals National Seminar (Seminar Nasional Serealia) 2011: 237-244.
38. Sirappa, M. P. 2003. Prospect of sorghum development in Indonesia as alternative commodity for food, feed, and industrial uses (Prospek pengembangan sorgum di Indonesia sebagai komoditas alternatif untuk pangan, pakan, dan industry). Jurnal Litbang Pertanian 22(4): 133-140.
39. Suarni, and I. U. Firmansyah. 2016. The structure, nutrient composition and processing technology of sorghum (Struktur, komposisi nutrisi dan teknologi pengolahan sorgum). Cereals Plant Research Institute (Balai Penelitian Tanaman Serealia). pp.1-21. [Downloaded 25 March 2020]. Available at: http://balitsereal.litbang.pertanian.go.id/wp-content/uploads/2016/11/anis.pdf
40. Tilley, J. M. A., and R. A. Terry. 1963. A two stage technique for the in vitro digestion of forage crop. Journal of the British Grassland Society 18: 104-111.
41. Umiyasih, U., and E. Wina. 2008. Processing and nutritional value of corn by-product as ruminant feed. WARTAZOA 18(3): 127-136.
42. Wild, K. J., H. Steinga, and M. Rodehutscord. 2019. Variability of in vitro ruminal fermentation and nutritional value of cell-disrupted and nondisrupted microalgae for ruminants. GCB Bioenergy 11: 345-359.
43. Wulandari, E., F. S. P. Sihombing, E. Sukarminah, and M. Sunyoto. 2019. Characterization of protein isolate functional properties of red sorghum (Sorghum bicolor (L.) Moench) from Bandung local varieties (Karakterisasi sifat fungsional isolat protein biji sorgum merah (Sorghum bicolor (L.) Moench) varietas lokal Bandung). Chimica et Natura Acta 7 (1): 14-19.
44. Yang, H., W. Min, P. Bi, H. Zhou, and F. Huang. 2013. Stimulatory effects of Coix lacryma-jobi oil on the mycelial growth and metabolites biosynthesis by the submerged culture of Ganoderma lucidum. Biochemical Engineering Journal 76:77- 82.
45. Yu, F., J. Gao, Y. Zeng, and C. X. Liu. 2008. Inhibition of Coix seed extract on fatty acid synthase, a novel target for anticancer activity. Journal of Ethnopharmacology 119: 252-258.