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ORIGINAL ARTICLE

Potency of local feed ingredients and ability of livestock to use the feed: An *in-vitro* study

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ABSTRACT

Objective: The study obtained data on the potential of local feed ingredients, both in quantity, quality, and continuity and to observe the absorption power and ability of livestock to use feed designed *in vitro*.

Materials and Methods: The method uses a survey method of potential sources of animal feed and calculates the carrying capacity of ruminants and nutritional analysis of feed ingredients with proximate analysis. Feed formulations were made based on proximate analysis results of four formulas (P_1, P_2, P_3, and P_4) and tested *in vitro*.

Results: First, Nganjuk district has the highest of the local food potential with the production of agricultural waste and agricultural industries, reaching 802,341.94 tons/year. Second, the most top carrying capacity analysis reached in Tulungagung district, which reached 62,534 ST/year or 43% of the total population of ruminants. Third, the results of the study of the quality of local feed ingredients indicate that each type of feed material has the right and proper nutrition given to ruminants. Fourth, the *in vitro* testing included showing P_1 feed that had a very significant effect ($p < 0.01$) on dry matter digestibility and digestibility of organic matter of cows, respectively, 74.69% and 73.39%.

Conclusion: The *in vitro* technique of making animal feed can be developed in the areas that have the potential to produce agricultural waste and agricultural industries to increase the carrying capacity of livestock.

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Introduction

The direct impact of climate change on the agricultural sector results in the increasingly limited availability of forage. The increasingly limited supply of animal feed encourages farmers to make changes in the pattern of animal feed supply. The farmers in Indonesia generally maintain extensively traditional livestock. The indicated by the provision of feed in the form of forage for livestock originating from grasses [1]. The extensive maintenance pattern utilizes grass plants as the main feed ingredients for ruminants, including in raising cattle—grass plants harvested from roadside, river, rice field, or moor. The availability of forage in extensively raising cattle depends on the season. At the time of the rainy season, the amount is very abundant, while in the dry season, the amount is much less [2]. Likewise, in terms of quality, so that the availability of forage for livestock, both in quantity and quality, cannot be said to be continuous throughout the year and always fluctuates [3].

In continuity, deficits, and fluctuations in animal feed in cattle maintenance have an impact on the process of local cattle breeding. The continuity and availability of animal feed ingredients, especially during the peak of the dry season, are an essential concern in the reproduction of local cows [4]. Because of the importance of the impact of animal feed ingredients in the maintenance of domestic cattle, efforts must be made to provide feed ingredients from local locations. Thus, it is necessary to know the potential

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of local animal feed ingredients that can use as a source of animal feed in raising cattle. Availability of animal feed is vital for the sustainability of livestock because the cost of fulfilling feed is the most considerable cost reaching 60%–70% of the total cost of raising livestock [5].

One way of exploring, managing, and using local animal feed ingredients as a source of animal feed for cattle is the use of agricultural waste and agricultural, industrial waste [6]. Farming wastes and agricultural, industrial wastes still have sufficient nutritional quality for animal feeds for local cows, and cheap economic value [7]. The farm waste has potential in each region are rice straw, corn straw, sugar cane shoots, rice bran, corn bran, onggok, and cassava while agricultural. The other side is industrial wastes include soybean processing industry, processing industry of sugar cane, and peanut processing industry [8].

The utilization of agricultural waste and the agricultural industry into animal feeds of local cattle will encourage the development of local cattle breeding agribusiness in an integrated manner in an integrated production system with agriculture and the agricultural industry. This pattern of integration is known as the "zero waste production system" [9]. Therefore, the excavation and exploration of local animal feed ingredients are essential to do. The community farmers consider utilizing agricultural waste as a source of forage for beef cattle feed because it takes into account the low price and abundant availability during the harvest season [10]. Also, things to consider in utilizing waste include chemical composition of feed ingredients, processing, preparation of rations, and livestock needs [11].

Diversifying the use of by-products which are considered waste from agriculture and plantations into feed can encourage ruminant agribusiness. Development can be done integratively in an integrated production system with patterns of agriculture and farms through environmentally friendly biomass recycling or known as zero-waste production systems [12]. The database regarding the information on nutrient content and feed distribution patterns has not yet existed in Indonesia [13]. Mostly, the farmers use limited food to meet the needs based on feed quantity. They are not considered regard to the adequacy of nutrients contained in the feed so that it is necessary to evaluate feed nutrients to support livestock performance. Utilization of farm waste as new animal feed reaches 30% of the potential currently available. Most of the waste not used correctly and even disposed of, burned, or used for non-livestock needs [8].

Utilization of agricultural waste as an alternative feed is one of the solutions to supply feed for the business of developing the beef cattle. The extent of rice fields in an area is a good potential for producing waste as raw material for beef cattle feed [7]. Agricultural waste has great potential that has not utilized optimally. At present, only around 30%–40% of agricultural and plantation waste has used as animal feed [14]. Feeds available throughout the year can be utilized by livestock and can be obtained at competitive costs, which are ideal conditions and become a challenge in a livestock business [15].

The potential and carrying capacity of agricultural waste as ruminant feed in Indonesia amounted to 51,546,297.3 tons of dry matter (DM) [16]. The most significant production of agrarian waste was rice straw (85.81%), corn straw (5.84%), peanut straw (2.84%), soybean straw (2.54%), cassava shoots (2.29%), and sweet potato straw (0.68%) [17]. Furthermore, a ruminant livestock population of 11,995,340 LU. The carrying capacity of agricultural waste is still above the needs of the population. The addition of ruminant livestock populations in Indonesia to 2,755,437.1 LU or can increase by 18.68% of the population available [12]. Agricultural waste that commonly stored as animal feed in the dry season is rice straw, peanut straw, soybean straw by drying it. Drying an average of 3–4 days direct sun drying, then stored in a cage. This study aims to obtain the potential data of local animal feed ingredients, both in quantity, quality, continuity, carrying capacity, quality of local feed ingredients, and ready feed and *in vitro* digestibility values.

Material and Methods

This research examines the *in vitro* digestibility analysis of animal feed from agricultural waste, including digestibility of dry matter (DMD) and digestibility of organic matter (OMD). The analysis was carried out using a Completely Randomized Design. The test used seven times; the total number of samples reached 28 units of finished animal feed. *In vitro* method to test the ability of livestock to consume animal feed from agricultural waste using the technique of Tilley and Terry [18]. The process divided into two stages, namely, the phases of microbial fermentation and proteolytic digestion. Oven dry feed samples of 60°C, namely, P_1, P_2, P_3, and P_4, each of 0.5 g put into the fermentor tube then 10 ml of rumen liquid was added and 40 ml of McDougall solution ($NaHCo_3$, $Na_2HPO_4.7H_2O$, KCl , NaCl, $MgSO_4.7H_2O$, and $CaCl_2$) with a temperature of 39°C and filled with CO_2 gas for 30 seconds. The tube is fermented for 24 hours so that the hydrolysis digestion process takes place. Then, added 0.2 ml of saturated $HgCl_2$ solution and centrifuged at 3,000 rpm for 15 minutes. The next step, enzymatic (proteolytic) digestion process continued with the fermentation. The residue by adding 50 ml of 0.2% pepsin solution and incubated with a water bath shaker for 48 hours. The remaining digestion was filtered with Whatman filter paper No. 41 and weighed. Measurement of residual DM by evaporating the water content into the oven at a temperature of 105°C for 24 hours and put into the excitatory for 15 minutes. The method used is the survey method to obtain secondary data on the potential sources of local animal feed ingredients and carrying capacity. The analysis of the nutritional quality of local animal feed materials was carried out by Proximate analysis. Proximate analysis for levels of DM, coarse protein (CP), coarse fat (CF), and coarse fiber (CFi). Making animal feed formulations based on the availability of agricultural waste is carried out at the Islamic University Animal Husbandry Laboratory in Tables 1 and 2.

The research variables consisted of:

1) Agricultural waste production (ton/ha/year) = [crop production × proportion of agricultural waste] × material utility (%);
2) Carrying capacity is the number of Livestock Units (LU) that can be accommodated and produced in a certain land area [19,20]. The formula of carrying capacity as follows:

$$\text{Carrying capacity} = \frac{\text{fresh production of animal feed plants}}{\text{averages fresh consumption of 1 livestock unit / year}}$$

The need for forage for one LU ruminants to produce well is around 35 kg/LU/day. Forage needs of livestock are equivalent to 12,775 kg/LU/year or equivalent to 12.8 tons/ST/year [20];

3) Carrying capacity of the agricultural waste index (CCAWI) is a benchmark for waste carrying capacity for the availability of animal feed with four criteria for bearing capacity index (BCI) calculation, namely: (a) very critical regions (BCI < 1), (b) critical areas (BCI < 1 – 1.5), (c) prone areas (BCI = 2), and (d) safe areas (BCI > 2) [3,4,20] . The formula of CCAWI as follows:

$$\text{CCAWI} = \frac{\text{Total available feed potential}}{\text{total feed requirements}}$$

4) Evaluation of the nutritional quality of local feed ingredients was tested using a proximate analysis of feed ingredients. In the proximate analysis, it will be known as DM, crude fat, and crude protein [21];
5) *In vitro* measurements of DMD and OMD [22,23].

Table 1. Nutritional needs for female beef cattle weight 400 kg requirement amount (%).

Requirement	Amount (%)
CP	≤ 11.15
Coarse fiber (CFi)	≤ 15.14
CF	≥ 8

Source: NRC (2001)

Result and Discussion

The agricultural waste product obtained from the calculation of the area harvested rice, corn, soybeans, peanuts,

Table 3. Production of agricultural crop waste and livestock capacity in Blitar district.

No	Type of Agricultural Waste	Land Area (Ha) *	Main Production (Ton/Year) *	Assumption of Utility (%)	Waste Production (Ton/Year) **	LU *	Livestock Capacity (LU/ Year) **
1	Rice straw	50.176,00	340.399,00	100	386.355,20	179.820	30.184
2	Rice Husk	50.176,00	340.399,00	100	78.291,77	179.820	6.117
3	Corn straw	47.360,00	245.251,89	60	63.274,99	179.820	4.943
4	Cassava leaves	8.403,71	171.178,09	75	51.353,43	179.820	4.012
5	Rice Bran	50.176,00	340.399,00	100	34.039,90	179.820	2.659
6	Tofu waste	10.625,17	13.216,00	100	32.300,52	179.820	2.523
7	Corn Husk	47.360,00	245.251,89	100	29.430,23	179.820	2.299
8	Cassava skin	8.403,71	171.178,09	100	27.388,49	179.820	2.140
9	Onggok	8.403,71	171.178,09	100	19.514,30	179.820	1.525
10	Peanut straw	5.518,00	974.450,26	75	18.623,25	179.820	1.455
11	Corncob	47.360,00	245.251,89	100	17.167,63	179.820	1.341
12	Peanut skin	5.518,00	974.450,26	100	10.263,48	179.820	802
13	Soybean straw	10.625,17	13.216,00	50	5.339,26	179.820	417
14	Corn cob skin	47.360,00	245.251,89	100	2.452,52	179.820	192
	Amount	-	-	-	775.794,97	-	60.609

Source: * Blitar Statistical (BPS, 2017), ** Data processed (2018) cassava, sweet potatoes at times with the production of DM tons/ha of straw/shoots of agricultural waste. For agricultural waste production based on total digestible nutrient (TDN) and CP obtained from DM production at times with TDN and CP content of each agricultural waste. DM production conversion rate (tons/ha), TDN, and CP content of each agricultural waste. Some of the agricultural waste products that can use as ruminant animal feed as like rice straw, corn straw, peanut straw, soybean straw, cassava shoots, and sweet potato straw. The comparison of agricultural waste products between the districts, calculation of the concentration of feed of agricultural waste calculated. The index of agricultural waste feed concentration is the ratio of district agricultural waste products to the average provincial agricultural waste production. The index category> 1.0 is high (above average), 0.5–1.0 is average, and <0.5 is low.

Animal feed ingredients potential

The alternative to providing animal feed ingredients in the development of local cattle uses animal feed derived from agricultural waste and agricultural, industrial waste. The types and variations of agrarian waste are very diverse, such as waste from rice, corn, cassava, sugar cane, and soybean. The results of the analysis of the potential of animal feed ingredients in four regencies are as follows:

Blitar district

Based on the statistical data of Blitar in 2018, rice plants have the largest land area of 50,176.00 ha with the primary production 340,399.00 ha/year, while the smallest land area in peanut plants is 5,518.00 ha with the primary production being 974,450.26 ha/year. Rice waste provides 30,184 LU/year of animal feed for rice straw, 2.659 LU/year for rice bran. The total production of agricultural waste and agricultural industry amounting to 775,794.97 tons/year. There can accommodate ruminant livestock populations reached 60,609 LU/Year is equivalent to 33.7% of the total population of ruminants in Blitar district, showing in Table 3 [24].

Almost all the agricultural lands have the potential to be used as livestock development areas. For example, rice paddy fields every time harvest can be obtained straw

Table 2. Animal feed formulation for research.

No	Animal feed ingredientss	Formula P_1 (%)	Formula P_2 (%)	Formula P_3 (%)	Formula P_4 (%)
1	Corn straw	15	25	15	18
2	Corn Husk	3	6	5	6
3	Corncob	5	0	3	4
4	Corn kernels	17	16	15	16
5	Rice straw	5	25	16	18
6	Rice rice bran	16	14	15	17
7	Cassava leaves	8	5	4	6
8	Cassava skin	4	0	5	0
9	Cassava pulp	6	0	0	0
10	Tofu waste	5	0	0	0
11	Soybean meal	4	5	3	3
12	Peanut straw	5	0	0	0
13	Soybean straw	0	0	10	6
14	Sugar cane shoots	0	0	3	0
15	Molasses	4	0	4	4
16	Mineral	0.5	0.5	0.5	0.5
17	Premix	1.5	0.5	0.5	0.5
18	Urea	1	0.5	1	1
Nutritional content					
1	DM (%)	78.81	85.85	88.33	86.31
2	CP (%)	12.27	11.16	11.45	11.31
3	CF (%)	2.74	1.75	4.70	3.93
4	CFi (%)	15.14	21.89	17.98	20.14

Source: primary data, 2018

and bran by-products which can be used as animal feed. Sources of agricultural waste derived from food crop commodities and availability are influenced by cropping patterns and harvested area of food crops in a region. Types of agricultural waste that can use as ruminants are rice straw, corn straw, soybean straw, peanut straw, sweet potato straw, and cassava shoots.

Nganjuk district

Based on the Nganjuk statistics in 2018, rice plants have the largest land area of 78,799.43 ha with the primary production of 255,248.20 ha/year. The lowest land area in peanut plants is 1,935.57 ha with a primary output of 20,499.42 ha/year. Waste from rice plants provides a ruminant animal feed of 47,403 LU/year of rice straw and 363 LU/year of rice bran. The total production of agricultural waste and agricultural industry amounted to 802,341.94 tons/year. There can accommodate ruminant livestock populations reaching 62,683 LU/year are equivalent to 39.5% of the total population of ruminants in Nganjuk district showing in Table 4 [25]. The higher the production of wasteland area unity, the higher the ability to accommodate much livestock at a particular time. However, prevention is needed so that the livestock population does not exceed its carrying capacity.

Kediri district

Based on the statistics of Kediri in 2018, rice plants have the largest land area of 53,803.71 ha with the primary production 320. 254.97 ha/year. The lowest land area in soybean plants is 512.71 ha with an output of 674.6 ha/year. Rice crop waste provides ruminants animal feed of 32,366 LU/year of rice straw, 2,502 LU/year of new rice. Total production of farm waste and agricultural industry is 802,341.94 tons/year. There can accommodate ruminant livestock populations reaching 73,657 LU/year is equivalent to 30% of the total population of ruminants in Kediri district in Table 5 [26]. The exceed of the carrying capacity of land resources that take place continuously without prevention result in land degradation and reduced availability of forage for livestock. The action is needed to increase the carrying capacity of lands, such as the efficiency of land use, planting of legumes, development of agroforestry, and reforestation.

Tulungagung district

Based on Tulungagung statistical data in 2017, rice plantations have the largest land area of 54,272.57 ha with a production of 309,713.31 ha/year. The lowest land in peanut plants is 1,311.00 ha with an output of 2,195.38 ha/year. Rice waste provides rice straw 32,648 LU/year of ruminant animal feed, and rice brand 2,420 LU/year. Total production of agricultural waste and agricultural industry amounting to 802,341.94 tons/year. There can accommodate ruminant livestock populations reaching 62,534 LU/year is equivalent to 43% of the total population of ruminants in Tulungagung district in Table 6 [27].

Rice is the main agricultural product to meet basic food needs. Have a waste of rice straw and rice bran which are

Table 4. Production of agricultural crop waste and livestock capacity in Nganjuk district.

No	Type of Agricultural Waste	Land Area (Ha) *	Main Production (Ton/Year) *	Assumption of Utility (%)	Waste Production (Ton/Year) **	LU *	Livestock Capacity (LU/Year) **
1	Rice straw	78.799,43	255.248,20	100	606.755,60	158.500	47.403
2	Corn straw	30.381,29	173.054,96	60	44.648,18	158.500	3.488
3	Tofu waste	9.808,86	16.709,16	100	29.818,93	158.500	2.330
4	Cassava leaves	4.570,90	77.880,70	75	23.364,21	158.500	1.825
5	Corn Husk	30.381,29	173.054,96	100	20.766,60	158.500	1.622
6	Rice Husk	78.799,40	88.176,65	100	20.280,63	158.500	1.584
7	Cassava skin	4.570,90	77.880,70	100	12.460,91	158.500	974
8	Corncob	30.381,29	173.054,96	100	12.113,85	158.500	946
9	Onggok	4.570,90	77.880,70	100	8.878,40	158.500	694
10	Soybean straw	9.808,86	16.709,16	50	6.750,50	158.500	527
11	Peanut straw	1.935,57	20.499,42	75	6.532,55	158.500	510
12	Rice Bran	78.799,40	46.408,76	100	4.640,88	158.500	363
13	Peanut skin	1.935,57	20.499,42	100	3.600,16	158.500	281
14	Corn cob skin	30.381,29	173.054,96	100	1.730,55	158.500	135
	Amount	-	-	-	802.341,94	-	62.683

Source: * Nganjuk Statistical (BPS, 2017), ** Data processed (2018)

Table 5. Production of agricultural crop waste and livestock capacity in Kediri district.

No	Type of Agricultural Waste	Land Area (Ha) *	Main Production (Ton/Year) *	Assumption of Utility (%)	Waste Production (Ton/Year) **	LU *	Livestock Capacity (LU/Year) **
1	Rice straw	53.803,71	320.254,97	100	414.288,60	245.539	32.366
2	Sugar cane drops	23.135,62	521.209,98	100	26.060,50	245.539	16.679
3	Corn straw	50.567,43	311.205,46	60	80.291,01	245.539	6.273
4	Corn Husk	50.567,43	311.205,46	100	37.344,65	245.539	2.918
5	Sugar cane shoots	23.135,62	521.209,98	50	36.484,70	245.539	2.850
6	Cassava leaves	4.635,66	110.003,44	75	33.001,03	245.539	2.578
7	Rice Bran	53.803,71	320.254,97	100	32.025,50	245.539	2.502
8	Rice Husk	53.803,71	320.254,97	30	22.097,59	245.539	1.726
9	Corncob	50.567,43	311.205,46	100	21.784,38	245.539	1.702
10	Cassava skin	4.635,66	110.003,44	100	17.600,55	245.539	1.375
11	Onggok	4.635,66	110.003,44	100	12.540,39	245.539	980
12	Peanut straw	3.233,00	4.675,37	75	10.911,38	245.539	852
13	Peanut skin	3.233,00	4.675,37	100	6.013,38	245.539	470
14	Corn cob skin	50.567,43	311.205,46	100	3.112,05	245.539	243
15	Tofu waste	512,71	674,60	100	1.558,65	245.539	122
16	Soybean straw	512,71	674,60	50	272,54	245.539	21
	Amount	-	-	-	755.386,90	-	73.657

Source: * Kediri Statistical (BPS, 2017), ** Data processed (2018)

Table 6. Production of agricultural crop waste and livestock capacity in Tulungagung district.

No	Type of Agricultural Waste	Land Area (Ha) *	Main Production (Ton/Year) *	Assumption of Utility (%)	Waste Production (Ton/Year) **	LU *	Livestock Capacity (LU/Year) **
1	Rice straw	54.272,57	309.713,31	100	417.898,79	143.972	32.648
2	Rice Husk	54.272,57	309.713,31	100	71.234,06	143.972	5.565
3	Corn straw	36.080,20	249.282,50	60	64.314,89	143.972	5.025
4	Cassava leaves	7.378,00	185.310,14	75	55.593,04	143.972	4.343
5	Rice Bran	54.272,57	309.713,31	100	30.971,33	143.972	2.420
6	Corn Husk	36.080,20	249.282,50	100	29.913,90	143.972	2.337
7	Cassava skin	7.378,00	185.310,14	100	29.649,62	143.972	2.316
8	Sugar cane drops	5.779,70	24.409,80	100	1.220,49	143.972	1.907
9	Onggok	7.378,00	185.310,14	100	21.125,36	143.972	1.650
10	Corncob	36.080,20	249.282,50	100	17.449,78	143.972	1.363
11	Soybean straw	7.628,71	7.080,60	50	17.279,03	143.972	1.350
12	Peanut straw	1.311,00	2.195,38	75	14.110,80	143.972	1.102
13	Sugar cane shoots	5.779,70	24.409,80	75	2.563,03	143.972	200
14	Corn cob skin	36.080,20	249.282,50	100	2.492,83	143.972	195
15	Peanut skin	1.311,00	2.195,38	50	1.219,23	143.972	95
16	Tofu waste	7.628,71	7.080,60	100	215,25	143.972	17
	Amount	-	-	-	777.251,42	-	62.534

Source: * Tulungagung Statistical (BPS, 2017), ** Data processed (2018) very potential to be used as animal feed. The most significant waste production is rice straw with 77% waste from the main crop, whereas rice bran has a 10% amount of trash from the main plant (Table 6). The utility level reaches 100%, meaning that rice waste preferred by livestock. Likewise, overall corn straw can directly use as animal feed [10]. The utility level of rice bran reaches 100%, while rice bran production generally reaches 8%–10% of the total rice harvest [12].

Sugar cane has waste in the form of shoot sugar cane, and sugar cane crops. Sugar cane bagasse pulp produced at 35%–40% of each sugar cane that is processed in sugar mills production. There are utilized only 5%, the rest is sugar cane drops (molasses), sugar cane waste, and water [28]. The sugar cane crops used to make ethanol and make monosodium glutamate. Sugar cane produces waste from the planting period to harvesting. Dry cane sugar leaves called "klethekan or daduk," sugar cane shoots, to "sogolan" (base of sugar cane); raises its lawn difficulties to throw it away [2]. Of the two wastes, sugar cane shoots are a big waste compared to sugar cane crops. Sugar cane shoots that used as animal feed are the top end of the stem. Sugar cane follows 4–7 leaves that cut from sugar cane harvested for sugar cane seeds or milled seeds [28].

Sugar cane starts the waste in the form of sugar cane shoots and sugar cane crops. The most significant waste found in sugar cane shoots 43%, the utility level of sugar cane shoots reaches 50%, whereas sugar cane drops are only 5% of the main crop. Sugar cane waste can use as animal feed [29]. Besides, the trash can be processed and stored using processing technology and at the same time, can improve the quality of processed food.

Corn plants have waste in the form of corn straw, corn husk, corncob, and corn cob skin. Of the four corn plant wastes, the most waste is corn straw, which is 43% of the main crop. Corn plants that are used as feed ingredients or animal feed only reach 5.2 million tons or as much as 50% of the total waste produced [30]. The level of corn straw utility can reach 100% so that the overall corn straw can directly use as an animal feed.

Cassava (*Manihot utillisima*) is the third staple food after rice and corn for the people of Indonesia. Cassava has waste in the form of cassava leaves, straw cassava, cassava skin, and cassava waste. Of the four residues, cassava leaves are the most waste, which is 40%. Cassava skin is Cassava processing agro-industry waste, such as tapioca flour industry, fermentation industry, and food staple industry [17]. The level of utility of leaves of cassava is assumed to be around 75%. Onggok and cassava skin have a production of 27,388.49 tons/year and 19,514.30 tons/year and are expected to have a utility level of 100% [31].

Soybean is a type of protein source plant that is widely used by the community. Soybean has waste in the form of soybean straw and tofu waste. The most waste is soybean straw reaching 80.8% of the plant. Peanuts are a type of plant that is widespread in Indonesia. Plants from nuts are rich in protein. The use of peanut straw as animal feed is expected to be able to meet the needs of livestock. Peanuts have waste in the form of straw peanuts and skin peanuts [32].

The carrying capacity of the agricultural waste index

CCAWI is a measure of the carrying capacity of waste to the availability of animal feed. The following is a Table 7 on the calculation of potential development and CCAWI of each research location.

Based on Table 7 above, the highest CCAWI is in Tulungagung, which is equal to 0.43, and the lowest CCAWI is in Kediri. It can only accommodate a population of 7,676.27 ST. These shows CCAWI < 1, which means that the status of conditions in the category of very critical or carrying capacity of agricultural waste is not sufficient for the needs of ruminants in four regencies. CCAWI < 2 can be categorized as very critical and confirmed by [33]. BCI reflects the level of feed security in an area, to support livestock life above it. "Safe" criteria are characterized by BCI > 2; BCI < 1.5–2 shows the criteria for "vulnerable"; BCI < 1–1.5 shows "critical" criteria and BCI < 1 indicates "very critical" criteria [34].

The main problem in the livestock business, especially ruminants, is the availability of non-continuous feed [10]. The limited land owned for forage for livestock is one of the obstacles for farmers in certain seasons feeding will be difficult. Availability that is not continuous makes it necessary to have a storage place for agricultural waste. The different nutritional value of agricultural waste is also an obstacle [35].

Table 7. Agricultural Waste Support Index for ruminants.

No	District	The population of Ruminant Animals(LU/year)	Waste Production (ton/year)	Livestock capacity (LU/year)	CCAWI
1	Blitar	179.820	775.794,97	60.609	0.33
2	Nganjuk	158.500	802.341,94	62.683	0.40
3	Kediri	245.539	755.386,90	73.657	0.24
4	Tulungagung	143.972	777.251,42	62.534	0.43

Source: Data processed (2018)

Evaluation of the nutritional quality of local feed ingredients

Based on the proximate analysis of some feed ingredients in Table 8, the average DM content of feed ingredients is quite high. The water content in the feed material is small so that it can store for a long time. However, there is a feed with a low average DM so that it can increase bacteria, fungi that can damage the nutrient content if stored for a long time. The average CP content in feed ingredients has met the nutrient standards needed for nutrient quality with the NRC 2001 guideline [21]. The ordinary coarse fiber (CFi) of feed ingredients is high, and this indicates that the content of top organic compounds is expected to help digestion process of ruminants by giving lactic acid bacteria in the rumen.

Rice straw has a low, CP content (3%–5%) and has a high crude fiber (CFi) content, which is 28%–33%. This condition causes rice straws to have a low digestibility rate, namely: 35%–37%. Low nutritional value and digestibility of rice straw dry ingredients require technological innovation to improve the quality of rice straw as an animal feed [36]. The methodology approaches can make to improve the nutrition of rice straw, chemically, physically, and biologically. The combination of the three processes is more often applied to improve the quality and digestibility of rice straw feed.

Based on the nutritional content of feed ingredients in Table 2, rice bran is a type of waste that has the highest protein content, which is 12.68%. So that, rice bran has massive potential for the supply of ruminant animal feed ingredients and non-ruminant livestock. One advantage of using feed ingredients from rice plant waste is that it does not compete with human needs. Rice bran is a by-product in the processing of grain into the rice which contains a non-thick outer part but mixed with the cover of rice. It affects the high content of CFi bran [6].

Based on Table 8, waste containing CP is cassava waste, which is 1.20%. Onggok is a by-product of tapioca cassava. The food composition contained in cassava waste is 2.89% CP; 1.21% ash; 0.38% CF, and 14.73% coarse fiber. The use of cassava waste as feed raw material has several obstacles. The protein content is shallow, while the CFi and hydrogen cyanide (HCN) content are quite high, besides the high carbohydrate content and water content. That facilitates the microbial activity of decomposers and cause unpleasant odors due to very rapid decay [32]. One alternative technology for using cassava waste as raw material for animal feed is by turning it into a quality product, namely, through a fermentation process [37].

Table 8 also shows that peanut skin waste has a high coarse fiber (CFi) content of 61.64%. Peanut skin is an agricultural waste that has quality constraints, namely, its low nutritious value. Peanut skin also has a protein content of 4%–7% and CFi, which is high 65.7%–79.25% [32]. Although ruminants have rumen to help digest fiber, forage digestibility only reaches 50%–60% [10].

Measurements in vitro of DMD and OMD

DMD measurements

Based on the results of DMD variance analysis in four feed formulations showed a very significant effect ($p < 0.01$) on Formula 1 treatment with a DMD value of 74.69% in

Table 8. The results of material nutrition quality analysis of the local feed.

No	Ingredients	DM	CP	CF	CFi
1	Rice straw	91.95	6.16	1.90	18.15
2	Rice Bran	93.57	12.68	11.74	10.42
3	Peanut straw	23.67	3.91	0.08	6.36
4	Sugar cane drops	67.87	4.55	0.00	0.00
5	Peanut skin	89.06	10.94	2.08	61.64
6	Tofu waste	13.64	2.04	0.10	1.74
7	Soybean straw	88.01	7.65	0.86	46.46
9	Corn straw	88.55	6.50	0.28	30.16
10	Corn Husk	91.37	2.07	0.33	28.93
11	Cassava leaves	30.85	8.71	1.02	4.48
12	Cassava skin	85.14	6.81	0.61	16.85
13	Sugar cane shoots	84	5.26	1.25	26.48
14	Corncob	88.96	3.59	0.12	26.95
15	Onggok	60.46	1.20	0.02	8.85

Source: data processed, 2018. Note: DM – dry matter; CP - oarse protein; CF – coarse fat; CFi - coarse fiber

Table 9. DMD measurement results for four feed formulations.

Treatment	Average DMD (%)
Formula 1 (P_1)	74.69 ± 0.85[b]
Formula 2 (P_2)	69.32 ± 1.15[ab]
Formula 3 (P_3)	68.53 ± 0.86[ab]
Formula 4 (P_4)	66.63 ± 1.09[a]

Source: primary data, 2018.

Table 10. OMD measurement results for four feed formulations.

Treatment	Average OMD (%)
Formula 1 (P_1)	73.39 ± 0.85[b]
Formula 2 (P_2)	66.864 ± 1.15[ab]
Formula 3 (P_3)	68.53 ± 0.86[ab]
Formula 4 (P_4)	65.4 ± 1.09[a]

Source: Primary data, 2018.

Table 9. Due to the content of feed fiber that is suitable for the needs of female cattle, which is 15.24% and the lowest compared to other treatments. Digestion is also closely related to its chemical composition, especially its coarse fiber content. Feed digestibility is closely related to chemical composition, namely, CFi content and CP forage for livestock [38].

OMD measurements

Based on the results of the analysis of variance of OMD measurements in four feed formulations showed a very significant effect ($p < 0.01$) on treatment P_1 with the OMD 73.39% in Table 10. The P_1 treatment has the highest OMD. Because the protein content of the feed is 1% higher, and the fiber content is the lowest compared to other treatments. The higher level of CP feed, the palatability of livestock and feed digestibility also increases. It can interpret that by giving different levels of CP feed to animal, palatability, and response to consumption are also different [39]. The lower the coarse fiber (CFi) in the pasture, the easier it will be to digest, because the cell wall of the material is thin so that the digestive sap quickly penetrates it.

Rations with high CFi content caused low KcBO because the upper the CFi tends to increase the content of cellulose, hemicellulose, and top feed lignin. So that, it influences the content of organic matter, causing a decrease in digestibility of feed ingredients [23,40].

Conclusion

Nganjuk has the highest of the local food potential with the production of agricultural waste and agricultural industries reaching 802,341.94 tons/year. Tulungagung is the most top carrying capacity analysis, which reached 62,534 ST/year or 43% of the total population of ruminants. Rice bran is a type of waste that has the highest protein content, which is 12.68%. So that, rice bran has massive potential for the supply of ruminant animal feed ingredients and non-ruminant livestock. The treatment formula P1 has a DMD value of 74.69% and the OMD 73.39%.

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Conflict of interests

The authors declare that they have no conflict of interests.

Authors' contribution

Rahmawati designs research substance, methods research, interprets data, and composes article manuscripts. Lisnanti was active in data collection and also contributed to the preparation of the document. Muladno and Atabani took part in preparing data analysis and critically examining this text.

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