The nutritional value of agricultural waste forages fed to ruminants from agroecosystem in Grobogan Regency

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Abstract. This study examines the nutritional composition of tropical agricultural waste forage fed to cattle, sheep, and goats (ruminants). The explanation for the variation in nutrients between forages depends on soil fertility and water adequacy in upland agroecosystems. Agricultural waste ingredients for ruminant livestock feed come from rice straw, corn, soybeans, and the carrying capacity of these feeds. Agricultural waste feed ingredients are arranged in a complete feed formula. The nutritive value of complete feed includes crude protein, crude fiber, crude fat, energy, and ash. The aim of this study is to make complete feed of ruminants as animal feed for cost efficiency and feed stock in the dry season.

1. Introduction
Production of soybean plants in 1 ha can produce 1.75 tons BK of soybean straw. Soybean plantations covering an area of 379 thousand hectares have the potential to produce 663,250 tons of dry material for soybean pods. If used as a source of feed, it can feed 1,188,620.07 cows [1]. One animal unit (1 AU: animal unit) of ruminants requires dry feed material of 6.25 kg/day [2]. It means every 1 ha soybean harvest can produce soybean straw (leaves, stems, and pod skins) as feed cattle for 280 units of livestock/day.

In addition, each 4 tons of paddy rice yield from superior varieties can produce 4 tons dry matter/ha of rice straw waste which able to support 640 cattle/day as feed. Moreover, if the productivity of maize per hectare is 5 tons, it will produce three times the amount of corn stover, i.e. 15 tons of dry feed ingredients. It means that each harvest of corn in 1 ha can support animal feed from its waste up to 2,400 units of livestock/day. It has been reported that the carrying capacity of dry matter, crude protein, and Total Digestible Nutrient of food plant waste were 9664 AU, 5240 AU, and 8090 AU respectively [3].

Agricultural land in Indonesia is divided into several agroecosystems. For the lowlands, it is divided into dry land agroecosystems and irrigated land. Each agroecosystem has different productivity due to the availability of water throughout the year. Soil moisture deficit is the main abiotic stress factor that limits crop productivity in rainfed rice fields. The amount of rainfall received during the season is negligible, whereas evaporation losses are much higher, resulting in a rapid reduction in soil moisture from the root zone (0-30 cm) [4]. In addition, there is other challenge in the productivity, including the number of nitrite in the soil. Nitrogen and cow urine fertilized soil collectively represent a significant amount of nitrite accumulation in the agroecosystem due to the widespread use of N fertilizers in fertile crops, and also intensive and extensive livestock that creates large amounts of urine waste on agricultural land [5].
Although there are many challenges in rainfed lowland agroecosystems, there is wide scope for growing post-rainy season crops through proper soil moisture conservation and bio-systems engineering approaches. The purpose of this study was to evaluate the nutritional value of agricultural waste forage used as ruminant feed with a complete feed formula in rainfed land agro-ecosystems.

2. Materials and methods
The study was carried out in rainfed rice fields at the Loh Jinawi III Farmers Group in Boloh Village, Toroh District, Grobogan Regency. The implementation time was from January to December 2019. The materials used were agricultural waste of rice straw, corn stover, and soybean straw according to the growing season and tofu by-products (tofu and soy sauce).

Production of agricultural waste (tons of dry matter/year), i.e. rice straw, corn straw, and soybean straw was 5.95, 6, and 2.79 [1]. The calculation of agricultural waste carrying capacity according to [6] is the following:

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\text{dry matter carrying capacity} = \frac{\text{Dry matter production}}{\text{Dry matter requirement}} \frac{\text{kg}}{\text{AU/year}}
\]

The nutritional value of complete feed from agricultural waste was analyzed using procedures according AOAC method to measure the content of crude protein, crude fat, fiber, and ash [7].

3. Results and discussion
The complete feed was made using agricultural waste raw materials available on site, so that the complete formula and nutrient content of the feed are adjusted to the availability of agricultural waste (Table 1).

| Materials          | Formula I | Formula II | Formula III | Formula IV |
|--------------------|-----------|------------|-------------|------------|
| Rice brand         | 20.00     | 6.63       | 5.22        | 4.42       |
| Tofu waste         | 15.00     | 11.06      | 8.72        | 7.38       |
| Waste soy sauce    | -         | 10.24      | 8.07        | 6.83       |
| Molasses           | 5.00      | 2.39       | 1.88        | 1.59       |
| Salt               | 1         | 0.41       | 0.32        | 0.27       |
| Mineral mix        | 1         | 0.40       | 0.32        | 0.27       |
| Starter            | -         | 0.20       | 0.16        | 0.13       |
| Maize silage       | 28.00     | 32.00      | 25.26       | 36.80      |
| Rice straw silage  | -         | -          | 50.04       | 42.31      |
| Soybean by product | 30.00     | 36.61      | -           | -          |
| Total              | 100.00    | 100.00     | 100.00      | 100.00     |

**Nutrient content *)**:
- Moisture: 11.13, 43.28, 62.76, 57.99
- Crude protein: 7.96, 17.19, 7.44, 8.03
- Crude fiber: 27.15, 17.88, 46.64, 52.55
- Crude fat: 2.03, 1.06, 1.70, 2.83
- Ash: 15.96, 14.30, 16.60, 12.43
- Total digestible nutrients: 58.73, 59.62, 41.53, 37.99

*) Results of proximate analysis, Laboratory of Nutrition and Feed Science, Faculty of Animal Husbandry and Agriculture, Diponegoro University 2019.
The complete feed formula shows that formula II has a higher nutrient content than other formulas because it uses soybean straw waste and the by-products of tofu and soy sauce with a crude protein content of 17.19 and a TDN of 59.62. Other feed formulas show low nutrient content because of high use of rice straw in which the nutrient content is low.

The use of agricultural waste biomass will increase nutritional value and digestibility if fermented with fungi because fungi is able to break down lignin in rice and corn straw into structures that are easily digested by ruminants [8]. Making complete fermented feed with yeast for ruminants can improve performance, and it is environmentally friendly because it reduces methane production [9]. This study used lactic acid bacteria to improve the quality of complete fermented feed from agricultural waste feed ingredients [10]. The addition of lactic acid bacteria to complete fermented feed had a positive effect on the enrichment of bacteria on silage quality [11].

The area of paddy fields in Toroh District is divided into 2613 ha of irrigated land and 2850 ha of rainfed land. With cattle population of 18395 AU, the need of feed is 41963.59 tons/year. The production of agricultural waste from rice straw, corn stover, and soybean straw is shown in Table 2. This shows that in Toroh District, the waste of rice and corn straw is still able to support cattle, while soybean straw waste is not able to support cow feed. Farmers plant rice twice a year and then in the dry season they plant corn and soybeans. However, the soybean harvest area begins to decline due to the low selling price of soybeans.

| Agricultural waste | Production (dry matter ton / year) | Feed requirements (Dry matter ton / year) | Carrying capacity (Animal Unit) |
|--------------------|----------------------------------|------------------------------------------|-------------------------------|
| Rice straw         | 86858.10                         | 41963.59                                 | 2.07                          |
| Maize              | 77304.00                         | 41963.59                                 | 1.84                          |
| Soybean straw      | 4047.71                          | 41963.59                                 | 0.10                          |

Financially, the price of complete fermented feed is relatively cheap. For example, the price of formula II feed using agricultural waste is Rp 2,800 per kg (Table 3).

| Feed ingredients       | Amount (kg) | Price (Rp) |
|------------------------|-------------|------------|
| Soybean straw @ Rp 500 / kg | 36.60       | 18,300     |
| Corn stover @ Rp 100 / kg     | 32.10       | 3,210      |
| Tofu waste @ Rp 1000 / kg    | 10.20       | 10,000     |
| Rice brand @ Rp 3000 / kg    | 6.60        | 19,800     |
| Waste soy sauce @ Rp 2500 / kg | 11.10     | 27,750     |
| Mollases @ Rp 7000 / kg      | 2.40        | 15,000     |
| Mineral mix @ Rp 7000 / kg   | 0.40        | 2,800      |
| Starter (Biofad) @ Rp 15000 / kg | 0.20    | 3,000      |
| Salt @ Rp 12500 / kg         | 0.40        | 5,000      |
| Fuel @ Rp 8000 / liter       | 0.51        | 4,000      |
| **Sub-Total**               | **100.0**   | **108,000**|
| Labors                     |             | 170,000    |
| **Total**                  |             | **278,800**|
| **Price per kg**           |             | **2,789**  |

The use of feed ingredients from agricultural waste for ruminant feed will increase the efficiency of feed costs. The use of compost from livestock feces as organic fertilizer on agricultural land can improve soil structure and the efficiency of fertilization costs.

Bioconversion of agricultural waste will increase soil pH, conditions of cation exchange capacity, availability of the N and P main elements for plants [12].
4. Conclusion
Studies in complete fermented feed formulas with agricultural waste material show that feed formulas with soybean straw waste have a higher nutritional value than rice and corn straw. Complete fermentation of feed can increase feed efficiency. The carrying capacity of soybean straw at the location of the activity is not sufficient for cow/ruminant feed.

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