Determinants of rice by-product utilization as a potential local feed for ruminants in Magelang Regency, Indonesia

N A A Widarni1, A Astuti2, S Andarwati1, T A Kusumastuti1 and A R S Putra1*

1 Department of Livestock Social Economics, Faculty of Animal Science, Universitas Gadjah Mada, Sleman, Yogyakarta, Indonesia
2 Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Sleman, Yogyakarta, Indonesia

Corresponding author: ahmadromadhoni@ugm.ac.id

Abstract. This study was conducted to determine the factors that influence farmers in using rice straw as feed for their ruminants. Primary data was obtained from a survey through face-to-face interviews involving a total of 395 farmers as respondents in Magelang Regency, Central Java, Indonesia. Farmers were selected by multistage random sampling. The data, then, were analyzed by using logistic regression. The results showed that 45.06% (178 respondents) used rice straw as feed, where only 3.37% (6 respondents) adopted the fermented straw. The type of ruminant kept by farmers, the amount of training attended, and land size affected the rice straw utilization as ruminants feed. Adopters of rice straw utilization are farmers who maintain large ruminants and tend to manage large areas of land. This finding also revealed that providing continuous training on feed technology for farmers is important. Furthermore, periodic assistance by extension workers is needed to enhance farmers in adopting the innovation of agricultural technology.

1. Introduction

Indonesia’s total rice production over the last 4 years, from 2014-2018, continued to increase with an average of 4.07% annually [1]. Approximately 53.04% of Indonesian total rice is from Java Island, where Central Java Province occupies the second highest producer. An increase in rice production makes total rice by-products also escalate up to 78% over the last 30 years [2]. Therefore, management of rice straw resources is gaining attention due to the abundance of rice straw.

Previous studies reveal about 62% of rice straw is burned in the farmland [3,4]. Burning is the fastest and most cost-effective method of disposing straw, without requiring additional input and labor [5]. Burning may help to reduce disease that may occur due to reinfection from inoculum in the straw biomass [5,6]. However, the burning method causes severe air pollution by releasing a large number of air pollutants [7]. The rice straw burning also affects atmospheric visibility, health problems, and global climate change [5,8].

Large quantities of rice straw resources actually provide a great potential feed for livestock, partially for ruminants [9]. The utilization of rice straw as fodder means converting agricultural waste into renewable resources, which is one form of sustainability practice [10]. Unfortunately, the use of rice straw for livestock feed only reaches 31%, while about 7% is used as raw material for small industries [3,4,11]. The utilization of agricultural straw in Indonesia is low when compared to India, which has
reached 50%-60% [12]. Therefore, the use of rice straw for fodder needs to be increased in order to reduce the amount of straw burned by disseminating straw utilization technologies.

From the theories and literature, the factors influencing rice straw utilization behavior could be affected by personal or farmer characteristics, farm business size, and access to information [13,14]. Personal characteristics such as age, education, farming experience, and household size affect the feed adoption of rice straw [13,15]. Farmers have access to information and knowledge by contacting extension workers, participating in training and joining groups [11,16]. Farm size such as total area cultivated, livestock ownership, tenure status, and number of livestock is related to farmer’s feed adoption of rice straw [11,13]. Given the above-mentioned literature, this study aimed to analyze factors that affected the adoption of rice straw utilization as ruminant feed.

2. Materials and methods

A household survey method was conducted with a cross-sectional approach. The survey was carried out in 7 sub-districts (i.e., Bandongan, Candimulyo, Kaliangkrik, Ngluwar, Salam, Sawangan and Windusari) as representative areas of Magelang Regency. Magelang Regency is one of the well-known districts in Central Java Province which have agricultural intensification and beef cattle development programs. Primary data was collected from February to September in 2019. Data collection was obtained by using a structured questionnaire, which was distributed randomly to 395 farmer households as respondents. All questions were asked through face-to-face interviews.

Data from the survey included information on farmer characteristics (age, formal education, farming experience, household size, main income, and side job), farm characteristics (family labor, ruminant type, number of livestock, total land area, also ownership of livestock and land), and farmer access on information (such as join farming group, have access to extension agents, and amount of training). Table 1 shows all variables that were used as determinants of the utilization of rice straw as feed.

| Table 1. List of variables |
|---------------------------|
| Variable’s name           | Definition                              | Data type |
| Independent variables     |                                         |           |
| Age                       | Age of household main farmer in years   | Continues |
| Formal education          | Household main farmer spent time on formal education in years | Continues |
| Farming experience        | Farming experience of household main farmer in years | Continues |
| Household size            | Number of family members in a household | Continues |
| Family labor              | Family members in a household help the main farmer = 1; otherwise = 0 | Dummy |
| Main income               | Household main income is farming = 1; otherwise = 0 | Dummy |
| Side job                  | Household main farmer has non-farming job = 1; otherwise = 0 | Dummy |
| Length of membership      | Length of membership and involvement in farming organizational in years | Continues |
| Amount of training        | Number of feed processing training      | Continues |
| Extension agents          | Seek information from extension agents privately = 1; otherwise = 0 | Dummy |
| Ruminant type             | Keep large ruminant = 1; keep small ruminant = 0 | Dummy |
| Livestock number          | Number of livestock in TLU (topical animal unit) | Continues |
| Livestock ownership       | Farmer keep their own ruminants = 0; otherwise = 0 | Dummy |
| Land Size                 | Farming size in hectare (ha)            | Continues |
| Land tenure               | Land where managed by farmer is their own land = 1; otherwise = 0 | Dummy |
| Dependent variable        |                                         |           |
| Feed utilization          | Farmer utilize rice straw as ruminant feed = 1; otherwise = 0 | Dummy |

Data, then, were analyzed with descriptive statistics, unpaired t-test and logistic regression analysis. Descriptive statistics analysis was used to identify the profile of the respondents. Unpaired t-test analysis was used to differentiate the mean of continuous variable between adopter and non-adopter of rice straw utilization as fodder. Binary logit is used to analyze the factors that determine the adoption of its utilization. The binary logit model is a regression model used to analyze the dependent variable with a
probability between 0 and 1 [17]. The utilization of rice straw as ruminant feed delivers two outcomes, which is non-adopter farmer as 0 and adopter farmer as 1. The logit model equation used in this study is written as follows:

\[ Pr(Y = 1) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p + e \]

where \( Pr(Y=1) \) is the probability of the utilization of rice straw as fed by individual farmers given the independent variables \( X_1, X_2, \ldots, X_p \). \( \alpha \) stands for an intercept. \( e \) represents the disturbance term that refers to uncertainty factors.

3. Result and discussion

3.1. Respondent profile

Through a descriptive statistics analysis, characteristics of the respondents can be identified. Table 2 represents the descriptive statistics of the respondents, disaggregated by their choice of rice straw utilization. As seen in Table 2, the average age of total main farmers is 54.68 years old. The average age of adopters is younger than the mean age of non-adopters, but there is no statistically significant difference between them. Most of the farmers had a primary school education. Adopter farmers have a higher education than non-adopter farmers significantly. Higher mean values and statistically significant differences between the mean of adopters and non-adopters are also observed for length of membership, amount of training, livestock number, and land size. This indicates that adopter farmers have more information and larger farm size compared to non-adopter farmers.

**Table 2. Characteristics of the respondents: continues variables**

| Variable’s name               | Total of respondents n = 395 | Adopters (1) n = 178 | Non-adopters (0) n = 217 | diff (1-0) |
|-------------------------------|-----------------------------|----------------------|--------------------------|------------|
| Age                           | 54.68 [(10.39)]             | 53.85 [(10.69)]      | 55.35 [(10.10)]               | -1.49      |
| Formal education              | 6.93 [(3.25)]               | 7.44 [(3.28)]        | 6.52 [(3.17)]               | 0.93**     |
| Farming experience            | 23.20 [(16.22)]             | 23.68 [(15.93)]      | 22.79 [(16.47)]             | 0.91       |
| Household size                | 4.08 [(1.51)]               | 4.11 [(1.45)]        | 4.05 [(1.56)]               | 0.07       |
| Length of membership          | 6.55 [(7.75)]               | 7.40 [(8.30)]        | 5.85 [(7.21)]               | 1.55**     |
| Amount of training            | 0.53 [(0.04)]               | 0.80 [(1.01)]        | 0.31 [(0.63)]               | 0.48***    |
| Livestock number              | 0.68 [(0.59)]               | 0.92 [(0.70)]        | 0.49 [(0.43)]               | 0.42***    |
| Landsize                      | 0.28 [(0.24)]               | 0.33 [(0.31)]        | 0.24 [(0.16)]               | 0.09***    |

*** and ** = significant at level 1% and 5%, respectively.

diff (1-0) is the mean difference score between adopters and non-adopters in unpaired t-test analysis.

Table 3 presents the distribution of binary independent variables. As seen in Table 3, both adopters and non-adopters rely on family members to provide farming labor. The small scale of farm size causes farmers unable to hire farm workers. Besides, using family members as farm workers, farmers will not incur daily or seasonal expenses like using hired workers. Only few farmers approximately 25.84% and 11.52% from adopter and non-adopter farmers seek extension agents privately for consultation, respectively. Then, among the adopter group, 93.82% farmers keep large ruminants (beef cattle) and 6.18% keep small ruminants (sheep and goat). More than half of the respondents’ own livestock and
crop land by themselves. All of the respondents are categorized as small-scale farmers which have a small number of livestock and manage farmland less than 2 hectares.

### Table 3. Characteristics of the respondents: dummy variables

| Variable’s name            | Category          | Total of respondents | Adopters (1) n = 178 | Non-adopters (0) n = 217 |
|----------------------------|-------------------|----------------------|-----------------------|---------------------------|
|                            |                   | n | %      | n | %      | n | %      |
| Family labor               | Yes               | 225 | 56.96 | 97 | 54.49 | 128 | 58.99 |
|                            | No                | 170 | 43.03 | 81 | 45.51 | 89  | 41.01 |
| Main income                | Yes               | 325 | 82.28 | 144 | 80.90 | 181 | 83.41 |
|                            | No                | 70  | 17.77 | 34 | 19.10 | 36  | 16.59 |
| Side job                   | Yes               | 219 | 55.44 | 97 | 54.49 | 122 | 56.22 |
|                            | No                | 176 | 44.56 | 81 | 45.51 | 95  | 43.78 |
| Extension agents           | Yes               | 71  | 17.97 | 46 | 25.84 | 25  | 11.52 |
|                            | No                | 324 | 82.03 | 132| 74.16 | 192 | 88.48 |
| Ruminant type              | Large ruminant    | 198 | 50.13 | 167| 93.82 | 30  | 13.82 |
|                            | Small ruminant    | 197 | 49.87 | 11 | 6.18  | 187 | 86.18 |
| Livestock ownership        | Own               | 274 | 69.37 | 121| 67.98 | 153 | 70.51 |
|                            | Joint ownership   | 121 | 30.63 | 57 | 32.02 | 64  | 29.49 |
| Land tenure                | Own               | 235 | 59.49 | 101| 56.74 | 134 | 61.75 |
|                            | Rent              | 160 | 40.51 | 77 | 43.26 | 83  | 38.25 |

3.2. **Determinants influence the utilization of rice by-products**

A logit regression was conducted by using Stata 14, and the result is represented in Table 4. The pseudo $R^2$ of the model is 0.5815 indicating that the explanatory variables in the model affect the rice straw utilization by 58.15%. Based on the analysis, the factors positively influencing the utilization of rice by-products were ruminant type, amount of training, and total area of crop land.

### Table 4. Results of logistic regression

| Variable’s name          | Coef. | St. Err | z    | P value |
|--------------------------|-------|---------|------|---------|
| Age                      | -0.020| 0.022   | -0.94| 0.349   |
| Formal education         | 0.031 | 0.063   | 0.50 | 0.618   |
| Farming experience       | 0.006 | 0.013   | 0.49 | 0.624   |
| Household size           | 0.153 | 0.119   | 1.28 | 0.201   |
| Family labour            | 0.222 | 0.380   | 0.58 | 0.559   |
| Main income              | 0.308 | 0.499   | 0.62 | 0.538   |
| Side job                 | -0.356| 0.411   | -0.87| 0.386   |
| Length of membership     | -0.032| 0.022   | -1.44| 0.150   |
| Extension agents         | 0.013 | 0.533   | 0.03 | 0.980   |
| Amount of training       | 0.829 | 0.288   | 2.87 | 0.004***|
| Ruminant type            | 4.678 | 0.435   | 10.76| 0.000***|
| Livestock number         | 0.235 | 0.366   | 0.64 | 0.521   |
| Livestock ownership      | -0.133| 0.404   | -0.33| 0.743   |
| Land Size                | 1.645 | 0.983   | 1.67 | 0.094*  |
| Land ownership           | -0.482| 0.389   | -1.24| 0.216   |
| Constanta                | -3.380| 1.607   | -2.10| 0.035   |
| Number of observations   | 395   |         |      |         |
| LR chi2(15)              | 316.20|         |      |         |
| Prob>chi2                | 0.0000|         |      |         |
| Pseudo R2                | 0.5815|         |      |         |

***, **, and * = significant at level 1%; 5%; and 10%, respectively.
Farmers who keep large ruminants (beef cattle) tend to utilize rice straw as fodder by 10.76 times compared to farmers who keep small ruminants (goats and sheep). This is related to the ability of large ruminants to digest crude fiber better than small ruminants [18,19]. Trained farmers are more likely to utilize rice straw as fodder. Training is usually conducted with practical demonstrations and exercises that are offered by extension agents. Although, in this study, farmers rarely consult their farming problem privately to extension officers, they still play an important role in demonstrating technical practices. A previous study reveals that practical training facilitates the decision-making process of rice by-products utilization [20]. This type of training usually involves participatory approaches where farmers learn through observation and practice [21]. Landsize also determines the adoption of rice straw as feed. The increase of farmland that is managed by farmers will increase the adoption of rice straw utilization.

In this study, about 45.06% respondents utilize rice by-products as fodder for their ruminant. Among them, only 3.37% adopters carried out straw fermentation. Farmers who dry and chop rice straw are about 19.66%. The common rice straw processing is chopping with 76.97%. This indicates that the adoption of rice by-products technologies is relatively low. From the literature, the major constraints of rice straw utilization as ruminant feed are the sufficient of the other feed resources such as forages, shortage of labor to collect straw, no storage place for feed, lack of inputs (e.g., chemicals and bacteria), and lack of skill and awareness on utilization [9,11]. Lack of skill and awareness on utilization may be enhanced by providing continuous technical training in feed technology [21]. Social assistance, mentoring, and coaching need to be carried out by extension workers to assist farmers in gaining insight and overcoming obstacles that farmers may face while adopting the agricultural technologies [21,22].

4. Conclusion
We assume that the technology adoption of rice straw utilization was relatively low in Magelang Regency. The utilization of rice by-products as ruminant feed by farmers was positively related to their characteristics such as ruminant type, amount of training, and total area of farm land. It reveals that there is a need for providing continuous training in feed technology, as well as periodic assistance carried out by extension workers.

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