The potential of cassava-goat integration in aerial and fertilizer production in Lampung

Potensi integrasi singkong-kambing dalam produksi aerial dan pupuk di Lampung

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This study aimed to evaluate the integration potential of cassava plants with goats in aerial production and goat manure-derived fertilizers. This research was conducted by purposive sampling with the consideration that Lampung Province is the central region of cassava production in Indonesia and is the region with the highest population of goats outside Java Island. Sampling was carried out in Central Lampung and East Lampung with high-production cassava and goats. Analysis using LQ, FPCI, carrying capacity, and fertilizer production from goat manure. The data obtained was then presented descriptively. The results showed that FPCI was located in Central Lampung, East Lampung, North Lampung, Tulang Bawang, and Tulang Bawang West. The highest aerial carrying capacity of cassava, 31.6%, was concentrated in Central Lampung, thereby affecting the livestock carrying capacity. LQ analysis obtained showed that around 66.7% of the area in Lampung was a goat livestock base. The highest production of fertilizer from goat manure was obtained by South Lampung, which covers around 24.5% of the total area of Lampung. The conclusion from this study was that areas that have potential for development supported by the provision of feed sourced from aerial sources from cassava plant waste if integrating cassava plants and goat livestock were East Lampung, Central Lampung, North Lampung, Tulang Bawang, and Tulang Bawang Barat districts.

INTRODUCTION

The development of agribusiness-based countries to face free competition needs to increase the ability to produce good products, especially livestock commodities. This situation needs support for the utilization of regional resource factors, especially livestock because it is an inherent livelihood for farmers in Indonesia. Livestock that has the potential to be developed, especially in Lampung Province, such as goats, considering that Lampung Province is an area with the largest population of goats outside Java Island. The report (DITJENPKH, 2022) states that the national goat population will be 18.9 million in 2021, while the population in Lampung Province is 1.6 million or 8.5% of the national population. The prospect of small ruminant livestock to fulfill the domestic market requires at least 5.6 million head/year taking into account the birth rate of 1.22% as a result of religious activities, as well as being open for export to neighboring countries which have not been fulfilled (BPS, 2022; Maesya & Rusdiana, 2018).

The potential for goat farming in Lampung is because it is close to market access (Java Island and other parts of Sumatera) and supports feed sources from cassava waste. The total area of cassava was 222,746 hectares, with 2021 production of 5.64 million tonnes/year and a national production of 15.73 million ton/year which accounts for one-third of national production (KEMENTAN, 2022). The ratio of the top of the cassava plant to the tubers at harvest reached 1:1 to 3:2. When 25% of the plant proportion is used as a feed from the top of the plant, it has the potential to produce 3.34 million tonnes of feed/year. Upper waste is generally highly available at any given time. Preservation technology was needed, as well as techniques to reduce cyanide, namely with silage, hay, and complete feed silage (Basri et al., 2015; Ndaru et al., 2014; Sandi et al., 2018).

Limited land, management, capital, and technology lead to low goat productivity. The main problem with the low productivity of goats was caused by the availability of feed sources, and the lack of nutritional quality, especially during the dry season. Goat productivity in Lampung was reported to be 46.58 g/head/day (Basri et al., 2015); 52.77 g/head/day (Artanti et al., 2019) lower than in other areas 98.2 g/head/day (Rudiah, 2011); 160.12 gr/head/day (Sabaha et al., 2018). Therefore, a strategy is needed to increase the productivity of beef goats by providing adequate feed in quality and quantity. Forage feed from cassava waste in the form of leaves was reported to have a crude protein content of 19.8% and a combination of leaves and stems of 12.76% (Suharti et al., 2017); ether extract of 1.8%, crude fiber of 33.7% (Fanani et al., 2022).

The management of livestock and crops by farmers tends to be sub-sectoral which runs on its own, so that income becomes less than optimal. In addition, the conversion of agricultural land due to population growth is increasing. This is a problem because of reduced productive land but the need for food continues to increase. Even though it has been controlled by Law no. 41 of 2009 concerning the Protection of Sustainable Food Agricultural Land, the area of agricultural land in 2014 from 36.89 million Ha to 34.83 million Ha in 2018 shrank by 5.6% (DPR RI, 2023; KEMENTAN, 2023). In addition to area shrinkage, cassava productivity in Lampung has also decreased from 26.4 tons/ha in 2014 to 26 tons/ha in 2018 (KEMENTAN, 2020). Cultivation of cassava in Lampung is mostly done on dry land which has a deficiency of low nutrient content. The report of Prabowo et al. (2015) was cassava farmers in Lampung sometimes do not apply the use of organic fertilizers. Even though returning crop residues as organic fertilizer to the land provides higher yields than just chemical fertilizers (Radjit et al., 2014).

Therefore, the development of efficient sustainable livestock must go hand in hand and complement each other with agriculture. The application of a system that was suitable for the...
situation of farmers needed to be developed so that it became a comprehensive plan to increase motivation and optimize production and benefits (Tani, 2017). One solution that can be adopted is the utilization of regional resources by integrating goats and cassava, where cassava waste is used as goat feed while goat manure is used for fertilizer which is an important element needed by plants and improving soil nutrients. Based on the above, it is necessary to evaluate the potential of goat livestock and cassava plant integration systems in the production of aerial cassava and goat manure.

MATERIALS AND METHODS

Location and Time of Research
The research was carried out in Lampung Province in January-February 2021. Location determination purposive sampling takes into account the areas that have an average production of goat meat, the existence of cassava land which is commonly cultivated on dry land, and the highest number of goat populations outside Java Island.

Data Collection
Primary data collection of waste sampling was carried out in East Lampung and Central Lampung which are production areas located in Lampung. Secondary data sources were collected from related agencies including statistical data on an overview of the area, land potential, cassava plant resources, and livestock. Supporting data were study reports and various literature sources related to this research.

Data Analysis Methods
Analytical method of Location Quotient (LQ) which functions to determine the basis and non-base of a commodity in an area in the same sub-sector and the LQ formula used was as follows:

\[ LQ = \frac{R_i}{R_t} \frac{N_i}{N_t} \]

Information: \( R_i \) = value of commodity i (goat) in sub-district, \( R_t \) = total ruminant livestock sub-sector in sub-district, \( N_i \) = value of commodity i (goat) in the district, \( N_t \) = total ruminant livestock sub-sector in the district (Fanani et al., 2020).

Aerial production of cassava (stems, stalks, leaves) was cut 40 cm above the ground as well and waste carrying capacity was calculated for the production of DM, CP, and TDN of cassava aerial/ha multiplied by the cassava land and divided by the demand for animal feed for a year (Rab et al., 2016). Assuming the requirement for 1 animal unit (AU) is equivalent to an adult cow weighing 450 kg ADG 0.5 kg with a consumption of 9.1 kg DM/day (Kearl, 1982). The basis of the regional ability to produce aerial was the value of the feed production concentration index (FPCI) obtained from the district crop waste production divided by the provincial average crop waste production (Mariam & Syamsu, 2021). Regency areas with FPCI values ≥ 1 were areas that had superior production with a high category in the type of plant waste compared to other regions. Goat manure production was obtained by multiplying the number of livestock (AU) by goat feces production (kg/day), while nutrient production was obtained from the total goat manure production multiplied by each nutrient value of goat feces (%).

The data obtained was presented descriptively. This method was used to determine the character of research observations as well as a benchmark in continuing research and was the fastest analysis to describe conditions in the field (Suhardi et al., 2023).

RESULTS AND DISCUSSION

Aerial Production of Cassava Plants
Based on aerial production surveys of cassava plant waste, the average of fresh yield, DM, CP, and TDN was shown in Table 1. Data on the harvested area of cassava plant waste was calculated for the fresh yield of waste production. The total fresh yield of cassava plant waste in Lampung Province was 2.46 million tons, or an average of 11.84 tons/ha, with DM production of 677.7 thousand tons. Based on TDN production, cassava plant waste in Lampung was 380.4 thousand tons and the amount of CP production was 85.7 thousand tons. The production of CP and TDN in cassava plant waste was related to the CP content and TDN of the plant waste; therefore its use as an animal feed ingredient requires other feed ingredients. According to Kurniawan et al. (2021), that the factor that could affect livestock growth was feed. Furthermore, in animal husbandry, the availability of feed is a problem that is often encountered (Abadi et al., 2019; Wardah & Poernomo, 2020).
The production of cassava plant waste for each district in the table above showed that the largest production contribution from the provinces sequentially was Central Lampung Regency with 29.21% (214,029 tons of DM), North Lampung 22.14% (131,901 tons of DM), East Lampung 18.78% (122,527 tons of DM). Nearly three-quarters of cassava plant waste production in Lampung was in these three districts. The high production of cassava plant waste was caused by the high area of cassava plants which affected the production of DM and TDN. It was further reported that aerial cassava contains CP and TDN respectively 15.3 g/100 g and 61.3 g/100 g (Fanani et al., 2022).

The results of the feed production concentration index on cassava plant waste were calculated based on DM production. The production of cassava plant waste was in the high production category in Central Lampung, North Lampung, East Lampung, Tulang Bawang, West Tulang Bawang, and the medium production category, in Way Kanan. The high FPCI value was due to the fact that the basis for the development of cassava plants was in the central part of Lampung to the east, supported by the presence of a tapioca processing factory. FPCI value ≥ 1 was an area that had a high production advantage compared to other regions (Mariam & Syamsu, 2021).

### Carrying Capacity of Cassava Aerial

The carrying capacity of cassava plant waste is the ability of the region to provide feed from food crop waste, which can accommodate a number of livestock based on forage production. Carrying capacity was a comparative method utilizing forage sources (Wantasen et al., 2016). Calculating the carrying capacity of cassava plant waste was carried out using the assumption that 1 animal unit (AU) equivalent to the weight of a 450 kg adult cow which requires 9.6 kg/day of dry matter, 0.67 kg/day of crude protein and 5.1 kg/day total digestible nutrient (Kearl, 1982). The carrying capacity analysis was carried out based on the consumption of these assumptions and the availability of cassava plant waste in each region.

The results of the carrying capacity analysis are presented in Table 2. Based on the analysis of the cassava plant waste production, Lampung Province had great potential. Lampung Province could provide feed for goats in Lampung based on the carrying capacity with a DM basis of 193,420...
AU or the equivalent of 1.4 million small ruminants, as well as 350,058 AU and 204,361 AU based on CP and TDN, respectively. Each carrying capacity of DM, CP, and TDN showed a different value based on livestock needs. The region that had the highest carrying capacity compared to other districts was Central Lampung with the carrying capacity of cassava plant waste based on dry matter was 31.6% of the province’s availability. Meanwhile, the lowest carrying capacity of cassava plant waste in Lampung Province is Bandar Lampung City and Metro because they are administrative cities. Lampung Province had potential from plant waste of aerial cassava and strategic geography in the development of ruminants, especially goats (Bilyaro & Lestari, 2022; Fanani et al., 2020; Sirat et al., 2022; Habsari & Irwani, 2021).

The calculation between the carrying capacity of cassava plant waste (AU) and the number of goat livestock (AU) in each district was used to determine the carrying capacity index of cassava plant waste. The division of the carrying capacity index category was into 4 namely safe, vulnerable, critical, and very critical (Jumiyanti, 2018). It could be seen that the districts included in the safe category were Central Lampung, North Lampung, East Lampung, Tulang Bawang, and West Tulang Bawang. The vulnerable category was Way Kanan Regency and the rest were critical and very critical categories. Safe and critical areas were districts that were able to provide feed sources from cassava plant waste for goats so that they could still maximize the potential of cassava plant waste for livestock. Regions in the low and very low categories were because the district was not an area for developing cassava plants with more coffee, banana, and cocoa commodities which tend to dominate the central region to the south and the topography was uneven (BPS, 2022). Food crop waste was a source of feed for livestock that could be utilized, so adequate feed availability was needed to obtain optimal livestock yields (Rusdiana & Praharani, 2019; Agustono et al., 2017; Khalil et al., 2017).

### Total Population of Goats and Location Quotient

The goat population in Table 3 was based on an analysis of the goat population according to the animal age and animal unit of population in the Lampung Province, which was 142,972 AU. The total goat population, which reaches 95%,
was dominated by the small ruminant population. Regencies with high populations were South Lampung of 32,885 AU; Central Lampung at 22,009 AU; Tanggamus at 17,166 AU; and East Lampung at 15,090 AU.

LQ analysis was used to predict the ability of livestock commodities in a district area to serve as a base location for the same sub-sector coverage at the provincial level. Based on the comparative advantage mapping, the LQ value > 1 was obtained, for the districts based on goat livestock, such as West Lampung, Tanggamus, South Lampung, North Lampung, Tulang Bawang, Pesawaran, Pringsewu, Mesuji, West Tulang Bawang, and Bandar Lampung. Thus, it could be seen that the sub-districts in Central Lampung Regency were not the basis for goats by 33.3%. The region showed the potential as a supplier that had advantages over other regions. A high level of specialization compared to the reference area was a category in the base area (Jumiyanti, 2018; Hajeri et al., 2015). There were factors that could influence livestock development and population including environmental potential which were feed availability, socio-cultural conditions, and breeder characteristics (Ikun, 2018).

### Production of Goat Fertilizer and Nutrients

The analysis of manure production from goat manure was calculated based on total goat livestock (AU) multiplied by a coefficient of 2.4 kg/AU/day, then linked to the nutrient content of nitrogen (N), phosphate (P), and potassium (K) in the fertilizer. Based on Table 4, the production of manure in Lampung was as much as 117,808 tons/year, and the production of N, P, K were 2,014.5 tons/year, 506.6 tons/year, and 801.1 tons/year, respectively. The highest district production was in South Lampung with production reaching 24.5%, followed by Central Lampung with 16.4% of provincial production.

The role of fertilizer produced from goat manure was as a source of nutrients for plants and to improve the biological condition of the soil as a growing medium (Junaidi & Tyasmoro, 2022; Hartatik et al., 2015). It was explained that the addition of organic matter was used to maintain and increase soil fertility in Lampung so that cassava productivity increased (Soelaeman & Haryati, 2012). Furthermore, the aerial waste of the cassava plant was used as goat feed, so there was a symbiosis between sub-sectors.

The application of crop-livestock

### Table 3. Goat population in 2021 and LQ in Lampung Province

<table>
<thead>
<tr>
<th>Regency</th>
<th>Amount</th>
<th>Percentage from province</th>
<th>LQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Child</td>
<td>Time</td>
<td>Mature (AT)</td>
</tr>
<tr>
<td>West Lampung</td>
<td>747</td>
<td>1,721</td>
<td>4,854</td>
</tr>
<tr>
<td>Tanggamus</td>
<td>1,713</td>
<td>3,947</td>
<td>11,134</td>
</tr>
<tr>
<td>South Lampung</td>
<td>3,359</td>
<td>7,739</td>
<td>21,831</td>
</tr>
<tr>
<td>East Lampung</td>
<td>1,616</td>
<td>3,723</td>
<td>10,503</td>
</tr>
<tr>
<td>central Lampung</td>
<td>2,700</td>
<td>6,219</td>
<td>17,544</td>
</tr>
<tr>
<td>North Lampung</td>
<td>666</td>
<td>1,534</td>
<td>4,328</td>
</tr>
<tr>
<td>Way Kanan</td>
<td>489</td>
<td>1,127</td>
<td>3,179</td>
</tr>
<tr>
<td>Onion bones</td>
<td>1,071</td>
<td>2,467</td>
<td>6,959</td>
</tr>
<tr>
<td>offer</td>
<td>502</td>
<td>1,157</td>
<td>3,265</td>
</tr>
<tr>
<td>Pringsewu</td>
<td>399</td>
<td>919</td>
<td>2,591</td>
</tr>
<tr>
<td>Mesuji</td>
<td>406</td>
<td>934</td>
<td>2,636</td>
</tr>
<tr>
<td>West Onion Bones</td>
<td>695</td>
<td>1,600</td>
<td>4,515</td>
</tr>
<tr>
<td>West Coast</td>
<td>71</td>
<td>165</td>
<td>464</td>
</tr>
<tr>
<td>Bandar Lampung</td>
<td>28</td>
<td>64</td>
<td>181</td>
</tr>
<tr>
<td>Metro</td>
<td>124</td>
<td>285</td>
<td>804</td>
</tr>
<tr>
<td>Amount</td>
<td>14,586</td>
<td>33,600</td>
<td>94,786</td>
</tr>
</tbody>
</table>

Note: AU = animal unit; LQ = Location Quotient
integration was faced with two phenomena. On the one hand, agriculture was required to provide fast food, so it was highly exploratory for existing natural resources. On the other hand, there was a correction to the agricultural model, which indicates the need for sustainable agro-ecosystem-based agricultural development (Lagiman, 2020; Arham et al., 2019). The crop-livestock integration system needed to consider aspects of sustainability that were environmentally friendly, socially acceptable to the community, economically feasible, and politically acceptable (Anwar, 2022; Ningsih & Sjaf, 2015; Suhendrata, 2020). Therefore, agricultural development in an integrated manner, when carried out by farmers, would provide a synergy effect between branches of farming, such as food crops, livestock businesses and maybe even other commodities, so that the application of integration needed to pay attention on the carrying capacity of an area.

**CONCLUSION**

Areas that have the potential to develop goat livestock with the support of providing feed sourced from aerial sources of cassava plant waste during the integration of cassava plants and goat livestock were the regencies of East Lampung, Central Lampung, North Lampung, Tulang Bawang, and Tulang Bawang Barat.

**REFERENCES**


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**Table 4. Manure production, N production, P production, and K production**

<table>
<thead>
<tr>
<th>Regency</th>
<th>Manure</th>
<th>N production</th>
<th>P production</th>
<th>K production</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Lampung</td>
<td>6,508</td>
<td>111.29</td>
<td>27.99</td>
<td>44.26</td>
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<tr>
<td>Tanggamus</td>
<td>15,038</td>
<td>257.14</td>
<td>64.66</td>
<td>102.26</td>
</tr>
<tr>
<td>South Lampung</td>
<td>28,807</td>
<td>492.6</td>
<td>123.87</td>
<td>195.89</td>
</tr>
<tr>
<td>East Lampung</td>
<td>13,219</td>
<td>226.04</td>
<td>56.84</td>
<td>89.89</td>
</tr>
<tr>
<td>Central Lampung</td>
<td>19,280</td>
<td>329.69</td>
<td>82.9</td>
<td>131.11</td>
</tr>
<tr>
<td>North Lampung</td>
<td>5,447</td>
<td>93.14</td>
<td>23.42</td>
<td>37.04</td>
</tr>
<tr>
<td>Way Kanan</td>
<td>4,259</td>
<td>72.83</td>
<td>18.32</td>
<td>28.96</td>
</tr>
<tr>
<td>Onion bones</td>
<td>7,662</td>
<td>131.02</td>
<td>32.95</td>
<td>52.1</td>
</tr>
<tr>
<td>offer</td>
<td>4,178</td>
<td>71.45</td>
<td>17.97</td>
<td>28.41</td>
</tr>
<tr>
<td>Pringsewu</td>
<td>2,709</td>
<td>46.33</td>
<td>11.65</td>
<td>18.42</td>
</tr>
<tr>
<td>Mesuji</td>
<td>3,377</td>
<td>57.74</td>
<td>14.52</td>
<td>22.96</td>
</tr>
<tr>
<td>West Onion Bones</td>
<td>5,592</td>
<td>95.63</td>
<td>24.05</td>
<td>38.03</td>
</tr>
<tr>
<td>West Coast</td>
<td>590</td>
<td>10.09</td>
<td>2.54</td>
<td>4.01</td>
</tr>
<tr>
<td>Bandar Lampung</td>
<td>267</td>
<td>4.56</td>
<td>1.15</td>
<td>1.81</td>
</tr>
<tr>
<td>Metro</td>
<td>875</td>
<td>14.97</td>
<td>3.76</td>
<td>5.95</td>
</tr>
<tr>
<td><strong>Amount</strong></td>
<td><strong>117,808</strong></td>
<td><strong>2,014.50</strong></td>
<td><strong>506.6</strong></td>
<td><strong>801.1</strong></td>
</tr>
</tbody>
</table>

Note: N = nitrogen; P = phosphate; K = potassium.


