# The integration model of sweet potato-pigs in the Papua highlands

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**Abstract.** Sweet potato-pigs integration system (*hipere-wam*) is a model that farmer can apply to maintain production in highland area. The aim of this study is to produce a specific location model of sweet potato-pigs integration technology in the sweet potato center area. The results of the study show that sweet potato production during the four months of the assessment with the wet tuber weight for Musan cultivar was 0.90 kg/ plant or 21.67 t/ha and Cangkuang cultivar was 1.06 kg/plant or 25.47 t/ha, respectively. Biomass production was 0.84 kg/plant or 20.24 t/ha for Musan cultivar and 0.76 kg/plant or 18.31 t/ha for Cangkuang cultivar, respectively. The increase in the body weight of introduced pigs was 157 g/head/day, compared to the farmer's which was of 50 g/head/day. Based on the calculation of the level of consumption of pigs during the assessment, it shows that the average feed requirement from sweet potato was 1.5 kg /head/day or 180 kg /head /4 months or 2.880 kg/16 heads/4 months. The calculation of organic fertilizer from wet livestock manure for four months of maintenance was 480 kg or 30.0 kg/head or 0.30 kg/head/day. If it is assumed that 0.065-0.066 hectare land contains 1.733-1.760 plants, the contribution of organic fertilizer from pig manure to sweet potato plants is 130 - 140 g/plant/4 months.

## 1. Introduction

Sweet potato is an important plant in terms of utility because it is versatile and is used for human food, animal feed and industrial raw materials [1]. The plant is rich in carbohydrates, vitamin A, sugar and minerals. In the highlands of Papua, sweet potato is used as a source of food for local residents but also as a source of pig feed, therefore sweet potato has a triangular relationship with humans and pigs [2].

Certain varieties of sweet potato can produce tubers above 25 t/ha, even local cultivars Musan in the Baliem Valleys and Dosak-2 in Manokwari, Papua, produce 31.65 t/ha and 35.61 t/ha with dry matter production of 5.93 t/ha and 5.03 t/ha [3,4]. These two cultivars are usually used for hog feed by local farmers in the highlands of Papua, because of their bad taste. The chemical composition of the sweet potato tubers showed dry matter content (17-23%) and digestibility above 70% [5].

Generally, sweet potato cultivars planted in the highlands of Papua have long and thick vines and high biomass which is mostly prefer by the farmers in the highlands of Papua because its is used as a source of pig feed. However, the system for raising pigs carried out by local farmers is generally simple. They basically feed the cattle in the morning with tubers and sweet potato biomass, then released the animals to find their own feed and in the afternoon the cattle will enter the sheds without any more feeding. This maintenance system causes livestock productivity to be very low due to

insufficient energy requirements and the threat of disease caused by loose rearing. Because it takes a location-specific technology assembly model that should bring sweet potato gardens closer to cattle sheds to reduce the workload that is divided due to too far away from the garden and improve housing management by confining livestock to avoid contact with toxic food and other sources of disease from other livestock outside. Pen and reduce livestock movement which causes a lot of energy to be lost. Particular model that can be applied is to integrate plants with pigs which is known as sweet potato-pigs integration (*Hipere-Wam*). The purpose of this study was to obtain high productivity from sweet potato and hogs through the sweet potato-pigs integration model.

## 2. Materials and methods

The research was conducted on dry land in Wesakin Village, Wouma District, Jayawijaya Regency, Papua Indonesia (138°.57 ' East Longitude, 04° 04' LS, 1550 m above sea level) from May - August 2018. The materials used in this study were two cultivars of sweet potato, namely Musan (local wamena) and Cangkuang (superior variety), 16 piglets with an average initial weight of 10-12 kg/piglet, manure and organic fertilizer (basic fertilizer). The tools used are scale (100 kg), Waskom, shovel and *sege* (wood for harvesting sweet potato). The experiment was carried out on farmers' land by involving them actively in planning and modeling, implementing activities from preparation to implementation. The integration model of sweet potato-pigs (*hipere-wam*) studied is shown in table 1.

**Table 1.** Technology Components of Sweet Potato Integration and Non-Integration System.

| Commodity | Component | Integration Pattern | Non-integration pattern |
|---|---|---|---|
| Sweet potato | Varieties/cutting | Superior varieties, labeled | Own seeds |
| | Spacing | Spacing 50 x 75 cm | irregular |
| | Planting system | Mound | Mound |
| | Fertilization : | | |
| | - Organic fertilizers | Organic fertilizers, 10 - 20 t/ha | Without fertilization |
| Pigs | Types of livestock | Local/mixed pigs | - |
| | Feed composition | SP 50%+ sweet potato leaves 50% + additional feed + local specific feed types | SP + SP leaves (not measurable) |
| | Housing | Laleken model cages for adult pigs measuring 5 $m^2$ /pig and small pigs 10 $m^2$/ piglet | traditional |
| | Disease control | Deworming + vitamins | - |
| | Livestock manure | Used as organic fertilizer | Untapped |

The observation variables were: 1) Sweet potato farming includes: The growth and production of sweet potato include tuber production and cassava biomass production; 2) Livestock farming includes: Weaning weight of piglets (kg) measured by weighing the final weight of the piglets at 2 months of weaning, final weight (kg) measured by weighing the cattle at the end of the activity, average daily gain (ADG) is calculated based on the following equation [6]:

$$\text{ADG (g/head/day)} = \frac{\text{Final body weight (g) - Initial body weight (g)}}{\text{Long maintenance (day)}}$$

and the weighing of livestock is carried out every 2 weeks, feed consumption (g/head/day) calculated by reducing the feed given minus the remaining feed, feed conversion is the ratio of feed consumption to weight gain body.

Observation variables for the growth and production of sweet potato as well as the growth and production of livestock were analyzed descriptively. Data were analyzed using Microsoft Excel 2010.

## 3. Results and discusion

*3.1. Productivity of sweet potato and raised livestock.*

Existing conditions of swine development areas the Dani people is an indigenous knowledge in Jayawijaya, who inhabit the Baliem Valley. Pigs have a special meaning for them due to its important socio-cultural and economic values. Pigs have a very important role in custom and culture, especially in terms of payment such as a means of paying fines if they violate customs/norms, as a means of making peace due to customary issues, dowry payments, when doing any events such as "*bakar batu*", a traditional custom where the people burning the stones in traditional ceremonies and religious rituals. Pig raising systems or cultivation methods are generally adapted to the environmental conditions in which pigs are kept from generation to generation.

Wesakin Village is one of the villages in Wouma District which is located in an urban area in Jayawijaya Regency. In addition to raising pigs, farmers mostly grow sweet potato and vegetables which are used to meet their daily food needs for consumption and some are used as feed for their pigs. The pattern of raising pigs observed in this area is generally pigs that are housed all day long, but there is a small part of it in the village area, they still raise livestock semi-intensively where at night the cattle are locked up, while in the morning until the afternoon they are released/slaughtered. For cattle that are penned all day long, the feed is fully provided by the farmer while for the released livestock only a small portion of the feed is given by the farmer, most of the pigs also get their feed from or around the environment where the pigs roam looking for food.

The feed or forage that is usually consumed by pigs is the types of local feed available in locations that have good nutritional content such as *sundaleka* (*Pueraria* sp), *napsarika* (*Bidens spilosa* sp), *wurikaka*, soak, and others besides sweet potato and sweet potato leaves. The nutritional value of local plants/forage and the introduction of alternative forage in the Baliem Valley based on crude protein and crude fiber content, respectively, are Wurikaka's local forage 18.32%; 30.96%, Calopogonium 17.13%; 31.86%, *Sida rhombifolia* 15.48%; 32.05%, Locop 13.80%; 28.00%, Yelaga 13.78%; 28.03%, Girimi 11.81%; Lukaka 11.19%; Suwiriwi 10.55%; 27.77%, Jagat 6.53%; 37.69%, while for introduced forage plants such as *Stylosanthes guianensis* 12.18%; 34.64%, Paspalum 8.90%; 34.36%, Setaria 6.39%; 27.02% while for sweet potato plants, the crude protein content is around 16-20% and crude fiber from 14-22% varies according to the variety [7]. However, the fact is that the existing pigs that are raised by farmers are not developed optimally and even there is a decline in population because the rate of slaughtering cattle is quite high at certain times, namely when there are religious ceremonies and death both in the family and in family members due to cultural customs, livestock. Pigs is always accompanied in these activities. In addition, pigs that are raised do not routinely experience disease prevention so that if there is an outbreak of disease, the pigs will easily catch the disease which results in a high rate of livestock mortality.

*3.1.1. Sweet potato production.* Sweet potato has an important position because it is the main source of feed for pigs, both tubers and leaves. Apart from being a source of animal feed, sweet potato is also a staple food for humans, especially people who live in the Jayawijaya highlands. The philosophy is that sweet potato must be available, especially for humans but also for pigs, therefore the productivity of sweet potato must be maintained because it has a relationship triangle namely human- sweet potato and pigs. Table 2 shows that sweet potato production during the four months of the assessment had an average wet tuber weight for the Musan cultivar of 0.9 kg/plant or 21.67 t/ha and an average biomass

weight of 0.84 kg/plant or 20.24 t/ha. Whereas Cangkuang cultivar had an average wet tuber weight of 1.06 kg/plant or 25.47 t/ha and an average biomass weight of 0.76 kg/plant or 18.31 t/ha.

*3.1.2.Relationship between pig and sweet potato.* Based on the calculation of the level of consumption of pigs during the assessment, it shows that the average need for sweet potato is 1.5 kg/heads/day or 180 kg/heads/4 months or 2,880 kg/16 heads/4 months. If it is assumed that 60 percent of hog feed needs must be met for four months from sweet potato, then it will get 1,728 kg of tubers and biomass that must be met during maintenance. This means that to meet the animal feed needs of sweet potato, the average area of sweet potato land that must be fulfilled is 6.6 acres or 660 meters$^2$ for the Musan cultivar, while for the Cangkuang cultivar it takes an average area of sweet potato land which must be fulfilled covering an area of 6.5 acres or 650 meters$^2$ (table 2).

**Table 2.** The relationship between sweet potato-pigs (*hipere-wam*) farming during the 4 month maintenance period.

| **No.** | Farming | Production | Growth | Non-Integration Pattern |
|---|---|---|---|---|
| I. | Pig livestock (kg/head) | ± 18.87 | ± 28.87-30.87 | 0.16 |
| II. | Sweet potato tubers and biomass (kg/ha) | - | ± 41.91-43.78 | 2,880 |
| III. | The need for feed from sweet potato (60%) kg/4 months | - | 180 | 1,728 |
| IV. | The need for fertilizer from pigs (kg/head) | ± 0.25 | 1,733-1,760 | 30.0 |

Note: Primary data processed, 2018.

Table 2 shows the calculation of organic fertilizers produced from livestock manure showing that the average wet manure during the four-month assessment was 240 kg or 30 kg /plant. In other words, each head produces 0.25 kg of wet manure per day (table 2). If it is assumed that the land of 6.5-6.6 are or 0.065- 0.066 hectares, there are 1,733-1,760 plants, then each plant will get organic fertilizer from pig manure of 0.13-0.14 kg or 130-140 g/plant for Cangkuang and Musan cultivars. This calculation is still below the fertilizer requirement for sweet potato plants which is 1-2 kg/plant, but this calculation is based on raising pigs for four months, meaning that the fertilizer supply during subsequent rearing will certainly increase as the pig's weight increases during maintenance.

*3.2. Pig productivity*

The productivity of reared pigs can be measured by knowing the weaning weight, body weight gain, feed consumption and hog feed conversion, as shown in table 3.

**Table 3.** Performance of development of pigs during 4 months of rearing.

| No. | Description | Treatment | |
|---|---|---|---|
| | | Integration Pattern | Non Integration Pattern |
| 1. | Wean Weight (kg) | 12.00 | - |
| 2. | Weight gain (g/head/day) | 157.29 | - |
| 3. | Feed consumption (g/head/day) | 815.00 | - |
| 4. | Efficient use of feed | 0.19 | - |
| 5. | Feed conversion | 5.18 | - |

Note: Primary data processed, 2018.

*3.2.1. Weaning weight.* Weaning weight of piglets is the stage of animal growth when it is no longer dependent on its mother's milk and begins to consume both liquid and solid feed [8]. The weaning

weight of piglets is one of the factors affecting the performance of pigs. Table 3 shows the average weaning weight of 2-month old pigs used in this study is 12 kg with a weight range between 10-14 kg. This condition is almost the same as that reported by [9] in a study at the Kupang city that the weaning weight in this study ranges from 10 kg-15 kg with an average range of 12.5 kg. The results of the average weaning of the two studies were also not different from those reported by [10] in Jayawijaya in Wamena and Hubikosi districts, showing that the average weaning weight of pigs for the two districts was 12.5 kg and 12.10 kg, respectively at the age of 3 months. In contrast to the observations made in Tomohon City that the weaning weight of pigs maintained for 28 days or 4 weeks reaches an average weight of 7.14 kg with a range of 5.2 - 8 kg [11]. The weaning weight achievement is almost the same as reported by [12], which is the average weaning weight of 7.54 kg. This difference is due to several factors, including the breed of the sow, birth weight, sex, and age at weaning. Weaning age greatly affects the appearance of pig production starting from the accelerated growth stage after weaning.

Weaning age in this study was carried out at the age of 2 months with the consideration that the piglets were able to escape from the mother. The results of [13] study showed that differences in weaning age in piglets had an effect on weaning weight. The average weaning weight obtained from this study is still relatively low when compared to the results of other studies, this is related to several weaning systems that are often carried out by breeders based on age, namely early weaning systems aged 14-19 days, weaning piglets aged 3-4 weeks or 33-53 days, and the age of 4-6 weeks and in some places, piglets are generally weaned at the age of 2 weeks, 3 weeks and 6 weeks. In addition, the weaning time carried out on livestock is usually at the age of 2 months [14,15,16]. However, too early weaning will affect the piglets to consume milk so that it affects the growth to get optimal weaning weight. Conversely, too long weaning age will also affect the interval from birth to first lust [17]. [18] states that the growth rate of pigs is strongly influenced by weaning weight, piglets with large weaning weight will grow faster and require less time to reach slaughter weight than piglets with smaller weaning weight so that weaning weight is closely related to the ability of livestock to grow and develop after weaning. In connection with this, the weaning weight is very much determined, among others by gender, body weight of the mother, age of the mother, the condition at which the cattle are born, the ability of the mother to breastfeed her children, the quantity and quality of rations, the ambient temperature and the off spring/type of parent. The types of pigs in Papua are pigs from crossing several types of pigs that have been kept in Indonesia for a long time, such as Javanese pigs, Toraja pigs, Balinese pigs and others. Papuan pigs have very diverse characteristics, depending on the results of crossing what kind of breed the pigs come from and are generally small, with various coat colors and sharp snouts [3]. The factors that influence body weight gain are the production of mother's milk, the number of children born, the maintenance of nursing mothers, the quality of rations and the genetics of pigs [12].

*3.2.2. Increase in body weight.* The appearance of pigs can be seen from the increase in body weight and the amount of feed consumed. Good feed must contain very high energy and protein according to the needs of the livestock to grow and develop. This is because at this stage the pigs undergo a process of maximum growth and development so that the feed must be considered very much. Table 3 shows the average body weight gain of 157.29 g/head/day. The results of this study are slightly higher than those of [19] namely 155 g/head/day. This difference is due to the slightly different composition of the feed given, namely 60% sweet potato + 15% sweet potato leaves + 15% Sundaleka + 10% bran while the feed for this study used 50% sweet potato + 50% sweet potato leaves + additional feed in the form of concentrate + local forage which has high protein content. This illustrates that local feed with a balanced nutritional value will affect the productivity of pigs. [2] suggests that the amount of body weight gain is strongly influenced by management and the physiological environment, especially feed, so that if the feed consumed by livestock is not sufficient for livestock, in this case its nutrient content, it cannot achieve optimal growth.

The results of the study of sweet potato and sweet potato leaf-based feed management for pig farm conditions in the Baliem Valley, Jayawijaya, namely the feed formula "Wamena # 1" composition: 56% cooked sweet potato leaves + 33% cooked sweet potato tubers + 11% cooked banana stalks + 0.5 grams salt, body weight gain of 150-200 g/day; "Wamena # 2" with the composition: 33% cooked sweet potato leaves + 22% cooked sweet potato tubers + 34% silage of sweet potato and sweet potato leaves + 11% cooked banana stems, body weight gain of 150-200 g/day; "Wamena # 3" composition: 33% raw sweet potato leaves + 22% raw sweet potato + 34% yam silage and sweet potato leaves + 11% raw banana stems, body weight gain of 150 - 170 g/day; "Wamena # 6" composition: 50% cooked sweet potato + 30% cooked sweet potato leaves + 20% cooked fish offal, body weight gain of 250 - 300 g/day [20]. The results of this study indicate that the value of protein content is the main factor of feed in determining the growth of pigs, that the high protein content of feed will have a positive impact on the productivity of growing pigs.

*3.2.3. Consumption, efficient feed use and feed conversion.* The average pig feed consumption in this study was 815 g/head/day, the results of this study were higher than those of [12], which was 750 g/head/day. This difference is due to the different composition of the feed given in terms of both the amount and nutritional value contained in each feed ingredient given to pigs. Feed consumption is largely determined by the amount of nutrient content in the feed, especially protein and energy content in feed. The high feed consumption in this study was due to the additional intake of concentrate feed and some local forage grown in Laleken for consumption of pigs, which contained a high enough protein content. One aspect that determines the high and low quality of the ration is the content of protein, energy, vitamins, minerals and other ingredients that support growth and biological digestion processes [15]. [7] reports the protein content of several types of local forage that are widely available in the Baliem Valley, Jayawijaya and most often eaten by pigs, namely Wurikaka (18.32%), Calopogonium (17.13%), *Sida rhombifolia* (15.48%), Docop (13.80%), Yelaga (13.78%), Girimi (11.81%), Lukaka (11.19%), Suwiriwi (10.55%), and Jagat (6.53%). In addition, several factors affect feed consumption, namely body weight, age, condition of livestock and stress caused by the environment such as temperature, humidity and sunlight [16]. Other research results based on sweet potato feed and sweet potato silage, both raw and cooked (1: 1 ratio) given to growing pigs, can replace 50% commercial feed (16% crude protein) resulting in good daily body weight gain and feed conversion value. more efficient [21].

The average efficiency of using feed in this study was 0.19. The value of the efficiency of using the feed in this study is lower than the results of the study [15,16], which is in the range of 0.22, while the recommendation of NRC (1988) is 0.368-0.421. The low efficiency value of this study indicates that the feed consumed is less efficient to convert into meat, on the other hand, the high efficiency value of feed use indicates that the feed consumed is very efficient to convert into meat. According to [22], efficient use of feed is the weight gain produced by each unit of feed consumed, on the efficiency of feed use. This does not affect the use of feed, and there is no difference in the efficiency of the use of feed as a result of this study due to the low body weight gain and the high amount of consumption as a measure of the efficiency of feed use. The opposite of feed use efficiency is feed conversion. Feed conversion is the amount of feed needed to produce a certain body weight gain. In Table 3, it can be seen that the average feed conversion result in this study is 5.18. The value 5.18 means that to form one kilogram of body weight gain a pig requires 5.18 kg of feed. The results of this study are still higher than the results of the previous study by [19], namely 4.82 but the conversion of hog feed as a result of this study can still be tolerated in the range of feed conversion rates that are quite efficient for pigs, namely 2 - 5 because pigs are livestock. most efficient in utilizing feed when compared to other livestock [2].

*3.2.4. Improvement of Housing system technology (Laleken) for disease control.* The condition of the pig raising system in Wesakin Village is generally carried out traditionally/released, but since getting assistance from pigs and counseling from the Agriculture Office of local government, some members

of the farmer group have implemented an intensive pig raising system using the open stage cage model with plank floors and sengk roofed, but the condition of the pigs is quite apprehensive. It can be seen that the condition of the livestock is not healthy, the skin is wrinkled, rough, wounds and the housing is not clean. The results of the discussion and identification in the field need to be considered to create a place to confine pigs and provide a yard for playing pigs or Laleken. Laleken is a special place to indulge pigs, which is built near the pen so that it makes it easier for the pigs to move from the pen to the laleken, so a road is built between the pen and laleken, where this road is a place for pigs to dump manure with a road width of 1 m. The laleken size for small pigs with a capacity of 6 heads is 6 m x 10 m and for adult pigs with a capacity of 2 heads is 10 m x 12 m. While the height of the laleken fence is approximately 1.5 m as illustrated in figure 1.

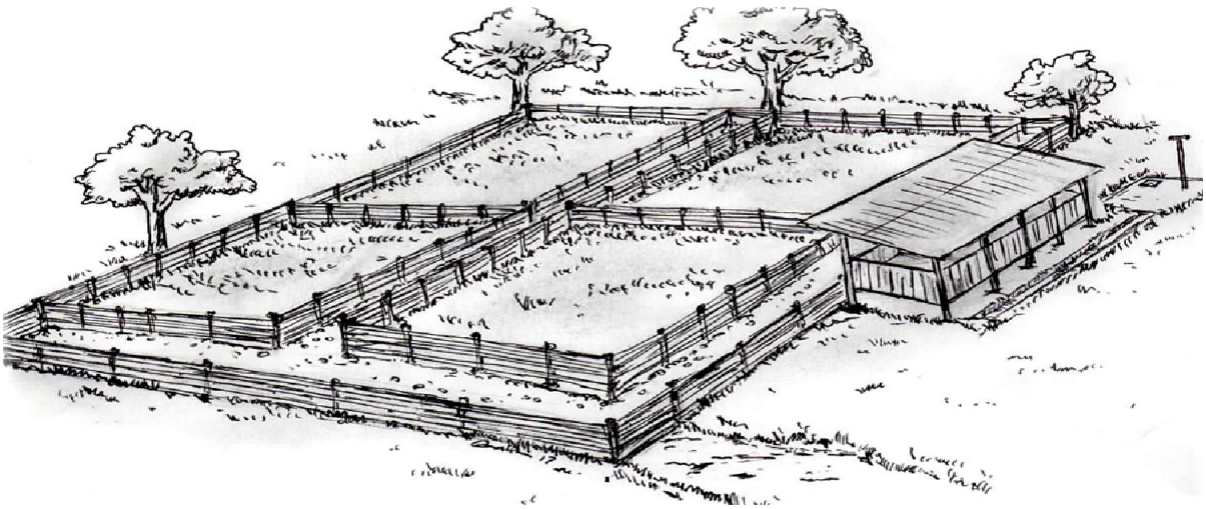

**Figure 1.** Illustration of Introduced *laleken* (padog) model.


**Figure 2**. The *laleken* (padog) model of the study was overgrown with high protein grass from a different angel (a, b)

The results of this study follow the recommendations suggested by [7,20] regarding disease control, where the pigs raised in laleken are more resistant to worm parasites and have faster growth. These results indicate that the pigs kept in Laleken show good growth and are not prone to disease. Besides that, disease prevention and control are routinely carried out by giving worm medicine and vitamins regularly.

## 4. Conclusion

The experiment on the integration model of sweet potato and pigs can give results of the tuber weight for Musan cultivar was 0.90 kg/plant or 21.67 t/ha and Cangkuang cultivar was 1.06 kg/plant or 25.47 t/ha, respectively. Biomass production was 0.84 kg /plant or 20.24 t/ha for Musan cultivar and 0.76 kg/plant or 18.31 t/ha for Cangkuang cultivar, respectively. The increase in body weight of introduced pigs was 157 g/head/day, compared to the farmer's pattern of 50 g/head/day. Based on the calculation of the level of consumption of pigs during the assessment, it shows that the average feed requirement from sweet potato is 1.5 kg/head/day or 180 kg/head/4 months or 2.880 kg/16 heads/4 months. The calculation of organic fertilizer from wet livestock manure for four months of maintenance is 480 kg or 30.0 kg/head or 0.30 kg/head/day.

## Declarations

Contribution: In this article, Alberth Soplanit and Siska Tirajoh acts as the main contributor and Batseba MW Tiro, Ghalih P Dominanto and Merlin K Rumbarar acts as a member contributor.

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