Quantifying Feeding Regimes on Weaned Sows Under Tropical Papua Pig Keeping Systems

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Abstract. Body weight measurement of weaned sow using several feeding regimes was done under traditional pig keeping systems in West Papua, Indonesia. Feeding quantification using local and non-conventional feeds applied by pig farmers were rationed. Feeds used were 1, 2 and 3 kg in fresh basis. Energy contents of each ration were 34.73, 32.63 and 36.39 MJ kg DM, respectively and protein rations were of 0.62, 0.34 and 0.99 kg CP DM. Initial sow's body weight was in the average of 87 kg. The second feeding regimes with 2 kg day^{-1} on offer, obtained ransom with quality of balance, energy rich and protein rich, i.e. 22.69, 21.99 and 24.92 MJ kg DM, respectively and protein in ransom of 0.35, 0.26 and 0.72 kg CP DM. Feeding regimes with 1 kg day^{-1} on offer, we obtain ration with quality of balance, energy rich and protein rich, i.e. 12.04, 11.34 and 12.46 MJ kg DM, respectively and protein in ransom with 0.27, 0.18 and 0.36 kg CP DM. Initial weaned body weight was 87 kg. A simulation using one factorial of feeding regimes was established, which was drawn and simulated using Simile version 4.7 and no environmental factors were incorporated in this model simulation. The results of this study showed the increasing body weight of sows was detected by using 3 kg of feed daily in 14 days after weaning. While 2 kg feed day^{-1} only met the maintenance requirement. Therefore, there were no meat or fat deposition. Feed of 1 kg per day could induce negative impact in starvation and body weight lost. Insufficient feed intake can induce negative impact on physiological mechanism of the sows. This is at risk while weaned sow would enter mating season and gestation period. Feeding regimes with more that 3 kg and energy ration of 34.73 MJ kg DM and digestibility of 0.82 resulted in a positive effect on sow body weight gain.

Keywords: quantification, feeding, weaned sow, traditional pig keeping systems

Abstrak. Pengukuran bobot tubuh dari anak babi lepas sapih menggunakan beberapa cara pemberian pakan dilakukan dengan sistem pemeliharaan babi tradisional di Papua Barat, Indonesia. Kuantifikasi pemberian pakan menggunakan pakan lokal dan non konvensional yang diterapkan oleh peternaak babi. Pakan yang digunakan adalah 1, 2 dan 3 kg pakan segar. Kandungan energi dari setiap ransum adalah 34,73, 32,63 dan 36,39 per kg BK dan protein ransum adalah 0,62, 0,34 dan 0,99 kg protein kasar berdasar BK. Berat awal babi betina rata-rata 87 kg. Pemberian pakan cara yang kedua adalah 2 kg per hari, dengan ransum yang kaya energi dan protein yaitu berturut-turut sebesar 22,69, 21,99 dan 24,92 MJ per kg BK, dan protein dalam ransum sebesar 0,35, 0,26 dan 0,72 kg proten kasar berdasar BK. Pada pemberian pakan sebanyak 1 kg per hari didapatkan ransum yang kaya energi dan protein yaitu 12,04, 11,34 dan 12,46 MJ/kg BK dan protein dalam ransum sebesar 0,27, 0,18 and 0,36 kg protein kasar berdasarkan BK. Bobot badan awal lepas sapih 87 kg. Simulasi menggunakan pemberian pakan dengan cara satu faktor telah ditentukan, yang digambarkan dan disimulasikan menggunkan Simile versi 4.7 dan tak ada faktor-faktor lingkungan yang dimasukkan dalam simulasi model ini. Hasil penelitian ini menunjukkan bahwa, terdeteksi peningkatan bobot badan babi betina pada pemberian pakan harian sebanyak 3kg, pada 14 hari setelah penyapihan. Sementara pemberian pakan harian sebanyak 2 kg hanya memenuhi kebutuhan maintenance/hidup pokok. Oleh karena itu, tak ada deposisi daging maupun lemak. Pemberian pakan harian sebanyak 1 kg dapat menyebabkan dampak negatif dan kelaparan, dan kehilangan bobot badan. Konsumsi pakan yang kurang cukup dapat menyebabkan dampak negatif terhadap mekanisme fisiologis pada babi. Ini berisiko pada saat babi betina lepas sapih memasuki musim kawin dan bunting. Pemberian pakan harian lebih dari 3 kg yang mengandung enerji sebesar 34,73 MJ/kg BK dan daya cerna sebesar 82% menimbulkan efek positip terhadap pertambahan berat badan babi betina.

Kata kunci : kuantifikasi, pakan, babi lepas sapih, sistem pemeliharaan babi tradisional

Introduction

Producing body mass of pigs each day is the aim in raising pigs. In the field research under tropical Papua condition (Iyai, 2008) comfirmed that the average body mass of sows ranges between 48 to 87 kg. Neither sows' body mass which has low body mass, boars, growers and piglets body mass are under Asian pig farming systems (Kunavongkrit and Heard, 2000; Lemke et al., 2006). In Wamena, Papua-Indonesia, Cargill and Mahalaya (2007) reported that the average daily gain was 442 g day^{-1}. In Madagascar black-skinned breed and Thailand's Tao Yuan breed (Serres, 1992), average daily gain were 400 g day^{-1} and 362 g day^{-1}, respectively. Under subtropical condition based on Philippines experiences (Eusebio, 1980), the average daily gain of piglets (5-10 kg) was 260 g and with 60-90 kg weight of animals, pigs could achieve gain of about 600 g day^{-1}. Serres (1992) reported about 500 -700 g day^{-1} daily gain under tropical condition. Increasing body mass has linear correlation with increasing maintenance of body mass (Gomez et al., 2000), protein (Gomez et al., 2002) and fat accretion (Gill, 2006). Feeding and its combination then become the crux in raising pigs due to its contribution in body mass gain.

Feeding affects reproduction in sows, producing of a healthy progeny and body growth in suckling and weaned piglets. Inadequate nutrition of sows can lead to lose of body mass since lean and fat body are used to maintain body weight at certain age levels. Energy and protein expenditure (Whittemore, 1993) are interchangeable due to deposition of protein and fat (de ligt et al., 2002). due to extreme climates in particular high and fluctuating temperature and humidity, which is experienced by tropical pig farmers.

The shortages in knowledge of feeding quality and quantity induce farmers are inefficient in composing appropriate dietary feeds. It is therefore important to seek for recommendations on feeding diets made up of locally available feedstuffs that are linked to the feeding requirements of pigs under different pig keeping conditions (Canas et al., 2005). Feed diets have to match animal requirements for maintenance, energy for deposition, and maternal weight gain, and milk production (Silva et al., 2009). These requirements are dependent on genetic diversities (Knap et al., 2003; Kanis et al., 2008), age of the animal and its physiological stages, i.e. conception and/or gestating, foetus development and lactating phase (Whittemore, 1993).

There are many simulation models and/or quantification methods (Grant and Swannack, 2008) developed for commercial, intensive and under subtropical conditions. In contrary simulation models and/or quantification methods are rare designed for extensive, small-scale and tropical based pig keeping systems. By quantifying effects of feedstuff that is locally available, alternatives or improved diets, in particular the sow can be recommended in its effects on animal performance, e.g. lean deposition, fat deposition and maintenence (Schinckel et al., 2008). The objective of this study was to simulate growth of weaned sows and to quantify its performances in terms of production (body mass gain) and maintenance based on effects of locally available feeding regimes routinely applied by Papuan pig farmers.

Materials and Methods

Pools identified in this model were total pool of feed taken up in the gut, which was ready to supply to each physiological body function, i.e. maintenance, heat thermoregulation, meat and fat deposition (Knap et al., 2003). The two previous terms are the so called meat and fat pool. The second pool was meat pool and the third one was fat pool. Before proceed it into a simulation model, a loop diagram must always be the first step to start. A loop diagram itself is a diagram that represents the relation between each quantity in one single model. In this loop diagram there were seven quantities, i.e. ration, maximum uptake, body weight, digestibility, feed intake conversion ratio, and the pool. Inflow entering the pool came in from feed intake, which was affected by maximum feed uptake (kg) and feed ration (kg/day). Maximum feed intake dependently was determined by body weight (kg) and feed digestibility (kg/kg).

Table 1. Feed ingredients of sow feeding nutrient at Papua

Feed ingredients	Energy (MJ/kg)	CP (kg/kg)
Cassava*	11.088	0.02376
Sweet potatoes*	11.941	0.03688
Coconut*	8.900	0.18245
Maize*	12.571	0.07071
Fish*	14.168	0.64308
Tofu*	12.719	0.27492
Bakso**	4.311	0.01528
Mixed Rice**	5.447	0.01946
Rice bran*	11.623	0.12434

*Based on Sauvant et al., (2004). ** Based on Yafur (2008).

The higher diet digestibility, the higher feed can be taken up, and vice versa. Digestibility was computed using Whittemore (1993). Thus, the rate of feed intake per day could determine the amount of feed that can be taken up and in turn, determine the amount of deposited feed nutrient, in terms of protein and fat.

Feed intake was obtained by multiplying maximum uptake, feed ration with conversion ratio and maximum uptake was computed by multiplying body weight with digestibility. Body weight (BW) was determined using metabolic body weight (kg$^{0.75}$), whose formulation was derived from the function of meat and fat deposited in the pool, i.e. body weight (kg) = BW= $(Fat + Meat)^{1.25}$. Energy digestibility was obtained by using the ratio of digested energy divided by gross energy of the offered feed (digestibility=DE/GE). The first outflow went to undigested nutrients. The second outflow went to maintenance requirement. The third and the forth outflows would be devoted to meat and fat developments. There were 11 quantities in this loop diagram, i.e. pool, excretion, intake, digestibility, maintenance, meat requirement, starvation, MJ (energy) to fat ratio, maintenance requirement, maintenance requirement ratio and body weight, offered feed, maximum uptake, body weight, digestibility, feed intake conversion ratio and the pool. Energy and protein used for maintenance were deposited from the pool, which was utilized to maintain meat requirement. Undigested nutrient was then excreted, which followed the following mathematical function, i.e. excretion = intake × (1-digestibility). Inflow to the meat pool came from the total pool.

The amount of meat pool was determined by meat growth/development (kg day^{-1}), which was depended on the ratio of mega-joule per kilogram (MJ kg^{-1}), meat deposit and meat requirement. Meat requirement was an auxiliary variable which was determined by some parameters and other auxiliaries. Some parameters were MJ (energy) to fat ratio, maintenance requirement rate (MRR) and some auxiliary variables were maintenance requirement, body weight, starvation, and fat requirement.

There were 13 quantities in this meat loop diagram, i.e. pool, meat growth, MJ to kg meat ratio, maintenance meat, MJ meat ratio, maintenance requirement, starvation, fat pool, MJ to fat ratio, fat requirement, MRR and body weight (BW). The outflow from meat pool went to meat maintenance, which was determined by meat requirement and ratio of mega-joule meat. Meat requirement was explained as meat inflow above. Mathematically, the function of meat growth can be written as follows; meat growth (kg day^{-1})

$$= Meat\_req \times \frac{1}{Meatratio} - \frac{Meat}{dt}$$

If meat_req. was > 0, then meat growth was not equal to 0. Meat requirement (Meat_req) was then computed as Meat_req= total-pool_m-starvation-fat_ratio. In addition to meat requirement we needed to compute maintenance requirement (Maintenance_req) as follows; Maintenance_req = BW $\times MRR$. Body weight, metabolic body weight ($kg^{0.75}$) was the function of the sum of fat and meat pool. MRR stood for maintenance requirement rate. Fat pool consisted of inflow from the total pool. Fat pool was determined by fat growth rate and conversion rate, mega joule (MJ) to kilogram of fat deposited in the fat pool. The rate the amount of fat deposited was affected by fat requirement needed as maintenance requirement. There were 11 quantities in this fat loop diagram, i.e. pool, growth fat, fat pool, MJ to kg fat ratio, maintenance requirement, maintenance requirement rate (MRR) and body weight. Mathematically, the function of fat growth can be written as follows; Fat Growth

(kg day^{-1})= $fat\_req \times \frac{1}{fatratio} - \frac{Fat}{dt}$.

Its unit analysis was then fat growth per day, If fat_req was >0, then fat growth was not equal to 0. In addition to compute fat growth, fat requirement was incorporated. Fat requirement was a function of total pool minus pool-maintenance. In the model, it was also assumed that at that certain stage, if the sow would not maintain the fat deposit then the sows would convert an amount of energy to energy maintenance. Then energy cost would be needed to burn the fat. The general structure and parameterization of this quantification is presented in Table 3. Parameterization is a process of defining or deciding the parameters-usually of some model- that are salient to the question being asked of that model. The state variable is a quantity that defines, or helps to define, the state of the system at given point in time (France and Thornley, 1984). The state variables in this model were the pool, meat and fat. These state variables had inflows and outflows, which would be explained in the next paragraph. The rate variable is a quantity that defines some process within the system at a given point in time. The rate always have dimensions of quantity per unit time; they cannot be measured instantaneously (as can a state variable), but only over an increment of time Δt. The rate variables in this model were intake, growth meat, maintenance meat, maintenance, excretion, growth fat and starvation. Auxiliary is additional to the state variables which alone define the system completely. It also varies with time. Auxiliary variables are variables which most commonly represent the process or concepts in the system-of-interest that we wish to indicate explicitly, which otherwise would be implicit in the information transfers among model components (constants, driving variables, state variables, material transfers). The auxiliary variables in this model were filling (gut), relative growth rate of fat, switch, maintenance requirement, and body weight. In this model we considered a situation, where weaned sow will have some starvation, in which the supply of feed and pool would not adequately provide the amount of energy and protein for maintenance. The parameters and constants are quantities appearing in the equations of a model that do not vary with time. The term parameters are usually applied to quantities whose value is less certain, but are kept constant throughout a run of the model. Constants are numerical values describing the important characteristics of a system that do not change, or that can be presented as unchanging, under all of the conditions encountered in a given scenario simulated by the model (Grant and Swannack, 2008). The parameters and constants in this model were feed, diet digestibility, MRR (maintenance requirement rate), and relative growth rate of meat. The complete of parameters, state, rate and auxiliaries can be seen in Table 3.

In this model simulation, the offered feed was given based on energy metabolism (EM) kg

Table 2. Diet formulation that are generally used in Manokwari, Papua

Feed regime (kg)	Mixed feedstuffs	Average energy/kg	Average CP/kg	Diet (kg)	Energy (MJ)	CP (kg)	MJ/kg	CP kg/kg	CP/Energy Ratio (CP/MJ)	Quality of ransom	Diet digestibility
3	Tofu+fish	13.44	0.46	1.00	13.44	0.46					0.82
	Cassava+SP+ Coconut	10.64	0.08	2.00	21.29	0.16					
	Total diet				34.73	0.62	11.58	0.21	0.017883	Balanced	
2	Tofu+fish	13.44	0.46	0.50	6.72	0.23					0.82
	Cassava+SP+ Coconut	10.64	0.08	1.50	15.96	0.12					
	Total diet				22.68	0.35	7.56	0.12	0.015474	Balanced	
1	Tofu+fish	13.44	0.46	0.50	6.72	0.23					0.82
	Cassava+SP+ Coconut	10.64	0.08	0.50	5.32	0.04					
	Total diet A				12.04	0.27	4.01	0.09	0.02242	Balanced	

SP: sweet potato

Table 3. Parameterization (state, rate auxiliary variables) of quantification feeding regimes

Parameter	name	unit	Value	Quantification	Unit analysis
	Feed	kg	3		Kg
	Digestibility	kg	0.82	Average DE/GE	kg/kg
	MRR (maintenance requirement rate)	MJ/kg BW	0.44	106 kcal/kg BW^0.75 × 0.004187	(kcal×MJ/kcal)/kg BW
	Relative growth rate meat	kg	0.130	Derived from Gompertz value Pr=(B×A)/e	kg×1/*e*
	MJ_ratio	MJ/kg	12		
State	**name**	**unit**	**initial value**		
	Pool	MJ	31.32	3 kg × 0.870 DM ×12 MJ/kg	kg× MJ/kg
	Meat	kg	11.26	0.17× BW	Kg
	Fat	kg	17.23	0.18 × BW	Kg
Rate	**name**	**unit**	**Equation**	**Quantification**	**Unit analysis**
	Intake	MJ/day	Feed*(digestibility)*MJ_ratio		kg/day× (kg/kg)×MJ/kg
	Growth meat	kg/day	RGM*(Pool-maintenance)*1/(MJ ratio)		(MJ/day)×(MJ-MJ)*(1/(kg/MJ))
	Maintenance	MJ/day	MRR*BW^0.75		(MJ/kg/day) ×kg
	Excretion	kg/day	intake*(1-Digestibility)		kg/day×(1-kg/kg)
	Growth fat	kg/day	RGF*(Pool-maintenance)*1/(MJ ratio)		(MJ/day)×(MJ-MJ)*(1/(kg/MJ))
Auxiliary	**name**	**Unit**	**Equation**	**Quantification**	**Unit analysis**
	Filling (gut)	Kg	0.013*BW/(1-Digestibility)		kg/(1-kg/kg)
	Relative growth rate fat	Kg	0.5*RelGrowthRateMeat		Kg
	Maintenance requirement	MJ	MRR*pow(BW,0.75)		(MJ/kg) ×kg
	Body weight (BW)	Kg	pow((Meat+Fat),1.25)		(kg+kg)

dry matter (DM). Feeding regimes offered were 1 kg day^{-1}, 2 kg day^{-1}and 3 kg day^{-1}, by which these feeds were simulated to obtain body weight gain of the sow during 14 weaned days. We used an average initial sow body weight of 87 kg at the first farrowing under tropical pig keeping systems. The equations used in this model simulation were based on Whittemore (1993). In addition, some parameters incorporated in this simulation were adapted from Canas et al. (2003), Verstegen et al. (1987), and Yuan et al. (2008). Simile software was used in designing the relational diagram simulation.

Results and Discussion

Relational Diagram

In this initial study, the relational diagram (Laffelaar, 1999) was used to visualize the state variables, rate variables, driving variables, auxiliary feedback loops and parameters. This was the simple growth model that was established based on single factorial component, i.e. feeding regimes, including dietary digestibility. Growth model was used to parameterise biological and physioological components and to analyse their effects on its its production (Hermesch et al., 2003). The details of the relational diagram is shown by Figure 1.

In relational diagram, the system can be made by developing other subsystems or incorporating subsystems in the general system. Subsystems can be in line with environmental components, status of physiological reproduction, diseases and the effect of stimulising hormones such as models that is established by Knap et al., (2003), Lovatto and Sauvant (2003). In this initial study we did not incorporate environmental components or variables of temperatures and humidity (Farmer et al., 2001; Renaudeau et al., 2003), insulation and pig genetics (Kanis et al., 2005), floor types (Silva et al., 2006), and pig density, as thought to be the determinant limiting factors to achieve production with regards to body weight gain, meat and fat production, and progeny such as piglets weight and weaned piglet weight. At this situation feeding regimes with several different nutrient digestibility were considered as limiting factors to potential production.

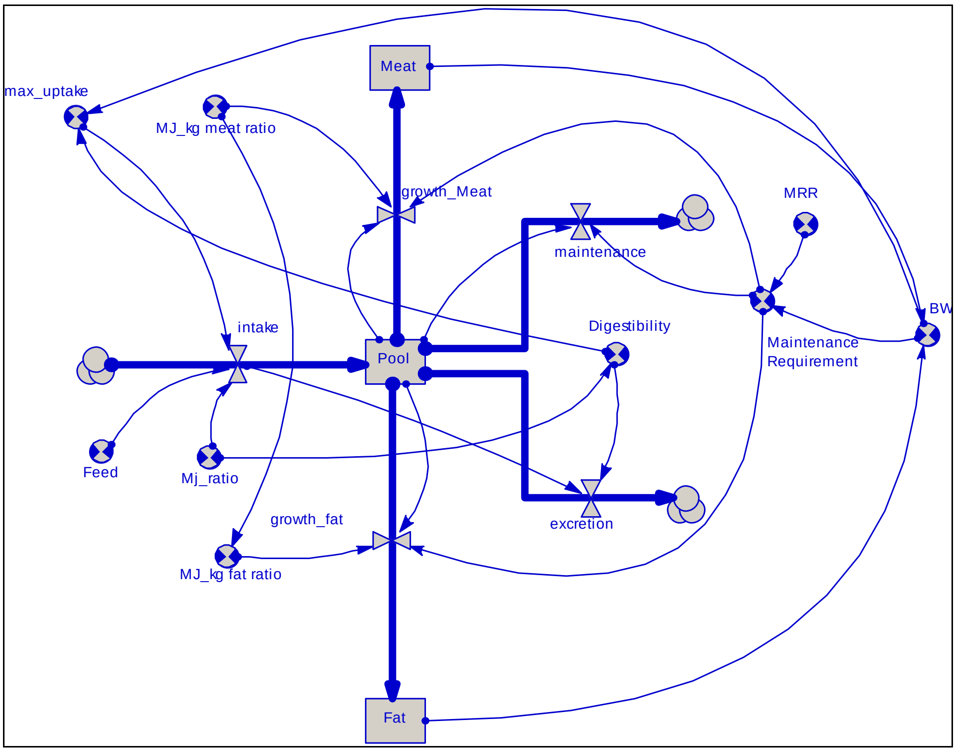

Figure 1. The relational diagram of feed ration and sow body weight run in this model

As in the tropical countries with abundant of crops but scare in utilization and qualities, there are challenges to seek for proper combination of quality feed types available for feeding the pigs. In the subsequent simulation model we stated that these two features can be integrated and shaped of body protein and body lipid turnover which can be built into mathematical model to simulate mechanistic model. In addition, considering crop production and its residues to be utilized as sources of pig feeding would be prioritized.

Feeding Regimes

In the first feeding regimes with ration of 3 kg day^{-1}, it was computed that energy in ration with quality of balance, energy rich and protein rich were 34.73, 32.63 and 36.39 MJ kg DM, respectively and protein in ration were 0.62, 0.34, and 0.99 kg CP DM, respectively. The second feeding regimes with ration of 2 kg day^{-1} had ration with quality of balance, energy rich and protein rich, i.e. 22.69, 21.99 and 24.92 MJ kg DM, respectively and protein in ration were 0.35, 0.26, and 0.72 kg CP DM, respectively. The first feeding regimes with ration of 1 kg day^{-1}, ration of quality of balance, energy rich and protein rich subsequently were 12.04, 11.34 and 12.46 MJ kg DM and protein in ration were 0.27, 0.18 and 0.36 kg CP DM, respectively. Eusebio (1980) states that only those feed nutrients that are digested can promote growth, body maintenance and production of milk. In tropical countries, growing pigs fed a high energy diet tend to lower their feed consumptions. Gilts and sows should be on rationed and restricted feeding; they should be given 1.5 kg in the morning and another 1.5 kg in the afternoon. Kunavongkrit and Heard (2000) stated that raw materials harvested locally and used in pig feeds include maize, rice, manioc, sweet potato, peanut, soybean, cotton seed, copra, coconut oil, fish meal, blood meal, meat and bone meal, sea shell and limestone. This author reveals that the formulation can be could then incorporate those environmental variables such as pig genetic, and diseases (Knap et al., 2003), homeorhesis and homeostasis (Lovatto and Sauvant, 2003), to be taken into account. Lovato and Sauvant (2003) obtained from a feed composed of the following ingredients; 46% broken rice or corn, 16% rice bran, 2% fish meal, 4% molasses, 11% soya, 15% copra meal, 3% coconut oil, 1.5% limestone and 1.5% mineral and vitamins. These feed ingradients should determine pig energy and protei demand (Eusebio, 1980; Sauvant et al., 2004).

In urban areas farmers fed their pigs with available and cheap feeds. Feed therefore, can be kitchen wastes, disposals from restaurants and hotels, and purchased on local markets (Pattiselanno and Iyai, 2005). Yafur (2008) estimated wastes from restaurants of bakso and cooked-rice, waste rice, i.e. 16.5 kg day^{-1} and 13.5 kg day^{-1}. This similar author analysed nutrient content of both feedstuffs per kg dry matter, i.e. protein and energy contents of 21.25% and 4873.61 Cal kg^{-1} (0.02040483 MJ kg^{-1}), and 15.02% and 4601.21 Cal kg^{-1} (0.019264346 MJ kg^{-1}), respectively. Crop products in particular are becoming expensive constraining the use of these products. But, on the other hand, rural pig farmers produce crop products and residues that could be used to feed their pigs, such as soybean wastes. These feed types are fiberouse dietary feeds that can be used to feed sows and lactating sows (Renaudeau et al., 2003). In Vietnam, gestating and lactating sows are fed with roughage, maize, rice brand, broken rice, cassava (fresh and dry), concentrate, soybeans and fish (Lemke et al*.,* 2006). In Baliem valley, Wamena-West New Guinea, Cargil and Mahalaya (2007) used sweet potatoes and vine silage to feed pigs. These ingredients were purchased and collected from market and cropland. This author reported also that different reproductive stages, gilts, empty sows, gestation and lactation, receive various amounts of feed, i.e. 25.4, 27.5, 33.0 and 39.5 MJ kg feed, respectively.

Table 4 depicts that the ration of 1 kg feeding was insufficiently contributing in body mass gain. Body mass was slightly decresed. The energy maintenance of sows was higher on the day 1 and declined on the subsequent days due to insuffiecient ration regime of 1 kg day^{-1}. This induced severe effects on declined protein and fat acretion in the mody mass. In one hand, there is a tendency of growing body protein and fat. This is due to determined demand of energy maintenance of the sow and due to less energy contents of 12.54 MJ. Day one had high energy retention and therefore there is no lean and fat deposited. The cases of starvation as incorporated in this model would occur. Declining body weights occurs every day consecutively followed by energy for maintenances. Meat and fat subsequently demobilised as a result of insufficient feeding uptake. It can therefore be concluded that offering feeding less than 1 kg has negative effect on inadequate energy maintenance, growth meat and fat. Figure 2 is visualizing the effect ration of 1 kg feeding.

Simulation ration of feeding in Table 5 showed that ration of 2 kg sufficiently required energy maintenance demand of the sow. It seemed that 2 kg of feeds provided to weaned sow of 87 kg body mass was still insufficient. As body weight is positively grown, energy used for maintenance will linearly increase (Figure 3.). Meat grew and fat were positively deposited; however its number was still low (0.0774 kg day^{-1}) and was declining. Although there was a positive body weight gain, due to increased energy for maintenance, the growths of meat and fat were still in risk. The declining meat and fat growths still existed. Meat and fat were subsequently demobilised as a result of insufficient daily feeding uptake of 2 kg.

We therefore conclude that offering feeding less than 2 kg day^{-1} has negative effect on sufficient energy needed for maintenance. Therefore, the feeding ration of 2 kg is still in risk for weaned sows. Increasing the number of daily feeding of 3 kg was shown to have a positive impact on body weight gain. Offered ration of 3 kg feeds for weaned sow on 87 kg was adequate (Table 6). As body weight positively grew, energy used for maintenance was demanded, and linearly increased as well. Meat and fat were deposited. However, their weights were still insufficient (0.1676 and 0.0838 kg day^{-1}). Although positive increase in body weight gain, due to increased energy for maintenance, the growths of meat and fat were still interchange and at risk due to immeasureable exercises that were not taken into account in this model. The growths of meat and fat were still slightly declining. The meat and fat were subsequently demobilised as a result of insufficient feeding uptake of of 3 kg ration. Feeding digestibility at 0.82 should then be increased, therefore, increasing the values of meat and fat growths to enhance fat deposition. Similar finding was revealed by Renaudeau et al., (2003). In lactating season, sows only consume slightly greater amount of ration of 3447 g day^{-1}. While in warm season, feed consumption could reach 4907 g day^{-1}.

Maintenance Requirement

Based on physiology function of sow with initial body weight of 87 kg (or metabolic body weight of 28.5 kg$^{0.75}$), energy needed for maintenance is equal to 0.44 MJ kg$^{-0.75}$ or equal to 12.54 MJ kg$^{0.75}$. While protein needed for maintenance is equal to 0.0370 kg 0.0013 $\times W^{0.75}$ (Whittemore, 1993) and metabolic energy need $M_{EM}=\alpha \times BW^{0.75}$ (Knap et al., 2003). Protein maintenance obtained from feeding regimes can available to be retained in the form of body protein. Protein deposited in the body based on feeding regime is inadequately providing meat body weight. Of the three ration feeding regimes, ration of 1 kg was insufficiently available and therefore requires energy maintenance demand of the sow, due to providing less energy contents than 12.54 MJ. The cases of starvation as incorporated in this model would occur. Chwalibog et al. (2008) in their paper best described about phenomenon of starvation. These authors precisely explained the pattern of substrate oxidation switched from oxidized carbohydrate to oxidized fat.

The implication of this is that the sows will loss its body weight due to deamination of body fat and protein during weaning days. Energy needed for deamination of fat and protein is 0.05 MJ and 0.002 MJ. It is contrary with the other two feeding regime, gaining body weight in these two feeding regimes seems to be promising. Protein and energy (CP/MJ) ratio can be an important parameter as to the high rate of protein content in diet, high protein value can be retained by the meat pool. Low value of digestible diet will decrease digested feed by the gut and increasing excretion rate.

Protein (meat) Gain

Total protein contents in the feed of 2.61 kg DM was 365 g kg DM. If it was assumed that the digestibility of feed was 0.82, then the total amount of protein contents was 299.3 g. From the digested feed, total protein that will be excreted was 53.87 g (1-digestibility=1-0.82=0.18*299.3 g). Therefore, total crude net protein that was available in the body was 245.43 g, in which 4 g day^{-1} will be used for maintenance and 241.53 g for deposition in the body. The energy value of protein deposition in meat is 12.84 Mcal/kg (Yuan et al., 2008). This amount can be overestimated or simulated (Halas et al., 2004) and shows an odd ratio. If we incorporate the determinant factors in this simulation such as animal genetic, temperature, insulation, pig density, a result in the form of reduction in net feed intake may happen. The genetic of the pigs has shown its potential as a protein-deposition factor (g day^{-1}), as explained by Canas et al. (2003). Pigs with very low genetic quality could deposit 70 g day^{-1} (indicating "low" genetic), whereas pigs with high genetic quality could deposit 150 g day^{-1} protein or even more, 190 g day^{-1} (Skorupsky et al., 1995). The genetic quality of pigs kept by smallholder pig farmers in Papua varies. As introduced by Dutch administration in the early 1960's with no upgrading genetic, the genetic quality of pig in Papua still remains low. Therefore, the selections of the genetic quality of pigs in Papua are still needed (Kanis et al., 2008).

Fat Gain

Increasing the weight of body fat was able to be evidently achieved by offering 3 kg feed in fresh matter basis (or 2.61 kg DM). This amount of DM feed had 32.32 MJ of total energy. Yuan et al. (2008) informed, the energy value of energy deposition is 12.84 Mcal/kg DM. High amount of fat depositions that were achieved in the other two feeding regimes were questionable. As explained in starvation stage by Chwalibog et al. (2004), the second feeding regime of 2 kg fresh matter (FM) or 1.74 kg DM would only sufficient for daily maintenance requirement. At the dynamic stage and increasing amount of maintenance requirement, it is hardly difficult to achieve positive body weight gain and conversely, the losing amount of body weight may happen. Proper gain in fat and protein body weight will induce productivity of sow reproduction in the subsequent life cycle such as the length of weaning to service index (Einearson and Settergen, 1994) and post-weaning follicular development (Kauffold et al., 2008).

Gestating Body Weight (foetus, maternal gain)

In simulating gestation sow production and reproduction, factors to be taken into account were maintenance, maternal gain and foetus development. The number of foetus produced per sow was needed to be investigated under tropical and small-scale pig production. Foetus development is at risk in particular in the first farrowing gilt and even the first week of foetus implantation in the uterus. Reducing feed intake can be wise step to avoid frequency of foetus death in the onset of foetus development. The important of Parturition body weight (milking piglets) period is the readiness of the sow to enter farrowing time. This period is also at risk of birth death rate. Sow has to be avoided from high stress condition. The sources of stress can be induced by feeding, environment, and management decisions. The first 3 days of farrowing, sows provide high amount of milk protein contents and it was slightly decreasing in the next coming days. Colostrum is the source of external body immune obtained via milk colostrum. High birth body weight (kg) of the piglets can be an indicator of high survivability (%) (Whittemore, 1993).

Scenarios in Simulation

These sow life cycles are utmost important in upgrading productivity of pigs. It is simply due to their roles in transferring and shaping maternal genetic value through individual development of the pigs. Well planning decision of a farmer will have high productivity and longevity of production of the sows. In lactation period, 10 kg of sow body weight will be devoted to provide milk for suckling piglets by converting protein and energy into milk nutrients. Therefore, there is no additional gain of body mass in lactating sows as confirmed by Peng et al., (2007). The average piglets per farrowing (litter size) that was considered in this simulation is needed to be studied further in Papua, although Iyai (2008) confirmed the average piglet produced is in the range of 6 piglets per farrowing (litter size of 6). Their energy will be much burned and back fat will be decreased. It is therefore wise to let the weaned sow to obtain proper feeding in order to enter the mating season. Weaned sows are in their preparation period to enter their reproduction cycles. During non-productive days (NPDs), sows should be fed with proper feeding. This proper feeding has the positive implications in terms of greater rate of FSH and LH productions, in turn, resulting in the increasing number of follicular being produced and the number of ova being shed that are needed to be fertilized by sperm in oviduct tract.

Table 4. Quantifying ration of 1 kg feeding and digestibility of 0.82

Day	Body Weigth (kg)	Maintenance (MJ/day)	Growth Meat (kg/day)	Growth Fat (kg/day)
0	87	0	0	0
1	86.8359	12.5341	-0.0292	-0.0146
2	86.659	12.5163	-0.0290	-0.0145
3	86.4833	12.4972	-0.0288	-0.0144
4	86.3091	12.4782	-0.0286	-0.0143
5	86.1361	12.4593	-0.0284	-0.0142
6	85.9645	12.4406	-0.0282	-0.0141
7	85.7942	12.422	-0.028	-0.014
8	85.6252	12.4036	-0.0278	-0.0139
9	85.4575	12.3852	-0.0276	-0.0138
10	85.2911	12.367	-0.0274	-0.0137
11	85.1259	12.349	-0.0272	-0.0136
12	84.9620	12.331	-0.027	-0.0135
13	84.7994	12.3132	-0.0268	-0.0134
14	84.638	12.2955	-0.0266	-0.0133

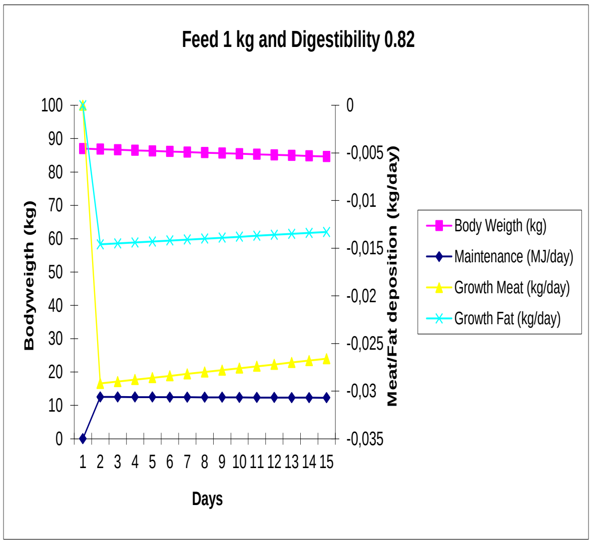

Figure 2. Quantifying ration of 1 kg feeding and Digestibility of 0.82.

Table 5. Quantifying ration of 2 kg feeding and digestibility of 0.82

Day	Body Weigth (kg)	Maintenance (MJ/day)	Growth Mea (kg/day)	Growth Fat (kg/day)
0	87	0	0	0
1	87.4874	12.5341	0.0774	0.0387
2	87.9577	12.5867	0.0768	0.0384
3	88.4253	12.6374	0.0763	0.0381
4	88.8902	12.6878	0.0757	0.0379
5	89.3523	12.7378	0.0752	0.0376
6	89.8118	12.7874	0.0747	0.0373
7	90.2685	12.8367	0.0741	0.0371
8	90.7226	12.8856	0.0736	0.0368
9	91.1739	12.9342	0.0731	0.0365
10	91.6226	12.9824	0.0726	0.0363
11	92.0686	13.0303	0.072	0.036
12	92.512	13.0779	0.0715	0.0358
13	92.9527	13.1251	0.071	0.0355
14	93.3908	13.1719	0.0705	0.0353

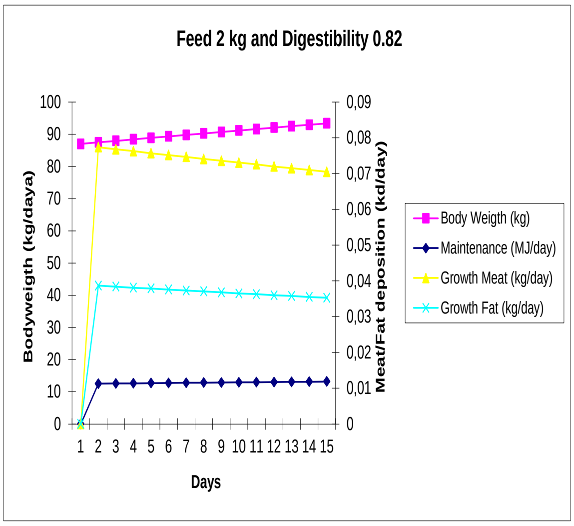

Figure 3. Quantifying ration of 2 kg feeding and Digestibility of 0.82

Table 6. Quantifying offered feeding of 3 kg and digestibility of 0.82

Day	Body Weigth (kg)	Maintenance (MJ/day)	Growth Meat (kg/day)	Growth Fat (kg/day)
0	87	0	0	0
1	88.14	12.5341	0.184	0.092
2	89.2613	12.657	0.1827	0.0913
3	90.378	12.7776	0.1814	0.0907
4	91.4902	12.8973	0.1801	0.09
5	92.5978	13.0162	0.1788	0.0894
6	93.7007	13.1342	0.1775	0.0888
7	94.799	13.2513	0.1762	0.0881
8	95.8926	13.3677	0.175	0.0875
9	96.9814	13.4832	0.1737	0.0869
10	98.0655	13.5978	0.1725	0.0862
11	99.1449	13.7117	0.1713	0.0856
12	100.2194	13.8247	0.17	0.085
13	101.2891	13.9369	0.1688	0.0844
14	102.3539	14.0483	0.1676	0.0838

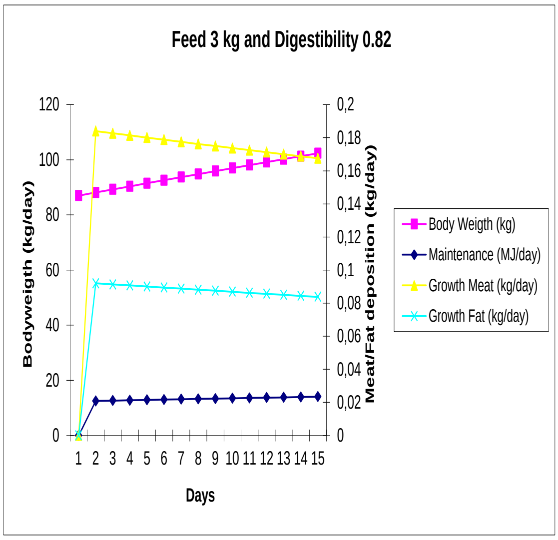

Figure 4. Quantifying offered feeding of 3 kg and Digestibility of 0.82

Conclusions

Weaned sows by feeding less than 3 kg day^{-1} should be in consideration for farmers. Increasing the weight of feed day^{-1} will satisfy basal needs of feeding. If it is less than 3 kg, the subsequent effect is starvation. Body weight will decline, growth meat and fat will decline and pigs will be lean and skinny. This in turn will cause negative effect on other physiological mechanisms. Additional weight of feeding can be increased to satisfy feeding uptake (≥ 3kg). As current pig researches experience high progress, it is recommended to seek for more related parameters and coefficients that can be better used in predicting dynamics of pig production and reproduction. On the other hand, using data bases as resulted from emphyric data would be precisely convincing.

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