International Journal of Fauna and Biological Studies
Available online at www.faunajournal.com

ISSN 2347-2677
www.faunajournal.com
IJFBS 2020; 7(3): 37-42
Received: 22-03-2020
Accepted: 24-04-2020

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Effect of *Moringa oleifera* leaf flour supplementation in diets on the characteristics of the local pig carcass in East Timor

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Abstract
The objectives of this study was to evaluate the effects of inclution differents level of Moringa oleifera leaf powder in diet on the characteristics of the local pig carcass of East Timor. A total of forty local pigs male in growth phase were grouped into five weight groups in a complete randomized block design (CRBD) with four treatments. Pigs were allotted to four treatments and five blocks as replicates, and each block used 8 pigs with homogeneous body weight. The experiments were carried out in the following way: Treatment A: basal diet without the supplement of *Moringa oleifera* leaf flour; treatment B: supplemented with 3% of *Moringa oleifera* leaf flour; treatment C: supplemented with 6% of *Moringa oleifera* leaf flour; and treatment D: supplemented with 9% of *Moringa oleifera* leaf flour, repectively. The results showed that the carcass length and the commercial part of the carcass (shoulder roast, shoulder picnic roast, loin, back ribs, spare ribs) in all treatment swine groups (A, B, C, and D) showed no significantly difference ($P>0.05$). There were significant differences ($P<0.05$) in slaughter weight, carcass weight, carcass percentage, back fat thickness, and leg roast steaks between treatments. We concluded that supplementation in basal diets of 6% Moringa oleifera leaves powder can increase slaughter weight, carcass weight, carcass percentage, and leg roast steaks of local pigs East Timor.

Keywords: Carcass, *Moringa oleifera*, back fat thickness, piglets

Introduction
The pig farm business is one of the activities that has a multiplier effect of work and income in all productive sectors of the economy. Pigs are high quality meat-producing monogastric livestock, and have beneficial abilities, including fast growth, high litter size and a high percentage of carcasses between 65-80% of body weight when compared to other types of meat-producing livestock (Bidura and Gomez, 2019) [6].

In general there are three main factors that determine or influence the rate of growth, body composition and chemical composition of carcasses, namely: livestock germs, feed given to livestock and their management. Selection of the right feed ingredients will get quality feed ingredients to meet basic living needs and production. One of the local feed ingredients for pigs that have a high nutritional content and is almost complete is the leaves of *Moringa* (*Moringa oleifera*) that have not been used optimally, especially the old leaves and other follower products.

Moringa oleifera is known in the world as a plant that has high nutrition, so it has been recommended as an alternative feed that is quite potential to overcome the problem of malnutrition (Broin, 2010) [8]. The most nutritionally rich plant, contains more vitamins, minerals, antioxidants, complete essential amino acids, and added with other compounds that are needed by the body (Chukwuebuka, 2015) [10].

The *Moringa oleifera* plant is known in 82 countries with 210 different names, including *Moringa*, and by the people of Timor-Leste named *Marungi*. *Moringa* leaves are one part of the *Moringa* plant which has been studied a lot of nutritional content and uses. This type of leaf is very rich in nutrients in addition to the content of several phytochemical compounds (Chukwuebuka, 2015) [10]. *Moringa* leaf flour is one alternative feed from herbal plants which is assumed to contain growth promoters or complete amino acids to be able to stimulate the growth of pigs. Teteh *et al.* (2013) [38] states that one type of herbal feed that has been known as a substitute for the use of antibiotics for growth (growth promoter antibiotics) is *Moringa*

leaf flour with a low dose of 0.10-2% can improve growth rates and also does not affect the quality of carcasses in broilers. Bidura and Gomez (2019) [6] assert that in an effort to increase livestock production depends also on the pattern and quality of feed provided. Chukwuebuka (2015) [10] reports that *Moringa* leaves contain very high minerals and vitamins that can increase metabolic activity in the body. Rations that contain minerals and vitamins that are high can increase nutrient absorption, so that feed efficiency increases, as well as increasing weight gain of pigs (Partama, 2019) [26].

Some phytochemical compounds in *Moringa* leaves which are anticbacterial, and contain β-carotene which act as carcass color active substances which in principle are one of the conditions for evaluating meat quality. Phytochemical compounds contained in *Moringa* leaves include: flavonoids, saponins, tannins, and several other phenolic compounds that have antimicrobial activity (Bukar *et al*., 2010; Gomez *et al.*, 2019) [9, 17]. Estrogen-like flavonoids have been shown to be able to slow down bone mass (osteomalasia), reduce blood cholesterol levels and increase HDL levels, whereas saponins have been shown to be efficacious as anticancer, antimicrobial, and reduce blood cholesterol levels (Santoso *et al*., 2002; Bidura *et al*., 2017) [31, 7].

The antimicrobial activity of several phytochemical compounds in herbal plants has been investigated and the possibility of using them to develop antimicrobial drugs (Dalukdeniya *et al*., 2016; Elangovan *et al.,* 2014; Goel, 2013) [11, 12, 15] as a substitute for the use of antibiotics which is now banned from antibiotics its use. Several previous studies (Ashok *et al*., 2014; Chukwuebuka, 2015; Dalukdeniya *et al*., 2016) [5, 10, 11] reported that extracts or compounds isolated from *Moringa*, appeared to have antioxidant, anti-carcinogenic, anti-diabetic, anti-inflammatory, and anti-hypertensive properties, and the ability to protect liver damage. Preliminary research shows that giving *Moringa* leaf flour at a level of 3-9% in the ration, can significantly improve feed performance and efficiency in local pigs in East Timor (Gomez *et al*., 2019) [17]. *Moringa* leaf flour has several positive effects on animals, as reported by Sanchez *et al*. (2005) [30], that the main means of action of phytochemical active ingredients of *Moringa* leaves are inhibition of pathogenic microbes and endotoxins in the intestine and increased pancreatic activity, resulting in better metabolism and utilization of nutrients (Windisch *et al*., 2008; Grashorn, 2010) [39, 18].

This study aims to examine the effect of adding *Moringa* leaf flour in basal diets to the carcass characteristics and fat thickness of local EastTimor piglets.

Material and Methods

Animals and experimental design: This study used 40 local Timor Leste male pigs (*Fahi*) that had been castrated in the growth phase with a weight range of: 14.36±6.92 kg. The local pigs were bought from the communities around the research sites that were maintained by traditional extensive systems. To prevent CSF (Classical Swine Fever) disease, all pigs were vaccinated and given 1 cc of Vitamin B Complex per pig. All pigs were grouped into five weight groups in a complete randomized block design (CRBD) with four treatments. Pigs were allotted to four treatments and five blocks as replicates, and each block used 8 pigs with homogeneous body weight. The experiments were carried out in the following way: Treatment A: basal diet without the supplement of *Moringa oleifera* leaf powder; treatment B: supplemented with 3% of *Moringa oleifera* leaf powder; treatment C: supplemented with 6% of *Moringa oleifera* leaf powder; and treatment C: supplemented with 9% of *Moringa oleifera* leaf powder, repectively. The animals were given water and feed *ad libitum* during the experimental period of 90 days. In Figure 1 the physical form of male local pigs (*Fahi*) in Timor Leste was presented in the finisher phase.

Fig 1: Male local pig (*Fahi*) in East Timor

Growth performance traits and diets: The compositions of the basal diets are shown in Table 1. The basal diet was formulated and manufactured before starting the trial, without the inclusion of any antibiotic growth promoters or antibiotic growth promoter alternatives. The experimental diets were formulate on the basis of yellow corn, rice bran and soybean meal, and *Moringa oleifera* leaf powder. To complement the mineral requirements has been added 2% of Mineral-mix. To get the ideal ration, it is formulated based on animals needs in accordance with NRC (1998) [23] recommendations. Pigs had free access to experimental diets and drinking water. A combination of daylight and artificial light was used, with a 12-h light/dark cycle.

Process of making flour *Moringa* leaves: *Moringa oleifera* leaves were dark green, thinly sliced and dried at room temperature for 1-2 days, then dried in an oven at 50 °C for 24 hours. Then the *Moringa* leaves were pounded into fine powder. Laboratory analysis results show that *Moringa oleifera* leaves were contain: 89.52% dry matter; 33.68% Crude protein; 29.10% Crude fibre; 15.92% Ether extact; metabolizable energy: 2,815.40 kcal/kg; and beta-carotene: 25560 mg/100 g (Gomez *et al*., 2019) [17].

Pig Slaughtering Procedure: At the end of the observation, pigs enter the slaughtering stage, pigs were first fasted for 12 hours to obtain empty body weight, namely: body weight that has been reduced by the contents of the digestive tract (Soeparno, 2009) [36]. Drinking water was still provided to avoid stress on livestock. The method of slaughtering was adapted to the instructions of slaughtering pigs, ie. pigs are stunned by electric current techniques with a low voltage of about 80 volts. The electric current passes through the brain, so pigs immediately pass out. Before being stunned, pigs were first doused with cold water to be clean and facilitate the flow of electric current. After the pigs faint, the cutting process was

immediately slaughtered by the technique of cutting the neck into large blood vessels and the heart near the anterior end of the sternum, so that the blood process comes out as much as possible at the time of cutting. The next process was scalding and hair removal (scurfing). This process was carried out by inserting the slaughtered pig into hot water at a temperature of 60 -70 ^{0}C for approximately five minutes followed by the removal of fur and epidermis using a knife (Soeparno, 2009) [36].

The process of removal of internal organs contained in the pig's abdominal cavity (*Cavum abdomen*) and chest cavity (*Cavum thoracis*) by cutting the ventral abdomen in the medium, which starts from the navel to the front to the back end of the back of the breastbone segment (*Cartilago xiphoideus*) and back until the front edge *Os pubis*, so that the chest cavity and abdominal cavity open. The front and back legs were cut at the bottom of the foot, namely *Articulatio carpo metacarpeae* and *Articulatio tarso metatarseae* (Sena *et al*., 2015) [32]. The head was separated from the body in the *Articulatio atlanto occipitalis*, which was a meeting between the first vertebrae of the neck (*Atlas*) and the backbone (*Os occipital*). The tail was cut at the base of the tail, which is between the joints of the first tailbone segment (*Vertebrae cocygeae* I) and the last segment (*Os sacrum*).

Carcass weight is the weight of the body part of the slaughtered pork after being separated from the blood, fur, lower leg (on the tarsus bone), the head is right on the cervical bone and internal organs except the heart and heart. Furthermore, carcasses are divided into six commercial carcass breaks including: Loin. Shoulder roast, shoulder picnic roast, leg, baby back ribs, and spare risbs (Bidura and Gomez, 2019) [6]. The carcass fracture was weighed to determine its weight (g/100g carcass).

- Carcass length is measured from the first rib to the front end of the aitch bone caudal bone. Measurement using the metric band.
- Back fat thickness can be measured using a 150 mm (6 ") digital calipers measured on the back of the carcass between the 10th and 11th ribs.
- Commercial pieces of shoulder picnic roasts, shoulder roasts, back ribs, spare ribs, serloin chops, leg roast steaks are the best indicators and are widely used against carcasses produced by pigs. Measurements are adjusted to each carcass cut size.
- Percentage of carcass is the result of dividing carcass weight by weight cut by one hundred percent.

Statistical analysis: Data analysis used one-way analysis of variance (ANOVA). If there were significant differences between treatments, then followed by Duncan's test (Sampurna and Nindhia, 2008) [29].

Results

The results of the study are presented in Table 1. Carcass length and the commercial part of the carcass (shoulder roast, shoulder picnic roast, loin, back ribs, spare ribs) in all treatment swine groups (A, B, C, and D) showed no difference (P>0.05). There were significant differences (P<0.05) in slaughter weight, carcass weight, carcass percentage, back fat thickness and leg roast steaks between treatments.

Supplementation of 6% *Moringa* leaf flour (Group C) in the basal ration, were significantly different (P<0.05) increasing slaughter weight, carcass weight, and carcass percentage, namely: 27.43%; 26.80%; and 3.67% higher than control (Group A). Back fat thickness in pigs of Group D (9% *Moringa* leaf flour) was 13.40±1.57 mm. The average value of back fat thickness in the carcass of pigs treated in Groups A, B, and C, were 94.85%; 70.15%; and 64.40% higher than back fat thickness of Group D.

The results showed the average of the commercial cut parts of the leg roast steaks carcass in the control treatment (Group A) was 16.83±1.32 g/100 g carcass weight (Table 1.). Supplementation of *Moringa l*eaf flour in basal ration at level 3% (Group B); 6% (Group C); and 9% (Group D), were: 14.02%; 21.57%; and 12.89% significantly (P<0.05) higher than controls.

Table 2: Effect of *Moringa* leaf flour (MLF) in diets on the characteristics of the local pigs carcass of East Timor

Variabel	Perlakuan[1]				CV[3]
	A	B	C	D	
Slaughter weight (kg)	27.52±6.57b[2]	30.10±10.77b	35.07±6.59a	27.26±1.40b	22.75
Carcass weight (kg)	19.63±5.93b	20.94±8.35b	24.89±5.08a	18.60±1.81b	25.26
Carcass percentage (%)	69.12±3.29b	67.69±2.07b	71.66±1,54a	66.91±3.59b	4.56
Carcass length (cm)	45.40±5.13a	48.40±8.79a	48.80±2.77a	47.00±1.87a	10.76
Back fat thickness (mm)	26.11±11.50a	22.80±5.60a	22.03±1.80a	13.40±1.57b	24.28
Commercial pieces of carcasses (g/100 g carcass weight)					
Shoulder roast	12.52±3.58a	13.86±4.39a	12.94±3.28a	11.04±1.24a	24.58
Shoulder picnic roast	13.75±4.05a	15.78±2.73a	14.99±1.38a	12.03±3.49b	20.63
Loin	12.54±3.61a	14.75±3.53a	14.79±3.62a	10.93±2.40a	21.51
Back ribs	11.52±4.74a	12.70±4.38a	14.79±2.68a	12.00±2.44a	25.06
leg roast steaks	16.83±1.32b	19.19±1.93a	20.46±0.63a	19.00±1.65a	14.78
Spare ribs	6.84±3.05a	8.83±3.19a	8.32±1.09a	8.18±1.49a	28.51

Note:

1. A: The basal diet without *Moringa* (control); B: the basal diet with 3% *MLF*; C: the basal diet with 6% *MLF*; and D: the basal diet with 9% *MLF*, respectively.
2. Means with different superscripts within raw values are significantly different (P<0.05)
3. CV: Coefficient of Variance

Discussion

Slaughter weight and carcass weight in the group of pigs that received Moringa leaf flour as much as 6% (Group C) in the ration was significantly higher than the other pigs group (Groups A, B, and D). The average value in detail is presented in Table 1. This shows that the provision of 6% Moringa leaf

flour in the ration has met the nutritional needs to meet the basic life and growth of pigs, one of the indicators is the weight of cut and carcass. Amino acid content in Moringa leaf flour, among others: arginine, threonine, and lysine are herbal nutrients that are very good for accelerating the process of livestock growth (Hernandes *et al*., 2004) [20].

The increase in sloughter weight and carcass weight in pigs fed 6% *Moringa* leaf flour was also caused by the presence of phytochemical compounds in *Moringa* leaves, as reported by Prasad and Ganguly (2012) [28] and Siti *et al.* (2019) [35] that *Moringa* leaves are a source of vitamin A, riboflavin, nicotinic acid, pyridoxic acid folic acid, ascorbic acid, β-carotene, calcium, iron and α-tocopherol. The same thing was reported by Akhouri *et al*. (2013) [3] that the *Moringa oleifera* plant is also efficacious for strengthening the heart, eyes, brain, bile, and immune system. The research results of Ahmed *et al.* (2017) [2] showed that supplementation of *Moringa* leaf flour in the ration affected the bioactive mass of eggs and egg yolks. Antioxidants, flavonoids, carotenoids, amino acids, additional proteins, and energy levels that result in a decrease in egg water content can be a reason for increasing nutrient density in egg yolk (Nkukwana *et al*., 2014[25]; Nimalarante and Wu, 2015) [24]. Some research results on the effects of herbal extracts in poultry were conducted by Akhouri *et al.* (2013) [3] that giving *Moringa* leaf powder at 250 mg/kg body weight can significantly increase body weight and feed efficiency in broilers. According to Mabusela *et al*. (2018) [22], giving *Moringa* seed flour in ration markedly improved the quality of external eggs, and increased the profile of fatty acids. Bidura *et al.* (2017) [7] reported the administration of 5 cc/100 cc herbal extract (*Sauropus* and Garlic leaves) in drinking water increased the efficiency of feed absorption, egg production and total egg weight.

The percentage of carcasses in local pigs obtained in this study showed that the group of pigs that were given *Moringa* leaf flour as much as 6% in the ration the highest results were: 71.66 ± 1.54% compared to other pig groups. This shows that as much as 6% *Moringa* leaf flour in the ration can produce a fairly high percentage of carcasses, which is about 3.54% higher than the control. The results obtained in this study were lower when compared with the results of Silalahi and Sinaga (2010) [34] research which reported that the average percentage of carcasses in pigs was: 77.17%. Likewise, Aritonang *et al.* (2011) [4] research reported that the percentage of pig carcasses was: 77.15%. The percentage of pig carcass obtained in this study, if classified as still in class I according to the USDA recommendation that the range of percentage of pig carcasses with a range: 68-72% is normal.

The mineral and vitamin content in *Moringa* leaves is very high (Chukwuebuka, 2015) [10] which can increase metabolic activity in the body, so as to increase body weight and carcass weight. Partama (2019) [26] research reported that increasing mineral and vitamin content in the ration significantly increased nutrient absorption, feed efficiency and pig growth. Ca minerals are needed by the body, especially in the formation of body skeletons and some chemical reactions in the body (El-Husseiny *et al*., 2018) [13]. Minerals are not digested, but are absorbed directly by the body and cannot be stored in the body, but are excreted or thrown out of the body (Abdulla *et al*., 2016) [1]. Phosphorus mineral is the second most mineral in the body, about 1% of body weight. Phosphorus minerals are the main food ingredients used by all organisms for sources of growth and energy. Phosphorus is present in bones and teeth, and in cells, namely muscles and extracellular fluid (Peters and Mahan, 2008) [27].

Carcass weight and percentage of carcass in pigs produced are closely related to growth, because it depends on the growth process when pigs are still alive (Forrest *et al.,* 1975) [14]. The low commercial carcass weight in this study is thought to be caused by breeds and local pig growth which is not optimal or slow.

The average length of carcasses in pigs results of their study Sihombing (2006) [33] was 75.97 cm. The length of this carcass, was apparently much longer than the average length of the carcass in local pigs obtained in this study. According to Guniwala *et al.* (2016) [19] that carcass length is closely related to breed and body length of pigs while still alive. Timor Leste's local pigs are genetically slow growing and have a body size that is less long compared to the length of other breeds.

The use of *Moringa* leaf flour in pig rations in this study only had a significantly higher effect on the commercial section of the leg carcass (thigh), while other commercial carcass pieces (shoulder roast, shoulder picnic roast, baby back ribs, spare ribs, and loin) did not show there was a significant difference between treatments. Commercial carcass pieces, especially the Leg section shows that the group of pigs that got *Moringa* leaf flour each: 3%; 6%; and 9% in the ration was higher compared to the control pig group (without *Moringa* leaf flour). This means that the use of *Moringa* leaf flour at the level of 3-9% in feed can only increase the commercial section of the Leg carcass, but has not been able to affect growth maximally, so that it has not obtained the weight of the commercial carcass pieces evenly. In addition, it is thought to be caused by the growth of local pigs which are less than perfect and maximal from the previous phase. This is in line with the opinion of Bidura and Gomez (2019) [6] who reported that good pig growth will also have a good effect on slaughter weight, carcass weight, and weight of commercial carcass pieces produced after slaughter.

The average thickness of back fat in local pigs obtained in this study showed that administration of 9% *Moringa* leaf flour in the ration produced the lowest back fat thickness among treatments, namely: 13.40±1.57 mm. This means that the use of *Moringa* leaf flour as much as 9% in the ration can reduce the thickness of back fat around: 51.68% lower than the control treatment. This is due to the content of antioxidant compounds in *Moringa* leaf flour can help reduce fat absorption, so that it can produce low fat pork carcass. This is in line with the opinion of Srinivasan (2005) [37], also Godinez-Oviedo *et al.* (2016) [16] that antioxidant compounds in *Moringa* leaves can stimulate the production of bile salts in the liver, which produce fat emulsification and reduce fat absorption, thereby reducing triglyceride levels in the carcass.

The thickness of back fat indirectly describes the production of fat or meat in the carcass. Thin thickness of back fat gives a high percentage of meat yield, on the contrary thick high back fat gives a low percentage of meat. Bidura and Gomez (2019) [6] stated that the thickness of back fat is one of the assessment of carcass quality in pigs that is affected by pig type, age, ration, body weight and castration. Increased protein in feed can increase protein content and reduce meat fat (Soeparno, 2009) [36]. It was also reported that high-energy feed consumed by livestock can produce high fat deposits in the body, and decreased levels of protein and water in the carcass.

According to Leeson and Summers (2000)[21], in general rations with high energy content and low protein will produce higher carcass fat, and rations with high protein can produce carcasses with low fat content.

Conclusion

In conclution, based on the results of this research, supplementation in basal diets of 6% *Moringa oleifera* leaves flour were increased slaughter weight, carcass weight, carcass percentage, and leg roast steaks of local pigs East Timor.

Acknowledgements

The author would like to thank to Mr. Xanana Gusmao for the scholarship and Prof. Dr. Fransisco Martins as a Rector of National University, Timor Lorosa'e, East Timor for support and including research funding. The author would like to thank to the Staff of Laboratorium of Nutritions, Faculty of Animal Science for their support during this sample analyzed.

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