

RESEARCH ARTICLE

Improving Yield and Quality of Wild Pork and Pigs in Thai Nguyen, Vietnam - and Solutions to Enhance Competitiveness to Thailand and China

Bui Thi Thom¹ • Dinh Tran Ngoc Huy^{2*} • Tran Van Phung³

¹PhD, Thai Nguyen University of Agriculture and Forestry, Vietnam. E-mail: buihithom@tuaf.edu.vn

²MBA, Banking University HCMC, Ho Chi Minh City, Vietnam.

International University of Japan, Japan. E-mail: dtnhuy2010@gmail.com

³Associate Professor, PhD, Thai Nguyen University of Agriculture and Forestry, Vietnam. E-mail: tranvanphung@tuaf.edu.vn

ARTICLE INFO

Article History:
Received: 16.04.2021
Accepted: 18.05.2021
Available Online: 28.06.2021

Keywords:

Yield
Pig Farming
Wild Pork
Cross-bred Wild Boar and Pigs
Vietnam
Thai Nguyen
China
Thailand

ABSTRACT

Thanapongtharm (2016) stated that in Thailand, pig production intensified significantly during the last decade, with many economic, epidemiological and environmental implications. Also detailed geographical analysis of the different production systems will be used to spatially-inform planning decisions for pig farming accounting for the specific health, environment and economical implications of the different pig production systems.

Pig farming is very important in Vietnam, esp. In Thai Nguyen city and Northern provinces, pork products are suitable for people's taste. At present, most pig breeds are selected and raised in accordance with local conditions, especially wild boar and hybrids are very popular with people, the demand for products is increasing day by day.

Lander et al (2020) pointed Pigs have played a central role in the subsistence and culture of China for millennia. The close relationship between pigs and people began when humans gradually domesticated wild pigs over 8,000 years ago. While pigs initially foraged around settlements, population growth led people to pen their pigs, which made them household trash processors and fertilizer producers.

Study results show for instance, For commercial cross-bred wild boar farming, a diet with a protein level of 16-14% and a metabolic energy level of 3000-2900 kcal/kg of feed in the diet for growth and fattening most appropriate, which has both the growth ability of hybrid wild pigs and economic efficiency under semi-wild breeding conditions in Thai Nguyen ecological environment.

Last but not least authors present food processing of wild pigs into delicious stir-dried pork.

Please cite this paper as follows:

Thom, B.T., Huy, D.T.N. and Phung, T.V. (2021). Improving Yield and Quality of Wild Pork and Pigs in Thai Nguyen, Vietnam - and Solutions to Enhance Competitiveness to Thailand and China. *Alinteri Journal of Agriculture Sciences*, 36(1): 746-752. doi: 10.47059/alinteri/V36I1/AJAS21104

Introduction

With the development of society, the demand for wild pork meat and pure local pigs are being preferred. Therefore, farmers are gradually taming farming in the direction of concentration but still keeping their wild behavior.

In order to raise pure wild boar and wild boar effectively, it is important to balance the nutritional composition of the feed in terms of metabolic energy and the appropriate level of crude protein in the diet for this pig breed based on natural food sources. necessary. With appropriate nutrition, it will be a favorable condition for wild boars and crossbreeds to promote genetic potential and good characteristics of breeding products, easy to raise in

* Corresponding author: dtnhuy2010@gmail.com

concentrated and semi-wild ways to improve people's income. local. Currently, animal feed accounts for 70-75% of the total cost, but the unit price of high-protein feedstuffs of animal and plant origin increases, increasing input costs for pig production, which has motivated people to Animal husbandry and feed manufacturers seek to reduce feed costs, calculate appropriate diets to reduce feed costs and improve economic efficiency of farmers.

Literature Review

Wild pig with scientific name is *Sus scrofa*, also known as Loi pig, Kun Bui. Wild boars are present all over the world. It is the ancestor of the domestic pig breeds, which have 21 subspecies that live in a very wide range including parts of Europe and northern Asia, as well as southern and northern Africa. In Vietnam, wild pig is found in most of the forest areas of the provinces, especially in the northern mountainous areas and along the Truong Son mountain range. Taming and raising them to become a pet is completely new in Vietnam.

According to Dao Le Hang (2008): Wild boar, the whole body is covered with short hairs, similar to bamboo roots, usually dark brown in color. The head and body length of an adult pig is about 90 - 180 cm, the tail length is about 30 cm, the height of the shoulder is about 55 - 110 cm. Herds of wild boar can travel together on long journeys to new settlements, but do not migrate. Wild boars are more active at night, at dusk and at dawn. When the pigs matures it will leave the herd and live independently around 50-350 kg, with some domesticated pigs up to 450 kg. Males are usually larger than females. Wild pigs have 4 pairs of fangs and 6 pairs of breasts.

Feeding conditions, not only affect the amount of digestive juices secreted, but also change the activity of digestive enzymes markedly. V.A. Teletnep (1966) (Excerpt from Ton That Son et al. (2006), when studying the digestive enzyme secreting activity of pancreatic juice, it was found that the protease activity depends on the intensity of secretion of the pancreas and its composition. Ration. With diets that are well balanced in nutritional composition relative to the body weight and age of the pig, there is little variation in trypsin intake.

According to the authors: Hoang Toan Thang, Cao Van (2006), when studying the effect of the same level of protein on the nitrogen digestion in the small intestine of pigs, it was found that, in the diet, there are different types of feeds. different diets, the content of nitrogen forms in the intestinal chyme is different. This directly affects the ability to absorb and use nitrogen in the digestive tract. Therefore, it requires the study of different protein levels, on the basis of stabilizing the content of some essential amino acids as well as the change in the ratio and content of amino acids on the same protein level. were established on the same type of diet, to eliminate errors caused by differences in diets.

In the world, the authors have focused a lot on research in the field: Determining the protein and energy needs of pigs to promote growth, complete development, reduce costs and increase livestock efficiency. The balance between protein/ME in pigs is an important requirement for growth, meat quality, and lean percentage at the growing stage of pigs.

Survey results on 77 wild boar breeding facilities across the country by the National Institute of Livestock Production showed that 61.1% of the establishments raised pure Thai wild boar, 38.9% raised many types, including wild boar. Thailand, Vietnam, native pigs and hybrids. There are 6 establishments that also raise pure Vietnamese wild boar. The Thai wild boar is imported from Thailand. However, in the South, there are also Malaysian wild boars, which Mr. Chau Xuan Vu (Phu Quoi commune, Long Ho, Vinh Long) imported dozens of pigs from Malaysia in 2006.

Methodology

Authors also use statistic and data to make analysis an propose solutions. Experiences in Vietnam food processing also mentioned. Beside, Authors mainly use combination of quantitative methods and qualitative methods including synthesis, inductive and explanatory methods.

Main Results

Overview

Distribution of Wild Pigs in the World

According to a study by the Center for International Cooperation in Agricultural Development (France), wild boar has 36 breeds distributed in almost every continent in the world.

The growth rate (for wild boars that have been raised in Thailand and Vietnam) is slow (average is only about 0.15 - 0.3 kg/day). Physiological life span of wild boar lasts from 15 to 25 years.

Table 1. Classification of wild pigs breeds in the world

Order	Pig Breed name	Distribution place
1	<i>Sus scrofa</i> Affimis	India, Sri Lanka
2	<i>Sus scrofa</i> Anolamanensis	Tunisia, Algeria, Maroc
3	<i>Sus scrofa</i> Andamanensis	Andaman Island - India
4	<i>Sus scrofa</i> Attila	Hungary; Iran-Ukraine; Russia; central Belarus
5	<i>Sus scrofa</i> Baeticus	Balear; southern Spain; Northern Morocco
6	<i>Sus scrofa</i> Barbarus	North Africa, Tunisia, Algeria, Morocco
7	<i>Sus scrofa</i> Castilianus	Northern Spain
8	<i>Sus scrofa</i> Chirodontus	China
9	<i>Sus scrofa</i> Coreanus	North Korea
10	<i>Sus scrofa</i> Cristatus	Southern Himalayas, Nepal, India, Thailand, Romania
11	<i>Sus scrofa</i> Davidi	Southern Himalayas, Iran, Pakistan, Romania, Northwest India
12	<i>Sus scrofa</i> Falzfeini	Poland
13	<i>Sus scrofa</i> Ferus	Northern Europe
14	<i>Sus scrofa</i> Floresianus	Flores Island - Indonesia
15	<i>Sus scrofa</i> Jubatus	Malaysia
16	<i>Sus scrofa</i> Leucomystax	China
17	<i>Sus scrofa</i> Libycus	Turkey; Palestine; Yugoslavia; Uzbekistan; Kazaktan
18	<i>Sus scrofa</i> Majoli	Central Italy
19	<i>Sus scrofa</i> Mandehuricus	China
20	<i>Sus scrofa</i> Mediterrancus	Spain
21	<i>Sus scrofa</i> Meridionalis	Audalousie; Sardaigue; Cose
22	<i>Sus scrofa</i> Moupinensis	South China Coast and South Vietnam
23	<i>Sus scrofa</i> Nicobaricus	Nicobar Island - India
24	<i>Sus scrofa</i> Nigripes	Central Asia; coastal Caspian; Agganistan; Mongolia; China;
25	<i>Sus scrofa</i> Papuensis	Guinea
26	<i>Sus scrofa</i> Raddeanus	Mongolia
27	<i>Sus scrofa</i> Reiseki	Yugoslavie; Albania; Grice; Hungary
28	<i>Sus scrofa</i> Riukinanus	Rycon Island - Japan
29	<i>Sus scrofa</i> Sardous	Cadague; Corse
30	<i>Sus scrofa</i> Serofa	Spanish island; Northern Italy; Virtue; France; Benelux; Denmark; Poland, Czech Republic; Slovakia; Albania
31	<i>Sus scrofa</i> Sennaarensis	Sudan
32	<i>Sus scrofa</i> Sibiricus	Munkinok; Sayan; Mông Cổ; Siberia; Transbaikalia
33	<i>Sus scrofa</i> Sukvianus	China
34	<i>Sus scrofa</i> Taivanus	Taiwan
35	<i>Sus scrofa</i> Ussusicus	Russia; Corsica; China
36	<i>Sus scrofa</i> Vittatus	Indonesia; Malaysia; Bali; Po Cang Island

Source: the international cooperation research on agricultural development (France) Livestock Journal No. 10 - 2008.

Table 2. Features of the reproductive ability of wild pigs

Order	Content	Explain
1	Age of first estrus	6 - 7 months of age
2	First estrus weight	18 - 20 kg
3	Mating age	7 - 8 months age
4	Weight at mating	30 - 35 kg
5	Pregnant period	110 - 130 days
6	Time of estrus	2 - 3 days (for gilts Sows)
		3 - 4 days (Sows)
7	The estrus scycle	20 - 22 days
8	Frequency	1,2 - 1,3 litter /năm
9	Number of pigs born in each time	4 - 8 pigs

(Source: Dao Le Hang, 2008)

Lessons from China and Thailand

In Thailand and China, wild boars have also been domesticated and crossed with native pigs to become livestock in the breeding system for 12-18 years.

Purebred Thai wild pork has many advantages over Vietnamese wild boar such as high resistance, less care, self-fertilization without human intervention, simple housing, low cost. livestock production is low but the output is stable.

Below figure shows pig production in Thailand:

Year	No. of Sows	Annual piglets produced	Annual fattener produced : heads x 1,000,000
2006	0.85	11.56	9.83
2007	0.93	12.23	10.4
2008	1.00	19.40	11.63
2009	1.16	15.89	15.50
2010	0.80*	16.30	15.49
2011	1.09	17.76	13.92
2012	1.08	17.57	13.95
2013	1.01	17.88	16.21

*HP-PRRS epidemic Jun 2010
Source: Department of Livestock Development

Figure 1. Number of sows and Thai pig production

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Sum
Pig production	25	36	21	23	16	30	28	30	33	56	298
- Genetics	0	2	1	0	0	2	3	1	5	2	16
- Nutrition	3	6	4	5	2	5	4	5	7	5	46
- Farm management	5	12	10	5	6	6	7	6	4	22	83
- Health	17	16	6	13	8	17	14	18	17	27	153
Processing	4	0	1	2	2	3	6	2	4	2	26
Logistic, Packaging and Branding	1	0	0	0	0	1	0	0	0	0	2
Trade and Marketing	0	1	0	1	3	1	3	0	0	0	9
Environment	0	1	1	0	2	1	0	4	1	1	11
Social and Regulations	0	0	0	0	0	2	1	3	0	0	6
Sum	30	38	23	26	23	38	38	39	38	59	352

Figure 2. Number of pig and pork articles and publications in Thailand

(Source: https://www.fftc.org.tw/htmlarea_file/activities/20140314102754/CR%201%20Dr.%20Wichai%20Tantasuparuk.pdf, access date 22/6/2021)

In recent years, Vietnam has also started raising wild boar breeds. Its origin is by many ways such as: Imported from Thailand, China by official and unofficial channels and some also came from the domestication of wild boars of Vietnam. But all the places where wild boar are raised are only based on experience and partly from simple, sketchy documents of farms in Thailand, or a few articles written in emotional or subjective form only. In terms of its biology and behavior, little is known about it.

This is picture of Thai wild pigs



Wild boar - Kaeng Krachan



Figure 3. Wild pigs
(Source: internet)

Vietnam Experiences in taking Care of Wild Pigs

1. The Role of Feed-exchange Energy in Pig Survival

All living, developing and reproductive activities of pigs are associated with the process of using and exchanging energy. Energy in food is stored in the physical forms of food such as fat, sugar, protein, and carbohydrates. Pigs receive food energy from the outside, through digestion, absorption in the digestive tract into the body and synthesized into fat, glucose, and pure protein of the pig's body.

1.2. The Source of Energy for Pigs

*Fiber

Fiber includes 2 types: neutral fiber and acid fiber. In the composition of neutral fiber there are cellulose, hemicellulose and lignin, in the composition of acid fiber there are cellulose and lignin. The ability of pigs to use fiber depends on the physico-chemical composition of the feed, the age and weight of the pig. If the amount of fiber in the diet exceeds 8%, it will reduce the feed intake of pigs, affecting the growth ability of pigs, especially piglets (Tran Van Phung et al., 2004).

*Starch

Starch is the main source of energy for all types of pigs. The starch digestibility of pigs is up to 95-98%. For piglets, the mother can only digest starch at the 3rd week of age onwards. During the period before 3 weeks of age, suitable energy sources for piglets are glucose and lactose. The ability of piglets to utilize starch is highly dependent on starch-digesting enzymes.

*Lipids

Tran Van Phung et al., 2004 reported that adding fat to piglet diets would reduce growth rate and feed intake but increase the gain in weight/feed ratio. For porkers from the growing-finishing stage with a weight of 20-100 kg, adding fat to the diet will have the effect of increasing growth,

reducing feed intake, and increasing weight gain. / food increased but back fat thickness increased.

1.3. Role of Nutritious Food for Wild Pigs Feeding

The food of wild pigs is mainly plants, it is not recommended to abuse nutrient-rich food to raise pigs because it will change the quality of wild boar, sometimes pigs will have diarrhea (loss of herd productivity).

Forages are mainly tubers, fruits, grasses and other forages that are easy to find and cheap. In order for pigs to have year-round food and enough nutrients, we have a number of basic food processing methods for wild boar: such as fresh feeding, the method of making grass powder (green powder), the method of making vegetables. Processing and preserving feed from a number of by-products, which can be mixed with refined feed to raise wild boar with high efficiency.

Experimental results have higher concentrate consumption and lower green forage compared to research results of Nguyen Van Gioi (2010) on Thai forest crossbreds and local sows in Pac Nam. This shows that diets with higher protein levels have the effect of making pigs grow faster, leading to better feed efficiency.

Research results of Phung Thang Long et al. (2004) showed that when reducing the protein ratio from 18-16 %, feed consumption/kg weight increase increased to 8.76%, when decreased to 14% Feed consumption/kg increased weight by 13.89%. In other words, when increasing the protein level of the diet, there was an effect of reducing feed consumption/kg weight gain of pigs, which is relatively consistent with our experimental results when studying pigs. hybrid forest. Experimental results for F2 wild boar are illustrated in figure following:

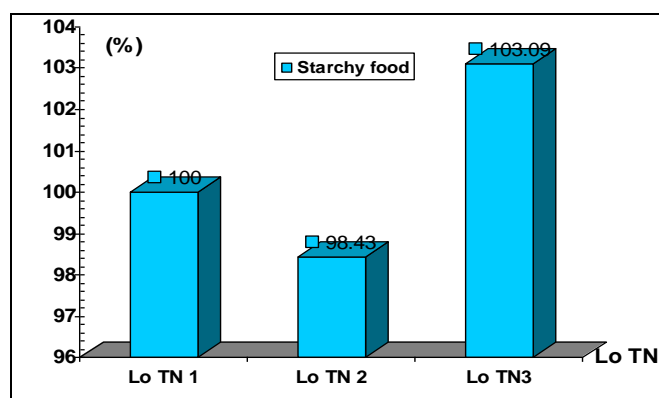


Chart 1. Comparison chart of feed consumption/kg weight gain of experimental pigs

(source: Wild pig project, Bui Thi Thom et al, 2013)

Chart 1 shows that in experiment the lowest amount of food consumed, while in experiment 3, the consumption of concentrates and greens increased from 3.28 to 3.24% compared to experiment 1. This shows It was found that in diets with low protein ratio (15-13%), the dietary requirements of F2 hybrid wild boars increased, maybe this diet is not reasonable, the body requires higher nutritional needs. But in experiment 2 (protein level in the diet 16 -

14%), the need to eat decreased more than 1.44 - 2.35%, respectively, for green and refined food compared to the diet with a protein ratio of 17-15. %. Regarding feed consumption, experiment 2 had a protein level of 16-14% in the diet, corresponding to the growth and fattening stages, giving the most reasonable results.

Food Processing with Wild Pork

Wild boar hybrids meat has a rich and higher nutrient content than domestic pork, helping us to compensate for vitamins that vegetables and fruits do not have or have very little, such as vitamins B1, B2, B6, B12, A and D.

Vitamin B1 plays the role of a catalyst in the process of converting substances into energy, enhancing brain activity, helping the body fight fatigue and weakness. The amount of vitamin B1 in wild boar meat is 6 to 10 times higher than in other meats.

Besides, vitamin B2 has the effect of eliminating toxins and is good for the skin. Without this vitamin, there is a high risk of skin diseases, especially in women.

Vitamin A plays a role in helping to keep eyes healthy and strengthen the body's resistance.

Vitamin D plays an important role in the absorption of calcium for stronger bones.

Below figure shows us steps to make delicious wild pork:



Figure 4. Steps to make stir-fried wild pork meat (source: internet)

Steps to make Stir-fried Wild Pork Meat

Put the onions, carrots, lemongrass, chili, vermicelli, and mushrooms prepared in step 1 with coconut milk into the pot of pork and cook to match. Tasting spices to taste. When the ingredients are cooked, turn off the heat. Put the pot on the stove and heat a little cooking oil, add the garlic and fry until fragrant. Continue to stir-fry the pork with a little water with low heat until the meat is soft. stir-fried wild boar roll on plate.

Discussion

The results of the survey showed that: The percentage of carcass meat in 3 experimental groups had no significant difference (68.57 - 68.65 - 68.25%). For slaughter pigs, the percentage of lean meat is the most important and valuable parameter in carcasses. The higher the percentage of lean meat, the higher the quality of the carcass, and the higher the selling price of pork. Among the 3 experimental groups, the lean percentage was highest in TN1 group (56.85%), TN2 and TN3 groups were 55.65% and 54.89%, respectively. However, the results of Table 4.7 show that in the

experimental groups, with the same results of the experimental pigs, the lean percentage in the experimental groups with a high percentage of protein is higher but the percentage of fat tends to increase. However, the difference was not significant, not statistically significant ($P > 0.05$).

Conclusion

- With protein levels in the diet for wild boar F2 did not have much effect on yield and meat quality. But cholesterol content in the blood tends to increase gradually when reducing the proportion of protein in the diet (17-15 %; 16-14%; 15-13%) respectively from 1.65 - 2.15 - 3.11 mol/L and blood triglyceride levels also increased (2.3 - 2.8 - 2.6 mmol/L) when the percentage of fat in the experimental groups increased (14.06 - 14.26 - 14.69 %) experimental batch 1, 2 and 3 respectively.
- For the experiment with an energy level of 3000-2900 kcal/kg of feed, with a corresponding protein level of 16-14%, the growth rate increased to 4.31% (0.89 kg/head) and birth rate. absolute growth increased by 5.59% (5.21 g/head/day); reduced feed consumption in which 4.71% concentrate and 5.97% green feed, and at the same time reduced feed cost by 4.74% compared to the experimental batch with energy level of 2900-2800 kcal/kg food at the same age.
- Evaluation of pork performance in Experiment 2 between the experiments, there was no significant difference between the ratio of jaw hook, lean meat, and sawn meat and there was no statistical significance. It also does not affect the chemical composition of the meat.
- Thus, for commercial wild boar farming, the diet has a protein level of 16-14% and a metabolic energy level of 3000-2900 kcal/kg of feed in the diet for growth and fattening stages respectively. is the most reasonable, both capable of growth of hybrid wild boar and economically effective in breeding conditions by semi-wild method in ecological conditions of Thai Nguyen. (source: Wild pig project, Bui Thi Thom et al, 2013).



Figure 5. Feeding wild pigs in Thai Nguyen city, Vietnam
(Source: internet)

Acknowledgement

Thank you editors, friends and brothers to assist this publishing.

References

- ARC- Agricultural Research Council., 1981. The nutrient Requirement of pigs, Commonwealth agricultural Bureaux, Slough, England, 124s.
- Andersson-Eklund, L., Marklund, L., Lundström, K., Haley, C. S., Andersson, K., Hansson, I., and Andersson, L., 1998. Mapping quantitative trait loci for carcass and meat quality traits in a wild boar× Large White intercross. *Journal of animal science*, 76(3): 694-700.
- Bikker, P., Verstegen, M.W., and Bosch, M.W., 1994. Amino acid composition of growing pigs is affected by protein and energy intake. *The Journal of nutrition*, 124(10): 1961-1969.
- Campbell, R.G., and Taverner, M.R., 1985. Effect of strain and sex on protein and energy metabolism in growing pigs. *Energy Metabolism of Farm Animals, EAAP*, 32: 78.
- Chung C.S., and Nama. S. (1998). Effects of feeding regimes on the reproductive performance of lactating sows and growth rate of piglets. *Animal Breeding abstracts*, 66(12): 8369.
- Chung, T.K., and Baker, D.H. (1992). Utilization of methionine isomers and analogs by the pig. *Canadian Journal of Animal Science*, 72(1), 185-188.
- Cole, D.J.A., 1992. Interaction between energy and acid amin balance. *2nd International Feed Production Conference, Piacenza, Italy*. 25-26.
- Hang, D.L., 2008. *Department of Livestock Production. Some basic biological characteristics of wild boar*. Livestock magazine February.
- Fuller, M.F., Menie, I., and Crofts, R.M.J., 1979. The acid amin supplementation of barley for the growing pig, 2, Optimal additions of lysine and threonine for growth. *British Journal of Nutrition*, 41(2): 333-340.
- Fuller, M.F., McWilliam, R., Wang, T.C., and Giles, L.R., 1989. The optimum dietary amino acid pattern for growing pigs: 2. Requirements for maintenance and for tissue protein accretion. *British journal of Nutrition*, 62(2), 255-267.
- Fuller, M.F., 1991. *In Protein Metabolism and Nutrition: Proceeding of the 6th International Symposium on Protein Metabolism and Nutrition*, 116-126. Edited by B.O. Eggum, S. Boisen, C. Borsting, A. Danfear and T. Hvelplund. E.A.A.P. Publication No. 59. Foulum: National Institute of Animal Science.
- Thi Hang, N., Thi Tinh, D., Ngoc Huy, D.T., and Hong Nhung, P.T. (2021). Educating and training labor force Under Covid 19; Impacts to Meet Market Demand in Vietnam during Globalization and Integration Era. *Journal for Educators, Teachers and Trainers*, 12(1).
- Kvisna, Keosua, Phia Kraixeng Xrium - Thailan, 2005. *Technical process of breeding and developing wild boar*, Translation by Le Van Hien and Le Tuan Tu.
- Kuhn, G., Kanitz, E., Tuchscherer, M., Nürnberg, G., Hartung, M., Ender, K., and Rehfeldt, C., 2004. Growth and carcass quality of offspring in response to porcine somatotropin (pST) treatment of sows during early pregnancy. *Livestock production science*, 85 (2-3), 103-112.
- Litten, J.C., Corson, A.M., Hall, A.D., and Clarke, L. (2004). The relationship between growth performance, feed intake, endocrine profile and carcass quality of

- different maternal and paternal lines of pigs. *Livestock Production Science*, 89(1): 33-39.
- Mörlein, D., Link, G., Werner, C., and Wicke, M. (2007). Suitability of three commercially produced pig breeds in Germany for a meat quality program with emphasis on drip loss and eating quality. *Meat Science*, 77(4): 504-511.
- Marsico, G., Rasulo, A., Dimatteo, S., Tarricone, S., Pinto, F., and Ragni, M. (2007). Pig, F1 (wild boar x pig) and wild boar meat quality. *Italian Journal of Animal Science*, 6(sup1): 701-703.
- Noi, N.V., (2010). *Research on polymorphisms of some genes that regulate growth and meat production ability of pigs crossed between Thai forest and Pac Nam local sows*. Master's thesis in agriculture, School of Agriculture and Rural Development. Thai Nguyen University of Agriculture and Forestry, 45-50.
- Hao, P.X., (2007). Evaluation of growth, yield and meat quality in Landrace, Yorkshire and F1 pigs (Landrace x Yorkshire), *Journal of Agricultural Science*, 5(1): 31-35.
- Townsend, W.E., Brown, W.L., McCampbell, H.C., and Davis, C.E., 1978. Comparison of chemical, physical and sensory properties of loins from Yorkshire, crossbred and wild pigs. *Journal of Animal Science*, 46(3): 646-650.
- Thong, H.T., and Liebert, F., 2004. Acid amin requirement of growing pigs depending on acid amin efficiency and level of protein deposition. *1st communication: threonine*. *Archives of Animal Nutrition*, 58(1): 69- 87.
- Wang, T.C., and Fuller, M.F. (1990). The effect of the plane of nutrition on the optimum dietary amino acid pattern for growing pigs. *Animal Science*, 50(1): 155-164.
- Warriss, P.D., and Brown, S.N. (1995). The relationship between reflectance (EEL value) and colour (L*) in pork loins. *Animal Science*, 61(1): 145-147.
- Phùng, T.V., Hiển, T.Q., Vân, T.T., and Hào, H.T., 2004. *Textbook of pig breeding (University)*. Agriculture Publishing House, Hanoi, 16-25; 113-115.
- Van de Ligt, C.P.A., Lindemann, M.D., and Cromwell, G.L., 2002. Assessment of chromium tripicolinate supplementation and dietary protein level on growth, carcass, and blood criteria in growing pigs. *Journal of animal science*, 80(9): 2412-2419.
- Giang, V.D., Hong, N.T.L, and Son, T.T., 1999. *Nutrition and fodder*. Agriculture Publishing House, Hanoi.
- Vietnam Livestock Association, 2002. *Pig Breeding Manual*. Hanoi Agricultural Publishing House, 26-27, 70-72.
- https://www.fftc.org.tw/htmlarea_file/activities/20140314102754/CR%201%20Dr.%20Wichai%20Tantasuparuk.pdf