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Effect of cross-inbred lines and supplementation of brewed ground corn on the productivity and carcass quality of black pig

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ABSTRACT

The study intended to compare the growth performance and carcass quality of black pigs fed four different supplements of brewed ground corn (BGC) as an appetizer before feeding commercial feed. The breeding program was assigned using crossing inbred lines of L_1 male to L_1, L_2, and L_3 female to generate L_1L_1, L_1L_2, and L_1L_3 piglets, respectively. Then, healthy weaning piglets (n = 8 of each cross-inbred line) with nearly the same body weight were randomly allocated to the pen for two piglets each (one male and one female each). The BGC was given daily as an appetizer at 0, 0.5, 1.0, and 1.5 percent of body weight. Pigs were raised in twelve experimental pens of 2 x 3 meters in size and fed with a commercial diet to meet nutritional requirements according to their age up to 16 weeks. The analysis of variance was used to evaluate the datasets, and the means were compared using Duncan's new multiple-range test. Data indicated that pigs had substantially higher body weight gain but lower feed conversion and feed cost per gain than L_1L_1 and L_1L_3. Carcass percentage and some characteristics such as pH, temperature, pork color, and drip loss were not substantially different between the three black pig cross-inbred lines ($P>0.05$). The LSQ index and back fat thickness showed that three sets of black pigs had moderate lean and fat percentages. The BGC supplementation may increase feed intake. On the other hand, it has no discernible effect on growth rate, carcass characteristics, or quality. The L_1L_3 black pig demonstrated excellent growth efficiency, decent quality pork, and carcass percentage. However, BGC supplementation has no discernible effect on growth rate, carcass characteristics, or quality. The L_1L_3 black pig demonstrated great efficiency of growth performance, acceptable quality pork, and carcass percentage. The L_1L_3 can be the priority option and can be implied for improving the pig output of small farmers in Nan Province. The BGC supplementation at the rate of 1.0 percent of body weight/day may increase the feed intake while not affecting black pig growth or carcass.

Keywords: black pigs, small farm, growth performance, carcass characteristics

INTRODUCTION

Thailand's pig industry has been transforming and proliferating since the 1980s by importing pig breeds from European countries and the United States. The climate control house technologies and quality feed and feeding management were induced, supporting the potential genetic increase. The higher the genetics potential, the higher the nutritional feed and good management were needed (Rocadembosch et al., 2016; Homma et al., 2021). Industry pig production is entirely produced under the closed housing system with controlled environmental conditions. These led to increasing the cost of production (Rocadembosch et al., 2016). This was why the pig industry belonged to some of the big companies in Thailand. Since then, pig production in the village has declined because farmers have inadequate financial support for raising the high genetics potential pigs breed (Charoensook et al., 2019). The small farmers have some choices only to the contact farming system. So, the new alternative pig breed may need to fulfill supporting pig production in the village. Pig production for the rural may, sometimes, require a lower growth rate and lower lean percentage than commercial breeds. The alternative pig breeds need less intensive management and low cost for production. Moreover, the lifestyle and culture of villagers may be a consideration for creating the breeding plan. The breeding plan may introduce Thai Native Pigs (TNP) due to Raad, Kra Done, Puang, Hailum, and Kwai breeds for crossing with the commercial breed. Although the TNP is very low in production performance and carcass quality but is more suitable in the case of climate endurance, the scarcity of feed, tropical disease, and poor management. There were three pig breeding plans, which were constructed due to cross-breeding between Duroc Jersey (D) x Meishan (M), called DM (L_1), Pietrain (P) x TNP, called PN (L_2), and (Duroc Jersey-Pietrain) x (Large White-Meishan), called DPYM (L_3). The DM and PN

were improved by the Bureau of Animal Husbandry and Genetics Improvement (BAHG, 2005). The DPYM was proposed by the Department of Animal Science and Fishery, Rajamangala University of Technology Lanna Nan (RMUTLN). All kinds of crossbred pigs were selected for the black-coated color that the local people in Northern Thailand required. In case a new pig breed is released, the production and feeding systems are needed to test, support, and be suitable for the new breed. Some feedstuff was residual leftover from alcoholic production in the rural. Villagers always utilize residual leftover feeding pigs and find evidence of good performance for growth and tasty pork. Ano et al. (2020) reported that feeding distillation remnants of Shochu, a traditional Japanese liquor, can reduce stress and improve the sirloin tenderness, juiciness, umami, and fat tastiness of fillets. Therefore, this research aimed to test growth performance and carcass quality of the crossing between the inbred lines of black pigs due to L_1L_1, L_1L_2, and L_1L_3 with different substitution levels of fermented corn gain with alcoholic yeast in commercial feed.

MATERIALS AND METHODS

Breeding plan of produced black pig

There were three inbred lines of the black pig called DM, PN, and DPYM. DM or Line 1 (L_1) was a crossbreed between Duroc Jersey x Meishan. PN or Line 2 (L_2) was a crossbreed between Pietrain x Thai Native pig. DPYM or Line 3 (L_3) was a crossbreed between Duroc Jersey- Pietrain x Large White- Meishan. The inter-se mating system produced an inbred line of each black pig for the three generations. Then, the selected L_1 male was crossed to the L_1, L_2, and L_3 females using the artificial insemination techniques. So, there are three crossings of inbred lines of piglets due to L_1L_1, L_1L_2, and L_1L_3. After weaning, the piglets were selected based on good health and have nearly the same body weight for piglets per crossed inbred lines breed (4 males and 4 females each). After that, the male and female piglet within the same crossed inbred line was randomly matched as a couple for testing on growth performance and carcass quality.

Preparation of brewed ground corn

The grain corn was roughly crushed using the hammer mill. Then, the ground corn was packed into the container to produce brewed ground corn (BGC). The composition of BGC consisted of 100 kg of ground corn, 1.5 kg of brown sugar, 1.5 kg of molasses, 150 g of dry alcoholic yeast, and 50 liters of clean water. Preparation of yeast was processed by taking clean water of about 10 liters along with brown sugar, and molasses into the same bucket. Then, the mixer was stirred using a wooden paddle until all was completely dissolved. After that, the alcoholic yeast was added and gently stir until white foam happens. The solution after that was poured to mix with the remaining water in another bucket and added air using an air pump for about two hours. The ground corn was packed into the container by allowing air space above about 12 inches (about 50 kg per container) and then poured with the solution that was prepared before until the solution level was higher than the ground corn level by about three centimeters. The containers were enclosed using the lid or plastic bag and stored at room temperature for at least three weeks before taking to feed the pigs as an appetizer before feeding the main commercial diet during the experiment.

Experimental design

Weaning piglets of the same cross-inbred line were carried and mixed together in the same pen. After that, the healthiest piglet at the same body weight was inspected and selected for testing on growth performance. One female and one male on the same cross-inbred line were randomly matched and taken into the experimental pen. There were 12 pens where the same cross-inbred line breed piglets belonged to 4 pens. So, there were 24 piglets in the total for this study due to 3 types of cross-inbred lines piglets. The pen size was 2 x 3 meters, including a water basin size of 1 x 2 meters for reducing body temperature. All experimental pens were installed in the same facility for raising. Pigs were made full-feeding with a commercial diet following the nutrient requirement depending on age periods and body weight (10-30, 30-60, and 60-100 kg). The brewed ground corn was supplemented at four levels due to 0, 0.5, 1.0, and 1.5 percent of pig body weight as a fed basis. Pigs were fed three times daily at 07.00 am, 12.00 am, and 4.00 pm. All pigs were allowed access to the water supply as needed using the nipple. Pigs were weighed every week simultaneously through 16 weeks of an experiment. Feed intake was recorded and summarized every week. Data, after that, were modified and conversed to an average daily gain (ADG), feed conversion ratio (FCR), and feed cost per gain (FCG), respectively.

Carcass characteristics and evaluation

After finishing, all twelve male fattening pigs were taken to study the carcass characteristics and evaluation for quality. All were carried to Nan municipal slaughterhouse and skipped feeding for 12 hrs except for the water that allowed free drinking

as needed. Pigs were weighed before slaughter. The carcass was separated into left and right sides using an electric splitting saw. The hot left and right carcasses were weighting separately. Back fat thicknesses were measured at the angle base of the gluteus medius muscle (bf3), at the peak of the gluteus medius muscle (bf4), and at the top angle of the gluteus medius (bf5). The Lenden-Speck Quotient (LSQ) index (Pfeiffer and Falkenberg, 1972) were measured as a proportion of backfat thickness to the wide of longissimus dorsi muscle (b) as shown in Figure 1.

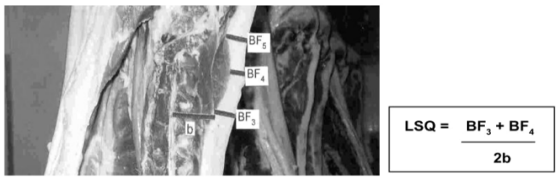

Figure 1. The location to measure the lean and backfat thickness of pig carcass (left) and the formula to calculate LSQ index (right). Source: Sethakul et al. (2010)

Carcass evaluations were measured for pH and temperature 45 minutes after slaughter and 24 hours of chilling at 4°C. The portable spectrophotometer (HunterLab MiniScan EZ 4500) measured the lean colors. The marbling score was measured from the longissimus-dorsi muscle following the Thai agricultural commodity and food standard method: 6000-2004 (TACFS, 2004).

Data analysis

Growth performance, carcass characteristics, and evaluation were analyzed using the analysis of variance (ANOVA) following the statistical model below.

$$Y_{ijk} = \mu + \propto_i + \beta_j + \varepsilon_{ijk} \quad \ldots\ldots. [1]$$

Where, Y_{ijk} = observation data

μ = an overall mean

$\propto_i$ = effect of cross-inbred lines of black pig (i = L_1L_1, L_1L_2, and L_1L_3)

$\beta j.$ = effect of supplementation of corn fermented (j = 0, 0.5, 1.0, and 1.5% of body weight as fed basis)

εijk = random residual effect

The statistics of the model [1] were an arithmetic mean and standard deviation. The mean comparison was tested against Duncan's new multiple range test (DMRT). Those can be done using the procedure of the Statistical Analysis System (SAS) software (SAS, 1999).

RESULTS AND DISCUSSION

Growth performance of black pig

The effect of a cross-inbred line of black pigs on growth performance is shown in Table l. The result found the final body weight (FBW) and body weight gain (BWG) was high for those of L_1L_3, and differed significantly from L_1L_2, and L_1L_1, respectively. These may become from a fractional of the breed that L_1L_3 consisted higher the European pig breed than that of L_1L_1 and L_1L_2. The three patterns of the cross-inbred line affected an average daily gain (ADG) and feed intake (FI) but were not significantly different. The ADG of this research was a bit lower than that of the pure breed Large White (816 g/d), Land Race (814 g/d), and Duroc (779 g/d) under the testing on pig performance of Kamphaeng Saen Central Testing Station (KPSCTS) reported by Chomchai et al. (1998). However, the feed conversion ratio (FCR) differed significantly between cross-inbred lines of black pigs. The FCR of L_1L_3 was the lowest and differed from that of L_1L_1, and L_1L_2 cross-inbred lines. This study showed better growth performance than that of the crossbred pigs between Duroc Jersey-Meishan (DM) tested by BAHG (2005). They reported ADG equal to 524 and 542 g/d, and FCR equal to 2.71 and 2.86 for DM crossbred in filial 1 and 2, respectively. The performance resulted in the range of three breeds cross fattening pigs (Chomchai et al., 1998; Srikanchai et al., 2005), GPP pure breed (Tungtrakoolsub, 2013) under hot-humid conditions testing.

Table 1. Effect of cross-inbred lines on production efficiency of black pig

Items	Types of cross-inbred lines of black pig			Pr > F
	L_1L_1	L_1L_2	L_1L_3	
	Mean ± SD	Mean ± SD	Mean ± SD	
FBW (kg)	90.13 ± 5.50^{ab}	84.25 ± 2.06^{b}	99.75 ± 4.70^{a}	0.014
BWG (kg)	77.08 ± 5.48^{b}	72.33 ± 2.40^{b}	85.25 ± 3.54^{a}	0.018
FIPD (kgDM)	1.84 ± 0.11	1.81 ± 0.11	1.95 ± 0.16	0.214
ADG (kg)	0.69 ± 0.05	0.65 ± 0.02	0.76 ± 0.03	0.769
FCR (kgDM)	2.67 ± 0.11^{ab}	2.79 ± 0.08^{a}	2.56 ± 0.11^{b}	0.003
TFC (baht)	3,141.56 ± 182.53	3,088.80 ± 184.81	3,345.57 ± 268.40	0.208
FCG (baht)	40.81 ± 1.67^{b}	42.68 ± 1.17^{a}	39.20 ± 1.73^{c}	0.003

FBW = final body weight, BWG = body weight gain, FI = feed intake per day, ADG = average daily gain, TFC = total feed cost, FCG = feed cost per gain.

^{abc}The different superscripts on the same row indicated significant differences ($P<0.05$).

There were no significant differences in feed intake per day (FIPD) and total feed cost (TFC) between the three types of cross-inbred lines of black pigs. However, feed conversion ratio (FCR) and feed cost per gain (FCG) indicated significantly different ($P<0.05$) between the three types of black pigs. The L_1L_3 showed lower FCR and FCG than those of L_1L_1 and L_1L_2, respectively. These may become from breed fractions of black pigs affecting growth performance efficacy. The fraction breed of L_1L_3 consisted 37.5%Duroc Jersey: 12.5%Pietrain: 12.5%Large White: 37.5%Meishan that was 62.5%European pig breed: 37.5%Asiatic pig breed. That was higher than that of L_1L_1, and L_1L_2, which have a proportion of 50%European pig breeds: 50%Asiatic pig breeds. The L_1L_2 showed less performance efficacy than those of others. This may be the effect of the Thai native pig breed that was included as a fractional line breed. However, the main objective of the breeding plan needed black coated color of pig and endured to climate and scaring management of small farmers in the rural area. So, the Asiatic breed was induced to breeding plans like Meishan, Thai native breeds such as Kra Done, Puang, and Kwai.

The effect of the level of brewed ground corn (BGC) on the growth performance of black pigs is shown in Table 2. The result found that the final body weight (FBW), body weight gain (BWG), feed intake per day (FIPD), and average daily gain (ADG) was not significantly different between the treatment that supplemented BGC to the control. Supplementation of BGC for 1.5% body weight of pigs can affect the feed conversion ratio (FCR) of black pigs. However, supplementation BGC for 0.5 and 1.0% body weight can affect FCR not significantly different compared to control treatment. Supplementation BGC for about 1.5% can affect the total feed cost (TFC) and feed cost per gain (FCG) higher than these of the others.

This indicated that BGC could be supplemented to commercial feed with about 1.0% body weight and may enhance the FIPD and ADG of black pigs. The properties of brewed ground corn with yeast have 4.18±0.05 in pH, 5.99±0.36 in salinity, 4.98±0.27 percentage in alcohol, 59.86 in dry matter percentage, and 9.7% in crude protein contents. Many researchers reported that nutrients in leftover fermented gain like corn and barley (Ano et al., 2020), can reduce stress and plasma cortisol (Ano et al., 2020), improve feed intake and growth rate (Suzuki et al., 2018), and resulted in better-tasting sirloin and fillets (Suzuki et al., 2018; Ano et al., 2020). By observation, black pigs with supplementation BGC consumed more time lying down and sleeping after feeding (Figure 2). Pig behavior in this study looked like the previous experiment that was supplementation of L-tryptophane in pig diets (Kuha et al., 2012). These because alcohol may affect the pig to decrease their activity and can help to preserve energy for growth. The result was also familiar to many farmers who fed residual leftovers from liquor production, called Nam joe, in Nan province (personal communication). Since the pigs were less stressed, they produced higher-quality meat, especially sirloin and filet cuts.

Table 2. Effect of supplementation levels of brewed ground corn on production efficiency of black pig

Items	Levels of supplementation of brewed ground corn				Pr > F
	0%	0.5%	1.0%	1.5%	
	Mean± SD	Mean± SD	Mean± SDS	Mean± SD	
FBW (kg)	89.67 ± 7.22	91.50 ± 8.05	91.50 ± 11.53	92.83 ± 8.50	0.894
BWG (kg)	76.13 ± 6.06	78.73 ± 7.75	78.00 ± 9.30	80.00 ± 6.96	0.698
FIPD (kgDM)	1.81 ± 0.11	1.80 ± 0.10	1.85 ± 0.16	2.00 ± 0.12	0.211
ADG (kg)	0.68 ± 0.05	0.70 ± 0.07	0.70 ± 0.08	0.71 ± 0.06	0.768
FCR (kgDM)	2.67 ± 0.14^{ab}	2.57 ± 0.16^{a}	2.66 ± 0.09^{ab}	2.80 ± 0.09^{b}	0.014
TFC (baht)	3,102.86 ± 179.01	3,087.43 ± 181.27	3,165.20 ± 271.96	3,412.42 ± 204.16	0.229
FCG (baht)	40.83 ± 2.17^{b}	39.35 ± 2.46^{b}	40.68 ± 1.33^{b}	42.72 ± 1.29^{a}	0.015

FBW = final body weight, BWG = body weight gain, FI = feed intake, ADG = average daily gain, TFC = total feed cost, FCG = feed cost per gain.
The different superscripts on the same row indicated a significant difference (P<0.05).

Figure 2. Black pigs always laying down to sleep after feeding.

Some carcass characteristics and quality are shown in Table 3. Hot carcass weight and hot carcass percentage were not significantly different between the three groups of different line cross breeds of black pig. An average back fat thickness significantly differed between three cross-bred lines of black pigs. The L_1L_3 was the thinnest differed from L_1L_1 but not L_1L_2. The LSQ index was not different between the three groups of black pigs. The LSQ index following the criteria graded by Sethakul et al. (2003) reported that the LSQ indexes equal to ≤ 0.20, 0.21-0.26, 0.27-0.32, 0.33-0.38, 0.39-0.44, and ≥ 0.45 had the lean percentage equal to 48.47, 46.88, 45.05, 43.37, 42.00, and 40.31 and the fat percentage equal to 14.39, 16.34, 18.07, 19.49, 20.62 and 22.11, respectively. The correlation between the LSQ index and lean percentage, and fat percentage was about 0.69 and 0.67, which can be used LSQ index to predict lean and fat percentages with a high confidence level (Sethakul et al., 2003). So, the L_1L_3 black pig was a more lean percentage and less fat percentage than others. The other items observed for pork quality due to marbling score, carcass pH and temperature, drip loss, and pork colorization were significant differences between the 3 groups of black pigs. The pork of L_1L_1 trended to be more red color (a*) than that of L_1L_3.

The supplementation levels of BGC on some carcass characteristics and quality of black pigs are shown in Table 4. The hot carcass weight and hot carcass percentage were not different between the different levels of supplementation of BGC. Backfat thickness was sequentially increased if the levels of supplementation BGC increased. This can imply that more supplementation of BGC can affect the high backfat thickness. There were no significant differences due to the LSQ index, marbling score, carcass pH and temperature, drip losses, and colorized of pork. The LSQ indexes were low in the case of supplementation BGC 0.5 and 1.0 percent body weight that, related to low backfat thickness.

Table 3. Effect of cross-inbred lines of the black pig on carcass characteristics and quality

Items	Types of cross-inbred lines of black pig			Pr > F
	L_1L_1	L_1L_2	L_1L_3	
	Mean ± SD	Mean ± SD	Mean ± SD	
Fasting body weight (kg)	99.33 ± 5.51	103.00 ± 4.11	106.75 ± 4.11	0.384
Hot carcass weight (kg)	79.70 ± 5.00	77.80 ± 4.60	82.40 ± 4.60	0.841
Hot carcass percentage (%)	80.30 ± 4.30	75.50 ± 1.70	77.10 ± 1.70	0.641
AVG. back fat (cm)	3.10 ± 0.60[a]	2.70 ± 0.60[b]	2.50 ± 0.60[b]	0.059
LSQ index	0.40 ± 0.10	0.50 ± 0.10	0.30 ± 0.10	0.296
Marbling score	1.90 ± 0.85	3.00 ± 0.47	2.68 ± 0.47	0.975
Carcass pH				
30 min post-mortem	5.47 ± 0.33	5.91 ± 0.25	5.44 ± 0.25	0.333
24 hr chilled	5.57 ± 0.04	5.43 ± 0.62	5.89 ± 0.62	0.356
Carcass temperature				
30 min post-mortem	37.98 ± 1.37	37.85 ± 1.22	37.76 ± 1.22	0.626
24 hr chilled	12.57 ± 2.18	13.00 ± 1.47	11.63 ± 1.47	0.860
Drip loss (%)	3.50 ± 2.08	2.23 ± 1.26	3.20 ± 1.26	0.384
Lean color				
L*	56.05 ± 4.32	55.82 ± 1.71	60.18 ± 4.92	0.105
a*	8.03 ± 1.43	7.20 ± 0.46	6.60 ± 1.46	0.090
b*	16.23 ± 1.03	15.59 ± 0.37	15.29 ± 1.07	0.127

[abc]The different superscripts on the same row indicated a significant difference (P<0.05).

Table 4. Effect of supplementation levels of brewed ground corn on carcass characteristics and quality of black pig

Items	Levels of supplementation of brewed ground corn				Pr > F
	0%	0.5%	1.0%	1.5%	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Fasting body weight (kg)	103.00 ± 0.00	104.50 ± 0.71	101.00 ± 9.90	105.50 ± 9.19	0.776
Hot carcass weight (kg)	78.90 ± 1.60	81.50 ± 4.90	81.10 ± 2.60	81.80 ± 9.60	0.981
Hot carcass percentage (%)	76.60 ± 1.50	78.00 ± 4.20	80.50 ± 5.30	77.40 ± 2.40	0.879
AVG. back fat (cm)	2.60 ± 0.10[bc]	2.10 ± 0.60[c]	3.00 ± 0.40[ab]	3.30 ± 0.40[a]	0.038
LSQ index	0.50 ± 0.10	0.30 ± 0.10	0.30 ± 0.00	0.40 ± 0.10	0.439
Marbling score	2.50 ± 0.71	2.70 ± 0.00	2.00 ± 1.41	2.50 ± 0.71	0.230
Carcass pH					
30 min post-mortem	5.50 ± 0.58	5.38 ± 0.41	5.55 ± 0.16	5.62 ± 0.08	0.614
24 hr chilled	5.48 ± 0.07	5.52 ± 0.02	5.66 ± 0.07	6.19 ± 0.86	0.610
Carcass temperature					
30 min post-mortem	37.18 ± 0.95	37.90 ± 1.98	38.18 ± 1.45	38.18 ± 0.11	0.550
24 hr chilled	11.60 ± 1.98	11.90 ± 2.40	11.95 ± 1.48	13.15 ± 1.91	0.859
Drip loss (%)	2.10 ± 0.19	2.22 ± 0.11	3.21 ± 0.98	3.25 ± 1.10	0.776
Lean color					
L*	58.20 ± 4.40	57.80 ± 3.20	60.20 ± 7.40	56.10 ± 3.20	0.489
a*	6.50 ± 1.10	7.40 ± 1.30	7.20 ± 2.20	7.80 ± 1.10	0.417
b*	15.10 ± 1.10	15.90 ± 1.10	16.20 ± 1.20	15.60 ± 0.90	0.288

[abc]The different superscripts on the same row indicated a significant difference (P<0.05).

CONCLUSIONS

There was no significant between the growth performance of the three types of cross-bred black pigs due to the feed intake per day and total feed cost. The L1L3 black pigs showed significantly high body weight gain, but less in feed conversion, and feed cost per gain compared to L1L1. The carcass percentage, and some properties due to pH, temperature, pork color, and drip loss, were not significantly different between the three cross-inbred lines of black pigs. The back fat thickness and LSQ index indicated that three groups of black pigs have moderate lean and fat percentages. Supplementation of CGF may improve the feed intake of black pigs and reduce stress due to more sleep. Black pigs can consume CGF about 1.0 percent of body weight daily by not adversely affecting growth performance and carcass quality.

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