Review Article

Importance of Backfat Thickness to Reproductive Performance in Female Pigs

Atthaporn Roongsitthichai[1*] Padet Tummaruk[2]

Abstract

Backfat in pigs consists of water, collagen, and lipid. Apart from age, body weight, and number of estrus expression, backfat thickness is one of the significant parameters to consider when selecting female pigs into breeding herds since it dominates a number of reproductive performances, *e.g.* puberty attainment, total piglets born (TB), and farrowing rate. Besides, backfat is one of the significant sources of hormones related to puberty attainment, such as leptin, insulin-like growth factor-I (IGF-I), and progesterone (P_4). Evaluation of backfat thickness is majorly performed by an A-mode ultrasonography at P2 position; it provides more accurate body condition than visual scoring. High backfat gilts attain puberty earlier than low backfat gilts. Moreover, gilts with high backfat thickness at insemination deliver one more piglet than low backfat gilts. Furthermore, piglets born from high backfat gilts have higher growth rate and weaning weight than those born from low backfat gilts. Besides, removal opportunity is frequently found in low backfat gilts since they produce very small litter size. During pregnancy and lactation periods, husbandmen should frequently monitor sows' body weight to protect backfat loss, especially in first and second parities. Lactating sows with high relative weight loss have considerably long weaning-to-service interval. To acquire decent reproductive performance of sow in higher parity, replacement gilts should possess backfat thickness of 18.0-23.0 mm at the first insemination and should have body weight control to protect backfat loss during gestation and lactation periods.

Keywords: backfat, pig, reproduction, reproductive performance

[1]*Department of Veterinary Clinical Science, Faculty of Veterinary Sciences, Mahasarakham University, Mahasarakham 44000, Thailand*

[2]*Department of Obstetrics, Gynaecology and Reproduction, Faculty of Veterinary Science, Chulalongkorn University, Bangkok 10330, Thailand*

***Correspondence:** *atthaporn.r@msu.ac.th*

Introduction

Productivity has been regarded as one of the major topics in the current swine commercial industry. Because the tendency of replacement rate has been increasing every year (Engblom et al., 2007), selection of quality pigs should be substantially focused on in order to acquire healthy pigs and subsequent decent yields. To maximize production targets in modern commercial piggeries, an evaluation of pigs' body condition has become one of the significant issues to be underscored. Optimal body condition of the sows not only signifies welfare improvement, but it is also a prerequisite to attain sufficient productivity, especially in high-producing herds (Maes et al., 2004). Moreover, the heritability of backfat depth in pigs is relatively high (h^2~0.5) (Li and Kennedy, 1994). Although the measurement of body condition is considered important, evaluation in an objective way, under field condition, is not easy to perform. Generally, visual examination, ranging from 1 to 5 according to the fatness of the pigs, is performed to evaluate the body condition of pigs. This method can be applied very well within some herds, e.g. outdoor systems. Nonetheless, a number of drawbacks of this assessment are observed. First, thin sows can possess high amount of backfat. Second, it is regarded as an imprecise and subjective method since the evaluation relies on personal scoring skills. Third, less attention is paid to the evaluation when visual scoring has to be performed in the same herd over time (herd blindness). Last, difficulties of evaluation occur when the herd contains more than one breed of e pigs due to variation in conformation among breeds (Whittemore and Schofield, 2000).

To assess body condition score visually, from 1 (very thin) to 5 (very fat), is considered very subjective system; it might vary from one evaluator to the other. Accordingly, the measurement of backfat thickness is regarded as a more objective and more accurate method to appraise the condition of pigs' body than visual scoring (Charette et al., 1996). For instance, a previous study in a number of swine production herds in Canada and the United States of America revealed that sows with body condition score of 3 (intermediate) could have backfat thickness from 9 to 28 mm. This implies that body condition score and backfat thickness correlated poorly (r=0.19) (Young et al., 1991). Consequently, those necessitate the need for more objective methods in determining the body condition in pigs.

This review accentuates on the significance of backfat thickness in female pigs to reproductive performance and productivity in swine breeding herds. Testimonials and present information concerning composition of backfat, measurement of backfat thickness, backfat thickness and puberty attainment, along with major reproductive indicators, and relationship between backfat and outstanding hormones relevant to reproductive efficiency in pigs are described.

Composition of backfat

In pigs, major elements of backfat or subcutaneous fat consist of water, collagen, and lipid. The major composition of lipid in subcutaneous fat is triacylglycerol. The amount of fat and feed intake affects the concentration of fatty acid in subcutaneous fat (Wood et al., 1989). In addition, the firmness and the cohesiveness of fat tissue are dependent on the quantity of fatty acids (Wood, 1984). Likewise, a previous study reported that fat at the loin joint in leaner breeds had less cohesiveness than in fatter breeds (Warriss et al., 1990). In addition, the concentration of fatty acid within the backfat determines nutritional quality, as judged by energy content. It would be proportional to lipid concentration and ratio between polyunsaturated and saturated fatty acid. Nonetheless, such thickness less affects the concentration of fatty acids. Besides, the thickness of subcutaneous fat affects the concentration of water, collagen and lipid; while concentration of water and collagen substantially declines, lipid increases. However, backfat component in male and female pigs is a little different. That in the male pigs is composed of higher water and collagen, but lower lipid, than that in the female pigs (Wood et al., 1989).

Measurement of backfat thickness

To measure backfat thickness in pigs, two kinds of probes are basically used: optical type and ultrasonic type probes. Ultrasonic probe works on the criterion of the reflection of sound wave, whereas optical probe works on the basis of light reflectance between muscles and fat depth, entailing the value of backfat thickness (Kempster et al., 1981; Pomar et al., 2002). A recent study discovered that ultrasonic instruments had consistency and accuracy in measuring backfat thickness in live pigs to maximize economic productivity (Magowan and McCann, 2006).

As for the position to investigate the backfat depth, many studies evaluated different areas. However, P2 position (approximately 6-8 cm away from dorsal midline at the last rib curve) is the most appropriate site to evaluate the backfat depth in live pigs (Fig 1). In general, the measurement of backfat thickness is performed by A-mode ultrasonography. An average value from both sides of P2 position is used as backfat thickness (mm) of individual pigs (Tummaruk et al., 2009b). In Northern Ireland, P2 is only the site to appraise carcass lean content (Magowan and McCann, 2006). Nevertheless, some controversial findings on the accuracy of measurement at this position were reported, for instance, Suster et al. (2003) found that P2 could only be a moderate predictor of the fat content in pigs since the dispersion of fat content in the animal's body was considerably variable. Nonetheless, P2 has currently been the most accurate position for investigating backfat depth in pigs according to a number of researches. Moreover, ultrasonic probe is preferred for backfat assessment in live pigs at P2 position. Normally, backfat thickness in gilts is averagely 1.2 mm higher than in boars of the same age and body weight. Nonetheless, even if boars were leaner than gilts at the same condition, results from ultrasonic probe at P2 position were not affected by sex of the pigs (Magowan and McCann, 2006).

Backfat thickness and puberty attainment

In pigs, puberty attainment is recognized when occurrence of first estrus and first ovulation takes place. Puberty in gilts is predominated by both internal (breed, body weight, backfat) and management (nutrition, boar contact, surroundings) factors, mediated by endocrine-reproductive axis (Evans and O'Doherty, 2001). In addition, age at puberty determines lifetime performance of female pigs; gilts achieving puberty late were inclined to be culled from the herd earlier than those reaching puberty earlier (Koketsu et al., 1999). Nevertheless, age at puberty could not be identified exactly; therefore, age at first observed estrus is basically used to define puberty in gilts instead (Evans and O'Doherty, 2001; Tummaruk et al., 2009b). Generally, gilts express age at first observed estrus at approximately 200 days (Tummaruk et al., 2007; Roongsitthichai et al., 2013). A former study demonstrated that gilts with higher backfat thickness attained puberty faster than those with lower one (Nelson et al., 1990). This indicated that gilts with high backfat could service faster than those with low backfat (Tummaruk et al., 2001). Moreover, a previous study stated that gilts with high backfat thickness (17.8 mm), fed ad libitum, reached puberty at 198 days of age, whereas those with low backfat thickness (14.7 mm), restricted to 80% feed, attained puberty at 203 days of age (Rydhmer, 2000). Moreover, age at puberty had somewhat high heritability (h^2=0.3) respect to other reproductive traits (Rydhmer, 2000). This implies that the selection of replacement gilts on the basis of backfat depth could contribute to magnificent reproductive performance of the herd.

Furthermore, metabolic signals are crucial to puberty initiation (Barb et al., 1997).It was apparently found that some metabolic hormones were closely related to backfat and puberty attainment (Booth et al., 1994; Rozeboom et al., 1995). In numerous domesticated species, leptin and insulin-like growth factor-I (IGF-I) have been recognized as the regulators of cellular growth and differentiation, onset of puberty, and body composition (Bidanel et al., 1996).

Leptin is recognized as one of the significant metabolic hormones among adipose tissues, energy homeostasis, and puberty attainment (Campfield et al., 1995). Adipocytes are the biggest reservoir of leptin, a 16-kDa protein hormone, production (Barb and Kraeling, 2004). Ahmed et al. (1999) reported that fat mass had a relationship with puberty in females. In addition, an escalation of serum leptin is relevant to pubertal onset (Maqsood et al., 2007). Furthermore, it was found that serum leptin concentration was elevated during pubertal development in pigs (Qian et al., 1999) prior to an increase in luteinizing hormone (LH) and estrogen (Barb et al., 2000). Likewise, serum leptin concentration increases during puberty attainment in gilts (Hausman et al., 2012). It, subsequently, was thought that leptin performed as a permissive metabolic signal for the initiation of puberty attainment via LH secretion (Barb et al., 2005). This phenomenon took place not only in pigs, but it also happened in mice (Chehab et al., 1997) and heifers (Garcia et al., 2002). In women, negative relationship between age at first menarche and serum leptin level was observed (Matkovic et al., 1997). Consequently, leptin might be a circulating signal from nutritional status which activates the reproductive axis. It was

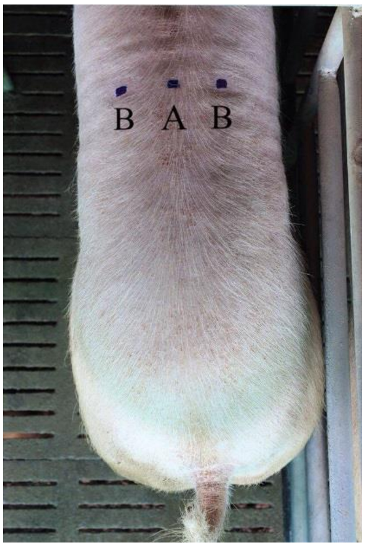

Figure 1 Position for backfat thickness measurement in live pigs. (A) body midline (B) P2 position (6-8 cm away from body midline at the last rib level). An average from bilateral measurement is a representative of individual backfat.

found that an increase in adipocyte mass was proportional to an increase in serum leptin concentration (Considine et al., 1995). In addition, a further study evidently demonstrated that serum leptin concentration positively correlated with backfat depth at P2 position (r=0.476) (Berg et al., 2003). Moreover, positive correlation between leptin messenger RNA level and backfat thickness in pigs was observed (Robert et al., 1998). These signified that the pigs with high backfat thickness reached sexual maturity earlier than those with low backfat thickness.

IGF-I has been proved as one of the significant metabolic factors affecting puberty onset in pigs (te Pas et al., 2004). This implies that gilts with high level of IGF-I attain puberty faster than those with low level of IGF-I. Recent studies depicted the relationship among backfat thickness, serum IGF-I concentration, and pubertal age in the gilts. Those with high backfat thickness (≥17.0 mm), at mating day, had higher serum IGF-I level (31.1±1.1 vs 26.0±1.4 nmol/l, p=0.008) than those with low backfat thickness (≤13.5 mm) (Roongsitthichai et al., 2013). Moreover, gilts with high concentration of serum IGF-I attained onset of puberty faster than those with low serum IGF-I level (<153 vs 168-180 days, p<0.05) (Patterson et al., 2010). Likewise, an ovulation could not take place in the female mice with IGF-I null mutation, even if gonadotropin administration was undertaken (Baker et al., 1996). In contrast, one study disputed that no association was found between the level of plasma IGF-I and age at puberty in growing pigs (Lamberson et al., 1995). However, a recent study found that IGF-I, in most mammalian species, promoted granulosa cell proliferation, steroid production, and oocyte growth development (Silva et al., 2009). These reflect the reasons why gilts with high backfat thickness acquired sexual maturation earlier than those with low backfat thickness; it is mediated via the underlying predomination from such important metabolic hormones.

Backfat and estrous cyclicity

Not only metabolic hormones relate to backfat affect reproductive axis in pigs. Fat was scientifically examined that it was the reservoir of an important sex steroid hormone, so called progesterone (P_4) (Hillbrand and Elsaesser, 1983). Due to the lipophilic property of P_4, the deposition of P_4 in adipose tissue has been found in many species such as cows (McCracken, 1964) and pigs (Hillbrand and Elsaesser, 1983). Moreover, an alteration in backfat quantity evidently affects P_4 concentration during swine estrus cycle. The results from backfat biopsy, 2-5 cm away from dorsal midline above the longissimus dorsi muscle, in gilts revealed a close relationship between plasma and backfat P_4 levels (Hillbrand and Elsaesser, 1983). Naturally, the corpus luteum reaches maximal secretory capability of P_4 between day8 and 12 of the estrus cycle (approximately 21 days) and starts to decline on day 13 onwards (Foxcroft and Van de Wiel, 1982). At mid luteal phase (day 11), the concentration of P_4 stored in fat tissues was 36 mg/ 100 mg backfat, meanwhile approximately 0.2 mg of plasma P_4 was detected (Foxcroft and Van de Wiel, 1982). This reflects that the amount of P_4 is reserved in fat tissue almost 200 times when compared to such in the blood. In addition, the concentration of P_4 detected from backfat, during estrus cycle, delayed for a few days, later than that from blood examination (Hillbrand and Elsaesser, 1983). The mechanism of P_4 storage was investigated in vitro that the steroid could get intofat tissue from the buffer system. In addition, rate and percentage of that penetration were based on the lipophilic characteristics of steroids (Claus and Rattenberger, 1979).

Furthermore, the study of P_4 comparison between backfat and plasma was also conducted in ovariectomized pigs. Results revealed that P_4 dynamics was proportional to that of intact gilts. Plasma and backfat P_4 rapidly declined in the first 20 h; it, afterwards, gradually diminished. Interestingly, the initial half-life of plasma P_4 is 2 h meanwhile that of backfat P_4 is 34 h. These differences imply the significant function of adipose tissue as an embankment to preclude the catabolism of P_4 (Hillbrand and Elsaesser, 1983).

Backfat thickness and litter size at birth

Indicators for measuring litter size at birth in pigs include total number of piglets born per litter (TB), number of piglets born alive per litter (BA), mummified fetuses per litter (MM), and stillborn piglets per litter (SB).Generally, litter size is smallest in the first parity and is largest during parity number 3-6. Subsequently, it continually declines according to increased parity numbers (Tummaruk et al., 2000). Evident findings how backfat thickness predominates litter size at birth were demonstrated. Backfat thickness at the first observed estrus affected TB and BA in the first three parities. It was found that gilts with backfat thickness of 13.1-15.0 mm had significantly larger TB (10.6 vs 9.4) and BA (9.8 vs 8.8) than those with backfat thickness of 11.1-13.0 mm through three parities (Tummaruk et al., 2007). In addition, Roongsitthichai et al. (2010) reported that gilts with backfat thickness ≥17.0 mm at the first insemination delivered 13.1±0.4 TB, meanwhile those with backfat thickness of 14.0-16.5 mm farrowed 12.0±0.4 TB ($p<0.05$). Correspondingly, a study of Filha et al. (2010) demonstrated that, at first mating, gilts with backfat thickness of 18.0-23.0 mm significantly farrowed almost one TB more than those first mated with backfat thickness of 10.0-15.00 mm (12.9±0.16 vs 12.0±0.16 TB). However, no significant difference in BA between groups was noticed. Furthermore, a recent study revealed that piglets delivered from high backfat gilts had higher growth rate during lactation (214.3 vs 202.4 g/day, $p=0.05$), together with higher weaning weight (7.43 vs 7.03 kg, $p=0.04$), than those born from low backfat gilts (Amdi et al., 2013). This might be due to the fact that a higher percentage of milk fat is found in high backfat gilts, entailing to the promotion of weight accumulation and fat deposition which functions as an insulator for piglets (Revell et al., 1998).

On the other hand, those with high backfat thickness could farrow a great number of SB (Roongsitthichai et al., 2010). A recent study reported that the significantly higher percentage of SB came from the primiparous sows with backfat thickness, at first mating, of 18.0-23.0 mm than that from those with backfat thickness, at first mating, of 10.0-15.0 mm (8.7±0.83% vs 5.5±0.61%) (Filha et al., 2010). Because the maximum acceptable number for SB is less than 7% (Dial et al., 1992; Muirhead and Alexander, 2000), the percentage of SB from gilts with high backfat thickness should be taken into emphasized consideration. Moreover, a positive correlation between backfat thickness at first insemination and body weight was observed (r=0.21) (Filha et al., 2010). This signifies that overweight pigs might be in the same group with high backfat pigs. The phenomenon of substantial number of SB might be due to the problem of birth canal obstruction from fat deposition, causing difficulty in parturition (Ash, 1986; Dial et al., 1992; Muirhead and Alexander, 2000). A high number of SB result from prolonged parturition; the uterus had weak contraction. In addition, secondary uterine inertia involved in the high number of SB, especially in the pigs with large litter size and/or large piglets (Ash, 1986).

In addition, thin and poor body condition pigs gain special attention from herd staff by considerably increasing feed amount, in gestation pens, in order to reach targeted body condition. This contributes to overfeeding status, resulting in excessive backfat accumulation for the gestating sows (Roongsitthichai et al., 2010). A previous study reported that the amount of feed in gestating period affected porcine embryo survival and important hormone for pregnancy maintenance (P_4). Provided that the pigs were fed with large amount of gestating feed, 71.9% of embryo survival and 11.8 ng/ml of P_4 were examined. Nonetheless, if the lower quantity of gestating feed was given, 82.8% of embryo survival and 71.9 ng/ml of P_4 were observed (Aherne and Kirkwood, 1985).

Backfat thickness and removal

According to culling patterns, planned and unplanned removals are classified. The first category is frequently found in high parity sows such as old age or low productivity, meanwhile the latter is due to several causes, such as anestrus, locomotive problems, and abnormal vaginal discharge (Engblom et al., 2007). In addition, a majority of the culled is sows in lower parity, especially primiparous sows (Tummaruk et al., 2009a), according to a report. About 15-20% of the removed sows produced only one litter (López-Serrano et al., 2000). Currently, most sows culled from the herd with unplanned reasons. The highest incidence has been reproductive failure, which accounts for approximately one third of the entire removal (Engblom et al., 2007). Common reproductive problems in gilts include anestrus, repeated breeding, non- pregnancy, abnormal vaginal discharge, abortion, and birth problems at first farrowing (Heinonen et al., 1998). Anestrus is the highest portion of culling gilts (Tummaruk et al., 2009a). One of the crucial causes of the unreadiness to express observed estrus might be related to body fat storage since some of the vital metabolic hormones are produced and acquainted with body fat. Accordingly, pigs with an inappropriate backfat thickness are inclined to be removed from breeding herds. The probability of culling increased in both high and low backfat pigs, but it was in greater proportion in thin sows with low backfat depth (Young et al., 1991). A previous study reported that the high proportion of culling was found in gilts with backfat thickness less than 12 mm (Whittemore et al., 1988). Moreover, a former study reported that gilts with low backfat thickness (<16 mm at the end of the growth test) produced a litter size at weaning less than 7.5 piglets (Tarrés et al., 2006). These pigs highly tended to be removed from the herd owing to the low productivity. This apparently points out that low backfat status signifies the unreadiness to be parentstock because the pigs had low energy storage not only for regulating their normal physiological processes, but also for maintaining pregnancy in the future (Tarrés et al., 2006). However, the increased culling of sows in higher parities was not apparently relevant to backfat thickness (Young et al., 1991). To protect backfat loss in sows, live weight should be focused on. During pregnancy, sows should gain about 28 kg in order to maintain backfat thickness (Yang et al., 1989). Not only maternal body fatness, but body weight during gestation also affects growth rate of piglets. Moreover, lactating gilts should gain between 8.8 and 16.8 kg in order to maintain backfat thickness (Young et al., 1991). That is because sows with high relative weight loss (>15%) during lactation had significantly longer weaning-to-service interval (WSI) than those with low relative weight loss (<8%) (9.5 vs 6.8 days, p<0.05) (Tantasuparuk et al., 2001).This phenomenon is apparently found in first and second parity sows; those in parity 1 and 2 with high relative weight loss had WSI of 13.2 and 11.9 days, respectively, meanwhile those in parity 3 and 4 with high relative weight loss had WSI of 6.4 and 6.5 days, respectively (Tantasuparuk et al., 2001). Sows with low backfat and high weight loss during pregnancy and lactation period possessed poor reproductive indices, contributing to the removal from the herd eventually.

Conclusion

Backfat thickness is one of the vital indicators for selecting pigs into breeding units. It helps reduce subjectivity from the visual scoring by human. The measurement of backfat thickness could be conducted bilaterally at P2 position by an A-mode ultrasonography. In addition, several important hormones relevant to reproduction, such as leptin, IGF-I, and P_4, are stored in swine backfat. Backfat thickness affects a number of major reproductive indices of female pigs, *e.g.* puberty attainment, litter size at birth, piglets' growth rate and weaning weight, farrowing rate, and the removal. Those with high backfat thickness attain puberty faster, produce bigger litter size with higher piglets' growth rate and weaning weight, have higher farrowing rate, and are culled from the herd later than those with low backfat thickness. Nevertheless, an extremely high backfat contributes to drawbacks, especially in terms of stillborn piglets, due to an obstruction of birth canal, prolonged parturition, and secondary uterine intertia. As a result, replacement gilts are suggested to have backfat thickness of 18.0-23.0 mm at the first insemination and have weight gain controlled during gestation and lactation to possess magnificent reproductive performance in further parities.

Acknowledgments

The Commemoration of Agricultural Technology Transfer Center, Mahasarakham University was appreciated for the provision of specimen figure. Assistant Professor Sayamon Srisuwatanasagul, Department of Anatomy, Faculty of Veterinary Science, Chulalongkorn University, was thanked for bibliographical assistance.

References

Aherne FX and Kirkwood RN 1985. Nutrition and sow prolificacy. J Reprod Fertil. 33 (Suppl): 169-183.

Ahmed ML, Ong KK, Morrell DJ, Cox L, Drayer N, Perry L, Preece MA and Dunger DB 1999. Longitudinal study of leptin concentrations during puberty: sex differences and relationship to changes in body composition. J Clin Endocrinol Metab. 84(3): 899-905.

Amdi C, Giblin L, Hennessy AA, Ryan T, Stanton C, Stickland NC and Lawlor PG 2013. Feed allowance and maternal backfat levels during gestation influence maternal cortisol levels, milk fat composition and offspring growth. J Nutr Sci. 2: 1-10.

Ash M 1986. Management of the farrowing and lactating sow. In: Current Therapy in Theriogenology. 2nd ed. DA Morrow (ed). Philadelphia: Saunders Company. 931-934.

Baker J, Hardy MP, Zhou J, Bondy C, Lupu F, Bellve AR and Efstratiadis A 1996. Effects of an Igf1 gene null mutation on mouse reproduction. Mol Endocrinol. 10(7): 903-918.

Barb CR and Kraeling RR 2004. Role of leptin in the regulation of gonadotropin secretion in farm animals. Anim Reprod Sci. 82-83: 155-167.

Barb CR, Kraeling RR, Rampacek GB and Dove CR 1997. Metabolic changes during the transition from the fed to the acute feed-deprived state in prepuberal and mature gilts. J Anim Sci. 75(3): 781-789.

Berg EP, McFadin EL, Maddock RR, Goodwin N, Baas TJ and Keisler DH 2003. Serum concentrations of leptin in six genetic lines of swine and relationship with growth and carcass characteristics. J Anim Sci. 81(1): 167-171.

Bidanel J, Gruand J and Legault C 1996. Genetic variability of age and weight at puberty, ovulation rate and embryo survival in gilts and relations with production traits. Genet Sel Evol. 28(1): 1-13.

Booth PJ, Craigon J and Foxcroft G 1994. Nutritional manipulation of growth and metabolic and reproductive status in prepubertal gilts. J Anim Sci. 72(9): 2415-2424.

Campfield LA, Smith FJ, Guisez Y, Devos R and Burn P 1995. Recombinant mouse OB protein: evidence for a peripheral signal linking adiposity and central neural networks. Science. 269(5223): 546-549.

Charette R, Bigras-Poulin M and Martineau G-P 1996. Body condition evaluation in sows. Livest Prod Sci. 46(2): 107-115.

Chehab FF, Mounzih K, Lu R and Lim ME 1997. Early onset of reproductive function in normal female mice treated with leptin. Science. 275(5296): 88-90.

Claus R and Rattenberger E 1979. Improved method for progesterone determination in milk-fat [dairy cattle]. Br Vet J. 135(135): 464-469.

Considine RV, Considine EL, Williams CJ, Nyce MR, Magosin SA, Bauer TL, Rosato EL, Colberg J and Caro JF 1995. Evidence against either a premature stop codon or the absence of obese gene mRNA in human obesity. J Clin Invest. 95(6): 2986-2988.

Dial G, Marsh W, Polson D and Vaillancourt J 1992. Reproductive failure: differential diagnosis. In: Diseases of swine. 7th ed. AD Leman, BE Straw, WL Mengeling, S D'allaire, and DJ Taylor (eds). Ames: Iowa State University Press. 88-137.

Engblom L, Lundeheim N, Dalin A-M and Andersson K 2007. Sow removal in Swedish commercial herds. Livest Sci. 106(1): 76-86.

Evans A and O'Doherty J 2001. Endocrine changes and management factors affecting puberty in gilts. Livest Prod Sci. 68(1): 1-12.

Filha WS, Bernardi ML, Wentz I and Bortolozzo FP 2010. Reproductive performance of gilts according to growth rate and backfat thickness at mating. Anim Reprod Sci. 121(1-2): 139-144.

Foxcroft G and Van de Wiel D 1982. Endocrine control of the oestrous cycle. In: Control of Pig Reproduction. DJA Cole and GR Foxcroft (ed). London: Butterworth Scientific. 161-177.

Garcia MR, Amstalden M, Williams SW, Stanko RL, Morrison CD, Keisler DH, Nizielski SE and Williams GL 2002. Serum leptin and its adipose gene expression during pubertal development, the estrous cycle, and different seasons in cattle. J Anim Sci. 80(8): 2158-2167.

Hausman GJ, Barb CR and Lents CA 2012. Leptin and reproductive function. Biochimie. 94(10): 2075-2081.

Heinonen M, Leppavuori A and Pyorala S 1998. Evaluation of reproductive failure of female pigs based on slaughterhouse material and herd record survey. Anim Reprod Sci. 52(3): 235-244.

Hillbrand FW and Elsaesser F 1983. Concentrations of progesterone in the backfat of pigs during the oestrous cycle and after ovariectomy. J Reprod Fertil. 69(1): 73-80.

Kempster A, Chadwick J, Jones D and Cuthbertson A 1981. An evaluation of the hennessy and chong fat depth indicator, and the ulster probe, for use in pig carcass classification and grading. Anim Prod. 33(03): 319-324.

Koketsu Y, Takahashi H and Akachi K 1999. Longevity, lifetime pig production and productivity, and age at first conception in a cohort of gilts observed over six years on commercial farms. J Vet Med Sci. 61(9): 1001-1005.

Lamberson W, Safranski T, Bates R, Keisler D and Matteri R 1995. Relationships of serum insulin-like growth factor I concentrations to growth, composition, and reproductive traits of swine. J Anim Sci. 73(11): 3241-3245.

Li X and Kennedy B 1994. Genetic parameters for growth rate and backfat in Canadian Yorkshire, Landrace, Duroc, and Hampshire pigs. J Anim Sci. 72(6): 1450-1454.

López-Serrano M, Reinsch N, Looft H and Kalm E 2000. Genetic correlations of growth, backfat thickness and exterior with stayability in Large White and Landrace sows. Livest Prod Sci. 64(2): 121-131.

Maes D, Janssens G, Delputte P, Lammertyn A and de Kruif A 2004. Back fat measurements in sows from three commercial pig herds: relationship with reproductive efficiency and correlation with visual body condition scores. Livest Prod Sci. 91(1): 57-67.

Magowan E and McCann M 2006. A comparison of pig backfat measurements using ultrasonic and optical instruments. Livest Sci. 103(1): 116-123.

Maqsood AR, Trueman JA, Whatmore AJ, Westwood M, Price DA, Hall CM and Clayton PE 2007. The relationship between nocturnal urinary leptin and gonadotrophins as children progress towards puberty. Horm Res. 68(5): 225-230.

Matkovic V, Ilich JZ, Skugor M, Badenhop NE, Goel P, Clairmont A, Klisovic D, Nahhas RW and Landoll JD 1997. Leptin is inversely related to age at menarche in human females. J Clin Endocrinol Metab. 82(10): 3239-3245.

McCracken J 1964. Plasma progesterone concentration after removal of the corpus luteum in the cow. Nature. 198: 507-508.

Muirhead M and Alexander T 2000. The management of infertility. A pocket guide to recognizing and treating pig infertility. In: The Management of Infertility. MR Muirhead and TJL Alexander (eds). Sheffield: 5M Enterprise. 43-102.

Nelson A, Mabry J, Benyshek L and Marks M 1990. Correlated response in reproduction, growth and composition to selection in gilts for extremes in age at puberty and backfat. Livest Prod Sci. 24(3): 237-247.

Patterson J, Beltranena E and Foxcroft G 2010. The effect of gilt age at first estrus and breeding on third estrus on sow body weight changes and long-term reproductive performance. J Anim Sci. 88(7): 2500-2513.

Pomar C, Fortin A and Marcoux M 2002. Successive measurements of carcass fat and loin muscle depths at the same site with optical probes. Can J Anim Sci. 82(4): 595-598.

Qian H, Barb CR, Compton MM, Hausman GJ, Azain MJ, Kraeling RR and Baile CA 1999. Leptin mRNA expression and serum leptin concentrations as influenced by age, weight, and estradiol in pigs. Domest Anim Endocrinol. 16(2): 135-143.

Revell D, Williams I, Mullan B, Ranford J and Smits R 1998. Body composition at farrowing and nutrition during lactation affect the performance of primiparous sows: II. Milk composition, milk yield, and pig growth. J Anim Sci. 76(7): 1738-1743.

Robert C, Palin M-F, Coulombe N, Roberge C, Silversides FG, Benkel BF, McKay RM and Pelletier G 1998. Backfat thickness in pigs is positively associated with leptin mRNA levels. Can J Anim Sci. 78(4): 473-482.

Roongsitthichai A, Koonjaenak S and Tummaruk P 2010. Backfat thickness at first insemination affects litter size at birth of the first parity sows. Kasetsart J (Nat Sci). 44: 1128-1136.

Roongsitthichai A, Koonjaenak S and Tummaruk P 2013. The association among age at first observed estrus, backfat thickness, and serum insulin–like growth factor–I in replacement gilts. Thai J Vet Med. 43: 41-48.

Rozeboom DW, Pettigrew JE, Moser RL, Cornelius SG and el Kandelgy SM 1995. Body composition of gilts at puberty. J Anim Sci. 73(9): 2524-2531.

Rydhmer L 2000. Genetics of sow reproduction, including puberty, oestrus, pregnancy, farrowing and lactation. Livest Prod Sci. 66(1): 1-12.

Silva J, Figueiredo J and Van den Hurk R 2009. Involvement of growth hormone (GH) and insulin-like growth factor (IGF) system in ovarian folliculogenesis. Theriogenology. 71(8): 1193-1208.

Suster D, Leury B, Ostrowska E, Butler K, Kerton D, Wark J and Dunshea F 2003. Accuracy of dual energy X-ray absorptiometry (DXA), weight and P2 back fat to predict whole body and carcass composition in pigs within and across experiments. Livest Prod Sci. 84(3): 231-242.

Tantasuparuk W, Dalin A-M, Lundeheim N, Kunavongkrit A and Einarsson S 2001. Body weight loss during lactation and its influence on weaning-to-service interval and ovulation rate in Landrace and Yorkshire sows in the tropical environment of Thailand. Anim Reprod Sci. 65(3): 273-281.

Tarrés J, Tibau J, Piedrafita J, Fàbrega E and Reixach J 2006. Factors affecting longevity in maternal Duroc swine lines. Livest Sci. 100(2): 121-131.

te Pas MF, Visscher AH and de Greef KH 2004. Molecular genetic and physiologic background of the growth hormone–IGF-I axis in relation to breeding for growth rate and leanness in pigs. Domest Anim Endrocrinol. 27(3): 287-301.

Tummaruk P, Kesdangsakonwut S and Kunavongkrit A 2009a. Relationships among specific reasons for culling, reproductive data, and gross morphology of the genital tracts in gilts culled due to reproductive failure in Thailand. Theriogenology. 71(2): 369-375.

Tummaruk P, Lundeheim N, Einarsson S and Dalin A 2000. Factors influencing age at first mating in purebred Swedish Landrace and Swedish Yorkshire gilts. Anim Reprod Sci. 63(3): 241-254.

Tummaruk P, Lundeheim N, Einarsson S and Dalin A 2001. Effect of birth litter size, birth parity number, growth rate, backfat thickness and age at first mating of gilts on their reproductive performance as sows. Anim Reprod Sci. 66(3): 225-238.

Tummaruk P, Tantasuparuk W, Techakumphu M and Kunavongkrit A 2007. Age, body weight and backfat thickness at first observed oestrus in crossbred Landrace x Yorkshire gilts, seasonal variations and their influence on subsequence reproductive performance. Anim Reprod Sci. 99(1-2): 167-181.

Tummaruk P, Tantasuparuk W, Techakumphu M and Kunavongkrit A 2009b. The association between growth rate, body weight, backfat thickness and age at first observed oestrus in crossbred Landrace x Yorkshire gilts. Anim Reprod Sci. 110(1-2): 108-122.

Warriss PD, Brown SN, Franklin JG and Kestin SC 1990. The thickness and quality of backfat in various pig breeds and their relationship to intramuscular fat and the setting of joints from the carcasses. Meat Sci. 28(1): 21-29.

Whittemore C and Schofield C 2000. A case for size and shape scaling for understanding nutrient use in breeding sows and growing pigs. Livest Prod Sci. 65(3): 203-208.

Whittemore C, Smith W and Phillips P 1988. Fatness, live weight and performance responses of sows to food level in pregnancy. Anim. Prod. 47: 123-130.

Wood J 1984. Fat deposition and the quality of fat tissue in meat animals. In: Fats in Animal Nutrition. J Wiseman (ed). London: Butterworths. 407-435.

Wood J, Enser M, Whittington F, Moncrieff C and Kempster A 1989. Backfat composition in pigs: differences between fat thickness groups and sexes. Livest Prod Sci. 22(3): 351-362.

Yang H, Eastham P, Phillips P and Whittemore C 1989. Reproductive performance, body weight and body condition of breeding sows with differing body fatness at parturition, differing nutrition during lactation, and differing litter size. Anim. Prod. 48: 181-201.

Young L, King G, Shaw J, Quinton M, Walton J and McMillan I 1991. Interrelationships among age, body weight, backfat and lactation feed intake with reproductive performance and longevity of sows. Can J Anim Sci. 71(2): 567-575.

บทคัดย่อ

ความสำคัญของความหนาไขมันสันหลังต่อความสามารถทางการสืบพันธุ์ในสุกรเพศเมีย

อตถพร รุ่งสิทธิชัย[1*] เผด็จ ธรรมรักษ์[2]

ไขมันสันในสุกรหลังประกอบด้วยน้ำ คอลลาเจน และไขมัน นอกเหนือจากปัจจัยอายุ น้ำหนักตัว และจำนวนครั้งที่แสดงอาการเป็นสัด ความหนาไขมันสันหลังถือเป็นปัจจัยสำคัญอย่างหนึ่งในการพิจารณาเลือกสุกรเพศเมียเข้าสู่วงจรการผลิต เนื่องจากความหนาไขมันสันหลังมีอิทธิพลต่อสมรรถภาพทางการสืบพันธุ์หลายอย่าง อาทิ การเข้าสู่วัยเจริญพันธุ์ จำนวนลูกสุกรแรกคลอด อัตราการเข้าคลอด ฯลฯ นอกจากนี้ไขมันสันหลังยังเป็นแหล่งฮอร์โมนสำคัญที่เกี่ยวข้องกับการเข้าสู่วัยเจริญพันธุ์ของสุกรด้วย เช่น เลปติน อินซูลินไลค์แฟคเตอร์-วัน (ไอจีเอฟ-วัน) และโปรเจสเตอโรน การประเมินความหนาไขมันสันหลังในสุกรส่วนใหญ่ใช้อัลตร้าซาวด์ชนิดเอ-โหมด วัดที่ตำแหน่ง P2 ซึ่งการประเมินความหนาไขมันสันหลังสามารถให้ค่าคะแนนร่างกายได้แม่นยำกว่าการประเมินด้วยสายตา สุกรที่มีความหนาไขมันสันหลังสูงสามารถเข้าสู่วัยเจริญพันธุ์ได้เร็วกว่าสุกรที่มีความหนาไขมันสันหลังต่ำ นอกจากนี้ยังพบว่าแม่สุกรที่มีความหนาไขมันสันหลังสูง ณ วันผสมพันธุ์สามารถคลอดลูกได้มากกว่าแม่สุกรที่มีความหนาไขมันสันหลังต่ำประมาณ 1 ตัว อีกทั้งยังพบว่าลูกสุกรที่เกิดจากแม่สุกรที่มีความหนาไขมันสันหลังสูงมีอัตราการเจริญเติบโต และน้ำหนักหย่านมสูงกว่าลูกสุกรที่เกิดจากแม่สุกรที่มีความหนาไขมันสันหลังต่ำอีกด้วย ในการคัดทิ้งสุกรออกจากฝูง พบว่าสุกรที่มีความหนาไขมันสันหลังต่ำมีโอกาสถูกคัดทิ้งมากกว่าสุกรที่มีความหนาไขมันสันหลังสูง เนื่องจากให้ผลผลิตต่ำมาก ในช่วงอุ้มท้องและเลี้ยงลูก ผู้เลี้ยงควรมีการควบคุมน้ำหนักแม่สุกรอย่างสม่ำเสมอเพื่อป้องกันการสูญเสียความหนาไขมันสันหลัง โดยเฉพาะอย่างยิ่งในแม่สุกรลำดับท้องที่หนึ่งและสอง เนื่องจากแม่สุกรที่สูญเสียน้ำหนักตัวสัมพัทธ์ในช่วงเลี้ยงลูกจะมีช่วงระยะหย่านมถึงผสมยาวออกไปมาก เพื่อให้แม่สุกรมีสมรรถภาพทางการสืบพันธุ์ที่ดีในลำดับท้องถัดไป สุกรสาวทดแทนควรมีความหนาไขมันสันหลัง 18.0-23.0 มม ในการผสมพันธุ์ครั้งแรก และควรมีการควบคุมน้ำหนักทั้งในช่วงอุ้มท้อง และช่วงเลี้ยงลูกเพื่อป้องกันการสูญเสียความหนาไขมันสันหลังในช่วงดังกล่าวด้วย

คำสำคัญ: ความหนาไขมันสันหลัง สุกร ระบบสืบพันธุ์ สมรรถภาพทางการสืบพันธุ์

[1]*ภาควิชาคลินิกทางสัตวแพทยศาสตร์ คณะสัตวแพทยศาสตร์ มหาวิทยาลัยมหาสารคาม จังหวัดมหาสารคาม 44000*

[2]*ภาควิชาสูติศาสตร์ เธนุเวชวิทยา และวิทยาการสืบพันธุ์ คณะสัตวแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย กรุงเทพฯ 10330*

***ผู้รับผิดชอบบทความ E-mail:** *atthaporn.r@msu.ac.th*