INFLUENCE OF BODY CONDITION ON THE REPRODUCTIVE PERFORMANCE OF THE SOW

INFLUENCIA DE LA CONDICIÓN CORPORAL EN EL DESEMPEÑO REPRODUCTIVO DE LA CERDA

INFLUÊNCIA DA CONDIÇÃO CORPORAL NO DESEMPENHO REPRODUTIVO DA PORCA

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ABSTRACT
Backfat thickness (BFT) is an indicator of sow body condition. Maintaining optimal body condition in high-producing sows is important for their performance, reproductive efficiency, and longevity. A BFT between 17 and 22 mm at the end of gestation is associated with larger litter size and piglet birth weight, higher growth rate and piglet weaning weight, and a shorter weaning-to-estrus interval (WEI). Furthermore, it is associated with fewer piglets with intrauterine growth restriction (IUGR) and with a linear increase in BFT gain from weaning to day 109 of the following gestation. Therefore, it is recommended that nulliparous and multiparous sows have a BFT between 15 and 18 mm at breeding. A low BFT delays the onset of puberty. In this regard, leptin and insulin-like growth factor I (IGF-I) have been observed to be associated with BFT and age at puberty. Likewise, a low BFT has been associated with lower litter size and growth, as well as prolonged WEI. A very high BFT (>26 mm) has been associated with less mammary development, potentially translating into lower milk production and litters with lower weight gain during lactation. Excessive feed intake during early gestation should be avoided, as it increases embryonic mortality in gilts and decreases feed intake during lactation. Evidence indicates that an BFT less than 15 mm or greater than 26 mm at the end of gestation may affect the sow's reproductive performance.

Keywords: Backfat Thickness. Sow. Reproductive Performance. Litter Size and Weight.

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RESUMO
A espessura de gordura dorsal (EGD) é um indicador da condição corporal da porca. Manter a condição corporal ideal em porcas de alta produção é importante para seu desempenho, eficiência reprodutiva e longevidade. Uma EGD entre 17 e 22 mm no final da gestação está associada a um maior tamanho da ninhada e peso ao nascer dos leitões, maior taxa de crescimento e peso ao desmame dos leitões e um menor intervalo desmame-estro (IDE). Além disso, está associada a um menor número de leitões com restrição de crescimento intrauterino (RCIU) e a um aumento linear no ganho de EGD do desmame até o dia 109 da gestação seguinte. Portanto, recomenda-se que porcas nulíparas e multíparas tenham uma EGD entre 15 e 18 mm na reprodução. Uma EGD baixa atrasa o início da puberdade. Nesse sentido, observou-se que a leptina e o fator de crescimento semelhante à insulina I (IGF-I) estão associados à EGD e à idade na puberdade. Da mesma forma, um EGD baixo tem sido associado a menores tamanho e crescimento da ninhada, bem como a um IDE prolongado. Um EGD muito alto (> 26 mm) tem sido associado a um menor desenvolvimento mamário, o que pode se traduzir em menor produção de leite e ninhadas com menor ganho de peso durante a lactação. O consumo excessivo de ração durante o início da gestação deve ser evitado, pois aumenta a mortalidade embrionária em marrãs e diminui o consumo de ração durante a lactação. Evidências indicam que um EGD menor que 15 mm ou maior que 26 mm no final da gestação pode afetar o desempenho reprodutivo da porca.

Palavras-chave: Espessura de Toucinho. Porca. Desempenho Reprodutivo. Tamanho e Peso da Ninhada.

RESUMEN
El espesor de grasa dorsal (EGD) es un indicador de la condición corporal de las cerdas. Mantener la condición corporal óptima en las cerdas de producción alta es importante para el rendimiento, la eficiencia reproductiva y la longevidad de éstas. Un EGD entre 17 a 22 mm al final de la gestación está asociado a un mayor tamaño de la camada y peso del lechón al nacimiento, mayor tasa de crecimiento y peso del lechón al destete, así como un menor intervalo destete a celo (IDC). Además, se asocia con un menor número de lechones con restricción del crecimiento intrauterino (RCIU) y con aumento lineal en la ganancia de EGD desde el destete hasta el día 109 de la siguiente gestación. Por ello, se recomienda que la cerda nulípara y multípara tengan un EGD entre 15 y 18 mm al empadre. Un bajo EGD retarda la presentación de la pubertad. Al respecto, se ha observado que la leptina y el factor I de crecimiento similar a la insulina (IGF- I) están asociados con el EGD y la edad a la pubertad. Asimismo, Un bajo EGD se ha asociado con un menor tamaño y crecimiento de la camada; así como, un IDC prolongado. El EGD muy alto (>26 mm) se ha asociado con menor desarrollo mamario, lo que potencialmente se traduce en menor producción de leche y camadas con menor ganancia de peso durante la lactancia. Se debe evitar el consumo excesivo de alimento durante la gestación temprana, ya que aumenta la mortalidad embrionaria en las primerizas y disminuye el consumo de alimento durante la lactancia. La evidencia indica que un EGD menor de 15 mm o mayor de 26 mm al final de la gestación puede afectar el desempeño reproductivo de la cerda.

Palabras clave: Espesor de Grasa Dorsal. Cerda. Desempeño Reproductivo. Tamaño y Peso de la Camada.

1 INTRODUCTION

The body condition of the sow during the reproductive cycle can affect her reproductive performance. Maintaining optimal body condition in high-yielding sows is important for sow reproductive performance, reproductive efficiency, and longevity (Clowes *et al*., 2003; Houde *et al*., 2010; Kim *et al*., 2015). EGD is an indicator of sow body condition (Kim *et al*., 2013); its measurement constitutes an objective and accurate method to assess the body condition of sows (Charette *et al*., 1996). It has been suggested that maintaining EGD throughout the reproductive cycle is more important than setting this parameter only in service (Houde *et al*., 2010). Kim *et al*. (2016), observed that sows with 20 mm or more EGD had piglets with higher body weight, higher growth rate, and more weaned than sows with less than 20 mm EGD at 107 days of gestation. Zhou *et al*. (2018), observed that sows with EGD between 19 and 22 mm on day 109 of gestation had piglets with higher live weight at birth and weaning than sows with EGD less than 19 mm. In a similar study, Vavrisinova *et al*. (2009), observed that sows with EGD between 20 and 22 mm had heavier piglets at birth and at 21 d of age, and the heaviest piglets were those of sows with EGD of 22 mm, and a lower weight in piglets of sows with EGD less than 20 mm. Kim *et al*. (2015), showed that an EGD of 17 to 21 mm is associated with a larger litter size at weaning. It has been suggested that it is important to maintain a moderate EGD in the sow, since during the last phase of gestation and lactation feed intake is not sufficient to meet the nutrient requirements for maintenance, fetal growth and lactation, leading to the mobilization of backfat and reserve proteins (Aherne *et al*., 1999). Excessive loss of back fat and body protein during gestation and lactation has been shown to be associated with a higher percentage of stillborn piglets (Maes *et al*., 2004), smaller litter size at birth, and low litter growth during lactation (Clowes *et al*., 2003) and prolonged IDC (De Rensis *et al*., 2005; Serenius *et al*., 2006). On the other hand, excess body fat at the end of gestation leads to farrowing difficulties and more stillborn piglets (Zaleski and Hacker, 1993), postpartum dysgalactia and higher sow culling rate due to locomotion difficulties (Dourmad *et al*., 2001), as well as a higher proportion of fetuses with IUGR, lower weight gain and litter size at weaning (Kim *et al*., 2015). In domestic species such as pigs, fetal growth restriction is associated with increased perinatal morbidity and mortality, negative effects on postnatal growth, body composition, and meat quality (Lekatz *et al*., 2010). Zhou *et al.* (2018), observed that excess (≥25 mm) in the EGD at 109 days of gestation increased the number and percentage of piglets born with a weight of less than 800 g. Torres-Rovira *et al*. (2013), observed IUGR in 21.9% of obese sows. Wu *et al*. (2006), showed that maternal overnutrition during gestation impaired fetal development and postnatal survival, as well as a higher number of piglets with IUGR. Zhou *et al*. (2018), observed that an EGD between 19 and 20 mm is associated with a lower number and percentage in newborn piglets with IUGR. The present review aims to document the influence of body condition on sow reproductive performance.

1.1 COMPOSITION OF BACK FAT

In pigs, the main elements of back fat or subcutaneous fat consist of water, collagen, and lipids. The main composition of lipids in subcutaneous fat is triacylglycerol. The amount of fat in the feed and feed intake affect the concentration of fatty acids in the subcutaneous fat (Wood *et al*., 1989). In addition, the firmness and cohesion of fat tissue depend on the amount of fatty acids (Wood, 1984). It has been observed that back fat in thinner breeds has less cohesion than in more robust breeds (Warriss *et al*., 1990). In addition, the concentration of fatty acids within the back fat determines nutritional quality; Judging by the energy content, this would be proportional to the concentration of lipids and the ratio of polyunsaturated to saturated fatty acids. However, EGD affects the concentration of fatty acids less. Also, EGD affects the concentration of water, collagen and lipids; As the concentration of water and collagen decreases substantially, lipids increase. However, the backfat component in male and female pigs is a bit different. That of male pigs is composed of more water and collagen, but less lipids than that of females (Wood *et al*., 1989).

2 MEASUREMENT OF BACK FAT THICKNESS

Two types of probes are basically used to measure EGD in pigs: optical and ultrasonic probes. The optical probe works on the basis of the reflection of light between the muscles and the depth of the fat, which implies the value of the EGD, while the ultrasonic probe works based on the reflection of the sound wave (Pomar *et al*., 2002). Ultrasonic instruments have been observed to have consistency and accuracy in measuring EGD in live pigs to maximize economic productivity (Magowan and McCann, 2006). The P2 position (approximately 6 to 8 cm from the dorsal midline at the level of the last rib) is the most appropriate site to assess the depth of back fat in live pigs. In general, EGD measurement is performed by mode A ultrasonography. The average value of both sides of the P2 position as EGD (mm) of each pig is used (Tummaruk *et al*., 2009). However, Suster *et al*. (2003) found that the P2 position could only be a moderate predictor of fat content in pigs, since the dispersion of fat content in the animal's body is considerably variable. However, P2 is currently the most accurate position for measuring EGD in live pigs (Magowan and McCann, 2006; Tummaruk *et al*., 2009); in addition, the ultrasonic probe is preferred for the measurement of EGD in pigs at the P2 position.

2.1 INFLUENCE OF BACK FAT THICKNESS ON THE PRESENTATION OF PUBERTY IN THE SOW

In sows, the presentation of puberty is recognized when the first heat and ovulation occur. Puberty in gilts is determined by both internal factors (breed, body weight, back fat) and management factors (nutrition, boar contact, environment), mediated by the endocrine-reproductive axis (Evans & O'Doherty, 2001). In addition, the age of puberty determines the lifetime performance of sows; it has been observed that gilts that reach late puberty are discarded before those that reach puberty at a younger age (Koketsu *et al*., 1999). However, the age of puberty cannot be accurately identified; therefore, the age of the first estrus observed is basically used to define puberty in gilts (Evans and O'Doherty, 2001; Tummaruk *et al*., 2009). Generally, gilts express the age of the first estrus observed at approximately 200 days (Tummaruk *et al*., 2007; Roongsitthichai *et al*., 2013). First-time sows with higher EGD have been shown to reach puberty faster than those with lower EGD (Nelson *et al*., 1990). This indicates that gilts with high backfat content could be served at an earlier age than those with lower backfat content (Tummaruk *et al*., 2001). In addition, it has been observed that gilts with high EGD (17.8 mm), fed *ad libitum*, reach puberty at 198 d of age, while those with lower EGD (14.7 mm), restricted to 80% feed, reach puberty at 203 d of age (Rydhmer, 2000); these same authors indicated that age at puberty has a heritability (h2 = 0.30). which is superior to other reproductive traits. This implies that the selection of replacement gilts based on EGD could contribute to the better reproductive performance of the herd. In addition, metabolic signals are crucial for the onset of puberty (Barb *et al*., 1997). It has been observed that some metabolic hormones are closely related to back fat and the achievement of puberty (Rozeboom *et al*., 1995). Leptin and insulin-like growth factor I (IGF-I) have been recognized as regulators of cell growth and differentiation, the onset of puberty, and body composition (Bidanel *et al*., 1996). Leptin is recognized as one of the metabolic hormones of adipose tissue, important in energy homeostasis and the achievement of puberty (Campfield *et al*., 1995). Adipocytes are the largest reservoir of leptin production, a 16 kDa protein hormone (Barb & Kraeling, 2004). Serum leptin concentration has been observed to rise during pubertal development in pigs (Qian *et al*., 1999), prior to an increase in luteinizing hormone (LH) and estrogen (Barb *et al*., 2000). In addition, serum leptin concentration has been observed to increase during puberty in gilts (Hausman *et al*., 2012). Leptin has also been observed to function as a permissive metabolic signal for the onset of puberty through LH secretion (Barb *et al*., 2005). This phenomenon has not only been observed in pigs, but also occurred in mice (Chehab *et al*., 1997) and heifers (Garcia *et al*., 2002). Consequently, leptin could be a metabolic signal of nutritional status that activates the reproductive axis. In this regard, it was found that an increase in adipocyte mass is proportional to the increase in serum leptin concentration (Considine *et al*., 1995). In addition, serum leptin concentration was shown to be positively related to EGD at the P2 position (r = 0.476) (Berg *et al*., 2003). A positive association between leptin messenger RNA level and EGD in pigs was also determined (Robert *et al*., 1998). This explains why pigs with high EGD reach sexual maturity earlier than those with low EGD. Additionally, IGF-I has been shown to be one of the significant metabolic factors affecting the onset of puberty in pigs (te Pas *et al*., 2004). This implies that gilts with a high IGF-I level reach puberty faster than those with a low IGF-I level. An association has been observed between EGD, serum IGF-I concentration, and pubertal age in gilts. Nulliparous sows with high EGD (≥17.0 mm) on the day of mating had a higher serum IGF-I level (31.1±1.1 *vs.* 26.0±1.4 nmol/L, p = 0.008) than those with low EGD (≤13.5 mm) (Roongsitthichai *et al*., 2013). In addition, gilts with high serum IGF-I concentration reached puberty faster than those with a low serum IGF-I level (<153 *vs.* 168-180 days, p <0.05) (Patterson *et al*., 2010). It has also been observed that ovulation does not occur in female mice with IGF-I mutation, even if gonadotropins are administered (Baker *et al*., 1996). In contrast, one study questioned whether no association was found between plasma IGF-I level and age at puberty in growing pigs (Lamberson *et al*., 1995). However, in a subsequent study, IGF-I, in most mammalian species, was found to promote granulosa cell proliferation, steroid production, and oocyte growth (Silva *et al*., 2009). This information reflects the reasons why gilts with high EGD acquire sexual maturity earlier than those with low EGD.

3 INFLUENCE OF BACK FAT THICKNESS ON ESTROUS CYCLICITY

It is not only metabolic hormones related to back fat that affect the reproductive axis in pigs. Fat is the reservoir of an important sex steroid hormone in estrous cyclicity, progesterone (P4) (Hillbrand and Elsaesser, 1983). Due to the lipophilic property of P4, deposition of P4 in adipose tissue has been found in cows (McCracken, 1964) and pigs (Hillbrand and Elsaesser, 1983). In addition, an alteration in the amount of back fat evidently affects the concentration of P4 during the estrous cycle of the sows. Biopsy results of backfat in gilts, between 2 to 5 cm from the dorsal midline above the *longissimus dorsi* muscle, revealed a close relationship between plasma levels of P4 and backfat (Hillbrand and Elsaesser, 1983). Naturally, the corpus luteum reaches maximum P4 secretory capacity between days 8 and 12 of the estrous cycle (approximately 21 days) and begins to decline from day 13 (Foxcroft and Van de Wiel, 1982); These researchers determined that during the luteal phase (day 11) the concentration of P4 stored in fat tissue was 36 mg/100 mg of back fat, while approximately 0.2 mg of P4 was detected in plasma. This reflects that the amount of P4 is stored in adipose tissue almost 200 times more than in blood plasma. Hillbrand and Elsaesser (1983) observed an association between plasma P4 concentration and EGD during the estrous cycle. These authors observed a high storage of progesterone in back fat (approximately 0.9 ng/mg fat) that showed a 2-day delay in the reduction of P4 concentrations after luteolysis compared to plasma concentrations; thus, it was observed that the half-life of plasma P4 is 2 h, while that of P4 stored in back fat is 34 h. These differences imply the important function of adipose tissue as a storehouse to prevent P4 catabolism; whose release by fatter gilts can have potentially negative effects on their subsequent reproductive performance (Thitachot *et al*., 2021).

4 INFLUENCE OF BACK FAT THICKNESS ON LITTER SIZE AT BIRTH AND WEANING

Indicators to measure litter size at birth in sows include total number of piglets born (TLN), number of piglets born alive (LNV), mummified fetuses (FM) and stillborn piglets (LNM). Generally, litter size is smaller at first calving and is larger during births 3 to 6; subsequently, it continuously declines according to the increase in the number of births (Tummaruk *et al*., 2000). It has been determined that EGD in the first observed estrus affects TLN and LNV in the first three calvings. In this regard, it has been observed that gilts with EGD of 13.1 to 15 mm have an average TLN (10.6 *vs.* 9.4) and a number of LNVs (9.8 *vs.* 8.8), significantly higher than those with an EGD of 11.1 to 13 mm during the first three deliveries (Tummaruk *et al*., 2007). In addition, Roongsitthichai *et al*. (2010), observed that gilts with EGD equal to or greater than 17.0 mm at first insemination gave birth to 13.1±0.4 LNV, while those with EGD from 14 to 16.5 mm gave birth to 12.0±0.4 LNV (p <0.05). Filha *et al*. (2010), showed that gilts, with EGD of 18 to 23 mm in service, gave birth almost one LNV more than gilts covered with EGD of 10 to 15 mm (12.9±0.16 *vs.* 12.0±0.16 LNV). Cechova and Tvrdon (2006) observed that primiparous sows with higher EGD at 90 kg body weight achieved litters of larger size and performance. On the other hand, sows with excessive EGD (obese) may farrowe more LNM (Roongsitthichai *et al*., 2010). In this regard, it has been observed that the highest percentage of LNM comes from gilts with EGD between 18 and 23 mm in the first service compared to those with EGD of 10 to 15 mm (8.7±0.83% *vs.* 5.5±0.61%) (Filha *et al*., 2010); in addition, a positive correlation was observed between EGD at first insemination and sow body weight (r = 0.21; p <0.05); This means that overweight sows could be in the same group as sows with high backfat. Because the maximum acceptable percentage of LNM is less than 7% (Muirhead and Alexander, 2000), the percentage of LNM of gilts with high EGD should be taken into account. The phenomenon of a substantial number of LNMs could be due to the problem of obstruction of the birth canal by fat accumulation, which causes difficulty in delivery (Muirhead and Alexander, 2000). Excess EGD at the end of gestation is also associated with postpartum dysgalactia, locomotion difficulties and higher sow culling rate (Dourmad *et al*., 2001). Thus, increasing the amount of feed during gestation to achieve the desired body condition, without a basis in EGD, contributes to the state of overfeeding, resulting in excessive accumulation of backfat in pregnant sows (Roongsitthichai *et al*., 2010). On the other hand, the amount of feed consumed during the gestation period affects the survival of the pig embryo and the hormone important for the maintenance of pregnancy (P4); since, in the sows that were overfed during gestation they had 71.9% embryo survival and 11.8 ng/mL of P4; however, when less food was administered, embryo survival was 82.8% and 71.9 ng/mL of P4 (Aherne and Kirkwood, 1985). Maes *et al*. (2004), found a negative association between the percentage change in EGD during lactation and litter size at weaning. In that study, regardless of the sow's EGD, the lowest litter size (10.6 LNV) was observed in first-farrowing sows, while the highest (12 LNV) was observed in third-farrowing sows. In a similar study, Cechova and Tvrdon (2006), found that the lowest litter size (10.5 LNV) occurred at the first farrowing and the highest litter size (12.1 LNV) was observed during the fifth farrowing. Kim *et al*. (2015), observed that in sows with very high EGD (more than 25 mm), on day 109 of gestation, piglets had a lower weight gain and smaller litter size at weaning than sows with moderate EGD (20 to 24 mm); however, an EGD of 17 to 21 mm is associated with a larger litter size at weaning; in addition, the increase in EGD in the sow on day 109 of gestation was associated with a linear increase in the amount of back fat from weaning to day 109 of the next gestation. Another study revealed that first-time sow LNVs with 19 mm EGD at 110 days of gestation had a higher growth rate during lactation (214.3 *vs.* 202.4 g/day, $p = 0.05$), along with a higher weaning weight (7.43 *vs.* 7.03 kg, $p = 0.04$), than those born to gilts with 14.4 mm EGD (Amdi *et al*., 2013). The results of the studies indicate that an EGD that is too low or too high has adverse effects on the reproductive efficiency of sows. Therefore, maintaining moderate backfat thickness, throughout the sow's reproductive cycle, is important for greater reproductive efficiency.

5 IMPORTANCE OF BODY CONDITION DURING GESTATION AND LACTATION IN SOW REPRODUCTIVE PERFORMANCE

During the last stage of gestation and lactation, maintaining an optimal body condition of sows is essential to improve animal welfare, achieve adequate reproductive efficiency and longevity of sows (Maes *et al*., 2004; Houde *et al*., 2010). The body condition of the sow can be judged by measuring the EGD during various stages of gestation and lactation (Charette *et al*., 1996). It is well established that maintaining optimal body condition during the last third of gestation and early lactation is crucial for later reproductive performance (Tummaruk *et al*., 2000, 2001, 2007; Houde *et al*., 2010). Kim *et al*. (2015), observed a positive association between EGD on day 109 of gestation and EGD of the sow at weaning and the loss of back fat during lactation. Kim *et al*. (2016), observed no effects of EGD at 107 days gestation on sow feed intake during lactation, but back fat losses during lactation were lower in sows with less than 20 mm EGD than in sows with 20 mm or more; however, body weight, growth rate and number of weaned piglets were higher in sows with an EGD of 20 mm or more than in sows with an EGD of less than 20 mm, which could explain the greater fat loss during lactation in sows with an EGD of 20 mm or more at 107 d of gestation. It has also been observed that sows with lower EGD wean fewer piglets per litter (McKay, 1993). Whittemore *et al*. (1995), observed that sows with higher EGD had larger litter size and higher litter performance than sows with lower EGD. However, Maes *et al.* (2004) observed a negative association between EGD and litter size at weaning. Maes *et al*. (2004) and Houde *et al*. (2010), observed that EGD loss in gilts and multiparous sows occurred mainly during lactation. In this regard, it has been observed that the loss of backfat is proportional to the number of piglets weaned (Maes *et al*., 2004) and sows with lower EGD weaned fewer piglets per litter (McKay, 1993). De Rensis *et al.* (2005), determined a positive relationship between EGD at calving and backfat loss during lactation, but weaning-estrus interval was not associated with EGD at farrowing. It has been suggested that maintaining EGD throughout the reproductive cycle is more important to achieve efficient performance than to fix EGD in service or late gestation (Houde *et al*., 2010). Variations in sow feed intake, feeding pattern and milk production during lactation are probably responsible for the variation in EGD and backfat losses at weaning (Maes *et al*., 2004).

6 INFLUENCE OF BACK FAT THICKNESS ON FEED INTAKE DURING LACTATION

Deficiency in feed intake during the lactation period results in excessive loss of body weight and difficulties in maintaining milk production and litter growth (Kim *et al*., 2015); however, an excessive increase in EGD at 109 days of gestation results in a reduction in feed intake. In this regard, Estienne *et al*. (2003), observed that during lactation, obese sows consumed less feed compared to thin and medium sows. Also, O'Grady *et al*. (1985) showed that body condition at farrowing influenced feed intake during lactation, with sows consuming 4.9, 4.7 and 4.5 kg per day for skinny, fat and very fat sows, respectively; in addition, an increase of one mm in EGD on day 109 of gestation was associated with a reduction of 60 to

120 g in daily feed intake; in accordance with the above, Mullan and Williams (1989) observed that a decrease of one mm in EGD at birth was associated with an increase of 0.1 kg in voluntary feed intake during lactation. Reduced feed intake and larger litter size at weaning are probably responsible for higher EGD losses during lactation. Excessive feed intake during early gestation has been shown to increase embryonic death in gilts (Jindal *et al*., 1996) and decrease feed intake during lactation (Weldon *et al*., 1994). In general, feed intake during lactation is influenced by numerous factors such as parity, environmental temperature, and feeding level during pregnancy, through the integration of neural, hormonal, and nutrient signals. Leptin, a hormone secreted by adipose tissue cells, can modulate appetite and metabolism (Barb *et al*., 2001); this hormone is highly related to body fat mass and can suppress feed intake in pigs (Estienne *et al*., 2000). Kim *et al*. (2015), suggested that the reduction in feed intake with increased EGD at day 109 of gestation could be due in part to the high level of leptin in fat sows.

7 LIPID METABOLISM DURING GESTATION: EFFECT OF OVERFEEDING ON PLACENTAL DEVELOPMENT

Two main changes in lipid metabolism occur during pregnancy: the accumulation of fat in maternal deposits during the first two-thirds of gestation and the inhibition of the accumulation of fat deposits as a result of increased lipolysis and lipid mobilization during the last third of gestation (Herrera and Ortega-Senovilla, 2014). Sow obesity during gestation results in reduced fatty acid absorption and storage along with increased lipolysis (Jarvie *et al*., 2010); also, the accumulation of ectopic fat in placental tissues is promoted, which is associated with a lipotoxic placental environment (Saben *et al*., 2013; 2014). Zhou *et al*. (2018), observed that the increase in EGD at 109 days of gestation resulted in a higher concentration of placental lipids; in this sense, it was observed that the placenta of obese women contained 50% more lipids than the placenta of thin women (Saben *et al*., 2014). In a mouse model of maternal obesity, induced by a high-fat diet, placental lipids were markedly higher than in controls (Qiao *et al*., 2015). Zhou *et al*. (2018), observed a negative association between placental lipids and piglet weight at birth, litter weight at birth, and piglet weight at weaning. On the contrary, there is a positive association between placental lipid and the number of piglets weighing less than 800 g; suggesting that sows with an EGD of 25 mm or more at the end of gestation result in lower litter performance, which exerts a positive effect on the number of piglets with IUGR, associated with the lipotoxic placental environment. Other studies have shown that maternal obesity increases lipotoxins in the placental environment, which is associated with increased inflammation and oxidative stress (Oliva *et* *al*., 2012; Saben *et al*., 2014) which, consequently, may contribute to the deterioration of placental development and vascular function, as well as blockage of placental nutrient transport and alteration of fetal growth.

8 INFLUENCE OF BODY CONDITION ON THE WEANING INTERVAL

It is known that adequate fat reserve can have a favorable impact on mating efficiency and sow fertility (Bocian *et al*., 2010). It has been observed that EGD between 15 and 18 mm at mating is the recommended level to achieve optimal reproductive performance (Dourmad *et al*., 2001). Guedes and Nogueira (2001) observed that first-farrowing sows are more susceptible to backfat loss during lactation than multiparous sows. On the contrary, Esbenshade *et al.* (1986) did not observe significant changes in the EGD of sows between farrowings during the lactation period. It is well known that primiparous sows tend to enter a catabolic state at the end of gestation because they have high energy requirements for both their developing fetuses and their own growth and development (Cole, 1990). Zak *et al*. (1997), observed a longer IDC in sows that had increased catabolism before weaning. Houde *et al*. (2010), observed that the IDC of first and second calving was slightly different from that of those of third calving and above (IDC of 7.04, 5.96, and 5.36 d, for calvings 1, 2, and 3 and above, respectively). IDC with modest increases can have a significant effect on subsequent reproductive performance of sows; in this regard, a decrease of 1.5 to 2 piglets per litter was observed for an IDC of 7 to 10 d, compared to an IDC of less than 4 d (Le Cozler *et al*., 1998). Houde *et al*. (2010), observed that 65% of the sows of first and second farrowing, which had a greater mobilization of adipose tissue, repeated heat. Weight and tissue losses before weaning can have a great influence on subsequent reproductive performance (Guedes & Nogueira, 2001; Thaker & Bilkei, 2005). De Rensis *et al*. (2005), observed that greater loss of back fat during lactation was associated with a lower rate of subsequent gestation.

9 INFLUENCE OF DORSAL FAT THICKNESS ON MAMMARY GLAND DEVELOPMENT

Sow milk production is a determining factor in the growth rate of lactating piglets. It can be affected by several factors, and one that requires more attention is the body condition of gilts. It is known that the conditioning of gilts can affect lifetime reproductive performance and, therefore, longevity (Rozeboom, 2015). It has been suggested to achieve an EGD between 16 and 19 mm (Tarrés *et al*., 2006) or between 18 and 20 mm (Yang *et al*., 1989) at first calving to optimize fertility, productivity, survival and reduce the incidence of leg problems. A longitudinal study conducted on five farrowings, with sows showing a wide range of EGD, indicated an advantage, in terms of lifetime performance, for genetically fatter sows

(Lewis and Bunter, 2013). However, obesity (36 mm EGD) has a negative impact on breast development (Head and Williams, 1991), potentially resulting in lower milk production (Head *et al*., 1991). Farmer *et al*. (2017), suggested that it is beneficial for primiparous sows to have an EGD between 20 to 26 mm at the end of gestation to show optimal mammary development and greater litter body weight gain in subsequent lactation; however, the exact cut-off point is unclear and will likely be affected by breed. When an 18 mm EGD cut-off point was used to compare the lactation performances of primiparous sows, and 20 mm was used as the cut-off point for multiparous sows, no differences in piglet growth rate were reported (Rekiel *et al*., 2015). Kim *et al*. (2015), compared small ranges of EGD on day 109 of gestation and concluded that regardless of parity, litter weight gain increases quadratically with EGD to reach an optimal cut-off point between 17 and 21 mm, above which there is no further increase in body weight gain. In fact, sows with very high EGD (>25 mm) had litters with lower body weight gain compared to sows with EGD of 20 to 24 mm. Farmer *et al.* (2017), when using 17.6 mm as a cut-off point to compare the composition of parenchymal tissue, observed a higher percentage of fat and a lower percentage of protein and RNA concentrations in sows with higher EGD; suggesting, that it is favorable for primiparous sows to have a higher EGD (from 20 to 26 mm) at the end of gestation to achieve optimal mammary development and greater litter body weight gain in subsequent breastfeeding. The findings indicate that it is more harmful for primiparous sows to be too thin than too fat at the end of gestation. In general, the available information indicates that a very low (<15 mm) or too high (>26 mm) EGD at the end of gestation can lead to a reduced growth rate of piglets; therefore, maintaining a moderate body condition seems to be the best strategy.

10 CONCLUSIONS

Back fat thickness is an indicator of the body condition of the sows. The best reproductive performance, reproductive efficiency and longevity of the sows is obtained with an EGD between 15 to 22 mm. At the end of gestation, it is recommended that the sow has an EGD of 17 to 22 mm to ensure the energy supply for fetal growth and to avoid physical wear and tear during lactation; an EGD between 15 and 18 mm at the time of service ensures good reproductive performance of the weaned sow and the gilt sow. In general, it is advisable to maintain a moderate EGD (15-22 mm) during the reproductive cycle. It is important to conduct studies to determine the influence of EGD on the reproductive behavior of hyperprolific females.

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