# Induction of parturition by double administration of prostaglandin F2α in sows reduces the variation of gestation length without affecting the colostrum yield and piglet performance

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**ABSTRACT.** The objective of the present study was to investigate whether double intra-vulvo submucosal administration of prostaglandin F2α (PGF2α) could improve farrowing synchronization compared to single administration, and the effects of the induction of farrowing on colostrum yield and piglet performances. In total, 91 sows were randomly assigned to one of three groups: *i*) treatment with a single or *ii*) double administration of PGF2α or *iii*) control group without any treatment. A synthetic analogue of PGF2α was administrated via the intra-vulvo submucosal route on day 114 of gestation, at 0800 hr (single administration) or at 0800 and 1400 hr (double administration). The animals were monitored during the farrowing process. The time interval from the first administration of PGF2α to the onset of parturition was compared between groups. The proportion of sows that farrowed within 32 hr of induced parturition was higher in the double administration group than in the single administration group (100 *vs.* 84.4%, *P*=0.046). The duration of farrowing was higher in single administration sows than in control (241.1 *vs.* 169.5 min, *P*=0.004) and tended to be higher than in double administration sows (241.1 *vs.* 190.3 min, *P*=0.088). Birth interval of piglets born after double administration of PGF2α was shorter than those born after a single administration (14.6 and 20.1 min, *P*=0.024). In sows, the induction of parturition using a double administration of PGF2α reduces variation in gestation length and significantly increases the proportion of sows with an early response to PGF2α.

**KEY WORDS:** colostrum, farrowing, litter size, reproduction, sow

Gestation length in sows generally lasts for 114 to 116 days, with 10% of sows farrowing before 114 days and 25% of sows farrowing after 116 days of gestation [16]. Moreover, in practice, the onset of farrowing in sows naturally farrowing is not always occurred during daytime. Therefore, it is difficult to supervise farrowing and piglet delivery to improve neonatal survival. In general, farmers prefer sows to farrow during working hours, i.e., 0700–1700 hr, so that supervision can be done effectively. Therefore, induction of parturition using prostaglandin F2α (PGF2α) is frequently used in commercial swine herds worldwide. The main objective of the farrowing induction in sow is to reduce the variability of gestation length and to direct onset of farrowing towards daytime and facilitates an intensive farrowing supervision [4].

In practice, different induction protocols have been implemented [1–3, 8, 11]; these are mainly based on the administration of PGF2α 1 to 2 days prior to the expected farrowing date [10]. The benefits of the induction of parturition in sows, in combination with the supervision of farrowing, include a decreased risk of stillborn piglets, decreased postpartum complications in sows and a lower incidence of postpartum dysgalactia syndrome. Furthermore, induction permits efficient neonatal piglet care and cross-fostering management, thereby reducing the risk of neonatal mortality [12]. Nevertheless, the onset of farrowing still occurs at unpredictable times in the 24–36 hr after PGF2α administration. In addition, a previous study has demonstrated that the serum IgG

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concentration was higher in piglets from sows induced parturition than piglets from control sows [14]. This indicates that induced parturition may increase the efficiency of farrowing supervision and improve colostrum intake of the neonatal piglets with benefit to passive immunity. However, to our knowledge, the association between induced parturition and colostrum intake of neonatal piglets has never been comprehensively determined.

In swine, many induced parturition protocols and administration route have been done in both research scale and in clinical practice [4, 7, 9]. The practical protocols are based on the use of a single dose PGF2α [4, 7], a combination of PGF2α and oxytocin [4, 7] or carbetocin [1] and double administration of PGF2α with a 6-hr interval [4, 10]. The success of induced parturition protocol is determined by the percentage of sows starting to farrow within an expected time, e.g. during the working hours [4]. However, the use of single administration of PGF2α protocol are sometime results in incomplete luteolysis. Therefore, the use of double PGF2α administration technique has been recommended [5, 10]. Under tropical conditions, the success of induced parturition protocols using a single or double administration of PGF2α has not been compared. Therefore, the objective of the present study was to investigate whether double intra-vulvo submucosal administration of PGF2α could improve farrowing synchronization compared to single administration, and the effects of the induction of farrowing on colostrum yield and piglet performances.

## MATERIALS AND METHODS

This experiment followed the guidelines of The Ethical Principles and Guidelines for the Use of Animals for Scientific Purposes by the National Research Council of Thailand, and was approved by the Institutional Animal Care and Use Committee (IACUC) in accordance with the university regulations and policies governing the care and use of experimental animals (animal use protocol no. 1531053).

### Animals and experimental design

The experiment was performed in a commercial swine herd, with 1,500 sows on production, in the eastern region of Thailand. The trial was conducted between September and November 2015. The average temperatures (24 hr) during this period was 25.9 ± 1.6°C (range 20.3−28.1°C) and the average humidity (24 hr) was 81.8 ± 7.7% (range 61.0–98.0%). In total, 91 Landrace × Yorkshire crossbred sows were included in the experiment. However, due to missing data, only 77 sows were included in the analyses on farrowing duration and 89 sows were used in the analyses on litter traits. The average parity number of sows was 2.15 ± 1.45 (range 1–7). All sows included in the experiment had a good body condition score before farrowing. The animals were randomly assigned to one of three groups: i) the sows were administered a single dose (2 ml) of PGF2α (n=32) or ii) the sows received half dose (1 ml) of PGF2α twice (double administration or split doses) with a 6-hr interval (n=23) or iii) control (natural farrowing) (n=36). The prostaglandin used in the current study was a synthetic analogue of PGF2α (0.092 mg cloprostenol sodium per ml, Planate®, Merck Animal Health, Madison, NJ, U.S.A.). In the first group, 2 ml of PGF2α was given at 0800 hr on day 114 of gestation via intramuscular route. In the second group, 1 ml of PGF2α was given at 0800 and 1400 hr via intra-vulvo submucosal route [6, 8]. The third group of sows were served as a negative control by letting the sows farrow naturally. The farrowing process was monitored for 24 hr consecutively. The sows were interfered with as little as possible during farrowing. Birthing assistance was performed only when >30 min had elapsed from the birth of the previous piglet and consisted of a manual intervention to remove piglets and the administration of oxytocin.

Additionally, a completed data of 974 newborn piglets from 89 sows were investigated. The newborn piglets were weighed with a digital balance immediately after birth and again at 24 hr after birth. The colostrum intake of each individual piglet was estimated and was compared among groups of sows. Other piglet traits, i.e. birth interval, the proportion of piglet that need farrowing assistance and body weight at birth of each piglet were also compared among group of sows.

In addition, data of gestation length in sows were collected from a computer data base of the herd. The data included 13,421 litters that farrowed during a 4-year period from 2014 to 2017. The data included sow identity, parity number, service date, farrowing date and litter size at birth. Gestation length was defined as the interval between service and farrowing. The first day of service were regarded as day one of gestation.

### General management

Gestating sows were kept in a conventional open-housing system and were provided with fans and individual water sprinklers to control the temperature. They were fed twice a day following a standardized feeding pattern. On average, the sows received 2.5 kg of feed per sow per day to meet or exceed their nutritional requirements [13]. Gestating sows were moved to a farrowing house approximately 1 week before the expected date of parturition. The sows were placed in individual crates (1.5 m$^2$) at the center of the farrowing pens (4.2 m$^2$). The pens were fully slatted, with a concrete base at the center for the sows and with steel slats on both sides of the farrowing crate for the piglets. Each pen had a warm creep area for piglets (0.60 m$^2$) on one side of the pen. A heating lamp was provided in the creep area for the first week after farrowing. The heating lamp was turned on during the night or when the environmental temperature fell below 30°C. Sows were fed a commercial lactation diet twice a day. The amount of feed offered to the sows was reduced to 2.0 kg for 2 to 3 days prior to farrowing. After farrowing, the amount of feed offered to sows increased daily according to the litter size and body condition of the sow, until *ad libitum* feeding was reached after 1 week of lactation. Sows and piglets had *ad libitum* access to water via one nipple drinker for the sow and one nipple drinker for the piglets. We performed routine procedures on 1-day-old piglets, including weighing, tail docking, teeth clipping and an intramuscular administration of 200 mg (2 ml) iron dextran (ABI-DEX 100®, ABIC, Ramat-Gan, Israel).

*Measured variables*

We recorded the following data from sows: gestation length (the interval between service and farrowing), farrowing duration (defined as the time interval between the expulsion of the first and last piglets), birth interval (total duration of farrowing divided by number of piglets born), total number of piglets born per litter (TB), number of piglets born alive per litter (BA) and the proportion of born dead piglets per litter (i.e. the sum of stillborn and mummified fetus, BD, %). The use of farrowing assistance was also recorded (yes, no). Farrowing assistance was performed when the birth interval exceeds 30 min. The farrowing assistance consisted of a manual extraction of the piglet and, in some case, followed by 10 IU administration of oxytocin intramuscularly to stimulate uterine contraction. The time interval from the first PGF2α administration until the onset of parturition was compared between groups. Sows that farrowed between 0700 and 1700 hr were defined as sows that farrowed during working hours.

*Determination of colostrum production*

Colostrum intake of the piglets was estimated by using the following formula, from a previous study [6]: Colostrum intake (g)=[−217.4 + (0.217 × t) + (1861019 × BW24hr/t) + BW × (54.8–1861019/t) × ((0.99853.7 × $10^{-4}$ × tFS) + (6.1 × $10^{-7}$ × tFS$^2$)]; where BW=birth weight (kg), BW24hr=body weight 24 hr after birth (kg), t=time elapsed between the first and second weighing (min), and tFS=the interval between birth and first sucking (min). Colostrum yield for sows was defined as the sum of the individual piglet's colostrum intakes.

*Statistical analyses*

Statistical analyzes were conducted in SAS (SAS Institute Inc., Cary, NC, U.S.A.). Descriptive statistics (i.e., number of non-missing values, means, standard deviations (SD), minimum and maximum values) were calculated for all variables. Frequency analysis was performed by using FREQ procedure of SAS to determine the frequency distribution of gestation length in sows that farrowed during a 4-year period in the studied herd. A multivariate analysis of variance was conducted to analyze the effect of treatment groups (control, single dose and double dose of PGF2α), sow parity (primiparous *vs.* multiparous) and the interaction between treatment group and sow parity. The statistical models were built using the general linear model (GLM) procedure of SAS. Dependent variables included: farrowing duration (n=77), birth interval (n=77), litter size at birth (i.e. TB, BA and BD, n=89), gestation length (n=91), colostrum yield of sows (n=73) and average birth weight of the piglets in each litter (n=73). Normality of the dependent variables was determined by calculating residual of the variables using the GLM procedure. Thereafter, residual of each dependent variable was determined by using UNIVARIATE procedure with PLOT option and the normality test was analyzed by using Kolmogorov-Smirnov statistic. The variables that differ significantly from normal distribution (i.e. farrowing duration and birth interval) were log-transformed and were analyzed by using the log-transformed data. For colostrum intake (n=836), the data were analyzed by using general linear mixed model (MIXED) procedure of SAS. The statistical model included the effect of group, parity (primiparous and multiparous) and interaction between group and parity as fixed effects. Sow identity nested within group was included in the model as a random effect. Least square means were obtained from each class of the factors and were compared by using least-significant difference tests. In addition, the proportion of sows that farrowed during working hours (from 0700 to 1700 hr) and the proportion of sows that need farrowing assistance (yes, no) were compared among groups by using logistic regression analysis using GENMOD procedure of SAS. A logistic regression model was performed using a logit link function for a binary dependent variable (yes, no). The statistical estimation was carried out by using Wald test. Least square means from each treatment group (control, single dose and double dose of PGF2α) and were compared by using least-significant difference test. In addition, odd ratios were calculated and were compared between groups. The proportion of sows that farrowed within 32 hr of induced parturition and the proportion of sows farrowed at 115 days (yes, no) were compared between single and double administration groups by using $X^2$ test. A probability of $P<0.05$ was considered statistically significant.

## RESULTS

*Gestation length*

Frequency distribution on the gestation length of sows in the studied herd are presented in Fig. 1. On average, the gestation length of the sows in this herd was 114.8 ± 1.8 days. Of these sows, 35.1% had gestation length ≥116 days and 22.5% farrowed before 114 days of gestation (Fig. 1).

*Farrowing characteristics*

Descriptive statistics of the farrowing characteristics and reproductive performances of all sows included in the experiment are summarized in Table 1. The proportion of sows that farrowed at 115 days of gestation was higher amongst sows given a double administration of PGF2α (100%, 23/23) than amongst sows induced using a single administration of PGF2α (71.9%, 23/32; *P*=0.017) (Fig. 2).

The distribution on the timing of the onset of parturition that occurred in each quarter of the day are presented in Fig. 3. The proportion of sows that farrowed during working hours (from 0700 to 1700 hr) after a double administration of PGF2α, single administration of PGF2α or no treatment (natural farrowing) was 56.5, 65.6 and 50.0%, respectively (*P*=0.429). However, the proportion of sows that farrowed within 32 hr (i.e. 24 hr after the first administration of PGF2α + 8 hr of working hour) of induced parturition was higher in the double administration group than the single administration group (100 *vs.* 84.4%, respectively; *P*=0.046). The frequency of sows that need farrowing assistance were 15/36 (41.7%), 15/28 (53.6%) and 4/15 (26.7%) in control,
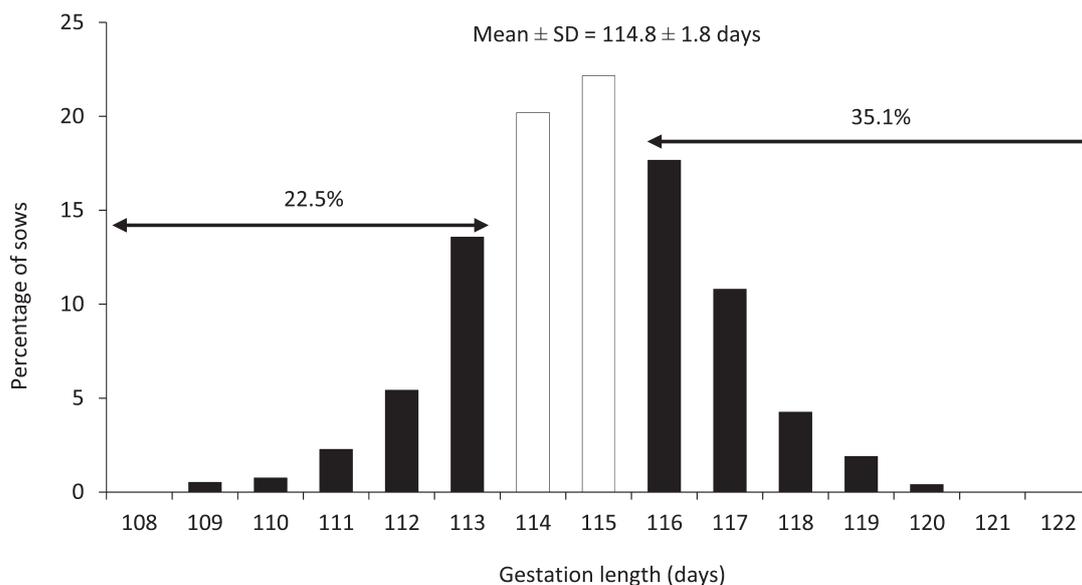
**Fig. 1.** Frequency distribution of gestation length in sows in the studied herd from 13,421 litters that farrowed during a 4-year period from 2014 to 2017.

**Table 1.** Reproductive outcomes in sows that farrowed naturally compared to sows induced to farrow with a single or double administration of prostaglandin F2α (PGF2α)

| Variable | Natural farrowing | Single PGF2α administration | Double PGF2α administration |
|---|---|---|---|
| Number of sows | 36 | 32 | 23 |
| Total number of piglets born per litter (TB) | $13.4 \pm 0.66$ | $12.3 \pm 0.65$ | $13.6 \pm 0.82$ |
| Number of piglets born alive per litter (BA) | $11.0 \pm 0.66$ | $11.2 \pm 0.64$ | $12.2 \pm 0.81$ |
| Born dead piglets (%) | $11.7 \pm 2.3$ | $8.8 \pm 2.3$ | $9.8 \pm 2.9$ |
| Piglet birth weight (g) | $1,263 \pm 45.1$ | $1,293 \pm 49.2$ | $1,301 \pm 64.4$ |
| Birth interval (min) | $13.3 \pm 1.36$[a] | $20.1 \pm 1.46$[b] | $14.6 \pm 1.89$[a] |
| Farrowing duration (min) | $169.5 \pm 16.8$[a] | $241.1 \pm 17.9$[b] | $190.3 \pm 23.3$[a,b] |
| Piglets needs farrowing assistance (%) | $10.6$[a] | $11.8$[a] | $2.7$[b] |
| Colostrum intake (g) | $273.2 \pm 7.4$ | $271.5 \pm 10.4$ | $287.6 \pm 7.7$ |
| Colostrum yield (g) | $3,050 \pm 195.7$ | $3,376 \pm 213.5$ | $3,233 \pm 279.5$ |
| Primiparous sows (n=29) | $2,746 \pm 330.8$ | $2,716 \pm 301.9$ | $2,853 \pm 395.4$ |
| Multiparous sows (n=44) | $3,354 \pm 209.2$ | $4,035 \pm 301.9$ | $3,612 \pm 395.4$ |

Data are presented as the least square means ± SEM. a,b) Different superscripts within rows differ significantly ($P<0.05$).

single administration and double administration of PGF2α, respectively. The frequency of farrowing assistance in sows given a single administration of PGF2α was 2.0 times (odd ratio=2.00 with 0.81−4.98, 95% confidence limits) higher than those given a double administration of PGF2α ($P=0.090$).

The farrowing duration in sows who received a single administration of PGF2α was higher than sows that farrowed naturally ($241.1 \pm 17.9$ *vs.* $169.5 \pm 16.8$ min, $P=0.004$) and tended to be higher than sows who received a double administration of PGF2α ($241.1 \pm 17.9$ *vs.* $190.3 \pm 23.3$ min, $P=0.088$). Additionally, the number of piglets that needed farrowing assistance was reduced after treatment with a double administration of PGF2α compared to the single PGF2α dose administration or those who received no treatment (natural farrowing) (2.7, 11.8 and 10.6%, for double administration of PGF2α, single administration of PGF2α and no treatment, respectively) (Table 1).

*Piglet performance*

The TB, BA and BD from sows who farrowed naturally did not differ significantly compared to sows induced parturition with a single and double administration of PGF2α (Table 1). The piglet birth weight determined immediately after the piglets were born (i.e. before colostrum ingestion) did not differ significantly among groups (Table 1). Birth interval in sows who received a single administration of PGF2α was higher than in sows who received a double administration of PGF2α ($20.1 \pm 1.46$ *vs.* $14.6 \pm 1.89$ min, $P=0.024$) and in sows that farrowed naturally ($20.1 \pm 1.46$ *vs.* $13.3 \pm 1.36$ min, $P=0.001$). Likewise, the proportion of piglets that need farrowing assistance in sows induced parturition with double administration of PGF2α was lower than that in sows
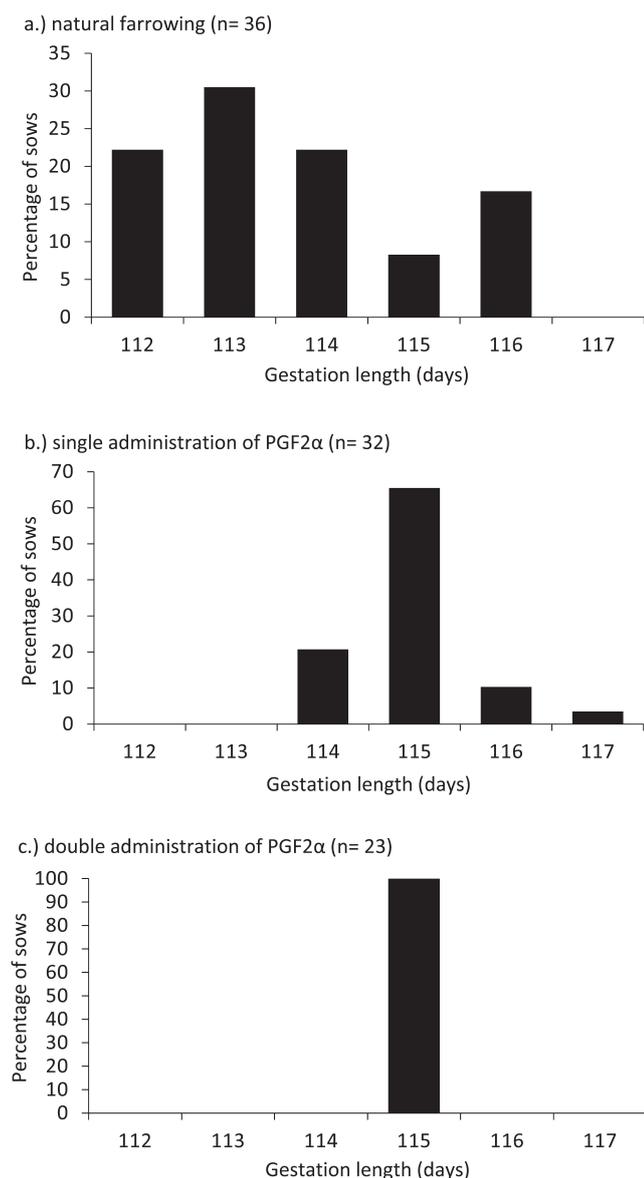
**Fig. 2.** Frequency distribution of gestation length in sows that farrowed naturally (a) compared to sows with induced parturition using a single (b) and double administration (c) of prostaglandin F2α (PGF2α).
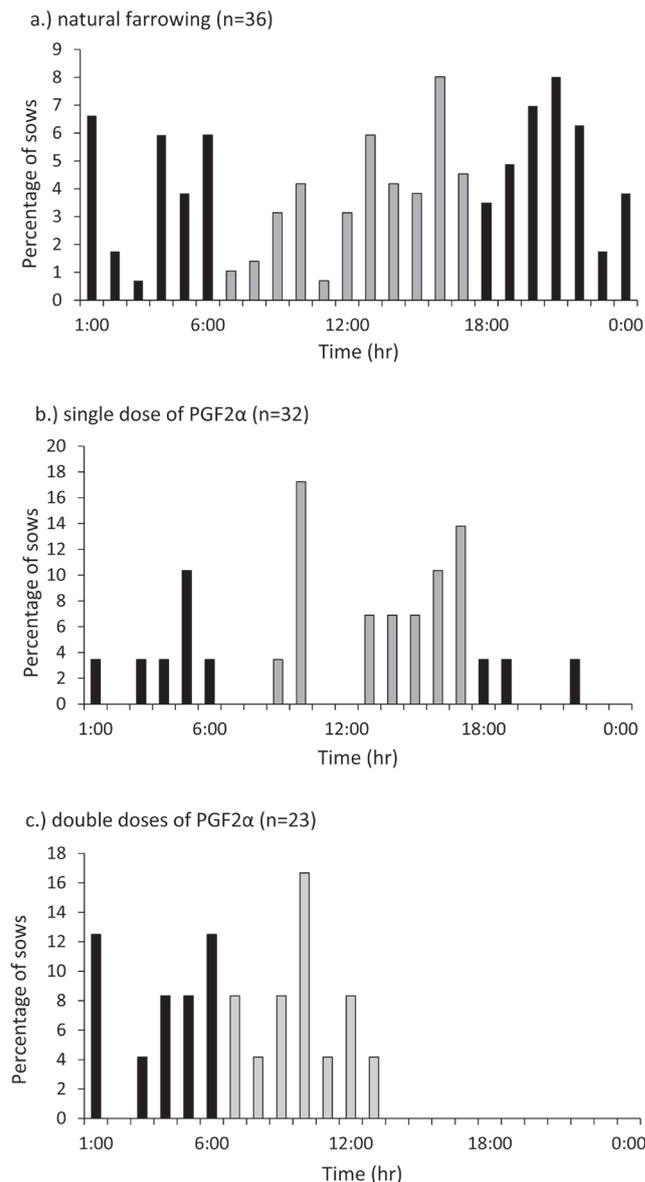


**Fig. 3.** Frequency distribution of the timing of the onset of farrowing in sows that farrowed naturally (a) compared to sows with induced parturition using a single (b) or double administration (c) of prostaglandin F2α (PGF2α).

induced parturition with a single administration of PGF2α (2.7 and 11.8%, respectively, $P$=0.001). Moreover, the result revealed that colostrum intake of each individual piglets did not differ significantly between sows induced parturition using either a single or double doses of PGF2α compared to the piglets born naturally (Table 1).

*Colostrum yield*

On average, the colostrum yield of sows was 3,254 ± 1,111.5 g and the colostrum intake by each individual piglet was 281.2 ± 130.3 g. Colostrum yield varied between individual sows, ranging from 1,203 to 6,356 g. The colostrum intake varied between piglets, ranging from 0 to 792 g. Induction of parturition did not influence colostrum yield of sow and colostrum intake of piglet (Table 1). However, parity of sows significantly influenced colostrum yield (Table 1). On average, the colostrum yield in multiparous sows was higher than in primiparous sows (2,772 ± 199.1 and 3,667 ± 180.8 g, respectively; $P$<0.001). Likewise, the colostrum intake of piglet in multiparous sow litter also tended to be higher than the piglet in primiparous sow litter (300.3 ± 14.2 and 267.0 ± 17.3 g, respectively; $P$=0.130).

## DISCUSSION

The objective of the present study was to investigate whether double intra-vulvo submucosal administration of PGF2α could improve farrowing synchronization compared to single administration, and the effects of the induction of farrowing on colostrum yield and piglet performances. Although farrowing induction in sows by using a double administration of PGF2α via intra-vulvo submucosal route has been used in some recent study [14], the comparison with a single administration has not been reported. A previous study showed that repeated doses of PGF2α, administered intramuscularly, increased the proportion of early-responding sows [10]. It has been demonstrated that 94.4% of sows farrow within 8 to 32 hr after receiving a double administration of PGF2α, whereas only 75.5% farrow within this time frame after a single administration of PGF2α [10]. In our study, 56, 65 and 50% of sows treated with double, single PGF2α administration or no treatment farrowed during working hours (i.e. 0700 to 1700 hr). Of these sows, 100% of sows treated with double administration of PGF2α farrowed at day 115 of gestation, while this occurred in only 71.9% of sows treated with a single administration of PGF2α and 8.3% of control sows. These results clearly indicate that the double administration of PGF2α significantly reduces variability in gestation length. This effect could be related to the fact that the physiological release of PGF2α is pulsatile and single administration may not have initiated complete luteolysis. In sheep, terminal luteolysis occurs after a pulsatile release of PGF2α [17].

One of the main concerns of induction via prostaglandin is the risk of increased requirements for manual intervention and the possibility of side effects on milk yield and piglet performance. Our study rejected both these concerns. In fact, farrowing assistance was reduced after treatment with a double administration of PGF2α compared to a single administration of PGF2α and sows that farrowed naturally. The double administration of PGF2α may induce better luteolysis compared to the single administration, reducing the need for farrowing assistance. Likewise, Decaluwé et al. [4] did not observed any dystocia problem in sows induced parturition by using double administration of PGF2α via intramuscular route.

With respect to the effect of treatments on born dead piglets (stillborn + mummy), piglet birth weight and the colostrum yield, there were no differences between PGF2α treatments and control sows. To our knowledge, there is no published data that has evaluated these aspects, but this is an important observation because one of the major concerns associated with the induction of farrows in sows is the side effect on the survival of neonatal piglets. Likewise, no significant difference on the proportion of stillborn piglets and the piglet mortality within one day postpartum was found between sows farrowed naturally compared with sows induced parturition by using double administration of PGF2α at day 114 of gestation [4].

In the present study, data of gestation length in sows in the studied herd was also investigated. The data from 13,421 litters indicated that the average gestation length of the sows in this herd was 114.8 ± 1.8 days and 35% of them had gestation length ≥116 days. Therefore, to aware early induction of parturition in these animals, we decided to start the first PGFα administration on day 114 of gestation. Based on these data, if the double administration of PGFα on day 114 of gestation was implemented in this herd, up to 35% of the sows (n=4,705 sows) will be farrowed within 115 days of gestation and the average farrowing interval of sows in the herd will be reduced. Thus, the number of piglets produced per sows per year could be increased. Moreover, when the sows with delayed farrowing was reduced, the duration of preparing farrowing pen for subsequent farrowing batch could be increased and, therefore, reduced the risk of pathogen contamination between batch of farrowing. In addition, the reduced variation of gestation in sows also allow the stockperson to concentrate more on the farrowing supervision and increase the efficacy of cross fostering management. However, the disadvantage of the farrowing induction using double administration of PGF2α protocol include an increase of labor and the cost of the hormonal treatment.

In the current study, the induction of parturition was initiated at 114 days of gestation instead of at 112–113 days. The reason is due to that induced parturition at 112–113 days of pregnancy is some time too early since the gestation length in some herds is longer than 114 days. The consequence of induced parturition too early includes increase the number of immature piglets at birth, poor colostrum production and increase piglet pre-weaning mortality [4, 12]. Therefore, under filed conditions, the precise timing of the induced parturition must be carefully considered. As demonstrated in the present study, the average gestation length of sows in this herd was 114.8 days and up to 35% of them had gestation length above 116 days. This clearly indicates that administration of PFG2α at 112–113 days of gestation might lead to several clinical disorders in both sows (i.e. colostrum production and composition) and piglets (i.e. piglet birth weight and vitality). Thus, considering these data carefully, we decided to induce parturition at 114 days of gestation. Moreover, recent studies have demonstrated that induction of parturition in modern genetic sows at 114 days of pregnancy had no or minor effect on colostrum production, colostrum composition and reproductive performance of sows [4, 15].

In conclusion, this study indicates that the induction of farrowing at 114 days gestation by double administration of PGF2α via the intra-vulvo submucosal route reduces farrowing variability and the need for farrowing assistance, compared to a single administration of PGF2α or with natural farrowing. Finally, the induction of farrowing by double administration of PGF2α does not affect the birth interval, the number of dead born piglets, piglet weight nor the colostrum yield.

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