ปัจจัยที่มีอิทธิพลต่อปริมาณน้ำนมเหลืองที่ลูกสุกรได้รับและระดับของอิมมูโนโกลบูลินจีและอิมมูโนโกลบูลินเอที่จำเพาะต่อเชื้อไวรัสพีอีดีในน้ำนมเหลืองของแม่สุกร

นางสาวพัทธวรรณ จุฑามณี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Factors influencing colostrum consumption of piglets and levels of immunoglobulin G and immunoglobulin A specifically against PED virus in colostrum of sows

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พัทธวรรณ จุฑามณี : ปัจจัยที่มีอิทธิพลต่อปริมาณน้ำนมเหลืองที่ลูกสุกรได้รับและระดับของอิมมูโนโกลบูลินจีและอิมมูโนโกลบูลินเอที่จำเพาะต่อเชื้อไวรัสพีอีดีในน้ำนมเหลืองของแม่สุกร (Factors influencing colostrum consumption of piglets and levels of immunoglobulin G and immunoglobulin A specifically against PED virus in colostrum of sows) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ศ. เผด็จ ธรรมรักษ์, 50 หน้า.

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อวิเคราะห์ปัจจัยที่มีความเกี่ยวข้องกับปริมาณน้ำนมเหลืองที่ลูกสุกรแรกคลอดได้รับและตรวจวัดความเข้มข้นของอิมมูโนโกลบูลินจีและอิมมูโนโกลบูลินเอที่จำเพาะต่อเชื้อไวรัสพีอีดีในน้ำนมเหลืองของแม่สุกร การทดลองประกอบด้วย 2 ส่วน คือ ส่วนที่ 1 ศึกษาข้อมูลจากลูกสุกรแรกคลอดจำนวน 1,140 ตัว จากแม่สุกรจำนวน 80 แม่ โดยทำการตรวจวัดน้ำหนักตัวของลูกสุกรแรกคลอด ลำดับการคลอด ระยะห่างระหว่างการคลอด การอัตราการเต้นของหัวใจ ปริมาณออกซิเจนในเลือดของลูกสุกรแรกคลอด อุณหภูมิที่ทวารหนักหลังคลอด 24 ชั่วโมง ระยะเวลาตั้งท้อง จำนวนลูกสุกรแรกคลอดมีชีวิตต่อครอก คะแนนรูปร่าง และลำดับท้องของแม่สุกร ทำการวิเคราะห์ข้อมูลทางสถิติด้วยวิธี Pearson’s correlation ส่วนที่ 2 ทำการศึกษาน้ำนมเหลืองที่ถูกเก็บจาก 2 ช่วงเวลา คือ ชั่วโมงแรก กับ 6 ชั่วโมงหลังคลอด โดยแบ่งแม่สุกรตามลำดับท้องออกเป็น 4 กลุ่ม คือ ลำดับท้องที่ 1 จำนวน 19 ตัว ลำดับท้องที่ 2 จำนวน 30 ตัว ลำดับท้องที่ 3-5 จำนวน 30 ตัว และ ลำดับท้องที่ 6-8 จำนวน 20 ตัว ทำการตรวจวัดปริมาณอิมมูโนโกลบูลินจี (IgG) และอิมมูโนโกลบูลินเอ (IgA) ทั้งหมด และ ที่จำเพาะต่อเชื้อไวรัสพีอีดีในน้ำนมเหลืองด้วยวิธี ELISA ผลการศึกษาพบว่าค่าของเฉลี่ยน้ำนมเหลืองที่ลูกสุกรได้รับ เท่ากับ 404.7 ± 183.35 กรัม ซึ่งปริมาณน้ำนมเหลืองที่ลูกได้รับมีความสัมพันธ์กับน้ำหนักตัวของลูกสุกรแรกคลอด ($r = 0.29$, $P < 0.001$) ลำดับการคลอด ($r = 0.22$, $P < 0.001$) จำนวนลูกสุกรแรกคลอดทั้งหมดต่อครอก ($r = -0.21$, $P < 0.001$) จำนวนลูกสุกรแรกคลอดมีชีวิต ($r = -0.19$, $P < 0.001$) คะแนนรูปร่างของแม่สุกร ($r = 0.06$, $P < 0.05$) การอัตราการเต้นของหัวใจ ($r = 0.11$, $P < 0.05$) อุณหภูมิที่ทวารหนักหลังคลอด 24 ชั่วโมง ($r = 0.30$, $P < 0.001$) นอกจากนี้ยังพบว่าปริมาณของ IgA ของแม่สุกรนางมีค่าสูงกว่าแม่สุกรสาวอย่างมีนัยสำคัญ (8.58 และ 6.34 ตามลำดับ $P = 0.012$) แต่ระยะเวลาตั้งท้อง ระยะห่างระหว่างการคลอด และปริมาณออกซิเจนในเลือดไม่มีความสัมพันธ์กับปริมาณน้ำนมเหลืองที่ลูกสุกรได้รับ นอกจากนี้ยังพบว่าแม่สุกรลำดับที่ท้อง 6-8 มีปริมาณของ IgG ที่จำเพาะต่อเชื้อไวรัสพีอีดีในน้ำนมเหลืองสูงกว่าแม่สุกรลำดับท้องที่ 3-5 อย่างมีนัยสำคัญ (0.56 ± 0.08 vs 0.40 ± 0.06, $P<0.05$) แต่ปริมาณ IgA ของสุกรสาว (0.55 ± 0.07) กับแม่สุกรลำดับท้องที่ 2 (0.54 ± 0.06) สูงกว่าแม่สุกรลำดับท้องที่ 3-5 (0.41 ± 0.06, $P<0.05$) ปริมาณ IgG ในน้ำนมเหลืองที่เก็บหลังคลอด >360 นาที มีค่าลดลงอย่างมีนัยสำคัญเมื่อเปรียบเทียบกับน้ำนมเหลืองที่เก็บหลังคลอด 0-60 นาที ($P<0.05$) จากการศึกษาสรุปได้ว่า ปริมาณน้ำนมเหลืองที่ลูกสุกรได้รับมีความแปรปรวนตาม น้ำหนักแรกคลอดของลูกสุกร ลำดับการคลอด ขนาดครอก คะแนนรูปร่างของแม่สุกร อัตราการเต้นของหัวใจ และอุณหภูมิที่ทวารหนักหลังคลอด 24 ชั่วโมงของลูกสุกร ความเข้มข้นของ IgG และ IgA ที่จำเพาะต่อเชื้อไวรัสพีอีดีในน้ำนมเหลืองมีความแปรปรวนตามลำดับท้องของแม่สุกรและช่วงเวลาหลังคลอด แม่สุกรอายุมากมีปริมาณ IgG สูงกว่าแม่สุกรอายุน้อย ความเข้มข้นของทั้ง IgG และ IgA ในน้ำนมเหลืองจะสูงที่สุดในชั่วโมงแรกหลังคลอด และลดลงอย่างมีนัยสำคัญหลังจาก 6 ชั่วโมง

ภาควิชา สูติศาสตร์-เธนุเวชวิทยาและวิทยาการสืบพันธุ์ ลายมือชื่อนิสิต .....

สาขาวิชา วิทยาการสืบพันธุ์สัตว์ ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

ปีการศึกษา 2560

5975511031 : MAJOR THERIOGENOLOGY
KEYWORDS: COLOSTRUM, DIARRHEA, IMMUNOGLOBULIN, PED, SOW / ฐ้นมเหลือง ท้องเสีย อิมมูโนโกลบูลิน พีอีดี แม่สุกร

PATTHAWAN JUTHAMANEE: Factors influencing colostrum consumption of piglets and levels of immunoglobulin G and immunoglobulin A specifically against PED virus in colostrum of sows. ADVISOR: PROF. PADET TUMMARUK, D.V.M., M.Sc., Ph.D., 50 pp.

The aims of the present study was to investigate factors associated with colostrum consumption of the neonatal piglets and determine the concentrations of total immunoglobulins G (IgG) and immunoglobulins A (IgA) against porcine epidemic diarrhea (PED) virus in colostrum for sow. The study consisted of two parts: Part I, the study included data of colostrum consumption from 1,140 neonatal piglets from 80 sows. Factors associated with piglet's colostrum consumption included body weight at birth of the piglet, birth order, birth interval, heart rate, blood oxygen saturation, rectal temperature at 24 h, gestation length, total born, born alive, sow body conditions score and sow parity number. The association among these factors and colostrum consumption of the piglets was analyzed by using Pearson's correlation. Part II was performed 81 Landrace x Yorkshire crossbred sows. Colostrum were randomly collected from the sows twice after farrowing. The time interval from the onset of farrowing until colostrum collection was classified into 2 groups, i.e., 0 and >6 hour and also classified according to parity number of sows into 4 groups, i.e., 1 (n=19), 2 (n=30), 3-5 (n=30) and 6-8 (n=20). The concentrations of immunoglobulins in colostrum was determined by ELISA. The results revealed that the colostrum consumption averaged 404.7 ± 183.35 grams. Mean of body weight at birth of the piglet (r=0.29, P<0.001), birth order (r = -0.22, P<0.001), total born (r=-0.21, P<0.001), born alive (r=-0.19, P<0.001), body conditions score (r=0.06, P<0.05), heart rate (r=0.11, P<0.05) and rectal temperature (r=0.30, P<0.001) were significantly correlated with colostrum consumption of the neonatal piglets. The concentration of IgA in multiparous sows was significantly higher than primiparous sows (8.58 vs 6.34, P= 0.012). On the other hand, gestation length, birth interval, blood oxygen saturation were not correlated with colostrum consumption. Sows parity numbers 6-8 had a higher IgG concentration than sows parity numbers 3-5 (0.56 ± 0.08 vs 0.40 ± 0.06, P<0.05), respectively. In contrast, the IgA concentration was higher in primiparous sows (0.55 ± 0.07) and 2 (0.54 ± 0.06) than sows parity number 3-5 (0.41 ± 0.06, P<0.05). *The concentration of IgG in the colostrum collected at >360 min after farrowing was lower than that in the colostrum collected at* 0-60 min after farrowing (P<0.05). In conclusion, the body weight at birth of the piglet, birth order, litter size, body conditions score, heart rate and rectal temperature (°C) were significantly associated with piglet colostrum consumption in the swine herd. The concentrations of IgG and IgA against PED virus in the colostrum varied significantly among parity number of sows and time interval after farrowing. Old sows had a higher IgG concentration than young sows. The concentrations of both IgG and IgA in the colostrum was highest during the first hour of farrowing and significantly declined after 6 h.

Department:	Obstetrics Gynaecology and Reproduction	Student's Signature	.....
		Advisor's Signature	.....
Field of Study:	Theriogenology		
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ABBREVIATIONS

BWB	body weight at birth
CSFV	classical swine fever virus
FMDV	foot-and-mouth disease virus
Cm	centimeter
CORR	correlation analysis
CV	coefficient of variation
CY	colostrum yield
ºC	degree Celsius
ELISA	enzyme-linked immunosorbent assay
g	gram
h	hour
HR	heart rate
m^2	square millimeter
mg	milligram
mg/dL	milligram per deciliter
mg/kg	milligram per kilogram
mL	milliliter
MM	number of mummified fetuses per litter
NTB	number of total piglets born per litter
NBA	number of piglets born alive per litter
PDS	post-partum dysgalactia syndrome
PED	porcine epidemic diarrhea
PRRS	porcine reproductive and respiratory syndrome
SAS	statistical analysis system
SB	number of stillborn piglet per litter
SD	standard deviation
SEM	standard error of mean
USA	United States of America

CHAPTER I
INTRODUCTION

Importance and rational

Porcine epidemic diarrhea (PED) has become one of the most important diseases causing economic loss in swine industry in both Asia and United States of America (USA) during recent years (Lee, 2015; Gerber et al., 2016). The development of serological test for determining antibody titer against PED virus is one of the most interesting research area for either epidemiological study or vaccination development (Gerber et al., 2016).

Olanratmanee et al. (2010) found a comprehensive spread of PED virus infection in Thailand during 2007- 2008. The clinical signs of PED include watery diarrhea and vomiting in suckling piglets. Morbidity and mortality is highest in piglets with age below 7 days. The mortality rate can be up to 100% (Olanratmanee et al., 2010; Tummaruk et al., 2016; Poonsuk et al., 2016a).Humeral antibodies and maternal secretory IgA in colostrum contribute to the protection of neonatal pig against PED infection (Poonsuk et al., 2016a). In addition to the mortality induced by PED virus in suckling piglets, the disease also impairs the growth performance of the surviving pig (Bjustrom-Kraft et al., 2016). In herd infected by PED virus, up to 100% mortality was found in pre-weaning piglets for 3-4 weeks before enough immunity was developed (Yamane et al., 2016).In sow, the reproductive performances that was affected by PED virus included a decreased conception rate, a decreased farrowing rates, an increased mummified fetuses and a decreased number of piglets born alive per litters (Olanratmanee et al., 2010). A previous study demonstrated that, after experimentally challenging PED virus to the piglets, the antibody-positive piglets could returned to normal conditions faster and had a higher survival rate than piglets without PED virus antibody (Poonsuk et al., 2016b).

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It is well established that colostrum provides neonatal piglets with both energy and immunoglobulins, thereby playing an essential role on piglet survival. Adequate colostrum consumption of neonatal piglets is therefore ensure optimal passive immunity for piglets(Muns et al., 2016). To our knowledge, only one study determine antibody titer against PED virus in the sow colostrum has been demonstrated (Poonsuk *et al.,* 2016a). Additional research needs to be done on the associated factors causing the variation of immunoglobulin concentration among sows under field conditions. The objective of the present study are to investigate factors influencing colostrum consumption of piglets and levels of immunoglobulins G (IgG) and A (IgA) against PED virus in the sow colostrum.

Objectives

1. To investigate factors influencing colostrum consumption of piglets
2. To determine the concentrations of IgG and IgA against PED virus in colostrum of sow

Expected output

1. Understand factors influencing PED antibody titer in the sow colostrum
2. Improve controlling method to prevent PED virus infection in swine herds in Thailand
3. Understanding factors associated with colostrum consumption

CHAPTER II
LITERATURE REVIEW

Porcine epidemic diarrhea

Porcine epidemic diarrhea was first discovered in Europe in 1970s. During recent years, PED virus has become one of the most important diseases causing economic loss in swine industry in both Asia and USA.(Olanratmanee et al., 2010; Gerber et al., 2016). Importantly, PEDV infected piglets had high rate of morbidity and mortality. PED virus is an enveloped RNA virus in the genus *Alphacoronavirus*, family *Coronaviridae* that infected by fecal-oral transmission (Alvarez et al., 2015). Diarrheal feces, vomitus and other contaminated fomites, such as transport vehicles, equipment, feed and animals can be major transmission sources of the virus (Jung and Saif, 2015; Le Dividich et al., 2005). Porcine epidemic diarrhea virus binds and infects small intestinal villous enterocytes expressing aminopeptidase N (APN), that identified as the receptor for PED virus (Li et al., 2007). Porcine epidemic diarrhea virus replicates in the enterocytes within 12-18 h post infection and reaches maximum replication within 24 h. Porcine epidemic diarrhea virus infection caused villous atrophy in small intestine that contributed to malabsorption with severe watery diarrhea and dehydration (Jung and Saif, 2015; Song et al., 2015). Porcine epidemic diarrhea virus infection induces greater disease severity and deaths within 2-3 days of ages in suckling piglets (Jung et al., 2006). Porcine epidemic diarrhea virus outbreak often occurs in winter (Pensaert, 1999). There are two type of clinical sign PED virus infection. Type I appeared clinically in all ages of pig except pre-weaning piglets but Type II showed by acute diarrhea in all age of pig. The clinical signs of PED virus infection include anorexia, depression, watery diarrhea, agalactia and may cause abortions. In sow herd that are infected with PED virus, conception rate, farrowing rate and number of piglets born alive per litter are lower that herds without PED virus infection. The co-infection of PED and PRRS viruses reduce digestible nutrients and energy on total digestion tract (Schweer et al., 2016). Porcine epidemic diarrhea virus control and prevention protocols includes 4 strategies:

PED vaccination, intentional exposure (feedback), biosecurity and improving colostrum consumption of neonatal piglets. Biosecurity is one of most important of strategies that minimize PED virus transmission into swine herd. Additionally, restricting person traffic between dirty unit to clean unit or between farm due to reduce transtited PED virus (Lee, 2015). Vaccination should be considered about route of the vaccine, type of vaccine (Song et al., 2015). Articificial passive immunization are specific antibody with PED virus by oral route such as chicken egg yolk and colostrum of cow. In addition, chemical inhibitor form natural plant and nutrition supplement that can reduce clinical sign of piglet (Lee, 2015).

Poonsuk et al. (2016b) conducted a study to determine lactogenic antibody from sow to protect the piglets from PED virus infection. The result of this study found that the anti-PED virus antibody significantly different responses to PED virus infection between piglets. Nevertheless, the correlation analysis did not detect an association parity of sows and number of litter size between specific levels of lactogenic antibody and the improvement of clinical effects. The researchers also concluded that after experimentally challenging PED virus to the piglets, the antibody-positive piglets could return to normal conditions faster and had a higher survival rate than piglets without PED virus antibody by lactogenic immunity and systemic antibodies of sow can contribute to the protection of the neonatal pig against PED virus infections.

Colostrum

Colostrum is first milk secreted by the mammary gland that piglets can absorb to gut only first 24 h of age (Le Dividich et al., 2005). It is well established that colostrum provides newborn piglets with both energy and immunoglobulins, thereby playing an essential role in piglet survival (Muns et al., 2016). Colostrum provides the newborn pig with highly metabolisable energy and its high content of fat and lactose is efficiently used by the newborn pig to cope with cold stress by increasing its metabolic rate and maintaining its homeothermic balance during the first day after birth (Herpin et al., 2005). The primary protein component of colostrum consists of immunoglobulins,

including IgG, IgM, and IgA isotypes. Immunoglobulin G is the most common bioactive compound in colostrum and is at its highest concentration in the first few hours postpartum and decreases rapidly within 24 h (Herpin et al., 2005; Vallet et al., 2013). As has been previously mentioned, piglets need to receive passive immunity from IgG in colostrum to reduce susceptibility to infection in the immediate postnatal period and also after weaning (Rooke and Bland, 2002). The absorption of IgG by newborn piglets occurs before gut closure (Quesnel et al., 2012). which occurs at approximately 24 h of age (Rooke and Bland, 2002). The IgG plasma concentration in piglets at 24 h of age is positively correlated with colostrum consumption (Devillers et al., 2011). Accordingly, Muns et al. (2014) observed that administering 15 mL of sow colostrum after farrowing to small piglets increased their IgG plasma concentration at 4 days of age. Porcine colostrum also contains different types of milk-borne growth factors (e.g., the insulin-like growth factors IGF-I and IGF-II, epidermal growth factor, insulin and transforming growth factor-β). IgA migrate to the mammary glands where they contribute S-IgA to milk and colostrum, when enteric coronavirus infection (McGhee et al., 1987; Langel et al., 2016). The piglets received lactogenic antibody shed less PED virus and exhibited better thermoregulation, higher growth rates, and higher survivability when comparing the course of PED virus infection in suckling piglets farrowed by immune and naïve dams (Poonsuk et al., 2016b).

According to Xu *et al.* (2000), milk-borne growth factors via colostrum feeding play a regulatory role in the stimulation of gastrointestinal tissue growth, and the maturation of its function. Colostrum feeding also enhances intestinal macromolecule absorption, the onset of gut closure, and enhances the repair of damaged mucosa (Xu et al., 2000; Rooke and Bland, 2002). All these process are required for the adaptive changes of the gastrointestinal tract during the postnatal period.

Quesnel *et al.* (2012) estimated that 250 grams/kg colostrum consumption per piglet should ensure an optimal growth and passive immunity to the animals. Previos study also reported that colostrum consumption stimulates the development of the hippocampus structure by the stimulation of brain protein synthesis and brain development during the early postnatal period (Pierzynowski et al., 2014). Colostrum consumption also increases the piglet body weight gain at weaning (Decaluwe et al.,

2014; Le Dividich et al., 2005) and up to 6 weeks of age, suggesting that it has a long-term effect on piglet growth (Devillers et al., 2011). Indeed, colostrum consumption has been positively associated with piglet survival at weaning (Devillers et al., 2011; Decaluwe et al., 2014). Any circumstance that impairs piglet colostrum consumption capacity will increase the risk of mortality or diminish its growth capacity. Factors that influence colostrum consumption include piglet vitality at birth, birth order, number of piglets born alive per litter, and sow nutrition (Quesnel et al., 2012; Theil et al., 2014). Reduced piglet vitality at birth or any other factor that affects the interval from piglet birth to first suckle and the ability of a piglet to stimulate a teat will negatively influence piglet colostrum consumption. Competition between littermates has a negative effect especially on the piglets of the litter born with lower body weight at birth (BWB), because a high litter size increases the number of fights at suckling (Milligan et al., 2001) and increases the risk of starvation and crushing of the small piglets. However, colostrum yield is highly variable among sows, even within the same breed and in the same conditions of housing and management (Devillers et al., 2007). Colostrum yield is independent of litter size, and is slightly influenced by litter weight and piglet body weight variability (Devillers et al., 2007; Decaluwe et al., 2013). A reduction or failure to produce colostrum or milk by the sow would have a negative impact on piglet survival and growth. It is suggested that insufficient milk production or lactation failure in sows might account for six to 17% of piglet pre weaning mortality (Alonso-Spilsbury et al., 2007). Colostrum yield depends on the breed, feed and water intake, energy status, sanitary status, and parity of the sow, and on other factors such as farrowing induction; environment and hormone status can also influence colostrum production by the sow variability (Devillers et al., 2007; Decaluwe et al., 2013). Besides, post-partum dysgalactia syndrome (PDS) is a multifactorial process with a considerable prevalence among herds, causing lactation failure usually during the first three days after farrowing. Late transferring of sows to farrowing facilities, ad libitum feeding during the first days of lactation, dystocia (Papadopoulos et al., 2010). constipation, poor floor hygiene, and high ambient temperature (Kirkden et al., 2013) are factors that have been observed to increase the odds for PDS.

CHAPTER III

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 (Approval no. 1731064).

Experimental designs

The study consist of two parts **Part I** was conducted in one commercial swine herd in Thailand to determine colostrum consumption of each individual piglet. The study included data of colostrum consumption from 1,140 neonatal piglets from 80 sows. Factors associated with the piglet's colostrum consumption were analyzed. Factors influencing piglet's colostrum consumption that were determined included birth weight of the piglet, birth order, birth interval, sow's parity number and the integrity of umbilical cord of the piglets. **Part II** Colostrum samples were collected from 99 Landrace x Yorkshire crossbred sows in a 3500-sows commercial swine herd in the western region of Thailand. The breed of the sows was crossbred Landrace x Yorkshire.The latest PED outbreak was observed in the herd two years ago. Colostrum were randomly collected from the sows at different time interval after farrowing. The interval from the onset of farrowing until colostrum collection was classified into 5 groups, i.e., 0–60, 61–120, 121–240, 241–360 and >360 min. The colostrum samples were also classified according to parity number of sows into 4 groups, i.e., 1 (n=19), 2 (n=30), 3-5 (n=30) and 6-8 (n=20). The colostrum was determined for IgG and IgA levels against PED virus. Factors associated with IgG and IgA levels in the sows colostrum, i.e., parity number, the time interval from the onset of farrowing until colostrum collection and herds, were evaluated.

Animals

Part I: A total of 80 postpartum sows were included in the experiment. The herd was located in the eastern region of Thailand. The breed of sows was Danish Landrace x Yorkshire F1 crossbred sows. The parity number of sows included 1, 2, 3, 4, 5 and 6. The sows were moved to the farrowing house before their expected farrowing date about one week. Sows were kept in individual farrowing crates (1.2 m^2) placed at the center of the pens with a space allowance of 4.2 m^2. The feed was provided twice a day (about 2-5 kg per day) during gestation. The gilts and sows received water ad libitum by water nipples. Both the replacement gilts and sows are vaccinated against classical swine fever virus (CSFV), Aujeszky's disease virus (ADV), porcine parvovirus infection (PPV), porcine reproductive and respiratory syndrome (PRRS) and porcine circovirus (PCV). The sows were vaccinated PCV and PPV after farrowing. Vaccination for FMD is performed in all gilts and sows every four months. This herd is seropositive for porcine reproductive and respiratory syndrome (PRRS). During lactation, the sows are fed three to four time a day (about 6-8.5 kg of feed per day).

Part II: The sows were moved to the farrowing house before their expected farrowing date about one week. Sows were kept in individual farrowing crates (1.2 m^2) placed at the center of the pens with a space allowance of 4.2 m^2. The feed was provided twice a day (about 2-5 kg per day) during gestation. During lactation, the sows were fed 3 times a day (about 3-6 kg of feed per day). The sows were vaccinated against CSFV, ADV, PPV, PRRS and PCV. The sows are vaccinated PCV and PPV after farrowing. All gilts and sows is performed FMD vaccine in every four months. The herd is seropositive for PRRS.

Data collection

The following reproductive variables of the sows were recorded: farrowing duration (i.e., time between the first and last born piglets), number of total piglets born per litter (NTB), number of piglets born alive per litter (NBA), number of stillborn piglet per litter (SB) and number of mummuified fetuses per litter (MM) and number of piglets at weaning per litter. Rectal temperature measured at 24 h after birth with a digital thermometer (Verridian Dual Scale 9-Second Digital Thermometer Model 08-357; Verridian Healthcare Co. Ltd., IL, USA; display resolution of 0.01°C and ±0.1°C accuracy). All piglets were individually identified by an ear tattoo. Body weight of the piglets were measured immediately at birth and again at 24 h after birth. The individual colostrum consumption of each piglet estimated by a previously reported equation (Theil et al., 2014): CC (g) = -106 + 2.26WG + 200BWB + 0.111D - 1414WG/D + 0.0182WG/BWB, where WG is piglet weight gain (g), BWB is birth weight (kg), and D is the duration of colostrum suckling (min). The colostrum yield of the sows defined as the sum of individual colostrum consumption of all piglets in the litter.

Measurements of body condition score of sow

Body condition score of sow were measured to define 5 score 1 (emaciated): hips and backbone visible, 2 (thin): hips and backbone noticeable and easily felt, 3 (normal): hips and backbone only felt with firm palm pressure, 4 (fat): hips and backbone cannot be felt and 5 (overfat): hips and backbone heavily covered. The body condition score of each individual sow was evaluated by 3 stockpersons and the average of body condition score from 3 persons was recorded.

Measurements of backfat thickness

Backfat thickness was measured using A-mode ultrasonography (Renco Lean-Meater®, Minneapolis, MN., USA.) before farrowing. Backfat thickness was measured at the level of the last rib at about 6 to 8 cm from the midline, on both sides of the sows (Tummaruk, 2013). An average between the left and the right sides was calculated.

Colostrum collection

Part I Colostrum samples (n=100) were collected from 50 sows at 0 and 6 h after the onset of parturition. The sows were classified into two groups according to their parity number at farrowing as primiparous sows (n=14) and multiparous sows (n=36). The colostrum samples were collected from all teat and were pooled. The samples were kept in a clean bottle (30 mL) and were stored on ice in a styrofoam box (4 ºC) during collection process. The samples were kept at -20 ºC until analyses.

Part II Colostrum sample 99 were randomly collected from the sows at different time interval after farrowing. The interval from the onset of farrowing until colostrum collection was classified into 5 groups, i.e., 0–60, 61–120, 121–240, 241–360 and >360 min. The colostrum samples were also classified according to parity number of sows into 4 groups, i.e., 1 (n=19), 2 (n=30), 3-5 (n=30) and 6-8 (n=20).

Determination of total IgG concentrations in the sow colostrum

The colostrum samples were centrifuged at 15,000 ×g for 20 min at 4 ºC (Centrifuge 5810 R, Eppendorf AG, Hamburg, Germany). Thereafter, the fat was discarded and the remaining liquid were collected. After that, the liquid part was diluted 1:500,000 with a sample conjugate diluent (50 mM Tris buffer, 0.14 M NaCl, 1%BSA and 0.05% Tween 20). The concentration of IgG was determined by using ELISA quantitation kit (Bethyl Laboratories Inc., Texas, USA). Briefly, 100 µl of anti-IgG antibody was added into each well and incubated at room temperature (25˚C) for 60 min and washed five times with washing buffer (50 mM Tris buffer, 0.14 M NaCl and 0.05% Tween 20). After that, a 200 µl of blocking solution (50 mM Tris buffer, 0.14 M NaCl and 1%BSA) was added into each well and incubated at room temperature (25˚C) for 30 min and washed five times with the washing buffer. Thereafter, a 100 µl of standard solution or colostrum sample were added into each well and incubated at room temperature (25˚C) for 60 min and washed five times with washing buffer. The concentrations of IgG in the standard solutions were 500.0, 250.0, 125.0, 62.5, 31.25,

15.6 and 7.8 mg/ml. All the samples were analysed in duplicates. Afterthat, a 100 µl of the horseradish peroxidase and antibody were added. The plates were incubated for 60 min at room temperature and were washed five times with the washing buffer. A 100 µl of TMB substrate solution was added into each well and incubated in the dark at room temperature. After 15 min, the colorimetric reaction produced a blue product, which turned yellow when the reaction was terminated by adding 100 µl of 0.18 M sulfuric acid. The absorbance was recorded at 450 nm using ELISA plate reader (Tecan Sunrise™, Männedorf, Switzerland). The IgG concentration in the colostrum samples were quantified by interpolating their absorbance from the standard curve generated in parallel with the colostrum samples. The inter- and intra-assays coefficient of variation were 2.6% and 2.2%, respectively.

Determination of total IgA concentration in the sow colostrum

The concentration of IgA in the sow colostrum was determined by using pig IgA ELISA quantitation kit (Benthyl Laboratories Inc., Texas, USA). The test kit contained affinity purified goat anti-pig IgA coating antibody, pig reference serum (0.89 mg/mL IgA) and conjugated goat anti-Pig IgA detection antibody. The concentration of standard solution varied from 15.6 – 1,000 ng/mL. The procedure of IgA determination was carried out following the manufacture instruction. Briefly, 100 mL of diluted coating antibody was added to each well and incubated at room temperature (20-25 °C) for 1 h. The plate was washed 5 times and 200 µl of blocking solution was added to each well and incubated at room temperature for 30 min. Thereafter, the plate was washed 5 time and 100 µl of standard or samples (diluted 1:60,0000) were added to the well. All the samples were tested in duplicate. The plate was incubated at room temperature for 1 h and was washed 5 time. After that, 100 µl of diluted HRP conjugated goat anti-pig IgA detection antibody (1:100,000) was added to each well and was incubated at room temperature for 1 h. The plate was washed 5 time and 100 µl of TMB substrate solution was added to each well. The plate was developed at dark room temperature for 15 min and the reaction was stopped by adding 100 µl

of stop solution into each well. Finally, the plate was measured by using ELISA plate reader at 450 nm (Tecan Sunrise™, Männedorf, Switzerland). The IgA concentration in the colostrum samples were quantified by interpolating their absorbance from the standard curve generated in parallel with the colostrum samples and were presented as mg/mL. The inter- and intra-assays coefficient of variation were 2.6% and 2.2%, respectively.

Enzyme-linked immunosorbent assay

The levels of IgG and IgA antibody titer against PED were determined by ELISA. Microtiter 96-well plates (Nunc MaxiSorp™, Nalge Nunc International, Rochester, New York, USA) were coated with recombinant spike protein 20 µg/ml or 50 µg/ml for IgG ELISA or IgA ELISA, respectively and held overnight at 4°C in 0.1 M $Na_2CO_3/NaHCO_3$ buffer, pH 9.6. The wells were blocked with 5 % (w/v) skim milk in PBS and incubated for 3 hours at room temperature. The wells were incubated with 500-folded diluted colostrum and milk at room temperature for 1 hour. Following five washes with washing buffer (0.5% PBS-T), anti-pig IgG-HRP or IgA-HRP (AbD Serotec, Kidlington, United Kingdom) was added and incubated for 1 h at 37°C, and then plates were washed four times with washing buffer prior to incubation with 3,3′,5,5′-tetramethylbenzidine (TMB) liquid substrate system for ELISA (Sigma-Aldrich, St. Louis, Missouri USA) at room temperature for 15 min. The reaction was stopped using 1 N H_2SO_4, and the optical density at 450 nm (OD450) value was read using an ELISA plate reader (AccuReader, Metertech, Taipei, Taiwan). Negative and positive serum, colostrum and milk samples from a herd free of PED and a herd with PED outbreak was used as assay controls. The antibody response was represented as sample-to-positive (S/P) ratios calculated as: S/P ratio = (sample OD- blank control OD)/ (positive OD- blank control OD). For IgG, the S/P ratio of 0.50 were defined as a positive antibody titer against PED virus. For IgA, the S/P ratio of 0.60 were defined as a positive antibody titer against PEDV (Srijangwad *et al.,* 2017)

Statistical analysis

The statistical analyses were carried out by using Statistical Analysis System software version 9.0 (SAS Inst. Inc., Cary, NC, USA.). Descriptive statistics were calculated by using PROC MEANS. The levels of IgG and IgA were analyzed by using multiple ANOVA. The statistical models included the sow parity number (1, 2, 3-5 and 6-8) and time after farrowing. Least-square means were obtained from each class of the factors and were compared by using least significant difference (LSD) test. The proportion of IgG and IgA positive samples were compared among groups by using Chi-square test. To identify the potential indicators for the piglet colostrum consumption, each recorded factor were analyzed by using Pearson's correlation and general linear model (PROG GLM). Categorical variables were individually tested using logistic regression analyses (PROC GENMOD). $P<0.05$ were regarded to be statistically significance.

CHAPTER IV
RESULTS

Descriptive statistics, including number of observations, means, standard deviation and ranges of the data on sow characteristics, are presented in Table 1. As can be seen, parity number, NTB, NBA and colostrum yield was 2.8 ± 1.88, 17.5 ± 3.78, 15.3 ± 3.71 and 5,915 ± 1,732.6 grams, respectively.

Table 1 Descriptive statistics on sow characteristics (n=80)

Variables	Means ± SD	Range
Parity number	2.8 ± 1.88	1 – 6
Gestation length (days)	115.6 ± 1.52	113 – 121
Total number of piglet born per litter	17.5 ± 3.78	3 – 26
Number of piglet born alive per litter	15.3 ± 3.71	1 – 21
Number of stillborn piglet per litter	1.3 ± 1.72	0 – 10
Number of mummified fetuses per litter	1.0 ± 1.97	0 – 15
Farrowing duration (min)	275.0 ± 187.52	58 – 986
Body condition score before farrowing	3.0 ± 0.12	2.7 – 3.4
Back fat thickness before farrowing (mm)	14.1 ± 2.62	8.0 – 24.0
Colostrum yield (gram)	5,915 ± 1,732.6	176 – 10,136

Table 2 Descriptive statistics on piglet characteristics (n=1,403)

Variables	N	Means ± SD	Range
Birth interval (min)	1,394	17.7 ± 51.12	0 – 926
Birth body weight (grams)	1,288	1,165 ± 327.1	195 – 2,245
Heart rate (time/ min)	930	112.8 ± 82.84	16 – 350
Blood oxygen saturation (%)	930	86.5 ± 13.87	3 – 100
Rectal temperature at 24 h (°C)	898	38.2 ± 1.02	31.4 – 40.3
Body weight at Day 1 (gram)	1,182	1,287 ± 348.3	350 – 2,435
Colostrum intake (grams)	1,140	404.7 ± 183.35	6.8 – 1,093.1

Descriptive statistics, including number of observations, means, standard deviation and ranges of the data on piglet characteristics, are presented in Table 2. As can be seen, birth body weight, body weight at day 1 and colostrum intake was 1,165 ± 327.1, 1,287 ± 348.3 and 404.7 ± 183.35 grams, respectively.

Table 3 Pearson's correlation between colostrum consumption (mean ± SD = 404.7 ± 183.35) and litters and newborn piglet's characteristics

Variables	Colostrum consumption (grams)		
	n	r	Significant levels
Gestation length (days)	1,140	0.01	*NS*
Total number of piglet born/ litter	1,140	-0.21	***
Number of piglet born alive/ litter	1,140	-0.19	***
Body conditions score	1,140	0.06	*
Body weight at birth of piglet	1,140	0.29	***
Birth order	1,329	-0.07	*
Birth interval (min)	1,140	-0.02	*NS*
Heart rate (beat/min)	872	0.11	**
Blood oxygen saturation (%)	872	0.05	*NS*
Rectal temperature (°C)	862	0.30	***

*$P<0.05$, ** $0.05<P<0.01$, *** $P<0.001$, *NS* = not significant

Table 3 demonstrates correlation between colostrum consumption and newborn piglet's characteristics. As can be seen, the colostrum consumption averaged 404.7 ± 183.35 grams. Body weight at birth of the piglet (r=0.29, $P<0.001$), birth order (r=0.22, $P<0.001$), NTB (r=-0.21, $P<0.001$), NBA (r=-0.19, $P<0.001$), body conditions score (r=0.06, P<0.05), heart rate (r=0.11, $P<0.05$) and rectal temperature (r=0.30, $P<0.001$) were significantly correlated with colostrum consumption of the neonatal piglets.

Table 4 Pearson's correlation between blood oxygen saturation and heart rate of the newborn piglets and the newborn piglet's characteristics (n = 930)

Variables	Blood oxygen saturation	Heart rate
Gestation length (day)	-0.06*	*NS*
Total born	*NS*	-0.09**
Born alive	*NS*	-0.10**
Birth interval (min)	*NS*	-0.09**
Colostrum intake (gram)	*NS*	0.11***
Rectal temperature (°C)	*NS*	*NS*

*P<0.05, ** 0.05<P<0.01, *** P<0.001, *NS* = not significant

Table 4 demonstrated correlation between blood oxygen saturation and heart rate of the newborn piglets and the newborn piglet's characteristics. As can be seen, NTB (r= -0.09, P<0.01), born alive (r= -0.10, P<0.01), birth interval (r= -0.09, P<0.01) and colostrum intake (r= 0.11, P<0.001) were significantly correlated with heart rate of the newborn piglets.

Table 5 Pearson's correlation among gestation length, total number of piglet born per litter (NTB), number of piglets born alive per litter (NBA), backfat thickness and body condition score of sows, piglet body weight at birth after farrowing and colostrum yield of sows

Variables	Colostrum yield of sows (grams)		
	n	r	Significant
Gestation length (day)	78	-0.37	***
NTB	78	0.31	**
NBA	78	0.59	***
Body condition score before farrowing	78	0.13	*NS*

*P<0.05, ** 0.05<P<0.01, *** P<0.001, *NS* = not significant

Table 5 demonstrated correlation among gestation length, NTB, NBA, backfat thickness, body condition score of sows, piglet body weight at birth and colostrum yield of sows. As can be seen, gestation length (r= -0.09, P<0.01), NTB (r= -0.10, 0.05<*P*<0.01) and NBA (r= 0.11, *P*<0.001) were significantly correlated with colostrum yield of sows (Table 5).

Table 6 Descriptive statistics on backfat thickness and body condition score of sows before farrowing, backfat thickness of sows during lactation and piglet body weight at birth after farrowing

Variables	Number of sows	Means ± SD	Range
Sow characteristics			
Parity number	80	2.83 ± 1.88	1 – 6
Gestation length (day)	80	115.6 ± 1.52	113 – 121
Body condition score before farrowing	80	2.99 ± 0.12	2.7 – 3.4
Back fat before farrowing (mm)	73	14.1 ± 2.61	8.0 – 24.0
Farrowing duration (hour)	76	275.0 ± 187.52	58 – 986
Piglet characteristics			
Piglet body weight at birth (kg)	80	1.17 ± 0.205	0.78 – 1.99

Table 7 Pearson's correlation among farrowing duration, birth interval and neonatal piglet's characteristics

Variables	Farrowing duration (min)		
	n	r	Significant
Sow's characteristics			
Number of stillborn piglet/ litter	80	0.53	***
Number of mummified fetuses/ litter	80	0.02	*NS*
Total number of piglet born/ litter	80	0.06	*NS*
Number of piglet born alive/ litter	80	-0.20	*NS*
Body condition score before farrowing	80	-0.21	*NS*
Back fat before farrowing (mm)	73	-0.07	*NS*
Colostrum yield of sows (gram)	78	-0.12	*NS*
Piglet's characteristics			
Birth interval (min)	80	0.86	***
Piglet body weight at birth (kg)	80	0.04	*NS*
Blood oxygen saturation (%)	62	-0.26	*
Heart rate (beat/min)	62	0.30	*

*$P<0.05$, ** $0.05<P<0.01$, *** $P<0.001$, *NS* = not significant

Table 7 demonstrated correlation among farrowing duration and birth interval and neonatal piglet's characteristics. As can be seen, the factor correlated with farrowing duration of sow included number of stillborn piglet/ litter ($P < 0.001$), birth interval ($P < 0.001$), blood oxygen saturation ($P<0.05$) and heart rate ($P<0.05$) (Table 7).

Concentrations of total IgG and IgA in sow colostrum

Descriptive statistics on reproductive data of 1,140 litters from 50 sows are presented in Table 8. The average of concentration of IgG, IgA and parity of sow were 54.9 ± 24.57 ng/mL, 7.8 ± 4.20 ng/mL and 2.9 ± 1.8, respectively.

Table 8 Descriptive statistics on reproductive performances variables and colostrum immunoglobulins in sows

Variables	N	Means ± SD	Range
Parity	50	2.9 ± 1.8	1 – 6
Gestation length (days)	50	115.6 ± 1.5	106 – 121
Body condition score	48	3.0 ± 0.1	2.70 – 3.40
Backfat thickness before farrowing (mm)	43	13.9 ± 2.4	10.0 – 19.0
Backfat thickness at 1 day postpartum (mm)	19	14.0 ± 3.0	8.5 – 19.5
Total number of piglets born/ litter	49	18.8 ± 3.4	11 – 26
Number of piglet born alive/ litter	49	15.8 ± 4.2	0 – 21
Number of stillborn piglet/ litter	49	1.2 ± 1.3	0 – 5
Number of mummified fetuses/ litter	49	1.3 ± 2.4	0 – 15
IgG (ng/mL)	100	54.9 ± 24.6	9.2 – 152.8
IgA (ng/mL)	100	7.8 ± 4.2	1.0 – 30.4

Table 9 Concentration of immunoglobulin G (IgG) and A (IgA) at 0 and 6 h after the onset of farrowing in sows (means ± SD)

Variables	Time period after the onset of farrowing (h)		Difference	*P* value
	0	6		
IgG (mg/mL)	59.6 ± 24.8	50.2 ± 23.7	-9.4 (-15.8%)	0.009
IgA (mg/mL)	8.1 ± 3.9	7.5 ± 4.5	-0.6 (-7.4%)	0.559

Table 9 demonstrated the concentration of IgG and IgA at 0 and 6 h after the onset of farrowing in sows. It was found that concentration of immunoglobulin G at 6 h after farrowing was significantly decreased compared with the first hour (Table 9).

Table 10 Concentration of immunoglobulin G (IgG) and A (IgA) at 0 and 6 h after the onset of farrowing in primiparous and multiparous sows (least-square means ± SEM)

Variables	Primiparous sows	Multiparous sows	*P* value
0 h			
IgG (mg/mL)	70.7 ± 6.4	55.2 ± 3.9	0.041
IgA (mg/mL)	6.8 ± 1.1	8.7 ± 0.7	0.153
6 h			
IgG (mg/mL)	45.5 ± 5.5	53.1 ± 4.3	0.278
IgA (mg/mL)	5.9 ± 3.94	7.5 ± 4.46	0.559

The concentrations of immunoglobulin G and immunoglobulin A in primiparous sows compared with multiparous sows were illustrated in the Table 10. As can be seen, the concentration of IgG in primiparous sows was higher than multiparous sows at 0 h after farrowing (70.7 ± 6.4 vs 55.2 ± 3.9, *P*=0.041).

Table 11 Correlation among the concentration of total IgG, IgA, backfat thickness, body condition score and reproductive performance in sows

Variables	Correlation coefficient	
	IgG	IgA
Body condition score	0.088 (*P* = 0.394)	0.219 (*P* = 0.031)
Backfat at 1 day postpartum (mm)	0.349 (*P* = 0.031)	-0.158 (*P* = 0.340)
Total number of piglets born/ litter	-0.058 (*P* = 0.571)	0.175 (*P* = 0.086)
Number of piglet born alive/ litter	0.056 (*P* = 0.579)	0.200 (*P* = 0.049)
Number of stillborn piglet/ litter	-0.050 (*P* = 0.624)	0.054 (*P* = 0.595)
Number of mummified fetuses/ litter	-0.169 (*P* = 0.096)	-0.025 (*P* = 0.806)

Table 11 demonstrated correlation among the concentration of total IgG, IgA, backfat thickness, body condition score and reproductive performance in sows. As can be seen, backfat thickness of sow at 1 day postpartum was positively correlated with the concentration of total IgG in colostrum (r= 0.349, *P* = 0.031). Additionally, the concentration of IgA in the sow colostrum was positively correlated with body condition score (r= 0.219 *P* = 0.031). Furthermore, the concentration of IgA was positively correlated with number of piglet born alive per litter (r= 0.200, *P* = 0.049).

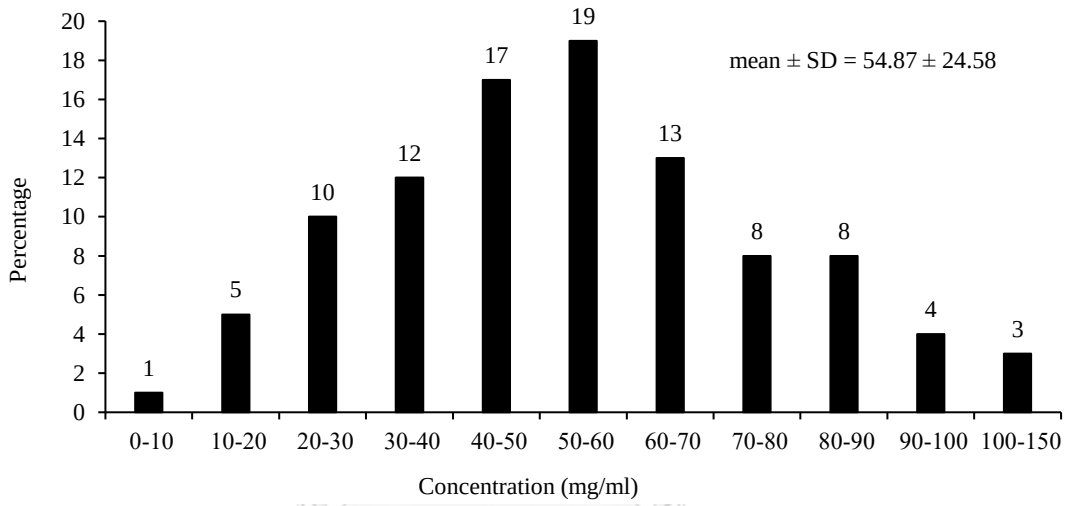

Figure 1 Frequency distribution of total immunoglobulin G (IgG) in the colostrum of sows during 0 – 6 h postpartum

Figure 1 illustrates the frequency distribution of total immunoglobulin G (IgG) in the colostrum of sows during 0 – 6 h postpartum. On average, the IgG of sow colostrum was 54.87 ± 24.58 mL. As can be seen, 19% of sow colostrum had IgG concentration of 50 – 60 mg/ml. Furthermore, the sow with the IgG concentration in colostrum above 60 mg/ml was 36.0 % and sow with IgG concentration below 30 mg/ml was 16.0 % (Figure 1).

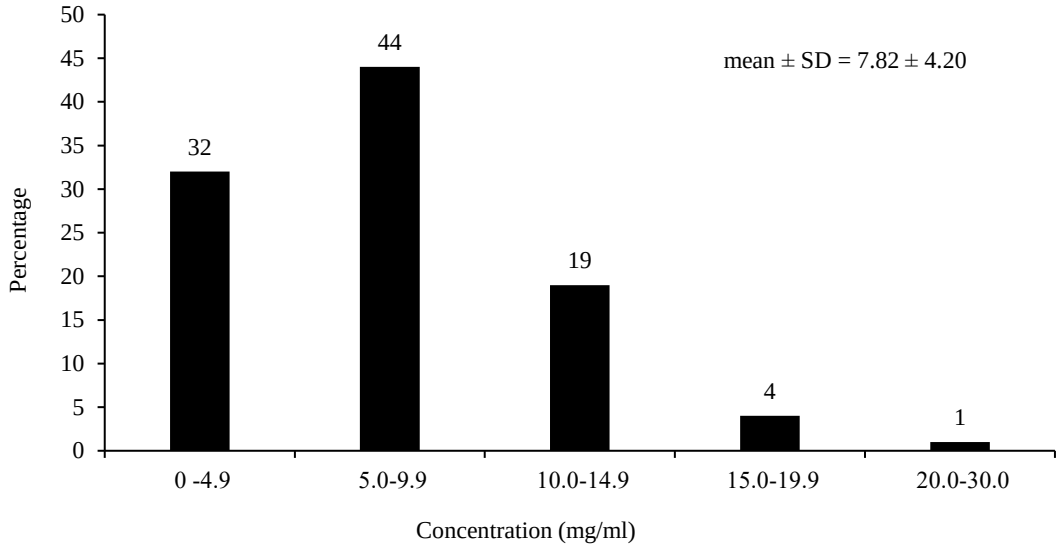

Figure 2 Frequency distribution of total immunoglobulin A (IgA) in the colostrum of sows during 0-6 h postpartum

Figure 2 illustrates the frequency distribution of total IgA in the colostrum of sows during 0 – 6 h postpartum. As can be seen, 45% of sow colostrum had IgA concentration of 5.0 – 9.9 mg/ml. On average, the IgA of sows colostrum was 7.8 ± 4.2 mL. Interestingly, up to 32.0 % of the colostrum sample had IgA concentration below 5.0 mg/mL. On the other hand, only 5.0 % of the colostrum sample had IgA concentration above 15.0 mg/ml (Figure 2).

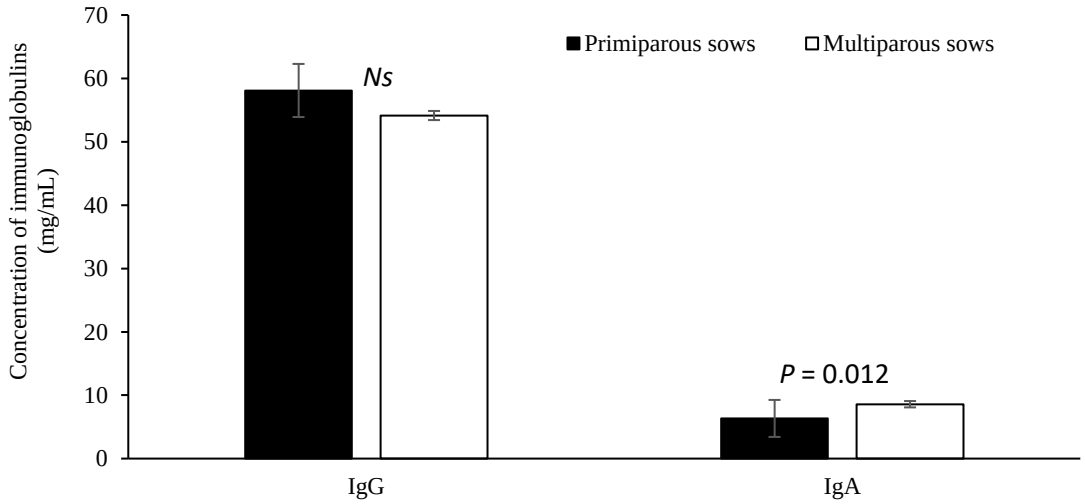

Figure 3 Concentration of total immunoglobulin G and immunoglobulin A in primiparous sows compared with multiparous sows, *Ns* = not significant

The concentrations of total immunoglobulin G and immunoglobulin A in primiparous sows compared with multiparous sows were illustrated in the Figure 3. As can be seen, the concentration of IgA in multiparous sows was significantly higher than primiparous sows (8.58 vs 6.34, *P*=0.012).

Concentrations of IgG and IgA specifically against PED virus in colostrum

On average, the IgG and IgA concentrations specifically against PED virus were 0.51 ± 0.25 and 0.51 ± 0.23, respectively. Sows parity numbers 6 – 8 had a significantly higher IgG concentration than sows parity numbers 3 – 5 (0.56 ± 0.08 *vs* 0.40 ± 0.06, *P*<0.05) respectively. In contrast, the IgA concentration was higher in primiparous sows (0.55 ± 0.07) and 2 (0.54 ± 0.06) than sows parity number 3 – 5 (0.41 ± 0.06, *P*<0.05).

Table 12 Descriptive statistics on the sows data and concentrations of IgG and IgA specifically against PED virus in colostrum

Variables	Mean ± SD	Range
Parity	3.58 ± 2.23	1 – 8
IgG	0.510 ± 0.246	0 – 1.061
IgA	0.512 ± 0.227	0 – 1.488

Table 13 Concentrations of IgG and IgA against PED virus in colostrum by parity number of sows (least-square means ± SEM)

Parity	IgG (n=99)	IgA (n=99)
1	0.513 ± 0.070^{ab}	0.554 ± 0.065^{a}
2	0.424 ± 0.065^{ab}	0.538 ± 0.060^{a}
3 – 5	0.396 ± 0.063^{b}	0.414 ± 0.059^{b}
6 – 8	0.556 ± 0.076^{a}	0.526 ± 0.070^{ab}

^{a,b} different superscript within column differ significantly ($P<0.05$)

The concentration of IgG in the colostrum collected at >360 min after farrowing was lower than that in the colostrum collected at 0 – 60 min after farrowing ($P<0.05$). Likewise, the proportion of colostrum samples having positive IgG and IgA against PED virus were relatively high during 60–120 min after the onset of farrowing and dramatically declined thereafter (Figure 4).

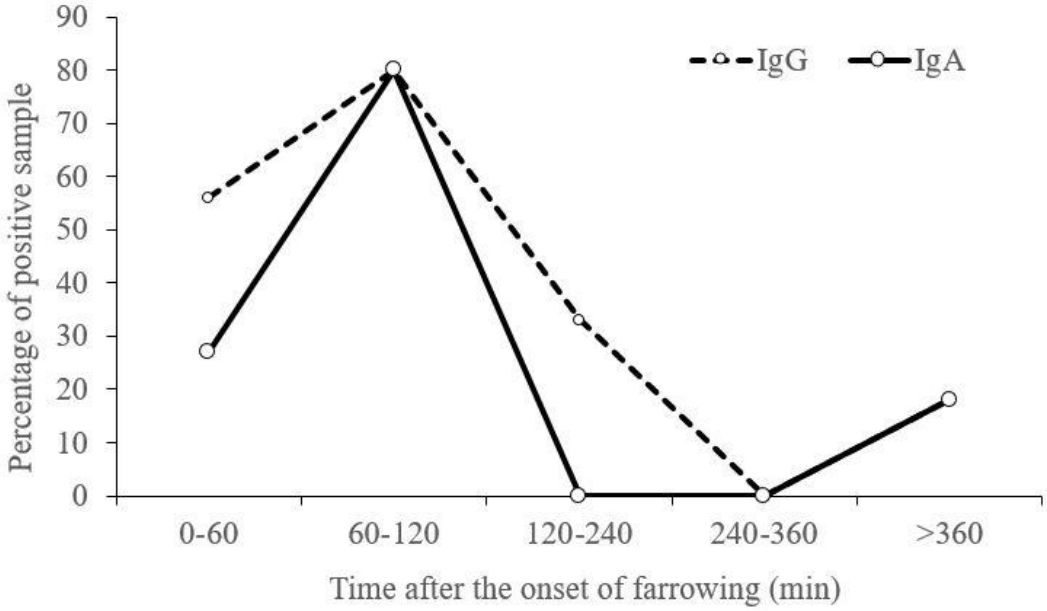

Figure 4 Proportion of colostrum samples having positive IgG against PED virus (S/P ratio >0.500) and positive IgA against PED virus (S/P ratio >0.600) by time after the onset of farrowing

In the present study, colostrum obtained from sows parity 6–8 and during the period between 0–120 min after the onset of farrowing tended to have enrich immunoglobulins against PED virus.

Table 14 Nutrition analyses from gestating and lactating sows diets in Herds A and B

	Herd A		Herd B	
Nutrition	Gestataion	Lactation	Gestation	Lactation
Protein (%)	15.56	17.09	18.85	17.11
Fat (%)	5.00	3.87	5.00	3.51
Moisture (%)	11.98	11.11	9.35	11.07
Ash (%)	5.02	4.96	6.49	6.63
Fiber (%)	4.25	3.58	5.96	6.66
Starch (%)	51.25	47.64	35.29	35.80
Calcium (%)	1.26	1.22	1.04	0.95
Phosphorus (%)	0.34	0.43	0.63	0.73

CHAPTER V
DISCUSSION

The present study demonstrates the colostrum consumption of piglets in a commercial swine herd in Thailand. Factors found to be associated with piglet colostrum consumption included body weight at birth of the piglets, total number of piglet born per litter, number of piglet born alive per litter, heart rate of the newborn piglet, birth order and body condition score of the sows before farrowing. Colostrum consumption is crucial for the survival and growth of piglets in commercial herds (Muns et al., 2016). From the previous study, 400 grams of colostrum consumption per piglet during the first 24 hours after birth is recommended to minimize the risk of death and to enhance growth performance until weaning (Theil et al., 2014). The recommended colostrum consumption from this study is considerably greater than that previously reported by Quesnel et al. (2012), who found that 200 grams of colostrum was required to reduce piglet mortality. The reason for this discrepancy is mainly due to differences in the prediction equations used by the two studies. The prediction model used in the current study has recently been shown to be more reliable, and this model estimates colostrum consumption approximately 50% higher than when the equation developed by Devillers et al. (2004) is used. In the present study, the average colostrum yield of sows was 5,915 grams and the piglet colostrum intake was 404 grams.

In the present study, the neonatal piglet rectal temperature is associated with colostrum consumption. Likewise, Tuchscherer et al. (2000) found that rectal temperature in piglets after birth is associated with colostrum consumption. In the previous study, rectal temperature after birth was identified as an important indicator for piglet survival (Nuntapaitoon et al., 2018), indicating that piglets with low rectal temperature after 24 h might have lower thermoregulation abilities. Thermoregulation is a crucial physiological event for all newborn piglets. The piglets that die during the first days of life are not able to maintain optimal rectal temperature during the first 24 h of life. Nuntapaitoon et al. (2018) found that rectal temperature at 24 h of life was significantly associated with piglet pre-weaning mortality rate. Therefore, increasing

colostrum intake of neonatal piglet during first day after birth is very important in swine herd.

In general, piglet birth weight is positively associated with their physiological maturity and, in turn, correlates with different physical and physiological parameters such as colostrum intake capacity and thermoregulation ability. The present study demonstrated a positive correlation between birth weight and piglet colostrum intake. This finding is in agreement with a number of previous studies (Devillers et al., 2007; Quesnel et al., 2012; Declerck et al., 2015). The reason is due to the fact that small piglets usually have decreased viability and a lower capacity to compete for a teat. Therefore, special care of small piglets is highly recommended to ensure optimal amount of colostrum intake. In a previous study, energy boosters can increase the immunity and reduce mortality of piglets (Muns et al., 2017). Moreover, oral supplementation with colostrum, split suckling and cross-fostering are management strategies that may enhance colostrum consumption and improve the survival and growth performance of piglets (Donovan and Dritz, 2000; Cecchinato et al., 2010; Muns et al., 2014).

The present study found that concentration of immunoglobulin G at 6 h after farrowing in sows was significantly decreased when compare with first hour. The concentration of IgG in primiparous sows was significantly higher than multiparous sows at 0 h after farrowing of sow. This indicates that the concentration of IgG maybe varied among sows. Furthermore, the onset of colostrum consumption by piglets is also influenced the concentration of IgG obtained by piglets. Thus, the newborn piglets should receive colostrum as soon as possible after birth to ensure an optimal amount of IgG.

The current study found that backfat thickness of sow at 1 day post-partum was positively correlated with the concentration of total IgG in colostrum. Additionally, the concentration of IgA in the sow colostrum was positively correlated with body condition score. Furthermore, the concentration of IgA was positively correlated with number of piglet born alive per litter. These indicated that the sow with a better body condition score yield a higher concentration of IgA in colostrum. Therefore, the control of sow body condition score before farrowing is important.

Interestingly, up to 32.0 % of the colostrum sample had IgA concentration below 5.0 mg/ml. On the other hand, only 5.0 % of the colostrum sample had IgA concentration above 15 mg/ml. This data indicates that IgA in sow colostrum is relatively low and may not enough for PED virus protection. In a previous study, after experimentally challenging PED virus to the piglets, the antibody-positive piglets could return to normal conditions faster and had a higher survival rate than piglets without PED virus antibody (Poonsuk et al., 2016a). The authors also concluded that both systemic antibodies and IgA in milk contribute to the protection of the neonatal pig against PED virus infections (Poonsuk et al., 2016a). Nevertheless, under filed conditions, a number of factors might interfere colostrum intake and the levels of immunoglobulins in the sow milk. Therefore, these factors need to be explored.

In the present study, colostrum obtained from sows parity 6–8 and during the period between 0–120 min after the onset of farrowing tended to have enrich immunoglobulins against PED virus. The reasons might be due to the fact that these sows have been naturally exposed to PED virus during the past 2 years. On the other hand, young sows have never been exposed to PED virus before.

In conclusions, under field conditions the average colostrum consumption of piglets was 404 grams and varied among individual piglet from 6.8 to 1,093 grams. The concentrations of total IgG and IgA in the colostrum was highest during the first hour of farrowing and significantly declined after 6 h. The concentrations of IgG and IgA specifically against PED virus in the colostrum varied significantly among parity number of sows and time interval after farrowing. Old sows had a higher IgG concentration specifically against PED virus than young sows.

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APPENDIX

VITA

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Publications

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