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Effect of different management techniques to enhance colostrum intake on piglets' growth and mortality

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Abstract

An experiment was conducted to study the effect four different management techniques to enhance colostrum intake had on piglet and litter performance. Treatments were performed on piglets born weighing 1.30 kg or less (SP) within 6 h of birth: control group (CON); split-nursing of the litter for 2 h allowing only the SP piglets free access to teats (SPLIT); oral supplementation with 15 ml of sow colostrum to the SP piglets of the litter (COL); and oral supplementation with 3 ml of an energy product (Calostrene®) to the SP piglets of the litter (EN). Thirty-nine primiparous sows (Large White × Landrace) and their litters (507 piglets) and 100 multiparous sows and their litters (1,375 piglets) were used. Litters were fixed at 12 piglets. Piglets were weighed through lactation. Mortality was recorded. For primiparous sows, oral supplementation with COL enhanced SP piglets bodyweight (BW) at day 1 compared to CON, SPLIT, and EN. However, no differences on BW were observed at day 18 nor on litter total pre-weaning mortality. Nonetheless, lower SP piglets' mortality rate was found in CON and EN compared to SPLIT and COL groups in primiparous sows. For multiparous sows, no differences among treatments were observed for SP piglets BW at day 1 or at day 18. Primiparous sows' SP piglets had higher BW at day 1 than multiparous sows' SP piglets. Colostrum supplementation of low birth weight piglets improved early weight gain in piglets born from primiparous sows, probably by enhancing their colostrum intake, but it did not affect piglets' weaning BW or pre-weaning mortality.

Keywords: *animal welfare, colostrum intake, colostrum supplementation, management routines, pig, sow*

Introduction

Piglet mortality during lactation is still a problem in commercial swine herds with mortality rates above 12% in the European Union (Interpig 2012). Piglet survival can be influenced by pre-natal factors, maternal behaviour, physical environment and management around farrowing (Vasdal *et al* 2011). Although piglet growth and survival are influenced by piglet birth weight and vitality (Muns *et al* 2013), colostrum intake is determinant for piglet survival. Colostrum provides piglets with the energy necessary for thermoregulation and body growth, and immunoglobulins (Quesnel *et al* 2012). Passive transfer of immunity via colostrum intake is crucial during the first 24 h of life due to the ephitheliocorial nature of the placenta in pigs and due to gut closure, which takes place at approximately 24 h of age (Rooke & Bland 2002). With the ongoing selection for prolific sows the numbers of small and immature piglets at birth have increased in commercial farms (Vasdal & Andersen 2012), resulting in more piglets at risk of low colostrum intake during the first hours of life. Different authors have focused on different management techniques to increase colostrum intake: drying and/or warming up the piglets (Christison *et al* 1997), drying and placing the piglets close to the udder (Vasdal *et al* 2011), administering some colostrum replacers (Holyoake *et al* 1995), providing piglets with extra oxygen (White *et al* 1996), or performing split-nursing (Donovan & Dritz 2000), are among the most successful techniques.

Intestinal macromolecular absorption in piglets (Svendsen *et al* 2005) and the effect of different source of immunoglobulins (Ig) fed to artificially reared piglets (Gomez *et al* 1998) have also been studied. However, little work has been focused on the effect of oral supplementation of newborn piglets on litter survival and growth under commercial conditions. Recently, our study group (Muns *et al* 2014), found positive results on piglets' early growth and survival after supplementing them with sow colostrum. However, colostrum benefits were highly dependent on the cross-fostering strategy performed.

We hypothesised that oral supplementation of newborn piglets could benefit their further growth and survival during lactation. The objective of the present study was to compare the effect of four different management techniques to enhance colostrum intake on piglets' survival and growth in commercial farms without the influence of the cross-fostering strategy. Results should allow the impact of management technique on piglet growth and survival to be assessed and help producers optomise piglets' management strategies early after farrowing.

Materials and methods

This study was conducted with approval from the Institutional Animal Care and Use Committee of the Universitat Autònoma de Barcelona (UAB) and conformed to Directive 2010/63/EU of the European Parliament and of the Council.

Animals, housing and management

This experiment was carried out on a 6,000-sow farm in Lleida, Spain. Sows were kept in individual stalls (1.20 m^2) during gestation and fed a commercial gestation diet. On day 109 of gestation, sows were moved to a climate-controlled (25ºC) farrowing room with a capacity of 12 pens per room. Farrowing pens (4.37 m^2) had plastic-slat flooring and a farrowing stall (1.20 m^2) in the centre. Each pen was provided with a creep area (0.42 m^2) on one side of the stall. In accordance with the protocol on the farm, the observation of farrowing symptoms was the cue for the feeder to be emptied and the sow offered no feed for the following 24 h. The amount of feed offered was increased daily until *ad libitum* was reached after one week of lactation. Sows were fed a commercial lactation diet twice a day according to NRC (1998) requirements. Sows and piglets had *ad libitum* access to human-grade water in separated nipple drinkers. Farm policy at farrowing consisted of placing drying paper at the back of the dam and having a heating lamp on the creep-area. The farm's usual procedure with piglets included a 1-ml iron supplement given to each piglet subcutaneously (Ferrovial, MEVET, Lleida, Spain), tail docking, and a farm identification tag clipped in the right ear at day 3 post-partum. Weaning took place at 23 (± 2) days of age. Throughout the experiment animals were checked daily for health and/or eating problems.

Experiment development

From four batches, a total of 1,882 piglets from 139 sows (Large White × Landrace) were used in the experiment. Two parity groups were differentiated: 39 primiparous sows and their litters (a total of 507 piglets) and 100 multiparous sows (second to seventh parity) and their litters (a total of 1,375 piglets). Once the farrowing was completed (determined by the expulsion of the placenta) piglets were weighed, individually identified with an ear-tag and classified as small (SP) or big piglets (BP), according to their bodyweight (BW) at birth: SP) piglets born weighing 1.30 kg or less; and BP) piglets born weighing more than 1.30 kg of BW. Bodyweight classification was fixed based on Milligan *et al* (2002b) who defined 3 BW categories for piglets: 1.70, 1.20 and 1.00 kg and is consistent with Bierhals *et al* (2012) who defined an 'intermediate' piglet as being born weighing 1.40–1.60 kg of BW. The number of piglets born alive, stillborn, and mummified were recorded after the farrowing was completed. Litters were allocated to one of the four treatment groups balancing treatments for sow's parity and total born piglets, and treatments were immediately performed: a control group with no extra management to piglets (CON); split-nursing of the BP piglets of the litter for 2 h allowing SP piglets free access to teats (SPLIT); oral supplementation with 15 ml of sow colostrum to the SP piglets of the litter (COL); and oral supplementation with one pulse (3 ml) of a condensed energy product (Calostrene®, Laboratorio JAER SA, Sant Vicenç dels Horts, Barcelona, Spain) to the SP of the litter (EN). Split-nursing for SPLIT group is defined as removal of the larger piglets (BP piglets) in a litter for a period of 2 h, during the 2-h period BP piglets were caged inside their respective farrowing pen and provided with an extra heating lamp to keep body temperature. Sow colostrum for the COL group was obtained manually from multiparous sows not included in the experiment ranging from second to fifth parity, pooled and used the same day. Equal to the COL treatment, the energetic product used in the EN treatment was administered only once.

On day 1 (18 to 24 h after birth) all the initial piglets were weighed again and then the animals were cross-fostered within the same treatment and within the same parity group obtaining litters fixed at 12.1 (± 0.08) and 12.0 (± 0.03) piglets for primiparous and multiparous sows, respectively. For a better interpretation of the results and to avoid a confounding effect with the cross-fostering strategy, cross-fostering was performed at a minimum level ensuring the minimum number of animal movements possible and with all the litters containing 4 or 5 SP piglets (4.9 [± 0.38] and 4.4 [± 0.14] SP piglets per litter, for primiparous and multiparous sows, respectively). All the surplus piglets were transferred to sows not included in the experiment that farrowed the same day.

Litter pre-weaning mortality was recorded through lactation. Back-fat thickness (BF) from sows was measured on the P2 spot (last rib 65 mm down the dorsal middle line) on both sides of the body using a Renco Lean Meater ultrasound system (Renco Corporation®, North Minneapolis, MN, USA) two days before farrowing and again on day 18 post-farrowing.

Statistical analysis

All statistical analyses were carried out using SAS 9.2 (SAS Inst Inc, Cary, NC, USA). All data were checked for normality and homogeneity of variance before being analysed with the ANOVA method. All variables were analysed using litters as experimental units (litter was introduced in all models as random effect and nested to treatment effect). The alpha level of significance was set at 0.05.

The different models for sows' variables (BF, total live born piglets, stillbirths and mummified) were analysed separately for primiparous and multiparous sows using GLIMMIX procedure of SAS. The models included the oral supplementation option as fixed effect, batch and farrowing room were introduced as fixed effects and removed from the model based on its significance. Differences among groups for the SP and BP piglets' BW variables were analysed by general linear mixed models using GLIMMIX procedure of SAS. The different models included the oral supplementation option and parity group (primiparous and multiparous) as fixed effects, and the interaction between oral supplementation option and parity group; batch, farrowing room, and piglet gender were introduced as fixed effects and removed from the model based on its significance. Initial BW (day 0) was introduced as covariate for BW at day 1

Table 1 Effect of oral supplementation[1] and dams' parity (gilts or multiparous sows) on bodyweight and growth performance for all the piglets included in the experiment.

All piglets	Bodyweight at day 0 (kg)	Bodyweight at day 1 (kg)	Bodyweight at day 18 (kg)	Bodyweight gain at day 18 (kg)	CV of litter body-weight at day 1 (%)	CV of litter body-weight at day 18 (%)
CON						
Gilts	1.28	1.51	5.61	4.10	16.6	19.3
Sows	1.44	1.51	5.68	4.18	19.6	21.3
SPLIT						
Gilts	1.3	1.50	5.55	3.93	17.1	16.1
Sows	1.36	1.50	5.77	4.26	19.6	21.8
COL						
Gilts	1.28	1.54	5.54	3.99	18.7	17.5
Sows	1.4	1.51	5.81	4.32	20.2	22.7
EN						
Gilts	1.31	1.51	5.53	3.97	18.6	18.8
Sows	1.35	1.51	5.71	4.20	19.5	22.8
SEM	0.070	0.018	0.149	0.139	1.84	1.87
P-*value*						
F-value	$F_{3,175}$ = 0.28	$F_{3,175}$ = 1.40	$F_{3,129}$ = 0.08	$F_{3,129}$ = 0.04	$F_{3,122}$ = 0.38	$F_{3,121}$ = 0.30
Treatment	0.837	0.244	0.973	0.989	0.769	0.824
F-value	$F_{1,175}$ = 9.50	$F_{1,175}$ = 2.02	$F_{1,129}$ = 5.03	$F_{1,129}$ = 15.22	$F_{1,122}$ = 4.08	$F_{1,121}$ = 6.93
Parity	0.002	0.155	0.025	< 0.001	0.046	0.010
F-value	$F_{1,1808}$ = 0.96	$F_{1,1807}$ = 0.93	$F_{1,1115}$ = 0.28	$F_{1,1116}$ = 0.25	$F_{1,122}$ = 0.27	$F_{1,121}$ = 0.59
Treatment × Parity	0.410	0.428	0.840	0.861	0.847	0.625

[1] Oral supplementation treatments: CON = control group with no extra management to piglets; SPLIT = Split-nursing of the bigger piglets of the litter for 2 h allowing SP piglets free access to teats; COL = Oral supplementation with 15 ml of sow colostrum to the SP piglets of the litter; EN = Oral supplementation with 3 ml of an energy product to the SP of the litter.

and BW at day 18 analyses. Differences among treatments for litter mortality, and coefficient of variation (CV) for litter BW were also analysed using GLIMMIX procedure of SAS. All the models included oral supplementation as fixed effect and batch was also included as fixed effect when significant, and for CV for litter BW at day 18, the CV for litter BW at day 1 was introduced as covariate.

Results

Back-fat measures two days before farrowing did not differ among treatments neither for primiparous (overall average of 18.2 [± 0.61] mm) nor multiparous sows (overall average of 16.8 [± 0.50] mm). Moreover, no differences for final BF were found among treatments for primiparous (overall average of 14.6 [± 0.51] mm) or multiparous sows (overall average of 14.3 [± 0.47] mm). Total live born piglets, stillborn, and mummified piglets per litter were, respectively, 13.3 [± 0.82], 1.24 [± 0.426], and 0.35 [± 0.212] for primiparous sows and 14.0 [± 0.59], 1.27 [± 0.495], and 0.43 [± 0.166] for multiparous sows, with no differences among treatments.

Bodyweight results for all the piglets (including SP and BP piglets) are shown in Table 1. Piglets born from primiparous sows had lower BW at both day 0 and day 18 than piglets born from multiparous sows (1.29 vs 1.39 [± 0.031] kg, and 5.55 vs 5.74 [± 0.084] kg; $F_{1,175}$ = 9.50; P = 0.002 and $F_{1,129}$ = 5.03; P = 0.025, respectively). Total BW gain from day one to day 18 was also lower for piglets born from primiparous sows compared to piglets born from multiparous sows (3.96 vs 4.24 [± 0.078] kg; $F_{1,129}$ = 15.22; P < 0.001). Coefficient of variation for litter BW did not differ among treatments after cross-fostering (day one) or at day 18 ($F_{3,122}$ = 0.38; P = 0.769 and $F_{3,121}$ = 0.30; P = 0.824, respectively). However, at day one, litters from primiparous sows had lower CV of BW than litters from multiparous sows (17.8 vs 19.7 [± 0.97]%; $F_{1,122}$ = 4.08; P = 0.046); that difference between primiparous and multiparous litters was still in evidence at day 18 (18.6 vs 22.0 [± 1.32]%; $F_{1,121}$ = 6.93; P = 0.010).

Bodyweight and BW gain during lactation (from day one to day 18) for SP piglets are shown in Table 2. Primiparous

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Table 2 Effect of oral supplementation[1] and dams' parity (gilts or multiparous sows) on bodyweight and growth performance for piglets born weighing 1.30 kg or less (SP).

Piglets born weighing < 1.30 kg	Bodyweight at day 0 (kg)	Bodyweight at day 1 (kg)	Bodyweight at day 18 (kg)	Bodyweight gain at day 18 (kg)
CON				
Gilts	1.13	1.15	4.83	3.68
Sows	1.13	1.14	4.89	3.75
SPLIT				
Gilts	1.14	1.15	4.85	3.67
Sows	1.11	1.14	4.91	3.77
COL				
Gilts	1.12	1.20	4.75	3.55
Sows	1.11	1.15	4.93	3.79
EN				
Gilts	1.11	1.16	4.78	3.62
Sows	1.10	1.15	4.83	3.62
SEM	0.036	0.021	0.167	0.162
P-*value*				
F-value	$F_{3,146} = 0.46$	$F_{3,145} = 2.08$	$F_{3,125} = 0.12$	$F_{3,125} = 0.22$
Treatment	0.712	0.105	0.948	0.885
F-value	$F_{1,146} = 0.48$	$F_{1,145} = 5.41$	$F_{1,125} = 0.82$	$F_{1,125} = 0.74$
Parity	0.490	0.020	0.367	0.391
F-value	$F_{1,521} = 0.35$	$F_{1,520} = 1.83$	$F_{1,290} = 0.09$	$F_{1,1291} = 0.34$
Treatment × Parity	0.789	0.141	0.967	0.796

[1] Oral supplementation treatments: CON = control group with no extra management to piglets; SPLIT = Split-nursing of the bigger piglets of the litter for 2 h allowing SP piglets free access to teats; COL = Oral supplementation with 15 ml of sow colostrum to the SP piglets of the litter; EN = Oral supplementation with 3 ml of an energy product to the SP of the litter.

sows' SP piglets had higher BW at day one than multiparous sows' SP piglets ($F_{1,145} = 5.41$; $P = 0.020$). For primiparous sows, oral supplementation with COL enhanced SP piglets' BW at day one compared to CON, SPLIT, and EN SP piglets ($t_{520} = -2.34$; $P = 0.020$, $t_{520} = -2.29$; $P = 0.022$ and $t_{520} = 2.00$; $P = 0.046$, respectively). Within multiparous sows, no differences among treatments were observed for SP piglets' BW at day one. At the end of the experiment no differences among treatments and no differences between parity groups were observed for BW at day 18 or BW gain until day 18. In Table 3, growth results during lactation from BP piglets are shown. BP piglets born from multiparous sows were heavier at day 0 than BP piglets born from primiparous sows ($F_{1,154} = 14.40$; $P < 0.001$), and BP piglets from multiparous sows also had both higher BW at day 18 and more BW gain from day one to day 18 than BP piglets from primiparous sows ($F_{1,128} = 8.22$; $P = 0.004$ and $F_{1,128} = 18.18$; $P < 0.001$, respectively).

Mortality results are presented in Table 4. Within primiparous sows, CON and EN treatments had lower SP piglets' mortality rate (percentage of total SP piglets present in the litter that died before weaning) than SPLIT and COL treatments ($P < 0.001$, respectively), while between CON and EN treatments and between SPLIT and COL treatments there were no differences ($P > 0.05$, respectively). Total mortality rate at the end of lactation did not differ among treatments for multiparous sows ($P > 0.05$) with an overall mean of 11.6 [± 2.15]%; in multiparous sows also no differences were observed among treatments for SP piglets mortality rate ($P > 0.05$) with an overall mean of 20.7 (± 4.94)%. Compared to multiparous sows, primiparous sows had lower total mortality rate (5.4 [± 2.96]% vs 11.6 [± 2.15]%; $P < 0.001$) and lower SP piglets mortality rate (12.8 [± 4.97]% vs 20.7 [± 4.94]%; $P < 0.001$).

Discussion

As expected, primiparous sows' offspring were born with lower BW than multiparous sows' offspring, which is consistent with results observed by Milligan *et al* (2002a). This difference was independent from total born piglets, it was due to lower weights of the bigger piglets rather than to the presence of lighter small piglets in primiparous sows.

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Table 3 Effect of oral supplementation[1] and dams' parity (gilts or multiparous sows) on bodyweight and growth performance for piglets born weighing more than 1.30 kg (BP).

Piglets born weighing > 1.30 kg	Bodyweight at day 0 (kg)	Bodyweight at day 1 (kg)	Bodyweight at day 18 (kg)	Bodyweight gain at day 18 (kg)
CON				
Gilts	1.54	1.68	5.99	4.31
Sows	1.63	1.69	6.15	4.46
SPLIT				
Gilts	1.48	1.67	5.84	4.17
Sows	1.59	1.67	6.22	4.55
COL				
Gilts	1.50	1.71	5.91	4.16
Sows	1.61	1.68	6.27	4.60
EN				
Gilts	1.53	1.69	5.91	4.20
Sows	1.57	1.69	6.15	4.46
SEM	0.042	0.013	0.173	0.164
P-*value*				
F-value	$F_{3,154} = 1.18$	$F_{3,145} = 2.08$	$F_{3,128} = 0.09$	$F_{3,128} = 0.23$
Treatment	0.321	0.252	0.964	0.878
F-value	$F_{1,154} = 14.40$	$F_{1,145} = 0.15$	$F_{1,128} = 8.22$	$F_{1,128} = 18.18$
Parity	< 0.001	0.695	0.004	< 0.001
F-value	$F_{1,1139} = 0.55$	$F_{1,1138} = 0.47$	$F_{1,692} = 0.31$	$F_{1,693} = 0.40$
Treatment × Parity	0.645	0.700	0.815	0.753

[1] Oral supplementation treatments: CON = control group with no extra management to piglets; SPLIT = Split-nursing of the bigger piglets of the litter for 2 h allowing SP piglets free access to teats; COL = Oral supplementation with 15 ml of sow colostrum to the SP piglets of the litter; EN = Oral supplementation with 3 ml of an energy product to the SP of the litter.

Moreover, primiparous sows' offspring also had lower BW and BW gain at day 18 compared to multiparous sows' offspring. Milligan *et al* (2002b) also observed that litters from middle-aged sows had higher mean weaning weights. Such differences might be partly attributed to the previous differences observed at day 0, for birth BW it is known to have an important influence on weaning BW (Casellas *et al* 2004; Pedersen *et al* 2011; Muns *et al* 2013). Carney-Hinkle *et al* (2013) suggested that progeny from first parity sows could have a reduced health status, due to a lower level of immune protection acquired through colostrum/milk, decreasing its growth capacity. Litters from primiparous sows also had lower total and SP piglets' mortality rate than litters from multiparous sows. Our results are not in accordance with Knol *et al* (2002) who found no influence on pre-weaning survival through an increase in parity. In contrast, Roehe and Kalm (2000) found that pre-weaning mortality increased with parity of the dam, although they related the influence of parity on mortality with litter size and individual BW. In our study, litters were fixed at the same number of piglets per litter. Once cross-fostering was completed (day 1), primiparous sows had lower CV for litter BW than multiparous sows. Lower mean birth weight of primiparous sows' offspring could indirectly explain the lower variability observed in primiparous sows' litters for piglets BW. Lower mean birth weight of the litter could represent lower weight of the heavier piglets, thus increasing BW homogeneity within primiparous sows' litters. However, the magnitude of the difference observed for CV for litter BW between primiparous and multiparous sows at day 18 compared to the difference observed at day one, suggests that multiparous sows increased CV for litter BW during lactation to a greater extent than primiparous sows. Since number of piglets per litter did not differ between primiparous and multiparous sows, such an increment of CV for litter BW at day 18 in multiparous sows could be due to different performance of SP and BP piglets' BW during lactation, as it is known that inherent variation in teat productivity can introduce variation in weight gain (Milligan *et al* 2001). Despite the initial differ-

Table 4 Effect of oral supplementation[1] and dams' parity on litter mortality.

Percentage	Total mortality rate	SP mortality rate[2]
CON		
Gilts	5.3	6.8[a]
Sows	9.7	20.3[b]
SPLIT		
Gilts	6.5	23.9[b]
Sows	12.0	20.7[b]
COL		
Gilts	5.5	14.6[ab]
Sows	13.3	18.8[b]
EN		
Gilts	4.2	6.0[a]
Sows	11.5	23.1[b]
SEM	2.24	5.69
P-value		
F-value	$F_{3,128} = 0.53$	$F_{3,128} = 30.05$
Treatment	0.659	< 0.001
F-value	$F_{1,128} = 12.65$	$F_{1,128} = 44.23$
Parity	< 0.001	< 0.001
F-value	$F_{3,128} = 0.53$	$F_{3,128} = 32.11$
Treatment × Parity	0.664	< 0.001

Values with different superscripts differ significantly ($P < 0.05$).
[1] Oral supplementation treatments: CON = control group with no extra management to piglets; SPLIT = Split-nursing of the bigger piglets of the litter for 2 h allowing SP piglets free access to teats; COL = Oral supplementation with 15 ml of sow colostrum to the SP piglets of the litter; EN = Oral supplementation with 3 ml of an energy product to the SP of the litter.
[2] SP piglets mortality rate = percentage of total SP piglets (piglets born weighing 1.30 kg or less) present in the litter that died before weaning.

ences at day one, SP piglets' BW at day 18 did not differ between primiparous and multiparous sows. However, BP piglets' BW at day 18 was heavier in multiparous sows.

At day one, within primiparous sows, SP piglets supplemented with 15 ml of colostrum had higher BW than the SP piglets of CON, EN and SPLIT treatments. Piglets' dependence on early energy and Ig intake through colostrum to overcome neonatal hypothermia, to be able to compete for a teat and keep suckling, and to acquire immune protection is well-documented (Tuchscherer *et al* 2000; Herpin *et al* 2005; Le Dividich *et al* 2005; Quesnel *et al* 2012). Still, colostrum intake during the first 24 h of life is highly variable among piglets and will determine piglets' future growth (Quesnel *et al* 2012). Colostrum supplementation could have been more efficient in improving SP piglets BW at day one than energy supplementation due to the possibility of better absorption at intestinal level (as a result of its composition nature) and also by its Ig content. Moreover, reducing the competition for teat access in the SPLIT treatment would not have been useful without previously supplementing SP piglets with an extra energy source. However, no treatment effect on litter total mortality was observed at the end of lactation for primiparous sows, yet CON and EN had lower SP piglet mortality rate than SPLIT and COL treatments. Dewey *et al* (2008) orally administered 12–20 ml of colostrum to chilled piglets and performed split-nursing for 1 h in litters with more than 12 piglets among various other duties in a 'maximal care' treatment obtaining increased piglets' BW at day 16, especially in low birth weight piglets, and also reducing mortality. In another study, Holyoake *et al* (1995) observed lower mortality of low birth weight piglets after providing them with colostrum supplementation, and after split-nursing litters with more than 12 piglets, among other duties in a 'good supervision' protocol. However, due to their experimental design, it is impossible to assess the individual impact on piglet and litter performance of colostrum supplementation or split-nursing of the litter from the experiments already mentioned. Nevertheless, our results observed in primiparous sows' offspring growth are consistent with our previous findings (Muns *et al* 2010) from which we observed improvements in low birth weight piglets' growth at first day of life when supplemented with 10 ml of colostrum. On the contrary, our mortality results differ from the results observed in Muns *et al* (2010) for piglets supplemented with colostrum. In another study, after supplementing the small piglets with colostrum, Muns *et al* (2014) found a reduction in numbers of dead piglets at weaning in non-homogenised litters but not in homogenised litters. While in the present study total mortality was similar among treatments for primiparous sows, SP piglets' mortality rate was strongly reduced in CON and EN treatments compared to SPLIT and COL treatments. This difference among treatments for SP piglets' mortality rate was not consistent with other experimental results so may be chance; however, as suggested by Vasdal *et al* (2011) in their study, SPLIT and COL treatments could involve more disturbance to litters and sows which could contribute to the mortality results. As we observed in our experiment, SPLIT treatment represented a disturbance to piglets and the dam, handling the piglets, isolating half of the animals, and requiring the presence of the experimenter in the pen twice during the first hours after birth. Moreover, we found that colstrum administration (COL) required a greater amount of time per piglet than the energy product administration (EN), resulting in longer handling of the piglet, and more disturbance to the sow and litter while performing the treatment. Due to its fluidity, colostrum had to be slowly administered to avoid it being poured out of the piglet's mouth, while the energy product had a high viscosity which allowed the piglet to swallow it slowly without it pouring out of its mouth.

Nonetheless, it could have been useful to record mortality and the cause of death, in the first week of life and during the rest

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of the lactation. One of colostrum's most important advantages is that it provides newborn piglets with passive immunity (Rooke & Bland 2002). Knowing that a 15-ml supplement of colostrum is enough to ensure a proper IgG levels in piglets at day 4 of life (Muns *et al* 2014), and assuming that immune status at weaning is directly influenced by the extent of passive immunity through colostrum intake (Quesnel *et al* 2012), animals with enhanced humoral immune protection should have less chance of suffering from inflammatory infections and/or diseases. For the previously mentioned reasons, it may have been of interest to observe the impact of colostrum supplementation on mortality rate and cause of death before and after the first week of lactation. Nevertheless, in this study, we aimed for minimum cross-fostering management in order to observe the genuine impact of oral supplementation on piglets with low birth weight. Our results are in concordance with Muns *et al* (2014), suggesting that cross-fostering might have a determinant influence on the final impact of oral supplemention of piglets with colostrum on piglets' growth and survival.

The lack of effectiveness of the SPLIT treatment in both primiparous and multiparous sows is in accordance with the results from Donovan and Dritz (2000), who only observed a decrease in ADG variation of pigs from birth to weaning with no effects on mortality or final BW after performing split-nursing during the first day of life. Low birth weight piglets are more prone to hypothermia at birth as reduced vigour may compromise suckling capacity (Herpin *et al* 2002). Therefore, removing competition from bigger siblings for a limited time, might not be enough to ensure proper suckling in low birth weight piglets. To ensure product effectiveness, it should be administered more often during the first hours of life, although this would become more labour-intensive on-farm.

Despite the findings regarding litters from primiparous sows, no effect was observed on litters from multiparous sows. Primiparous sows are presumed to have lower colostral immunoglobulin concentrations than higher parity sows due to its lower antigenic exposure (Farmer & Quesnel 2009). Thus, the the oral supplementation of low birth piglets with colostrum obtained from middle-aged sows might provide them not only with early extra energy input but with valuable immunological protection. Such protection will result in a comparative advantage helping to reduce mortality in low birth weight piglets born from primiparous sows. That circumstance may explain the greater impact of colostrum supplementation on piglets from primiparous sows compared to piglets from multiparous sows.

To conclude, colostrum supplementation of low birth weight piglets born from primiparous sows improved their weight on the first day of life, probably through enhancing colostrum intake. However, benefits of colostrum supplementation early in life were not maintained until the end of lactation, suggesting that piglets' oral supplementation with 15 ml of colostrum was insufficient to create a positive response at weaning. Our results also suggest the need for different management protocols for primiparous and multiparous sows' litters. Further studies on the impact of cross-fostering combined with colostrum supplementation on piglet growth and survival from different parity dams are of great interest, and will provide further information on management prioritisation on piglets.

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