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An economical assessment of providing suckling piglets with supplementary milk and prestarter

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Fertility of sows has shown marked increases, especially during the last decade. In order to raise as many piglets as possible without resorting to nursing sows, it is extremely important to provide the piglets with a diet covering all their nutritional needs. This study examined the influence of automatically providing suckling pigs with a supplementary diet of milk and prestarter on the number of weaned piglets, their weight development and on the condition of the sow. The results were used to carry out a cost-benefit analysis. This analysis shows that automatically providing supplementary milk and prestarter led to higher weaning weights. However, the system would only be cost effective if at least 0.65 additional weaned piglets were raised per litter through supplementary feeding.

Keywords
Piglets, supplementary feeding, lactating sows, milk cup

The number of weaned piglets is an important index for the efficiency of piglet production. This economic criterion is positively influenced by high fertility of the sow on the one hand, and the reduction of suckling piglets lost during weaning on the other hand (Täubert and Henne 2003, Roth 2014). The fertility of sows has markedly risen in the last decade, but this also entails risks such as higher mortality of the piglets and a decrease in the daily weight gain of the sucklings (Andersen et al. 2011, Vasdal et al. 2011, Rutherford et al. 2013).

In addition, the combination of weight gain of the piglets and the limited feed intake capacity of the sows leads to an energy deficit in the sows. In order to provide energy for the production of milk, body tissues are utilised, which in turn leads to weight loss in the sow (Roth 2014).

Natural and artificial nursing systems

Pig breeding farms not only move piglets from one sow to another within a weaning group so as to balance the load of raising the young, they also use various nursing systems. On the one hand, it is possible to shift some piglets to a sow whose own young have already been weaned. Supernumerary piglets can thus be raised naturally by a sow – the so called 'natural nurse'. These nurses may already have reached the fourth or fifth week of lactation; in this case, the composition of the milk is not ideal for piglets during their first postnatal week (Knoop 2009).

This problem can be avoided by so called 'serial shifting', i. e. by shifting litters of 1–2 weeks post natum to nurses in their 4th–5th week of lactation. The sow in its 1st–2nd week of lactation thus freed of its litter can be utilised as a nurse for piglets only a few days old (Wiedmann 2012).

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Several manufacturers offer 'artificial nurses' for use on the farm. These systems are similar in principle insofar as they all involve taking the piglets from the sow and raising them in separate pens or boxes. The pens are fitted with an automatic feeding system. However, farmers utilising such a system in Germany are on unsure legal ground as the German regulations for livestock welfare (§ 27(1), Tierschutz-Nutztierhaltungsverordnung) do not permit weaning of piglets before the 4th week post natum. The regulations permit exceptions in which the piglets may be taken from the sow before this time if it is necessary in order to prevent harm or pain to the sow or piglet (Knoop 2009). However, invoking this exception seems dubious as the numerical increase of piglets per litter always seems to provide justification for earlier weaning in praxis (i.e. hunger or lack of milk).

An alternative for aiding the sows in raising their piglets is the 'supplementary feeding of milk and prestarter'. This system entails the installation of milk cups in the farrowing pen, which are supplied with milk through a circular or stub line. This allows all piglets of a litter to stay with the sow and to feed ad libitum on milk substitutes from the milk cup. Since this technical system is used in the farrowing pen with the sow present and the piglets are not weaned before the 4th week post natum (in accordance with § 27(1) of the Tierschutz-Nutztierhaltungsverordnung), it does not infringe German regulations (Späth et al. 2015).

This study thus examines the influence of an automatic feeding system providing supplementary milk and prestarter on the performance and the Body Condition Score of the sows as well as on the weight gain of the piglets. The examination of these parameters related to the animals is complemented by an economic assessment of the system used in the experimental pen.

Animals, material and methods

The study was carried out on a farm in the district of Cloppenburg in Lower Saxony specialising in the production of piglets. The farm has 400 sows and facilities for raising their piglets and fattening pigs. It operates in a triweekly rhythm with a suckling time of four weeks. The sows belong to the Topigs line T 20 and are mated with Piétrain boars.

The experiment was carried out under practical conditions in a weaning pen for 28 piglets from May 13th 2015 to July 22nd 2015. The sows with piglets were fed through a chain feeding system with individual volume control for each sow. During the first week after farrowing, the sows were fed with 4–5 kg of a 13.0 MJ lactation feed. In the following weeks, the amount was raised by 1kg/week to 7–8 kg of the same feed.

The conventional farrowing pens have an area of 2.50 m × 1.80 m. The sows are held longitudinally in a box stand along which a heated lying area for the piglets is situated. In addition to the sow's milk, the suckling piglets are offered a solid prestarter (Culina28 by Bröring) from the 10th day post natum in a bowl placed in the farrowing pen (Figure 1).

Figure 1: Farrowing pen for the experimental group with milk cup; before (left) and during (right) the experiment (Photos: A. Rohe)

20 farrowing pens of the experimental station were used for the study, ten of which held the experimental group and the other ten a control group. The farrowing pens of the experimental group were equipped with the CulinaCupLine-system (by Bröring). The CulinaCupLine is a system used to automatically feed supplementary milk and fluid prestarter through special milk cups which are connected to a mixing system by a ring line. The pens for the control group were identical in construction, but did not contain milk cups.

Apart from the milk cups themselves, the CulinaCupLine consists of a mixing vessel, a stirring unit, a pump, circular lines, a heat exchanger and a control unit. The pump transports the milk through the circular line to the milk cups and then back to the mixing vessel, ensuring that the milk is continually in motion. The return part of the circular line is led through a warm water heat exchanger which keeps the milk at a constant drinking temperature of about 30 °C. The milk cups in the farrowing pens are fitted with a nipple with a backstop and overflow protection. This prevents the spread of germs to other pens and also hinders the piglets from making the milk cups overflow by activating the nipple too often.

Experimental procedure

The experiments were carried out during normal day to day operations of the farm. Directly after farrowing, the individual data of the sows (sow number, litter number) and the litter data (date of farrowing, litter size – number of live-born and stillborn piglets) were recorded for the experimental group and the control group.

On the first day post natum, only the control group underwent litter balancing based on the extensive practical experience of the farm manager in order to have litters homogenous in regard to number and weight of piglets. In the case of large litters (> 12 piglets) with widely differing natal piglet weights, the normal procedure in the farm was followed and the lightest piglets were removed from the group. This procedure led to 13 piglets with an average weight of 1.04 kg (± 0.19 kg) being taken from 8 sows in the control group. These piglets were not taken into consideration during the further course of the study. The sows whose data were used for this study did not suckle any piglets stemming from other litters than their own. The usual litter balancing practised on the farm was deliberately not carried out in the experimental group in order to examine the influence of the automatic supplementary feeding of milk an prestarter compared to the usual practise of the farm.

Data were recorded from 34 sows and their piglets in two successive farrowing periods. 18 of the sows and their litters belonged to the experimental group, 16 sows and their piglets were used as the control group. All piglets in both groups were individually marked with an ear tag on the first day post natum and weighed with a standard digital scale. Additional weightings were carried out on the 9^{th} and 18^{th} day of life (LT) as well as prior to weaning.

The piglets were offered milk substitute utilising the CulinaCupLine system from the second day of life onwards. During the first two days the milk cups were filled manually, so that the piglets came into contact with the milk by their normal inquisitive behaviour (touching with their snouts). The piglets thus knew that there was another source of milk which they later operated autonomously. Twice a day, an amount of milk substitute sufficient for the number of piglets and their size was manually prepared in the mixing vessel of the system. According to the instructions of the manufacturer, the milk was completely drained from the system at least once a day, and the mixing vessel and the circular line were flushed. In addition to the daily flushing with hot water, the whole system underwent a hygiene regime with acidic and alkaline solutions in order to achieve low levels of bacterial load and prevent diarrhoea in the piglets. This was carried out in accordance with the manufacturer's instructions and comprised an acidic cleansing with 1 % PHO CID Ultra solution every three days and an alkaline cleansing with 1 % Clean Super solution after 14 days of use. The whole system was flushed with a 2 % solution of the alkaline cleaner before the second run of the experiment took place.

The milk cups themselves were cleaned on a daily basis using a standard garden hose equipped with a shower head and splash guard. If the cups were heavily soiled, they were cleaned intensively with a brush and alkaline cleaner. The products used for supplementary feeding of the experimental group all belong to the portfolio of the manufacturer of the CulinaCupLine system. CulinaMilk is the milk substitute for piglets which was fed to the piglets in the milk cup from the second day post natum onwards. From the tenth day onwards, the solid prestarter Culina28 was added to mixture in the milk cup. After the sixteenth day, the milk substitute CulinaMilk was replaced in the milk cup by the fluid prestarter CulinaLiquid. The piglets in the control group were only offered the solid prestarter Culina28 the trough in addition to their mother's natural milk (Table 1).

Table 1: Piglets' feed in accordance to group membership

Day of life	Experimental group	Control group
1 to 28	Sow's milk	Sow's milk
2 to 15	Milk substitute (milk cup)	-
10 to 28	Solid prestarter (trough)	Solid prestarter (trough)
16 to 28	Fluid prestarter (milk cup)	-

The amount of milk powder (CulinaMilk) and fluid prestarter (CulinaLiquid) used was recorded on a daily basis during the mixing of the feed.

The sows were classified by sight according to Body Condition Score (BCS) after weaning. The BCS for all animals is determined by the same person using a scale of five points from one ("emaciated") to five ("highly adipose") (Kleine Klausing et al. 1998).

Statistical analysis

The influence of automatic supplementary feeding of milk and prestarter on the number of piglets born, on the litter weight and on the condition score of the sows was analysed using the SAS procedure Mixed (SAS Version 9.4, SAS Institute Inc., Cary, NC, USA). The fixed effects "milk cup" (yes/no), "experimental run" (1/2) and the interaction between the two were taken into consideration.

For the statistical analysis of the piglets' weight gain, the following time periods were used in addition to Total Gain (LT 1–27): Gain 1: LT 1–9, Gain 2: LT 10–18 and Gain 3: LT 19–27. In order to identify the influence of the automatic supplementary feeding with milk and prestarter on the weight gain of the suckling pigs, the fixed effects "milk cup" (yes/no), "experimental run" (1/2), "litter size" (1/2), the covariate "weight at birth" and the random effect "sow" was taken into account. Furthermore, the model was extended by the interaction "milk cup × litter size". The fixed effect "litter size after litter balancing (WW)" is divided into two classes. WW1 contains all piglets from litters with up to 12 members, and WW2 comprises all piglets from litters with 13 or more members after litter balancing. Using the described models, Least-Square Means (LSM) were estimated and tested for significant differences using t-testing. All in all, data from 34 sows and 418 piglets were used.

A cost-benefit analysis was used to calculate the economic efficiency of investing in the described system for automatic supplementary feeding of milk and prestarter. The cost-benefit analysis aims at systematically comparing the benefits and costs of an object undergoing calculation in order to judge its economic efficiency. Benefits in this sense are all monetary outputs of the investment, while the costs comprise all monetary inputs (Musshoff and Hirschauer 2011).

The calculation of economic efficiency was applied to the sow pen with a capacity of 250 sows which was used in the study. The costs for investments in machinery and the additional costs for feed and operating material were computed according figures supplied by the manufacturers. The price for piglets (30.00 Euro) used for the calculation was taken from the listings of the Raiffeisen Viehzentrale eG (RVZ), it represents the average price paid in 2013, 2014 and the calendar weeks 1 to 45 of the year 2015. This price does not include surcharges for quality, quantity or vaccinations (Raiffeisen Viehzentrale Eg 2015), so the specific surcharge paid to the farm on which the study was carried out is explicitly stated in the cost-benefit analysis.

Results and discussion

Influence of supplementary feeding on the performance and Body Condition Score of the sows

The influence of automatic supplementary feeding with milk and prestarter on the number of weaned piglets is shown in Table 2. The number of piglets born alive in both groups lay at 13.55 resp. 13.43 piglets/sow. However, the litter balancing carried out in the control group led to the number of suckling piglets/sow being on average 0.91 lower than in the experimental group. In addition, the litter weight in the experimental group was 0.83 kg higher than in the control group after litter balancing had been carried out there, without this difference being statistically significant.

Table 2: Influence of the milk cups on the performance and Body Condition Score of the sows

Parameter	With milkcup		Without milkcup		P-value (t-testing)
	LSM	SE	LSM	SE	
Number of piglets born/sow	13.54	0.30	13.44	0.32	0.8198
After removing 13 piglets from the group without milk cup					
Number of piglets/sow	13.54	0.28	12.63	0.29	0.0323
Litter weight [kg]	23.13	0.87	22.30	0.92	0.5243
Number of piglets weaned/sow	12.74	0.30	11.75	0.32	0.0321
Litter weight at time of weaning [k]	72.64	1.98	65.04	2.09	0.0133
Litter gain [kg/day]	1.77	0.007	1.53	0.008	0.0264
BCS of the sows at weaning	2.67	0.10	2.56	0.10	0.4639

LSM: Least Square Means
SE: Standard Error

Loss of piglets lay at a similar level in both groups with 6.2 % resp. 6.8 %. At the time of weaning, litter weight was higher by 7.62 kg in the experimental group than in the control group. Pustal et al. (2015) came to similar results. They were able to wean an average of 1.1 additional piglets by utilising the milk cups and they also report an average increase in litter weight of 7.60 kg after four weeks of suckling. In contrast to the present study, Pustal et al. (2015) carried out litter balancing in the experimental as well as in the control group in accordance with the number of fully functional teats of the sows. Litters provided access to a milk cup numbered as many piglets as the sow had functional teats, litters without milk cups numbered one piglet less than the number of functional teats of the mother animal.

There were no significant differences between the BCS of the sows after weaning. By utilising the automatic supplementary milk and prestarter feeding, it was possible to achieve a significantly higher litter weight and to wean more piglets without additional detrimental effects on the body condition of the sows. Pustal 2014 also found that the use of milk cups had no influence on the BCS of the sows.

For the present study, litter balancing was only carried out in the control group. As a precaution, 13 piglets were moved to sows not taking part in the study for their own good on the first day post natum. Because of the litter balancing, the number of 0.99 piglets weaned additionally in the experimental group could not be assigned to the effects of the automatic supplementary milk and prestarter feeding. The question whether these sows could have raised the piglets moved by the farm manager remains open.

Influence of the supplementary feeding on weight gain of the piglets

Piglets with access to a milk cup during the suckling period showed weight gain which was higher by 0.566 kg on average after four weeks of suckling. This higher weight gain was mainly achieved in the period form the 19th to the 27th day of life. Compared to the control group, the weight gain in this period of eight days was significantly higher with 0.486 kg in the experimental group (Figure 2). Up to an age of 18 days, access to the milk cup showed no significant effect on weight development. The study by King et al. (1998) came to similar results. The authors report that supplementary milk feeding up to the 14th day of lactation did not cause differences in growth rates of the piglets. After the 15th day of lactation higher growth rates could be achieved by supplementary feeding. However, Pustal (2014) was not able to show an increase in body mass development of piglets provided with access to milk cups.

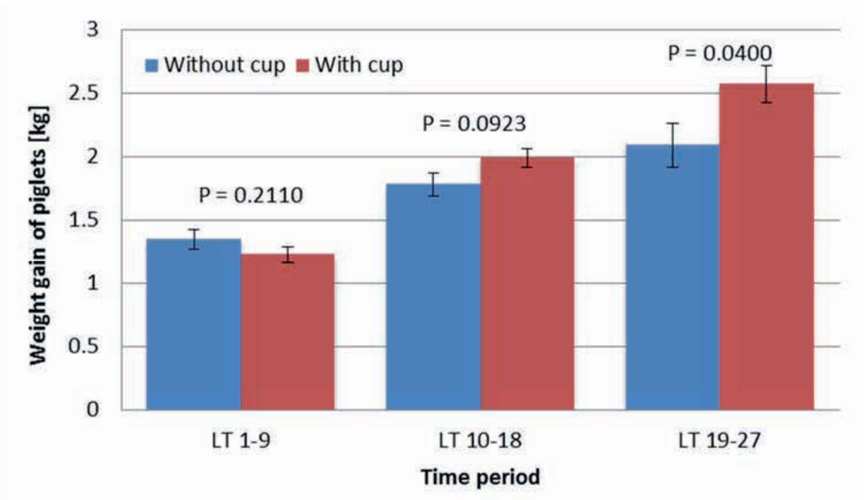

Figure 2: Least Square Means and Standard Errors in weight increase of piglets depending on age and milk cups (n = 418 piglets)

Depending on litter size ("< 13 piglets" resp. "≥ 13 piglets"), the milk cup also had a demonstrable influence. Animal from litters "≥ 13 piglets" without access to milk cups showed significantly lower weight increase than animals from the same class of litter weight who had access to milk cups (Figure 3). Piglets from large litters in the control group also showed a significantly lower weight increase (1.13 on average) than animals from smaller litters. This allows one to assume that the sow is not able to provide large litters with sufficient amounts of milk on her own. In the experimental group, litter size had no influence on the total weight gain of the piglets. During the first age period up to the 9th day of life, the piglets in the experimental group stemming from large litters were significantly inferior to the piglets from small litters in the control group. However, with 2.73 kg these piglets from large litters in the experimental group showed the highest weight gain in the age period from the 19th to the 27th day of life, significantly differing by 0.96 kg from the animals stemming from large litters in the control group.

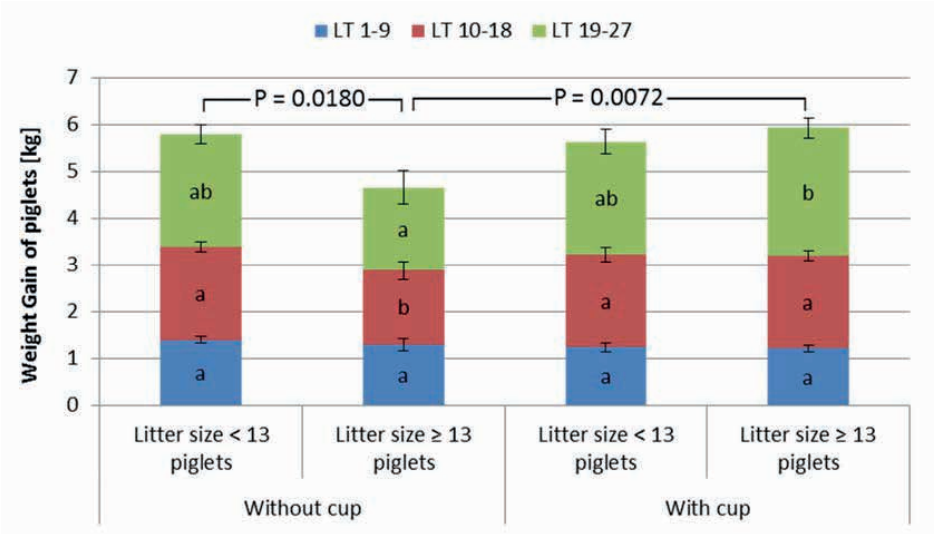

Figure 3: Least Square Means and Standard Errors in weight increase of piglets depending on litter size and milk cups (n = 418 piglets)

Figure 4 shows weight gain depending on birth weight and the appropriate regression lines. Piglets with low birth weight did not profit in regard to weight gain by access to milk cups. Piglets with a birth weight in excess of 1.5 kg do profit from the additional feed offered through the milk cups. This leads to the conclusion that it is not the piglets with lower weights who profit from the milk cup if natural milk is lacking – this would be the desirable result –, but the large, heavier piglets who avail themselves of the milk cups in addition to the milk from the sow.

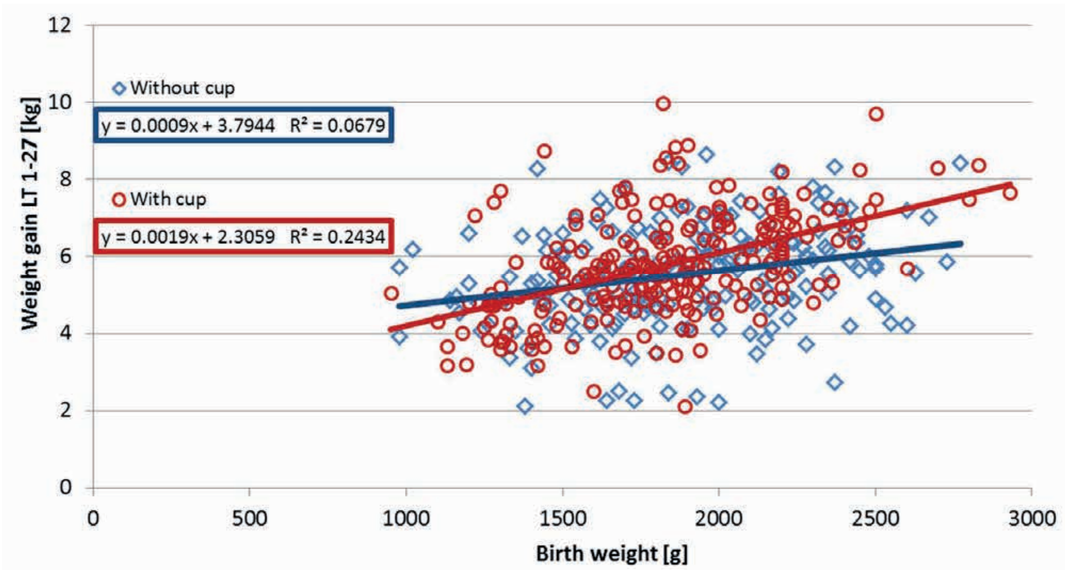

Figure 4: Regression of weight gain up to the 27th day of life to birth weight depending on access to milk cups (n = 418 piglets)

Quantity of artificial milk and fluid prestarter consumed

Figure 5 shows the amount of artificial milk and prestarter consumed per piglet and day in the experimental group. The quantity of artificial milk or fluid prestarter consumed rose continually from the 2nd day of suckling (4.35 g/piglet) to the 27th day of suckling (73.91 g/piglet). The drop in consumption on the 16th day is an exception caused by switching the feed offered. During the complete suckling period, an average of 236.30 g/piglet of artificial milk and 616.52 g of fluid prestarter were used. It can clearly be seen that the consumption of CulinaMilk and CulinaLiquid rises steadily and that the piglets consume an average of 62.17 g of CulinaLiquid in the fourth week of suckling.

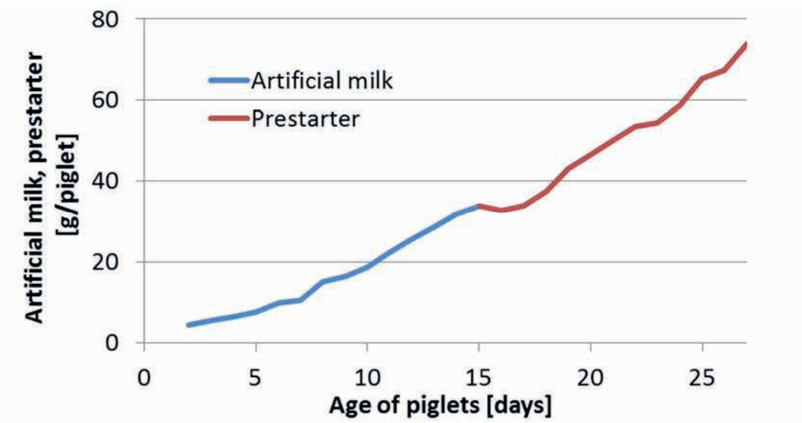

Figure 5: Average quantity of artificial milk and fluid prestarter consumed within the trial period (g per animal and day)

Economical evaluation

Table 3 shows the cost-benefit analysis taking the results of supplementary feeding from the previous chapters into consideration. The calculation of economic efficiency was applied to the sow pen with a capacity of 250 sows which was used in the study.

Based on the number of piglets weaned per sow in the group “without milk cup” (11.75 weaned piglets/sow, Table 2), the number of piglets was computed which would have to be additionally weaned through the use of milk cups for to make a profit. The scenarios computed took 0 to 1 additionally weaned piglets/sow into consideration (in steps of 0.1).

Table 3: Cost-benefit analysis for the CulinaCupLine system for the experimental station (250 sows capacity)

Item		Benefits
1	Litters per year	250 sows × 2.35 litters/year = 588
2	Piglets weaned/year (without milk cup)	588 × 11.75 (cf. Table 2 for the control group)
3	Additional piglets/year through utilisation of milk cup	588 litters × X (X = 0; 0.1;...;0.9;1 piglets additionally weaned)
4	Ø price of piglets + surcharge	30 € + 9 € = 39 €
5	Excess proceeds from sale of piglets	Item 3 × 39.00 €
6	Higher weight gain	0.566 kg × (Item 2 + 3)
7	Excess proceeds through higher weight gain	Item 6 × 1.00 €/kg
8	Sum of benefits	Items 5 + 7
		Costs
9	Depreciation 10 years; 4 % interest	10,540 € × WF[1)]4;10 (0.1233) = 1,300 €
10	CulinaLiquid	0.62 kg × 1.60 €/kg × (Items 2 + 3)
11	CulinaMilk	0.24 kg × 2.60 €/kg × (Items 2 + 3)
12	Daily workload	0.5 h/d × 365 d × 20 €/h = 3,660 €
13	Weekly workload	0.5 h/w × 52 w × 20 €/h = 520 €
14	Electricity	0,75 KW × 8760h × 0,20 €/KWh = 1,314 €
15	Water	43 m³ × 0,85€/m³ =36.55 €
16	Repairs; cleaning	500 € (estimated)
17	Sum of costs	Items 9–16
18	**Total profits**	Difference between items 17 and 8
19	**Profit per sow**	Item 18/250

[1)] WF = Recovery factor, parameters marked in red vary according to the scenario in question.

The table shows the litters per year in the pen with a capacity of 250 sows. The number of litters per year is multiplied by the number of piglets additionally produced through the utilisation of the milk cup (item 3). Then the number of piglets additionally weaned is multiplied by the average price of a piglet (based on a weight of 8 kg) in the past 3 years, augmented by the quality surcharge for the specific farm of 9.00 € (item 5). This computes to the benefits for the additionally weaned piglets. In order to take the higher weight gains into account as well, the total number of piglets weaned per year is multiplied by the additional gain (+ 0.566 kg) effected through supplementary feeding (item 7). The excess proceeds through higher weight gains are taken into consideration as item 7.

On the cost side, the initial item comprises the annual fixed costs of the feeding system. These consist of the depreciation for 10 years and an interest rate calculated as 4 %, totalling 1,300 € per year (item 9). Variable costs are calculated as follows: Items 10 and 11 are the costs for CulinaMilk and CulinaLiquid. Mixing the milk and cleaning the system is calculated at 0.5 h/day, and thorough cleaning of the system at 0.5 h/week, labour costs are taken to be 20 €/h (items 12 + 13). The costs for electricity are computed as 1,312 € and for water at 36.55 € (items 14 + 15). Repairs and costs of cleaning agents are estimated to be 500 € annually (item 16). The total annual costs are computed as the sum of the items 9–16. Profits are calculated as the difference between the benefits and the costs (items 17 and 8).

The results of the scenarios computed are shown in Figure 6. If only the higher weight gain through automatic supplementary feeding of the piglets in the study is taken into consideration, and if no additional piglets are weaned, then a financial loss of 57.92 €/sow is incurred. If 0.65 piglets or more per litter are weaned, the costs for the utilisation of the supplementary feeding system in the study are covered. If the actual increase in productivity is one piglet weaned additionally per litter, then the profit in this example is 31.37 € per sow and year.

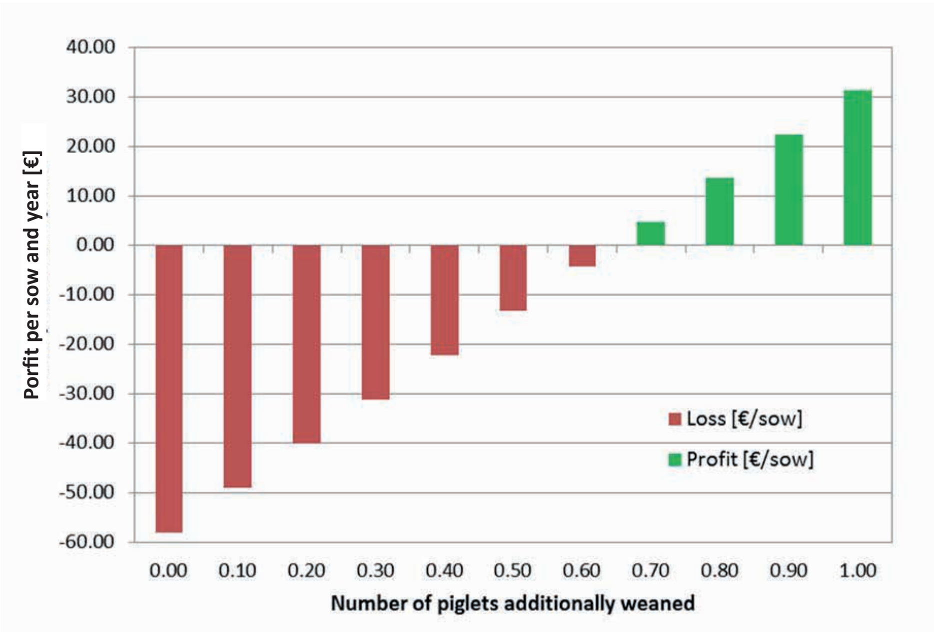

Figure 6: Annual profits or losses [€/sow] resulting from automatic supplementary feeding depending on the number of piglets additionally weaned (model farm with 250 sows)

Conclusions

The CulinaCupLine system is able to combine the advantages of natural and technical nurses. The piglets can stay with their mother in the accustomed surroundings and have access to a milk cup in the farrowing pen, allowing them to permanently feed ad libitum. In the model farm, the automatic supplementary feeding with milk and prestarter led to higher weaning weights (0.566 kg) of the piglets. However, the system would only be cost effective if at least 0.65 additional piglets were weaned per litter through supplementary feeding with milk and prestarter.

However, it was the piglets with a high birth weight which profited most, not the lighter ones as hoped. Towards the end of the suckling period, this caused high weight gains for heavier piglets in particular. These higher gains occurred mainly after the 19th day of life of the piglets and led to a high consumption of liquid prestarter (CulinaLiquid) and thus to high costs. For the end of the suckling period, a less expensive feed would thus be desirable, or a technical solution which would facilitate the utilisation of solid feeds such as solid prestarters of piglet feed.

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