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ECONOMIC EFFICIENCY OF FEEDING PIGLETS WITH MILK REPLACER

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Abstract

The study aimed to assess the impact of additional milk replacer feeding in the first week after weaning on growth, survival, feed efficiency, and economic indicators of piglets' growth. The reduction of weaning age and high multiparity of modern sows cause stratification of piglet litter by weight. This reduces their adaptability to housing and feeding conditions during growth. The inclusion of 130 g of liquid milk replacer per day in the first week after weaning provided 27.4% weight gain, 21.1% weight gain at the time of transfer to fattening, 10.3% improvement in feed conversion, 21.1% increase in piglet market value and 12.2% increase in profitability. At the same time, there was a 3.0% decrease in the cost of feed per 1 kg of gain, a 13.1% reduction in treatment costs, a 3.1% decrease in the price of 1 kg of gain, which contributed to a 2.7% increase in profitability and 6.9% higher profitability. Along with the positive results, a 13.9% increase in daily feed consumption, a 23.1% increase in its cost, 10.3% higher treatment costs, a 23.0% increase in the price of growing a piglet, and a 4.1% lower profitability of growing a piglet was recorded. Therefore, using milk replacer improves piglet productivity but requires additional costs to be considered.

Key words: *economic efficiency, feed cost, income, market value, profitability, pig*

INTRODUCTION

The life cycle of piglets in the industrial pig production system, from birth to slaughter, is filled with transitions between technological groups, the most important of which occurs during weaning. The weaning of piglets is stressful and, simultaneously, a critical period that affects them both socially and physiologically. According to [2, 3, 6, 7], piglets at this time experience dramatic changes in the physical and social

environment, as well as in care and diet. Weaning is traditionally associated with growth retardation and is often accompanied by post-weaning diarrhea [38]. Also, the rapid increase in litter size over the past decade has led to more significant variability in piglet weight within a litter. As a result, piglets are weaned at a lower weight, exacerbating the problems associated with this period. Piglets are weaned from their sows, mixed with other piglets, and as a result, the housing, microclimate, feed and feeding system are changed. All this leads to a high-stress load. A quick and trouble-free weaning period is the key to continued high productivity [10].

Weaning stress may result in decreased feed consumption, slower growth rates, and heightened vulnerability to diseases [46]. Following weaning, piglets undergo significant physiological adjustments, particularly in the structure and function of the gastrointestinal tract [39]. A decline in feed intake during this stage can cause atrophy of the small intestinal villi and a reduction in digestive enzyme activity, which adversely impacts nutrient absorption [1, 44, 50]. When the sow abruptly stops receiving milk, the function and structure of the digestive tract change: the height of the microvilli decreases, the depth of the crypts increases, and the absorption capacity decreases as the activity of the enzymes lactase and sucrase [24, 26] decreases. One method of mitigating this period is using rational feeding in the first days after weaning [45]. Simultaneously, advancements in pig breeding have considerably raised the number of piglets born per sow [7, 45]. As a result, the share of piglets with low weaning weight and potentially lower viability has also increased [33, 34]. Therefore, producers will face the problem of developing additional measures to improve the performance of low-weight piglets at weaning.

The most common way of feeding pigs post-weaning is dry compound feed, used on most pig farms due to its cost-effectiveness and simplicity [32, 35]. At the same time, liquid feeding is popular in European countries. It has its advantages, including improving the gut health of piglets [48], using food industry by-products, and reducing the cost of rearing [36]. Liquid feeds, such as milk replacers or prestarters, contribute to improved piglet weight at weaning and better adaptation to the post-weaning period [6, 30]. Studies show that moistened feed contributes to better hydration, enzyme activation, and faster weight gain in pigs [5]. A different opinion is held [17], which indicates that the consistency of the feed and its hydration level does not affect the growth rate of piglets from 3 days of age to weaning, as well as on the statement [43] - morphological characteristics of their stomachs. At the same time, according to reports [8, 17], feeding piglets with liquid or mash feed after weaning contributes to an increase in consumption compared to feeding the same diet in dry form. While some researchers [3] claim that adding liquid milk replacers to piglets during the suckling period improved growth before weaning but did not affect their growth in the subsequent growing and fattening periods. Also, published studies have confirmed that piglets fed liquid feed had higher average daily gains and better feed intake than counterparts fed dry feed only [12, 27]. In particular, an increase in average daily gains of 300-400 g during finishing and decreased veterinary treatment costs compared to piglets-fed dry feed mixtures were reported [29]. Other researchers [18] have recently shown that liquid feeding of piglets after weaning increases feed intake by 30% during the first 14 days of finishing.

However, at the same time, a number of scientists did not find a significant difference in the impact of different feeding methods on either the average daily gains of piglets [15] or feed conversion ratios [22, 23, 25] using both dry and liquid diets. This opinion is confirmed by [11], who report that liquid feeding of suckling piglets contributed to an increase in their weight before weaning compared to their peers who consumed only dry feed, but this did not subsequently affect their growth during the growing period. Also, it was stated [49] that feeding supplementary milk to piglets from 4 to 11 days after weaning helped reduce the negative effects of weaning and increased feed intake. However, its effect on growth, feed efficiency, and slaughter weight was not found. In support of this it was reported [47] that

feeding milk replacer, started 5 days before weaning, had a more pronounced effect than its introduction after weaning. It contributed to increased average daily feed intake and weight gain and improved feed conversion ratio 4 weeks after weaning. Also, it increased body weight by 1.4 kg at the end of the fourth week of growth compared to pigs that received the replacer only after weaning. It was stated [21] that about 46% of publications reported a positive effect of liquid supplementation of piglets during lactation on their performance before weaning, and 58% of studies noted its beneficial effect on the performance of piglets during the growing period. The best liquid feed for piglets during the growing period is a liquid milk replacer [16, 40]. Liquid supplementation with the same feed that the piglets received before weaning allows them to reduce their stress level after weaning. It was observed that such piglets showed fewer stressful behavioral reactions, which indicates their better adaptation to new conditions [19, 51].

Feeding piglets with liquid milk replacer improves their adaptation to the new diet [4]. It has been proven that using liquid feed in the first days after weaning reduces the risk of gastrointestinal disorders and increases the efficiency of nutrient absorption [49]. In particular, it was indicated [37] that piglets receiving liquid supplementary feeding during finishing had a lower incidence of diarrhea and other digestive disorders than the control group in which piglets consumed dry feed. In addition, using other liquid components allows to reduce the share of cereals in the diet, which is especially relevant in increasing prices for traditional feed [28]. The disadvantage of using liquid milk replacers, as with any liquid feed for pigs, is the possibility of pathogenic microflora spreading in the feed distribution equipment [9]. It is essential to recognize the significance of maintaining a clean and disinfected system, along with ensuring access to high-quality water. This process demands additional oversight and regular upkeep to sustain optimal conditions [14]. Also, liquid feeding of piglets requires additional costs for equipment installation and more qualified labor, but improved piglet productivity and reduced morbidity usually compensate for these costs in full [42]. However, contrary to the above, there is an opinion that supplementary feeding with liquid milk replacers in the first days after weaning requires minimal investment since the equipment for its distribution includes only portable or fixed feeders and additional costs for personnel [18]. However, according to reports [35], the main limiting factor for using milk replacers is their high cost, which accounts for 80–90% of the total cost of liquid feeding. This is estimated to result in additional costs of approximately DKK 430 per sow per year or approximately DKK 12 per weaned piglet. At the same time, the additional economic benefit is DKK 470, of which approximately DKK 300 is provided by increased piglet weight at weaning and DKK 170 by improved survival, equivalent to DKK 14 per piglet.

Therefore, despite the proven benefits of liquid milk replacers, scientists lack consensus regarding their impact on piglet performance and the economic feasibility of using liquid milk replacers during finishing, which requires further research.

The incorporation of liquid milk replacer in finishing piglets' diets can serve as an effective strategy to enhance survival rates and growth, particularly for those with lower birth weights. Research indicates that these piglets tend to exhibit considerably lower average weight gains, less efficient feed conversion, and reduced economic profitability in rearing [20]. It was found that liquid feeding improves feed conversion by 4.99%, reduces feed costs for raising an animal by 3.03%, and contributes to lowering veterinary expenses by 0.67%. At the same time, the feeding method significantly impacts the survival of piglets and feed conversion but does not significantly affect their growth rate [31]. The research demonstrated that implementing liquid and portioned liquid feeding enhances piglet performance, resulting in increased average daily gains (by 4.34–20.62%) and higher final weight at the end of the growing period (by 3.42–15.24%) compared to dry and wet feeding. However, piglet survival rates were slightly lower (by 0.03–0.53%) [41].

This study aims to assess the impact of liquid milk replacer on the adaptation of piglets after weaning, their average daily gains, feed consumption, feed conversion, and economic feasibility, and to determine the impact on the growth rate, survival, feed conversion, and economic efficiency of rearing one piglet and obtaining a unit of gain when feeding low-weight piglets milk replacer in addition to the main ration in the first week of rearing.

MATERIALS AND METHODS

The study focused on evaluating the productive traits and economic efficiency of raising hybrid pigs. These pigs were derived from crossbred sows of the Large White and Landrace breeds of English origin, mated with boars from the PIC-337 terminal line of the same genetic background.

For the research, a subset of low-weight piglets from the technological group at Reproducer No. 2 of LLC "NVP Globinsky Pig Complex" was randomly divided into two groups, ensuring a balanced distribution based on sex. Following group weighing, adjustments were made to equalize the weight distribution between the groups while maintaining the sex balance. Once the weight equalization was complete, piglets from the first group, determined by a counter-day system, were transferred to rearing workshop No. 4 and housed in building No. 1, with each pen accommodating 145 animals. Their counterparts from the second experimental group were transferred to the same complex but to building No. 2 with similar feeding and housing conditions.

The control group of piglets received a traditional diet from the first day of rearing according to the approved norms at the enterprise according to the standard three-phase scheme using the Hydro Mix Pro feed kitchen, where 2.7 parts of water were added to one part of dry compound feed.

The period of the experiment included a period of time of 3 months of 2024, namely: February, March and April. The experiment lasted 57 days. The number of piglets in group I (control) - 1,327, in group 2 (experimental) – 1,320 piglets. The duration of raising piglets in this experiment was 49 days. The average consumption of traditional feed during the growing period (49 days) in the control group was 0.7 kg per head/day. The experimental group's average consumption of experimental feed (Traditional feed and Milk replacer Nutrimilk Power) during the growing period (49 days) was 0.8 kg per head/day.

However, considering that Milk replacer Nutrimilk Power was consumed only 1 week out of 7, the average consumption of Milk replacer Nutrimilk Power without the main component was 0.120 kg per head/day (Table 1).

Table 1. Average feed consumption per day/head during rearing

Rearing period	Control group				Experimental group				
	Traditional compound feed, kg			Total	Traditional compound feed, kg			Milk replacer Nutrimilk Power	Total
	0-9	9-12	12-25		0-9	9-12	12-30		
1 week	0.250	0.0	0.0	0.250	0.220	0.0	0.0	0.120	0.340
2 week	0.420	0.0	0.0	0.420	0.420	0.0	0.0	0.0	0.420
3 т week	0.250	0.270	0.0	0.520	0.250	0.270	00	0.0	0.520
4 week	0.0	0.550	0.120	0.670	0.0	0.550	0.120	0.0	0.670
5 week	0.0	0.630	0.180	0.810	0.0	0.630	0.180	0.0	0.810
6 week	0.0	0.0	0.970	0.970	0.0	0.	0.970	0.0	0.970
7 week	0.0	0.0	1.250	1.250	0.0	0.	1.250	0.0	1.250

Source: own calculations.

The experimental group of piglets from the first day of rearing and up to the seventh day inclusive, in addition to the main diet, was fed the liquid milk replacer Nutrimilk Power using the modernization of the same feed kitchen. Veterinary treatments in the experimental and control groups were carried out according to the same protocol. In each of the experimental

groups, after the formation of the machines, two control machines were allocated, in which 290 piglets were simultaneously located, and these animals were weighed individually at the beginning and the end of rearing.

In both test groups, the intake of compound feed and whole milk replacer was tracked daily using the Hydro Mix Pro feed system, with all data systematically documented in the accounting records for each group. Deviations in the health of the animals and the veterinary care provided to them were also recorded daily. At the end of the rearing period, assessments were conducted based on group weighing, feed consumption records, and animal disposal data to evaluate survival rates, deviations from normal physiological conditions, and the number of piglets requiring veterinary care. Growth performance was analyzed using individual weighing in control units, while group weighing data were utilized to calculate feed conversion efficiency and economic viability in raising low-weight piglets.

Throughout the experiment, generally accepted standards of humane treatment of animals were observed. All procedures were performed by the current legislation on the use of animals in scientific research without causing pain or suffering. The results were analyzed using Microsoft Excel 2016. Values were considered statistically significant at the Student's t-test thresholds: $p<0.05$ – first level, $p<0.01$ – second, $p<0.001$ – third.

RESULTS AND DISCUSSIONS

The rise in sow fertility across most modern genotypes has resulted in greater variation in piglet litter weights at weaning. Consequently, a higher percentage of piglets in each litter exhibit slower growth compared to their peers. As the weaning age of piglets continues to decrease, leading to lower body weights at the start of the rearing phase, it becomes crucial to implement strategies that enhance their adaptability to housing and feeding conditions. One effective approach is extending the feeding of pig milk replacer beyond weaning. In our study, supplementing the piglets' diet with liquid milk during the first week post-weaning resulted in notable improvements in growth rates and feed conversion efficiency.

As presented in Table 1, the initial weight of piglets in both the control and experimental groups was similar at the beginning of the rearing period. However, after seven weeks, piglets in the experimental group demonstrated a significantly greater average weight—5.2 kg more or 21.1% higher than those in the control group—with a highly significant difference ($p<0.001$). This increase can be attributed to the enhanced growth rate observed in the experimental group, where average daily gains were higher by 106 g ($p<0.001$). Consequently, by the end of the rearing period, the absolute weight gain in the experimental group exceeded that of the control group by 5.3 kg ($p<0.001$), resulting in a greater body weight at the transition to the fattening stage. That is, daily consumption in addition to the main diet of about 130 g of liquid milk replacer in the first week after weaning of piglets contributed to an increase of 27.4% in average daily and absolute gains and an increase of 21.1% in the weight of piglets when transferred to fattening (Table 2).

Table 2. Growth rate of piglets on finishing

Indicators	Group of animals	
	I Group-Control 1,327 piglets	II Group-Experimental 1,320 piglets
The number of piglets at the beginning of the study, heads	1,327	1,320
Age of piglets upon placement for rearing, days	20.7	20.7
Average age of piglets at the time of transfer, days	70.1	70.1
Average body weight of an individual piglet at the start of the study, kg	5.1±0.11	5.0±0.09
Survival of piglets, %	96.83	96.77
Average weight of 1 piglet after completion of rearing, kg	24.6±0.36	29.8±0.24***
Absolute gain, kg	19.5±0.36	24.8±0.23***
Average daily gain during the rearing period, g	387±15.6	493±12.4***

Note: *** - $p<0.001$
Source: own calculations.

The variation in piglet growth rates is attributed to differences in feed consumption between the control and experimental groups. As can be seen from Table 3, piglets that were fed milk replacer in the first week in addition to the main diet throughout the growing period consumed 0.1 kg more feed daily. This resulted in 4.8 kg more of its consumption over the entire growing period by one piglet compared to analogs not fed milk replacer.

The variation in growth rates between piglets in the control and experimental groups led to differences in the consumption of feed from various formulations. Since the farm transitions animals to a new diet based on the average group weight, piglets in the experimental group consumed 0.5 kg more of the costliest initial prestarter (0-9 formulation) per pig, while their intake of the second prestarter (9-12 formulation) was 1.0 kg lower. In the final period of rearing, due to the greater intensity of growth, the piglets of the experimental group consumed 4.4 kg more of the cheapest starter feed during rearing compared to the analogs of the control group. Despite the greater daily consumption of feed and the amount consumed over the entire rearing period, the feed conversion in them was better by 0.18 kg due to the higher intensity of growth.

Table 3. Consumption of feed of different formulations for growing piglets and their cost

Indicators	Feeding method	
	I Group	II Group
Milk replacer used per piglet transferred to fattening, kg	0.0	0.9
Prestarter 0-9 used per piglet transferred to fattening, kg	8.6	9.1
Cost of prestarter 0-9 per 1 head, EUR	7.4	70.8
Prestarter 9-12 used per piglet transferred to fattening, kg	11.6	10.6
Cost of prestarter 9-12 per 1 head, EUR	6.0	5.5
Starter 12-25 used per piglet transferred to fattening, kg	14.2	18.5
Cost of starter 12-25 used per 1 head, EUR	5.3	7.0
Total feed used per 1 head, kg	34.4	39.2
Cost of all feed for finished pigs per 1 head transferred to fattening, EUR	18.7	23.0
Average cost of 1 kg of feed during finishing, EUR	0.5	0.6
Average daily feed consumption, kg	0.70	0.80
Conversion of feed for finished pigs, kg	1.76	1.58
Costs for prevention and treatment of 1 head transferred to fattening, kg	9.2	10.1
Costs for feed and veterinary drugs and treatment of 1 head, EUR	18.9	23.3

Source: own calculations.

Due to the use of an expensive milk replacer and a more significant amount of starter feed consumed, the cost of all feeds consumed by animals in the experimental group was 4.32 EUR higher compared to the cost of feeds consumed by analogs of the control group. As can be seen from Table 3. animals in both groups had uneven consumption of feeds of different formulations and, accordingly, their cost. Thus, per head, the cost of milk replacer consumed by an animal in the experimental group was 2.75 EUR, while the control group did not. Additionally, they spent 0.43 EUR more on the first prestarter feed and 1.64 EUR more on the least expensive starter feed, while the cost of the second prestarter feed they consumed was 0.51 EUR lower. Meanwhile, the inclusion of liquid milk replacers led to higher expenses for preventive veterinary measures in the control group, exceeding those of the experimental group by 0.02 EUR. Overall, the total costs for feed and veterinary products in the experimental group were 4.34 EUR greater compared to the control group.

Thus, piglets that continued to be fed liquid milk replacer in the first week of growth, which they were fed during the suckling period, compared to their counterparts that were not fed in this way, consumed 13.9% more feed during the entire growth period, had 23.1%

more feed cost. Still, due to higher absolute gains, they showed 10.3% better feed conversion. Additionally, expenses for disease prevention and treatment were 10.3% higher in the experimental group. The increased feed costs for rearing each piglet contributed to greater operational expenditures, which were 6.20 EUR higher in the experimental group than in the control. However, the greater live weight of the animals in this group at the end of the rearing period led to a market value increase of 15.34 EUR, generating an additional 9.14 EUR in revenue per piglet (Table 4). Considering the almost identical price of a piglet in both groups when placed for rearing and the different costs of the rearing process itself, upon its completion, the cost of one piglet was 5.87 EUR higher in animals that were fed milk replacer in addition to the main diet..

Table 4. Economic efficiency of growing one piglet using different feeding methods

Indicators	Feeding method	
	I Group	II Group
Cost of one piglet when placed for rearing, EUR	23.8	23.5
Cost price excluding VAT of 1 head upon completion of rearing EUR	27.0	33.2
Selling price (excluding VAT) of a single piglet at the end of rearing, EUR	72.7	88.1
Revenue from raising one piglet, EUR	45.7	54.9
Production cost of a piglet at the end of rearing, EUR	50.8	56.7
Profitability of rearing 1 head,%	169.6	165.4
Profit from the sale of 1 head, EUR	21.9	31.4
Profitability of sales,%	43.1	55.4

Source: own calculations.

The unequal cost of growing piglets under different feeding schemes and their different selling price upon completion caused a difference in the profitability of increasing piglets, which was 4.1% better in animals under the standard feeding scheme. In comparison, sales profitability was 12.2% better for animals, for which milk replacer was added to the main diet. Including whole milk replacer in the primary diet of growing piglets led to a 13.9% increase in average daily and total feed intake. However, due to the added expense of the milk replacer, feed costs were 23.1% higher compared to piglets on a conventional feeding regimen. This resulted in a 23.0% increase in the cost of rearing a single piglet and an 11.6% rise in costs by the end of the growth phase. At the same time, improved growth rates during rearing led to a 10.3% better feed conversion. The market price of a piglet at the end of the rearing period was 21.1% higher in the experimental group, contributing to a 12.2% increase in the profitability of selling animals when milk replacers were included in the diet. A radically different picture was observed when analyzing the economic efficiency of obtaining one kilogram of gain in the control and experimental groups (Table 5).

Table 5. Economic efficiency of a unit of gain under different feeding methods

Indicators	Feeding method	
	I Group	II Group
Expenses for whole milk replacer per 1 kg of weight gain, EUR	0.0	0.1
Feed cost per 1 kg of weight gain, EUR	1.0	0.9
Expenditures on treatment and disease prevention per 1 kg of weight gain in pigs transferred to fattening, EUR	0.0	0.0
Total cost of feed and veterinary medications per 1 kg of weight gain, EUR	1.0	0.9
Total production cost per 1 kg of weight gain, EUR	1.4	1.3
Revenue generated per 1 kg of weight gain, EUR	1.6	1.6
Profitability of weight gain during the rearing phase, %	113.9	120.8

Source: own calculations.

Piglets receiving milk replacers consumed 0.18 kg less feed per 1 kg of weight gain, leading to a reduction in feed costs by 0.02 EUR. Furthermore, the expenses for disease prevention and treatment decreased by 0.001 EUR per 1 kg of gain. Although the cost per head was higher, the increased growth rate contributed to a 1.8 kg lower cost per 1 kg of gain in the experimental group. Consequently, the additional revenue per unit of gain was 0.04 EUR higher, leading to a 6.9% improvement in profitability per kilogram gained. Incorporating milk into the primary diet of piglets during growth led to a 10.3% improvement in feed conversion, a 3.0% decrease in feed costs per 1 kg of gain, and a 13.1% reduction in treatment and prevention expenses per 1 kg of gain. Additionally, total expenditures on feed and veterinary drugs dropped by 3.2%, the cost of producing 1 kg of gain per piglet decreased by 3.1%, while profitability increased by 2.7% and overall profitability improved by 6.9%.

Our results indicate that supplementing the main diet with liquid milk replacer during the first week after weaning improved feed conversion, aligning with the findings of [49], who reported that providing additional milk to piglets between the 4th and 11th days post-weaning increased feed intake. However, our findings contradict their conclusion that milk supplementation does not influence growth and feed efficiency, as our study demonstrated increased average daily and absolute weight gains, as well as higher piglet weights at the transition to fattening. Conversely, our results are consistent with the research of [16, 40, 47], which found that feeding milk replacer before and after weaning enhanced daily feed intake, body weight gain, and feed conversion efficiency. Additionally, [21] reported that 58% of studies confirmed the positive impact of liquid milk replacer on piglet productivity during the growing phase. In contrast, our findings do not support the claims of [2], who stated that adding liquid milk replacer had no effect on piglet growth in later developmental stages.

Our conclusions about the higher cost of growing one piglet and its cost at the end of the period due to the high cost of milk replacer are in line with calculations [35] who consider their high cost to be the main deterrent to the use of milk replacers. Our studies also found increased costs for preventive and therapeutic measures for liquid feeding, which coincides with reports [9, 13], who also found additional costs for maintaining the zoohygienic parameters of the milk replacer and other liquid feed distribution systems.

It is appropriate to continue studies using different milk replacer formulations and study the impact on the economic efficiency of further fattening of animals fed liquid milk replacers during rearing.

CONCLUSIONS

Our study demonstrates that incorporating liquid milk replacer into the primary diet during the first week after weaning enhances feed conversion, which is consistent with the findings of [49]. They observed that supplementing piglets with additional milk between the 4th and 11th days post-weaning led to increased feed intake. However, our results contradict their assertion that milk supplementation has no effect on growth and feed efficiency, as we recorded higher average daily and absolute weight gains, along with greater piglet weights at the transition to fattening. On the other hand, our findings align with the studies of [16, 40, 47], which highlight that feeding milk replacer before and after weaning boosts daily feed intake, body weight gain, and feed conversion efficiency. Furthermore, [21] noted that 58% of studies identified a beneficial influence of liquid milk replacer on piglet productivity during the growing phase. Meanwhile, our data contradict the conclusions of [2], who reported no impact of liquid milk replacer on piglet growth in later development stages.

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