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THE EFFICIENCY OF RAISING PIGLETS UNDER DIFFERENT SYSTEMS OF THEIR FEEDING

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Abstract

The article studied the productivity indicators, the effectiveness of the use of feed and medical and preventive means, as well as the economic indicators for the rearing of piglets using dry feeding (from self-breeders), wet feeding (from automatic feeders), liquid feeding (prepared in containers for a building for rearing) and portioned liquid feeding (prepared at each individual automatic feeder). Better indicators of piglet productivity were found with liquid feeding and portioned feeding of piglets by hydration during feeding in the automatic feeder. In liquid feeding, piglets had 4.34–20.62% better average daily and absolute growth, 3.42–15.24% higher weight at the end of the period, but were 0.03–0.53% worse in terms of preservation than analogues using dry and wet feed. When using a liquid feeding system with feed mixture in containers designed for one room, the productivity indicators proved to be lower compared to feeding with portion feeding systems, but they outperformed the animals with dry feeding by 15,6% in terms of average daily and absolute gains and by 11.43% in terms of weight at the end of rearing, and they outperformed analogues consuming moistened feed in the feeder by 10.77% in terms of average daily and absolute gains and by 7.81% in terms of weight of piglets at the end of rearing. Piglets consuming wet feed during rearing were inferior to their liquid-fed counterparts in terms of key productivity indicators, but showed better productivity levels than their dry-fed peers.

Key words**:** *distribution of fodder, feeding, rearing of piglets, liquid fodder, dry fodder*

INTRODUCTION

A key role in raising pigs is played by rational and balanced feeding, which includes not only the correct composition of rations and the creation of an effective feed base, but also the use of modern highly efficient feeding systems [6, 22, 26].

The study of the aspects of feeding pigs enables a drastic increase in their productivity, especially in young animals in fattening, through a scientifically based balancing of rations in terms of energy content and the number of nutrients and biologically active substances [3, 24]. However, even an optimally high energy level and a balanced ration with biologically complete protein through essential amino acids (lysine, methionine, cystine, tryptophan, threonine), macro- and microelements and biologically active substances do not ensure 100% implementation of the fattening program if the producer does not pay the necessary attention to the feeding systems [11, 19, 25]. The organization of pig feeding in today's sense is

a set of complementary and appropriate technologies that can be used in the context of the selected type of feeding, provided that appropriate equipment is available and appropriate methods are followed [23, 33].

Today, there are two main types of pig feeding: liquid, dry, and less frequently, wet feeding in various combinations of water and feed. Until recently, most pig farms preferred dry feeding. This type of feeding was believed to be associated with lower costs for installation and maintenance of equipment [4] and to provide better sanitary and hygienic conditions for the farm [10]. Such a statement is valid only in relation to feeding with granulated compound feed. Modern equipment for dry fodder distribution through feeders combined with drinkers is relatively easy to maintain. It also reduces feed losses and pollution. In addition, modern equipment allows any feed dosing regime and ensures free access for pigs to feed [28]. Feeders of all leading manufacturers are equipped with feeding nipples or nipple drinkers. With their help, pigs can independently determine what consistency of feed to eat. A phase feeding system can be used with dry feeding, but not to the same extent as with liquid feeding. This is due to the limited choice of ready-made rations and the technical capabilities of the facilities [13]. However, pigs eat dry feed much slower than wet feed, which complicates their hierarchical relationship due to the longer duration of the feeding process [1]. Liquid feeding of pigs has been around since ancient times, as food waste traditionally formed the basis of pig feed, even in the era of small-scale pig production [21, 24]. A sharp increase in the number of pigs and the transition to industrial pig farming led to a need for a constant supply of large quantities of feed, which led to the development of technology for obtaining freeze-dried rations. The leader in liquid fattening of pigs among European countries is Ireland (90% of the herd), followed by Germany, Denmark and Holland (up to 50% of the herd). The United States and Canada remain supporters of dry feeding, while liquid feeding systems have been developed in the southwestern United States in recent years and already cover 20% of the pig herd [18, 26]. It should be noted that the advantages and disadvantages of dry feeding are clearer, while there is some lack of information on liquid feeding. Among the main advantages of liquid feeding is the possibility of using cheap waste from the food industry. Considering that 70% of expenditure in pig meat production is on feed, production costs can be significantly reduced by using cheap products in the composition of complete and balanced rations for pigs [21]. Other benefits include: significantly higher consumption of liquid feed compared to dry feed (by 5% or more) [14], improvement in feed conversion (up to 10%) [12], increase in live weight gain by up to 6% [7], faster attainment of slaughter live weight [30], reduction in feed losses [5]. According to published work [6], pigs fed liquid feed consumed it to a greater extent and achieved a higher pre-slaughter weight, higher average daily gains, and had higher meat content in the carcass (14%) than pigs fed dry feed. The liquid feed also met their physiological needs to a greater extent than the dry feed in the post-weaning piglets. In addition, the components included in the liquid ration contain lactic acid bacteria, which ferment the feed mixture, lowering its pH value and thus have a preservative effect. Lactic acid prevents the reproduction of pathogenic microflora in the feed [17, 32]. Modern automated liquid feeding systems, which are currently widely used in European countries, make it possible to ensure the preparation and highly precise dosed distribution of feed to the animals with minimal labour. With liquid feeding, it is also possible to reduce production costs by using cheap food waste [2, 34]. The disadvantages of liquid feeding include the following: high initial investment and qualified personnel are required for process management [29], as the risk of losses can be high if the technology is violated in any of the phases, then the hygienic condition can deteriorate if regulations are violated when cleaning the feed pipe systems [9, 21]. It was also reported that there was no likely difference in feed

conversion between groups of pigs receiving different types of feed based on moisture [20]
An alternative but less common way of preparing feed for growing piglets is to moisten dry feed in feeders. Piglets eat this feed better than dry feed but slightly worse than liquid feed, which also results in higher average daily gains for the animals compared to animals eating granulated dry feed mixes. The degree of feed digestibility is higher with liquid feeding than with wet or dry feeding. Feed conversion is higher than with dry feeding. Feeding young, growing animals in a moistened multiphase procedure followed by liquid feeding contributed to the formation of a certain consumption mode and mechanism of nutrient assimilation in piglets, resulting in more intensive accumulation of intramuscular fat [31]. However, other researchers have reported that feed consistency has no effect on nutrient digestibility in pigs [15], and the effect of wet feed on piglet growth during rearing has not been scientifically proven [16]. Thus, feeding piglets in the growth phase can be done with dry, wet, and liquid feeds, but each of these feeds has its own positive and negative effects on the growth intensity of the animals. Each type of feed is provided by different feeding systems, which differ in technological and organizational aspects and require an unequal amount of labor and financial resources for equipment, maintenance and ensuring efficient production [3, 4, 6, 24, 27]. The scientific study of the results of the use of different feeds, different systems of preparation and supply of growing plants with feed mixtures is constantly carried out and is characterized by diverse conclusions, which do not always coincide. Therefore, further research on the influence of the feed type on the growth of piglets is still urgently needed. Thus, the objective of the experiment is to investigate the relationship between the growth intensity of English-breed piglets and the use of dry, liquid, and wet feeds, as well as various methods of preparation and transportation under the conditions of an industrial pig enterprise.

MATERIALS AND METHODS

The materials for the study were piglets raised by half-breed sows of the Landrace and Large White English breed and boars of the synthetic terminal line PIC 337 of the English company PIC. The object of the study was the productive qualities and efficiency of piglet rearing under different systems of transport and distribution of feed. To conduct the study, four groups of 1,200 piglets each were formed according to the scheme of the experiment (Table 1) in the commercial breeder (No. 2) of LLC "Globinsky Pig Complex", Poltava region, Ukraine.

Table 1. Scheme of the experiment

Indicator	Groups			
	I (control)	II	III	IV
The number of piglets in the group	1200	1200	1200	1200
The number of piglets in pen	150	150	150	150
The method of transporting feed to feeders	Dry compound feed and chain-disc conveyor	Dry compound feed and mechanical, chain-disc conveyor	Liquid compound feed and hydraulic transportation through pipelines using clean water	Dry compound feed and pneumatic transportation using compressed air
A method of preparing a portion of fodder	Without preparation	Preparation in the feeder of the feed machine by the pigs	Preparation in hopper mixers provides liquid feed for each technological group separately.	Feed preparation in a mini-mixer for each individual pen.
Method of feeding fodder	Dry	With moistening in the feeder with the help of sprinklers	Liquid	Liquid
Feeding front for 1 piglet in pen	2.5 centimeters	2.5 centimeters	16 centimeters	16 centimeters

Source: Own calculations.

The animals of all groups were weighed separately when leaving the breeder and after setting up the pens in the breeding workshops. Two control pens were provided in each

experimental group for weighing the animals, which was done individually on the day of introduction into the experiment and at the time of changeover to the next feed recipe for 41 days and after completion of rearing for 70 days of life.

Piglets in all experimental groups were kept under identical conditions, 150 each in a 6 x 8.5 m pen with a warm floor of 0.1 m^2 per animal. Ventilation in all rearing rooms was done with negative pressure through exhaust roof fans and supply air valves. Manure removal was done at the expense of a periodic vacuum gravity system from the trays under the grid floor twice during the growing season.

The filling was performed using 8 height-adjustable nipple fillers and 8 cup fillers placed at a height of 20 cm above the floor.

The animals were fed with fully rational granulated feed produced by LCC "Globynsky Compound Feed Plant", Poltava region, Ukraine. From the day of weaning until reaching an average weight of 9 kg, piglets were fed pelleted pre-stage feed, which was also used during the weaning period. Thereafter, the piglets were switched to cheaper pre-starter feed, which was fed until the piglets reached a weight of 12 kg. After that, the piglets were switched to starter feed, which they received for 70 days of life until the end of the rearing period. The difference between the control and experimental groups was the type of feeding and the distribution of the feed for the piglets.

From the first day of rearing, control group I animals received a dry feed from the American Hog Slat feeders (Photo 1). The feed front was 2.5 cm per piglet that was in the vending pen. The number of feeding places in each automat was 24. The feed was transported to the feeders by a chain and pulley conveyor. The filling of the self-loading bunkers was controlled automatically. In the first days after weaning, to accustom the piglets more quickly to feed intake, the mixed feed was added to the main feeders four times a day and scattered on a solid part of the floor. The piglets were also given a mixture of one part mixed feed and three parts warm acidified water in portable drinkers six times daily. The mixed feed, which the piglets were to learn to eat, was taken from the same bunkers as the feed for the self-feeders. Accounting for the consumed fodder was carried out automatically based on the information obtained from the torsion scales on which the fodder storage hoppers were installed.

Photo 1. Conditions of keeping piglets of group I.
Note: 1 – pipeline, 2 – distribution pipeline, 3 – feeder
Source: processed photo of LLC “Globinsky Pig Complex”

The piglets of experimental group II were kept in the same complex under similar conditions in terms of housing, feeding, maintenance of microclimate, and manure removal (Photo 2). The piglets were fed from Tubomat-type feeders at a ratio of one feeder per 30 piglets. The feed front was also 2.5 cm per animal. The feed transport and distribution in the feeders' hoppers were similar to the animals in the control group. Each feeder was equipped with two feed spreaders, with the help of which the piglets moistened the dry feed in the troughs of the feeders to the desired moisture level. In the first week after being housed in the nursery, the piglets in this group were fed via the floor and the temporary feeders like the animals in the control group. Feed accounting was done automatically using sensors on the torsion scales of the storage bunkers.

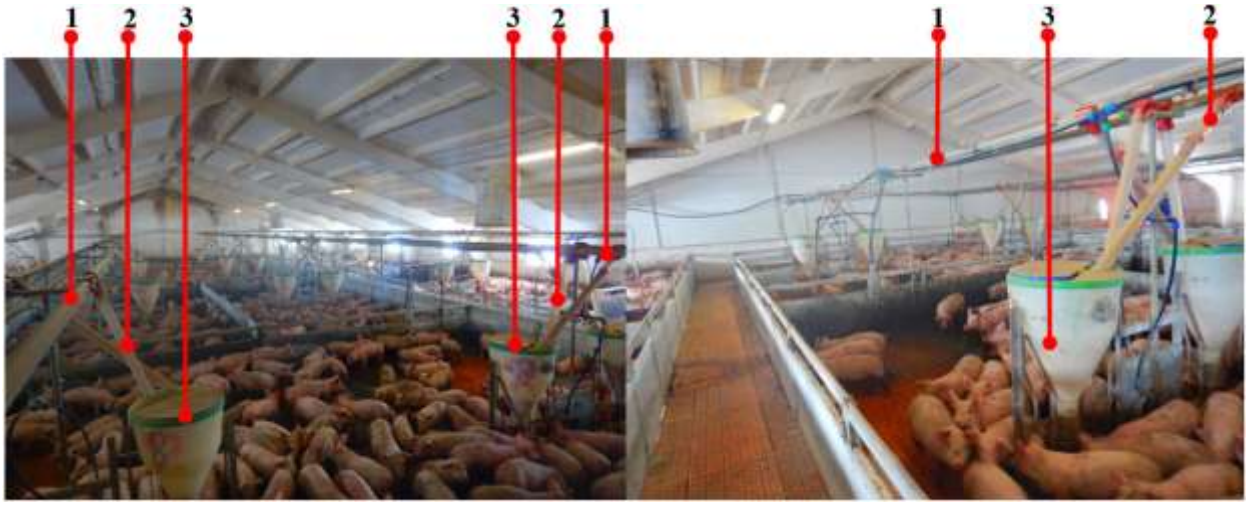

Photo 2. Conditions of keeping piglets of group II.
Note: 1 – pipeline, 2 – distribution pipeline, 3 – feeder
Source: Source: processed photo of LLC "Globinsky Pig Complex".

The animals in experimental group III were kept in similar pens as the first two groups (Photo 3) in the rearing facility (No. 4) with similar systems for maintaining the microclimate, manure removal and watering. Piglets were fed from the first day of rearing with liquid feed mixtures based on the appropriate mixed feed formulas mixed in the feed tanks of the feeding system Hydro Mix Pro of the Big Dutchman company, which consists of two mixing hoppers Mish Tank with a volume of 2 m^3, a tank for waste water, a Waser Tank with a volume of 1.2 m^3 and a Fresh Waser Tank with a volume of 10 m^3. A tank for mixed feed for a barn with 1200 animals. To manage the feed kitchen in automatic mode, the Big Farm Manager computer control system was used, which monitors the distribution, consumption of feed and filling of the feed tanks. This system also records both the dry feed and the supplementary feed added to the piglets' diet. The ratio of dry compound feed to water with tank mixers was automatically maintained at the level of 1 to 2.8 kg. The distribution of the feed portion dispensed from the hopper of the mixer was carried out by means of water transport to the pneumatic valves of the automatic feeder. The feed portion determined by the control system of the feed kitchen was pressed into the feed pipe, where it was transported to the appropriate valve of the corresponding pen with the help of a stream of clean water. By opening the valve, the feed enters the animal feeder. The level of the feeder was monitored by the level sensor. When the feeder was full, it was activated and the feeding system dispenses another portion of the feed. The feed front in this system was 16 cm per head. Feed accounting was done via the feed kitchen management system for

each feeding. The frequency of filling the feeders was 12 times per day.

Photo 3. Conditions of keeping piglets of group III.
Note: 1 – pipeline, 2 – distribution pipeline, 3 – feeder
Source: Source: processed photo of LLC "Globinsky Pig Complex".

The piglets in group IV were housed in a rearing facility (No. 3), where they were kept under identical conditions for maintaining the microclimate, manure removal and feeding, also in pens on a slatted floor with a partially warm floor. The feed was transported to the drinkers, distributed and fed to the piglets in this group from the first day of the experiment using the Spotmix II feeding (Schauer, Austria).

With this system, a feed portion calculated for a pen was put into a micromixer, to which microdoses of probiotics, medicines, acidifiers or other active ingredients were added specifically for the corresponding pen at the request of the control processor.

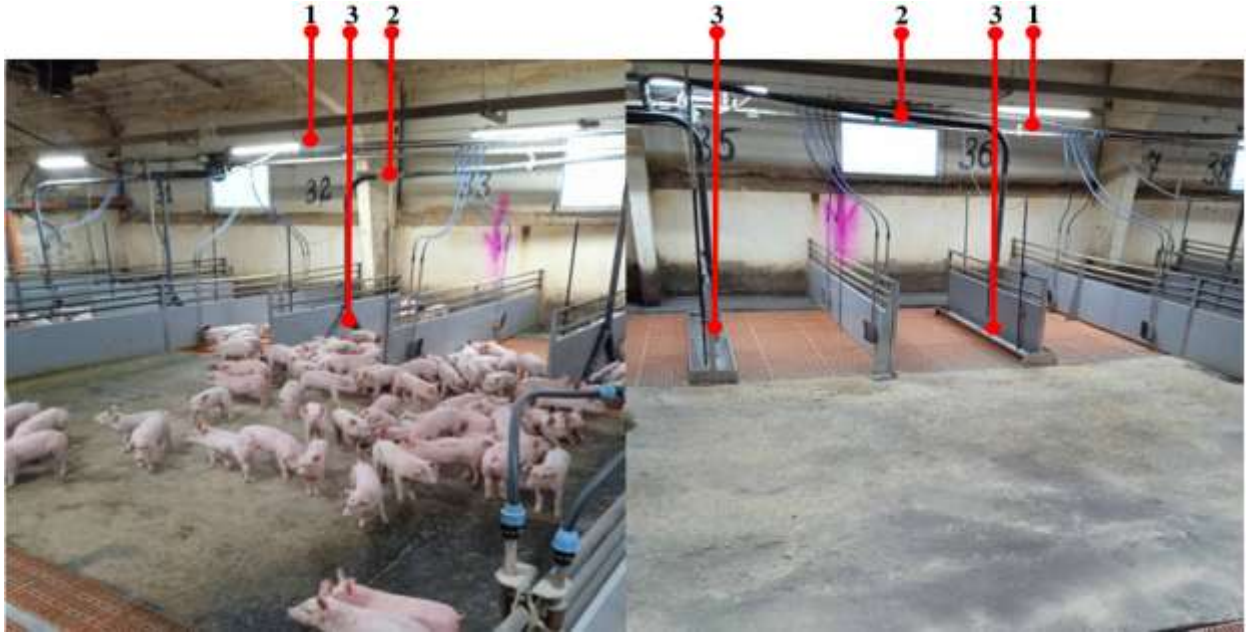

Photo 4. Conditions of keeping piglets of group IV.
Note: 1 – pipeline, 2 – distribution pipeline, 3 – feeder
Source: Source: processed photo of LLC "Globinsky Pig Complex".

This feed portion was then passed in dry form through piping by means of compressed air and a system of rotary joints to a separate feeder, where it was moistened as it was discharged from the piping system to a moisture level that was uniquely determined by the feeding controller.

The feeding front was 15 cm per piglet. The number of feedings was 12 times a day. Feed accounting was carried out by the control system at each mixing and unloading of feed into the pipelines.

The keeping of piglets in the experiment period was humane and in accordance with the policy of Council Directive 86/609/EEC [8]. Data analysis was finished using MS Excel 2016. The reliability of deviations from the average was assessed using the Student's t-test.

RESULTS AND DISCUSSIONS

As shown in Table 2, the weight of the piglets was practically the same when they were housed for rearing, ranging from 0.02 to 0.7 kg. In addition, the piglets were almost the same age when they entered the nursery. In the studies, the age of sows at the end of rearing and at the transition to fattening was almost the same. However, the weight of the piglets during this period differed significantly between the groups with different feeding systems. In our opinion, this was due to the unequal growth intensity of piglets under different feeding systems. The highest average daily weight gain during the rearing period was recorded by the animals of experimental group IV – 446.5 g, which was 18.6 (4.3%) g ($p < 0.05$) higher than in the animals of the experimental group III, by 60.2 (15.58%) g ($p < 0.001$) in comparison with the animals of the experimental group II and by 76.3 g (20.6%) ($p < 0.001$) in comparison with the piglets of the control group. At the same time, piglets in experimental group III were 57.8 g ($p < 0.001$) heavier than their counterparts when fed dry food and 41.6 g ($p < 0.01$) when fed wet food. The latter, in turn, had an advantage of 16.1 g in average daily gains over their peers in the control group.

The higher growth intensity led to inequalities between the animals of the experimental groups in the indicators of absolute growth. The highest value of this indicator was found in the piglets of the experimental group IV, which were transported, dosed and distributed using the portion feeding system Spotmix II. They exceeded the analogs of the experimental group III by 2.04 kg, those of the second experimental group by 2.95 kg, and those of the control group by 3.74 kg for this indicator.

The unequal absolute growth, with practically equal live weight at rearing, also resulted in different weight of piglets at the end of the rearing period.

The piglets in experimental group IV, which were fed liquid feed via the Spotmix II portion feeding system, had the highest weight at this time. The piglets of this group, by live weight at the end of rearing, probably exceeded by 3.68 kg or 15.24% ($p < 0.05$) the analogues of the control group, which received dry, non-moistened feed during rearing, by 2.87 kg or 11.50% ($p < 0.001$), the analogues of the experimental group II, which consumed moistened feed in drinkers, and by 0.92 kg or 3.41% ($p < 0.05$) the piglets of the experimental group III, which were fed with liquid feed mixed in large containers, as when using the drinker Hydro Mix Pro.

The latter, in turn, exceeded the piglets of the control group by 2.76 kg or 11.43% ($p < 0.001$) and the analogues of the II experimental group by 1.95 kg or 7.81% ($p < 0.01$) for this indicator.

At the same time, their peers from experimental group II, which consumed feed moistened in the feeders, outperformed the control group animals at the transition to fattening in terms of live weight by 0.81 kg or 3.35 ($p \geq 0.05$) and were inferior to the analogues of the experimental group III by 1.95 kg or 7.81% ($p < 0.001$) and peers of the experimental group IV by 2.87 kg or 11.50% ($p < 0.001$).

Table 2. Growth intensity and survival of piglets under different feeding systems

Indicator	Groups			
	I (control)	II	III	IV
The weight of the piglets when they are placed for rearing, kg	6.01±0.096	6.03±0.114	5.94±0.123	5.95±0.092
Age of piglets when placed for rearing, days	20.4	20.4	20.2	20.42
Weight of piglets when transferred to fattening, kg	24.15±0.306	24.96±0.312	26.91±0.321***	27.83±0.296***
Age of piglets when transferred to fattening, days	69.4	69.4	69.2	69.2
Absolute growth, kg	18.14±0.276	18.93±0.216*	20.97±0.309***	21.88±0.232***
Average daily growth, g	370.2±9.2	386.3±14.1	428.0±12.9***	446.5±11.3***
Preservation of piglets, %	96.81	96.33	96.06	96.27

* – p <0.05; *** – p <0.001
Source: own calculations.

The preservation of piglets did not show significant variations between experimental groups and proved to be 0.03–0.74% better in dry feeding than in liquid and wet feeding.

Thus, the best performance indicators of piglets during sprinkling were found in liquid feeding of piglets with the Spotmix II device with its batch mixing, pneumatic transport and humidification during feeding in the feeder. The animals in this group had 4.34–20.62% better average daily gains and absolute gains and consequently a 3.42–15.24% higher weight of piglets at the end of the rearing period. At the same time, they were 0.03–0.53% worse than their counterparts using dry and wet feeds in terms of animal survival during rearing.

When using a liquid feeding system with Hydro Mix Pro equipment, where the slurry was mixed in single-room containers and transported to the feeders via pipelines, the performance indicators were slightly lower compared to feeding with Spotmix II systems but outperformed the animals on dry feed by 15.6% in terms of average daily and absolute growth and by 11.43% in piglet weight at the end of the rearing period. Furthermore, piglets with this type of preparation for feed distribution and feeding had an advantage over their peers that consumed moistened feed in the feeder during rearing by 10.77% in average daily gains and absolute gains and by 7.81% in piglet weight at the end of rearing. Piglets fed wet feed during rearing were worse than piglets fed a liquid diet in terms of the main productivity indicators, but had better productivity levels than piglets fed a dry diet. With liquid feeding, piglets had a higher daily feed consumption of 0.05–0.06 kg compared to dry and wet feeding (Table 3).

Table 3. Average daily consumption and consumption of feed for different feeding systems of piglets

Indicator	Groups			
	I (control)	II	III	IV
Spent fodder per head, kg	32.5	32.6	35.0	35.2
Average daily feed consumption, kg	0.66	0.66	0.71	0.72
Feed conversion, kg	1.79	1.72	1.67	1,61
The average price of 1 kg of compound feed, EUR	0.32	0.32	0.31	0.31
Fodder cost of growing 1 piglet, EUR	10.34	10.37	10.97	11.03
Feed cost of 1 kg of gain, EUR	0.57	0.55	0.52	0.50

Source: own calculations.

This naturally led to an increase in their numbers during the rearing of 2.46–2.76 kg per piglet. However, the higher feed intake with liquid feeding resulted in higher growth intensity and consequently larger absolute gains, which contributed to an improvement in feed conversion by 0.05–0.18 kg. This indicator proved to be the best in the piglets of experimental group IV. It was 0.06 kg lower than for the animals in the experimental group

III, 0.11 kg lower than for the animals in the experimental group II and 0.18 kg lower than for the animals in the control group.

The average price of the mixed feed depends on the age at which the weight was reached between 9 and 12 kg. Reaching such weight later, when the animals were switched to cheaper feed, resulting in the average cost of compound feed being EUR 0.005 higher for the piglets in the first two groups.

Despite the lower price of the compound feed, piglets in the liquid feeding group were conspicuous by the higher cost of the compound feed consumed (feed cost) due to its greater quantity. Thus, compared to the analogues of group III, the animals of experimental group IV consumed EUR 0.06 more feed, the peers of group II EUR 0.66 and the piglets of the control group UAH 0.69. At the same time, animals in experimental group III consumed 2.46 UAH less feed than animals in experimental group IV, but EUR 0.59 and EUR 0.62 more than animals in the control and II experimental groups, respectively. Animals consuming unlimited amounts of dry and wet feed ate EUR 10.33 and EUR 10.36, respectively, EUR 0.59–0.69 less than the animals in the dosed liquid feed experimental group.

Despite the higher feed cost for the animals with their dosed liquid feed, the feed cost per 1 kg growth was EUR 0.02–0.06 lower compared to the animals consuming unlimited amounts of dry and wet feed from self-breeders and automatic feeders. Thus, in liquid feeding, the average daily feed consumption was higher by 7.56–8.19%, the feed cost per 1 head per period was higher by 5.78–6.70%, the feed cost for rearing 1 piglet was lower by 5.78–6.70%, but by 2.46–2.76% of feed consumption per 1 kg of growth and by 4.51–11.54% of feed cost.

Different methods of preparing, transporting, and distributing feed have different effects on the health status of piglets and on the economic indicators of their rearing, which was due to the different costs of the equipment itself and its ability to dose feed and medicines into the feed. As can be seen from Table 4, the depreciation costs of feeding equipment were the lowest for dry and wet feeding, as the investment in this equipment was significantly lower. For liquid feeding with mixing in feed bins, this cost per piglet was EUR 0.042–0.043 (81.91–84.69%) higher than for dry and wet feeding. The highest percentage of amortization costs for piglet feeding equipment was found for the Spotmix II liquid feeder. This device had EUR 0.021 (22.10%) more cost per animal compared to liquid feeding with Hudro Mix Pro equipment, EUR 0.063 (122.11%) compared to wet feeding from automatic feeders and EUR 0.064 (125.51%) compared to dry feeding from self–fertilizers.

The share of amortization costs in the cost of a piglet was in the range of 0.14–0.31% and was almost twice as high as in liquid feeding of piglets.

An important factor in piglet rearing was the health condition of the piglets, which has a significant impact on piglet productivity. Maintenance of this condition was done both by preventive measures and by treatment of the animals.

The various systems for transporting and distributing feed have different technical capabilities for incorporating prophylactics into feed. For example, the Spotmix II system doses and mixes the feed for each individual pen and enables more rational use of prophylactic agents in feeding. This contributed to the fact that the animals of research group IV had the lowest costs for the prevention of gastrointestinal diseases, which amounted to EUR 0.072 per piglet. In contrast, in liquid feeding with mixing in large containers, they were higher by EUR 0.060. In dry and wet feeding, this indicator was the highest at EUR 0.152 by EUR 0.019 compared to liquid feeding with Hydro Mix Pro equipment and by EUR 0.08 compared to feeding with Spotmix II equipment.

Lower costs of means for disease prevention contributed to the decrease in the share of preventive measures in the total cost of raising a piglet. Thus, it was almost twice as high in the animals of the experimental group IV compared to the animals of the other groups. This cost in terms of 1 kg growth of piglets

during rearing was almost twice as low compared to animals of group III and almost three times as low compared to animals of groups I and II under liquid portion feeding (experimental group IV).

Table 4. Component costs of raising piglets under different piglet feeding systems

Indicator	Groups			
	I (control)	II	III	IV
Operational cost of raising 1 piglet, EUR	13.26	13.29	14.06	14.14
Expenses for depreciation of equipment per piglet, EUR	0.05	0.05	0.10	0.12
The share of amortization costs for equipment for feeding piglets in the total cost of 1 piglet, %	0.14	0.14	0.25	0.31
Costs for preventive measures per piglet per period, EUR	0.15	0.15	0.13	0.07
The share of costs for preventive means in the cost of rearing 1 piglet, %	1.11	1.11	0.92	0.50
Costs for preventive measures calculated per kg of growth, EUR	0.008	0.008	0.006	0.003
Costs for the treatment of 1 head of piglets during rearing, EUR	0.23	0.26	0.10	0.02
Costs for treatment of diseases during growing up EUR/kg of growth	0.012	0.014	0.005	0.001
The share of the cost of treatment of piglets in the cost of rearing 1 piglet, %	1.65	1.87	0.68	0.15
Costs for preventive and curative measures per head, EUR	0.38	0.41	0.23	0.09
Veterinary cost of 1 kg of gain, EUR	0.021	0.022	0.011	0.004
Costs for feed for piglets, preventive and medical measures per head, EUR	10.72	10.78	11.20	11.13
Fodder and veterinary cost of 1 kg of gain, EUR	0.59	0.57	0.53	0.51

Source: own calculations.

More effective preventive measures contributed to lower morbidity in piglets and, consequently, to lower costs for their treatment. For example, liquid portion feeding with the Spotmix II device (IV experimental group) proved to be almost five times lower in the cost of treating piglets compared to liquid feeding with mixing in the general container and more than ten times lower compared to dry and wet feeding. A similar trend was observed in the cost of treatment per 1 kg of weight gain.

The total cost of preventive and curative measures per animal was the highest in piglets of research group II with EUR 0.409, which was EUR 0.032 more compared to animals of the control group, EUR 0.179 compared to peers of the research group III and EUR 0.316 compared to analogues of the research group IV.

Taking into account the different growth intensity of piglets during rearing under different feeding systems and the unequal costs of prevention and treatment of diseases, the veterinary component of the cost of 1 kg of growth differed significantly between the groups. Thus, this cost was the lowest in the animals of experimental group IV, where EUR 0.004 was spent on veterinary preventive means for 1 kg of live weight gain. In contrast, this indicator was 61.1% higher in research group III. The highest veterinary costs per unit of growth were incurred by piglets in the II research group, for which 8.58% more funds were spent on veterinary preventive measures than in the control group, and by 43.87 and 59.38% compared to the III and IV research groups, respectively.

Contrary to the trend of decreasing expenditure on veterinary preventive measures, the total expenditure on feed and medical and preventive measures was higher in the piglet groups with liquid feeding. Thus, these expenses were the highest in the animals

of experimental group III with EUR 11.19, while they were higher in the piglets of experimental group IV by EUR 0.071, in the animals of experimental group II by EUR 0.419 and in the peers from the control group by EUR 0.480. In the last group, the total cost of feed and medical and preventive measures was the lowest at EUR 10.71. But, taking into account the uneven growth of animals under different feeding systems, the trend of these costs per 1 kg of growth was completely different. Thus, the smallest expenses for feed and veterinary preventive measures per 1 kg of growth were found for piglets of the IV research group to be EUR 0.508, which was EUR 0.025 less compared to the analogues of the research group III and EUR 0.060 and 0.082 compared to the animals of II experimental and I control groups, respectively.

Thus, with liquid portioned feeding with the help of Spotmix equipment, the cost of one piglet after the completion of rearing, costs of equipment depreciation per piglet and their share in the cost of piglets, costs of feed and preventive and medical measures per head turned out to be the highest. At the same time, this method of distributing and feeding animals contributed to the lowest costs for preventive and therapeutic measures per 1 piglet and per unit of gain of piglets and the lowest feed and veterinary cost per 1 kg of gain. In the liquid feeding systems with feed mixture and its moistening in the general container for piglets, the cost of equipment for piglet feeding decreased by 4.77%, its share in the total cost of piglet rearing decreased by 0.06%, but the cost of preventive measures per animal increased by 45.63%, its share in the cost of piglet rearing was 47.90%, the cost of treatment of 1 piglet during rearing was 78.11%, the share of these costs in the cost of rearing and head was 78.06%, the cost of feeding piglets, preventive and curative measures per piglet by 0.64% and at 1 kg increase by 4.77% compared to the group of animals fed with liquid feed with the portion feeding system Spotmix II.

At the same time, transportation of dry feed and unlimited dry and wet feeding of piglets during rearing significantly reduced the depreciation cost of equipment by 81.91–125.51% and its share in the total cost of rearing 1 piglet was by 80.58–122.94%, by 3.23–4.48% of the cost of piglet feed, preventive and therapeutic measures per piglet. At the same time, the cost of preventive and curative measures per piglet increased significantly by 39.05–77.20%, their share in the cost of piglet rearing by 16.13–59.80%, and the cost of a piglet by 62.61–92.84% kilograms of growth compared to liquid methods of piglet feeding.

The decisive factor of modern competitive production is the yield and profitability of production. Considering the high share of feed in the cost of pork, the factor of its rational use is extremely important.

Table 5 shows the income and profitability of breeding pigs using different methods of transporting and distributing feed. As can be seen from this table, at the beginning of the experiment, with almost the same weight of piglets, their market value practically did not differ. The cost of rearing a piglet proved to be similar, although it was EUR 0.59–0.70 higher for liquid feeding compared to dry and wet feeding. At the same time, the animals gained different amounts of live weight during the rearing period and showed significant differences in this indicator at the end of the rearing period. This resulted in a difference in the market value of a piglet at the same market price for 1 kg live weight of the corresponding technological group of piglets.

It was highest in the piglets of the IV experimental group EUR 55.66. In contrast, the animals of experimental group III were cheaper by EUR 1.84 per piglet. At the same time, the animals of the control group fed with dry feed had the lowest sale value and were inferior in terms of this indicator to analogues of the experimental group IV EUR 7.36, peers of the experimental group III EUR 5.52 and to the animals of the experimental group II EUR 1.62. The latter had a market price close to that of the animals in the control group, but cost EUR 3.9 and EUR 5.74 less than the animals in experimental groups III and IV,

respectively. In general, the market price of piglets raised on standardised liquid feed was EUR 3.90 to EUR 7.36 higher than animals fed unlimited dry and wet feed.

Table 5. Profitability of rearing piglets under different piglet feeding systems

Indicator	Groups			
	I (control)	II	III	IV
The cost of one piglet without value-added tax at the beginning of rearing, EUR	23.72	23.80	23.45	23.49
Cost of 1 piglet upon completion of rearing, EUR	37.41	37.56	37.83	37.84
The market value of 1 piglet without value-added tax, EUR	48.30	49.92	53.82	55.66
Income from growing 1 piglet, EUR	10.89	12.36	15.99	17.82
Profitability of growing 1 piglet, %	29.12	32.92	42.26	47.09

Source: own calculations.

Despite the lower cost of raising piglets of the first two groups, the income from their sale turned out to be significantly lower compared to animals that were fattened with liquid feeding, which was caused by their lower market value. Thus, the income from the sale of one pig in the control group amounted to EUR 10.89, while in the II group, it was EUR 1.47, in the III group by EUR 5.09, and in the IV group by EUR 6.92 higher compared to the control.

The highest profitability of rearing piglets was distinguished by indicators in the IV experimental group, 47.09%. While the profitability of production in the III group was lower by 4.84%, the II group by 14.18% and the control group by 17.98%, respectively.

Thus, under the liquid method of distributing fodder and feeding piglets to grow-out piglets, the cost of their growth-out was set to be higher by 0.73–1.15%, their market value was higher by 7.81–15.24%, and higher by 29.31–63.61 % income from the sale of 1 piglet of piglets and the profitability of raising one piglet was higher by 9.14–17.98% compared to unlimited feeding of piglets with dry and moistened fodder.

After analyzing the experimental results, we found that our conclusions regarding the increase in production costs when liquid feed was used do not agree with the reports [2, 21, 34] that talk about a positive effect of liquid feed on reducing the costs of pig production. On the contrary, we found that the cost price of piglets fed liquid and wet feed increased compared to piglets fed dry feed. This trend was explained by the higher cost of technical equipment for liquid feeding compared to the cost of technical equipment for dry feeding. At the same time, the traditional decrease in the cost price of pork due to cheaper liquid feed was not present in our experiment, as the cost of dry and liquid feed was the same.

The evaluation of piglet growth intensity using different feed types showed higher average daily gains in pigs consuming both liquid and wet feed compared to piglets consuming dry feed, which was consistent with the data [6, 7] that had previously indicated a similar effect, and not consistent with the conclusions [16] that claimed the absence of a reliable influence of feed type and moisture level on piglet growth. The use of liquid feeding systems in our study increased the average daily feed intake, which has already been confirmed by other reports [14] and indicates a higher interest in the pigs in liquid feed compared to dry feed. The report [31] of better intake of granulated dry feed moistened directly in the feeder compared to completely dry feed was not confirmed by our data. Contrary to previous reports [20] about the absence of a probable difference in feed conversion between groups of pigs receiving different types of feed based on moisture, in the current experiment we found, on the contrary, an improvement in feed conversion in piglets receiving liquid feed, which was also reported by other researchers in their experimental data [12].

The statement of scientists [9, 10, 21] about the deterioration of the sanitary condition of

the pigsty when using wet feed could not be confirmed in our work, because the increase in the cost of preventive measures and the increase in the cost of treatment were observed in piglets that ate completely dry feed and dry feed followed by moistening in the feeder, and these indicators were lower in piglets fed liquid and wet feed. Usually, the deterioration of hygienic conditions in a pig house, where liquid feed was used, is detected when the technique of cleaning the equipment from feed residues is violated, so it is more likely to be a coincidence or a negligent attitude of the staff to their work [9, 21]. However, the level of preventive costs and the level of costs for the treatment of piglets is only an indirect sign characterising the sanitary and hygienic condition of the pig house, although they are often linked. The investigation of the effects of liquid feed on hygienic conditions in pig farming must therefore be examined in a further study.

CONCLUSIONS

The best performance indicators of the piglets were obtained with liquid portion feeding of the piglets from the feeder. With this feeding method, piglets had better average daily and absolute gains, higher weight at the end of rearing, but poorer preservation compared to their counterparts that consumed dry and wet feed.

When using a liquid feeding system with feed mix in containers designed for one room, piglet productivity proved to be lower compared to feeding with portioned feeding systems, but higher than that of animals fed dry feed.

When fed with moistened feed in feeders, the piglets were inferior to their liquid-fed peers in terms of dew intensity and feed conversion, but showed a better productivity level compared to their dry-fed peers.

For liquid feeding, compared with unlimited dry and wet feeding, average daily feed consumption, feed cost per 1 piglet, and feed cost for rearing 1 piglet were higher, but feed cost per 1 kg of growth and feed cost were lower.

For liquid feeding, higher cost per animal, cost of equipment depreciation and its share in piglet cost, cost of feed per animal and lower cost of preventive and therapeutic measures per animal and per unit of growth, feed cost and veterinary cost per kg of growth were found compared to unlimited dry and wet feeding.

For the liquid method of feed distribution and feeding piglets to nursery piglets, higher nursery costs, higher market value, higher income from the sale of 1 piglet, and higher profitability of raising a piglet were found compared to unlimited feeding of piglets with dry and wet feed.

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