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GROWTH INTENSITY AND FEEDING EFFICIENCY OF SURGICALLY AND IMMUNOLOGICALLY CASTRATED MALE PIGS ON A LIQUID TYPE OF FEEDING

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Abstract

In the article, the intensity of growth and preservation of surgically and immunologically castrated boars of the PIC-337 line of English breeding, their fattening qualities, consumption of feed and its cost during their rearing and fattening, and the economic efficiency of using immunological castration. It was established that when piglets were immunocastrated compared to their surgical castration under liquid feeding, average daily gains increased by 1.41% during rearing, and by 9.95%, during fattening and improved feed conversion during rearing by 13.0%, fattening by 3.15% and by 4.90% from birth to slaughter. Immunological castration contributed to the growth of absolute gains during fattening by 9.68% and by 7.70% of the live weight of animals at the end of fattening. At the same time, immunocastrated animals consumed 4.52% more feed during their lifetime, the cost of which was 5.38% higher compared to surgically castrated animals, and taking into account the cost of vaccination, it was 9.04% higher. At the same time, the cost of fodder and vaccine per 1 kg of gain turned out to be higher by only 1.17%. The cost per head of immunocastrated male pigs was 8.30% lower in the growing period, but 10.16% higher in the fattening period and 5.5% in the results of these two periods. As a result, at the end of fattening, the cost of one head was 7.44% higher, and the sales price without VAT was 7.70% higher compared to surgically castrated animals, which made it possible to get 8.00% more income from the sale of one head of animals of this group.

Key words**:** *castration, cost, growth, feed costs, income, pigs, profitability*

INTRODUCTION

Immunological castration of male pigs is currently a widespread practice in the pig industry, however, not yet widely enough compared to surgical castration [3]. At the same time, the use of physical castration is declining, as consumers increasingly criticize the pork production system in the sense of animal welfare [10, 11]. An alternative to surgical castration of pigs is the fattening of uncastrated male pigs and immunocastration. In recent decades, an immune castration method using a gonadotropin-releasing hormone (GnRH) vaccine has been developed and implemented for use in pork production to eliminate boar taint [12, 13]. Immunocastration is designed to address the issue of animal welfare while simultaneously ensuring sustainable and economically viable

pork production [24, 30]. The double vaccine immunocastration procedure is based on using the first injection of a drug to activate the boar's immune system without changing the size or function of the genital organs [18]. The next step is to administer a second dose of the vaccine injection at least 4 weeks later to block the release of GnRH from the hypothalamus and finally stop the production of luteinizing and follicle-stimulating hormones by the anterior pituitary and inhibition of testicular development [13, 19]. Pork producers can benefit from the production of androgens and estrogens by boars, which optimizes the assimilation of nutrients from the feed and the deposition of protein before starting the second dose of vaccine [7]. The period of application of the second dose of the vaccine is of significant importance and affects the probability of occurrence of unpleasant boar odor [4, 16, 17]. According to reports [2], highlighted according to the recommendations of the vaccine manufacturer, the second dose should be administered no later than 4 weeks before slaughter, so that the compounds that cause the boar odor in an uncastrated male can be eliminated by natural metabolism in order to prevent the development of unpleasant smell. Although the main recommendation [2] is to administer the second dose 4-5 weeks before slaughter. Previous studies [1] reported that there is minimal risk of boar taint if pigs are slaughtered within 10 weeks of the second dose of vaccine. Providing secondary immunization as early as 2 weeks before slaughter did not affect average daily gain, feed conversion, carcass quality, and concentrations of boar taint while reducing feed intake and reducing fat deposition [17]. Data from [4] found that surgically castrated and immunocastrated pigs had different carcass weights at slaughter. Longer feeding times in immunocastrated pigs may reduce lean meat yield due to increased subcutaneous fat deposition, but this may be offset by increased intramuscular fat deposition, which may improve pork quality [4]. Higher carcass weight and fat thickness were also reported in immunocastrates compared to surgically castrated counterparts [23].

The effect of immunocastration on growth, performance, and carcass properties depends on feeding method, carcass weight at slaughter, time of immunization, and genotype [20]. According to reports [23, 28], immune vaccination has a positive effect on the average daily gains of fattening pigs. Foreign researchers [21] conducted a study to study the influence of genotypes and sex on growth, productivity, and carcass quality using surgical and immune castration and found higher gains in pigs that were immunocastrated similar to the statements of other authors [26, 33]. Immunocastration to control boar taint offers several advantages for both consumers and agribusiness compared to physical castration. First of all, immunocastration improves animal welfare because it involves no painful procedures and reduces antagonistic, aggressive behavior in male pigs [5, 6]. Comparing the performance of surgically castrated boars with immunocastrated ones, scientists found that feed efficiency and lean meat yield from carcasses were higher in immunocastrated animals [12], which entailed economic and environmental benefits due to reduced feed costs and reduction of nitrogen emissions [15]. Similar statements were made in other works. In particular, it is common knowledge that surgical castration is an inexpensive veterinary procedure compared to immunological one. For its implementation, the farmer does not need to purchase an expensive vaccine or purchase injection equipment and personnel training, organization of veterinary monitoring of subcutaneous reaction in vaccinated piglets [14, 23]. However, surgically castrated males typically consume 10–15% more feed than immunocastrated males to produce the same amount of pork [27], which minimizes the cost of surgical castration. It has already been proven that feed consumption is more effective in immunocastrated wild boars than in surgically castrated ones, which will compensate for the higher costs of the immunological castration procedure [8]. A similar publication [9] reported that the lower cost of production of 1 kg of meat obtained from the carcass of immunocastrates,

compared to the cost of products obtained from surgically castrated counterparts, indicates that during the period of growing boars, from live weight of 30 kg to slaughter farmers in Denmark save 17.7 feed units per head when growing immunocastrates compared to surgical castrates. Similar conclusions were reached by other scientists [32], who proved that the costs of growing boars using immunocastration are compensated by higher animal productivity and better feed conversion. According to the data [29], during the fattening period, the best feed conversion was demonstrated by immuno-castrated animals, which spent 0.09 2.8% less feed per kilogram of growth compared to non-castrated animals and 11.4% compared to surgically castrated animals. A significant overall economic effect on the profitability of individual farms that sold pork from surgical castrates was observed in particular in the USA, due to increased demand for meat obtained in a more humane way [22]. However, other scientists [10, 25] take the opposite position and report that one of the problems of implementing immunocastration is that it can increase operational costs throughout the pork production chain, starting with farms and ending with the final product, as the profit does not always cover the cost of purchasing the vaccine. At the same time, another study became widespread [31], in which the authors established the absence of a significant effect of the use of the immune castration method on the profit of pig farms compared to the surgical method. Thus, despite long-term research and detailed study of the problem, there are still opposing views on the specifics of the influence of the castration method on the intensity of growth of pigs and the economic efficiency of pork production, which prompts further research in this direction, which remains relevant.

The aim of the work was to establish the dependence of the intensity of growth of piglets and to investigate the economic effect of the use of surgical and immune castration methods in the conditions of the industrial pig complex of the steppe zone of Ukraine.

MATERIALS AND METHODS

The research object was the technological processes of growing and fattening hybrid male pigs obtained from half-blood sows of the Great White and Landrace breeds, inseminated with the sperm of terminal boars of the PIC-337 line of English breeding. Productive indicators, feed payment, and economic efficiency of fattening pigs using surgical and immunological castration of pigs served as material for research. The research was conducted in LLC "NVP "Globynsky Pig Complex" of Kremenchuk District, Poltava Region. They were conducted during the farrowing of sows of a weekly technological group with a number of 350 heads at breeding complex No. 2, in the village of Two groups of 300 boars each were selected from Obiznivka (Table 1).

Table 1. Scheme of the experiment

Indicator	**Method of castration**	
	surgical	**immunological**
Group assignment	**Group I**	**Group II**
The number of piglets at the beginning of the experiment, pigs	300	300
Surgical castration in age, days	3	-
The method of feeding piglets during the suckling period	liquid	liquid
Duration of suckling period in piglets, days	21	21
The method of feeding piglets during the growing period	liquid portioned	liquid portioned
Duration of raising piglets, days	51	51
The method of feeding pigs during the fattening period	liquid	liquid
Duration of the first (growing) fattening period, days	50	50
Vaccination with the "Improvak" vaccine at age, days	-	112
Duration of the second (final) fattening period, days	55	55
Revaccination with the "Improvak" vaccine at age, days	-	140
Age of pigs at the end of fattening, days	178	178

Source: own calculations.

In forming experimental groups, two or four normally developed strands of similar weight

were selected from each nest for study. On the first day of life, they were weighed individually and marked with red (control group) and blue (experimental group) number clips. The animals in the first I group (control group) were surgically castrated on the third day of life. The animals in the II group (experimental group) were left uncastrated.

During the weaning period, the piglets of both experimental groups were housed together with their sows in identical farrowing compartments (Foto. 1). During this period, the sows were fed full-rational compound feed for lactating sows, balanced in terms of basic nutrients, produced at the Globino compound feed plant from the company's own cereal raw materials and a mineral-vitamin premix from Cargill. Piglets of both experimental groups were fed liquid pig milk substitute Opticare Milk from the Dutch company Swinco International from the second day of their lives with the help of the Cullina Mix Pro feed kitchen from the Big Dutchman company.

Photo. 1. Conditions for keeping experimental piglets during the suckling period
Source: processed photo of LLC “Globinsky Pig Complex”.

The experimental piglets were kept together with the sow in individual farrowing pens of 1.8 m x 2.5 m in size. Sows were kept fixed in the center of the machine throughout the lactation period.

The microclimate in the farrowing areas was maintained using equipment from the German company Big Dutchman and a negative pressure air exchange system. The creation of suitable conditions for suckling piglets was achieved through the use of special sections with floor heating in the piglet resting room and infrared lamps, which were additionally used in the first days of life.

Manure removal from the premises was carried out by a sewage system, which was used at regular intervals during the cleaning and disinfection phase of the area.

The sows were watered by means of an automatic nipple drinker located on the side of the feeder. The suckling piglets were watered using bowl-shaped automatic drinkers located in the manure area of the machine.

The feed was transported from the storage containers to the feeders by means of a chain-disc conveyor. Dosing was done by continuously operating Sov Max feed dispensers from the company HOG SLAT Ukraine. The sows were fed indefinitely from the second day of their lactation.

The veterinary preventive measures for the animals in the two experimental groups were identical. Throughout the suckling period, the weaning of the piglets in the experimental groups and the weight of the weaned animals were recorded. On the day of weaning, all experimental animals were weighed individually and transported by special vehicles to the piglet rearing workshop No. 3 of LLC "NVP "Globynsky Pig Complex" in the village of Demydovka. In the rearing workshop the experimental animals were placed in separate pens measuring 6 m by 8.5 m, which were located in one section, 150 in each (Fig. 2). Each pen has 60% slotted and 40% solid underfloor heating.

Air was exchanged in the extension by means of a uniform pressurised ventilation system using supply and exhaust air roof fans, the operation of which was coordinated by the control unit.

Manure removal from the tubs under the machines was done at the expense of a periodic sewage system, two times during the study period. For pigs feeding was used 8-feeder and 8-cup feeder.

The piglets in this farm were fed chopped pre-starter mixed feed of formula 0–9 kg, which was also used in the post-weaning period until pigs reached an midle weight of 9 kg. When the average weight of the animals in the group

was 9 kg, they were switched to feeding pre-starter mixed feed with the recipe 9–12 kg.

Photo 2. Conditions for keeping experimental piglets during the rearing period
Source: processed photo of LLC "Globinsky Pig Complex".

When the animals in the group had reached an average weight of 12 kg, they were switched to feeding complete feeds of the 12–30 kg formula produced at the Globino compound feed plant.

The distribution of the feed by the fattening farms, the transport to the feeders and the distribution to the animals as well as the feeding of the piglets of the experimental groups were carried out with the Spotmix II feeding system of the Austrian company Schauer. Feeding was done in liquid lumps in the ratio of 2,700 g of water per 1,000 g of dry feed, the feeding front was 8 cm per head, and the number of feedings reached 22–23 times per day. Fodder accounting for each feed place is carried out by the feed kitchen control system when dry fodder is unloaded into the pipelines. Veterinary, sanitary and preventive measures were the same for piglets of all groups during rearing were carried out according to an identical scheme. Every day during this period, the elimination of experimental piglets and their weight were recorded. After the piglets of both experimental groups reached 72 days after birth, all experimental piglets and piglets were weighed individually, loaded into special cars, and transported for fattening to feedlot No. 3 of LLC "NVP "Globynsky Pig Complex" located near the village of Hrynky placed them in pens on a completely slotted concrete floor, 50 heads in each, at the rate of 0.75 m^2 per head (Fig. 3).

Air exchange in the pig house was performed using a negative ventilation system from the German company Big Dutchman.

Photo 3. Conditions for keeping experimental pigs during the fattening period
Source: processed photo of LLC "Globinsky Pig Complex".

Manure removal from the farm was performed when the grate baths were filled every three to four weeks using a periodic vacuum gravity system. The pigs were watered using 6 automatic drinkers with height-adjustable nipples attached to the side walls of the pens. Preparation, transportation, and distribution of feed to the animals of the experimental groups was carried out with the help of the equipment of the Austrian company Weda using a liquid type of feeding, with a ratio of dry feed to water of 1 to 2.9.

The frequency of feeding during the experiment was 12 times per day, according to the feeding curve programmed in the control system of the feed kitchen. From the 72nd day of life, all the experimental animals were switched for five days to feeding with a compound feed of the recipe Grover 30–60 for the first phase of fattening, produced by the Globyno compound feed plant. Upon reaching the age of 120 days, the animals of both experimental groups were transferred to feed with finishing compound feed recipe 60–90 kg, produced by the Globino compound feed plant, for five days, until they reached an average weight of 90 kg in both experimental groups. At this weight, they were gradually transferred to feeding with finishing compound feed recipe 90-130 produced by

the Globino compound feed plant for the final stage of fattening, which was fed to the animals until the end of fattening. Feed accounting in each machine was carried out automatically with the help of the feed kitchen control system.

Animals in the experimental group were inoculated on the 112th day of life with the Improvak vaccine from Zoetis at a rate of 2 ml per head, and at 140 days of age they were re-administered the same vaccine at the same dose. At the end of feeding, all experimental animals were weighed individually. During the fattening period, all technological and veterinary preventive measures were the same for both experimental groups of animals, also during this period the elimination of pigs and their reasons, the date of elimination, and the weight of the animals that were eliminated were taken into account.

Based on the research results, the growth intensity, the preservation of surgically and immunologically castrated boars and their fattening qualities, payment of feed in stages and their costs during rearing and fattening were determined. Based on these data, the economic efficiency of immunological castration during rearing and fattening of male hybrid pigs in a liquid feeding system was calculated.

The results of the experiment were processed biometrically using application programs in the MS Excel 2016.

RESULTS AND DISCUSSIONS

During the experimental period, uneven productivity was observed in surgically and immunologically castrated pigs (Table 2).

As shown in the research results, the live weight of piglets at the beginning of the experiment was absolutely equal, while the weight of animals in the second group at the end of the weaning period was reliably ($p<0.05$) 0.27 kg or 4.1% higher than that of the peer 1 group.

This was due to the 13 g and 5.1% higher average daily gains in the animals of the experimental group, which in turn led to a 0.27 kg and 5.1% ($p<0.05$) increase in absolute gains during this period and caused higher indicators of piglet weight.

Table 2. Growth, preservation and fattening qualities of surgically and immunologically castrated male pigs, n = 30

Indicator	Group I	Group II
The number of boars in the group at the beginning of the experiment, pigs	300	300
Average weight of experimental animals at birth, kg	1.33±0.013	1.33±0.017
Preservation of piglets in the suckling period, %	94.3	93.67
Average weight of one piglet at weaning, kg	6.62±0.071	6.89±0.113*
Absolute growth of 1 head during the suckling period, kg	5.29±0.071	5.57±0.107*
Average daily growth in the subsucking period, g	252±5.8	265±7.4
Preservation of piglets during the rearing period, %	97.5	98.6
Absolute growth of 1 head during the growing period, kg	23.7±0.11	23.9±0.13
The average weight of 1 head at the end of growing, kg	30.3±0.12	30.8±0.13**
Average daily growth during the growing season, g	461±6.7	467±8.9
Average weight of 1 head of pigs at the end of fattening, kg	124.6±1.24	134.2±1.36***
Duration of fattening, days	105.5	105.1
Average age at weaning, days	177.7	177.2
Preservation of piglets during fattening, %	96.4	97.0
Absolute growth of 1 head for fattening, kg	94.3±1.17	103.4±1.32***
Average daily growth during fattening, g	895±7.2	985±10.3***

* – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$
Source: own calculations.

In addition, 0.63% better preservation in the post-weaning period was observed in non-castrated piglets, probably related to the absence of postoperative stress and postoperative complications.

During the growth period, the intensity of growth was almost the same in both groups, probably due to the stress of the piglets after weaning. This resulted in almost equal absolute growth during the growth period. However, the live weight of the pigs at the

end of this period was reliably ($p<0.05$) 0.5 kg or 1.7% higher in the non-castrated boars compared to their castrated counterparts, mainly due to higher absolute growth in the post-weaning period.

At the same time, the preservation of piglets, in contrast to the weaning period, in the growing period was 1.1% worse in the experimental group compared to the control group.

A completely different picture was seen during the pig fattening period. During this period, the animals in the experimental group probably ($p<0.001$) had a 90 g or 10.1% higher average daily gain. This, in turn, led to an increase in absolute gains during fattening by 9.1 kg or 9.7% ($p<0.001$), contributing to an increase in the average live weight of the animals on the 177th day of life by 9.6 kg or 7.7%.

It should also be noted that immunocastrated animals were 0.6% better preservation during the fattening period compared to surgically castrated animals.

During the growth and fattening period, the animals in the control and experimental groups consumed unequal amounts of feed with different formulations (Table 3). During this period, piglets in the experimental group consumed 0.1 kg or 12.2% less feed per day compared to the castrated animals.

At the same time, the animals in the research group consumed 1.90% more of the first starter and 19.55% more of the second starter per pig compared to the surgically castrated males. At the same time, they consumed 6.27 kg or 18.68% less starter feed than their castrated counterparts. In general, they consumed 5.27 kg (12.39%) less feed during rearing than the surgically castrated boars.

However, taking into account the slightly higher growth intensity in the suspension period and in the period of allocation of the piglets of the experimental group and the lower amount of feed eaten, the recovery in this group was 0.23 kg or 12.9% better than in the surgical castrates.

Table 3. Feed costs of different recipes during the period of rearing and fattening of surgically and immunologically castrated males, n=30

Indicator	Group I	Group II
Average daily consumption of fodder during the growing period, kg	0.82	0.72
Prestarter recipe 0-9 consumed per 1 piglet, kg	4.22	4.30
Prestarter recipe 9-12 per 1 piglet, kg	4.72	5.64
Starter compound feed of recipe 12-25 per 1 piglet was consumed, kg	33.58	27.3
Combined feed was consumed (prestarter and starter for 1 piglet, kg	42.51	37.25
Fodder conversion during the growing period, kg/kg	1.78	1.55
Consumption of grower compound feed recipe 30-60 per 1 piglet transferred to the meat processing plant, kg	58.02	86.38
Consumption of finished combined feed of the recipe 60-90 kg per 1 piglet transferred to the meat processing plant, kg	78.40	81.40
Consumption of finished combined feed of the recipe 90-130 kg per 1 piglet transferred to the meat processing plant, kg	135.59	123.70
Average daily feed consumption during fattening, kg	2.57	2.73
Feed conversion during the fattening period, kg/kg	2.87	2.77

Source: own calculations.

After the transition to fattening, uncastrated piglets consumed 28.36 kg (48.87%) more rearing feed per head compared to surgically castrated piglets. They also ate 3.0 kg (3.82%) more of the first finishing feed, while they ate 11.89 kg (8.77%) less of the 90-130 kg formula finishing feed. In general, immunocastrated piglets ate 14.2 kg (4.52%) less feed per head than surgically castrated piglets during the growing and finishing period.

Considering the different costs of compound feed of different formulations and the unequal consumption in the control and experimental groups, there were different feed costs for rearing and fattening 1 animal (Table 4).

Table 4. Economic efficiency of breeding and fattening of surgically and immunologically castrated piglets

Indicator	Group I	Group II
The cost of the first pre-starter feed for 1 piglet, EUR	4.14	4.22
The cost of the second pre-starter feed for 1 piglet, EUR	2.55	3.05
The cost of starter feed per 1 piglet, EUR	10.89	8.85
The cost of fodder for 1 piglet in the weaning period and the growing-out period, EUR	17.58	16.12
The cost of nursery fodder for 1 delivered piglet, EUR	13.33	19.85
The cost of the first finishing feed for 1 delivered head, EUR	14.39	14.94
The cost of the second finishing feed for 1 delivered piglet, EUR	22.44	20.47
The cost of all feed per 1 piglet, EUR	67,74	71.38
The cost of fodder per 1 kg of growth, EUR	0.55	0.54
The cost of the vaccine per 1 piglet, EUR	0.001	2.480
The cost of feed and vaccine per piglet, UAH	66.79	73.81
The cost of fodder and vaccine per 1 kg of gain, EUR	0.54	0.56

Source: own calculations.

Thus, during the growth period, the feed cost for one piglet was higher by EUR 1.45 or 8.29% for the animals in the control group. During the fattening period, the cost of fattening an animal was EUR 5.09 or 10.17% higher for immunocastrated animals compared to surgically castrated animals due to higher feed consumption in general and especially more expensive feed for rearing and first finishing fattening. However, taking into account the higher growth intensity and greater absolute growth, the feed cost for 1 kg growth was EUR 0.01 or 2.23% lower for immunocastrated males.

At the same time, EUR 2.48 was spent on vaccinating one head of pigs on the farm. The feed cost for a head of immunocastrated pigs thus increases by this amount and amounts to EUR 73.81, which is EUR 6.12 or 9.04% higher than for surgically castrated animals. However, due to the higher growth intensity and the associated larger absolute gains of an animal during growth and fattening, the cost of feed and vaccine per 1 kg of growth was almost the same and amounted to EUR 0.006 or 1.17% higher in immunocastrated pigs compared to surgically castrated ones.

Due to the uneven growth of pigs during ontogeny and the uneven cost of feeding different formulations during this period, the cost of rearing piglets differed at different stages of life (Table 5).

Table 5. Economic efficiency of breeding and fattening of surgically and immunologically castrated piglets

Indicator	Group I	Group II
The cost of one piglet when transferred for breeding, EUR	24.81	25.85
The cost of rearing 1 piglet, EUR	21.98	20.16
Cost of fattening 1 piglet, EUR	64.87	71.46
Cost of rearing and fattening 1 piglet, EUR	86.86	91.64
Cost of one head at the end of fattening, EUR	111.67	119.97
Realization price of one head at the end of fattening without VAT, EUR	211.83	228.14
Income from growing and fattening one piglet, EUR	100.16	108.17
Profitability of raising one piglet,%	89.69	90.16
The cost of fodder and vaccine per 1 kg of gain, EUR	0.55	0.56
The cost of one kilogram of growth, EUR	0.91	0.90
Sales price of one kilogram of gain, hryvnias	1.72	1.72
Income from cultivation and fattening per 1 kg of growth, EUR	0.81	0.81
Profitability of growing one kilogram of growth,%	89.69	90.16

Source: own calculations.

Due to the higher average weight of piglets at weaning, the cost of one piglet at rearing was EUR 1.04 or 4.21 % higher in the experimental group than in the control group.

In turn, the cost of rearing the surgically castrated piglets in the control group was EUR 1.82, or 8.30%, higher than that of the non-castrated ones. The cost of fattening the animals from the experimental group, on the other hand, was higher. For their fattening, EUR 6.59 (10.16%) more was spent in the group of surgically castrated animals than in

the group of immunologically castrated counterparts.

Due to these price variations, this indicator, which is based on the results of rearing and fattening, was EUR 4.77 higher for immunocastrated animals than for surgically castrated ones, or 5.50%. Taking into account the cost of a piglet at the time of rearing, the cost per animal at the end of the fattening period was EUR 8.30 or 7.44% higher for pigs in the second group, while the selling price for an animal in this group was 7.70% or EUR 16.31 higher.

Taking into account the different cost prices and the different selling prices, the proceeds from rearing and fattening of surgically and immunologically castrated male pigs were different. Thus, the revenue from the sale of the animals of the second group was EUR 8.00 or 8.00% higher than that of the animals of the control group. There was also no significant difference between surgically and immunocastrated pigs in terms of a 1 kg increase in live weight. Thus, the feed cost was EUR 0.006 higher in immunocastrated boars, while the cost of 1 kg gain was EUR 0.003 higher in surgically castrated animals. At the same time, the selling price for 1 kg gain in surgically castrated animals is higher by EUR 0.001, while the income from rearing and fattening of immunocastrated pigs is higher by only EUR 0.001 higher for animals of the second group.

In turn, the profitability of obtaining 1 kilogram of growth was only 0.47% higher in immunologically castrated animals. That is, no difference in the economic growth rates of surgically castrated and immunologically castrated pigs has been established.

Thus, immunocastration of piglets compared to surgical castration under liquid feeding was found to increase average daily gain during rearing by 1.41% and during fattening by 9.95% and absolute gain during fattening by 9.68%, improve feed conversion during rearing by 13.0% and during fattening by 3.15% and by 4.90% from birth to slaughter. Immunocastrated animals reached a 7.70% higher weight at the end of fattening than surgically castrated animals.

At the same time, immunocastrated animals consumed 4.52% more feed during their lifetime, the cost of which was 5.38% higher compared to surgically castrated animals, and when the cost of vaccination was taken into account, it was 9.04% higher. The cost of feed and vaccines per 1 kg of gain was 1.17% higher in immunocastrated animals than in surgically castrated animals. The cost of immunocastrated male pigs was 8.30% lower in the rearing phase, but 10.16% higher in the fattening phase, and 5.5% higher in the results of these two phases. As a result, the cost of an animal at the end of the fattening period was 7.44% higher and the selling price without VAT was 7.70% higher than for surgically castrated animals, generating 8.00% more income from the sale of an animal in this group.

Our results regarding increased growth intensity of immunocastrates compared to surgically castrated animals are consistent with data [21, 26, 28, 33] emphasizing improvement in indicators of average daily and absolute gains when immunococulation is used to eliminate boar taint in male pigs. Similar to the results of studies by foreign researchers [12, 15, 32] that indicated an improvement in feed consumption when immunocastration was used, we also obtained data that allowed us to detect an increase in this rate, contradicting other reports that indicated that surgically castrated males tended to consume 10–15% more feed than immunocastrated males [27]. The data [29] on improvement of fattening indicators of immunocastrated piglets based on feed conversion index compared to surgically castrated piglets were also confirmed in our current study, where we obtained better values of this indicator in immunocastrated boars during rearing and fattening.

Contrary to the data of many researchers [9, 22] about the positive effect of using the method of immune castration on the profitability of pork production and contrary to the conclusions of other authors [22] about the decrease in profit when growing immunocastrates, we found no significant difference in the efficiency of rearing and fattening of surgically castrated and

immunologically castrated pigs, as reported by other scientists [31].

CONCLUSIONS

Increase in average daily gains during rearing and fattening, improvement in feed conversion during rearing and fattening and from birth to slaughter, increase in absolute gains during rearing and live weight of animals after completion of rearing, feed consumption and their value in immunocastrated male pigs compared to surgically castrated. The cost of fattening immunocastrated male pigs was found to be higher, as was their selling price, so that a higher revenue could be obtained from the sale of an immunocastrated animal compared with surgically castrated pigs. The profitability of raising a head and a kilogram did not differ significantly among the different castration methods in each animal group.

REFERENCES

[1]Aluwé, M., Degezelle, I., Depuydt, L., Fremaut, D., Van den Broeke, A., Millet, S., 2016, Immunocastrated male pigs: effect of 4 v. 6 weeks time post second injection on performance, carcass quality, and meat quality. Animal, Vol. 10: 1466–1473. https://doi.org/10.1017/S1751731116000434

[2]Andersson, K., Brunius, C., Zamaratskaia, G., Lundstrom, K., 2012, Early vaccination with Improvac: effects on performance and behavior of male pigs. Animal, Vol. 6: 87–95. https://doi.org/10.1017/S1751731111001200

[3]Batorek-Lukač, N., Kress, K., Čandek-Potokar, M., Fazarinc, G., Škrlep, M., Poklukar, K., Wesoly, R., Stefanski, V., Vrecl, M., 2022, Immunocastration in adult boars as a model for late-onset hypogonadism. Andrology, Vol. 10(6): 1217–1232. https://doi.org/10.1111/andr.13219

[4]Boler, D.D., Killefer, J., Meeuwse, D.M., King, V.L., McKeith, F.K., Dilger, A.C., 2012, Effects of slaughter time post-second injection on carcass yields and bacon characteristics of immunologically castrated male pigs. J. Anim. Sci., Vol. 90: 334–344. https://doi.org/10.2527/jas.2011-4071

[5]Bonneau, M., Weiler, U., 2019, Pros and Cons of Alternatives to Piglet Castration: Welfare, Boar Taint, and Other Meat Quality Traits. Animals, Vol. 9: 884. https://doi.org/10.3390/ani9110884.

[6]Brewster, V., Nevel, A., 2013, Immunocastration with Improvac (TM) reduces aggressive and sexual behaviours in male pigs. Appl. Anim. Behav. Sci., Vol. 145: 32–36. https://doi.org/10.1016/j.applanim.2013.01.012.

[7]Brunius, C., Zamaratskaia, G., Andersson, K., Chen, G., Norrby, M., Madej, A., Lundstrom, K., 2011, Early immunocastration with Improvac® – effect on boar taint, hormones and reproductive organs. Vaccine, Vol. 29: 9514–9520. https://doi.org/10.1016/j.vaccine.2011.10.014

[8]Buhr, B., Tonsor, G., Zering, K., Dipietre, D., Cowles, B., de Moraes, P.J.U., 2013, Comprehensive Economic Analysis of Improvest® Adoption by the U.S. Pork Industry. Zoetis Technical Update, June. https://www.
zoetisus.com/products/pork/improvest/pdf/
ImprovestEconomicTechnicalBulletin.pdf., Accessed on August 10, 2023.

[9]Christiansen, M. G., Maribo, H., 2021, Economic aspects of producing castrates, male pigs and immunocastrates. Trial report. SEGES Pig Research Centre, Vol. 123: 1–12. https://pigresearchcentre.dk/-/media/PDF/English-site/Publikationer/Meddelelse_1234_UK.ashx, Accessed on August 10, 2023.

[10]De Roest, K., Montanari, C., Fowler, T., Baltussen, W., 2009, Resource efficiency and economic implications of alternatives to surgical castration without anaesthesia. Animal, Vol. 3(11): 1522–1531. https://doi.org/10.1017/s175173110999051

[11]Di Pasquale, J., Nannoni, E., Sardi, L., Rubini, G., Salvatore, R., Bartoli, L., Adinolfi, F., Martelli, G., 2019, Towards the Abandonment of Surgical Castration in Pigs: How is Immunocastration Perceived by Italian Consumers? Animals : an open access journal from MDPI, Vol. 9(5): 198. https://doi.org/10.3390/ani9050198

[12]Dunshea, F.R., Colantoni, C., Howard, K., McCauley, I., Jackson, P., Long, K.A., Lopaticki, S., Nugent, E.A., Simons, J.A., Walker, J., 2001, Vaccination of boars with a GnRH vaccine (Improvac) eliminates boar taint and increases growth performance1. J. Anim. Sci., Vol. 79: 2524–2535. https://doi.org/10.2527/2001.79102524x.

[13]Gao, H., Liu, K., Zhang, L., Wang, Y., Fu, X., Guo, Y., Bai, M., Shen, Y., Wang, M., 2023, Palmitic acid-modified GnRH-Th epitope peptide immunocastration vaccine (W/O/W adjuvant) can effectively ensure the castration and reduce the smelly smell in boars. Frontiers in veterinary science, Vol. 10: 1174770. https://doi.org/10.3389/fvets.2023.1174770

[14]Jacobs, L., Neary, J., 2020, Castration in the U.S. Swine Industry: Animal Welfare Implications and Alternatives. Virginia Cooperative Extension, Virginia Tech, APSC-174P. https://vtechworks.lib.vt.edu/bitstream/handle/10919/105585/APSC-174P.pdf?sequence=1, Accessed on August 10, 2023.

[15]Kress, K., Millet, S., Labussière, É., Weiler, U., Stefanski, V., 2019, Sustainability of Pork Production with Immunocastration in Europe. Sustainability, Vol. 11: 3335. https://doi.org/10.3390/su11123335.

[16]Kubale, V., Batorek, N., Skrlep, M., Prunier, A., Bonneau, M., Fazarinc, G., 2013, Steroid hormones, boar taint compounds, and reproductive organs in pigs according to the delay between immunocastration and slaughter. Theriogenology, Vol. 79: 69–80. https://doi.org/10.1016/j.theriogenology.2012.09.010

[17]Lealiifano, A.K., Pluske, J.R., Nicholls, R.R., Dunshea, F.R., Campbell, R.G., Hennessy, D.P., Miller, D.W., Hansen, C.F., Mullan, B.P., 2011, Reducing the length of time between slaughter and the secondary gonadotropin-releasing factor immunization improves growth performance and clears boar taint compounds in male finishing pigs. J. Anim. Sci., Vol. 89, 2782–2792. https://doi.org/10.2527/jas.2010-3267

[18]Lin-Schilstra, L., Ingenbleek, P.T.M., 2022, A Scenario Analysis for Implementing Immunocastration as a Single Solution for Piglet Castration. Animals, Vol. 12: 1625. https://doi.org/10.3390/ani12131625

[19]McCauley, I.M., Watt, D., Suster, D., Kerton, J., Oliver, W.T., Harrell, R.J., Dunshea, F.R., 2003, A GnRF vaccine (Improvac) and porcine somatotropin (Reporcin) have synergistic effects upon growth performance in both boars and gilts. Aus. J. Agric. Res., Vol. 54: 11–20. https://doi.org/10.1071/AR02037

[20]Morales, J.I., Camara, L., Berrocoso, J.D., Lopez, J.P., Mateos, G.G., Serrano, M.P., 2011, Influence of sex and castration on growth performance and carcass quality of crossbred pigs from 2 Large White sire lines. J. Anim. Sci., Vol. 89: 3481–3489. https://doi.org/10.2527/jas.2010-3357

[21]Morales, J.I., Serrano, M.P., Camara, L., Berrocoso, J.D., Lopez, J.P., Mateos, G.G., 2013, Growth performance and carcass quality of immunocastrated and surgically castrated pigs from crossbreds from Duroc and Pietrain sires. J. Anim. Sci., Vol. 91: 3955–3964. https://doi.org/10.2527/jas.2012-6068

[22]Morgan, L., Itin-Shwartz, B., Koren, L., 2019, Physiological and economic benefits of abandoning invasive surgical procedures and enhancing animal welfare in swine production. Sci Rep., Vol. 9: 16093. https://doi.org/10.1038/s41598-019-52677-6

[23]Mykhalko, O., Povod, M., Sokolenko, V., Verbelchuk, S., Shuplyk, V., Shcherbatiuk, N., Melnyk, V., Zasukha, L., 2022, The influence of the castration method on meat cuts indicators of pig carcasses. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(3): 451–458. https://managementjournal.usamv.ro/pdf/vol.22_3/Art48.pdf, Accessed on August 10, 2023.

[24]Needham, T., Hoffman, L.C., 2015, Carcass traits and cutting yields of entire and immunocastrated pigs fed protein levels with and without ractopamine hydrochloride supplementation. J. Anim. Sci., Vol. 93: 4545–4556. https://doi.org/10.2527/jas.2015-9183

[25]Niemi, J. K., Ollila, A., Voutila, L., Valros, A., Oliviero, C., Heinonen, M., Peltoniemi, O., 2015, Economic aspects of immunocastration in the pigs. Animal Production, Animal Welfare and Protection of Animal Health. 25th Congress. Nordic view to sustainable rural development, June 16–18, 339–340. https://llufb.llu.lv/conference/NJF/NJF_2015_Proceedings_Latvia-339-340.pdf, Accessed on August 10, 2023.

[26]Oskam, I.C., Lervik, S., Tajet, H., Dahl, E., Ropstad, E., Andresen, Ø., 2010, Differences in testosterone, androstenone, and skatole levels in plasma and fat between pubertal purebred Duroc and Landrace boars in response to human chorionic gonadotrophin stimulation. Theriogenology, Vol. 74: 1088–1098.

[27]Pauly, C., Luginbühl, W. Ampuero, S., Bee, G., 2012, Expected Effects on Carcass and Pork Quality When Surgical Castration Is Omitted – Results of a Meta-Analysis Study. Meat Science, Vol. 92(4): 858–62. https://doi.org/10.1016/j.meatsci.2012.06.007.

[28]Potter, M.L., Tokach, L.M., Dritz, S.S., Henry, S.C., DeRouchey, J.M., Tokach, M.D., Goodband, R.D., Nelssen, J.L., Rowland, R.R., Hesse, R.A., Oberst, R., Anderson, J., Hays, M., 2012, Genetic line influences pig growth rate responses to vaccination for porcine circovirus type 2. J. Swine Health Prod. Vol. 20: 34–43. https://www.aasv.org/shap/issues/v20n1/v20n1p34.pdf, Accessed on August 10, 2023.

[29]Povod, M.G., Shpetniy, M.B., Mykhalko, O.G., Zhizhka, S.V., Pelypenko, A.M., Mikhailik, V.O., 2019, Intensyvnist rostu ta oplata kormiv svynei pry riznykh metodakh kastratsii [Intensity of growth and payment of feed of pigs for different methods of castration]. Visnyk Sumskoho natsionalnoho ahrarnoho universytetu. Seriia: Tvarynnytstvo (in Ukrainian) [Bulletin of Sumy National Agrarian University. The Series: Livestock], Vol. 4(39): 25–36. https://www.researchgate.net/publication/342370036_INTENSIVNIST_ROSTU_TA_OPLATA_KORMU_SAMCIV_SVINEJ_ZA_RIZNOGO_SPOSOBU_KASTRACIIAccessed on August 10, 2023.

[30]Rikard-Bell, C., Curtis, M.A., van Barneveld, R.J., Mullan, B.P., Edwards, A.C., Gannon, N.J., Henman, D.J., Hughes, P.E., Dunseha, F.R., 2009, Ractopamine hydrochloride improves growth performance and carcass composition in immunocastrated boars, entire boars, and gilts. J. Anim. Sci., Vol. 87: 3536–3543. https://doi.org/10.2527/jas.2009-2002

[31]Šprysl, M., Kluzáková, E., Čítek, J., Stupka, R., Zadinová, K., 2019, Economic Aspect of Growing Pigs with Respect to Sex and Immunocastration, AGRIS on-line Papers in Economics and Informatics, Vol. 11(2): 95–102. https://doi.org/10.7160/aol.2019.110209.

[32]Verhaagh, M., Deblitz, C., 2019, Economic viability of alternatives to piglet castration without anesthesia - updating and expanding the business calculations. Braunschweig: Johann Heinrich von Thünen Institute, 56 p, Thünen Working Paper 110, https://doi.org/10.3220/WP1542016654000

[33]Xue, J., Dial, G.D., Holton, E.E., Vickers, Z., Squires, E.J., Lou, Y., Godbout, D., Morel, N., 1996, Breed differences in boar taint: relationship between tissue levels of boar taint compounds and sensory analysis of taint. J. Anim. Sci., Vol. 9: 2170–2177. https://doi.org/10.2527/1996.7492170x