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Original Paper

Influence of enrichment materials on the behaviour and productive traits of fattening pigse

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In industrial complexes, the environment for fattening pigs has limited space and often does not respect natural behaviour of pigs. The implementation of EU legislation in Ukraine requires from farmers to use enrichment materials that improve the welfare of pigs. This article shows possible solution for big industrial challenge – creating of comfortable conditions for pigs, which meet their ethological needs. The experiment was performed on 180 pigs. From 77 days of age, all experimental animals were divided into three groups (on the principle of analogues) of 60 heads in each. As criteria of aggressive social behaviour the fights and biting were chosen. It was found that at the first period of fattening in pigs of the control group (no enrichment materials) 24 cases of biting were registered, in animals with straw blocks (experimental group II) – 6, with plastic bottles filled with grain (experimental group III) – 4 cases. At the second period of fattening, the situation regarding intragroup aggression was identical to the first one, which was reflected by the level of the cortisol in the blood serum. Among pigs that had free access to enrichment materials, a significant increase in their live weight by 2.4–5.8%, and in average daily gain by 1.4–27.6% compared with animals in the control group was registered. This study aims to prove that the use of enrichment materials for fattening pigs helps to identify their natural behaviour in industrial complexes, avoids social aggression, increases productivity and improves their welfare.

Keywords: pigs, welfare, aggressive behaviour; enrichment materials, cortisol level

1 Introduction

The pigs are intelligent and social animals with a wide range of exploratory and cognitive behaviours, they spend half of their time satisfying their own natural behaviour, especially in unlimited space (Stolba & Wood-Gush, 1989). Animals reared in the open space spend enough time exploring the environment and finding feeds (Barnett et al., 2001). Thao s why modern domestic pigs remain highly motivated to search their environment (Beattie & O'Connell, 2002).

Pigs in a restricted environment do not worry about feed, water and nesting, but still show their natural behaviour searching feed by studying the environment. Searching behaviour of domestic pigs is well studied, and the objects of study are usually the floors, chains, straw and a number of other toys for pigs (Wemelsfelder et al., 2000; Bolhuis et al., 2006; Kittawornrat et al., 2011, Lykhach et al., 2020).

The technology of rearing pigs on an industrial basis differs from natural conditions, resulting in the development of their stereotypical behaviour (Apple & Craig, 1992). The environment in pens for pigs has limited space and does not allow animals to express searching behaviours. This leads to the increasing of cases of severe aggression in pigs and abnormal forms of behaviours (Boissy et al., 2007). If animals don't have access to a suitable substrate or manipulative material, they can redirect their search behaviour to each other, leading to the development of tail and ear bites (Fraser et al., 1991). The pathological

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desire of some animals to bite the tails and ears of others is the most serious form of harmful social behaviour and causes injuries: animals lose blood, become weak and die (Zebunke et al., 2013).

The aggressive interactions between pigs occur to determine the order of dominance (Turner et al., 2006). However, high level of aggression influence productivity of animals and decrease the economic efficiency of the enterprise (Harley et al., 2014; Haigh & O'Driscoll, 2019). The aggressive social interaction indicates that the environment does not meet the behavioural needs of pigs.

To avoid aggressive interactions, the different enrichment materials can be used. Author et al. (2020) reported that enriching of the environment for pigs reduces the time spent without action and the time spent on aggressive behaviour. In some studies (Zonderland et al., 2010; Scollo et al., 2013), the effectiveness of enrichments for reduction of abnormal behaviour of pigs was proven. Straw is generally considered to have the highest potential to meet the criteria for effective enrichment material (Van de Weerd & Day, 2009; Haigh et al., 2019). However, it should be noted that slotted floors are prevalent in many pig farms, and the use of straw can cause significant difficulties in some sewer systems (Tuyttens, 2005; Amdi et al., 2015). Therefore, the plastic bottles filled to 50% of their capacity with grain can be seen as alternative. This type of the enrichment is useful for initiating play, demonstration searching behaviour, increasing locomotor activity and, compared to straw, is easier to use and safer to operate sewer systems.

When housing systems do not contain or are not equipped enough with enrichment materials for pigs (straw, toys etc.), it triggers not only aggressive behaviour but also causes suffering from chronic stress (De Jong et al., 2000; Wemelsfelder et al., 2000). The chronic stress can also be associated with depression (van de Weerd & Day, 2009). Ruis et al. (1997) indicated that pigs, housed in a restricted environment, were pessimistic and their playing behaviour was less or even absent.

Therefore, the availability of manipulative objects in industrial pig farms increases search, cognitive, and playing activity of animals. This stabilizes intragroup hierarchy and significantly reduces aggressive behaviour (biting tails and ears) and so, has great importance for the welfare of pigs. The purpose of our study was to evaluate the effect of the use of different enrichment materials on the behaviour of piglets, on the level of the hormone cortisol in blood serum as a marker of stress and on productivity of pigs.

2 Material and methods

2.1 Experimental design

A total of 180 heads of fattening pigs were used in the experiment. Maternal form was a combination of the Large White with Landrace breed and the paternal form was the terminal line «Maxter». The animals were housed on the farm of the Limited Liability Company «Tavria Pigs» (Skadovsk district, Kherson region, Ukraine). Fattening was divided into two periods: Ist period of fattening (grower) – animals with live weight of 30–60 kg (77–110 days) consumed feed 2.4–2.6 kg per head per day. Pigs were housed on a concrete slotted floor with an area at the rate of 0.65 m^2 $head^{-1}$; IInd period of fattening (finisher) – animals with live weight of

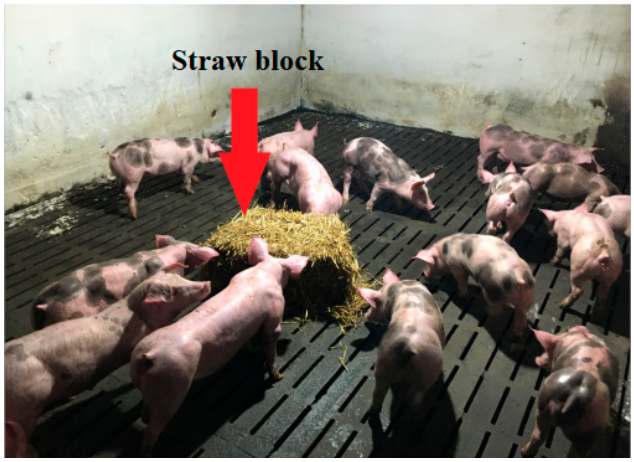

Figure 1 Enrichment material for pigs of the II experimental group in the form of straw block

Figure 2 Enrichment material for pigs of the III experimental group in the form of plastic bottles with wheat grain

61–100 kg (111–161 days) consumed feed 2.8–3.0 kg per head per day. Pigs were housed on a concrete slotted floor with an area of 0.85 m^2 $head^{-1}$. All experimental animals were divided into three groups (on the principle of analogues) of 60 heads (2 feeders × 30 heads) in each: I – control group, the animals were housed without the use of enrichment material; II – experimental group, animals were housed using straw block (Figure 1); III – experimental group, animals were housed using plastic bottles filled with up to 50% of their capacity with grain (wheat) (Figure 2). Distribution of sex across all three groups was: 50% castrated boars and 50% gilts. Feeding was identical in all groups according to detailed feeding norms and was carried out using bunker feeders with automated feed distribution, watering was carried out through automatic nipple drinkers, ventilation was "supply and exhaust" type. The straw pack and bottles in the II and III experimental groups were constantly replaced every week.

2.2 Behaviour

During the experiment, timing of behavioural acts of pigs of three experimental groups was measured using Full HD 1080p video recorders (with a maximum resolution of 1920 × 1080, 30 frames s^{-1}) with AVI recording format.

The visual observations of the animals were performed from 7.00 a.m. until 7.00 a.m. of next day for three consecutive days at the age 12^{th}, 14^{th}, 17^{th} and 22^{nd} week of life to determine the duration (in minutes) of behavioural acts – rest, feed and water intake, movement, aggressive actions (fights, bites), search (object study), interaction with the object, movement and playing.

2.3 Cortisol

The blood sampling for measurement of cortisol level was carried out at the 12^{th}, 14^{th}, 17^{th} and 22^{nd} week of life of pigs. Blood samples were taken direct in the boxes, where the pigs were kept. Piglets were fixed for the upper jaw with a special manual loop. 10 ml of blood from jugular vein was taken from 10 randomly selected piglets from each group at 6.00 a.m. and 9.00 p.m and placed into vacuum tube with heparin. The whole procedure took up to 3 minutes per piglet.

The blood samples were analysed in the clinical laboratory of the Ukrainian Medical Diagnostic Centre (Kyiv). In the blood serum the cortisol concentration was measured by standard methods using ELISA (EIA-1887, «Cortisol ELISA», USA)

At the age of 12, 14, 17, 22 weeks the live weight (in kg), as well as average daily gain (in g) were measured and the proportion of slaughtered pigs due to injury or illness (in %) were calculated.

2.4 Statistical analysis

Results are presented as mean ±standard deviation (x ±SD). Data were analysed using Statistica 12.0 (StatSoft Inc., 2014, www.statsoft.com). The differences between traits (P <0.05) were calculated by analysis of variance (ANOVA). The following significance levels were used for the study: P <0.05; 0.01 and 0.001.

2.5 Ethics

The animal treatment in the experiment were fully complied with the requirements. Comfortable conditions for feeding, watering, housing, care, prevention and treatment in accordance with European legislation on the protection of animals and their comfort (Council Directive 2008/120/EU «On the establishment of minimum standards for the protection of pigs» of December 18, 2008) and the Order of the Ministry of Economy of Ukraine «On approval of the requirements for the welfare of farm animals during their housing» of February 18, 2021 were organized. The protocol of experimental blood sampling in piglets was approved by the local Commission on Bioethics of the National University of Life and Environmental Sciences of Ukraine.

3 Results and discussion

The differences in the main behavioural acts of piglets in the control and experimental groups was observed already on 12^{th} week of life (Table 1), just one week after the beginning of the experiment.

Animals, that had access to the environmental enrichments, and especially pigs of the II experimental group, characterized by a longer duration of the rest (P <0.05) and playing period, they were less aggressive (P <0.05) and had shorter duration of fights and bites, compared to piglets of the control group. Piglets of the experimental groups in the presence of enrichments spent more time studying new object and interacted with it compared with the analogues of the control group (absence of material).

At 14 weeks of age, piglets, that had access to plastic bottles half-filled with wheat grains, exhibited more active locomotor activity by increasing the length of time for playing. It is need to be noted that the pigs of the experimental groups, housed with the environmental enrichment, decreased almost in 13 times the intensity of inter-individual aggression (P <0.001). Important result of the reduction of aggressive behaviour among animals, which had free access to enrichments, is a reduction in the number of cases of harmful social behaviour – biting the tails and ears. During the first period of fattening 24 cases of biting were registered between the animals of

Table 1 The influence of the environmental enrichments on the duration of behavioural acts of pigs in the I fattening period (grower) (min)

Behavioural act	Group (n = 60)		
	I – control, x ±Sd	II – experimental, x ±Sd	III – experimental, x ±Sd
12 weeks			
Rest	740.1 ±11.30	802.5 ±8.66*	782.8 ±9.81
Taking food and water	138.2 ±5.34	145.6 ±4.61	146.2 ±3.67
Movement	342.6 ±1.72	188.4 ±1.03***	194.4 ±1.08***
Studying the object	0	69.9 ±2.74	72.4 ±3.45
Interacting with an object	0	42.3 ±1.42	41.8 ±1.28
Playing	6.2 ±0.81	24.8 ±1.56***	39.2 ±1.43***
Aggressive actions (fights, bites)	212.9 ±1.42	166.5 ±3.26***	163.2 ±2.74***
14 weeks			
Rest	751.3 ±17.47	799.6 ±15.52	795.0 ±14.85
Taking food and water	141.7 ±6.90	141.9 ±7.48	142.4 ±8.16
Movement	312.8 ±16.23	315.2 ±14.65	320.6 ±13.46
Studying the object	0	74.2 ±3.46	78.2 ±4.29
Interacting with an object	0	52.3 ±8.62	55.7 ±9.24
Playing	5.8 ±1.21	34.2 ±2.45**	36.7 ±2.84***
Aggressive actions (fights, bites)	228.4 ±3.80	17.2 ±1.56***	16.8 ±1.28***

Notes: * – P <0.05, ** – P <0.01, *** – P <0.001 (comparing to control)

Table 2 Influence of the environmental enrichment on the duration of behavioural acts of pigs in the II fattening period (finisher), min

Behavioural act	Group (n = 60)		
	I – control, x ±Sd	II – experimental, x ±Sd	III – experimental, x ±Sd
17 week			
Rest	867.8 ±16.24	812.6 ±14.73	820.3 ±16.29
Taking food and water	162.3 ±9.10	154.5 ±8.95	155.0 ±7.64
Movement	295.8 ±11.41	301.5 ±12.17	302.2 ±10.76
Studying the object	0	60.8 ±6.55	56.7 ±5.29
Interacting with an object	0	53.2 ±4.44	54.7 ±6.17
Playing	2.4 ±0.36	42.8 ±7.68***	40.8 ±6.44***
Aggressive actions (fights, bites)	111.7 ±6.32	14.6 ±1.89***	10.3 ±0.67***
22 week			
Rest	920.6 ±10.43	869.5 ±12.38	854.8 ±11.42
Taking food and water	166.4 ±10.26	156.8 ±7.84	162.0 ±8.25
Movement	274.2 ±9.42	286.7 ±10.17	283.8 ±8.91
Studying the object	0	52.6 ±4.21	54.5 ±4.82
Interacting with an object	0	40.7 ±6.55	45.2 ±8.36
Playing	2.1 ±0.31	20.4 ±4.18**	28.8 ±6.44**
Aggressive actions (fights, bites)	76.7 ±10.14	13.2 ±6.92***	10.9 ±5.96***

Notes: ** – P <0.01; *** – P <0.001 (comparing to control)

the control group. At the same time between the piglets, which had the opportunity to transfer their aggression to straw blocks (group II) – 6 such cases were registered, and in experimental group III with plastic bottles filled with grain – only 4 cases.

At the age 17th and 22nd week of life (Table 2) significant difference between groups was registered only for duration of fights (P <0.001) and playing behaviour (P <0.01). For other behavioural acts, significant difference was not determined. Pigs of the experimental groups generally decreased intragroup aggression in 4–12 times (P <0.001). Among the animals of the control group during the second period of fattening 22 cases of biting were registered, while among piglets of group II – 4 such cases were registered, and in experimental pigs of group III – 1 case.

Level of cortisol in blood serum of animals of the control and experimental groups was different (Figure 3, 4). At the beginning, at the age of 12 weeks both in the morning and in the evening, the animals of all groups had a level of cortisol twice higher (P <0.001) than the biological norm. This occurred obviously due to influence of the stress after the transfer of piglets from the rearing condition to a new facility because of their aggressive behaviour and increased locomotor activity. However, high level of cortisol at that time indicated adequate response of the hypothalamic-pituitary-adrenal system on the influence of stress factor.

Beginning from the age of 14 weeks of life the cortisol level in blood of pigs of the control group increased even comparing to the level at the age 12 of weeks and was higher (P <0.001) then in pigs of other groups, which indicates the presence of chronic stress.

This analysis of level of the cortisol in the control and experimental groups shows, that pigs in the absence of the enrichments stayed under the influence of chronic stress. These animals shown inter-individual aggressive activity, which highly destabilized animal behaviour, led to the manifestation of abnormal forms of reaction (biting the tails and ears).

In general, the difference in behaviour of animals of the control and experimental groups caused the differences of their productivity (Table 3).

At the age of 11 weeks, all piglets had a live weight of 33–34 kg. Piglets from experimental groups II and III have shown the better growth performance and significantly surpassed analogues from the control group in live weight and average daily gain in all ages. Described above results allow us to conclude that pigs having access to environmental enrichment (experimental groups II, III) became more relaxed/quiet, which had noticeable positive effect on their growth performance. It is need to mention that the enrichment materials for animals of the experimental groups helped to reduce the number of cases of slaughtering of animals due to injuries (fights, contacts, attacks) and diseases.

Advantages and disadvantages of using different types of enrichment environment for pigs during the fattening period is presented on the Table 4.

Enrichment object must be acceptable, must be used on farms and it is important that these materials improve the welfare of pigs with minimal labour costs (Telkänranta et al., 2014). Studies of different authors have shown that enrichment of environmental increased the time of searching behaviour of pigs and therefore had positive

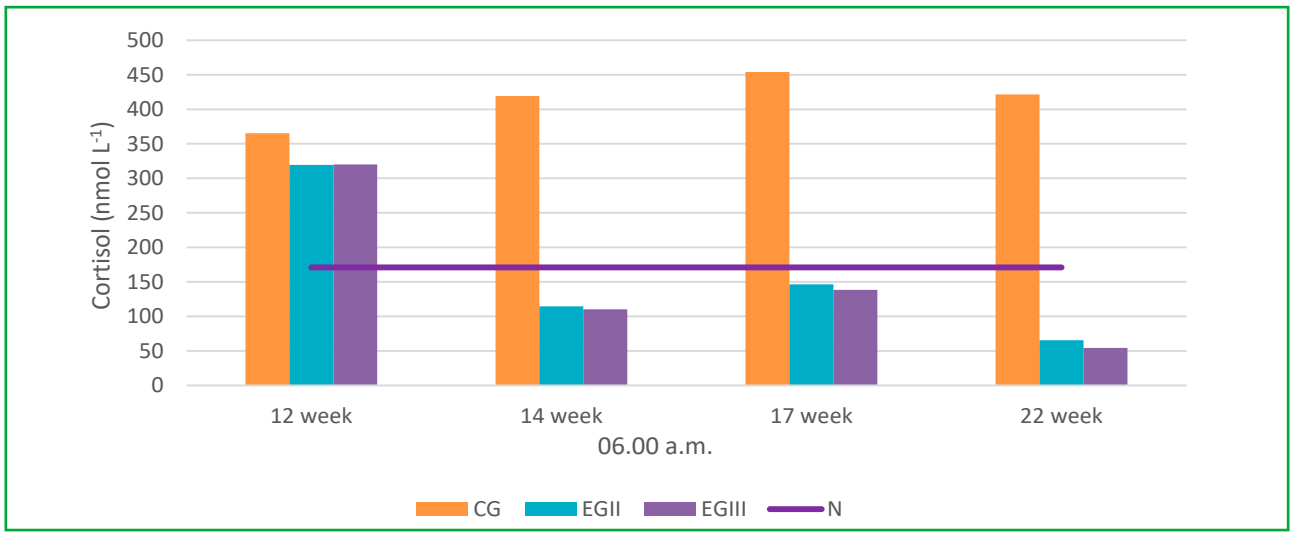

Figure 3 The effect of the environmental enrichment on the concentration of cortisol in the serum of pigs at 6.00 a.m. depending on the week of life (n = 10)
CG – control group I; EG II – experimental group II; EG III – experimental group III; N – biological reference interval 171 nmol L^{-1}

Table 3 Influence of the environmental enrichment on productivity of pigs

Index	Group/age (n = 60)		
	control I	experimental II	experimental III
			11 weeks
Live weight (kg)	33.70 ±0.262	33.93 ±0.221	33.97 ±0.232
12 weeks			
Live weight (kg)	37.93 ±0.229	38.83 ±0,237*	39.37 ±0.206**
Average daily gain (g)	604.3 ±2.04	700.0 ±1.90***	771.4 ±2.02***
Culling (injuries, diseases), (%)	6.7	1.7	1.7
14 weeks			
Live weight (kg)	47.93 ±0.254	49.20 ±0.228**	50.00 ±0.224***
Average daily gain (g)	714.3 ±1.77	740.5 ±2.03***	759.5 ±2.05***
Culling (injuries, diseases), (%)	7.1	5.1	1.7
17 weeks			
Live weight (kg)	64.80 ±0.274	67.30 ±0.282**	68.57 ±0.271***
Average daily gain (g)	803.2 ±1.98	861.9 ±1.56***	884.1 ±1.51***
Culling (injuries, diseases), (%)	3.8	1.8	–
22 weeks			
Live weight (kg)	94.70 ±0.298	98.27 ±0.274**	98.90 ±0.339***
Average daily gain (g)	854.3 ±1.52	884.8 ±1.35***	866.7 ±1.79***
Culling (injuries, diseases), (%)	2.0	–	–

Notes: * – P <0.05, ** – P <0.01, *** – P <0.001 (comparing to control)

Table 4 Advantages and disadvantages of using of different enrichments (manipulative material) for pigs during fattening

No.	Index	Straw block	Bottles filled with grain
1	Imitation of natural behaviour	X	X
2	Attractive sound effect	–	X
3	Mobility of enrichment object	–	X
4	Safety for pigs of enrichment object	X	X
5	Easy to destroy	X	–
6	Danger of destroying of the sewer system	–	–
7	Danger mycotoxins-, fungi development	X	–
8	Low cost	X	X
9	Labour costs for relocation	X	X

Notes: X – advantage; – negative effect/no effect

effect on pigs' interaction with the objects (Beattie et al., 2000; Oliveira et al., 2016). This was confirmed by the results of present study: pigs spent 257.5 min in II group and 261.8 min in III group studying the objects, as well as 188.5 min and 197.4 min correspondently, interacting with an object.

Casal-Plana et al. (2017) observed an increase in searching behaviour offering various things as enrichment for pigs (hemp ropes, sawdust, rubber balls, plant compound), which stimulated an increase not only in searching but also in playing behaviour of pigs of experimental groups compared to those, housed without environmental enrichment. In our study the duration of time for playing activity increased in 3–10 times (P <0.01) in experimental group, comparing with control group, regardless of the week of life and fattening period. This means that piglets, having access to enrichment materials, activate interpersonal interaction and demonstrate their own natural behaviour. In addition, it should be noted that the effectiveness of the enrichment materials depends on the nature of the object, as pigs prefer chewing and

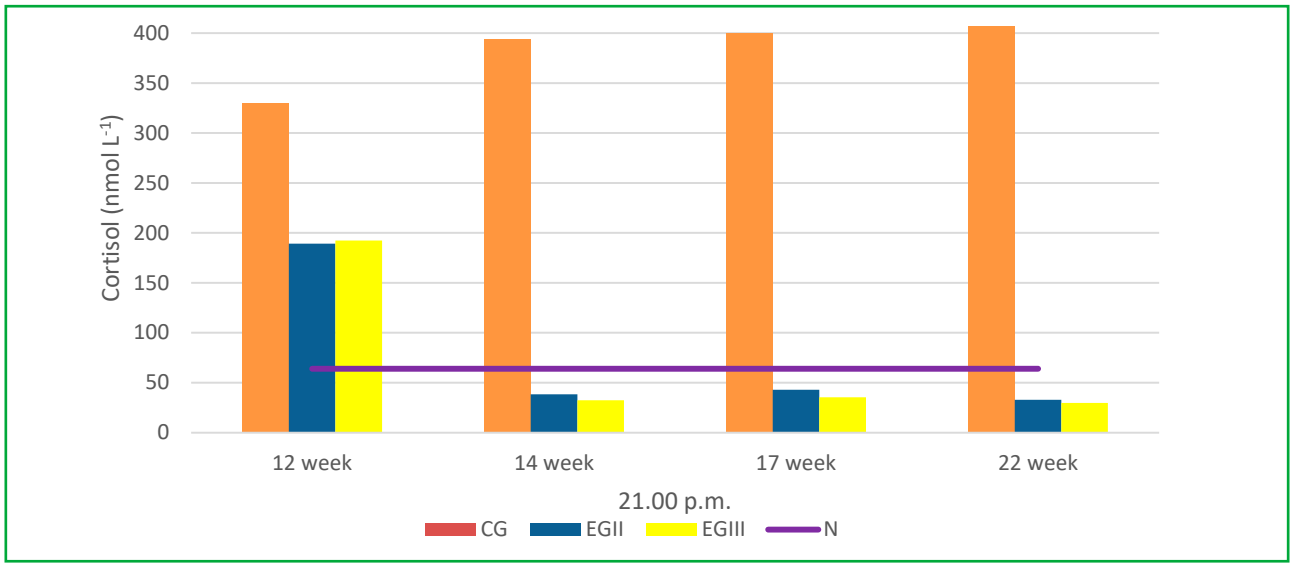

Figure 4 The effect of the environmental enrichment on the concentration of cortisol in the serum of pigs at 9.00 p.m. depending on the week of life (n = 10)
CG – control group I; EG II – experimental group II; EG III – experimental group III; N – biological reference interval 64 nmol L^{-1}

deforming of materials (Bolhuis et al., 2005). Presented study (with straw bales and plastic bottles filled with 50% wheat grain) confirmed this statement.

Access to enrichment materials can reduce aggressive behaviour in piglets both after weaning and during fattening, which can also help piglets develop and stabilize the level of cortisol (De Jong et al., 2000). The lack of enrichment materials increases the risk of ear and tail bites (Telkänranta et al., 2014; De Jong et al., 2000), reduces playing behaviour, which is confirmed by our results. Cocchi et al. (2009) note that pigs suffer from nervous system disorders, in particular, from depression. Tomohiro et al. (2012) reported that the level of cortisol in saliva in piglets in the open air was lower than in piglets that did not have access to walking, which is associated with high levels of stress obtained in hog pens. The obtained results shown that the enrichment of environmental of pigs of both II and III experimental groups provide decreasing of cortisol level in serum comparing with control group (P <0.001). This is confirmed by the results of studies of Bolhuis et al. (2005) where the pigs in heavy industrial conditions also had physiological signs of stress.

The industrial technologies for housing of pigs, as a rule, have slat floors, which during acts of defecation and urination of animals become too slippery and lead to unwanted injuries during aggressive behaviour. Pigs in a pens, uninsulated from a concrete floor can also get pneumonia in the cold seasons, especially when the indoor temperature is not controlled. In this study was found out that pigs housed in the presence of the enrichments (straw, bottles) had significantly higher growth performance by 6.3–27.6% (P <0.001) and lower by 2.0–5.4% culling rate due to fights, bites, injuries and diseases in animals of the control group.

However, the intensive industrial technology of pork production has a number of advantages: protection from predators, climate control, animal control, easy for cleaning and management (Haigh et al., 2019). At the same time there are disadvantages of such technology: low level of environmental stimulation, lack of ability for pigs to express their behaviour, such as nuzzling, wallowing or searching. In order to minimize the negative shortages of intensive technology, it is necessary to enrich the environment for pigs with some subjects, like straw bales and plastic bottles filled with 50% wheat grain. Thus, the use of enrichments is necessary in the intensive production systems to improve welfare and provide high productivity of pigs. However, the different materials/objects have a number of advantages and disadvantages, so the question of the effectiveness of the use of a special enrichment object is relevant and should be studies further.

4 Conclusions

Our research has shown that the presence of enrichment objects for pigs in fattening period has a positive effect on behaviour of pigs. The results shown that the pigs with granted access to manipulative material had decreased intensity of interpersonal aggression between the animals, increased search-, cognitive- and playing activities without abnormal forms of stereotypical behaviour. Such animals had reduced blood serum cortisol level and increased growth performances. The results could be interesting for farmers, which try to

create animal friendly environmental conditions in the frame of intensive technology and looking for proper enrichments to meet animal welfare criteria and keep profitable production.

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