EFFECT OF THE DIETARY CHROME PICOLINATE SUPPLEMENTS GIVEN TO FATTENING PIGS ON THE QUALITY PARAMETERS OF THE PIG LEG

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Abstract

A 4-week study on fattening pigs evaluated the effect of the dietary chrome picolinate (CrPic) on the growth performance and feeding quality of the pig leg. The experiment was conducted under the same conditions on 18 castrated Landrace × Large White males with an initial bodyweight of 73.55 kg, assigned to three batches (C, E1 and E2). The basal diet consisted of corn and soybean meal for all batches. The diets for the experimental batches were supplemented with 200 ppm CrPic (E1) and 400 ppm CrPic (E2). Blood samples were collected in the end of the experiment, following which all animals have been slaughtered and samples of pig leg were collected. The feeding quality of the collected samples was evaluated from the results on the crude fat, crude protein, cholesterol level and antioxidant capacity. The weight gain (kg/day) was lower in the experimental batches than in the control batche. The classification according to carcass fat was the following: E2 (14.33 mm), E1 (16.50 mm), C (17.17 mm). The fat to protein ratio was lower in group E2 (47.46% fat; 42.51% protein), than in group C (49.11% fat; 39.37 % protein). The cholesterol concentration determined in the meat samples from the pig legs was lower in batches E1 and E2 than in group C (0.073% - E1, 0.075% - E2 and 0.087% - M), but the difference was not significant.

Key words: fattening pigs, chrome picolinate, pig leg, cholesterol, antioxidant capacity

INTRODUCTION

Several researchers consider that the chrome (Cr) is a trace element indispensable for the proper functioning of the animal organism and that is plays a beneficial role in increasing the quality of animal foods. Thus, some researchers [2] consider that this trace element is essential for the metabolic processes of the human organism because it potentiates the action of the insulin. He also showed that Cr is involved in protein synthesis and nucleic acid and lipid metabolism. Other researchers [11, 14] reported that trivalent chromium is considered to be an essential element both in animal feeding and human nutrition. The stable forms of Cr are the trivalent Cr(III) and the hexavalent Cr(VI) species. Chromium (VI) is considered the most toxic form of Cr [3, 5]. According to [6] who performed a test on voluntaries, the use of Cr (III) as picolinate is beneficial for the reduction of the serum cholesterol concentration. After the chrome in absorbed into the organism, its ions bind to the oligopeptides and become biologically active [1]. Chrome stimulates the intracellular activity and improves the inclusion of glucose into the muscle cells. The same authors show that the permeability of the cell membrane increases under the influence of chrome, thus increasing the activity of GLUT4 transporter in the hyperglycaemic states.

Although there is no recommendation for Cr in pigs in NRC (1998), some experimental studies on pigs suggest that the dietary supplements of this trace element have a positive influence on carcass quality. A study on growing finishing pigs concluded that 100 or 200 ppb of Cr from CrPic increases *Longissimus* muscle area and the percentage of muscling and decreases rib fat [13]. In a test on fattening pigs, it has been shown that chrome nanoparticles have a beneficial influence on pig

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carcass characteristics, the quality and quantity of skeleton muscles [17]. The animal trials monitoring the effects of the chrome on the animal organism used chrome from the following sources: chrome picolinate, chrome nicotinate, chrome chloride, nanoparticles and less chrome propionate [15, 17].

In the Romanian literature on this subject there are no papers reporting the use of Cr in farm animals' diets. This paper is the result of an experimental study which evaluated the effects of chrome supplements given to (finishing) fattening pigs on the quality parameters of the pig leg. We used chrome picolinate, a source of Cr (III) which the literature considers to be highly available [4].

MATERIAL AND METHOD

Animals

The experiment run for 4 weeks, under farm conditions, in the experimental farm of IBNA Balotesti, on 18 fattening (finishing) castrated Landrace × Large White male pigs. The pigs had an average initial body weight of 73.55 ± 2.67 kg. The pigs were assigned to 3 groups (C, E1, E2) depending on their body weight and housed in collective pens (6 pigs/pen). The pigs were fed ad libitum, with two daily meals at 8.00 and 14.00. The pigs had free access to the water dispensed by nipple drinkers. The pigs were weighed individually at the start and at the end of the experiment. The given feed was weighed on a daily basis. The following parameters were calculated from the records of the body weights and feed intake: average daily weight gain, average daily feed intake and feed conversion ratio (feed/gain). Blood samples were collected in the start and end of the experiment. All pigs were slaughtered in the end of the experiment. Carcass quality was evaluated and meat samples were collected from the pig legs.

Diets

The three experimental groups (C, E1, E2) received the same basal diet (Table 1). The diets of the experimental groups (E1 and E2) differed from the diet for the control group (C), by the inclusion of Cr^{3+} in the premix. This supplement brought the chrome level to 200 µg Cr/kg feed in E1 and 400 µg Cr/kg feed in E2. The supplemented chrome was added as chrome picolinate: tris (2pyridine carboxylate-N,O) chrome(III) which has a concentration of 12-13 % $Cr3^{+}$. The feeds were manufactured by the pilot station of IBNA Balotesti.

Table 1 Diet formulation

Ingredients	***%***
Corn	27.00
Wheat	40.00
Rice flour	10.00
Soybean meal	13.00
Sunflower meal	6.00
Methionine	0.03
Lysine	0.21
Ca carbonate	1.65
Monocalcium phosphate	0.61
Salt	0.40
Premix with choline	0.10
Zoofort P_{3+4} *	1.00
TOTAL	100
Analysed	
ME, kcal	2908.10
CP %	17.68
Fat %	3.42
Fibre %	5.91
Ash %	6.63

*Premix produced by IBNA Balotesti

Samples and analyses

The *samples of raw feed ingredients and of compound feeds* were collected during the process of feeds manufacture. They were assayed for dry matter (DM), protein, fat, fibre and ash according to the ISO methods (The Romanian Standardized Association-ASRO- Standardized Bulletin, 2010).

Blood samples were collected in heparin tubes from the jugular vein from each pig in the beginning and end of the experiment. These blood samples were assayed for alkaline phosphatase, cholesterol, calcium, phosphorus, zinc, copper, iron and chrome. The determinations were performed in a licenced third party laboratory with a Mindray BC 2800 Vet, Auto Haematology Analyser (Shenzhen, China) for the alkaline phosphatase, cholesterol, Ca, P and Fe). Zinc, Cu and Cr were determined by atomic absorption absorption flame (Zn, Cu) or graphite tube (Cr), using a Perkin Elmer Analyst 700 apparatus.

Carcass quality was evaluated with the ZWEI PUNKTE (ZP) method in order to calculate the meat percentage. This is the

method stipulated by the norms for pig carcass grading issued by the Romanian Ministry of Agriculture, Forestry and Rural Development [12].

The *meat samples (pig meat)* were collected at slaughtering from the left leg of each carcass. Two samples (500 g/sample) were collected from each pig, one of them being dried and ground (SR ISO 144:2010 English version). The dried samples were assayed for protein (SR ISO 973: 2007); fat (SR ISO 1444:2008); cholesterol (AOAC International 1996 AOAC Official Method 99410: cholesterol in foods). The fresh pig meat samples (1 sample/pig) were assayed for: *lipid peroxidation:* (determination of thiobarbituric acid reactive substances-TBARS, Vyncke method) and *myoglobin oxidation*; *determination of sulfhydryl groups* (spectrophotometry with Ellman reagents).

StatView software was used to analyse statistically the experimental results. ANOVA was used for the significant differences.

RESULTS AND DISCUSSIONS

The chrome source, chrome picolinate (CrPic) is a feed-grade supplement used in human nutrition too. The formulation of the experimental diets took into consideration EFSA opinion from 2009 which set the "safe" and recommended level of chrome toxicity to the amount of 200 µg/kg. The effect of the chrome from picolinate [13, 18] on the quality of pig carcasses was studied with Cr levels from 100 to 800 µg/kg feed.

Pig performance (Table 2) showed significant differences ($P \leq 0.05$) between the groups for the three investigated parameters. Thus, the final weight and average daily gain recorded for group E2 (400 µg Cr/kg feed) were significantly ($P \leq 0.05$) lower than the corresponding values for the other two groups (table 2).

Table 2 Animal performance

Parameter	C	E1	E2
	0 µg Cr/kg feed	200 µg Cr/kg feed	400 µg Cr/kg feed
Initial weight (kg)	73.67 ± 1.97	73.67 ± 2.34	73.33 ± 3.72
Final weight (kg)	108.17 ± 4.45 ^{c}	105.17 ± 3.71 ^{c}	100.67 ± 4.59 ^{ab}
Average daily gain (kg/pig/day)	1.33 ± 0.14 ^{c}	1.21 ± 0.09 ^{c}	1.05 ± 0.24 ^{ab}
Average daily intake (kg/pig/day)	4.61 ± 0.88 ^{c}	4.35 ± 0.60	4.07 ± 0.61 ^{a}
Feed conversion ratio (kg fees/kg gain)	3.47 ± 0.662 ^{c}	3.59 ± 0.523	3.87 ± 0.589 ^{a}

where a, b, c – significantly different (P≤0.05) C, E1 and E2, respectively

This data is in agreement with the results published by [13] obtained in an experiment on fattening pigs treated with 5 different levels of Cr (100, 200, 400 and 800 µg/kg feed) from CrPic. He showed that the average feed intake decreased with the dietary chrome level. Unlike [16] who reported the improvement of feed conversion ratio with the increase of CrPic level (0, 250 and 500 µg Cr/kg feed) from the diets given to fattening pigs, in this experiment, the level of 400 µg Cr/kg feed (E2) produced the highest feed conversion ratio (kg feed/kg gain). Other researchers showed that the use of 200 µg Cr/kg feed for fattening pigs improved significantly the feed conversion ratio compared to the control group with no dietary CrPic [18].

Figure 1 shows the values of the biochemical parameters determined in the serum from the blood collected in the end of the experiment. Similarly to the other biochemical parameters shown in Figure 1, no statistically significant differences between groups were detected for the cholesterol level either. It has been reported that CrPic decreased serum cholesterol [13] while other researchers [15], showed that the total cholesterol was increased in pigs fed the diet with 100 and 200 ppb Cr relative to pigs fed the diet with no added Cr or 300 ppb Cr. The detected level of serum Cr was 0.0867 µg/dl (E2), 0.0700 µg/dl (E1) and 0.0695 µg/dl (M).

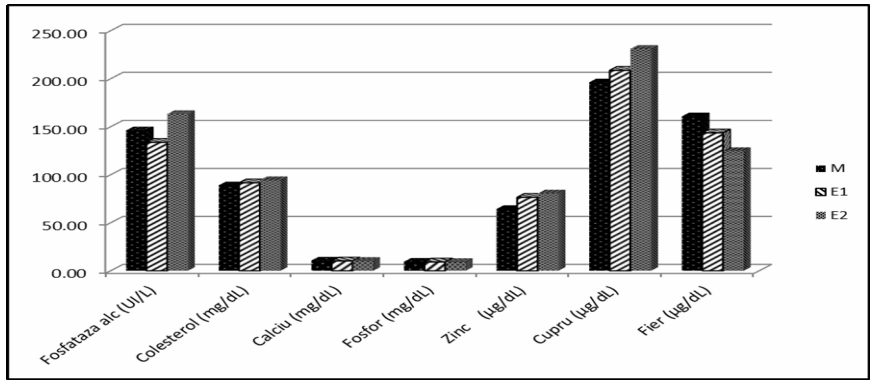

Fig. 1 Biochemical parameters determined in the serum collected at the end of the experiment

The results produced by carcass quality evaluation (Table 3) were similar with those reported [9] in a study which compared different grading methods used for pig carcasses.

Table 3 Evaluation of carcass quality (ZWEI PUNKTE method)

Parameter	C	E1	E2
	0 µg Cr/kg feed	200 µg Cr/kg feed	400 µg Cr/kg feed
Final carcass weight (kg)	81.00 ± 3.22	80.33 ± 2.50	77.50 ± 3.62
Fat layer (mm)	17.17 ± 3.60	16.50 ± 4.46	14.33 ± 3.50
% of meat in the carcass	56.08 ± 2.68	56.59 ± 3.54	57.70 ± 2.26

The data of Table 3 (no statistically significant differences between the three groups) show that the fat layer decreased inversely proportional with the dietary Cr level, but this was on the background of the fact that the average weight of the carcasses from group E2 was about 4% lower than that of groups E1 and C. On the other hand, the proportion of meat in the carcass increased directly proportionally with the dietary Cr (Table 4). These observations are in agreement with the report of [18] who used 200 µg Cr/kg feed. The evaluation of carcass quality (Table 4) shows that the dietary Cr treatment of the fattening pigs produced carcasses with improved properties compared to the conventionally-fed pigs, being graded with an "E" according to the reference proportion of lean meat in the carcass immediately after weighing.

The protein and fat analysis of the pig leg meat samples largely support the data produced by carcass grading. The fat content in group E2 (47.46% DM) was lower than in groups C (49.11% DM) and E1 (51.81% DM) (no statistically significant differences). However, the protein level in group E2 (42.51 % DM) was higher than in groups C (39.37% DM) and E1 (38.09% DM) (no statistically significant differences).

The cholesterol level in the meat samples collected from groups E1 and E2 were significantly ($P \leq 0.05$) lower than in group C. Figure 2 shows the differences between groups.

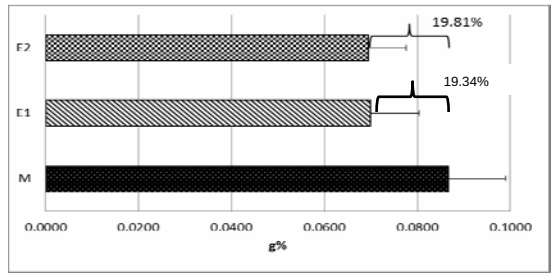

Fig. 2 Percent differences of the cholesterol level in the meat samples

Table 4 shows the intensity of the oxidative processes within the lipids and proteins from the meat samples. The data shown in Table 4 show that TBARS value for group E1 was about 18% lower than the corresponding value for the control group or for group E2.

Table 4 Data on the oxidative processes in the pig meat samples

Specification	C	E1	E2
TBARS mg MDA/kg meat	0.634±0.002	0.518±0.005	0.633±0.001
SH groups mmol/g meat	1.83±0.001	1.54±0.003	1.79±0.007
%MetMb	32.86±0.488	33.90±0.425	35.95±0.531

Regarding myoglobin oxidation, the lowest level of metmyoglobin was noticed in the muscle tissue from the control group. The spectrophotometric evaluation of the metallothioneins showed that they decreased in the muscle tissue of the pigs from group E1 (200 µg Cr/kg feed) and increased when the diet was supplemented with 400 µg Cr/kg feed (E2). The decrease of –SH groups when the 200 µg Cr/kg feed supplement was used, may be due to the binding of this metal to the sulph-hydril groups, while their increase when the 400 µg Cr/kg feed supplement was used, may be due to the stimulation of metallothioneins biosynthesis as defence reaction of the animal organism against toxicity. The increase of metallothioneins concentration in the different tissues was also noticed when the experimental animals have been challenged with other heavy metals too [10, 7, 8].

CONCLUSIONS

The use of CrPic in the diets for fattening pigs, under the conditions shown above, produced differences in the performance of the different groups of animals. In group E2 (400 µg Cr/kg feed), the final weight of the pigs was significantly ($P \leq 0.05$) lower than the final weight of the animals from groups M and E1, under the conditions of a significantly ($P \leq 0.05$) higher feed conversion ratio (feed/gain) compared to C.

The chrome treatments (200 and 400 µg Cr/kg feed) of the fattening pigs decreased ($P \leq 0.05$) the cholesterol concentration in the pig leg meat, thus improving the quality of this product.

In group E1 (200 µg Cr/kg feed) we noticed the best values for the oxidative processes as shown by the quantification of the thiobarbituric acid reactive substances and by the spectrophotometric evaluation of the metallothioneins (SH groups).

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