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Effect of medium chain fatty acids (MCFA) on growth performance and nutrient utilization in broiler chickens

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The aim of this study was to determine the effect of medium chain fatty acids as potential growth promoters in feeding of broiler chickens. The experiment was conducted on 6 groups of birds fed the diets with the same shares (0.85%) of caproic, caprylic and capric acids and their mixture (33:33:33%). The two other groups constituted controls (negative, positive). In the positive control the diet included an addition of a coccidiostatic – salinomycin in the amount of 70 mg/kg. In the period from days 1 to 35 of rearing supplementation with capric acid resulted in a reduction of feed intake and lower weight gains of chickens in comparison with the positive control and an improvement of feed conversion ratio in the periods from 15 to 35 and from 1 to 35 days of life in comparison with the negative control (P≤0.05). In the case of caprylic acid and a mixture of the three organic acids, identical statistical relations were observed in all the periods of the experiment in the group supplemented with salinomycin (P≤0.05). In chickens fed the diets supplemented with caproic acid, deterioration of the feed conversion ratio in the period from 15 to 35 days and from 0 to 35 days of life was recorded (P≤0.05). In contrast, no statistically significant correlations were found for the other experimental parameters (P≤0.05).

KEY WORDS: organic acids / salinomycin / broiler chickens

Elimination of antibiotic growth promoters (AGPs), which are banned from the diet for poultry, has frequently resulted in a deterioration of rearing results, at a simultaneous increased use of therapeutic antibiotics, which are extensively administered in human medicine, such as sulphonamides, tetracyclines or aminoglycosides [11]. Additionally, many EU member countries are currently considering a possible ban on the use of coccidiostats in feed mixtures for broiler chickens and turkeys. The primary effect of antibiotics as well coccidiostats is to limit the colonisation of the alimentary tract in broiler chickens by certain populations of microorganisms [4, 10, 14]. Commonly administered ionophore coccidiostats (e.g. salinomycin) target pathogenic protozoan species from the genus *Eimeria* [4, 10, 14], while they also cause a reduction in the populations of certain groups of intestinal

bacteria. This promotes increased body weight gains and improved utilisation of feed nutrients by broiler chickens [4, 10, 14]. Organic acids are frequently proposed as substitutes for AGP [23]. The mechanism of action in the case of these compounds has not been completely clarified to date. However, some scientific papers have reported that medium chain fatty acids (MCFA) penetrate inside bacterial cells while being in an undissociated form. Then these acids are dissociated in the protoplasm of bacteria, leading to an increased concentration of hydrogen ions [27]. Lower intracellular pH may promote inactivation of bacterial enzymes [30], which results in cell death. According to various authors [2, 3, 5, 7, 16, 17, 21, 31], the action of organic acids in diets for poultry may produce different effects depending both on the composition of the applied additive and on its share. In a study by Celik [7] a mixture of propionic and formic acids resulted in an increase in the final body weight of chickens at a simultaneously recorded decrease in feed intake. The same effect was observed in the case of butyric acid [2]. In turn, other authors stated that an addition of citric acid improves the utilisation of organic phosphorus [21]. Lactic acid enhances resistance of chickens as well as results in increased body weight gains and dressing percentage [5, 31]. In contrast, some acids supplementing the feed mixture have a negative effect on chicken rearing results. An addition of malic and gluconic acids was reported to cause a reduction of weight gain at a marked increase in the feces water contents [3]. A similar effect connected with a deterioration of growth parameters is observed in chickens fed mixtures enriched with benzoic acid [16, 17]. However, available literature sources lack information on the potential effect of caproic (6C), caprylic (8C) and capric (10C) acids on rearing results of broiler chickens. In turn, scientific literature includes reports describing bacteriostatic and bactericidal properties of these acids [13, 15, 29].

The aim of these experiments was to determine the effect of selected medium chain fatty acids (MCFA), i.e. caproic, caprylic and capric acids, on rearing results of broiler chickens fed provocation diets.

Material and Methods

The experiment was conducted on a population of 576 one-day-old cockerel chicks (ROSS 308) assigned to six experimental groups, with 12 replications in each. Birds were kept on straw bedding in brooders of 0.5 m^2 at a stocking of 16 birds per 1 m^2. In the negative control (NC) no additives were used, while in the positive control (PC) a coccidiostat (salinomycin) was added at 70 mg/kg. In the other groups the NC diet was supplemented with identical amounts (0.85%) of individual acids or with their mixture, according to the following experimental design: caproic acid was used in group 3, caprylic acid was applied in group 4, capric acid – in group 5, while a mixture of these acids was administered in group 6 (33:33:33%). Feed was used *ad libitum* in a powder form. In the period from days 1 to 14 it was starter, while in the period from day 15 to 35 it was grower feed (Table 1).

Feed intake (FI) and body weight of chickens were recorded at the time of feed change and at the completion of rearing. At the same time points body weight gain (BWG) and feed conversion ratio (FCR) were calculated. Results were subjected to one-way analysis

Table 1
Shares of components (%) and feeding value of mixtures used in the experiment

Specification	Diets	
	Starter (days 1-14)	Grower (days 15-35)
Wheat	32.68	32.07
Barley	25.00	30.00
Soybean meal 46%	21.54	18.00
Beef tallow	3.00	3.00
Lard	5.37	5.85
Rapeseed meal	6.00	5.00
Fish meal 70%	3.00	3.00
Monocalcium phosphate	1.10	1.00
Limestone	0.42	0.40
Premix	1.00*	1.00**
L-lysine HCL 98	0.28	0.20
NaCl	0.26	0.20
DL-methionine	0.21	0.15
Na_2CO_3	0.10	0.10
L-threonine	0.03	0.03
Calculated nutritive value		
ME (MJ)	13.0	13.3
crude protein (%)	22.00	19.00
lysine (%)	1.30	1.16
met+cys (%)	0.93	0.81
Ca (%)	0.85	0.86
P available (%)	0.42	0.45

*vit. A 12000 IU, vit. D_3 3000 IU, vit. E 35 mg, vit. K 2.5 mg, vit. B_1 3 mg, vit. B_2 6 mg, vit. B_6 8 mg, vit. B_{12} 0.03 mg, niacin 30 mg, D-pantothenic acid 15 mg, folic acid 2 mg, biotin 1 mg, choline 200 mg, betaine 125 mg
**vit. A 10000 IU, vit. D_3 2400 IU, vit. E 30 mg, vit. K 2 mg, vit. B_1 2 mg, vit. B_2 5 mg, vit. B_6 5 mg, vit. B_{12} 0.03 mg, niacin 24 mg, D-pantothenic acid 17.4 mg, folic acid 0,8 mg, biotin 0.8 mg, choline 200 mg, betaine 100 mg

of variance (ANOVA) followed by the Duncan test using the SAS 9.1.3 statistical software package (1996). Statistical significance was set at $P \leq 0.05$.

Results and Discussion

Rearing results of broiler chickens are presented in Table 2. In the first period of rearing in most experimental groups no statistically significant differences were found in any analysed parameters under the influence of applied feed additives. It may be assumed that the observed lack of effects of these compounds stimulating growth and feed conversion may have been caused by high titres of maternal antibodies found in chickens during the first two weeks of their lives. These antibodies may reduce growth of pathogenic microflora by binding with cell membranes of bacteria, which as a consequence activates the complement system, destroying their cell membranes. This mechanism has been presented in various scientific papers [1, 12, 20, 22, 24, 25]. Statistically significant differences in comparison to the negative control were recorded only in the case of chickens fed a mixture containing an addition of capric acid, which caused a significant deterioration of body weight gains. An identical effect in comparison to that of the mixture with capric acid was observed in chickens fed mixtures with an addition of caprylic acid and three medium chain fatty acids.

When analysing intake levels of the experimental feed in the first two weeks of life a significant reduction was recorded in feed intake by chickens fed feed mixtures with caprylic and capric acids as well as the mixture of the three medium chain fatty acids. Authors of some scientific reports stated that these acids stimulate secretion of cholecystokinin as well as other intestinal hormones, which induce the sensation of satiety, as a consequence resulting in reduced feed intake [18, 19]. However, this theory has been contested in other studies, in which it was shown that these acids affect the secretion of cholecystokinin only to a limited extent [28]. In turn, caproic acid had no effect on a reduction of feed intake, which corresponded to the levels recorded in the positive and negative controls.

In the case of feed conversion ratio (FCR) in the first period of rearing no statistically significant differences were found between the analysed groups.

Similarly, in the second period of rearing no statistically significant increase was observed in body weight gains in chickens fed mixtures with an addition of medium chain fatty acids in comparison to the negative control. Statistically significant differences were recorded only in chickens, which diet was supplemented with an addition of salinomycin, as it did not differ from the other experimental groups containing an addition of medium chain fatty acids. A positive effect of the addition of salinomycin was also recorded in studies on broiler chickens by Engberg et al. [10]. In comparison to the negative control trends towards increased body weight gains may be observed, which is reflected in the statistically significant decrease in the feed conversion ratio (FCR). This is connected with a reduced feed intake, in which statistically significant differences were recorded. The presented trends may be connected with the bactericidal as well as bacteriostatic effect of medium chain fatty acids, as presented in their studies by Hermans et al. [13] or Johny et al. [15].

Table 2
Effect of medium-chained fatty acids (MCFA) on basic parameters of rearing the chicken

Group	7-14 day			15-35 day			1-35 day		
	BWG	FI	FCR	BWG	FI	FCR	BWG	FI	FCR
Control (-)	298^{a}	355^{a}	1.19	1765^{b}	2894^{ab}	1.64^{a}	2232^{ab}	3456^{a}	1.55^{a}
Control (+)	284^{ab}	341^{ab}	1.21	1837^{a}	2897^{ab}	1.58^{b}	2287^{a}	3441^{ab}	1.51^{b}
0.85% caproic acid	301^{a}	359^{a}	1.19	1823^{ab}	2961^{a}	1.62^{a}	2294^{a}	3523^{a}	1.54^{a}
0.85 caprylic acid	289^{ab}	335^{b}	1.16	1824^{ab}	2901^{ab}	1.59^{b}	2270^{ab}	3430^{abc}	1.51^{b}
0.85% capric acid	280^{b}	323^{b}	1.16	1785^{ab}	2819^{b}	1.58^{b}	2215^{b}	3335^{c}	1.51^{b}
0.85% 3 acids (capric, caprylic, caproic)	285^{ab}	331^{b}	1.17	1783^{ab}	2815^{b}	1.58^{b}	2230^{ab}	3345^{bc}	1.50^{b}
SEM	15.98	18.49	0.06	59.38	89.62	0.02	65.23	97.03	0.02
P	0.0630	0.0015	0.4022	0.0890	0.0150	<0.0001	0.0613	0.0020	<0.0001

BWG – body weight gain (g); FI – feed intake (g); FCR – feed conversion ratio;
Groups: control (-) – without addition of salinomycin; control (+) – with addition of salinomycin 70 mg/kg

Analyses of the entire experimental period (from day 1 to day 35 of life) showed no statistically significant effect of medium chain fatty acids on improvement of body weight gains in chickens. These results confirm earlier studies conducted on broiler chickens [26]. The experimental group fed a mixture with an addition of capric acid, which did not differ statistically from groups 4 (caprylic acid) and 6 (a mixture of acids), was characterised by inferior body weight gains in comparison to the control with an addition of salinomycin. These results are not consistent with those recorded in the experiments conducted on pigs, in which body weight gains increased by as much as 10% [8, 9]. Despite a lack of statistically significant differences positive trends (P=0.0613) were observed in the case of the groups, in which an addition of caproic and caprylic acids was applied, as they corresponded to the results in the control with an addition of salinomycin.

Statistically significant differences were recorded in the case of feed intake. An addition of capric acid and a mixture of three organic acids caused a reduction of feed intake. Similar conclusions, but this time concerning caprylic acid, were also reported in other studies [6, 27, 30]. It seems unlikely for this reduction of feed intake to be connected with toxicity of these acids. Various tests on their oral, parenteral and cutaneous administration in several animal species, including chickens, showed no acute toxicity caused by medium chain fatty acids [29].

In all the experimental groups, except for the group receiving an addition of caproic acid, a reduction was recorded in the values of feed conversion ratio, which correspond to the values in the positive control. Similar results were also recorded by Solis de los Santos et al. [26].

Summing up, based on the conducted experiment it may be stated that an addition of medium chain fatty acids (MCFA) provides similar rearing results to those recorded at the addition of salinomycin. It may also be assumed on the basis of these experiments that diets for broiler chickens should not be enriched with an addition of capric or caproic acids, since they cause a considerable deterioration of rearing results. In view of the economic aspect the application of medium chain fatty acids as substitute for salinomycin is not fully justified, since the cost of 1 kg medium chain fatty acids is on average two times higher than the respective cost of salinomycin. in the case of these compounds the only argument providing support for the advisability of their application is connected with the fact that medium chain fatty acids are a group of natural origin compounds requiring no withdrawal period.

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