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Original scientific paper

Influence of phytobiotics in feed on the cost-effectiveness of broiler production during fattening

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A b s t r a c t: The aim of this study was to determine the effect of using phytobiotics in broiler feed on the economic efficiency parameters of fattening. The study was conducted on 240 broilers originating from a commercial incubator station, and the dietary trial was based on the group-control principle and lasted for 42 days (control group C — without the addition of phytogenic additives; experimental OI group — with the addition of phytogenic additive containing thymol and cinnamaldehyde, 100 g/t of food; experimental OII group — with the addition of phytogenic additive containing cumin, mint, cloves and anise, 150 g/t of food and; experimental OIII group — with the addition of phytogenic additive containing thymol, 750 g/t of food). The production results (body weight, average daily gain, feed conversion ratio) and economic efficiency parameters of broiler fattening were calculated for three intervals (1–10, 1–20 and 1–42 days). All production results in each interval were significantly better (p<0.01) in experimental broilers than in the control broilers. The best values of European factor of production efficiency and European broiler index were recorded in experimental groups that received feed with added phytobiotics (values were significantly higher, p<0.01, than in the control broilers). Also, the results obtained were compared with standard values for COBB 500 hybrids. The values obtained in this research were significantly lower (p<0.05) than standard values for Cobb 500. Analysing the data obtained from our study, the positive effects of including phytogenic additives in broiler feed mixtures were measured.

Keywords: *Cobb 500, production results, EBI, EPEF, antibiotic replacement.*

Introduction

On the economic side, in livestock (including poultry) production, economic viability is very important, and is affected by the feed composition and production results. For the production of fattening broilers, the world's major producers have their own nutrition guides (Cobb and Ross) and three feed mixtures are most often used, depending on the age of the chickens (starter, grower, finisher) (*Baltić et al*., 2011).

In recent years, as a consequence of the ban on antibiotics, various supplements, including phytobiotics, have been used to preserve animal health and obtain good production results. Increasing attention in animal nutrition is focused on phytogenic additives (phytobiotics) as possible acceptable alternatives to antibiotics. The use of phytogenic additives in poultry nutrition achieves similar effects as the use of antibiotics, but they do not leave residues or have withdrawal periods, and they could become ideal feed additives and successfully replace antibiotics as growth promoters in food (*Glamočlija et al*., 2016; Šević, 2016).

Poultry is a very profitable branch of livestock production, because in a relatively short time, with little investment, large quantities of high quality products can be produced for which there is a constant demand on the market and which are very easy to sell (*Basić and Grujić*, 2013). In addition to meeting market needs, broiler meat production is especially interested in the economic viability of broiler fattening. In recent years, two indices have been used to calculate the cost-effectiveness of fattening: the European factor of production efficiency (EPEF) and the European broiler index (EBI). EPEF is used worldwide as an indicator of broiler growth performance (*Aviagen*, 2019; *Van*, 2003; *Susim et al*., 2020). Some authors, in addition to EPEF, use EBI, which can be calculated for flocks of different ages, to assess the performance of broilers (*Van*, 2003; *Marcu et al*., 2013; *Cengiz et al*., 2019). EPEF is a tool for measuring the growth performance of

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broilers (*Aviagen*, 2019; *Van*, 2003). Therefore, the factors involved in the EPEF are body weight gain (BWG), feed coversion ratio (FCR) and viability and are considered universal measures for evaluating broiler performance (*Marcu et al*., 2013).

In some countries, the EBI is used for measuring broiler growth performance, calculated for flocks with different slaughter ages. In this case, the factors involved in calculating the EBI are average daily gain (ADG), feed conversion ratio (FCR) and viability. EBI values are always lower than EPEF, because in the ADG calculation, the chicks' weight to one day is excluded (*Van*, 2003). Higher EPEF or EBI values indicate better fattening economics (*Marcu et al*., 2013; *Lukić et al*., 2020).

The aim of this study was to determine the effect of using phytobiotics in broiler diets on the economic parameters of fattening.

Materials and Methods

The study was conducted on a broiler farm in Srbac (45.0989° N, 17.5217° E), Republika Srpska (Bosnia and Herzegovina), with broilers originating from a commercial incubator station. The dietary trial was based on the group-control principle and lasted for 42 days. One-day-old Cobb 500 chickens of both sexes were used, and females and males had an average body weight of 46.33±3.57 g and 46.93±3.83 g, respectively. The study was conducted on a total of 240 broilers divided into four groups of 60 animals housed in groups of 10 birds per pen in six repetitions (control group C — without the addition of phytogenic additives; experimental OI chickens — with the addition of phytogenic additive containing thymol and cinnamaldehyde, 100 g/t of food; experimental OII chickens — with the addition of phytogenic additive containing cumin, mint, cloves and anise, 150 g/t of food, and; experimental OIII chickens — with the addition of phytogenic additive containing thymol, 750 g/t of food). The study was divided into three phases. The first phase lasted 0–10 days, the second phase 11–20 and the third phase 21–42 days. Conditions in the facility (ventilation, heating, lighting and relative humidity) were according to the technological standards and recommendations for this hybrid (*NRC*, 1994; *Cobb-Vantress*, 2018a; *Cobb-Vantress*, 2018b). Pens were bedded with straw and broilers provided with fresh water and feed *ad libitum*.

During the study, the broilers were fed with complete mixtures for fattening chickens that contained standard raw materials and chemical composition. Three mixtures were used (Table 1) that fully met the needs of broilers at different phases of fattening (*Cobb-Vantress*, 2018a). A complete mixture for feeding OI chickens (starter) was used from 0–10 days, then a complete mixture for feeding OII chickens (grower) was used from 11–20 days and a complete mixture for feeding OIII chickens (finisher) was used from 21–42 days. The broiler feed consisted mainly of corn, wheat, soy, minerals, amino acids and premixes. The average contents of protein, moisture, cellulose, fat and ash in the broiler feed mixtures are shown in Table 1. Data in Table 1 show the feed mixtures used for broiler fattening in the age groups were of standard chemical composition and fully satisfied the needs of broilers in all fattening phases.

The main task of the study was to determine the impact of broiler diets with feed mixtures containing different phytogenic additives on production results and yield parameters, and determine if the use of natural growth stimulants in intensive broiler farming is justified from an economic point of view.

Table 1. Raw material composition of broiler feed mixtures used in fattening, mean % ± standard deviation

Mixture (age of chickens in days)	Moisture	Ash	Protein	Fat	Cellulose
Starter (0–10)	8.04±0.24	5.45±0.14	24.98±0.57	6.09±0.37	2.04±0.05
Grower (11–21)	9.38±0.09	4.88±0.13	22.17±0.21	7.03±0.26	2.16±0.04
Finisher (22–42)	9.98±0.07	4.76±0.21	20.91±0.87	5.44±0.11	2.38±0.26

Therefore, minimal corrections were made to the mixtures in order to achieve the desired goal. The control group of broilers was fed a mixture without phytogenic additives, while the experimental groups received feed with phytogenic additives.

During the study, the health status of broilers and production results (body weight, weight gain, feed conversion) were monitored, and mortality was recorded. At the beginning and end of each phase of the study (starter, grower, finisher), the body weight of each individual animal and pen feed consumption were measured and complete feed mixtures were analysed, then other production results were calculated from the obtained data. The economic efficiencies of broiler production during fattening were calculated as EPEF (*Baltić et al*., 2011; *Van*, 2003) and EBI (*Van*, 2003). The following formulas were used to calculate these indicators:

BWG (g) for the period = BW (g) at the end of period − BW (g) on first day

$$\textbf{ADG}\ \text{(g/chick/d)} = \frac{\text{BWG (g)}}{\text{number of days in the growth period}}$$

$$\textbf{FCR}\ \text{(kg feed/kg gain)} = \frac{\text{Cumulative feed intake (kg)}}{\text{total weight gain (kg)}}$$

Viability (%) = number of broilers at the end of each fattening period (%)

$$\textbf{EPEF} = \frac{\text{Viability (\%)} \times \text{BW (kg)}}{\textit{age}\ \text{(d)} \times \text{FCR (kg feed/kg gain)}} \times 100$$

$$\textbf{EBI} = \frac{\text{Viability (\%)} \times \text{ADG (g/chick/d)}}{\text{FCR (kg feed/kg gain)} \times 10}$$

Statistical analysis

The results obtained were compared by statistical analysis using Microsoft Excel 2010 and GraphPad Prism software, version 8.00 for Windows (GraphPad Software, San Diego, California USA, www.graphpad.com). To determine the significance of the differences between the examined groups of compared parameters, the analysis of variance (ANOVA) was used. Testing of the significance of the difference between the arithmetic means of the compared parameters and the standard values (i.e. the recommendations for this hybrid (*Cobb-Vantress*, 2018a)) was conducted according to *Petz et al*. (2012). Differences were considered significant if $p<0.01$ or $p<0.05$ were observed.

Results and Discussion

Table 2 shows the production results of broilers during fattening, as well as the calculated economic efficiency parameters of broiler fattening. On day 10 of fattening, a significant difference ($p<0.05$) was found between the control and experimental groups of broilers. The same significant difference was established on day 21 and at the end of fattening. The control broilers had a significantly lower ($p<0.05$ — day 21; $p<0.01$ — day 42) body weight compared to the experimental broiler groups. The ADG of broilers during fattening was calculated for three intervals, i.e. from 1 to 10 days, from 1 to 21 days and 1 to 42 days. In all three intervals, the ADG of control broilers was significantly ($p<0.01$) lower than those of the experimental groups. Also, on day 10, the ADG of OII broilers was significantly lower ($p<0.01$) than that of the other experimental groups. At the end of broiler fattening, significant differences in ADG were found between the experimental groups of broilers ($p<0.05$; $p<0.01$).

FCR is shown (Table 2) for the individual fattening intervals. Control broilers produced the worst FCR in all fattening intervals, in relation to experimental groups of broilers. On day 10, the FCR of control and OIII broilers differed significantly ($p<0.05$). Observed for the whole study, the best FCR was achieved by OI broilers (1.85), followed by OIII (1.855) and OII (1.89) broilers.

Production efficiency was assessed using EBI and EPEF. The best EPEF and EBI in this study were recorded in broilers that received feed with added phytobiotics. These economic parameters were significantly higher ($p<0.01$) in the experimental broiler groups than in the control broiler group, although significant differences ($p<0.01$) were found between the experimental groups (Table 2).

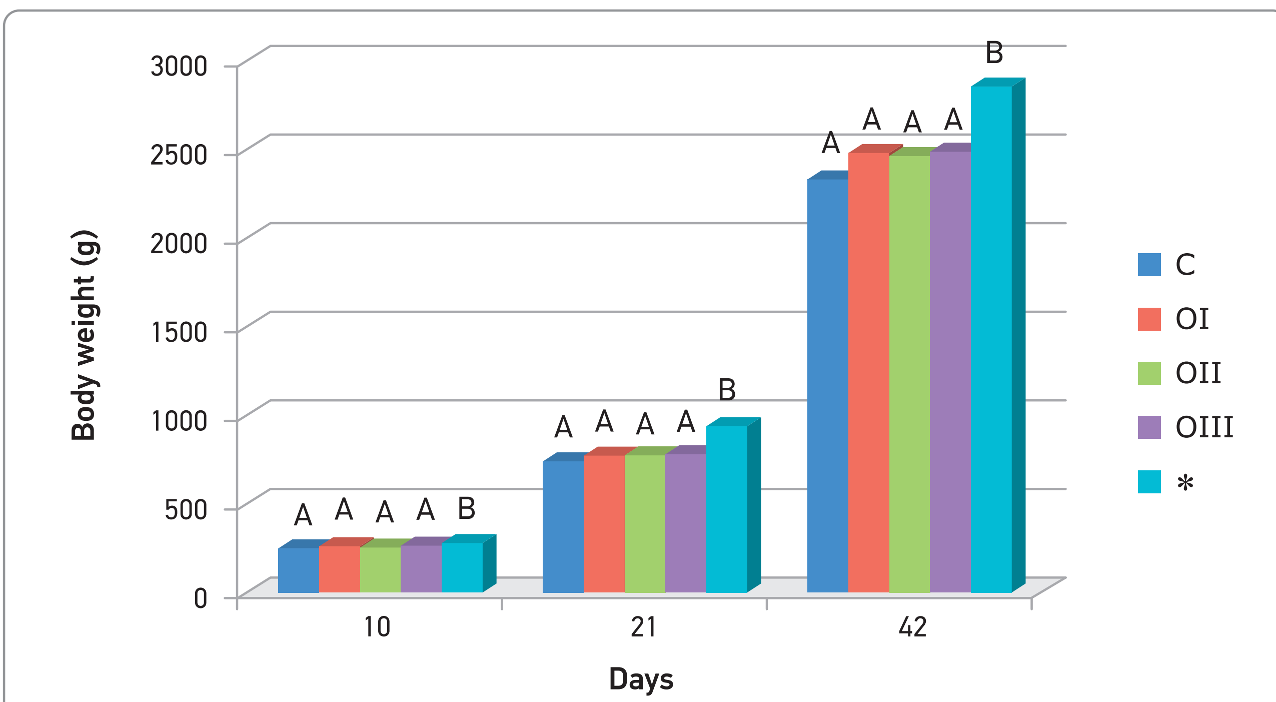
The results obtained were compared with standard values for COBB 500 hybrids. Figures 1 and 2 show broiler weight and FCR, respectively, after different fattening intervals (1–10 days; 1–21 days, and 1–42 days). The values obtained in this research were significantly lower ($p<0.05$) than the standard weight and FCR for Cobb 500 broilers after 42 days' fattening.

The realized EPEF and EBI values (Figures 3 and 4, respectively), cumulative indicators of the final result and success of fattening, were significantly higher in experimental broilers than in the control broilers ($p<0.05$), while the values obtained for broilers in this study were significantly lower than standard values for Cobb 500 broilers.

Table 2. Production results and economic efficiency parameters during broiler fattening

Fattening interval, days	Parameters	Control	OI Broilers	OII Broilers	OIII Broilers
1to 10	BW (kg)	0.254^{abc}±0.017	0.265^{a}±0.021	0.257^{b}±0.024	0.266^{c}±0.028
	ADG (g)	20.78^{ABC}0.149	21.79^{AD}±0.098	21.10^{BDE}±0.110	21.96^{CE}±0.080
	FCR (kg feed/kg gain)	2.16^{a}±0.108	1.96±0.158	1.99±0.123	1.94^{a}±0.111
	Viability (%)	98	99	99	100
	EPEF	115.69^{ABC}±1.435	133.85^{ADa}±2.642	127.85^{BDE}±2.007	137.11^{CEa}±1.309
	EBI	94.29^{ABC}±3.032	110.05^{AD}±2.448	104.99^{BDE}±1.831	113.21^{CE}±1.472
1 to 21	BW (kg)	0.744^{abc}±0.082	0.778^{a}±0.040	0.778^{b}±0.044	0.784^{c}±0.063
	ADG (g)	33.20^{ABC}±0.242	34.84^{A}±0.172	34.86^{B}±0.104	35.11^{C}±0.323
	FCR (kg feed/kg gain)	1.89±0.142	1.73±0.135	1.77±0.167	1.76±0.193
	Viability (%)	98	98	98	99
	EPEF	183.70^{ABC}±3.493	209.87^{A}±2.817	205.12^{Ba}±2.116	210.00^{Ca}±2.991
	EBI	172.17^{ABC}±2.55	197.34^{A}±3.22	193.00^{B}±2.06	197.49^{C}±3.70
1 to 42	BW (kg)	2.334^{ABC}±0.148	2.485^{A}±0.218	2.461^{B}±0.191	2.489^{C}±0.210
	ADG (g)	54.46^{ABC}±0.323	58.06^{Aa}±0.104	57.49^{BDa}±0.349	58.16^{CD}±0.351
	FCR (kg feed/kg gain)	2.07±0.12	1.85±0.199	1.89±0.103	1.85±0.193
	Viability (%)	98	98	98	99
	EPEF	263.09^{ABC}±2.106	313.42^{ADa}±2.033	303.83^{BDE}±1.984	317.13^{CEa}±2.724
	EBI	257.85^{ABC}±2.44	307.54^{ADa}±1.51	298.10^{BDa}±3.01	311.21^{CE}±1.65

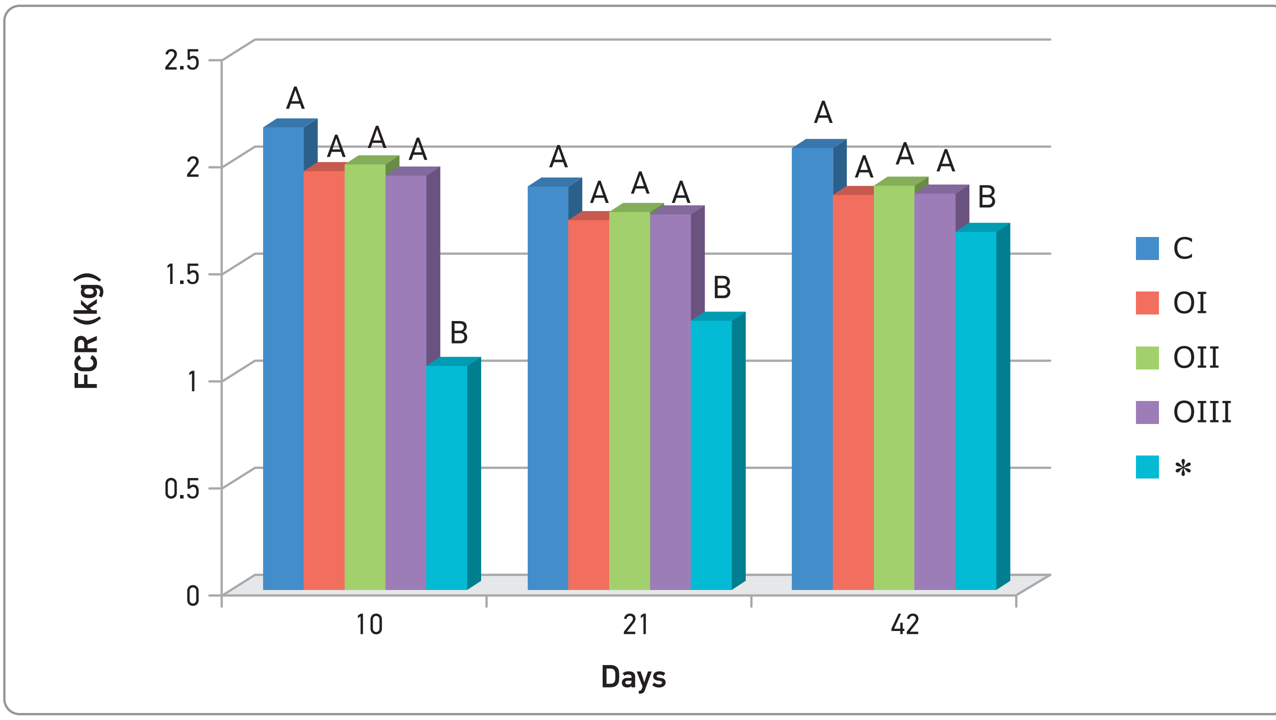
Legend: BW – body weight; ADG – average daily gain; FCR – feed conversion ratio; EPEF - European Production Efficiency Factor; EBI – European Broiler Index; Same letter in a row ^{a,b,c} p<0.05; ^{A,B,C,D,E} p<0.01.



Legend: * According to the Cobb 500 broiler guide; Different letters $^{A, B}$ indicate body weight differs (p<0.05)

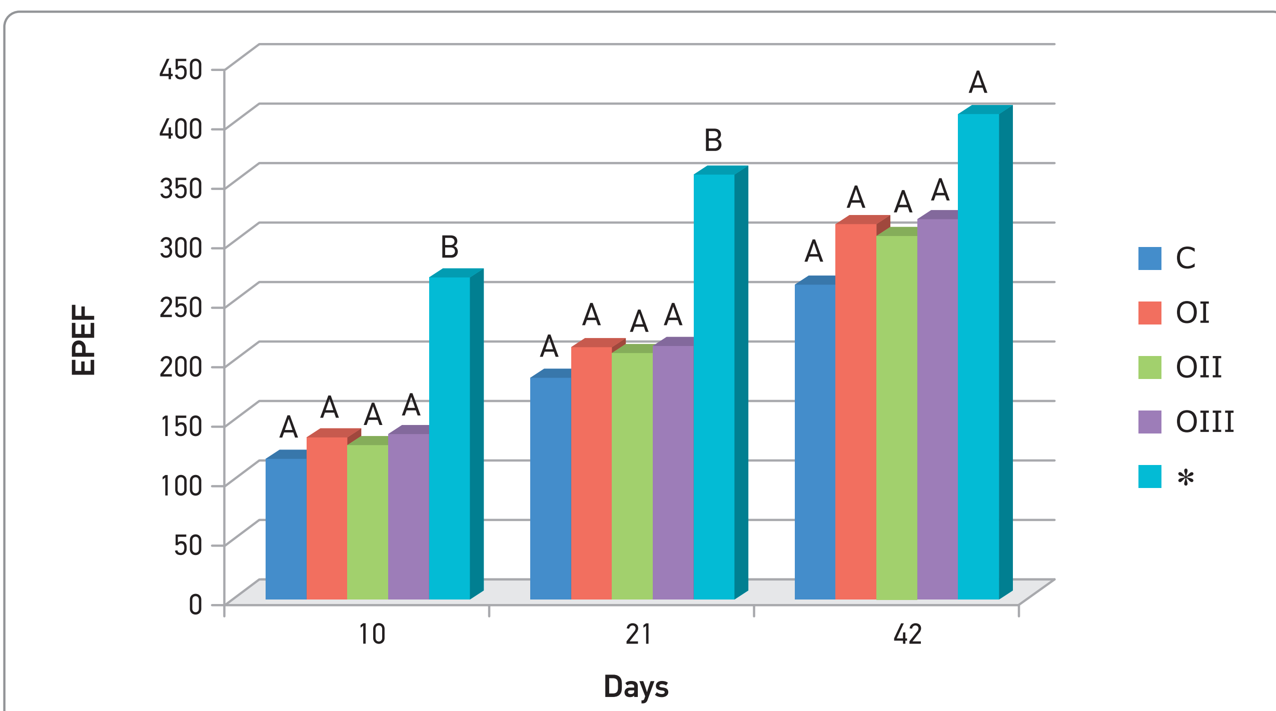
Figure 1. Average broiler weights (g) compared with standard weights for Cobb 500 broilers

Based on the production results (body weight, ADG, FCR etc.), it is difficult to talk about the economic viability of production, but rather, this can be better assessed on the basis of economic parameters. The production results obtained within this research were in accordance with the results of other authors (Šević, 2016; *Branković Lazić et al.*, 2021; *Baltić et al.*, 2018; *Milanković et al.*, 2019). However, anal-



Legend: *According to the Cobb 500 broiler guide; Different letters A, B indicate feed conversion ratio differs ($p<0.05$)

Figure 2. Average feed conversion ratio (kg) of broilers compared with standard values for Cobb 500 broilers



Legend: *According to the Cobb 500 broiler guide; Different letters A, B indicate different EPEF ($p<0.05$)

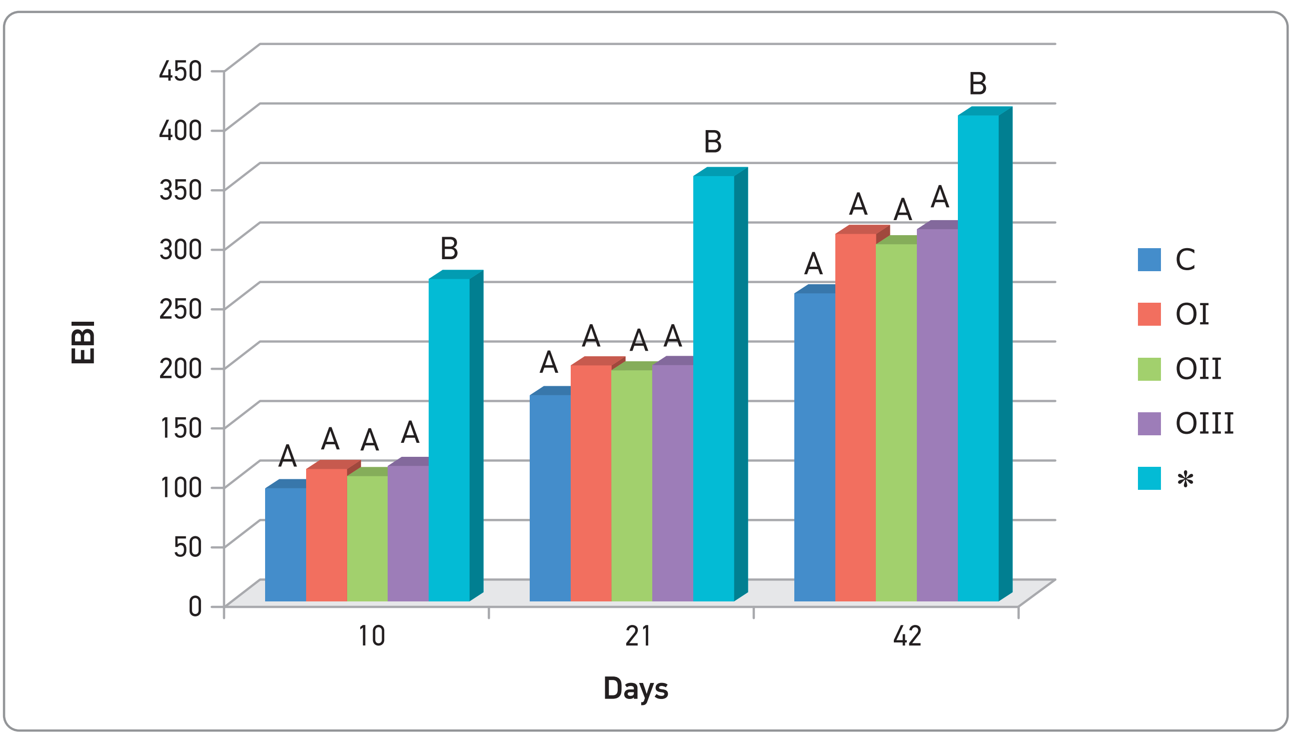
Figure 3. Average European factor of production efficiency (EPEF) for broiler groups compared with standard values for COBB 500 broilers

ysis of performance data (body weight, ADG, FCR and mortality) are essential to calculate the economic efficiency of broiler growth.

The profitability and cost-effectiveness of chicken meat fattening and marketing have been examined by various authors (*Hamra*, 2010; *Rhodes et al*., 2008; *Szollosi et al*., 2014). They emphasized that when calculating profitability and economics, it is necessary to know the selling prices of chicken meat and business costs. Costs are divided into fixed and variable. Variable costs vary according to the level of total activity or volume. Fixed costs do not change in relation to changes in volume or changes in the level of total activity. *Rhodes et al.* (2008) emphasize that broiler breeders must calculate variable and fixed costs when calculating profitability and economics. Variable costs include the costs of concentrate mixtures, electricity, cleaning, ongoing maintenance of facilities and equipment, telephones and alarms. Fixed costs include the costs of day-old chicks, labour, insurance, taxes and land use charges (real estate tax). With good management practice, a grower can reduce costs, which is a condition for increasing profits. The main feature of newer cost reduction strategies is less reliance on statistical sources of cost reduction (such as economies of scale or effects of experience) and increasing reliance on continuous improvement, innovation, restructuring, business process redesign and rigorous analysis of production activities (*Milićević*, 2003). *Salihbašić et al.* (2014) point out that the following types of costs occur within the costs of chicken meat production: one-day chickens, concentrate mixtures (starter, grower, finisher), immunoprophylaxis, cooperation in fattening chickens and dead and discarded chickens.

Investing in improving the welfare of broilers affects the cost of fattening. Calculating the cost of animal welfare is a complex task. Some animal welfare measures increase production costs, but this can be offset by higher quality products or lower losses due to reduced disease or injury. There are ways to improve animal welfare that do not compromise productivity and are not necessarily expensive. It is important to investigate the economic and social impact of animal friendly measures on production and production alternatives, in order to reconcile animal welfare and economic imperatives (*Hansen*, 2002; *Dawkins et al*., 2004; *Blandford*, 2006; *Bessei*, 2006; *Utnik-Banaś et al*., 2014). Improving animal welfare can lead to reduced disease and mortality, as well as reduced disease control and treatment expenditures (*Hansen*, 2002; *Dawkins et al*., 2004; *Blandford*, 2006).

Of the total costs of fattening chickens, the costs of concentrate mixtures account for about 70%. Efficient use of feed has the greatest impact on managing production costs. The basic parameters used to



Legend: * According to the Cobb 500 broiler guide; Different letters A, B indicate different EBI ($p<0.05$)

Figure 4. European Broiler Index (EBI) values of broilers compared with standard values for COBB 500 broilers

measure economy and profitability are outputs, revenues and expenditures. Effects are equally considered to be material products and services derived from the production process of the organization (*Utnik-Banaś et al*., 2014; *Tesić and Nedić*, 2015). Profit is the difference between the value of production (total income) of fattening and the cost of fattening and is determined at the end of fattening. The profit of fattening chickens, expressed in the simplest form, is the value of the final product less the input costs caused by the production of that product.

The use of phytobiotics in broiler diets in this study has produced better production results and better economic viability parameters (EPEF, EBI). Analysing the data obtained from our study, the positive effects of adding phytogenic additives to broiler feed mixtures were measured. Phytobiotics added to broiler feed had a positive impact on all measured production results. Broilers that received phytobiotics had higher body weight and total weight gain, lower feed consumption and better feed conversion than broilers that did not consume phytobiotics.

Conclusion

The results in this study support the use of phytobiotics in broiler diets, since this is economically justified given the good production results (broiler weight at the end of fattening, feed conversion, average daily gain, growth). Therefore, the use of phytobiotic preparations in broiler feed had a positive effect on increasing the economic viability parameters of broiler production. There is not much published research that has monitored the impact of different types of phytobiotics on the economic viability parameters (EPEF, EBI), so these and similar experiments open up numerous opportunities for further research.

Phytobiotics in poultry feed could become ideal feed additives and successfully replace antibiotics as growth promoters in broiler feed.

Ispitivanje uticaja delovanja fitobiotika u hrani na ekonomičnost proizvodnje brojlera u tovu

Jelena Janjić, Kristina Šević Savić, Radmila Marković, Dragan Šefer, Drago Nedić, Spomenka Đurić, Branislav Vejnović, Milorad Mirilović

A p s t r a k t: Cilj ovog istraživanja bio je da se utvrdi uticaj upotrebe fitobiotika u ishrani brojlera na ekonomske parametre tova. Eksperiment je sproveden na ukupno 240 brojlera poreklom iz komercijalne inkubatorske stanice, zasnovan na grupno-kontrolnom sistemu i trajao je 42 dana (kontrolna grupa K — bez dodatka fitogenih aditiva, ogledna OI grupa — sa dodatkom fitogenog aditiva koji sadrži timol i cinamaldehid, 100 g/t hrane, ogledna OII grupa - uz dodatak fitogenog aditiva koji sadrži kim, nanu, karanfilić i anis, 150 g/t hrane, i ogledna OIII grupa - uz dodatak fitogenog aditiva koji sadrži timol, 750 g/t hrane). Proizvodni rezultati (telesna masa, prosečni dnevni prirast, konverzija hrane) i parametri ekonomske efikasnosti tova brojlera su izračunati u tri perioda (od 0. do 10. dana; od 11. do 20. i od 21. do 42. dana). Svi proizvodni rezultati u svakom periodu bili su statistički bolji ($p<0,01$) u eksperimentalnim grupama nego u kontrolnoj grupi. Najbolje vrednosti EPEF i EBI u ovom istraživanju zabeležene su u eksperimentalnim grupama (značajno veće, $p<0,01$, nego u kontrolnoj grupi) koje su dobijale hranu sa dodatkom fitobiotika. Takođe, dobijeni rezultati su upoređeni sa standardnim vrednostima za hibride Cobb 500. Vrednosti dobijene u ovom istraživanju bile su značajno manje ($p<0,05$) od standardnih vrednosti za Cobb 500. Analizirajući podatke dobijene iz našeg eksperimenta, uočava se pozitivan efekat dodavanja fitogenih dodataka krmnim smešama za brojlere.

Ključne reči: *Cobb 500, rezultati proizvodnje, EBI, EPEF, zamena antibiotika.*

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