Proceedings of the 2015 International Conference "ECONOMIC SCIENCE FOR RURAL DEVELOPMENT" No37
Jelgava, LLU ESAF, 23-24 April 2015, pp. 152-159

ECONOMIC EFFICIENCY OF FEEDING A PROTEIN CONCENTRATE ADDITIVE TO BROILER CHICKENS

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Abstract. The EU Member States have a high deficit of domestic protein feeds, and approximately 70% of protein products are imported; thus, feed price fluctuations make the European livestock industry economically vulnerable. It is possible to use domestic agricultural by-products as a feed for agricultural animals in order to reduce the deficit of protein feeds and the cost with regard to purchasing such feeds. To tackle the problem regarding reducing the production cost of livestock products, a feeding experiment on broiler chickens was conducted using protein concentrate Baltiprot − an ethanol production by-product with high protein content − produced in Latvia.

The hypothesis is as follows: using the ethanol industry by-product − protein concentrate − in diets of poultry could increase broiler chicken productivity and reduce feed cost. In this aspect, the aim was to identify the most economically efficient amount of protein feed in the diet of broiler chickens. The research results showed that a greater slaughter weight of poultry (+6.48%), a lower production cost per kg of poultry meat (-7.11%), a higher production efficiency (386.2) and a lower feed conversion ratio (1.77) could be achieved by using the protein additive in the diet of broiler chickens.

Key words: poultry production, production efficiency

JEL code: O 13

Introduction

In Europe, meat and other livestock products comprise 45% of the total value of products produced by agriculture (Eurostat, 2013; Broring, 2010). Regardless of the significant proportion of livestock farming, the total area sown with protein crops in the European Union (EU) occupies only 3% of the total arable area, and this industry supplies only 30% of the total quantity of protein crops consumed as animal feed (Report on…, 2011). As the deficit tended to increase over the last decade, according to Eurostat, 70% of protein products, especially soya flour, were imported mainly from Brazil, Argentina and the USA. Such large imports of

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protein products make the European livestock industry vulnerable as well as cause feed price fluctuations, reducing the profitability and stability of the livestock industry.

A significant economic effect on raising the production efficiency of livestock products and the industry's stability can be ensured by consuming domestic by-products of agricultural processing (McDonald et al., 1995). The by-products of oil crops and grains produced by domestic enterprises are extensively used in animal diets. The use of these by-products, instead of imported ones, in animal diets may considerably enhance the quality of agricultural products and increase the revenues of domestic enterprises.

As it is known, the need for protein among agricultural animals and poultry is different, depending on the species, the kind of products produced, the physiological condition, etc.

Poultry, especially broiler chickens, feature an intensive growth rate and a high genetic potential of productivity (Marcu A. et al., 2013); accordingly, broiler chickens need feed with a high crude protein content (19.00-24.00%), while the cost of feed accounts for 60-75% of the total production cost for poultry enterprises in the EU and Latvia (Damme, 2010; Demircan et al., 2010; Poultry Meat and…, 2010; Onu et al., 2010; Adewunmi, 2008). So, in order to reduce the costs of feed and production, relatively cheap quality protein-rich feeds have to be used in poultry diets. In this aspect, it is required to assess the opportunity to use domestic feeds − ethanol production by-products − in poultry diets.

It is economically efficient to produce ethanol from grain, and wheat is the best choice. The main problem in the use of a by-product of the ethanol industry for poultry is its high variability of nutrient content and availability (Bregendahl, 2008). Therefore, literature says that different amounts of feed additives containing bio-ethanol industry by-products are used in broiler chicken feed. By applying innovative solutions and technologies, ethanol production waste is reprocessed in Latvia into a feed supplement registered as Baltiprot produced by EthaProt^{TM} Process technology (Bosenko et al., 2008). On average, it consists of 55-60% crude protein, 1.28% lysine, 0.52% methionine, 1.71% arginine, and 94.5% dry matter. During the production process the grain is divided into brans and milled endosperm, which contains starch and protein. The starch is converted into ethanol, through the instrumentality of ferments and food yeast Saccharomyces cerevisiae. Grain protein and yeast, that is, protein biomass is dried using a stream of CO_2 and dry concentrate containing protein is obtained − a feed additive (hereinafter referred to as the protein concentrate) (Martinez-Amezcua et al., 2007; Noll et al., 2007). The concentrate of protein feed, contrary to the mentioned one in literature, is of better quality, as it contains relatively more crude protein and amino acids.

The obtained protein concentrate may be used in agricultural animal diets; yet, few studies are available on its economic efficiency in poultry feed. The hypothesis is as follows: using the ethanol industry by-product − protein concentrate Baltiprot − in total mixed diets of poultry could increase broiler chicken productivity and reduce feed cost.

In this aspect, the aim was identify the most economically efficient amount of protein feed in the diet of broiler chickens. The following research tasks were set: 1) to identify the effect of the protein concentrate on the productivity of broiler chickens; 2) to determine the economic efficiency characteristics of broiler chicken meat production.

Materials and methods

The main objective of this experiment was to evaluate the economic effects of incorporating different amounts of protein concentrate in broiler performance trials. Commercial hybrid ROSS-308 animals were used in an intensive system on a permanent litter, with a density of 12 chicks per m^2. Broilers were randomly assigned into 4 equal groups in equal number per each sex. Broiler chickens were reared in the same housing and environmental conditions, and the composition of the basic diet was balanced according to the feeding instructions for the commercial hybrid ROSS-308 (Ross Broiler Management Manual, 2009). The growth technological system was in accordance with new European Union regulation on animal welfare compulsory from 2012 in all EU Member States (Laying down…, 2007).

In order to define the most economically viable amount of protein concentrate for use in broiler chicken feed, a feeding experiment using broiler chickens of cross ROSS 308 was performed according to the scheme shown in Table 1.

Table 1

Experimental design

Broiler chickens aged 0-27 days					
Group	Protein, %	Lysine, %	Methionine, %	In basic diets, %	
				Fodder yeast	Protein concentrate
Group 1 – control	21.0	1.23	0.45	2.5	–
Group 2 – trial	21.0	1.23	0.45	–	2.5
Group 3 – trial	21.0	1.23	0.45	–	5.0
Group 4 – trial	21.0	1.23	0.45	–	6.0
Broiler chickens aged 28-42 days					
Group 1 – control	19.0	1.0	0.37	3.0	-
Group 2 – trial	19.0	1.0	0.37	–	3.0
Group 3 – trial	19.0	1.0	0.37	–	5.0
Group 4 – trial	19.0	1.0	0.37	–	6.0

Broiler chickens of all the groups were fed with feed containing the same amounts of crude protein, lysine, methionine, Ca, P and other nutrients according to the requirements of the cross *ROSS 308* standards. Feed and water were given ad libitum.

The feed of Group 1 broiler chickens contained 2.5–3.0% fodder yeast. The feeds of Group 2, 3 and 4 broiler chickens contained different amounts of protein concentrate to be studied (2.5-3.0, 5.0 and 6.0%) instead of fodder yeast. The feeds of these groups' broiler chickens contained no fodder yeast.

The protein concentrate samples were analysed for dry matter (ISO 6496-1999), crude protein (LVS EN ISO 5983-1:2005) and amino acids (LVS EN ISO13903:2005).

The optimal amount of protein concentrate used in broiler chicken feed was evaluated in terms of productivity, live weight, carcass weight, breast muscle weight, and feed cost. Live performance, feed conversion ratio (FCR), and the production efficiency factor (PEF) were assessed at 42 days of age. Feed conversion ratio (FCR) (calculated as the amount of feed consumed divided by the live weight of birds); the production efficiency factor (PEF) was calculated by the formula:

$$\frac{\text{Liveability}\,\% \times \text{Live weight in kg}}{\text{Age at depletion (days)} \times \text{FCR}\left(\text{Feed conversion ratio, kg kg}^{-1}\right)} \times 100$$

(Ross Broiler Management…, 2009).

Breast muscle weight was determined using gravimetric measurements after deboning sampling 8 carcasses from each group, in equal number per each sex.

Results and discussion

Broiler chicken productivity

The efficiency of protein concentrate in the diet of broiler chickens was evaluated based on the most important productivity indicators: live weight change, daily live-weight gain and feed conversion ratio, production efficiency factor productivity index.

By feeding the broiler chickens with feed containing different protein concentrate amounts, the live-weight thereof ranged within 2840.0–2894.0 g, the average live-weight gain per day 67.6–68.9 g, the feed consumption per 1 kg live-weight 1.77–1.94 kg, the pectoral muscle mass 545.28–577.34 g and the production efficiency factor ranged within 349.20–386.20 (Table 2).

It means that 5% and 6% protein concentrate amounts in poultry feed promoted the productivity of broiler chickens, though the feed contained the same amount of nutrients. It is likely to be related to better availability of nutrients from the protein concentrate in the digestive tract of broiler chickens. The 5.0% protein concentrate in the content of broiler chicken feed (Group 3) ensured a higher PEF of poultry productivity.

The live-weight of broiler chickens accordingly increased by 3.54% ($p<0.05$) (Group 4), the feed conversion – positively – decreased by 4.7% ($p<0.05$) (Group 3) and the PEF increased by 28.5% ($p<0.05$) (Group 3), in comparison with the control group.

Table 2

Impacts of different protein concentrate amounts on the productivity of broiler chickens

Parameters	Groups			
	Group 1 – control	Group 2 – trial	Group 3 – trial	Group 4 – trial
Live-weight at the age of 42 days, g	2795.0±47.0	2840.0±65.4	2876.0±66.5	2894.0±58.7
% to control	-	+1.61	+2.89	+3.54
Feed conversion ratio (FCR)	1.86	1.94	1.77	1.80
% to control	-	4.1	-4.7	-3.4
Production efficiency factor (PEF)	357.70	349.2	386.2	383.50
± to control	–	-8.5	28.5	25.8
Live-weight gain per day, g	66.5	67.6	68.5	68.9
Breast muscle mass, g	536.64±21.0	545.28±34.1	557.34±19.8	558.54±22.1
Breast muscle mass, % of live-weight	19.2	19.2	19.4	19.3

When the amount of protein concentrate in feed was increased from 5.0% to 6.0%, that is by 1.0%, the live-weight of broiler chickens tended to increase ($p>0.05$), whereas the production efficiency factor decreased. The breast muscle is the most valuable portion of the chicken carcass on the market; even small differences in breast muscle yield among broiler chickens could have significant economic impact. The breast muscle mass of broiler chickens of the experiment groups at the age of 42 days ranged within 536.64–577.34 g, which was 19.2–19.4% of their live-weight. The differences in breast muscle mass between the groups were not significant ($p>0.05$).

Expenses and revenues in broiler production

All the expenses associated with raising broiler chickens and all the revenues gained from selling live broiler chickens were calculated to determine the most economically efficient size of protein concentrate portion in a broiler chicken feed mixture. The total variable cost included expenses on infrastructure, wages, etc., which were equal for all the groups (Table 3).

The lowest consumption of feed per 1000 broiler chickens raised was observed for Group 3, 5100.0 kg, or 1.9% less than for the control group. The cost of feed, too, to raise 1000 broiler chickens in Group 3 was lower by EUR 111.6 or 5.5% in comparison with the cost of feed for the broiler chickens of the control group.

However, the highest consumption of feed (5500 kg) and accordingly the highest cost of feed (EUR 2114.18) were registered for Group 2.

The cost of feed per 1000 broiler chickens raised was determined by the cost of 1 kg feed and the quantity of feed consumed. The price of 1 kg of feed for the control group was 0.39 EUR kg^{-1}. The cost of complete feed for the experiment groups of broiler chickens was determined by the cost of the protein concentrate incorporated in feed (2.5-6%).

The lowest cost of 1 kg of feed was achieved for Group 3 because the 5.0% protein concentrate was incorporated in the feed mixture, which was 3.65% less than for the control group.

Table 3

Economic characteristics of feeding the protein concentrate (in raising 1000 broiler chickens on the experimental conditions)

Parameters	Groups			
	Group 1 – control	Group 2 – trial	Group 3 – trial	Group 4 – trial
Number of poultry raised	1000	1000	1000	1000
Total slaughter weight of broiler chickens, kg	1956.5	2025.8	1988.0	2083.2
± against the control group, kg	-	+69.3	+31.5	+126.7
Feed consumption for raising broiler chickens, kg	5200	5500	5100	5200
Price of 1 kg of feed, EUR	0.390	0.384	0.376	0.386
Feed cost in raising broiler chickens, EUR	2028.47	2114.18	1916.86	2006.6
Feed cost to produce 1 kg of products, EUR	1.037	1.044	0.964	0.963
Total variable cost of broiler chickens (feed costs excluded), EUR	845.67	845.67	845.67	845.67
Total cost, EUR	2874.15	2959.85	2762.53	2851.94
1 kg slaughter weight price, EUR	2	2	2	2
Revenues from selling live chickens, EUR	3913.0	4051.6	3976.0	4166.4
± against the control group, %	-	+3.54	+1.61	+6.48
Difference between revenues and expenses, EUR	1038.85	1091.75	1213.47	1314.46
± against the control group, %	-	+5.09	+16.81	+26.53

The economic efficiency of feed may be determined based on the cost of producing a unit of products. The feed was most efficiently used for Group 4, as the cost of producing 1 kg of broiler chicken meat was EUR 0.963, which was 7.11% less than for the control group.

In the aspect of production, meat quality, to a great extent, is determined by the proportion of meat in animals' live weight, as the remaining part is composed of sub-products, by-products and waste (Melece, 2004). For this reason, bioeconomic aspects refer to the effects of the entire set of these indicators on economic performance results.

In the aspect of meat production, the quality of products produced, which is mainly determined by the proportion of meat in poultry's live weight, as the rest is composed of sub-products, by-products and waste, directly affect revenues from the products produced. The largest quantity of products (2083.2 kg) and accordingly the greatest revenue from the products sold (EUR 4166.4) was provided by Group 4, which was 6.5% more than by the control group. Group 3, in contrast, provided the smallest quantity of products (1988.0 kg) and the lowest revenue from the products produced (EUR 3976.0), which might be explained by a smaller quantity of feed consumed during the experiment and a lower proportion of meat in the poultry's carcasses. Yet, it has to be emphasised that all the experimental groups of poultry provided greater amounts of products and revenues, compared with the control group.

The difference between revenues and expenses shows that the greatest profit is gained if feeding broiler chickens with the 6% protein concentrate. In contrast, the 2.5-3.0% protein concentrate fed to the broiler chickens of Group 2 did not produce a sufficiently positive result – this was indicated by the high consumption of feed, the high feed cost and the high production cost per kg of meat (EUR 1.044) reducing the profit.

Conclusions

To tackle the problem of how to reduce the production cost of broiler chicken meat, a feeding experiment on broiler chickens was conducted using feed concentrates – by-products from industrially processed agricultural products – produced in Latvia.

The feeding experiment used a feed of high protein content – high protein concentrate Baltiprot.

1. The experimental results evaluated in terms of live weight of broiler chickens showed that compared with the control group, Group 3, in which the broiler chickens' feed was supplemented with the 5% protein concentrate, presented:
    - the highest production efficiency (386.2),
    - the lowest feed conversion ratio, i.e. the necessary quantity of feed per kg live weight gain (1.77 kg);
2. An analysis of the quantities of meat produced as well as the revenues and expenses leads to a conclusion that, compared with the control group, Group 4, in which the broiler chickens' feed was supplemented with the 6% protein concentrate, presented:
    - the highest slaughter weight of poultry (+6.48%),
    - the lowest production cost per 1 kg of meat (-7.11%),
    - the highest profit (+26.53%).

3. The most economically efficient ration of protein concentrate in the diet of poultry is 6% of the total quantity of feed.

Bibliography

1. Adewunmi, I.O. (2008) Economics of Poultry Production in Egba Division of Ogun State. *Agricultural Journal*, Volume 3, Issue 1, pp. 10−13.
2. Bosenko A., Sargautis D., Vaitaitis D.(2008) Method for Production of Ethanol and Fodder Product. *European Patent Application* EP 1988169 A1, 05.11.2008. Bulletin 2008/45.
3. Bregendahl, K. (2008). Use of Distillers Co − Products in Diets Fed to Poultry. In: Babcock, B.A., Hayes, D.J., Lawrence, D.J. (eds.) *Using Distillers Grains in the U.S. and International Livestock and Poultry Industries*, pp. 99-133.
4. Broring, S. (2010) Moving Toward Market Orientation in Agri-Food Chains: Challenges forFeed industry. In: Lindgreen A., Hingley M.K. (Eds.) *Market Orientation: Transforming Food and Agribusiness Around the Customer*. Gover Publishing Limited. pp. 53-68.
5. Damme, K. (2011) Economic Aspects of Poultry Meat Production in Germany. *Lohmann Information*, Volume 46, Issue 1, pp. 38−43.
6. Demircan, V., Yilmaz, H., Dernek, Z., Bal, T., Gül, M., Koknaroglu, H. (2010) Economic Analysis of Different Laying Hen Farm Capacities in Turkey. *Agricultural Economics*, Volume 56, Issue 10, pp. 489−497.
7. Eurostat (2013) Detailed Statistics on The EU and Candidate Countries. Retrieved: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/. Access: 15.11.2013.
8. Laying down Minimum Rules for The Protection of Chickens (2007). Council Directive 2007/43/EC−28.06.2007. Retrieved:http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0043. Access: 04.12.2014.
9. Marcu, A., Vacaru-Opriş, I., Dumitrescu, G., Marcu, A., Ciochină Petculescu, L., Nicula, M., Dronca, D., Kelciov, B. (2013) Effect of Diets with Different Energy and Protein Levels on Breast Muscle Characteristics of Broiler Chickens
10. Martinez-Amezcua, C., Parsons ,C. M., Singh, V., Skrinivasan, R., Murthy, G. S. (2007). Nutritional Characteristic of Corn Distillers Dried Grains with Solubles as Affected by the Amounts of Grains versus Solubles and Different Processing Techniques. *Poultry Science*, 86, 2624-2630.
11. McDonald P., Eduards R.A., Greenhalgh J.F.D., Morgan C.A. (1995) *Animal Nutrition*, 4th ed. Longman Scientific and Technical. p. 672.
12. Noll, S. L., Brannon, J., Parsons, C.M. (2007). Nutritional Value of Corn Distiller Dried Grains with Solubles (DDGS): Influence of Solubles Addition. *Poultry Science*, 86, 68.
13. Onu P.N., Ayo-Enwerm M.C., Ahaotu E.O. (2010) Evaluation of Performance, Carcass Characteristics and Cost Effectiveness of Broiler Chicks Fed Synthetic Lysine and Methoinine Supplemented Soyabean-based Diets. *International Jurnal of Science and Nature,* Volume 1, Issue 1, pp. 22−26.
14. *Poultry Meat and Eggs.* (2010). Agribusiness Handbook. Food and Agriculture organization of the United Nations, Rome. p. 77.
15. *Ross Broiler Managment Manual* (2009). Ross Breeders Limited, Newbridge, Midlothian EH28 8SZ, Scotland, UK, p 101.
16. Scheuermann, G. N., Bilgili, S. F., Hess J. B., Mulvaney, D. R. (2003) Breast Muscle Development in Commercial Broiler Chickens. *Poultry Science*: 82, pp.1648−1658. Retrieved: http://ps.oxfordjournals.org/content/82/10/1648.long. Access: 12.12.2014.
17. The EU Protein Deficit: What Solution for a Long-standing Problem? (2011) Report. (2010/2111(INI)). Retrieved: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+REPORT+A7-2011-0026+0+DOC+XML+V0//LV Access: 08.12.2014.