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# EFFECT OF CRUDE FIBRE CONCENTRATION IN PULLET DIETS (9-16 WEEKS) ON THEIR SUBSEQUENT PERFORMANCE

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***Abstract***

*The EU produces more than 190 million tons of meat, milk and eggs. About 450 million tons of feeds/year are needed to support this production in the 28 EU member states. Research and innovation in animal feeding and in feed manufacturing technology are basic for the support of animal production in the EU, being the most profitable investment for this industrial sector. One of the problems with market demands regards the economic efficiency of the production, which involves diet formulations and choosing feed ingredients. Fibre-high feed ingredients can decrease the cost of feeding because of their lower costs compared to the conventional raw materials used in poultry diets. The paper reports the findings of a study on the effect of higher dietary crude fibre levels given to replacement pullets on their subsequent performance. A feeding trial was conducted on 240 Lohmann Brown pullets (9-16 weeks). The pullets have been assigned randomly to four groups (C, E1, E2, and E3), with 60 pullets per group, housed in an experimental hall under controlled environmental conditions. The diets for the four groups were characterized by 14.5% CP and 2800 kcal/kg ME. Compared to the diet for group C (5% fibre/kg compound feed, CF), the experimental diets had different levels of dietary fibre, given by the different amounts of dietary alfalfa: 6% fibre/kg CF (E1), 8% fibre/kg CF (E2), and 10% fibre/kg CF (E3), in combination with 2 enzymatic products that improve fibre digestibility (Biozim M6000 and Digestarom). The production parameters (feed intake, body weight, weight gain and animal welfare) were monitored throughout the experimental period. The experimental results have shown that feeding pullets (9-16 weeks) with compound feeds high in fibre (6% - E1; 8% - E2 and 10% - E3), didn't affect the growth parameters. The positive results compared to group C were recorded for group E2 (8% dietary fibre). The average live weight of E2 pullets (1419.5±97.76g GV) was significantly (P≤0.5) higher (by 4.65%) compared to group C pullets (1356.33±110.64 g LW). The live weight of E2 pullets also was 6.73% higher compared to the values stated in the Lohmann Brown management guide (1330.00 g LW).*

**Key words**: *pullets, fibre, alfalfa, performance.*

## INTRODUCTION

One of the strongest challenges of the 21st century is to provide enough healthy food for the increasing global population. Over the past 20 years, the importance of animal feeding and nutrition stimulated the development innovative solutions in support of the "from Farm to Fork" concept. The objective of the innovation activities in animal nutrition is to provide pertinent and consistent answers to the demands of the current production. Thus, diets are redesigned both in terms of the ingredients and in terms of formulation. (Mateos et al., 2002; Pottgüte, 2008). The economic efficiency is a very important aspect of the feed formulations and the selection of ingredients is done according to their cost (Abdallah et al., 2015). The feed ingredients rich in fibre generally have rather low prices, although their protein concentration can be rather significant (van Krimpen et al., 2008). Usually, both poultry research and practice regarded fibre as something that dilutes the formulation (Rougière and Carré, 2010), with adverse consequences on the voluntary feed intake and nutrient digestibility (Mateos et al., 2002).
Therefore, the commercial diets, particularly for growing poultry, were thus formulated as to have less than 3% fibre. Wenk (2007) consider that animal diets must contain a minimal level of fibre, which maintains the normal physiological functions of the gut. The higher dietary fibre concentration is a major concern

because of the resulting lower dietary nutrients and lower net energy content. Several authors (Sklan et al., 2003; Amerah et al., 2009; Svihus, 2011; Knudsen et al., 1997; Walugembe et al., 2014) consider that the dietary fibre can have positive effects in maintaining gut health, for a higher satiety, improving animal behaviour and welfare. By its structure and properties, the dietary fibre influences the transit rate, digesta pH and the production of volatile fatty acids in the gut (Montagne et al., 2003; Raninen et al., 2011). The effects of the dietary fibre on poultry physiology and productivity depend on the dietary level and source of fibre (Jiménez-Moreno et al., 2011); on diet formulation (Jiménez-Moreno et al., 2009); on the physical structure of the source of fibre (Jiménez-Moreno et al., 2010); on the form of conditioning of the feed (Jiménez-Moreno et al., 2007); on poultry hybrid and age (González-Alvarado et al., 2010). In the practice of feeding, particle size and solubility of the cellulose fraction in the digestive environment and the level of lignification are key characteristics (Lindberg, 2014), which influence productivity due to their effect on the rate of passage (Saki et al., 2011).The feeding value of the available high-fibre forages can be increased by pelleting and by reducing particle size(Lindberg, 2014; Brufau et al., 2006), by the addition of exogenous enzymes (Svihus and Gullord, 2002) or by using enzyme-cereal grains combinations (Bedford, 2000; Ribeiro et al., 2011).

The purpose of this study was to study the effect of different dietary crude fibre levels on replacement pullets (9-16 weeks) performance.

## MATERIALS AND METHODS

A trial was conducted on 240 Lohmann Brown pullets (9-16 weeks), in agreement with Romanian laws (Law 206/2004, Ordinance 28/31.08.2011, Law 43/11.04.2014 and Directive 2010/63/EU). The experiment was performed in a hall with controlled environmental conditions (temperature: 21.94±1.96$^0$C and humidity 56.83±6.38%). The light regimen was adequate to the age category (8 h light/16 h dark). The pullets were assigned randomly to four groups (C, E1, E2, E3), and were housed in enriched cages (20 pullets/cage). The feed was given according to the hybrid guidebook, gradually increasing the amount of feed with the week of age and body weight of the pullets.

The compound feeds formulation took into consideration the objective of the trial, the species, hybrid, age and nutritional requirements of the Lohmann Brown hybrid. The feed ingredients were first assayed chemically and the compound feeds formulations were thereafter determined (Table 1). Pelleted alfalfa was used in the compound feeds for the experimental groups as additional source of fibre compared to the diet for group C, at the following rates: 4% for E1; 8% for E2 and 19.44% for E3. Alfalfa is one of the most important leguminous forages because of its high feeding qualities, its high production capacity and outstanding adaptability.

Table 1. Diet formulation

| **Specification** | **C** | **E1** | **E2** | **E3** |
|---|---|---|---|---|
| Corn, % | 67.92 | 66.50 | 61.97 | 52.02 |
| ***Pelleted alfalfa, %*** | ***-*** | ***4.00*** | ***8.00*** | ***19.44*** |
| Wheat bran, % | 8.85 | 6.91 | 3.00 | 3.00 |
| Soybean meal , % | 9.00 | 6.70 | - | - |
| Sun flower meal, % | 10.22 | 12.00 | 21.58 | 18.51 |
| Plant oil, % | - | - | 1.60 | 3.69 |
| Lysine, % | 0.09 | 0.14 | 0.27 | 0.23 |
| DL-methionine, % | 0.12 | 0.12 | 0.10 | 0.12 |
| Calcium carbonate, % | 0.98 | 0.73 | 0.55 | - |
| Monocalcium phosphate, % | 1.15 | 1.20 | 1.23 | 1.28 |
| Salt , % | 0.37 | 0.37 | 0.37 | 0.38 |
| Premix, % | 1.00 | 1.00 | 1.00 | 1.00 |
| TOP 3, %* | 0.20 | 0.20 | 0.20 | 0.20 |
| MICOFIX,%** | 0.10 | 0.10 | 0.10 | 0.10 |
| BIOZIM M 6000, %*** | - | 0.015 | 0.015 | 0.015 |
| DIGESTAROM, %**** | - | 0.015 | 0.015 | 0.015 |
| **Total ingredients** | **100** | **100** | **100** | **100** |
| *Calculated* | | | | |
| ME, kcal/kg | 2800 | 2800 | 2800 | 2800 |
| CP, % | 14.52 | 14.5 | 14.5 | 14.7 |
| EE, % | 2.29 | 2.16 | 3.47 | 5.25 |
| Crude fibre, % | 5.00 | 6.00 | 8.00 | 10.00 |
| Calcium, % | 0.9 | 0.9 | 0.9 | 0.9 |
| Phosphorus, % | 0.69 | 0.69 | 0.71 | 0.69 |
| Lysine, % | 0.65 | 0.65 | 0.65 | 0.65 |
| Methionine, % | 0.38 | 0.38 | 0.38 | 0.42 |

Premix IBNA (A3) = (1100000 IU/kg vit. A; 200000 IU/kg vit.D3; 5000 IU/kg vit. E; 200 mg/kg vit. K; 400 mg/kg vit.B1; 400mg/kg vit.B2; 1485 mg/kg pantothenic acid; 3600 mg/kg nicotinic acid; 300 mg/kg vitamin B6; 4 mg/kg vitamin B7; 100 mg/kg vitamin B9; 2 mg/kg vitamin B12; 2000 mg/kg vitamin C; 6200 mg/kg Mn; 4000 mg/kg Fe; 500 mg/kg Cu; 6000 mg/kg Zn; 37 mg/kg Co; 114 mg/kg I; 13 mg/kg Se; 6000 mg/kg antioxidant; *acidifying agent; **mycotoxin inhibitor; ***enzymatic product; ****phytogenic additive

It is an ingredient rich in protein, having a balanced fatty acids profile. Alfalfa also is a rich source of vitamins and carotenoids (Sen et al., 1998) and saponins, which have hypocholesterolaemic, anticarcinogenic and anti-inflammatory effects (Whitehead et al., 1981). It is often used in layer diets as source of xanthophylls to pigment the skin and egg yolk, or as source of the so-called unidentified growth factors (Leeson and Summers, 2005). Fibre digestibility from the experimental diets was improved with and enzymatic product (BIOZYM M6000) and a plant mixture (DIGESTAROM) produced by BIOMIN Company. Biozym M6000 is a multi-enzyme feed additive having beta-xylanase (produced by immersed fermentation of a selected strain of *Trichoderma longibrachiatum CNMC MA 6-10W*) and beta-glucanase as active products. This product is used stabilised source of enzymes. Digestarom is a phytogenic feed additive designed to improve digestion and to maintain gut health. It is a standard mixture of essential oils, herbs, spices and plant extracts (Biomin Catalogue of Additives and Specialties Premixes, Concentrates and Complete Feed, 2014).

The average daily feed intake (kg CF/pullet/day) and body weight (kg LW/pullet) were monitored throughout the experiment. Body weight curve was compared to that specified in the guidebook in order to anticipate the egg production as adult. Both the feed ingredients and the manufactured compound feeds (one batch/group) manufactured according to the formulations shown in Table 1 were assayed chemically (Tables 2 and 3). The chemical analyses were performed using methods from Regulation (CE) no. 152/ 2009 (Sampling and analytical methods for the official inspection of feeds): gravimetric method for the dry matter (DM); the Kjeldahl method for the crude protein (CP); extraction in organic solvents for the ether extractives (EE); acid hydrolysis followed by alkaline hydrolysis for the crude fibre (CF); gravimetric method for the ash (Ash); photocolorimetric method with ammonium metavanadate for phosphorus (P); spectrophotometric method with atomic absorption for lead (Pb) and cadmium (Cd). Calcium (Ca) was determined by titration according to standard: SR ISO 6490-1:2006.

The feeding costs for the four groups were also calculated.

*Statistical analysis:* The analytical data were compared by variance analysis (ANOVA), using Stat View for WINDOWS (SAS, version6.0). The differences between the average values within the groups were considered significant for P<0.05. The results were expressed as mean±SD for all measurements.

## RESULTS AND DISCUSSIONS

Table 2 shows the results of the chemical determinations on the samples of feed ingredients. Table data show that the pelleted alfalfa was rich both in protein (16.05%) and in fibre (27.43%). Similar results for alfalfa were also reported by Mouráo et al. (2006) for protein (17.5%) and fibre (24.1%) but a lower amount of metabolisable energy. Tedeschi et al. (2001) showed that the chemical composition of the alfalfa varies with the time and stage at harvesting (for instance, CP varies between 17.2-21.7%), while Homolka et al. (2008) reported a fibre content of 25.4-40.1% depending on the stage at harvesting.

Table 2. Chemical composition of the feed ingredients

| Specification | Corn | Alfalfa | Wheat bran | Soybean meal | Sunflower meal |
|---|---|---|---|---|---|
| DM, % | 86.34±1.44 | 85.68±9.42 | 88.38±2.10 | 88.36±1.56 | 90.28±0.03 |
| CP, % | 7.70±1.22 | 16.05±1.07 | 10.54±0.70 | 43.32±0.75 | 31.82±2.95 |
| EE, % | 2.37±0.20 | 1.06±0.07 | 1.03±0.10 | 1.17±0.07 | 0.72±0.03 |
| Fibre, % | 3.43±0.94 | 27.43±1.89 | 4.98±1.14 | 3.98±0.93 | 18.31±0.95 |
| Ash, % | 1.44±0.17 | 9.15±0.47 | 2.19±0.01 | 6.96±0.76 | 7.05±1.27 |
| Ca, % | 0.03±0.02 | 1.15±0.83 | 0.07±0.01 | 0.06±0.01 | 0.35±0.01 |
| P, % | 0.19±0.15 | 0.32±0.21 | 0.33±0.02 | 0.04±0.01 | 1.17±0.20 |

The determinations performed on the compound feed samples (Table 3) show that they balanced in terms of protein and energy supply.

The diets of the four groups had an average 14.5% CP and 2800 kcal/kg ME. Compared to the diet formulation for group C, the diets for groups E1, E2 and E3 had 2% more dietary fibre (Table 3) due to the pelleted alfalfa (Table 1).

Table 3. Chemical composition of the compound feeds (CF)

| Specification | CF C | CF E1 | CF E2 | CF E3 |
|---|---|---|---|---|
| Dry matter, (%) | 87.88 | 87.88 | 88.11 | 88.72 |
| Protein, (%) | 14.24 | 14.89 | 14.86 | 14.76 |
| Fat, (%) | 1.89 | 2.80 | 3.93 | 5.52 |
| Fibre, (%) | 5.00 | 6.19 | 8.42 | 10.66 |
| Ash, (%) | 4.83 | 4.90 | 5.48 | 5.21 |
| Calcium, (%) | 0.83 | 0.82 | 0.83 | 0.82 |
| Phosphorus, (%) | 0.82 | 0.70 | 0.70 | 0.73 |
| Lead, (ppm) | 0.361 | 0.123 | 0.113 | 0.034 |
| Cadmium, (ppm) | 0.056 | 0.041 | 0.039 | 0.043 |

The concentration of Ca in the compound feeds (Table 3) was not different between groups, even though group E3 had no calcium carbonate (Table 1). For this group, Ca (0.82%) was provided by the dietary alfalfa (19.44%), which has a concentration of 1.15% Ca (Table 2). It is important to provide a dietary calcium level according to the requirements of the hybrid, because this element is necessary both to the growth and development of the bone system of the pullets and, particularly, for the establishment of the calcium deposits that will be later used to form the egg shell.

Knowing the fibre concentration of each feed ingredient, we calculated the fibre concentration of each CF (Table 4). It can thus be noted that in the CF for group C (no alfalfa), corn provided most of the fibre (47%), followed by the sunflower meal (37%), wheat bran (9%) and soybean meal (7%). As the alfalfa concentration increased in the experimental CF, the fibre concentration also increased in these feeds. Thus, in the CF for group E1, the inclusion of 4% alfalfa provided 18% of the CF fibre, while in the CF for group E2 (8% alfalfa), this contribution doubled (Table 4). In the CF for group E3 (19.44% alfalfa), the fibre provided by alfalfa represented 50% of the dietary fibre concentration (Table 4).

A balanced diet during pullet growth is essential for its transformation into a mature bird. The pullet must be fed intensively on a particular type of feed. It was shown that a high proportion of very fine components, or a granulation that is too large, lead to selective, unbalanced feeding, some of the nutrients not being therefore assimilated (Amerah et al., 2011; Jiménez-Moreno et al., 2009).

Table 4. Supply of fibre by the ingredients of each compound feed formulation

| Specification | Fibre level of the feed ingredient (%) | CF C | | CF E1 | | CF E2 | | CF E3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Feed ingredient (kg) | Fibre (%) | Feed ingredient (kg) | Fibre (%) | Feed ingredient (kg) | Fibre (%) | Feed ingredient (kg) | Fibre (%) |
| Corn | 3.43 | 67.89 | 2.33 | 66.50 | 2.28 | 61.96 | 2.13 | 52.02 | 1.78 |
| Alfalfa meal | 27.43 | - | - | 4.00 | 1.10 | 8.00 | 2.19 | 19.45 | 5.34 |
| Wheat bran | 4.96 | 8.85 | 0.44 | 6.91 | 0.34 | 3.00 | 0.15 | 3.00 | 0.15 |
| Soybean meal | 3.98 | 9 | 0.36 | 6.70 | 0.27 | - | - | - | - |
| Sunflower meal | 18.31 | 10.22 | 1.87 | 12.00 | 2.20 | 21.58 | 3.95 | 18.51 | 3.39 |
| Fibre concentration/formulation, (%) | | **5.00** | | **6.19** | | **8.42** | | **10.66** | |

In this case, the growth performance of the poultry, their weight gain, is directly affected (González-Alvarado et al., 2010; Sklan et al., 2003). Due to the high fibre content of the compound feeds, pullet feeding was given particular importance.

The average daily feed intake was 67.14±4.43 g CF/pullet/day (Table 5), irrespective of the group. Starting with the second experimental week (week 10 of life), the amount of given feed increased by 2 grams/week, irrespective of the experimental group. Regarding the live weight of the pullets, Table 5 shows that the live weight of the pullets from group E2 was significantly ($P \leq 0.05$) higher than that of the control group (1356.33±110.64 g).

Table 5. Evolution of the feed intake and of the live weight of the pullets (average values/group)

| Age | Average daily feed intake, (g) | Live weight of the pullets, (g) | | | | |
|---|---|---|---|---|---|---|
| | | Lohmann Brown guidebook | C | E1 | E2 | E3 |
| 10 weeks | 60 | **874.00** | 880.50±72.05 | 876.50±127.78 | 895.67±86.23 [d] | 850.00±84.37 [c] |
| | | 100% | 0.74% | 0.29% | 2.48% | - 2.75% |
| | | | 100% | -0.45% | 1.72% | -3.46% |
| 11 weeks | 64 | **961.00** | 956.33±73.00 [d] | 975.17±94.64 [d] | 984.50±86.31 [d] | 918.83±91.02 [a,b,c] |
| | | 100% | - 0.49% | 1.47% | 2.45% | - 4.39% |
| | | | 100% | 1.97% | 2.95% | -3.92% |
| 12 weeks | 65 | **1043.00** | 1039.50±159.07 | 1045.83±105.24 | 1069.33±87.66 [d] | 1018.17±112.0 [c] |
| | | 100% | - 0.34% | 0.27% | 2.52% | - 2.38% |
| | | | 100% | 0.61 | 2.87 | -2.05 |
| 13 weeks | 68 | **1123.00** | 1129.00±103.03 | 1144.33±112.38 [d] | 1144.50±159.36 [d] | 1088.17±165.79 [b,c] |
| | | 100% | 0.53% | 1.90% | 1.91% | - 3.10% |
| | | | 100% | 1.36% | 1.37% | -3.62% |
| 14 weeks | 70 | **1197.00** | 1202.39±105.26 | 1230.16±113.89 [d] | 1230.34±125.98 [d] | 1169.78±140.14 [b,c] |
| | | 100% | 0.45% | 2.77% | 2.79% | - 2.27% |
| | | | 100% | 1.45% | 3.18% | -2.33% |
| 15 weeks | 71 | **1264.00** | 1258.33±107.50 [c] | 1277.50±115.42 [c] | 1318.83±92.61 [a,b,d] | 1243.50±114.49 [c] |
| | | 100% | - 0.45% | 1.07% | 4.34% | - 1.62% |
| | | | 100% | 1.52% | 4.81% | -1.18% |
| 16 weeks | 72 | **1330.00** | 1356.33±110.64 [c] | 1377.00±140.58 | 1419.50±97.76 [a,d] | 1370.83±131.04 [c] |
| | | 100% | 1.98% | 3.53% | 6.73% | 3.07% |
| | | | 100% | 1.52% | 4.66% | 1.07% |

*where: a, b, c, d show significant differences compared to C, E1, E2, E3

Figure 1 shows the body weight evolution in the Lohmann Brown replacement pullets, the experimental results being compared to the figures from the management guide. The higher level of dietary fibre produced a higher body weight and a better feed conversion ratio. Similar results have been reported by Abdallah et al., (2015) who investigated the effect of the different sources of fibre (sunflower meal and olive meal).

Figure 1 data show that in group E3 (10.66% fibre), live weight was lower compared to the hybrid management guidebook after the first week. At the end of the experiment, however, the live weight of group E3 was significantly ($P \leq 0.05$) higher, exceeding by 3.07% the value given by the hybrid management guidebook (Table 5). The compound feeds of groups E1 (6.19% fibre) and E2 (8.42 %fibre) were very well assimilated by pullet organism, which produced higher live weights compared to the reference values (Table 5).

Group E2 displayed a linear increase of the live weight from the first experimental week (Figure 2) so that, at the end of the trial, the live weight of the pullets was 4.66% higher compared to the value recorded for group C, and 6.73% higher compared to the hybrid management guidebook (Table 5). The live weight of the pullets from group E1 was just 1.52% higher than the control, and 3.53% higher than the management guidebook (Table 5). We may say that both the 8.42% and the 10.66% dietary fibre levels didn't affect pullet growth. Hetland and Svihus (2001) reported that the pullets maintained their body weight when the diets contain high levels of insoluble fibre, maybe because the fibre increases the rate of passage of the digesta through the digestive system and maintains the physical capacity of the gastrointestinal tract.

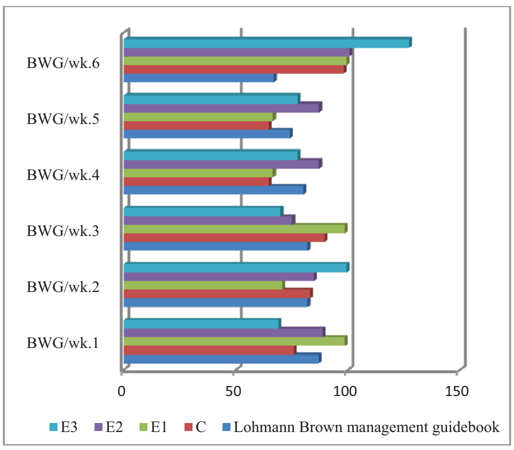


Figure 1. Comparison between the body weight gain of the pullets from groups C, E1, E2, E3 and the values from the Lohmann Brown management guidebook

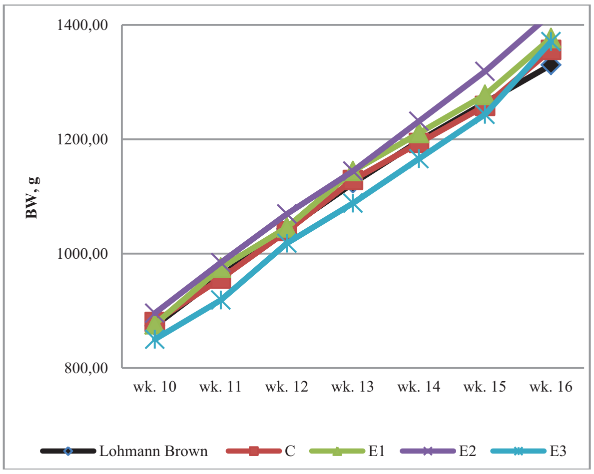


Figure 2. Evolution of pullet live weight

No significant economic changes were noticed in terms of the feeding cost, except for group E3, where it was 12.9% higher compared to group C (Table 6). This means 0.352 lei/pullet/experimental period more compared to the control. On the other hand, the feeding cost for group E2, with the best performance, was just 0.056 lei/pullet more than in group C.

Table 6. Economic efficiency of the trial which run throughout the period 9-16 weeks

| Item | Feeding days | CF consumption/ period (kg feed) | Price/ kg feed (lei) | Total cost /period, (lei) |
|---|---|---|---|---|
| C | 49 | 3.290 | 0.8306 | 2.733 |
| E1 | 49 | 3.290 | 0.8281 | 2.724 |
| E2 | 49 | 3.290 | 0.8477 | 2.789 |
| E3 | 49 | 3.290 | 0.9379 | 3.085 |

## CONCLUSIONS

The growth parameters of the pullets (9-16 weeks) were not affected when they were fed with compound feeds high in fibre.

Positive results compared to C were noticed in group E2 (8.42% dietary fibre). The average live weight of E2 pullets (1419.5±97.76 g) was significantly (P≤0.5) higher (by 4.65%) compared to the average live weight of group C pullets (1356.33±110.64 g) and 6.73% higher compared to the Lohmann Brown management guide (1330.00 g).

The use of alfalfa - feed in gradient rich in fibre - increased the cost of feeding proportionally with the dietary level of fibre. In group E1 (6.19% fibre), the cost of feeding was slightly lower compared to group C, which means that it is possible to use alfalfa at a level of 6.19% fibre/formulation, without affecting the price of the formulation

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***Romanian laws (Law 206/2004, Ordinance 28/31.08.2011, Law 43/11.04.2014 and Directive 2010/63/EU).

***Regulation (CE) no. 152 /2009 (Sampling and analytical methods for the official inspection of feeds).