CARCASS CHARACTERISTICS AND QUALITATIVE MEAT TRAITS OF BROILER CHICKENS FED SUPER PRE-STARTER DIET

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Abstract. The aim of present study was to assess the effects of animal blood plasma with soy protein concentrate and tryptophane in the super pre-starter diet of broiler chickens. The study was carried out with a 1000 *ROSS 308* cross broiler chickens of 1-42 day old. Broilers were divided into 2 groups of 500 chickens. The birds received the experimental diets from 1 to 8 d of age. The chickens were fed a standard pre-starter diet (Control) and super pre-starter diet (Treatment). In diet of treatment group, the wheat, soy-bean meal and corn were replaced with blood plasma meal (5%), soy-bean concentrate (5%) and tryptophan (0.046%). The birds of control and treatment groups received the same standard diets from 9 to 42 d of age. The parameters of productivity, such as body weight (BW), feed conversion ratio (FCR) and mortality during the experiment were estimated. At the end of the trial the chicks were killed and after laparotomy internal organs and digestive tract were removed and weighed. The length of intestinal tract was measured. Carcass meat characteristics were evaluated. The physical and chemical indices of the meat, such as drop losses, water holding capacity, meat cooking losses, meat tenderness, amount of intramuscular ash, fat, total protein and dry matter (DM) was determined. The results of the study showed, that the final BW by 3% were increased in treatment group ($P<0.05$). The FCR was decreased by 3% during all experimental period, compared with control ($P>0.05$). The intestinal weight with chymus, weight of heart, liver, gizzard and proventriculus were higher for broiler chickens which received a super pre-starter compound feed. Application of super pre-starter diet had a positive effect on carcass characteristics of broiler chickens. The carcass yield was improved by 2%, breast and leg muscle yield by 1%, compared with the control group ($P>0.05$). The drip-loss, water holding capacity, DM, intramuscular fats and ash of breast as well as the leg meat were increased, compared with control group ($P>0.05$). In summary the application of super pre-starter diet for broiler chickens at the age of 1-8 days could improve the BW and decrease the FRC with better carcass characteristics of broiler's meat.

Keywords: super pre-starter feed, carcass characteristics, meat quality, broiler chickens.

Introduction. Progress in genetics and management has allowed the poultry industry to produce heavier chickens in a more efficient manner. Consequently, the age to market in broiler chickens has been gradually reduced. On the other hand, research work conducted during the past decade in the area of the chick's early development has shown that during the first week post-hatch, the digestive system is not fully developed. Because the first week post-hatch currently represents a more critical part of the broiler's productive life, and the chick's digestive capabilities are limited at this age, special attention is being given to the nutritional needs of the chicken during this period in order to maximize performance. One strategy to address this is the use of super pre-starter diets, with the goal of providing highly digestible ingredients that the young chick will be able to utilize more efficiently (Garcia, 2006). The design of such feed will be different when it is to be part of a drug-free nutrition program. In such cases, not only alternative anti-pathogen agents are required, but proteins of high digestibility are also a must. Among them, animal plasma can provide a double function as a gut health agent, it have good balance of amino acids, especially lysine, in addition to being highly digestible (Mavromichalis, 2016). Longer intestinal villi have been observed after inclusion of porcine plasma in broiler diets (Jamroz et al., 2011, 2012). The activity of blood by-products has been associated with specific immunoreactive globulins and nucleotides that exist in the composition of blood products (Moretó and Pérez-Bosque, 2009).

Various processed soybean products have been used in animal and poultry feeding. These include soybean protein concentrates (SPC), soybean protein isolates (SPI), and products in which the soybean was pretreated with enzymes and/or microorganisms. Processed soy products are distinctly different to soybean meal (SBM) thus they have much lower ANFs activities, and contain a significantly lower amount of oligosaccharides and antigenic substances. Therefore, their nutritive value is much better than that of SBM and can be incorporated at high levels in animal diets (Peisker, 2001). Replacement of SBM with these processed products in animal diets is believed to result in a better growth performance because SBM may contain enough ANFs to exert their antinutritional effects (Saki et al., 2012). It has been concluded by van der Eijk (2015) that partial or complete

replacement of SBM with SPC in the diets of young turkeys enhanced their 8-week body weight. In the same experiment they found that inclusion of SPI in lieu of SBM significantly improved feed utilization. It has been found that 5% replacement of soybean with processed soy protein in broiler starter diet resulted in an improvement in body weight and feed efficiency when the diet was fed for seven days (van der Eijk, 2015). Similar improvements in body weight, mortality and feed conversion ratio of birds were found when the diet was fed for 10 days (Sleman et al., 2015).

The scientific evidence of application SPC and animal blood plasma mainly is focused on nutrition of piglets (Yang et al., 2007; Resende et al., 2017). There are many ingredients and additives that can be used to design a broiler super pre-starter compound feed (Mavromichalis, 2016).

The first week of life of a broiler chicken has a large impact on its health, welfare, and growth performance as it matures (Lemot, 2017). Broiler chickens have to get a good start for further growth. The important progress in broiler chickens nutrition research has been the development of the concept of an "Ideal Protein". One basic idea of this concept is that birds need amino acids in a certain balance to ensure optimum performance. Any absorbed amino acid which is in relative excess compared to the first limiting amino acid will be oxidised and nitrogen will be excreted. Therefore, adjusting the dietary amino acid supply according to the "Ideal Protein Concept" helps to maximise nitrogen utilization (Lemme, 2003). Dietary amino acid concentration should closely meet the quantitative requirement of animals dependent on genotype, gender, age, aimed performance and housing conditions. The amount of amino acids and it ratio depend on these factors also. In feed formulation only well-absorbed feed components should be applied.

Thus, the aim of present study was to assess the effects of animal blood plasma with soy protein concentrate and tryptophane in the super pre-starter diet of broiler chickens.

Materials and Methods. The research was carried out in compliance with the Republic of Lithuania "Law on Animal Custody, Storage and Use" 11-11-1997, No. 8-500/valid summary from July 5, 2016 ("State News", 28-11-1997, No. 108) and the substatutory act – Order of the State Food and Veterinary Service of the Republic of Lithuania "On Approval of Requirements for the Maintenance, Use and Use of Animals for Experimental and Other Scientific Research" ("State News", 22-01-2009, No. 8-287/valid summary from March 4, 2017). Also, it complied with Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 „On the protection of animals used for scientific purposes".

The study was carried out with a 1000 *ROSS 308* cross broiler chickens of 1-42 day old. Broilers were divided into 2 groups of 500 chickens in each group with 10 replicates per group. The birds received the experimental diets *ad libitum* from 1 to 8 d of age. The chickens were fed a standard pre-starter diet (Control) and super pre-starter diet (Treatment). In diet of treatment group, the wheat, soy-bean meal and corn were replaced with blood plasma meal (5%), soy-bean concentrate (5%) and tryptophan (0.046%). The birds of control and treatment groups received the same diets from 9 to 42 d of age. Diets were formulated to contain equal nutrient levels and to supply broilers' nutritional requirements (NRC, 1994). Water and feed were offered for *ad libitum* consumption. The nutrient profile of the diets is given in Table 1.

Table 1. **The nutritional composition of compound feed (%)**

	Control	**Treatment**		**Control and treatment**	
	Starter 1-21 d of age	**Super pre-starter 1-8 d of age**	**Starter 9-21 d of age**	**22-35 d of age**	**36-42 d of age**
ME (MJ/kg)	12.47	12.56	12.47	12.77	13.19
Crude protein*	21.00	22.50	21.00	20.00	18.50
Crude fat*	5.96	3.88	5.96	8.26	9.25
Crude ash*	6.34	7.04	6.34	6.05	5.42
Crude fiber*	2.60	2.48	2.60	3.38	3.33
Calcium*	0.96	0.96	0.96	0.87	0.78
Phosphorus*	0.71	0.63	0.71	0.70	0.60
Phosphorus (available)	0.53	0.48	0.53	0.49	0.41
Sodium	0.16	0.17	0.16	0.17	0.16
Magnesium	0.08	0.14	0.08	0.12	0.12
Potassium	0.90	0.78	0.90	0.83	0.76
Chlorine	0.18	0.19	0.18	0.19	0.19
Lysine	1.35	1.82	1.35	1.22	1.09
Methionine	0.63	1.02	0.63	0.48	0.53
Methionine+cystine	0.96	1.39	0.96	0.84	0.87
Trypthophane	0.26	0.35	0.26	0.25	0.23
*Analyzed value					

The procedures related to birds care used in this experiment followed EU Directive 2007/43/EC, which sets out the minimum requirements of care for broiler chickens (www.litlex.lt). The broiler chickens were kept on deep litter and had free access to feed and water from stationary drinkers. Broiler chickens individually and compound feed leftovers were weighed on days 7, 8, 21, 35 and 42 in order to determine body weight (BW) and feed conversion ratio (FCR). Mortality was also recorded.

At the end of the trial the chicks were killed by cervical dislocation according to the recommendations for euthanasia of experimental animals (Close, 1997). After laparotomy internal organs and digestive tract were removed and weighed. The visceral organs ant digestive tract was weighed (Itani, 2015). The length of intestinal tract was measured with flexible tape "Hoechstmass" (Hoechstmass, Germany) on a glass surface. The intestinal walls were washed with physiological solution, dried up with filter paper and weighed (Lentle et al., 1989).

Carcass meat characteristics were evaluated according to Dissection of Poultry Carcasses, INRA (2000).

Drip-loss, water holding capacity was determined by the weight loss over 24 hours. It kept hanging bags with net +4°C (Hamm, 1986). Meat cooking losses were determine weighing method of cooking meat with circulating water bath for 30 min., at 70°C, by weighing before and after cooking (Schilling, 1966). The tenderness of the meat by Warner–Bratzler shear force method were evaluated (AMSA, 1995). The amount of ash was determined by burning meat in 700°C degrees (LST ISO 936:2000). The dry matter content was determined drying meat to constant weight (at 105°C) (LST ISO 1442:2000), the fat content was determined by Soxhlet method, the fat extracted with chloroform to 8 hours. Total protein content was determined by the Kjeldahl method (King-Brink, Sebranek, 1993).

The results of the experiment were analyzed using the 1-way ANOVA test, and significant differences between groups were determined by Duncan's multiple range test. *Statistica* 8.0 for Windows™ software was used. Data in tables are given as means ± SEM. Differences were considered significant at $P<0.05$.

Results and discussion

The productivity characteristics of broiler chickens are shown in Table 2. The dietary treatment applied in this study had beneficial effect on BW of broilers ($P<0.05$). The lower FCR from 3 to 4% were observed.

In the case of broilers, the first three to five days actually represents a very significant proportion of a broiler's life. The primary aim of a super pre-starter ration is to fulfill the specific nutritional needs of the young chick, supporting its transition from eating the yolk sac to the first diet consumed. Availability of nutrients immediately after hatch is critical for growth and development. One of the aims of super pre-starter diet is promoting gut development. The gastrointestinal tract grows four times faster than the rest of the body during the first two weeks of life. It is this organ that is driving body weight gain and as such requires up to 40% of the energy and protein that the young bird consumes. High protein content is also necessary in diets for young birds, apart from for growth to help maintain body temperature. Development of the immune system starts in the embryo and continues after hatching. In the first week of life, there is a rapid increase in the number of leucocytes, due to the growth of the lymphoid organs. The synthesis of immune cells is a metabolically expensive process and is highly dependent on the presence of nucleotides. These protein building blocks can be found in significant amounts in certain concentrated protein products (Kay, 2017).

Even though broiler chickens seem capable of metabolizing high protein diet during the first week of life, it remains unknown whether there are any adaptive consequences when either switching to a lower protein diet, or when feeding broiler chickens super pre-starter diet after the first week of life is continued during the starter and grower phase (Lemot, 2017). The results of our study showed, that productivity of broiler were increased at the further growing phases.

Longo et al. (2005) evaluated the addition of spray-dried eggs (8%), blood plasma (5.6%), soy protein isolate (5.35%), corn gluten meal (7.3%) and dried sugar cane yeast (13.65%), in substitution for soybean meal, as protein sources for broiler pre-starter diets. No significant effects on weight gain were observed. However, there was a significant improvement in feed conversion in the chickens fed soy protein isolate and blood plasma.

Table 3 shows the relative weights of the digestive tract organs. The intestinal weight with chymus, heart, liver, gizzard and proventriculus weights were higher for broiler chickens which received a super pre-starter compound feed. We found similar results as reported by Lemot D. (2017), that broiler chickens adapted to super pre-starter diets lowered pancreas weight.

Maturation of the GIT in young broiler chickens is mainly reflected by increased overall intestinal length and weight. The small intestine increases about 3 times in relative weight during the first week of life, mainly due to villi development to increase the absorptive area of the GIT. Villi development is measured by greater villi length and increased villi density, resulting in a larger surface area available for absorption of nutrients provided through feed. The surface area of a single villi develops faster in the duodenum than in the jejunum and ileum (Geyra et al., 2001), but when combined with the number of villi per intestinal section (duodenum, jejunum, ileum), the jejunum has a larger total villus surface area compared to duodenum and ileum (Lemot, 2017). This could explain our results of decreased intestinal weight without chymus. In addition, we observed the higher BW of treatment group's broilers. In various studies substantial attention has been given to the importance of protein level and quality in relation to visceral organs and intestinal development, which has been reviewed by Wijtten et al. (2012).

The meat carcass characteristics are shown in Table 4. Application of super pre-starter diet had a positive effect on carcass characteristics of broiler chickens. The carcass yield was improved by 2%, breast and leg muscle yield by 1%, compared with the control group ($P>0.05$).

Table 2. **The effect of super pre-starter diet on productivity of broiler chickens**

Characteristics	Control	Treatment
Between days 1-8		
BW – day 1 (g)	49.23±0.23	49.34±0,22
BW – day 8 (g)	204.68[a]±1.62	214.81[b]±1,45
FCR (kg/kg)	1.17±0.04	1.13±0.03
Mortality (%)	0.40±0.01	0.60±0.02
Between days 9-21		
BW – day 21 (g)	967.66[a]±6.00	1010.43 [b]±8.62
FCR (kg/kg)	1.51±0.04	1.46±0.05
Mortality (%)	1.41±0.34	0.60±0.02
Between days 22-35		
BW – day 35 (g)	2529.95[a]±14.12	2607.65[b]±10.87
FCR (kg/kg)	1.48±0.04	1.42±0.03
Mortality (%)	3.05±1.02	2.02±0.72
Between days 36-42		
BW – day 42 (g)	3373.41[a]±17.61	3468.49[b]±15.17
FCR (kg/kg)	1.82±0.03	1.75±0.04
Mortality (%)	3.99±1.12	2.07±0.93
Between days 1-42		
BW – day 42 (g)	3373.41[a]±17.61	3468.49[b]±15.17
FCR (kg/kg)	1.54±0.03	1.50±0.02
Mortality (%)	8.60±0.25	4.80±0.17
Values with the different letters differ significantly; ab – P<0.05		

Table 3. **The effect of super pre-starter diet on development of visceral organs of broiler chickens**

Characteristics	Control	Treatment
Proventriculus (g)	12.58[a]±1.08	15.12[b]±1.29
Gizzard (g)	23.64±1.21	23.91±1.33
Intestinal weight with chymus (g)	159.02±9.58	163.72±7.41
Intestinal weight without chymus (g)	101.31±6.50	96.08±4.25
Intestinal length (cm)	265.90±13.53	252.70±6.36
Heart (g)	15.85±1.10	16.74±1.35
Liver (g)	74.02±2.79	75.08±6.37
Pancreas (g)	6.16±0.30	5.96±0.55
Values with the different letters differ significantly; ab – P<0.05		

It is generally accepted that higher BW results in higher relative carcass weights (Brake et al., 1993). An increased amino acid density in the diet of broiler chickens was associated with increased satellite cell proliferation and muscle development, thus resulting in increased breast meat yield at slaughter (Dozier et al., 2008). Similar results were found by Widyaratne G.P et al. (2001), who reported, that breast meat yield was significantly higher in broiler chickens, fed with increased protein diets, whereas these birds had significantly more abdominal fat. As noted Puspita U.E. et al. (2017) the increased amount of proteins in pre-starter diet of broiler chickens increased the development of breast muscles.

Table 4. **The effect of super pre-starter diet on development of carcass characteristics of broiler chickens**

Characteristics	Control	Treatment
Carcass yield (%)	75.26±0.99	77.17±0.79
Breast muscle yield (%)	30.70±1.40	31.32±1.33
Shin muscle yield (%)	8.22±0.22	9.23±0.57
Thigh muscle yield (%)	12.20±0.58	12.60±0.32
Leg muscle yield (%)	20.42±1.16	21.83±0.94
Abdominal fat yield	1.09±0.04	1.05±0.06
Values are not statistically significant		

As it presented in Table 5, the drip-loss and water holding capacity, DM, intramuscular fats and ash of breast meat were increased, compared with control group (P>0.05). Similar tendencies in thigh meat were observed. Longo F. A. et al. (2007) have reported that the content of DM and total proteins in muscles were increased, when broiler chickens received pre-starter diet first week of the age.

Table 5. **The effect of super pre-starter diet on physical and chemical composition of broiler chicken's muscle**

Characteristic	Control		Treatment	
	Breast muscle	Thigh muscle	Breast muscle	Thigh muscle
Drip-loss (%)	2.40±0.64	1.64±0.72	2.74±1.17	1.83±0.38
Water holding capacity (%)	62.16±2.57	64.82±1.65	64.14±3.03	64.62±2.20
Cooking loss (%)	14.52±2.48	10.9±2.47	12.49±2.99	11.54±2.37
Tenderness (kg/cm^2)	1.91±0.41	1.02±0.20	1.85±0.20	1.09±0.17
Dry matter (DM) (%)	25.33±0.49	27.42±1.64	25.82±0.87	27.02±1.27
Intramuscular fats (%)	2.06±0.39	6.63±0.62	2.64±0.47	6.59±0.87
Ash (%)	1.23±0.03	1.18±0.03	1.33±0.14	1.17±0.05
Total proteins (%)	22.04±0.82	19.6±1.09	21.85±1.18	19.27±0.62
Values are not statistically significant				

Conclusions. The application of super pre-starter diet, composed of animal blood plasma, soy protein concentrate and tryptophane for broiler chickens at the age of 1-8 days could improve the BW by 3% and decrease the FRC by 3% with better development of visceral organs as well as meat carcass characteristics.

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