How to cite: Boussaada, T., Ouachem, D., Shah, T., Özkan, S., Effect of transport duration, access to feed and water during transportation on growth performance and organ development of broilers, J. Anim. Prod., 2020, 61 (2): 109-120, https://doi.org/10.219185/hayuretim.777084

Research Article
(Araştırma Makalesi)

J. Anim. Prod., 2020, 61 (2): 109-120
https://doi.org/10.219185/hayuretim.777084

Tarek BOUSSAADA[1,2] 0000-0002-1437-9272
Derradji OUACHEM[2] 0000-0002-8116-6867
Tahir SHAH[3] 0000-0002-4748-2364
Sezen ÖZKAN[3] 0000-0002-9637-882X

[1] Scientific and Technical Research Centre for Arid Areas (CRSTRA), Biophysical Station, Touggourt, Algeria
[2] Food Sciences Laboratory, Institute of Veterinary and Agronomic Sciences, Batna1 University 05000, Algeria
[3] Ege University Faculty of Agriculture, Department of Animal Science, Izmir, Turkey

Corresponding author: sezen.ozkan@ege.edu.tr

Effect of transport duration, access to feed and water during transportation on growth performance and organ development of broilers

Günlük yaştaki etlik civcivlerde taşıma süresi ve taşıma sırasında yem ve suya ulaşımın gelişme performansı ve organ gelişimine etkileri

Alınış (Received): 05.08.2020 Kabul tarihi (Accepted): 10.11.2020

Keywords:

Broiler, day-old chicks, post-hatch transportation, access to feed and water during transportation, performance.

ABSTRACT

Objective: The aim of this study was to assess the effect of transport duration and access to feed and water during the transportation of broiler chicks on growth performance, yolk sac weight, development of intestine and immune organs, and carcass yields of broilers.

Material and methods: A total of 256 Cobb broiler chicks were obtained from a commercial hatchery. Depending on the treatment, chicks were divided into 4 groups and subjected to either 1.5 h (DS) or 6.0 h (DL) transportation with (AFW) or without access to feed and water (NFW) during the transportation. Chicks from each subgroup were assigned to 4 floor pens (16 pens in total) and reared until 42 d.

Results: Our results confirmed that AFW improved body weight, breast fillet, food consumption, yolk sac weight at day 2, and development of immune and intestinal at day 42, (7 d) as compared with the NFW. Our study also indicated that DL group attempted to compensate their growth retardation by increasing their feed intake during the first week of their lives as compared to DS group. However, DL group broilers did not catch up with the broilers from DS group at slaughter age and had worse FCR.

Conclusion: This study shows that there is a positive effect on broiler performance by providing feed and water during the transportation.

Anahtar Kelimeler:

Broiler, günlük civciv, çıkış sonrası taşıma, taşıma sırasında yem ve suya ulaşım, performans.

ÖZ

Amaç: Bu çalışmanın amacı bir günlük etlik civcivlerde taşıma süresi ve taşıma sırasında yem ve su verilmesinin büyüme performansı, sarı kese ağırlığı, sindirim ve bağışıklık organlarının gelişmesi ve karkas verimine etkisini belirlemektir.

Materyal ve Metot: Ticari bir kuluçkahaneden 256 adet Cobb etlik civciv temin edilmiştir. Civcivler rasgele 4 gruba ayrılmış ve 1.5 saat (DS) veya 6.0 saat (DL) boyunca yem ve su sağlanmış (AFW) ya da sağlanmamış (NFW) olarak taşımaya maruz bırakılmışlardır. Taşımadan sonra her grup 4 adet yer bölmesine yerleştirilmiş (toplam 16 bölme) ve 42. güne kadar büyütülmüştür.

Bulgular: Sonuçlar AFW uygulamasının NFW'e kıyasla 42. gün canlı ağırlığı iyileştirdiğini, göğüs eti, yem tüketimi ve 2. gün sarı kese ağırlığını artırdığını, erken yaşta (7 gün) bağışıklık ve sindirim organlarının gelişimini iyileştirdiğini göstermiştir. Çalışma aynı zamanda DL uygulamasının DS'e göre çıkış günü canlı ağırlığı düşürdüğünü ve DL grubunun DS'e kıyasla ilk hafta yem tüketimini artırarak telafi edici büyüme çabası içinde olduğuna işaret etmektedir. Ancak, DL grubu kesim yaşında DS grubunun canlı ağırlığına ulaşamamış ve daha kötü FCR elde edilmiştir.

Sonuç: Çalışma,taşıma süresinden bağımsız olarak günlük civcivlere taşıma sırasında yem ve su sağlanmasının etlik piliç performansını olumlu etkilediğini göstermiştir.

INTRODUCTION

Poultry, including broiler chicks, are commonly transported at the first day of life and this period between hatching and placement at the farm is considered one of the most critical stages in grow-out period. There are several factors contributing to stress in day old chicks before placement including holding time at hatchery with handling, crowding, noise, thermal micro-environment in transport vehicle and transportation duration accompanied by food and water deprivation during the transportation resulting in reduced production performance and welfare of broilers (Abeyesinghe et al., 2001; Kettlewell and Mitchell, 2001; Mitchell and Kettlewell, 2009; Bergoug et al., 2013; Jacobs et al., 2016).

Various studies suggest that long transport duration of one-day-old chick may have negative effects on the development and performance of chicks later in life (Bergoug et al., 2013; Jacobs et al., 2016) and results in stress related physiological responses (Khosravinia, 2015) including higher corticosterone response(Jacobs et al. 2017) indicating higher stress level in chicks. European Union legislation advices a maximum chicks transport duration of 24.0 h and deprivation of feed and water for at most, 72.0 h post-hatch (European Union Council, 2005). Bergoug et al (2013) reported that body weight of chicks subjected to 4.0 or 10.0 h of transport duration significantly reduced as compared with those not transported and this effect was persistent by 21 d old age. Jacobs et al. (2016) observed that there was significant reduction in body weight and yolk sac weight of broiler chicks after 11.0 h transportation in comparison to 1.5 h transportation at one d old age. Furthermore, the increased distance of transportation from 50 to 300 km, resulted in an increased mortality within first 7 day from 1.22 to 1.36% (Chou et al., 2004). However, during transportation, chicks are also being deprived of feed and water and it is not clear whether the observed effects were caused by transport duration or delayed access to feed and water. The longer deprivation of feed and water (fasting/holding time) has been proven to negatively affect growth performance of broiler chicks (Noy and Sklan, 1999; Decuypere et al., 2001;Noy et al., 2001; Gonzales et al., 2003; Uni et al., 2003), intestinal development (Lilburn and Loeffler, 2015) skeletal muscle growth through satellite cell proliferation (Halevy et al. 2000)and immunity of broilers (Juul-Madsen et al., 2004; Panda et al., 2015). Therefore, early feeding of broiler chicks at post hatch by supplying feed directly at hatching baskets (Sklan et al., 2000; Hollemans et al. 2018), in the chick transport boxes using regular feed (Kidd et al., 2007; Kovaříková 2013)or special designed commercial products (Batal and Parsons. 2002; Shivazad et al., 2007; Henderson et al., 2008)or using in ovo feeding method (Uni and Ferket, 2004; Uni et al., 2005; Kornasio et al., 2011) have been suggested as a tool to improve broiler performance. However, providing feed and water to chicks in transportation boxes has not been studied in large scale. Kidd et al. (2007) reported that significantly higher BW at 7 d old when chicks were provided with a moisturized starter feed at the hatchery and during the transportation (in total 5.0 h) before placement at the farm. However there was no effect on performance parameters at slaughter age of 35. Although many of the researches reported that early feeding improves only initial BW and performance; it might be beneficial especially under critical conditions such as disease and/or stress due to suboptimal rearing conditions (Shariatmadari, 2012).

Therefore the aim of the current study was to examine the effects of transport duration of one-day-old-chick and access to regular starter feed and water during transportation, as well as their interaction, on growth performance, internal organs, development of intestine and immune organs, carcass and carcass part yields of broilers.

MATERIALS and METHODS

The experiment has been approved by the Institute of Veterinary and Agronomic Sciences, Batna 1 University (Algeria) and all experimental procedures were complied with the European Union Directive on Legislation for the protection of animals used for scientific purposes, 2010-63-EU.

Experimental Design and Treatments

Effects of transport duration and access to food and water supply to 1-day-old mixed-sex chicks during the transportation were tested in a 2 × 2 factorial arrangement. A total of 256 Cobb 500 broiler chicks were obtained from a commercial hatchery immediately after release from hatcher. Experimental chicks were individually weighed, identified with leg bands and randomly distributed into 4 transportation boxes with 4 replications of 16 chicks per group. Depending on the treatment, transportation boxes were provided with a commercial starter feed on the box floor and 4 nipple drinkers attached to boxes (access to feed and water during the transportation, AFW) or left empty (no access to feed and water during the transportation, NFW). The stocking density was 21 cm^2/chick. Chicks were transported for either 1.5 h (Short duration, DS) or 6.0 h (Long duration, DL), which respectively correspond to mean and maximum transport durations in Algeria. This resulted in 4 subgroups: DS x NFW; DS ×AFW; DL × NFW; DL ×AFW. Transportation of chicks from hatchery to experimental farm was conducted under the same commercial conditions, using a van with air conditioning set at28 to 30°C and 36 to 38% relative humidity.

Housing

After transportation, chicks from each subgroup were immediately weighed and randomly distributed to 4 replicate pens (16 chicks/pen)in a single broiler housing unit (experimental farm).Each pen was covered with wood shavings, and was equipped with feeder and nipple drinkers. Diets were formulated to meet NRC recommendation. A two-phase feeding schedule was applied to broilers including a starter diet with 21% CP and 3000 kcal/kg ME from 0 to 15 d of age, and a grower diet with 20% CP and 3100 ME/kg from 16 to 42 d of age. Feed and water were available ad libitum throughout the experiment. Ambient temperature in the experimental farm was 35°C on day one and was gradually reduced to 20°C at slaughter age (42 d). The lighting regimen was 23L:1D throughout the experiment.

Measurements

Performance

The chicks were weighed individually and identified with leg-bands immediately before transportation from hatchery to the experimental farm. After transportation, all chicks were weighed again at farm. Change in body weight (BW) of chicks after transportation was calculated as a percentage (%) of BW before transportation using following formula: [(BW after transportation, g) - (BW before transportation, g)/BW before transportation, g] ×100. During the production period average body weight (BW) was evaluated per pen at 7, 14, 21, 28, 37 and 42 d. On the same days, feed consumption (FC) was measured and feed conversion ratio (FCR) was calculated per pen as the ratio of cumulative feed intake (g) to body weight gain (g). Mortality was recorded after transportation and then daily until the end of the experiment.

Yolk sac, internal organs and development of small intestine segments

At 48.0 h post hatch, two birds from each replicate (8 per subgroup) were randomly selected, weighed, killed by decapitation and then the yolk sac was removed from the abdomen and weighed individually. The precision of scale was 0.001g. At day 7, eight birds were selected randomly from each subgroup (two from each replicate), weighed, killed by decapitation for measurements on internal organs including proventriculus, gizzard, pancreas, liver, heart, bursa fabricus, and spleen. Relative weights were calculated as a percentage of the BW. Growth of small intestine segments, duodenum, jejunum and ileum, was evaluated on the basis of their lengths and density. The lengths of the duodenum (pancreatic loop), jejunum (from the pancreatic loop to Meckel's diverticulum) and ileum (from Meckel's diverticulum to 1 cm above the ileo-caecal junction) were recorded and expressed as percentages (%) of the small intestine length (duedonum, jejunum and ileum). The intestinal weight per unit of surface area of each segment (g/cm^2) was defined as the "intestinal density". Fragments of 5 cm for duodenum, jejunum and ileum were cut, emptied, weighed, then opened longitudinally and spread out on a flat surface to measure their length and width in cm and the area was calculated. The density expressed in g/cm^2 is calculated by the relation:

$$\text{Density (g/cm}^2\text{)} = \frac{segment\ weight\ (g)}{segment\ area\ (\text{cm2})}$$

Carcass and carcass parts yield

At d 42, two male birds from each replicate were randomly selected, giving a total of 8 chicks for each subgroup. Those chicks were weighed, culled and let to bleed out by neck cut (head was removed after slaughtering), de-feathered and eviscerated. The carcass were weighed and dissected in order to measure the thigh, drumstick, breast fillet and abdominal fat. Relative weight of carcass and cut up parts (%) in relation to live weight was calculated.

Statistical Analyses

All data from the experiment were subjected to ANOVA using the general linear model procedure of the JMP statistics package (SAS Institute Inc., 2002).Statistical model included two main effects of transport duration (short (DS)/ long(DL)) and access to feed and water (FW) during transportation (access (AFW)/ no access (NFW)) and their interaction. Pen was considered as experimental unit for BW, gain, feed consumption, and FCR traits. Individual chick was considered as experimental unit for the body weight at hatching day, yolk sac, carcass, internal organs, length and density of small intestine segments. Relative yolk sac weight data were subjected to log transformation prior to the analysis. Ls-means were separated using Student t-test when ANOVA indicated significant effect (P ≤ 0.05).

RESULTS

Growth and Production Performance

The effects of treatments on BW of birds are presented in Table 1. Immediately after transportation, the body weights of chicks were significantly reduced by DL (P ≤ 0.05) and positively affected by early access to feed and water (P ≤ 0.05). Chicks from DL lost 6.12 % of their BW during the transportation. However, DS group gained weight. BW loss was highest in DL×NFW and the lowest in DS ×NFW group. Although interaction effect was not significant for the change in BW after transportation, access to feed and water at DS condition resulted in a weight gain of 4.92±1.12 % in the chicks. BW loss of chicks in other subgroups were 8.14±1.12, 4.17±1.12, 1.11±1.12 % for DL× NFW, DL×AFW, and DS×NFW subgroups, respectively (means not tabulated). The negative effect of DL on BW of birds was found to be significant at d 28 and d 42(P ≤ 0.05). However, BW was positively affected by FW during the complete production phase (Table 1). No interaction effect between transport duration and early access to feed and water was observed.

Table 1. Effect of Transport Duration and Access to Feed and Water During Transportation on Body Weight (g) of Broilers and Change in BW After Transportation (%).

Çizelge 1. *Taşıma Süresi ve Taşıma Sırasında Yeme ve Suya Ulaşımın Etlik Piliçlerin Canlı Ağırlığına (g) ve Taşıma Sonrası Canlı Ağırlık Değişimine Etkisi (%).*

Treatments/ Age	BWBT	BWAT	Change in BWAT (%)	d7	d 14	d 21	d 28	d 42
Transport duration								
DS (1.5 h)	43.38	44.21^a	+1.90	144.5	357.5	786.5	1355.5^a	2580.7^a
DL (6.0 h)	43.55	40.86^b	-6.12	138.3	340.3	757.6	1276.7^b	2474.2^b
SEM	0.46	1.49	0.78	15.8	27.75	52	78.25	104.9
Access to feed and water								
NFW	43.52	41.50^b	-4.63	130.3^b	330.1^b	737.8^b	1272.0^b	2468.7^b
AFW	43.41	43.57^a	+0.37	152.6^a	367.7^a	806.3^a	1360.3^a	2586.2^a
SEM	0.46	2.04	0.78	10.7	21.5	40.15	74.95	101.7
				P values				
D	0.523	<0.001	<0.001	0.290	0.129	0.1716	0.037	0.036
FW	0.651	0.002	<0.001	0.001	0.004	0.005	0.022	0.023
D × FW	0.709	0.322	0.369	0.810	0.846	0.731	0.763	0.552

^{a,b}Means in the columns within same treatment with different superscripts differ significantly (P < 0.05).
BWBT: Body weight before transportation;
BWAT: Body weight after transportation;
Change in BWAT, %: [(BWAT,g) - (BWBT, g)/BWBT, g] ×100.
NFW: No feed and water during the transportation;
AFW: Access to feed and water during the transportation;
D: Transport duration;
FW: Feed and water during the transportation;
SEM: Standard error of the mean.

Transport duration had a significant effect (P ≤ 0.05) on feed consumption (FC) in the first week of the production phase (Table 2) Chicks subjected to DS had lower feed consumption than those subjected to DL. However, no significant effect was found at later ages. Access to feed and water during the Transport significantly increased FC from the second week until slaughter (P ≤ 0.05). Interaction between D and FW was significant at 7 day post hatch (P = 0.017). The interaction effect was presented by similar FC levels of birds from DL and DS (128.8 and 130.9 ±11.4 g, respectively) when feed and water was available. However, FC significantly differed between DL and DS groups with being greater in broiler chicks from DL (142.9±11.4 g) than the DS (110.9±11.4 g) when access to feed and water was not available during the transport (data not tabulated).

The shorter transport duration improved FCR (Table 3) in the first 2 weeks and at the end of the production period (P ≤ 0.05). However, access to feed and water had a positive effect on FCR in the first week only (P ≤ 0.05). No interaction between transport duration and access to feed and water during the transport was found on FCR.

There was no mortality during the transportation and only 4 birds died in the production period. All deaths occurred within the first 3 weeks of the experiment. The numbers of dead birds were 1, 0, 2, and 1 for DS×NFW, DS×AFW, DL×NFW, DL×AFW groups, respectively. No effect of treatments and interaction were observed on cumulative mortality of broilers (data not tabulated).

Table 2. Effect of Transport Duration and Access to Feed and Water During Transportation on Feed Consumption of Broilers (g/birds)
Çizege 2. *Taşıma Süresi ve Taşıma Sırasında Yeme ve Suya Ulaşımın Etlik Piliçlerin Yem Tüketimine Etkisi (g/piliç)*

Treatments/Age	D 07	D 14	D 21	D 28	D 42
Transport duration					
DS (1.5 h)	120.9[b]	398.5	994.7	1841.5	3997.5
DL (6.0 h)	135.9[a]	405.8	987.6	1842.6	4073.3
SEM	14.6	28.9	77.8	117	176.1
Access to feed and water					
NFW	126.9	386.9[b]	938.4[b]	1762.3[b]	3944.9[b]
AFW	129.9	417.3[a]	1044.0[a]	1921.9[a]	4125.9[a]
SEM	15.3	24.4	54	81.5	152.25
			P values		
D	0.031	0.580	0.811	0.981	0.349
FW	0.639	0.036	0.003	0.004	0.038
D × FW	0.017	0.578	0.867	0.991	0.387

[a,b]Means in the columns within same treatment with different superscripts differ significantly (P < 0.05).
NFW: No feed and water during the transportation;
AFW: Access to feed and water during the transportation;
D: Transport duration;
FW: Feed and water during the transportation;
SEM: Standard error of the mean.

Table 3. Effect of Transport Duration and Access to Feed and Water During Transportation on Feed Conversion Ratio of Broilers
Çizelge 3. *Taşıma Süresi ve Taşıma Sırasında Yeme ve Suya Ulaşımın Etlik Piliçlerin Yemden Yararlanma Oranı Üzerine Etkisi (g/g)*

Treatments/Age	D 07	D 14	D 21	D 28	D 42
Transport duration					
DS (1.5 h)	1.18[a]	1.26[a]	1.33	1.40	1.57[a]
DL (6.0 h)	1.45[b]	1.36[b]	1.38	1.50	1.68[b]
SEM	0.24	0.07	0.06	0.09	0.05
Access to feed and water					
NFW	1.46[b]	1.34	1.35	1.43	1.63
AFW	1.17[a]	1.28	1.37	1.46	1.62
SEM	0.24	0.09	0.06	0.10	0.08
			P values		
D	0.036	0.018	0.144	0.103	0.004
FW	0.029	0.110	0.491	0.567	0.895
D × FW	0.101	0.309	0.386	0.780	0.826

[a,b]Means in the columns within same treatment with different superscripts differ significantly (P < 0.05).
NFW: No feed and water during the transportation;
AFW: Access to feed and water during the transportation;
D: Transport duration;
FW: Feed and water during the transportation;
SEM: Standard error of the mean.

Yolk Sacand Internal Organs

The impact of the transport duration and access to feed and water during transportation on yolk sac utilization (d 2) and internal organ growth (at d 7) are shown in Table 4. There was no effect of transport duration on yolk sac and internal organ weights. Early access to feed and water increased the actual weight of internal organs but relative weights to body weight of broilers were lower. No interaction effect was observed for these traits.

Development of Bursa, Spleen and Small Intestine Segments

No effect of transport duration was found on actual and relative weight of bursa and spleen at 7 days (Table 5). However, AFW increased actual and relative weights of bursa and actual weight of spleenat7 days ($P \leq 0.05$).

There was no effect of transport duration on intestinal length and intestinal density of broiler chicks at 7 days (Table 5). However, AFW increased the relative length of duedonum (+1.19%), and densities of duodenum (+0.014%), and jejunum (+0.015%) significantly ($P \leq 0.05$). For any of the traits measured, the interaction effect was not significant ($P > 0.05$).

Table 4. Effect of Transport Duration and Access to Feed and Water During Transportation on Yolk Sac Weight (at d 2) and Internal Organ Weights of Broilers at d 7

Çizelge 4*. Taşıma Süresi ve Taşıma Sırasında Yeme ve Suya Ulaşımın Etlik Piliçlerin 2 Günlük Yaşta Sarı Kese ve 7 Günlük Yaşta İç Organ Ağırlıklarına Etkisi*

Treatments/Age	2 days		7 days									
	Yolk sac		Proventriculus		Gizzard		Liver		Heart		Pancreas	
	g	%	g	%	g	%	g	%	g	%	g	%
Transport duration												
DS (1.5 h)	1.17	2.45	0.89	1.03	3.67	4.24	3.76	4.33	0.76	0.89	0.41	0.47
DL (6.0 h)	1.37	2.71	0.91	1.01	3.68	4.19	3.84	4.24	0.81	0.91	0.43	0.49
SEM	0.54	0.63	0.16	0.16	0.65	0.39	0.94	0.60	0.14	0.10	0.07	0.08
Access to feed and water												
NFW	0.93^{b}	2.37	0.83^{b}	1.12^{a}	3.15^{b}	4.26	3.35^{b}	4.53^{b}	0.71^{b}	0.95^{a}	0.39^{b}	0.53^{a}
AFW	1.61^{a}	2.79	0.96^{a}	0.93^{b}	4.20^{a}	4.16	4.25^{a}	4.04^{a}	0.86^{a}	0.84^{b}	0.45^{a}	0.44^{b}
SEM	0.41	0.60	0.14	0.12	0.38	0.40	0.78	0.56	0.12	0.08	0.07	0.06
	P values											
D	0.178	0.261	0.669	0.658	0.900	0.684	0.784	0.652	0.31	0.501	0.324	0.33
FW	<0000	0.076	0.019	0.000	<0000	0.516	0.005	0.021	0.001	0.001	0.03	0.000
D × FW	0.154	0.674	0.635	0.525	0.156	0.245	0.518	0.320	0.906	0.799	0.979	0.908

[a,b]Means in the columns within same treatment with different superscripts differ significantly ($P < 0.05$).
NFW: No feed and water during the transportation;
AFW: Access to feed and water during the transportation;
D: Transport duration;
FW: Feed and water during the transportation;
SEM: Standard error of the mean.

Table 5. Effect of Transport Duration and Access to Feed and Water During Transportation on Actual (g) and Relative Weights of Immune Organs (%), Intestinal Length (%), and Intestinal Density (g/cm^2**)** of Broilers at 7 Days

Çizelge 5. *Taşıma Süresi ve Taşıma Sırasında Yeme ve Suya Ulaşımın Etlik Piliçlerin 7 Günlük Yaşta Gerçek (g) ve Oransal İmmun Organ Ağırlıklarına (%), Barsak Uzunluğuna,(%) ve Barsak Yoğunluğuna (g/cm^2) Etkisi*

Treatments	Bursa		Spleen		Intestinal length			Intestinal density		
	g	%	g	%	Duodenum	Jejunum	Ileum	Duodenum	Jejunum	Ileum
Transportation duration										
DS (1.5 h)	0.11	0.13	0.06	0.06	20.91	47.56	31.54	0.106	0.08	0.06
DL (6.0 h)	0.12	0.13	0.06	0.06	21.14	48.28	30.58	0.107	0.08	0.06
SEM	0.05	0.04	0.02	0.02	1.63	1.79	2.09	0.021	0.02	0.02
Access to feed and water										
NFW	0.08^{b}	0.11^{b}	0.04^{b}	0.05	20.43^{b}	48.04	31.53	0.10^{b}	0.07^{b}	0.07
AFW	0.15^{a}	0.15^{a}	0.07^{a}	0.07	21.62^{a}	47.79	30.59	0.11^{a}	0.09^{a}	0.06
SEM	0.03	0.03	0.02	0.02	1.49	1.81	2.09	0.02	0.02	0.02
	P values									
D	0.552	0.932	0.784	0,3417	0.674	0.276	0.212	0.985	0.689	0.581
FW	<0.000	0.002	0.000	0.063	0.038	0.700	0.217	0.049	0.039	0.084
D × FW	0.843	0.961	0.649	0.978	0.506	0.782	0.805	0.4108	0.092	0.220

[a,b]Means in the columns within same treatment with different superscripts differ significantly ($P < 0.05$).
NFW: No feed and water during the transportation;
AFW: Access to feed and water during the transportation;
D: Transport duration;
FW: Feed and water during the transportation;
SEM: Standard error of the mean.

Carcass and Carcass Parts Yield:

There were no overall significant differences in carcass yield at market age were found between birds subjected to the DL and DS (Table 6). However, AFW significantly increased relative weight of abdominal fat and breast fillet (P ≤ 0.05) as compared with the NFW chicks. No interaction effect was observed in any of the parameters investigated.

At 42 d of age, all measurements for internal organs, bursa, spleen and intestinal development were repeated. However, results indicated that there were no effect of treatments on any of the traits measured. Therefore data were not presented here.

Table 6. Effect of Transportation Duration and Access to Feed and Water During Transportation on Yield of Carcass and Carcass Parts (%) of Broilers at 42Days

Çizelge 6. *Taşıma Süresi ve Taşıma Sırasında Yeme ve Suya Ulaşımın 42 Günlük Yaşta Etlik Piliçlerin Karkas ve Karkas Parçalarının Verimine (%) Etkisi*

Treatments	Carcass	Abdominal fat	Thigh	Drumstick	Breast Fillet
Transportation duration					
DS (1.5 h)					
DL (6.0 h)	69.01	1.36	5.37	4.61	11.30
	67.46	1.54	5.24	4.58	10.70
SEM	2.49	0.33	0.41	0.38	1.04
Access to feed and water					
NFW					
AFW	68.47	1.29^{b}	5.41	4.53	10.57^{b}
	68.00	1.61^{a}	5.19	4.67	11.43^{a}
SEM	2.62	0.30	0.40	0.37	1.00
			P values		
D	0.099	0.089	0.342	0.803	0.086
FW	0.609	0.004	0.123	0.324	0.017
D × FW	0.521	0.278	0.223	0.056	0.356

^{a,b}Means in the columns within same treatment with different superscripts differ significantly (P < 0.05).
NFW: No feed and water during the transportation;
AFW: Access to feed and water during the transportation;
D: Transport duration;
FW: Feed and water during the transportation;
SEM: Standard error of the mean.

DISCUSSION

Growth and Production Performance

Earlier reports on the effects of transport duration and the moment of access to feed and water on growth performance are conflicting. In this experiment, the longer transportation (6.0 h) of one day-old-chicks negatively affected early and later life body weights at different time points having a statistical significance at d 1, 28 and 42ascompared with DS (1.5 h).Previous experiments with newly hatched broiler chicks subjected to different transport durations showed a negative effect of transportation on the performance in early life, but not in later life (Bergoug et al., 2013; Jacobs et al., 2016). Bergoug et al. (2013) reported significantly higher body weight, by 21 d of age, in broilers not subjected to transportation (0 h) as compared with those subjected to the short (4.0 h) or long (10.0 h) transportation. However, they did not find any effect of transportation duration on BW of broilers at slaughter age of 35 d. Jacobs et al. (2016), compared the BW of day-old chicks those transported for 1.5 or 11.0 h without access to feed and water and found significantly lower BWs in 11.0 h group as compared with the 1.5 h group. However, the negative effect of transportation on BW disappeared from d 7 and the authors concluded that transportation duration did not raise a significant impact for productivity and welfare of broiler chicks. In our experiment, two factors were studied; namely duration of transport and access to feed and water. Therefore, the overall mean weight gain observed in the DS group after transportation was not independent from the feed and water availability. Increased weight gain observed in DS ×AFW group was due to feed/water consumption during the transportation. Access to feed and water during the transportation prevented BW loss after transportation and even increased weight gain in chicks from DS group. However, BW loss in chicks subjected to DL was partly alleviated by feed and water availability. Although we did not measure stress related parameters in this experiment it could be possible that longer transport duration increased birds demand for energy due to stress and this could not be fully alleviated by feed and water availability during transportation.

Our results showed that access to feed and water during the transportation increased the body weight of broilers in all production phase. This positive effect was observed even just after transportation. These findings seem to be contradictory to some earlier studies. Hollemans et al. (2018) found that delayed access to feed and water impaired the weight gain of the broilers in the first two weeks of grow-out period, but did not change the final weight or feed efficiency at the end of the grow-out period. In contrary to our findings, Kidd et al (2007) provided starter feed and water to the chicks 5.0 h before placement, from pull out time at the hatchery until the placement at farm, and observed no advantage of earlier feeding at the slaughter age. In the same line, allowing turkey poults accessing to feed in transportation boxes resulted in higher BWs during the first two weeks with no effect on later life performance (Eratalar and Türkoğlu, 2017). However, it should be counted that duration of fasting that was experienced by chicks are always longer than transport duration when considering biological age reported by Careghi et al. (2005). Indeed, hatch window contributes to the magnitude of the effect of post-hatch holding/transportation time on chicks. It has been reported that early hatched chicks (0 by 22.0 h) are more benefited from early feeding than those hatched later (22.0 - 48.0 h) within the hatch window (Sklan et al., 2000). In our study, considering biological age as reported by Careghi et al. (2005) and Powell et al (2016) we may estimatea hatch window of 28.0 h (from hatchery records), a handling time of 3.0 h at the hatchery, and adding by 1.5 h (DS) and 6.0 h (DL) transport durations, chick subjected to DS and DL treatments were delayed in feed and water (NFW) for 32.5 h and 37.0 h, respectively. DL treatment in this study was just beyond the threshold (36.0 h) for to observe long lasting negative effect on body weight and mortality (de Jong et al. 2017). Therefore, differences among studies might partly be related with actual fasting duration of chicks as a result of hatch window differences among the hatcheries or small changes in transport conditions other than transport durations.

DL increased feed consumption at d 7 and significant interaction effect between transport duration and access to feed and water during the transportation was indicated by a significant increase in feed consumption in broiler chicks subjected to DL×NFW. Therefore, we may speculate that availability of feed and water during long transportation had a more pronounced effect on FC of birds at first week. Negative effects of longer transportation would partly alleviated by availability of food and water during the transport. This interaction effect may further suggests that longer transportation, accompanied by NFW probably resulted in an increased feed consumption in chick's early life to compensate longer deprivation of food thereafter in favor of compensatory growth phenomena (Plavnik and Hurwitz. 1985; Özkan et al., 2010). However, this increased feed consumption did not last at later ages and, although there was an attempt of DL chicks for compensatory growth at early ages (7, 14, and 21 d), they did not catch up with the broilers from DS group at slaughter age.

Higher FC observed in FW broilers was in line with the report of Vargas et al. (2009) who found that feed consumption was significantly higher in birds having early access to feed than those delayed access to feed. A better FCR observed with birds from the DS group was contrary to the findings of Bergoug et al. (2013) and Jacobs et al. (2016) who reported that the FCR was not affect by different transport durations. We also demonstrated that the earlier access to feed and water during the transportation had significant positive effect on FCR, only in the first week of life, which is consistent with prior research (Gonzales et al., 2003). The positive effects of AFW found in this study at 7 d, would partly related with the increase in relative length and density of duodenum and density of jejunum. Early gut development, resulting in efficient energy utilization and higher weight gain in broilers have been reported in the earlier reports (Batal and Parsons. 2002; Fairchild et al., 2006).

In this study, mortality was not affected by any of the treatments. In line with our finding, no significant difference between transport durations of 1.5 and 11.0 h was reported by Jacobs et al. (2017). Bergoug et al. (2013) found no clear effect of transport duration on mortality among the groups of 0.0, 4.0, 10.0 h transportation. Almeida et al. (2006) reported that total mortality were not different between the broilers those had fasting periods of 12.0 hand 24.0 h after hatching. On the other hand, Chou et al. (2004) suggested that each 1 km increase in transportation distance resulted in 0.05% increase in first week mortality in broilers. Our results may probably be related that we used a moderate transportation duration and optimum vehicle conditions during the transportation. Recent meta-analyses study also concluded that reduced body weight and increased total mortality up to six week were observed only after

36.0 h delay in feed and water access (de Jong et al., 2017).

Yolk Sac and Internal Organs

In our study, yolk sac utilization of chicks at two d of age did not vary with any of the treatments. This may be because of transport durations that were rather close to each other in this study. We compared a short (1.5 h) and moderately longer (6.0 h) transport durations with optimum conditions in transportation vehicle. In line with our finding, recent meta-analyses study also concluded that delayed access to feed and water between 24.0-48.0 h did not result in a significant reduction in relative yolk sac weight; but after 72.0 h delay, yolk sac weight was reduced (de Jong et al., 2017).Several factors may influence the yolk sac weight of chicks during the post-hatch transportation, particularly fasting period (Bhanja et al 2009) and physiological stress based on the transportation condition (Khosravinia 2015). Khosravinia (2015) who reported that the transportation of one day-old-chicks for distance up to 800 km decreased yolk sac weights of chicks linearly in rate of 0.063g per 100 km. However, max transportation distance in our study was about 450 km and may partly explain the differences between the studies.

We also found that actual weight of internal organs increased with the early access to feed at 7 days of age. However, in the contrary to actual weights, relative organ weights to body weight of broilers were lower. This clearly was due to the higher body weights of birds in AFW group (Table 1). Early access to feed and water resulted in faster growth rate thus higher body weight in these groups. However, this may not be accompanied by the same rate of growth for internal organs therefore resulting in reduced relative weight to BW. Our results are in accordance with the results of El-Husseiny et al. (2008) who showed that early feeding increased growth of internal organs (liver, heart, proventriculus and gizzard) compared with delayed access to feed with access to water. Fasting duration of 56 h in poults (Corless et al., 1999)48.0 and 72.0 h in broiler chicks (Maiorka et al., 2003)resulted in reduced proventriculus and gizzard weights. It seems that proventriculus and gizzard weights are negatively affected by delayed access to feed and water if the delay is at around or longer than 48.0 h. Bhanja et al. (2009) reported that early access to feed and water during the initial 24.0 h period resulted in higher relative weights of liver and pancreas in broiler chicks at first week as compared to those had a late access to feed (32.0– 48.0 hours). However, relative weights of gizzard and proventiculus were not affected by feed deprivation up to 48.0 h. In our study, we may speculate that 32.5 h and 37.0 h delays in feed and water access for DS and DL treatments were not large enough to yield significant changes in proventriculus, gizzard liver, heart, and pancreas.

Development of Bursa, Spleen and Small Intestine Segments

We observed improved actual and relative weight of bursa but only actual weight of spleen in AFW group at d 7. These results are similar to those reported by Dibner et al. (1998) who found significantly higher bursa weights on the 3rd day of chicks had an immediate accessed to feed after hatch as compared to those subjected to a fasting period for 48.0 hours. They reported that the delayed access to feed after hatch induced a delayed appearance of biliary IgA and germinal centers, after which decreased lymphocyte proliferation. Consequently, less mature of the bursa and delayed increase of B and T cell populations (Bar-Shira et al., 2005).In line with our findings, other studies reported that if chicks were subjected to a fasting period up to 24.0 h after hatch, the development of bursa and spleen were impaired (Bhanja et al., 2009 and Panda et al., 2010).

Increased duodenum length and density, and jejunum density in AFW group reported in this study are in accordance with the results of Ganjali et al. (2015) who found that the highest small intestine length were observed in birds had early access to feed (6.0h after hatching) as compared to the those delayed in feeding (18.0 h after hatching).

It has been well documented that delayed access to feed and water after hatching resulted in adverse effects on intestinal morphology and digestive enzymes thus delays growth of the intestinal tract (Uni et al.,1998, 1999; Corless and Sell 1999; Noy et al., 2001; Geyra et al., 2001; Bigot et al., 2003). Although we did not measure in this study, development of intestinal villi and crypts are improved by the early nutrition of 1-d-old chicks during transportation from hatchery to farm (Kovaříková 2013). The increase in weight and length of the small intestine might be accompanied by the increase in surface area of the small intestine (Yamauchi 2002). Increased duedonum length and densities of duedonum and jejunum found in this study probably are related with the increased surface area of small intestine, in which, affected by the length and width of the intestinal villi. The surface area of the small intestine can influence the ability of digestion and absorption of nutrients, thus an increase in growth performance of broiler could be associated with the increase in absorption activity in the small intestine (Ariyadi et al. 2019). It seems that some parts of the gastro-intestinal tract of chicks, such as the duodenum and jejunum, are more sensitive for early access to feed and water compared with the ileum by means of affected cellular proliferation (Geyra et al., 2001) and these finding were confirmed by our data.

Carcass and Carcass Parts Yield

Most profound effect of AFW treatment has been observed on the relative weight of breast fillets confirming the positive effects of earlier access to feed and water on breast muscle in earlier studies (Powell et al., 2016).

Within line with our results, Schivazad et al. (2007) concluded that immediate access to feed after hatch improved breast meat yield at 42 day compared to chicks that receive feed immediately at arrival to farm and those held an additional 12.0 h without feed. This finding might be explained by increased proliferation of satellite cell due to earlier access to feed and water which results in a higher muscle development reported by earlier studies (Halevy et al., 2000; Moore et al., 2005).

The relative weight of abdominal fat significantly increased by AFW during the transportation. This observation did not agree with the report from El-Husseiny et al. (2008) who did not find any effect of moment of first nutrition (ranging between one to 7 days after hatch) on abdominal fat in broiler chickens. In this study, early access to feed and water resulted in higher live weight and higher FC at the slaughter age of 42 d. Therefore, higher breast fillet, and higher abdominal fat probably associated with increased feed intake in this group. Although FCR was not improved and abdominal fat increased with early access to feed and water during the transportation, higher breast meat production would still be an advantage of AFW treatment.

CONCLUSION

Our results indicated the magnitude of earlier feeding in broiler chicks to reduce delay in feed and water access even at a narrow ranges between 32.5 h and 37.0 h (estimated under this study conditions) for DS and DL groups, respectively. These times for delay in feed and water are commonly practiced in commercial conditions. Results from this study also suggests that, regardless of the transport duration, allowing chicks accessing to feed and water during the transportation is a promising management tool for the broiler producers as consider with the apparent advantage of higher BWs by 42 d of age and higher breast yield at d 42. Improved actual and relative weights of bursa and actual weight of spleen in broiler chicks at 7 days were further advantages of AFW as associated with better immune status.

ACKNOWLEDGEMENT

Presented data was a part of PhD study of Tarek Boussaada and has been prepared for publication during his internship at Ege University. The authors would like to thank the Institute of Veterinary Sciences and Agricultural Sciences - Batna University (1) for the experimental work. The authors would like also to thank the Agriculture Faculty of Ege University for hosting Tarek Boussaada and collaboration to finalize this work.

REFERENCES

Abeyesinghe SM, Wathes CM, Nicol CJ, Randall JM. 2001. The aversion of broiler chickens to concurrent vibrational and thermal stressors. Applied Animal Behaviour Science73(3):199-215. https://doi.org/10.1016/S0168-1591(01)00142-3

Almeida JG, Vieira SL, Gallo BB, Conde ORA, Olmos AR. 2006. Period of incubation and posthatching holding time influence on broiler performance. Brazilian Journal of Poultry Science 8(3):153-158. https://doi.org/10.1590/S1516-635X2006000300003

Ariyadi B, Sudaryati S, Harimurti S, Wihandoyo, Sasongko H, Habibi M F, Rahayu D. 2019. Effects of feed form on smallintestinehistomorphology of broilers. IOP Conf. Series: Earth andEnvironmentalScience 387:012047. https://doi:10.1088/1755-1315/387/1/012047

Bar-Shira E, Sklan D, Friedman A. 2005. Impaired immune responses in broiler hatchling hindgut following delayed access to feed. Veterinary Immunology and Immunopathology 105(1-2):33–45. https://doi.org/10.1016/j.vetimm.2004.12.011

Batal AB, Parsons CM. 2002. Effect of fasting versus feeding oasis after hatching on nutrient utilization in chicks.Poultry Science 81(6):853-859. https://doi.org/10.1093/ps/81.6.853

Bergoug H, Guinebretière M, Tong Q, Roulston N, Romanini CEB, Exadaktylos V, Berckmans D, Garain P, Demmers TGM, Mcgonnell IM, Bahr C, Burel C, Eterradossi N, Michel V. 2013. Effect of transportation duration of 1-day-old chicks on postplacement production performances and padodermatitis of broilers up to slaughter age. Poultry Science 92(12):3300–3309. https://doi.org/10.3382/ps.2013-03118

Bhanja SK, Anjali DC, Panda AK, Shyam SG. 2009. Effect of post hatch feed deprivation on yolk-sac utilization and performance of young broiler chickens. Asian-Australasian Journal of Animal Sciences 22(8):1174-1179. https://doi.org/10.5713/ajas.2009.80528

Bigot K, Mignon-Grasteau S, Picard M, Tesseraud S. 2003.Effects of delayed feed intake on body, intestine, and muscle development in neonate broilers. Poultry Science 82(5):781–788. https://doi.org/10.1093/ps/82.5.781

Careghi C, Tona K, Onagbesan O, Buyse J, Decuypere E, Bruggeman V. 2005. The effects of the spread of hatch and interaction with delayed feed access after hatch on Broiler performance until seven days of age. Poultry Science 84(8):1314–1320.DOI: 10.1093/ps/84.8.1314

Chou CC, Jiang DD, Hung YP. 2004. Risk factors for cumulative mortality in broiler chicken flocks in the first week of life in Taiwan. British Poultry Science 45(5):573–577. http://dx.doi.org/10.1080/00071660400006248.

Corless AB, Sell JL. 1999. The effects of delayed access to feed and water on the physical and functional development of the digestive system of young turkeys. Poultry Science 78(8):1158–1169. https://doi.org/10.1093/ps/78.8.1158

de Jong IC, van Riel J, Bracke MBM, van den Brand H. 2017. A 'meta-analysis' of effects of post-hatch food and water deprivation on development, performance and welfare of chickens. PLOS ONE 12(12): e0189350. https://doi.org/10.1371/journal.pone.0189350

Decuypere E, Tona K, Bruggeman V, Bamelis F. 2001. The day-old chick: a crucial hinge between breeders and broilers. World's Poultry Science Journal 57(2):127–138. DOI: https://doi.org/10.1079/WPS20010010

Dibner JJ, Knight, CD, Kitchell ML, Atwell CA, Downs AC, Ivey FJ, 1998. Early feeding and development of the immune system in neonatal poultry. Journal of Applied Poultry Research 7(4):425–436. https://doi.org/10.1093/japr/7.4.425

EL-Husseiny OM, Abou El-Wafa S, El-Komy HMA. 2008. Influence of fasting or early feeding on broiler performance. International journal of poultry science 7(3): 263-271. DOI:10.3923/ijps.2008.263.271

Eratalar S, Türkoğlu M. 2017. The Effects of Immediate Feeding in Delivery Boxes Posthatch on Growth Performance of Turkey Poults. International Journal of Agricultural and Wildlife Sciences 3 (1): 33-39. DOI: 10.24180/ijaws.298456

European Union Council. 2005. Council Regulation (EC) No 1/2005 of 22 December, 2004, on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97. Off. J. Eur. Union L 3:1–44.

Fairchild BD, Northcutt JK, Mauldin JM, Buhr RJ, Richardson LJ, Cox NA. 2006. Influence of water provision to chicks before placement and effects on performance and incidence of unabsorbed yolk sacs. Journal of Applied Poultry Research 15(4):538–543. https://doi.org/10.1093/japr/15.4.538

Ganjali H, RajiAR, Zarghi H. 2015. Effect of post hatch delayed access to feed on performance, GIT physical and histological development and yolk absorption in young broiler chicks. Biomedical Pharmacology Journal 8(2):945-955. https://dx.doi.org/10.13005/bpj/846

Geyra A, Uni Z, Sklan D. 2001.The effect of fasting at different ages on growth and tissue dynamics in the small intestine of the young chick. British Journal of Nutrition 86(1):53–61. https://doi.org/10.1079/BJN2001368

Gonzales E, Kondo N, Saldanha ES, Loddy MM, Care-ghi C, Decuypere E. 2003. Performance and physiological parameters of broiler chickens subjected to fasting on the neonatal period. Poultry Science 82(8):1250–1256. https://doi.org/10.1093/ps/82.8.1250

Halevy O, Geyra A, Barak M, Uni Z, Sklan D. 2000. Early post-hatch starvation decreases satellite cell proliferation and skeletal muscle growth in chicks. The Journal of Nutrition 130(4): 858-864. https://doi.org/10.1093/jn/130.4.858

Henderson SN, Vicente JL, Pixley CM, Hargis BM, Tellez G. 2008. Effect of an early nutritional supplement on broiler performance. International Journal of Poultry Science 7(3):211–214. doi: 10.3923/ijps.2008.211.214

Hollemans MS., de Vries S, Lammers A, Clouard C. 2018. Effects of early nutrition and transport of 1-day-old chickens on production performance and fear response. Poultry Science 97(7):2534–2542. http://dx.doi.org/10.3382/ps/pey106

Jacobs L, Delezie E, Duchateau L, Goethals K, Ampe B, Buyse J, Tuyttens FAM. 2017. Impact of transportation duration on stress responses in day-old chicks from young and old breeders. Research in Veterinary Science 112:172–176. http://dx.doi.org/10.1016/j.rvsc.2017.04.015

Jacobs L, Delezie E, Duchateau L, Goethals K, Ampe B, Lambrecht E, Gellynck X, Tuyttens FAM. 2016. Effect of post-hatch transportation duration and parental age on broiler chicken quality, welfare, and productivity. Poultry Science 95(9):1973-1979. http://dx.doi.org/10.3382/ps/pew155

Juul-Madsen HR, Su G, Sørensen P. 2004. Influence of early or late start of first feeding on growth and immune phenotype of broilers. British Poultry Science 45(2):210–222. https://doi.org/10.1080/00071660410001715812

Kettlewell PJ, Mitchell MA. 2001. Mechanical ventilation: improving the welfare of broiler chickens in transit. Journal of the Royal Agricultural Society of England 162:175-184.

Khosravinia H. 2015. Physiological Responses of Newly Hatched Broiler Chicks to Increasing Journey Distance During Road Transportation. Italian Journal of Animal Science 14(3):3964. http://dx.doi.org/10.4081/ijas.2015.3964

Kidd MT, Taylor JW, Page CM, Lott BD, Chamblee TN. 2007. Hatchery Feeding of Starter Diets to Broiler Chicks. Journal of Applied Poultry Research 16(2):234–239. https://doi.org/10.1093/japr/16.2.234

Kornasio R, Halevy O, Kedar O, Uni Z. 2011. Effect of in ovo feeding and its interaction with timing of first feed on glycogen reserves, muscle growth, and body weight. Poultry Science 90(7):1467–1477.https://doi.org/10.3382/ps.2010-01080

Kovaříková L. 2013. The effect of feeding 0day chicken during transportation on intestinal development. MendelNet: Proceedings of International PhD Students Conference, 20-21 November 2013, Vol.20, Mendel University in Brno, Czech Republic, pp. 451-454. https://mnet.mendelu.cz/mendelnet2013/mnet_2013_full.pdf

Lilburn MS, Loeffler S. 2015. Early intestinal growth and development in poultry. Poultry Science 94(7):1569–1576.

Maiorka A, Santin E, Dahlke F, Boleli IC, Furlan RL, Macari M. 2003. Posthatching water and feed deprivation affect the gastrointestinal tract and intestinal mucosa development of broiler chicks. Journal of Applied Poultry Research 12(4):483-492. https://doi.org/10.1093/japr/12.4.483

Mitchell MA, Kettlewell PJ. 2009. Welfare of poultry during transport - a review, in: Proceedings of the 8th European Symposium on Poultry Welfare, 18-22 May 2009, Cervia, RA, Italy, pp.90-100.

Moore DT, Ferket PR, Mozdziak PE. 2005. Early posthatch fasting induces satellite cell self-renewal. Comparative Biochemistry and Physiology. Part A142(3):331–339.https://doi.org/10.1016/j.cbpa.2005.08.007

Noy Y, Geyra A, Sklan D. 2001. The effect of early feeding on growth and small intestinal development in the posthatch poult. Poultry Science 80(7):912–919. https://doi.org/10.1093/ps/80.7.912

Noy Y, Sklan D. 1999. Energy utilization in newly hatched chicks. Poultry Science 78(12):1750–1756. https://doi.org/10.1093/ps/78.12.1750

Özkan S, Takma Ç, Yahav S, Söğüt B, Türkmut L, Erturun H, Cahaner A. 2010. The effects of feed restriction and ambient temperature on growth and as cites mortality of broilers reared at high altitude. Poultry Science 89(5):974–985. https://doi.org/10.3382/ps.2009-00293

Panda AK, Bhanja SK, Shyam Sunder G. 2015. Early post hatch nutrition on immune system development and function in broiler chickens. World's Poultry Science Journal 71(2):285–296. https://doi.org/10.1017/S004393391500029X

Panda AK, Raju MVLN, RamaraoSV, Shyamsunder G, Reddy MR. 2010. Effect of Post hatch Feed Deprivation on Growth, Immune Organ Development and Immune Competence in Broiler Chickens. Animal Nutrition and Feed Technology 10(1): 9-17.

Plavnik I, Hurwitz S. 1985. The performance of broiler chicks during and following feed restriction at an early age. Poultry Science 64(2):348–355. https://doi.org/10.3382/ps.0640348

Powell DJ, Velleman SG, Cowieson AJ, Singh M, Muir WI.2016. Influence of chick hatch time and access to feed on broiler muscle development. Poultry Science 95(6):1433–1448. http://dx.doi.org/10.3382/ps/pew047

Shariatmadari F. 2012. Plans of feeding broiler chickens. World's Poultry Science Journal 68(1):21-31. https://doi.org/10.1017/S0043933912000037

Shivazad M, Bejaei M, Taherkhani R, ZaghariM, Kiaei MM. 2007. Effects of glucose injection and feeding oasis on broiler chick's subsequent performance. Pakistan Journal of Biological Sciences 10(11):1860-1864. DOI: 10.3923/pjbs.2007.1860.1864

Sklan D, Noy Y, HoyzmanA, Rozenboim I. 2000. Decreasing Weight Loss in the Hatchery by Feeding Chicks and Poults in Hatching Trays. Journal of Applied Poultry Research 9(2):142-148. https://doi.org/10.1093/japr/9.2.142

Uni Z, Ferket PR, Tako E, Kedar O. 2005. In ovo feeding improves energy status of late term chicken embryos. Poultry Science 84(5):764-770. https://doi.org/10.1093/ps/84.5.764

UniZ, Ferket RP. 2004. Methods for early nutrition and their potential. World's Poultry Science Journal 60(1): 101-111. https://doi.org/10.1079/WPS20038

Uni Z, Ganot S, Sklan D. 1998. Posthatch development of mucosal function in the broiler small intestine. PoultryScience 77(1):75–82. https://doi.org/10.1093/ps/77.1.75

Uni Z, Noy Y, Sklan D. 1999. Post hatch development of small intestinal function in the poult. Poultry Science 78(2):215–222. https://doi.org/10.1093/ps/78.2.215

Uni Z, Smirnov A, Sklan D. 2003. Pre- and posthatch development of goblet cells in the broiler small intestine: Effect of delayed access to feed. Poultry Science 82(2):320–327. https://doi.org/10.1093/ps/82.2.320

Vargas FSC, Baratto TR, Magalhães FR, Maiorka A, Santin E. 2009. Influences of breeder age and fasting after hatching on the performance of broilers. Journal of Applied Poultry Research 18(1):8–14. https://doi.org/10.3382/japr.2008-00029

Yamauchi K. 2002. Review on chicken intestinal villus histological alterations related with intestinal function. Journal of Poultry Science 39: 229-242. https://doi.org/10.2141/jpsa.39.229

.