

ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF
POULTRY SCIENCE

ANSI*net*

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Effect of Age on Selected Plasma Indices of Biochemical and Mineral Metabolism in Two Strains of Broiler Chickens

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Abstract: The aim of the study was to determine changes in plasma concentrations of 12 biochemical parameters of lipid, protein, carbohydrate and mineral metabolism in two strains of broiler chickens and to compare blood profile of the two groups. The investigation was conducted on 160 broiler chickens: 80 broilers Isa 15 strain and 80 broilers Arbor Acres strain. For the two strains, samples were held at 7, 14, 35 (59 days for Isa 15 strain, 57 days for Arbor Acres strain) and then analyzed. Most of the estimated parameters were age-dependent. Concentrations of plasma cholesterol and triglycerides showed a significant decrease along the experimental period ($p < 0.05$). Concentrations of plasma glucose decreased significantly ($p < 0.05$) until the 35th day of age in the two groups and then augmented statistically. A significant increase ($p < 0.05$) in plasma concentrations of total protein, creatinine and calcium was observed in the two strains during the experimental period. A significant decrease ($p < 0.05$) in plasma uric acid and plasma phosphorus was found in the two strains between the 7th day and the end of the fattening period. Plasma magnesium showed a constant significant decrease ($p < 0.05$) during all the experimental period in the two groups. Plasma urea and plasma albumin remained low in the two strains. Plasma concentrations of iron decreased ($p < 0.05$) until the 35th day of age in the two groups. A significant difference ($p < 0.05$) in plasma glucose, plasma uric acid, plasma creatinine, plasma calcium, plasma magnesium and plasma phosphorus was found between Isa 15 strain and Arbor Acres strain. The given results may be helpful for evaluating the health status, so that the genetic potential for growth and production of the bird is fully expressed. They will expand the current knowledge on the changes in the biochemical profile of broiler chickens.

Key words: Age-Arbor, acres-blood, chemistry-Isa, 15-growth potential

INTRODUCTION

Blood chemistry profile is extremely important in the health management of bird species (Quintavalla *et al.*, 2001; Kudair and Al-Hussary, 2010) and is a common tool for the early diagnosis and correction of nutritional and metabolic disorders before the emergence of more serious symptoms (Miranda *et al.*, 2008). The study of blood constituents can provide valuable information about the general health of an animal and therefore can be used for evaluating the health status (Al-Busadah, 2007; Bowes *et al.*, 1989). Observation of a deviation of certain blood parameters from their normal limits could be a guide for diagnosis or differential diagnosis of a disease condition (Omer *et al.*, 2006). However, blood analyses have been performed much less often in avian medicine in comparison to their routine use in large animal practices in veterinary medicine (Talebi, 2006). Several factors may have an influence on biochemical parameters in the chicken's blood including feed additives (Cetin *et al.*, 2002), drugs (Zaman *et al.*, 1995),

environmental temperature (Vecerek *et al.*, 2002) and poultry diseases (Koinarski *et al.*, 2001; Panigrahy *et al.*, 1986). In commercial conditions, when broiler chickens are fed on a standard diet and when no clinical symptoms of disease or abnormal mortality are observed, the breeding line and age of birds seem to be the main factors influencing the intensity of metabolism which is directly reflected in changes of the blood parameters (Piotrowska *et al.*, 2011). The effect of age on the blood chemistry of young growing broilers was examined in several studies, however, the values obtained are extremely variable (Bowes *et al.*, 1989; Silva *et al.*, 2007; Krasnodebska-Depta and Koncicki, 2000). Also, this is a scientific field that is still little exploited in Algeria and studies are needed to define reference values in different strains of broiler chickens. Therefore, this study was conducted:

- To evaluate body weights of Isa 15 strain and Arbor Acres strain at different ages

- To examine 12 biochemical parameters of lipid, protein, carbohydrate and mineral metabolism
- To compare blood profiles of these two groups

MATERIALS AND METHODS

Animals and housing: The study was conducted in the poultry farm Benboulaid (15 km far from Constantine, Algeria). Experiments were carried out on 160 broilers of two strains: 80 heavy fast growing broilers Arbor Acres strain and 80 lighter-weight, fast growing broilers Isa 15 strain. The two groups of animals were housed in two different battery brooders but subject to equivalent conditions including feeding. The temperature is maintained at 32°C during the first three days of life of the chicks and then it is reduced by 2°C each week until reaching a temperature of 22-24°C. The animals were exposed to a cycle of 24 h light in the first 03 days of life. The lighting is first reduced each week to 14 h light between 16 and 21 days of age and then increased by 2 h each week to 22 h light at 42 days of age until slaughter. Broilers Isa 15 strain were reared from 1 to 59 days of age and broilers Arbor Acres strain were reared from 1 to 57 days of age according to the technological recommendations for these breeds. Water and feed were provided ad libitum for the two strains. In our experimentation, no clinical symptoms of disease or abnormal mortalities were observed.

Diet: Broilers feed formulations have been loaned by the National Office of Livestock Feed (ONAB). Chickens Isa 15 strain and chickens Arbor Acres strain were fed during the first 11 days with a commercial starter diet (Table 1). The grower diet begins to be distributed at 12 days until the end of the fattening period (Table 2). The content of crude protein (%) and metabolizable energy (Kcal/Kg of diet) in the diets was as follows:

- starter 22.11, 2823.75, grower diet 20.32, 2908.53

Table 1: Composition of starter diet

Starter feed composition	Metabolizable energy	Proteins (%)
Maize: 50%		
Soya meals: 24%		
Milling issues: 23%	2823.75 Kcal/kg of diet	22.11%
Limestone: 1%		
Phosphate: 1%		
Mineral complex vitamins: 1%		
Source ONAB		

Table 2: Composition of grower diet

Grower feed composition	Metabolizable energy	Proteins(%)
Maize: 62%		
Soya meals: 26%		
Milling issues: 8.50%	2908.53 Kcal /Kg of diet	20.32%
Limestone: 0.90%		
Phosphate: 1.60%		
Mineral complex vitamin: 1%		
Source ONAB		

Blood samples: At 7, 14, 35, 57 days for Arbor Acres strain and 59 days for Isa 15 strain, twenty birds per strain were sacrificed by decapitation. Blood for analysis was collected from the jugular vein and harvested into heparinized polystyrene tubes. After sampling, blood plasma was separated by centrifugation at 3,000 rpm for 10 min and the obtained plasma was then analyzed.

Biochemical analysis: Plasma samples were assayed using clinical chemistry tests on the ARCHITECT ci 8200 system. The blood plasma was analyzed for total protein by the Biuret method (Kaplan and Pesce, 1989; Tietz, 1995). Albumin was analyzed using bromocresol purple (Pinnell and Northam, 1978). Urea was analyzed by the urease-GLDH method (Tiffany *et al.*, 1972). Creatinine was analyzed using a kinetic alkaline picrate method (Fabiny and Ertingshausen, 1971; Soldin *et al.*, 1978). Uric acid was analyzed by the uricase/POD method (Trivedi, 1978; Kabasakalian *et al.*, 1973). Glucose was determined using the hexokinase reaction (Farrance, 1987). Cholesterol was measured using the chromogenic method of Allain *et al.* (1974) and triglycerides by a colorimetric method described by Fossati and Prencipe (1982). Calcium was analyzed using the Arsenazo III method (Henry *et al.*, 1974) and magnesium using the Arsenazo magnesium reagent (Burtis and Ashwood, 1994). Blood plasma for phosphorus was determined by the formation of a complex of phosphate ion with a molybdate compound (Fiske and Subbarow, 1925). Blood plasma for iron was analyzed using a chromogenic method described by Tietz (1986).

Statistical analysis: The results were evaluated statistically by the Statview 1992-98 SAS Institute, Inc. Data were analyzed with one way analysis of Variance (ANOVA). The student's t-test was used to evaluate strain differences. Comparisons were considered significant when p-values were less than 0.05.

RESULTS

Body weights: Body weights presented in Table 3 indicate that broilers Arbor Acres strain have higher body weights than broilers Isa 15 strain during all the experimental period. The difference in weight between the two strains exceeds 480 g at the end of the fattening period, but was not statistically significant ($p > 0.05$).

Values of plasma indices of biochemical and mineral metabolism: The summarized data are shown in Table 4 and 5. Concentrations of plasma cholesterol and triglycerides showed a significant decrease along the experimental period ($p < 0.05$). Concentrations of plasma glucose decreased significantly ($p < 0.05$) until the 35th day of age in the two groups and then augmented

Table 3: Body weights (g) in Isa 15 strain and arbor acres strain

Strain	Age of broilers			Before slaughter
	7 days	14 days	35 days	
Isa 15 strain	157.35 ^a ±9.95	412.20 ^b ±11.27	1703.15 ^c ±25.21	2715.25 ^d ±33.99
Arboracres strain	167.00 ^a ±6.31	402.15 ^b ±25.74	1981.70 ^c ±28.66	3195.60 ^d ±42.52

statistically. A significant increase ($p < 0.05$) in plasma concentrations of total protein, creatinine and calcium was observed in the two strains during the experimental period. A significant decrease ($p < 0.05$) in plasma uric acid and plasma phosphorus was found in the two strains between the 7th day and the end of the fattening period. Plasma magnesium levels showed a constant significant decrease ($p < 0.05$) during all the experimental period in the two groups. Plasma urea and plasma albumin remained low in Isa 15 strain and in Arbor Acres strain. Plasma concentrations of iron decreased ($p < 0.05$) until the 35th day of age in the two groups. A significant difference ($p < 0.05$) in plasma glucose, plasma uric acid, plasma creatinine, plasma calcium, plasma magnesium and plasma phosphorus was found between the two strains.

DISCUSSION

The objective of the present study was to provide physiological reference values for plasma chemistry parameters of broiler chickens at different ages and to investigate the variation in these values arising from differences between broilers Isa 15 strain and broilers Arbor Acres strain. Obtained data is in accordance with technological norms for Arbor Acres and Isa 15 strains. Arbor Acres chickens are heavy broilers selected on fast growth (Uni *et al.*, 1996; Sterling *et al.*, 2006) and Isa 15 chickens are lighter-weight fast-growing broilers (Table 3). Pavlovski *et al.* (2009) have concluded that Arbor Acres genotype at the age of 42 days realized lower mortality, better feed conversion, higher body mass and higher realized value of production index. Abdullah *et al.* (2010) has reported that genetic variation between the strains could have resulted in body weight gain variation and different body growth potential.

Lipid metabolism: Lipid metabolites are strongly associated to energy metabolism (Piotrowska *et al.*, 2011) and reflect the marked differences between immediate posthatch and growing metabolism (Szabo *et al.*, 2005). The plasma triglycerides concentration peaked at the first sampling (7days) in Isa 15 strain and in Arbor Acres strain, reflecting a typically intensive early lipid metabolism and transport (Noble and Cocchi, 1990). A later general decrease of plasma triglycerides was observed in the two strains studied. Significant age-related differences were also observed in the concentration of total cholesterol which showed a

significant decrease ($p < 0.05$) until the 35th day of age in the two groups of chickens. Similar to our results, Peebles *et al.* (1997) observed a general decrease of blood triglycerides and cholesterol with age. Krasnodebska-Depta and Koncicki (2000) detected the tendency of triglycerides to decrease with age and did not show any association between age and cholesterol concentration in broilers. Szabo *et al.* (2005) described pronounced alterations in lipid blood metabolites in an experiment on growing turkeys and observed a sudden decrease of blood triglycerides content after the 3rd day of life as a result from a decline of the specific activity of the intestinal Fatty Acid Binding Protein (FABP) in the early posthatch period. According to the results of Krasnodebska-Depta and Koncicki (2000), both cholesterol and triglycerides are genetically dependent and this may be one of the reasons for their great variability.

Protein metabolism: Total plasma proteins are a common parameter used to assess the health status of animals. It is well known that blood plasma proteins play a key role in the maintenance of colloid osmotic pressure, as well as the transport of minerals and hormones. They are therefore essential to maintain homeostasis (Piotrowska *et al.*, 2011). The Biuret method is the method of choice for determining avian plasma or serum total protein levels. The normal plasma protein concentration in birds is less than in mammals, generally ranging from 25-45 g/L (Thrall *et al.*, 2012). The content of protein in the blood plasma of experimental chickens ranged from 25.60 to 33.19 g/L in Isa 15 strain and from 23.20 to 32.10 g/L in Arbor Acres strain and showed a significant increase ($p < 0.05$) between the beginning and the end of the experiment in the two groups, broilers Isa 15 strain demonstrating a constant significant increase ($p < 0.05$) from the 14th day to the end of the fattening period. Among numerous factors that can influence the level of plasma protein in broilers, age of the birds seems to be one of the most important factor, higher values are generally found in adult birds compared to young birds (Rodgers and Gass, 1983; Schmidt *et al.*, 2007; Silva *et al.*, 2007; Szabo *et al.*, 2005; Rajman *et al.*, 2006; Filipovic *et al.*, 2007). The early increase in plasma protein levels is due to an intense somatic development during the starter phase in birds, this increase is also observed in other domesticated birds such as turkeys (Szabo *et al.*, 2005) and emus (Costa *et al.*, 1993), as well as in wild birds such as storks (Montesinos *et al.*, 1997) and starlings (Jurani *et al.*, 2004).

No significant difference was found between the two strains for plasma total protein. This is contrary to the findings of Ibrahim *et al.* (2012) who reported a significant serum total protein difference among the genotypes of chickens.

In terms of quantity, albumin is the most important protein in serum/plasma and therefore, it is the primary source of amino acids for tissue protein synthesis particularly during the period of rapid somatic growth (Yaman *et al.*, 2000). Plasma albumin concentrations generally range from 8 to 20 g/L in normal birds (Thrall *et al.*, 2012). Maintaining the plasma oncotic pressure is mainly due to the higher concentration of proteins in the blood and particularly albumin concentrations (Martin *et al.*, 2006). Szabo *et al.* (2005) and Bounous *et al.* (2000) noted a rapid increase in plasma concentrations of albumin during the starter phase, period in which the growth is at its maximum, they also indicate that the increased levels of Growth Hormone at this period is a factor known to elevate plasma concentrations of albumin. In our experiment, the levels of plasma albumin showed an increasing significant ($p < 0.05$) tendency in the two strains, but remained low. The highest content of this protein fraction (5.14 g/L) was detected on the 14th day of age in Arbor Acres strain.

Most veterinary laboratories measure albumin using the dye bromocresol green (bcg), which has not been validated in companion avian species. Bromocresol green non-specifically binds protein. Binding of (bcg) causes increased color in the sample, which correlates with a higher reported albumin concentration. Avian albumin is markedly different in structure than mammalian albumin and binds (bcg) with decreased affinity. Comparison of gel electrophoresis and (bcg) have revealed that (bcg) results in lower concentrations reported than actually exist in the patient (Harr, 2006). Bromocresol purple (bcp) also is commonly used in human laboratories and has different protein binding affinity for albumin. Harr (2006) reported that bromocresol purple may results in more accurate avian albumin measurement and better diagnostic acuity. Our study revealed that the levels obtained are very low and may not be accurate. Thus, these two methods of measuring plasma albumin using bromocresol green or bromocresol purple are not validated in avian species and may be inaccurate at the low albumin concentrations found in avian plasma. Protein electrophoresis provides a more accurate measure of the albumin concentration as well as those of other plasma proteins (Cray *et al.*, 2011; Thrall *et al.*, 2012). Plasma concentrations of urea remained very low for the 2 strains studied. Broilers do not produce urea in large quantities because of the low arginase activity in the liver: enzyme responsible for the production of urea (Donsbough, 2006).

Table 4: Body weights and mean values of selected biochemical indicators ($\bar{x} \pm SD$) in blood plasma in Isa 15 strain and Arbor Acres strain

Parameter	Body weight (g)		Glucose (g/L)	Cholesterol (g/L)	Triglycerides (g/L)	Total protein (g/L)	Albumin (g/L)	Uric acid (mg/L)	Urea (g/L)
	Strain	Age							
Isa 15	7	20	1.58±0.19	0.99±0.53	26.20±2.94	4.40±0.50	58.55±15.59	0.04±0.01	2.55 ^a ±0.51
	14	20	1.25±0.07	0.71 ^a ±0.10	25.60±1.09	4.65 ^a ±0.48	49.23±18.78	0.04±0.01	2.55 ^a ±0.51
	35	20	0.88±0.1 ^c	0.66 ^a ±0.27	30.56±3.57	4.76 ^b ±0.51	40.37±9.06	0.04±0.01	2.47 ^b ±0.17
Arbor	59	20	0.98±0.17 ^c	0.75±0.17	33.19±3.16	4.80±0.44	31.52±9.11	0.04±0.01	2.96 ^b ±1.21
	7	20	1.40±0.19 ^c	0.98±0.19	23.20±1.73	4.10±0.30	91.10±23.44	0.04±0.01	2.35 ^b ±0.48
Acres	14	20	1.50±0.09 ^c	0.82±0.13	30.97±1.39	5.14±0.23	70.48±21.72	0.09±0.01	2.28±0.32
	35	20	0.82±0.40 ^c	0.56 ^a ±0.21	25.86±10.45	4.55±0.83	44.32±20.72	0.04±0.01	2.38±0.45
	57	20	1.05±0.18 ^c	0.54±0.15	32.10±3.95	4.45±0.51	52.40±23.43	0.04±0.01	2.70±0.47

^{a,b,c}Means in the rows with different letters differ significantly $p < 0.05$

In birds, uric acid is produced as the main elimination molecule product of azote metabolism (Donsbough *et al.*, 2010). It plays a critical role as a potent regulator of oxidative stress (Rajman *et al.*, 2006). Piotrowska *et al.* (2011) indicate that earlier studies on poultry revealed age-dependant changes in plasma uric acid concentration. Generally higher levels were detected in birds during the early rearing period in comparison to older chickens. Szabo *et al.* (2005) and Bowes *et al.* (1989) showed a direct relationship between the amount of ingested protein and the blood uric acid levels. The high protein concentration typical of starter diet results in a higher blood uric acid levels in reason of an increased nitrogen metabolism. In the present study, the change in diet from younger to older birds, results in a significant change ($p < 0.05$) in plasma uric acid. The values dropped with the change from 22% protein starter diet (Table 1) to a 20% protein grower-finisher diet (Table 2) at 12 days of age in the two groups of broilers. Okumura and Tasaki (1997), showed that the quantity of absorbed nitrogen reflected the plasma uric acid in the chickens and that the results obtained with blood uric acid in birds resemble those with blood urea in mammals. Considering that uric acid is the main product of nitrogen metabolism in avian species, its biosynthesis would be physiologically similar to the formation of urea in ureotelic species and in this context, xanthine dehydrogenase in birds assumes a similar role to that of arginase in mammals (Featherston and Scholz, 1968). Alvarez (2005) related the possibility that higher uric acid levels at younger ages would be reflecting some renal dysfunction in these individuals. In fact, this parameter can be used to judge the integrity of the kidney.

In the present study, a very significant difference ($p < 0.0001$) in plasma uric acid was noted between Isa 15 strain and Arbor Acres strain. The Arbor Acres strain showed higher values of plasma uric acid concentrations during the breeder period. Hartman *et al.* (2006), noted significant differences in plasma uric acid concentrations in five varieties of domestic turkeys (*Meleagris gallopavo*) and research has suggested that basal values of plasma uric acid are influenced by sex, weight, genetic background and may be independent of age.

Another important indicator of protein metabolism is creatinine, a metabolic byproduct of the phosphocreatinine breakdown in skeletal muscle (Wyss and Kaddurah-Daouk, 2000). Blood creatinine is a waste product found in muscle from a high energy storage compound (Ibrahim *et al.*, 2012). Its concentration is directly proportional to muscle mass, related to age and physical activity (Rajman *et al.*, 2006; Szabo *et al.*, 2005). In the present study, the concentration of creatinine decreased in the first's weeks of age in the two strains and then augments

significantly ($p < 0.05$) between the 35th day and the end of the experiment. Similar to our results, Piotrowska *et al.* (2011) also confirmed that the concentration of creatinine decreases slightly from the 2nd to the 3rd week of age and after increases significantly. In this study, the highest level of creatinine was determined at the end of the fattening period for the two strains studied, as a result of intensive muscle growth. Significant difference ($p < 0.05$) in plasma creatinine was found between Isa 15 strain and Arbor Acres strain. Oleyemi *et al.* (2006) cited by Ibrahim *et al.* (2012) also reported variations in plasma creatinine due to genotype in ducks.

Carbohydrate metabolism: Birds have a high metabolic rate and plasma glucose concentrations 150-300% higher than in mammals of similar body mass (Koochakasaraie *et al.*, 2010). Glucose is utilized by birds for a variety of functions with the main use being for energy production through cellular oxidation, glycogen synthesis in liver and glycolytic muscles, fatty acid synthesis as well as synthesis of nonessential amino acids, vitamin C and other metabolites (Braun and Sweazea, 2008). The level of blood glucose depends on the balance between the intake of carbohydrates and the endogenous glucose synthesis and release by the liver on one hand and storage, utilization and excretion on the other (Nwaoguikpe, 2010). Changes in plasma glucose showed a significant decrease ($p < 0.05$) between the 7th and the 35th day of age in the two groups and then augment statistically till the end of the fattening period. Our findings are in agreement with previous studies on birds which also revealed an age-dependent gradual decline in plasma glucose concentrations (Hernandez and Margalida, 2010). Bowes *et al.* (1989) reported that over the first eight weeks of age in broiler chickens, there was an increase in plasma glucose. Significant difference in plasma glucose ($p < 0.05$) was showed between Isa 15 strain and Arbor Acres strain. This difference reflects a greater efficiency of energy utilization by Arbor Acres strain and may be a consequence of the higher energy requirement of this heavy strain for muscle protein synthesis.

Mineral metabolism: Minerals are essential for broiler growth and are involved in many digestive, physiological and biosynthetic processes within the body (Piotrowska *et al.*, 2011). They function primarily as catalysts in enzyme systems within cells or as parts of enzymes. They are constituents of hundreds of proteins involved in intermediary metabolism, hormone secretion pathways and immune defense systems (Abdallah *et al.*, 2009; Yang *et al.*, 2011). Calcium is needed for the ossification of bones, regulation of skeletal and cardiac muscle activity, activation of several enzymes, transmission of nerve impulses, permeability of membranes and

Table 5: Mean values of ion concentrations (Mean±SD) in blood plasma in Isa 15 strain and Arbor Acres strain

Strain	Age	n	Parameter			
			Calcium (mg/L)	Phosphorus (mg/L)	Magnesium (mg/L)	Iron (µg/dL)
Isa 15	7	20	101.80 ^a ±3.95	58.70 ^a ±8.85	29.20 ^a ±4.02	125.05 ^a ±11.63
	14	20	101.10 ^{a,b,c} ±2.84	67.05 ^b ±4.78	22.20 ^b ±0.89	100.90 ^{b,d} ±8.98
	35	20	106.52 ^{b,c} ±6.36	62.43 ^b ±3.78	20.15 ^{c,d} ±2.66	77.10 ^c ±15.77
	59	20	104.44 ^c ±2.01	52.99 ^c ±6.25	19.01 ^d ±1.28	97.75 ^d ±15.49
Arbor	7	20	99.15 ^a ±3.15	75.85 ^a ±6.21	31.30 ^a ±1.78	134.55 ^a ±10.03
Acres	14	20	105.45 ^b ±5.33	91.66 ^b ±8.58	29.65 ^b ±1.98	92.25 ^{b,d} ±10.87
	35	20	83.17 ^c ±17.80	62.73 ^{c,d} ±4.36	20.89 ^{c,d} ±1.88	82.80 ^c ±21.38
	57	20	108.40 ^{d,b} ±2.78	60.40 ^d ±8.95	20.15 ^d ±2.97	101.00 ^d ±14.67

^{a,b,c,d}Means in the rows with different letters differ significantly $p < 0.05$

maintenance of osmotic pressure. Phosphorus is an important constituent of bones, nucleic acids and phospholipids (Ansar *et al.*, 2004). Magnesium activates a number of enzymes indispensable in carbohydrate and phosphorus-calcium metabolism as well as serves an important function in the contraction process of muscles. Iron is a constituent of multiple enzymes and metalloproteins. Iron bound in blood in the form of hemoglobin participates in oxygen transfer from lungs to tissues. In muscles it is a constituent of myoglobin: a red pigment of muscles that collects oxygen from red blood cells and utilizes it for the work of muscles (Wojcik *et al.*, 2009). The results of the present study showed a significant increase in plasma calcium ($p < 0.05$) and a significant decrease ($p < 0.05$) in plasma phosphorus between the beginning and the end of the experiment in the two strains studied. The results of previous investigations on the blood calcium and phosphorus in relation to the age of chickens are diversified. Some of them showed a clear increasing tendency in the first weeks of age and other studies revealed only fluctuations ($p > 0.05$) in calcium and phosphorus concentrations (Ansar *et al.*, 2004; Bowes *et al.*, 1989; Szabo *et al.*, 2005; Silva *et al.*, 2007; Talebi, 2006). Szabo *et al.* (2005) reported that the low blood calcium concentration in the immediate post hatch period may arise from the progressive early depletion of the egg-shell calcium source that was compensated from the diet in the post hatch period.

In the present investigation, there was a significant decrease ($p < 0.05$) in plasma magnesium during all the experimental period. Our results are in agreement with other studies which revealed an age-dependent gradual decrease in blood magnesium content in relation to dietary intake (Bowes *et al.*, 1989). The plasma iron concentration showed a clear tendency of decrease ($p < 0.05$) until the 35th. Previous studies revealed that blood iron values in poultry vary with age. The intensification of erythropoiesis decreases with age explaining the lower requirements for iron in older chickens (Piotrowska *et al.*, 2011). Mohanna and Nys (1998) reported that iron utilization in chickens decreased rapidly before the 21st day and thereafter only fluctuations were observed until the end of the fattening period. Significant differences ($p < 0.05$) were observed

between the two strains for plasma calcium, plasma phosphorus and plasma magnesium.

Conclusion: The results of the present study carried out on broiler chickens of Isa 15 strain and Arbor Acres strain during the breeder period (day 7-end of the fattening period) indicate that most of the analyzed parameters of lipid, protein, carbohydrates and mineral metabolism are age-dependent. Only concentrations of urea remained very low and did not show any significant changes. Strain differences in plasma glucose, uric acid, creatinine, calcium, phosphorus and magnesium were revealed. It should be pointed that protein electrophoresis provides a more accurate measure of the albumin concentration as well as those of other plasma proteins in avian blood. Plasma chemistry reference values can be obtained easily and may provide valuable information about the physical condition of individuals making them a useful tool in differentiating normal and healthy animals from abnormal or diseased states.

ACKNOWLEDGMENTS

We are deeply grateful to Pr Chérifa Benlatrèche (University medical center-Constantine-Algeria), to Dr. Abderrahmane Boukerrou (Regional veterinary laboratory-Constantine-Algeria) and to Pr Brigitte Siliart (LDH-Oniris-Nantes-France) and for their valuable contribution to the accomplishment of this study.

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