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RESPONSE OF BROILERS BODY FLUIDS AND SOME PHYSIOLOGICAL TRAITS TO CHANGES IN ENVIRONMENTAL CONDITIONS

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SUMMARY

This study was carried out during summer and was repeated in winter on Arbor-Acres broilers from hatching till the seventh week of age. Average ambient temperature was 33.5±3.5°C (28 to 40°C) and relative humidity was 46.5±11.5% (35 to 80%) in summer, while the corresponding values in winter were 25.5±3.5°C (12 to 28°C) and 54.4±4.5% (45 to 65%). In the summer experiment , 200 one-day old broiler chicks were randomly distributed into two groups. The first group was fed basal diet but the birds in second group were fed a basal diet supplemented with 1.0% sodium chloride.

In winter, 200 one-day old chicks were fed the same basal diet as that used in summer without salt supplement .

Rectal temperature (RT), respiration rate (RR), body fluid compartments (BFC), total body water (TBW), extracellular fluids (ECF), intracellular fluids (ICF), interstitial fluids (ISF), plasma volume (PV)) and plasma proteins (total proteins, TP), albumin (Al) and globulin (Gl)) were determined at 4, 5, 6 and 7 weeks of age.

Rectal temperature, RR and TBW were significantly higher in summer than in winter. The high ambient temperature during summer season significantly decreased ISF% but increased ECF%. Plasma volume and plasma total protein in summer were significantly lower than in winter .

Sodium chloride supplement slightly alleviated the adverse effect of high ambient temperature during summer on plasma albumin and total body solids (TBS%) measured at the seventh week of age but it did not alleviate the reduction in PV% at six and seven weeks of age.

Keywords: Broiler, ambient temperature, dietary sodium chloride, body fluids, plasma proteins

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INTRODUCTION

Mortality due to heat stress is a problem in broiler production . Economic losses attributable to heat prostration are especially large because they usually occur shortly before the broilers are marketable. Zhou and Yamamoto (1997) reported that, the broilers were most susceptible to heat during the last 3 weeks of the growing period.

Wilson (1982) stated that broilers suffered from heat stress when ambient temperature exceeded 32°C with 75% relative humidity. High ambient temperature and relative humidity stress causes a myriad of physiological and metabolic alteration in poultry (Belay and Teeter, 1996).

Heat stress decreased food consumption of broilers through its effect on the thermoregulation center in hypothalamus causing a significant reduction in daily gain. It also increased mortality rate specially during heat waves through its effect on heat and acid - base balances. Consequently, body temperature increased accompanied by the increase in panting within 15 minutes.

It was found that the lower plasma volume percentage in broilers (7weeks old) during hot season is a very serious problem which may be the most important factor causing high mortality rate incidence during summer (Khalifa *et al.*, 1994).

The objectives of the present study were to investigate the role of body fluids in homeostasis during different seasons and effect of salt addition to the diet on broiler thermal balance .

MATERIALS AND METHODS

Experimental Procedure

Two trials were carried out in the Poultry Research Farm and Laboratory of Poultry Physiology, Animal Production Department, Faculty of Agriculture, Cairo University, one during summer (July and August) and the other in winter (December and January). The average ambient temperature and relative humidity during experimental period (11 am to 3 pm) were 33.5±3.5°C and 46.5±11.5% in summer, versus 25.5±3.5°C and 54.4±4.5% in winter, respectively. In the summer trial, 200 one-day old Arbor-Acres broilers were randomly distributed into two equal groups. The first group fed on control basal diet (21% protein and 2800 kcal Me/Kg diet), while birds in the second group were fed on control basal diet supplemented with 1.0% sodium chloride (NaCl). In winter , 200 one-day old chicks were fed control basal diet which as that used in summer without salt addition. Body weight was recorded individually at 4, 5, 6 and 7 weeks of age, while water and feed consumption per pen were measured at the same intervals. The mean water (ml) consumed per kg live body weight were calculated.

Physiological Measurements

Eight birds from each group were taken at 4,5,6 and 7 weeks of age to determine rectal temperature (RT) and respiration rate (RR). Measurements were taken weekly at the hottest period of the day (11 am to 3 pm). RT was measured with clinical mercury thermometer inserted 2 cm in cloaca, RR was measured by counting the body wall movements per minute. Water consumption (% of body weight) and protein and fat content as percentage of carcass were determined .

Blood and Plasma Parameters

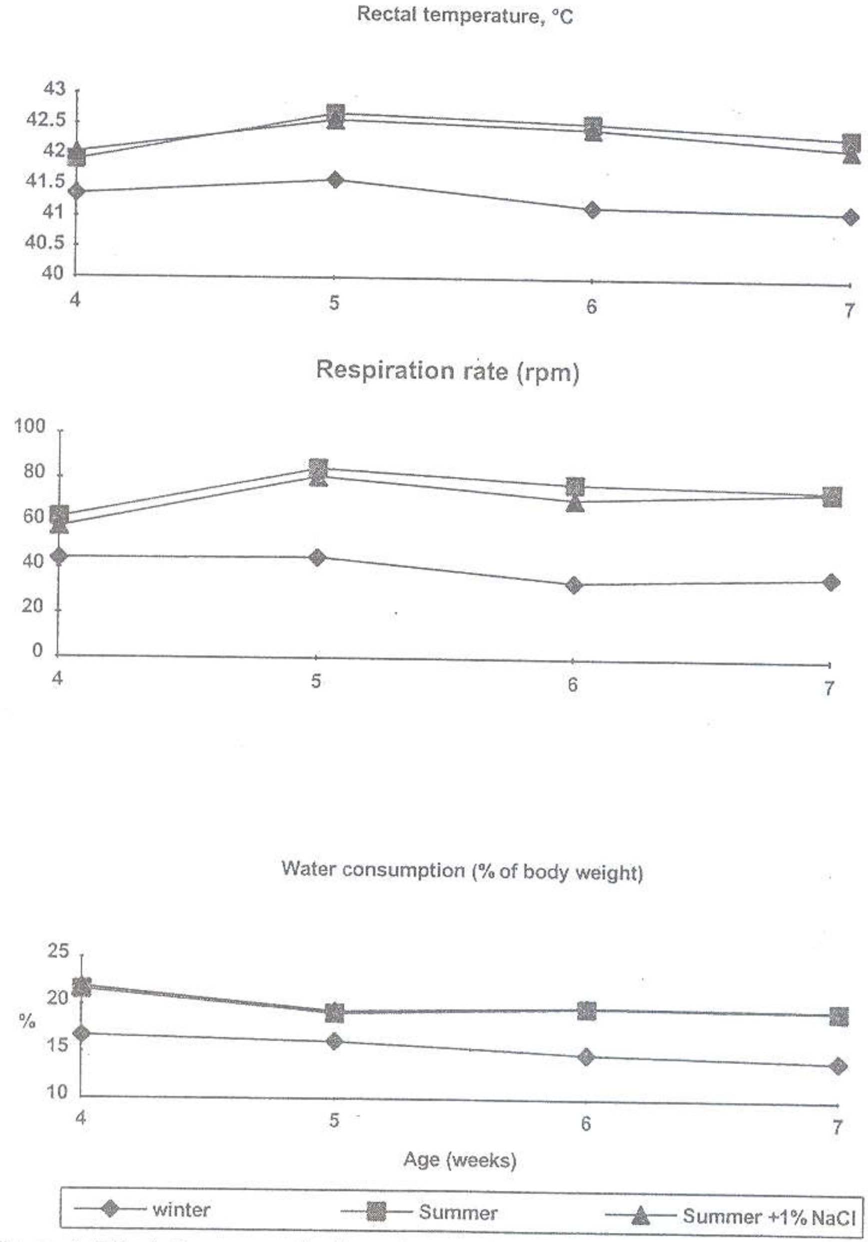
At 4,5,6,and 7 weeks of age, 8 birds from each group (a total of 96 birds) were used for blood tests. For the determination of body fluids, blood samples were withdrawn from wing vein before dye injection as a basal blank, in which plasma proteins were measured, thereafter other samples were collected at 30 , 45 and 60 min. post-injection with mixed dyes. The Injected solution for each Kg body weight was prepared by adding 2.0 ml antipyrine for the determination of total body water (TBW) as described by Weiss (1958), 0.5 ml sodium thiocynate to determine extracellular fluids (ECF) as described by Hix *et al.*(1959) and 0.5 ml Evan's blue to estimate plasma volume (PV) according to Kennedy and Millikan (1938) and modification of Mishra and Saxena (1983). Intracellular fluids (ICF) and interstitial fluids (ISF) were calculated by subtraction. Total plasma proteins (TPP) concentration was measured as described by Weichselbaum and Captain (1946) and plasma albumin (Al) concentration by method of Doumas *et al.*(1971).

Statistical Analysis

Data were subjected to standard statistical analysis of variance (one-way ANOVA) according to SAS (1988) and Duncan's Multiple Range Test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Rectal temperature (RT) and respiration (RR) were significantly higher in summer, with or without NaCl supplementation, than in winter at all ages (Fig. 1). During hot weather, NaCl supplementation to the basal diet caused a slight reduction in RT and RR. These results are in agreement with Ahmed and Maghraby (1995). The significantly higher RT and RR in summer than in winter indicated that birds suffered from heat stress when ambient temperature was higher than 30°C (in summer). Similar results were found by Kamar and Khalifa (1977), Sinurat and Balnave (1985) and Khalifa *et al.* (1994). The decrease in RT in summer at 6 and 7 weeks of age associated with increase in water intake (Fig. 1) might be due to the increase in evaporative cooling to reduce body temperature.


Rectal temperature, °C

Respiration rate (rpm)

Water consumption (% of body weight)

Figure 1. Effect of season and salt supplementation on rectal temperature, respiration rate and water consumption of broilers at successive ages.

Total body solids (TBS%) as percentage of body weight significantly increased with age in both seasons (Table 1 and Fig. 2). The changes in TBS% during the growing period were higher in winter than in summer. This may be due to the increase in protein and fat deposition (Fig. 3). Similar results were obtained by Khalifa *et al.* (1994). However, the higher TBS% in summer than in winter (at 4weeks of age) may be due to greater effect of high ambient temperature at this age which results in increasing water evaporation through faster respiration (panting) to increase the amount of heat dissipation. On the other hand Van Kampen (1980) stated that heat treatment in posthatching period, *i.e.* in a rapid fat- cell formation, will change body mass and composition. Also, Yousef (1982) stated that applying heat during the growing period regulated body composition. Addition of NaCl decreased TBS% during the first six weeks with slightly higher value at seven weeks of age. This indicates that Nacl had no significant effect on the ruduction of TBS% during summer.

Table 1. Effects of season and salt supplementation on body weight, total body solids and total body water as % of body weight at successive ages (mean± SE)

Age	Body weight (g)			Total body solids %			Total body water %		
(Week)	Winter	Summer	Summer+ 1%NaCl	Winter	Summer	Summer+ 1%NaCl	Winter	Summer	Summer+ 1%NaCl
4	1090^{Da}	689^{Dc}	771^{Db}	25.54^{Dc}	31.28^{Da}	28.74^{Db}	74.46^{Aa}	68.72^{Ac}	71.26^{Ab}
±SE	32	33	31	0.82	0.52	0.47	0.82	0.52	0.47
5	1468^{Ca}	1049^{Cb}	1090^{Cb}	35.05^{Ca}	33.30^{Cb}	31.59^{Cc}	64.95^{Bc}	66.69^{Bb}	68.41^{Ba}
±SE	38	31	31	0.53	0.42	0.48	0.53	0.42	0.48
6	1735^{Ba}	1236^{Bb}	1275^{Bb}	40.02^{Ba}	36.04^{Bb}	34.07^{Bc}	59.98^{Cc}	63.95^{Cb}	65.93^{Ca}
±SE	21	42	62	0.19	0.36	0.11	0.19	0.36	0.11
7	2139^{Aa}	1655^{Ab}	1709^{Ab}	43.86^{Aa}	39.15^{Ac}	41.46^{Ab}	56.14^{Dc}	60.85^{Da}	58.54^{Db}
±SE	58	47	43	0.28	0.67	0.21	0.28	0.67	0.21

^{A,B,C} Means within each trait in the same column bearing different superscripts are significantly different ($P \leq 0.05$).

a,b,c Means within each trait in the same raw bearing different superscripts are significantly different ($P \leq 0.05$).

Total body water as percentage of body weight (TBW%) in both seasons significantly decreased by advancing age (Table 1). The rate of reduction in TBW% was lower in summer control group than that in winter and NaCl group in summer (Fig.2). This may be due to higher fat deposition in birds reared in winter than in summer. Sturkie (1965) suggested that this reduction in TBW% with increasing age may a reflection of the increase in body fat deposition with aging in the bird. At 4 weeks of age TBW% in winter was significantly higher than those birds grown in hot weather, even if NaCl was added. While an opposite trend was observed at 5,6 and 7 weeks of age (Table 1). The addition of NaCl in summer increased significantly TBW% at 5 and 6 weeks of age than in winter and control summer groups. The higher TBW% in hot

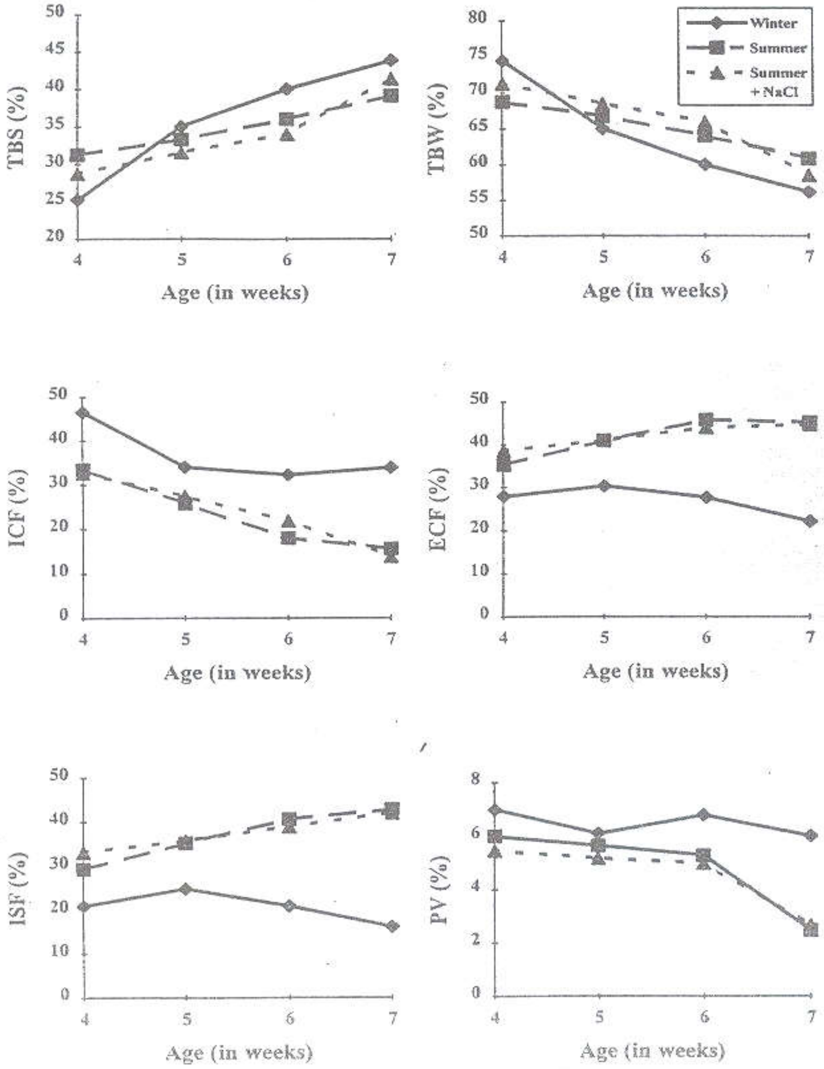


Figure 2. Effect of season and salt supplementation on body fluids as percentages of body weight at successive ages.

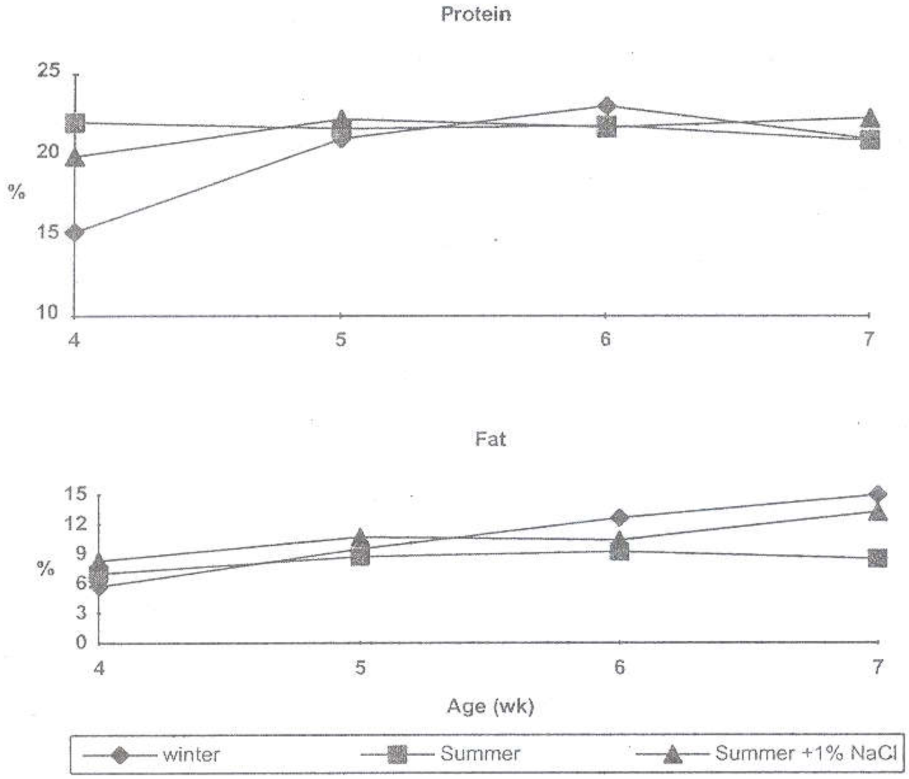


Figure 3. Effect of season and salt supplementation on chemical composition of broiler carcass.

season was essential to compensate the loss of body water through faster evaporative cooling (Whittow, 1968). The higher TBW% in summer may be attributed to the higher water intake (Fig. 1). Also , Abdel-Razik *et al.* (1985) suggested that this higher TBW% in summer might be due to higher water turnover rate during this season . Similar results were found by Khalifa *et al.* (1994).

Intracellular fluids (ICF%) decreased significantly with age in both seasons but the reduction was higher in summer groups than in winter (Table 2 and Fig. 2). At all ages, ICF% was significantly higher in winter than in summer, more obviously at older ages. Similar results were found by Khalifa *et al.* (1994). This is in accordance with Rodbard *et al.* (1951) who found that acute hyperthermia in chickens decreased volume of ICF, while hypothermia increased these fractions considerably. The addition of NaCl during summer

Table 2 . Effect of season and salt addition on chicks body fluids as % of body weight at different ages (mean ± SE).

Age (week)	Intracellular fluids			Extracellular fluids			Interstitial fluids			Plasma volume		
	Winter	Summer	Summer 1%NaCl	Winter	Summer	Summer 1%NaCl	Winter	Summer	Summer 1%NaCl	Winter	Summer	Summer 1%NaCl
4	46.56^{Aa} 0.86	33.44^{Ab} 0.83	32.68^{Ab} 0.42	27.89^{Bc} 0.15	35.28^{Cb} 0.51	38.57^{Ca} 0.39	20.90^{Bc} 0.18	29.28^{Db} 0.60	33.17^{Da} 0.50	6.99^{Aa} 0.10	5.99^{Ab} 0.26	5.46^{Ab} 0.21
5	34.03^{Ba} 0.55	25.81^{Bb} 0.68	27.44^{Bb} 0.74	30.92^{Ab} 0.46	40.89^{Ba} 0.35	40.96^{Ba} 0.38	24.83^{Ab} 0.47	35.24^{Ca} 0.28	35.79^{Ca} 0.44	6.09^{Ba} 0.17	5.64^{ABab} 0.21	$5.17^{AB b}$ 0.15
6	32.34^{Ba} 0.46	18.02^{Cc} 0.50	21.97^{Cb} 0.40	27.63^{Bc} 0.41	45.74^{Aa} 0.21	43.96^{Ab} 0.36	20.85^{Bc} 0.39	40.66^{Ba} 0.23	38.98^{Bb} 0.42	6.78^{Aa} 0.10	5.28^{Bb} 0.13	4.94^{Bc} 0.10
7	33.97^{Ba} 5.59	15.61^{Db} 0.82	13.85^{Dc} 0.24	22.16^{Cb} 0.52	45.20^{Aa} 0.40	44.86^{Aa} 0.24	16.16^{Cb} 0.56	42.76^{Aa} 0.40	42.03^{Aa} 0.25	5.99^{Ba} 0.13	2.47^{Cb} 0.13	2.65^{Cb} 0.09

^{A,B,C} Means within each trait in the same column bearing different superscripts are significantly different (p ≤ 0.05).

^{a,b,c} Means within each trait in the same raw bearing different superscripts are significantly different (p ≤ 0.05).

Table 3. Plasma proteins (g/dl) in chicks at different ages in summer and winter (mean ± SE).

Age (week)	Albumin			Globulin			Total plasma protein			A / G ratio		
	Winter	Summer	Summer 1%NaCl	Winter	Summer	Summer 1%NaCl	Winter	Summer	Summer 1%NaCl	Winter	Summer	Summer 1%NaCl
4	1.97^{Ba} 0.03	1.85^{Ab} 0.05	1.66^{Bc} 0.04	0.93^{Ca} 0.04	0.79^{Cb} 0.03	1.04^{Bc} 0.06	2.91^{Ba} 0.07	2.63^{Db} 0.4	2.70^{Cb} 0.04	2.13^{Aa} 0.07	2.38^{Aa} 0.14	1.65^{Ab} 0.15
5	1.91^{Ba} 0.04	1.74^{Ab} 0.04	1.63^{Bc} 0.02	1.09^{BCa} 0.05	0.99^{Ba} 0.05	1.07^{Ba} 0.02	3.00^{Ba} 0.09	2.72^{Cb} 0.03	2.70^{Cb} 0.04	1.78^{ABAb} 0.07	1.81^{Ba} 0.13	1.53^{Ab} 0.04
6	2.23^{Aa} 0.05	1.81^{Ab} 0.04	1.82^{Ab} 0.03	1.18^{ABa} 0.10	1.07^{Ba} 0.06	1.07^{Ba} 0.02	3.41^{Aa} 0.11	2.88^{Bb} 0.03	2.89^{Bb} 0.02	2.01^{ABa} 0.21	1.73^{Ba} 0.13	1.71^{Aa} 0.04
6	2.20^{Aa} 0.04	1.61^{Bc} 0.03	1.78^{Ab} 0.03	1.34^{Ac} 0.07	1.68^{Aa} 0.04	1.50^{Ab} 0.05	3.54^{Aa} 0.11	3.29^{Ab} 0.02	3.28^{Ab} 0.03	1.67^{Ba} 0.06	0.96^{Cc} 0.04	1.20^{Bb} 0.05

See footnote of Table 2

season had significant effect on decreasing ICF%, causing great drop from 6 to 7 weeks of age (Table 2).

Extracellular fluids (ECF) as percentage of body weight decreased significantly in winter with age except from 4 to 5 weeks of age (Table 2 and Fig. 2). On the contrary ECF% increased significantly in summer as age increased in both control and NaCl groups. It is clear that the trend of ECF% was opposite in the two seasons when birds were 5 weeks old or more. Also, the addition of NaCl to the diet in summer had slight effect on changes in ECF%. The reduction in ECF% with age in winter may be due to the increase in fat content as a result of high growth rate in adipose tissue (Fig. 3) which was previously observed by Singh and Essary (1974), Evans *et al.* (1976) and Amer (1977). The increase of ECF. % in summer may be due to the increase in water consumption (Fig. 1). The above results are in agreement with Khalifa *et al.* (1994).

Interstitial fluids % (ISF%) increased significantly in winter only from 4 to 5 weeks of age and decreased significantly after that up to 7 weeks of age (Table 2). This reduction may be due to the reduction in colloid osmotic pressure (albumin, Fig 4). This result is in agreement with those found by Khalifa *et al.* (1994). In summer the percentage of ISF significantly increased with increasing age (Table 2). Addition of NaCl in summer had slight effect on the changes in ISF% with age. The increase in ISF% with advancing age in summer was a function of water conservation mechanism to counteract the increase in evaporative cooling. The ISF% was significantly higher in summer than in winter at all ages (Table 2), the difference between seasons increased with age from about 8.4 at 4 to 26.6 % at 7 weeks of age (Fig. 2). Khalifa *et al.* (1994) found that ISF was higher in summer than winter by about 20.5 to 23%. Macfarlane *et al.* (1966) demonstrated that ISF expanded at high environmental temperature to compensate the loss in plasma volume through evaporative cooling. Addition of NaCl to the basal diet of broiler chicks in summer had slight effect on ISF%, however, it was significantly higher and lower at 4 and 6 weeks of age, respectively. It is worthnoting that the effect of season and salt addition with age on ECF are similar to that on ISF indicating that the changes in ECF were due mainly to changes in ISF.

Plasma volume% to body weight (PV%) in winter tended to decrease significantly from 4 to 5 and from 6 to 7 weeks of age indicating that these changes were due to the changes in all body fluid compartments as body weight increased with age (Table 1). The significant increase from 5 to 6 weeks may be due to the increase in the colloid osmotic pressure as plasma albumin % increased (Table 3). On the contrary in summer, slight decrease occurred in PV with advancing age with sudden drop at the 7*th* week of age. The sharp reduction of PV may be due to the reduction in colloid osmotic pressure as indicated by the decrease in plasma albumin% (Fig. 5).

The PV% was significantly lower in summer than in winter at all ages

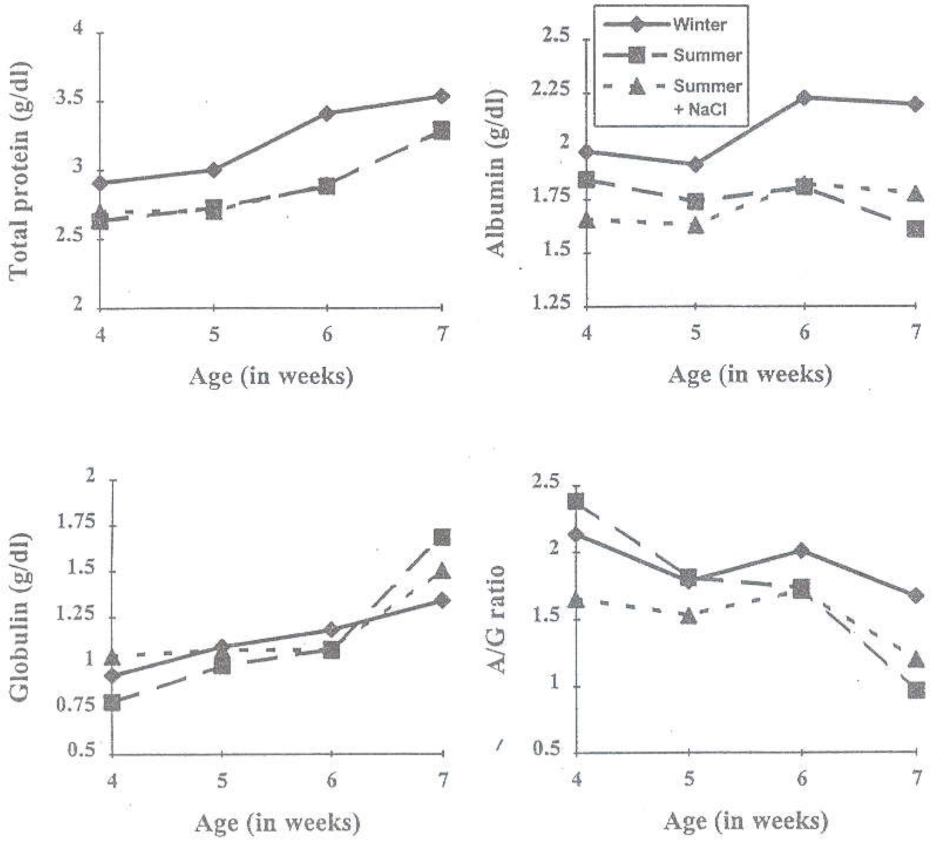


Figure 5. Effect of season and salt supplementation on plasma proteins concentrations (g/dl) at successive ages.

(Table 2). However, the effect was more pronounced at 7 week age when PV% in summer was half its value in winter. This result is consistent with Khalifa *et al.*(1994). The lower values of PV% in summer than in winter may be due to heat stress that caused reduction in plasma albumin % (Fig. 5). Adele *et al.* (1992) found that plasma albumin % of broilers were higher in winter than in summer. It is well known that approximately 80 % of plasma protein osmotic effect is due to albumin. Thus hypoalbuminaemia predisposes to the formation of increased amount of ISF and decreased PV (Forfar and Arneil, 1984). It is very important to note that addition of NaCl to broiler ration in hot season did not prevent the reduction in PV % because this reduction was due mainly to a reduction in colloid osmotic pressure.

As percentage from total body fluids, the fluid compartments had similar trends to those found when expresed as percentage from body weight (Fig. 2 and 4). This indicates that all changes in body fluid compartments with age or between seasons were due to shifts between different compartments regardless the changes in body weight.

Total plasma proteins (TPP) concentration in winter and summer (with or without NaCl) significantly increased with age (Table 3) . The TPP was significantly higher in winter than in summer even with added NaCl (Table 3 and Fig. 5). At 7 weeks of age, the significant decrease in TPP during hot season was due to a significant decrease in albumin (Al), although globulin (Gl) increased significantly causing a significant reduction in A/G ratio (Fig. 5). The reduction in Al during hot season was previously found by Adele *et al.* (1992). Addition of NaCl in summer did not alleviate the adverse effect of hot climate on plasma proteins, albumin, globulin and the value of Al./Gl. ratio.

Concequently, as age increased from six to seven weeks during summer fluids shifts from ICF and PV to ISF due to the reduction in colloid osmotic presure as indicated by almost similara trends in ISF and A/ G ratio.

It can be concluded that under hot climate body fluids shifts from ICF to ECF which increases with age as an acclimatization response against high evaporative water loss. This higher ECF in summer was due to higher ISF%, while PV% was lower in summer than in winter being severely significant at 7 weeks of age. These results revealed that when broilers raised under hot climate fluids shifts from PV and ICF to ISF may be due to a reduction in plasma colloid osmotic pressure (Figs. 2, 4 and 5).

The lower PV% in older chicken (7 weeks old) during the hot season is a very serious problem which may interrupt the general homeostasis mechanism leading to high mortality rate. Adequate PV is necessary for maintenance of normal body temperature via both; internal heat conduction between tissues and external dissipation of excess heat. Addition of NaCl did not prevent the reduction in PV% in summer indicating that it will not reduce mortality rate due to natural hot waves.

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إستجابة سوائل الجسم و بعض الصفات الفسيولوجية فى دجاج التسمين للتغير فى الظروف البيئية

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أجريت هذه الدراسة على كتاكيت تسمين أربور ـ ايكرز خلال فصل الصيف حيث كان متوسط درجة الحرارة ٣٣,٥° م ± ٣,٥° م ونسبة الرطوبة ٤٦,٥٪ ± ١١,٥٪ وكررت خلال فصل الشتاء حيث بلغ متوسط درجة الحرارة ٢٥,٥° م±٣,٥°م ونسبة الرطوبة ٥٤,٥٪ ± ٤,٥٪.

استخدم فى تجربة الصيف ٢٠٠ كتكوت تسمين عمر يوم ، قسمت عشوائياً إلى مجموعتين متساويتين. تم تغذية المجموعة الأولى على عليقة كنترول ـ وغذيت طيور المجموعة الثانية على عليقة المقارنة مضاف اليها ١ ٪ كلوريد الصوديوم . وفى الشتاء غذيت الطيور (٢٠٠) كتكوت على عليقة مماثلة لمجموعة المقارنة فى تجربة الصيف.

أخذت المقاييس الأتية على عمر ٤، ٥، ٦، ٧ أسابيع : درجة حرارة المستقيم، معدل التنفس ـ سوائل الجسم (نسبة الماء الكلى ـ نسبة السوائل الخلوية ـ السوائل خارج الخلايا ـ حجم البلازما) وبروتينات البلازما (البروتين الكلى ـ الألبيومين ـ الجلوبيولين) .

وجد أن درجة حرارة المستقيم ومعدل التنفس والنسبة المئوية للماء الكلى بالجسم أعلى فى الصيف عنه فى الشتاء. و إرتفاع درجة الحرارة فى الصيف أدى إلى انخفاض معنوى فى نسبة السوائل الخلوية وزيادة فى السوائل خارج الخلية ، انخفض حجم البلازما وبروتينات البلازما انخفاضا معنوياً فى الصيف عن الشتاء . إضافة كلوريد الصوديوم للعليقة خلال فصل الصيف حيث درجة الحرارة المحيطة المرتفعة ـ أدى إلى تحسن طفيف فى نسبة المادة الجافة والبيومين البلازما عند عمر ٧ أسابيع، ولكنه لم يحسن النقص الحادث فى حجم البلازما عند عمر ٦ و٧ أسابيع.

يمكن إستنتاج أنه بزيادة العمر من ٦ إلى ٧ أسابيع فى الصيف تنتقل السوائل من داخل الخلايا ومن بلازما الدم إلى السوائل بين الخلايا نتيجة لنقص الضغط الأسموزى لبروتينات البلازما (نقص الألبيومين ونسبة الألبيومين/ الجلوبيولين).