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Interrelationship Between Some Biochemical Constitutents of Blood Serum and Economic Egg Characters in Turkeys.

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PREVIOUS work suggested that there is a relationship between chemical constituents of blood serum and egg economic characteristics.

Twenty six hens and ten toms from each of Medium-weight Broad - breasted White studler turkeys, and native Broad-Breasted Bronze turkeys were used in this experiment.

Economic characteristics : egg production, egg weight, egg mass fertility and hatchability, and some chemical constituents of blood serum were estimated.

The results revealed that there was high and positive phenotypic correlations between calcium and all of the economic characteristics studied in both breeds.

The correlation between inorganic phosphorus and the economic characters were all positive.

Phenotypic correlations between magnisium and economic characters seemed to be similar to those calculated for serum calcium.

While correlations between serum sodium and each of the economic characters were low and positive for Bronze, they were low and negative for studler.

The negative correlations between serum potasium and each of the economic characters were higher for Bronze than for studler.

Chemical constituents of serum

Work done by Solmen (1971) showed a maximum plasma calcium level 2 hr after ovulation and a minimum level 14 hr after ovulation and during the latter half of shell calcification. Bacon et al., (1980) reported that turkey hens in reproductive pause had relatively low level of total plasma calcium in comparison to laying hens.

Greenberg et al., (1936) noted that serum inorganic phosphorus is directely correlated with increased blood calcium in laying hen. Recently, Manly et al., (1982) found that plasma phosphorus of laying turkeys was lowest at oviposition and remained relatively low until 6 hr postoviposition, The changes were assumed to be associated with egg shell calcification and bone resorption.

Solomen, (1971) showed that serum magnesium showed a maximum concentration (2·9 mg/100 ml.) two hours after ovulation, then it fell to 1 mg. /100 Ml. when the egg was in the isthmus, and there was little variation throughout the actual process of calcification. On the other hand Taylor and Hertelendy (1961) indicated that magnesium in plasma may be decreased when the hen is depositing shell on the egg.

The concentrations of sodium and potasium in plasma of 28 weeks old female turkey were 149 milliequivalents per liter and 23 mg/100 ml., respectively (kirshner et al., 1951) Sturkie (1976) reported that the quantity of sodium in the plasma greatly exceeds that of potasium, and added that the low potasium level in the plasma is fairly constant (4·5 mg/ leter).

Economic Characteristics

The average egg production per hen, artificially lighted beginning from January 15 to May 31 for Beltsville small type white, White Holland, Standard bred Bronze and Broad-Breasted Bronze were 62, 63, 76 and 59 eggs respectively. Parker (1947) and Shoffner et al., (1962) suggested that egg production decreased as seasonal temperatures increase during the breeding season.

Parker (1947) found that weight of terkeys egg increased from January to June. also, as the breeding season progressed, egg weights tended to increase (Thomason et al., 1972).

There were differences in fertility and hatchability of turkey eggs among breeds (Whitson et al., 1944) Although Clark and Sarakoon (1967) reported that fertility and hatchability in turkey eggs was affected by temperature surrounding females, Thomson et al. (1972) found that they were unaffected by the imposed temperature.

Material and Methods

This work was carried out at the poultry Research Center, Animal Production Department, Faculty of Agriculture, Cairo University.

Twenty-six hens and ten toms, 28-weeks - old, from each of Broad-Breasted White Studler turkeys, and native Broad Breasted Bronze turkeys were used in this experiment. They were chosen at random of similar body weight and restricted to about 9 hr of natural light for 4 weeks. At 32-week-old the birds were exposed abrupthy to 17 hr of light daily : 8 hr of natural light plus 9 hr of artificial light.

The experiment lasted until the hens reached 48-weeks old.

Semen was collected according to the method of Burrows and Marsden (1938) and modified by Parker (1946). Starting 21 days from the stimulatory light, the hens were inseminated deeply in the Vagina with pooled semen twice 2 days in a row with 0·05 ml. of semen and at bi-weekly intervals there after according to the method of Ferbee and Ernst (1967).

The hens were trapnested and the eggs were pedigreed. The egg weight was recorded daily to nearest gram and pedigreed eggs were incubated weelky in Funki-type incubator.

Fertility was checked visually. Hatchability was considered to be the percent poults hatched from the fertile eggs.

Blood samples were immediately collected by wing vein puncture using a syringe at 4 weeks intervals from 28 to 48 weeks of age. Blood samples of 7 to 8 ml. were centrifuged at 3000 rpm for 15 min. Sera were separated and stored at - 20°C. until the time of chemical determinations. Serum total calcium, magnesium, sodium and potassuim were assayed using a PYE Unicam atomic absorption spectro-photometer, according to A.0.A.C. (1975).

The levels of serum inorganic phosphorus were measured by the method of Fiske and Subbarow as described by (0ser, B.L., ed. 1965).

Statistical analysis was carried out according to Steel and Torrie (1960). The separation of means was applied according to Duncan (1955) and the phenotypic correlations between chemical constituents of serium between economic characteristics and between the two were computed.

Results and Discussion

Chemical Constituents of Surum

1. *Calcium*

The overall average of surum calcium in Bronze was higher (22.69 mg./100 ml.) than that in studler (20.45 mg/100 ml) (Table 1). The differences between breeds were significant (Table 2).

These results agree with those reported by Rhian et al., (1944). They found that turkey hens had a mean plasma calcium of 25.2 with a range of 12 to 28 gm/100 ml. during the laying period. A mean of 27.6 and a range of 13 to 38 mg/100 ml. were reported by Paulsen *et al.*, (1950) for turkey hens in the same reproductive state.

In both breeds, the total calcium increased enormously from 28 weeks up to the maximum value at 40 - 44 weeks of age (Table 1). The differences in surum calcium due to age were significant (Table 2).

The literature contains several reports about the quantity of calcium present in blood during reproductive cycle. It was early realized that the actively ovulating female bird had a double or thrice calcium level to that observed in sexually immature female (Urist *et al.*, 1960. The elevation accompanying the laying state is considered to be controlled by the endogenous estrogens which stimulate the appearance of phosphoproteins in the serum with a high calcium-binding capacity (Urist et al., 1958, and Winget and Smith, 1959).

TABLE 1. Average serum calcium and inorganic phosphorus for Bronze (B) and Studler (S) during the different periods.

Period (week)	Calcium (mg/100 ml)		Inorganic Phosphorus (mg/100 ml)	
	B	S	B	S
28—32	7.77[c]	10.28[c]	5.59[b]	6.14[b]
32—36	21.78[b]	20.20[b]	5.37[bcd]	5.69[bcd]
36—40	23.23[b]	20.53[b]	6.98[a]	7.21[a]
40—44	30.29[a]	25.02[a]	5.53[bc]	5.80[bcd]
44—48	30.36[a]	26.20[a]	5.34[bcd]	5.84[bc]

* Values in the same column followed by the same letter are not significantly different ($P < 0.05$) from each other.

TABLE 2. Analysis of variance of serum calcium, inorganic phosphorus, magnesium, sodium and potassium for Bronze and Studler during the experimental period.

Items	S.V.	d.f.	S.S.	M.S.
Calcium	Bet. breeds	1	325.48	325.48*
	Bet. ages	4	12468.84	3117.21*
	Error	254	11538.56	45.43
Inorganic phosphorus	Bet. breeds	1	9.19	9.19*
	Bet. ages	4	88.17	22.04*
	Error	254	463.58	1.83
Vagnesium	Bet. breeds	1	1.21	1.21Ns
	Bet. ages	4	126.35	31.59*
	Error	254	90.61	0.36
Sodium	Bet. breeds	1	6916.41	6916.41*
	Bet. ages	4	143282.01	35820.50*
	Error	254	49722.39	195.76
Potassium	Bet. breeds	1	564.48	564.48*
	Bet. ages	4	10068.67	2517.17*
	Error	254	4599.23	18.11

NS = Not significant * = Significant ($P < 0.05$)

Vanstone et al., (1955). Mclndoe (1959); Heald and Badmen (1963) and Redshaw and Follett (1972) demonstrated that a few days before the onset of laying, plasma calcium increased markedly in maturing pullets. Common et et al., (1965) and Mathur et al., (1966) reported that estrone level in the urine of domestic fowl reached a peak a few days before sexual maturity. Senior (1974) found plasma estradiol to be elevated before the onset of laying.

At sexual maturity the female chicken showed a great increase in blood calcium (Ghany et al., 1961). In accordance with Greenberg et al., (1936) and Common et al., (1948), this may be due to the increase in estrogen escretion at the onset of ovulation which increased the retention of dietary calcium.

The egg laying capacity is greatly related to the blood constituents. During egg formation, large quantities of calcium are deposited as carbonate on the developing shell. The site of shell formation, the oviduct shell gland, is not a calcium storage organ, consequently calcium must be mobilized repidly from body stores to meet the periodic requirements of shell formation. Charles and Hoghen (1933) found that plasma calcium concentration during egg formation was about 20 percent higher than during non-laying periods.

Egg formation is a complex process inovlving many organs and under elaborate endocrine control (Sturkie,1954), and it is quite likely that the dynamics of the calcium metabolism of laying hen are regulated by some process more general than shell formation.

2. *Inorganic Phosphous*

In general, the overall average of inorganic phosphorus in serum of Bronze and Studler were 5·76 and 6·14 mg/ 100 ml, respectively (Table 1). The differences due to breed were significant (Table 2). These results agree with those reported by Paulsen et al., (1950) who found that the inorganic phosphorus concentration in the serum of turkey hens to be ranged between 5·4 and 7·09 mg/ 100 ml. Plasma inorganic phosphorus in individual laying hens can vary between 2 and 12 mg / 100 ml. (Sturkie, 1965).

The inorganic phosphorus in serum of Bronze and studler slightly decreased from 28 weeks to 36 weeks of age, after that increased markedly, reaching a maximum value at 36-40 weeks of age in March (Peak of production). afterwards a marked decrease was observed up to 44 weeks of age followed by a slight decrease (Table 1). The differences due to age were significant (Table 2).

These results agree with Hunt et al., (1964) Who found that plasma inorganic phosphorus level at the onset of egg production in female geese began to rise reaching a maximum about the time of maximum egg production. Thereafter the level in female plasma declined as egg production decreased.Halman (1925) pointed out that egg production is associated with increased phosphorus catabolism and that during egg production the phosphorus lost from the body is much greater than contained in the egg laid.

In turkey hens, plasma total phosphorus increased during the two weeks prior the first egg (Bacon et al., 1980). This increase was associated with the protein and phospholipid fractions. Greenherg et al., (1936) noted that serum inorganic phosphorus is directly correlated with increased blood calcium in laying hen.

3. *Magnesium*

Serum magnesium in Bronze was lower (3.38 mg/ 100 ml) than that in studler (3.52mg/ 100 ml.) (Table 3). The differences due to breed were not significant (Table 2).

In Bronze and Studler serum magnesium increased markedly as age increased reaching a maximum value at 36-40 weeks of age in march (Peak of production), There after it decreased gradually with the advance of age (Table 3). The differences in magnesium concentration levels were significant among different ages under consideration (Table 2).

Part of the magnesium, like calcium is non-difusable and is presumably found to protein, the amounts are also pH-dependent. Few determinations had been made on avian blood, but the work of Taylor and Hertelendy (1961) indicates that both fractions of magnesium may be decreased when the hen is depositing shell on the egg.

TABLE 3. Average serum magnesium, sodium and potassium for Brozne (B) and Studler (S) during the different periods.

Period (week)	Magnesium (mg/100 ml)		Sodium (meq/1000 ml)		Potassium (mg/100 ml)	
	B	S	B	S	B	S
28—32	2.97^{d}	3.04^{d}	155.9^{c}	170.4^{a}	16.11^{b}	20.87^{b}
32—36	3.22^{bcd}	3.32^{bcd}	176.8^{ab}	174.4^{a}	21.11^{a}	26.35^{a}
36—40	3.95^{a}	4.27^{a}	181.3^{a}	150.5^{b}	11.72^{c}	18.71^{b}
40—44	3.37^{bc}	3.48^{b}	178.5^{ab}	152.8^{b}	8.52^{d}	8.31^{c}
44—48	3.40^{b}	3.48^{bc}	113.4^{d}	106.3^{c}	8.11^{d}	6.07^{c}

* Values in the same column followed by the same letter are not significantly different ($P < 0.05$) from each other.

4. *Sodium*

The overall averages of serum sodium was higher in Bronze (161·2 meq/ 1000 ml.) than that in studler (150·9 meq/ 1000 ml. Table 3). The differences in serum sodium between the two breeds were significant (Table 2).

In Bronze, serum sodium increased markedly from 28 to 36 weeks of age followed by an almost constant level up to 44 weeks of age. A steeper decrease was observed thereafter, reaching a minimum value at 44-48 weeks of age (Table 3).In studler, serum sodium slightly increased from 28 until 36 weeks of age, and decreased gradually after wards (Table 3). Differences in serum sodium due to age were significant (Table 2).

5. *Potassium*

Bronze turkey hens had lower overall serum potassium average than that of Studler ones (16·06 VS 13·11 mg/ 100 ml) (Table 3). The differences due to breed were significant (Table 2).

In both breeds, potassium increased markedly from 28 weeks of age, reaching a maxium value at 32-36 weeks, then a great decrease was observed (Table 3) The differences due to age were significant (Table 2).

These results indicate that the quantity of sodium in serum greatly exceeds that of potassium.

Economic Characteristics

1. *Egg Number*

Table 1 showes that the egg number in Bronze was higher than that in Studler. The differences in egg number due to breed were significant (Table 4) Asmundson (1938) reported that a complex of characters affecting egg production in turkeys were probably influenced by a number of genes just as chickens. Whitson *et al.*, (1944). reported that the average egg production per hen throughout the period from 15 th january to 31 st of May were 62, 63, 76 and 59 eggs for Beltesville Small-type, white Holland, standardbred Bronze and Broad-Brested Bronze, respectively.

The egg number increased enormously as age increased, reaching a maximum value at 40 weeks of age in March, and decreased gradually thereafter with the advance of age in both breeds (Table 5). The differences in egg number due to age were significant (Table 4).

These results may clarify that egg production decreases as seasonal temperature increases during the breeding season. Similar results were observed by Parker (1947) and Shoffner *et al.*, (1962).

TABLE 4. Analysis of variance of egg number (per hen) egg weight, egg mass (per hen), fertility and hatchability for Bronze and Studler during the experimental period.

Items	S.V.	d.f.	S.S.	M.S.
Egg number	Bet. Breeds	1	1492.35	1492.35*
	Bet. ages	3	2744.75	914.92*
	Error	203	166.33	0.82
Egg weight	Bet. Breeds	1	20.74	20.74^{Ns}
	Bet. ages	3	498.83	166.28*
	Error	203	10959.40	54.00
Egg mass	Bet. Breeds	1	878670.01	878670.01*
	Bet. ages	3	8607712.38	2869237.40*
	Error	203	5906693.10	29097.01
Fertility	Bet. Breeds	1	3316.81	3316.81*
	Bet. ages	3	680.93	226.98^{Ns}
	Error	203	67782.10	333.91
Hatchability	Bet. Breeds	1	91.64	91.64^{Ns}
	Bet. Aget	3	10499.34	3499.78*
	Error	203	90443.30	445.53

NS = Not significant
* = Significant ($P < 0.05$)

TABLE 5. Average egg number (per hen), egg weight and egg mass (psr hen) for Bronze (B) and Studler (S) during the different periods.

Period (week)	Egg number		Egg weight (mg)		Egg mass (gm)	
	B	S	B	S	B	S
32—36	6.15^{c}	2.70^{d}	69.5^{c}	72.1^{abc}	446.3^{b}	200.1^{d}
36—40	11.65^{a}	10.60^{a}	74.6^{a}	75.0^{a}	869.1^{a}	792.6^{a}
40—44	10.65^{b}	8.85^{b}	74.5^{ab}	74.5^{ab}	793.7^{a}	658.5^{b}
44—48	6.61^{c}	5.81^{c}	73.57^{ab}	73.2^{abc}	487.1^{b}	424.9^{c}

* Values in the same column followed by the same letter are not significantly different ($P < 0.05$) from each other.

2. **Egg Weight**

In general, the egg weight in Bronze was lower than that in Studler (Table 5). though differences were not significant (Table 4).

The egg weight increased as age increased , reaching the peak at 40 weeks of age in March (Table 5). and decreased slightly after wards in the two breeds. Age exerted a signficant effect on egg weight of turkey (Table 4). These results indicate that egg weight tended to increase as the breeding season progressed. The similar results were obtained by Thomason *et al.* (1972).

3. **Egg Moss**

The results given in Table (5) indicates that egg mass was higher in Bronze than in studler. The differences in egg mass due to breed were significant (Table 4).

With respect to age, egg mass in both breeds followed egg number pattern, it was increased as age increased, reaching a maximum value at 40 weeks of age in March and decreased gradually thereafter (Table 5) Differences in egg mass due to age were statistically significant (Table 4).

4. **Fertility**

For Bronze hens the overall average fertile aggs was higher than that of studler ones (Table 6). Statistical differences between breeds were significant (Table 3) Earlier information in turkeys by Whitson *et al.*, (1944). reported that percentage fertility of eggs were 92·8, 96·8, 94·5 and 81·5 for Beltsville Small-type White , White Holland , Standerber Bronze , and Brood-Breasted Bronze respectively.

In Bronze, the egg fertility increased gradually as age increased, reaching a maximum value at 40 weeks of age, and decreased slightly after wards Table 6). In Studler, the egg fertility slightly increased from the 32 nd. week up to the 44th one, and decreased slightly after wards (Table 6). The differences among ages were statistically not significant (Table 4).

In this study, the seasonal variation in egg fertility of turkey hens indicate generally that, the highest fertility was achieved during the late winter and early spring and declined as weather becames warmer. The work of Heywang (1944) indicated that high temperatures are, at least in part, responsible for the summer decline in fertility. Parker (1947) ascribed the decrease in fertility under high ambient temperature, to changes in the physiological activity of the male reproductive system.

5. *Hatchability*

Generally, the egg hatchability in Bronze was higher than that in Studler (Table 6). Differences in hatchability due to breed were not significant (Table 4 . Wilson and johnson (1946) reported that hatchability is inherited in turkeys is much the same manner as in chickens. Initial results in turkeys by Whitson *et al.*, (1944) reported that percentage hatchability of fertile eggs per hen given artificial lighting from january 15 to May 31 were 78·0, 71·0, 73·4 and 48·8 for Beltsville Small-type White, White Holland, Standardbred Bronze and Broad - Breasted Bronze respectively.

In Both breeds, the egg hatchability slightly increased as age increased, reaching the peak at 44 weeks of age in April, then followed by a rapid decrease (Table 6) The differences in hatchability among ages were significant (Table 4).

These results indicate that hatchability tended to decrease rather rapidly as the breeding season progressed and this findings is in agreement with that of Parker (1947)., and McCartney (1951) who suggested that hatchability of fertile eggs increased to late Febreuary followed by a decline as the breeding season progressed.

TABLE 6. Average percentage fertility and hatchability of eggs for Bronze (B) and Studler (S) during the different periods.

Period (week)	Fertility (%)		Hatchability (%)	
	B	S	B	S
32—36	69.4[abc]	56.2[abc]	61.1[ab]	56.2[ab]
36—40	77.2[a]	60.2[abc]	55.6[abc]	60.2[ab]
40—44	74.0[ab]	64.7[a]	67.6[a]	71.7[a]
44—48	66.5[abc]	57.7[ab]	48.5[bc]	37.2[c]

* Values in the same column followed by the same letter are not significantly different ($P < 0.05$) from each other.

Phenotypic Correlations

Chemical Constituents of Serum

Calcium. For both breeds, there were negative phenotypic correlations between serum calcium and each of serum inorganic phosphorus, serum sodium and serum potassium (Table 7). The magnitude of the correlations were lower for Bronze than for studler. The correlations between serum calcium and serum magnesium were positive though higher for Bronze than for studler.

TABLE 7 **Phenotypic correlations between serum calcium, inorganic phosphorus, magnesium, sodium and potassium for Bronze (B) and Studler (S) poults.**

Items	Breed	Calcium	Inorganic phosphorus	Magnesium	Sodium	Potassium
Calcium	B		—0.0572	0.6070	—0.1514	—0.6176
	S		—0.1970	0.3991	—0.6660	—0.6678
Inorganic phosphorus	B			0.7429	0.4504	—0.1432
	S			0.8057	0.0257	0.1790
Magdesium	B				0.2305	—0.4253
	S				—0.2558	—0.1062
Sodium	B					0.3830
	S					0.8226
Potassium	B					
	S					

Inorganic phosphorus. Phenotypic correlations of serum inorganic phosphorus with each of the other blood constituents studied were positive, except that calculated with potassium in Bronze poults (Table 7) The correlations between serum inorganic phosphorus and each of sodium and potassium of serum were mostly low

Magnesium. Except the correlation between serum magnesium and serum sodium in Bronze poults, low and negative correlations were calculated between serum magnesium and each of sodium and potassium in both Bronze and Studler poults (Table 7).

Sodium. The phenotypic correlation between serum sodium and potassium was higher in studler than in Bronze though the two correlations were positive (Table 7).

Economic Characteristics

From Table 8 it is clear that. a: for both breeds, correlations between egg number and each of egg mass, egg weight and fertility were high and positive. However, correlations with hatchability were low. b: Correlations between egg weight and each of egg mass, fertility and hatchability were positive in the two breeds, while correlation with hatchability was negative for studler. C: The correlations between egg mass and other characteristics seemed to be similar to those calculated for egg number . d: Correlations between fertility and hatchability were positive, and the magnitude was lower for Bronze than that for studler.

TABLE 8. Phenotypic correlations between egg number (per hen), egg weight, egg mass (per hen), fertility and hatchability for Bronze (B) and Studler (S) poults.

Items	Breed	Egg No.	Egg weight	Egg mass	Fertility lity	Hatch-ability
Egg number	B		0.7456	0.9999	0.9400	0.3464
	S		0.9983	0.9999	0.7338	0.4389
Egg weight	B			0.7529	0.4824	—0.1189
	S			0.9984	0.7702	0.4794
Egg mass	B				0.9393	0.3407
	S				0.7335	0.4486
Fertility	B					0.4412
	S					0.7341
Hatchability	B					
	S					

TABLE 9. Phenotypic correlations between serum chemical constituents and economic characters for Bronze (B) and Studler (S) poults.

Items	Breed	Egg number	Egg weight	Egg mass	Fertility	Hatcha-bility
Calcium	B	0.7797	0.9185	0.7751	0.8812	0.8657
	S	0.6805	0.9068	0.6729	0.9175	0.7566
Inorganic Phosphorus	B	0.5137	0.1688	0.5208	0.2421	0.1026
	S	0.5071	0.0206	0.5136	0.0115	0.0641
Magnesium	B	0.8964	0.7714	0.8970	0.8025	0.6710
	S	0.8666	0.6054	0.8691	0.5997	0.5842
Sodium	B	0.3786	0.0951	0.3800	0.2007	0.3010
	S	—0.3887	—0.4073	—0.3785	—0.3950	—0.0730
Potassium	B	—0.4843	—0.3599	—0.4922	—0.3166	—0.2397
	S	—0.4741	—0.3248	—0.4656	—0.3680	—0.1966

Phenotypic correlations between chemical constituents of serum and Economic characteristics

From Table 9 it is clear that:

Calcium: for both breeds , there were high and positive phenotypic correlations between calcium and all the economic characters studied.

Inorganic - Phosphorus: The phenotypic correlations between inorganic phosphorus and the economic characters studied were all positive. The magnitude was higher for Bronze than for studler.

Magnesium: The correlations between serum magnesium and each of the economic characters seemed to be similar to those calculated for serum calcium.

Sodium: Correlations between serum sodium and each of the economic characters studied were low and positive for Bronze , and they were also low but negative for studler.

Potassium: The correlations between serum potassuim and each of the economic characters studied though were higher for Bronze than for studler, they were all negative.

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العلاقة بين المكونات الكيميائية لسيرم الدم والخواص الاقتصادية للبيض فى الدجاج الرومى

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استخدم فى هذه الدراسة ستة وعشرون دجاجة ، وعشرة ديوك رومى من كل من نوعى ستودلر والبرونز .

وقد قدر كل من انتاج البيض ووزن البيضة ، وكتلة البيض ، ونسبة الخصوبة ، ونسبة الفقس ، وكذلك قدرات تركيزات بعض مكونات سيرم الدم الكيميائية .

وقد دلت النتائج على وجود ارتباطات موجبة عالية بين تركيز الكالسيوم فى الدم وكل من صفات البيض الاقتصادية فى كل من النوعين .

وكانت العلاقة موجبة بين تركيز الفوسفور غير العضوى وكل الصفات الاقتصادية للبيض .

وقد اتضح من التجربة أن العلاقة بين الماغنسيوم فى سيرم الدم وكل الصفات الاقتصادية كانت متشابهة لتلك العلاقة الموجودة بين الكالسيوم والصفات الاقتصادية .

وبينما كانت العلاقة بين الصوديوم وكل من الصفات الاقتصادية موجبة ومنخفضة فى نوع البرونز فقد كانت سالبة فى نوع ستودلر .

وكانت العلاقة السالبة بين البوتاسيوم والصفات الاقتصادية مرتفعة فى نوع البرونز فقد كانت منخفضة فى نوع ستودلر .