RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

4.1. Average body weight:

Data presented in table (3) showed the averages of body weight at hatch; 12 week; at sexual maturity and at the end of the experimental period for Hisex and Shaver pullets fed on different dietary calcium and vitamin D_3 levels.

From the results obtained, it could be observed that Shaver pullets showed the highest body weight averages at all periods of estimation while Hisex pullets had lowest averages. The genetic difference of the Shaver hybrid may be the main reason for its superiority in body weight over Hisex.

Analysis of variance for data obtained (ANOVA table 4) revealed a highly significant effect ($P<0.001$) due to the pullets hybrid on the average body weight at all periods of estimation. These results agree with the findings of El-Gendi (1985) who found that breed of pullets affect body weight.

Average of live body weights at the end of the 12^{th} week of was found to be 610.7; 561.5 and 546.4 g for pullets received 0.80, 122 and 1.61% calcium during the growing period and 3.5%, 4.5% and 5.5% calcium in the diets during the laying period, respectively. The statistical analysis of body weight at the end of the 12^{th} week of age indicate that differences in this trait among the experimental groups were highly ($P<0.001$) significant (ANOVA table 4). As presented in Table (3), averages of live body weights for the same experimental groups mentioned above were found to be 1154.1; 1029.3 and 991.4 g at sexual maturity and 1294; 1151.5 and 1116.5 g at the end of the experimental period, respectively. Analysis of variance (ANOVA table 4) revealed highly significant differences in live body weight due to dietary calcium level at 12 week, at sexual maturity and at the end of the experimental period.

In general, results presented in table (3) show that increasing dietary calcium level decreased live body weights during the growing and laying periods. These results are in accordance with the findings of Rogler and Parker (1972); Muir et al., (1975) and Keshavarz (1986).

Results presented in table (3) revealed that averages of live body weight of Hisex and Shaver growing chicks at 12 weeks of age were found to be 567.8; 558.0 and 592.8 g for pullets receiving 800, 1200 and 1600 IU vitamin D, respectively. The corresponding values at the end of the experiment were 1173.0; 1188.6 and 1200.3 g, respectively. This result indicate that body weight increase by increasing dietary vitamin D_3 level. Analysis of variance for data obtained (ANOVA table 4) revealed a highly significant effect ($P<0.001$) due to dietary vitamin D on the average body weight at the 12^{th} week of age only.

The interaction between hybrid by calcium at all periods of estimation, hybrid by vitamin D at the 12^{th} week and at the end of experimental period and between calcium by vitamin D_3 at the end of experimental period had significant effects on average body weight.

4.2. Age at sexual maturity:

Data concerning the effect of pullet's hybrid, dietary calcium and vitamin D_3 levels on age at sexual maturity are presented in Table (5). Inspection of data revealed that, inspite of the effect of dietary calcium and vitamin D_3 level, Shaver pullets had the highest average of age at sexual maturity (167.3 days) followed by Hisex pullets (162.5 days).

Table (3): Least square means and standard error for averages of live weight for Hisex and Shaver pullets as affected by dietary calcium and vitamin D_3 levels.

Item	Age in weeks			
	At hatch	12 week	At sexual maturity	At the end of experiment
Hybrid				
Hisex	38.5±0.1 a	511.0±5.9 a	989.2±9.7 a	1100.9±8.6 a
Shaver	37.5±0.1 a	634.7±5.8 b	1127.3±9.7 b	1273.7±8.6 b
Calcium				
3.5%	38.0±0.1 a	610.7±7.2 a	1154.1±11.9 a	1294.0±10.2 a
4.5%	37.9±0.1 a	561.5±7.2 b	1029.3±11.9 b	1151.5±10.6 b
5.5%	37.9±0.1 a	546.4±7.2 b	991.4±11.9 c	1116.5±10.8 b
Vitamin D_3				
800 I.U	38.0±0.1 a	567.8±7.2 a	1075.2±11.9 a	1173.0±10.2 a
1200 I.U	37.9±0.1 a	558.0±7.2 a	1041.3±11.9 a	1188.6±10.4 a
1600 I.U	37.8±0.1 a	592.8±7.2 b	1058.3±11.9 a	1200.3±10.9 a

+ Means with the same letters in each column are not significantly different.

Table (4) Analysis of variance for data presented in table (3).

S.O.V.	d.f	F-ratio			
		At hatch	12 week	At sexual maturity	At the end of experiment
Hybrid (B)	1	17.883	218.442***	99.608***	200.996***
Calcium (C)	2	3.774	21.526***	50.429***	81.222***
Vitamin D (V)	2	3.014	6.131**	1.998	1.673
B × C	2	1.916	7.302***	7.640***	19.018***
B × V	2	1.224	4.151*	2.697	24.463***
C × V	2	3.934	1.837	1.9333	6.342***
Remainder df	461				
Remainder MS		6.893	9034.863	8625.714	13692.290

* P<0.05 ** P<0.01 *** P<0.001

Analysis of variance for data obtained showed significant effect ($P<0.001$) due to pullet's hybrid on the average of age at sexual maturity (ANOVA table 6). Variation in average age at sexual maturity due to pullet's hybrid may be attributed to the variation in the rate of growth between different breeds which is closely related to the metabolic rate in general and the efficiency of the growth hormone activity which affects the date at which the long bones were closed. This stage is characterized by the lowering growth and the start of sexual activity of a given pullet. This result agree with the findings of El-Gendi (1985) and El-Sayed (1995).

Dietary calcium level was found to have a significant ($P<0.001$) effect on age at sexual maturity of pullets of different hybrid applied (ANOVA table 6). Pullets received 0.80% and 3.5% calcium level in diet during the growing and laying period, respectively had the lowest age at sexual maturity (161.1 days), followed by those fed 1.2 and 4.5% calcium (165.4 days), then by those fed 1.6 and 5.5% calcium (168.2 days) during the growing and laying period, respectively. From the results obtained it could be stated that age at sexual maturity increased as dietary calcium level increased.

The variation in average age at sexual maturity due to dietary calcium level may be attributed to the role of calcium in bone formation which in term is reflected as acceleration or retardation of growth rate and correspondingly to the age at which the pullets reached maturity.

Age at sexual maturity was found to be significantly affected by dietary vitamin D_3 level (ANOVA Table 6). Pullets fed diet containing 1200 I.U/kg vitamin D_3 had the lowest averages of age at sexual maturity (163.9 days), Table (5): Least -square means and standard error for age at sexual maturity in experimental birds as affected by studied factors.

Item	Age at sexual maturity (days)
Hybrid	
Hisex	162.5±0.2 a
Shaver	167.3±0.2 b
Calcium	
3.5%	161.1±0.3 a
4.5%	165.4±0.3 b
5.5%	168.2±0.3 c
Vitamin D_3	
800 I.U.	165.0±0.3 ab
1200 I.U.	163.9±0.3 a
1600 I.U.	165.9±0.3 b

+ Means with the same letters in each column are not significantly different.

Table (6): Analysis of variance for data presented in table (5).

S.O.V.	d.f	F-ratio
Hybrid	1	145.717***
Calcium (C)	2	111.690***
Vitamin D (V)	2	8.723***
B × C	2	6.954***
B × V	2	7.670***
C × V	4	30.139***
Remainder d.f	165	
Remainder MS		26.918

* P<0.05 ** P<0.01 *** P<0.001

followed by those fed 800 I.U. vitamin D_3 (165.0 days) then by those fed 1600 I.U/kg (165.9 days).

The interaction effects between all factors studied were highly significant ($P<0.001$) (ANOVA table 6). The effect of each pullets hybrid, dietary calcium and vit. D_3 on age at sexual maturity seems to be dependent on the effect of each other.

4.3. Feed consumption:

Averages of feed consumption during the laying period in grams per day for experimental groups of Hisex and Shaver pullets were listed in (table 7).

Regardless of the effect of dietary calcium or vitamin D_3 levels, Shaver pullets showed the highest averages of feed consumption throughout the experimental laying period (103.6 g/hen/day) when compared with pullets of Hisex (99.4 g/hen/day). Analysis of variance revealed significant differences ($P<0.05$) in the amount of feed consumed per pullet due to pullets hybrid. These results agreement with those reported by Moran et al., (1970); Davidson and Boyne (1970); Hulan and Nikolaizuk (1971); Ousterhout (1981); El-Gendi (1985) and Scheideler and Robeson (1997) who reported that, strain of pullets had a profound effect on feed consumption.

The significant variation in feed consumption found due to the pullets hybrid may be attributed to the difference existing in the rate of metabolism which is stated to be a function of bird's breed and reflected as variation in amount of feed consumed.

Dietary calcium level had highly significant effect ($P<0.001$) on feed consumption. Averages of feed consumption were found to be 107.5; 97.8

and 96.3 g/hen/day for pullets fed diets containing 3.5; 4.5 and 5.5% calcium, respectively. These results agree with the findings of Hurwitz et al., (1969); Hull and Scott (1969); Roland et al., (1985); Attia (1993); Abou Egla (1995) and Cantor et al., (1997) who reported that as percent of dietary calcium decreased, feed consumption increased.

Dietary vitamin D_3 level seemed to have insignificant effect on average feed consumption it was found to be 101.7; 100.4 and 99.5 g/hen/day for pullets received 800; 1200 and 1600 I.U./kg diet, respectively. These result disagreement with the findings of Aburto and Britton (1996) who stated that feed consumption increased as the level of vitamin D_3 increased.

Results obtained from Fig. (1) showed that averages of feed consumption per hen per day increased consistently after sexual maturity reaching its maximum value (106.9 g) at the 18th week after sexual maturity, then it decreased towards the end of the experimental period. This was quite true in pullets of two breeds and experimental groups.

The interaction effects between various factors studied showed significant effects (ANOVA table, 8) on feed consumption except the interaction between experimental period and either dietary calcium or vitamin D_3 levels which showed insignificant effect on feed consumption averages.

Table (7): Least square means and standard error for averages of feed consumption (g/hen/day) for Hisex and Shaver pullets.

Item	Average feed consumption (g/hen/day)
Hybrid	
Hisex	99.4±1.3 a
Shaver	103.6±1.3 b
Calcium	
3.5%	107.5±1.6 a
4.5%	97.8±1.6 b
5.5%	96.3±1.6 b
Vitamin D3	
800 I.U	101.7±1.6 a
1200 I.U	100.4±1.6 a
1600 I.U	99.5±1.6 a

+ Means with the same letters in each column are not significantly different.

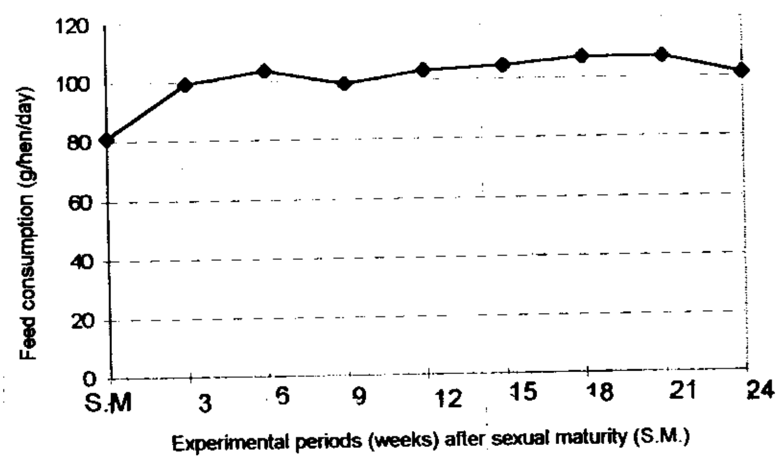

Fig (1): Effect of experimental periods on averages of feed consumption (g/hen/day)

Table (8): Analysis of variance for data presented in table (7).

S.O.V.	d.f.	F-ratio
Hybrid (B)	1	3.950*
Calcium (C)	2	40.286***
Vitamin D (V)	2	1.325
Period (P)	8	22.521***
B × C	2	8.223***
B × V	2	9.418***
B × P	8	4.569***
C × V	4	2.560*
C × P	16	1.301
V × P	16	0.752
Remainder d.f	1558	
Remainder MS		1408.454

* P<0.05   ** P<0.01   *** P<0.001

4.4. Feed conversion:

Least square means for feed conversion (kg ration/kg eggs) as affected by pullet's hybrid, dietary calcium and vitamin D levels and experimental intervals are showed in table (9).

Regardless the effects of either dietary calcium or vitamin D_3 level, Hisex pullets had the better feed conversion (2.83 kg ration/kg eggs) when compared with Shaver pullets (3.00 kg ration/kg eggs). This may be attributed to the variation in either feed consumption and rate of egg production existed between pullets of different hybrids. Analysis of variance showed insignificant effect due to pullet's breed on the average feed conversion (ANOVA table 10). These results disagree with the findings of Ousterhout (1981); Singh and Nordskog (1982) and El-Gendi (1985).

Dietary calcium level showed insignificant effect on feed conversion (ANOVA table 10). Pullets fed 3.5, 4.5 and 5.5% calcium consumed 2.74, 2.85 and 3.13 (kg ration/kg eggs), respectively. These results agree with the findings of Wilkinson (1961); Macntyre et al., (1964); Scholtyzssek (1964); Hurwitz and Bar (1966); Torteuro and Centeno (1973); Muir et al., (1975); Summers et al., (1976); Hamilton and Cipoera (1981) and Lenard and Roland (1981) who reported that dietary calcium level had no effect on feed intake and efficiency.

Regardless the effect of pullet's hybrid and dietary calcium level, the grand means of feed conversion for pullets fed 800, 1200 or 1600 I.U/kg diet vitamin D_3 were 2.70 ; 2.93 and 2.99 (kg feed/kg eggs) respectively. These differences were of significant value ($P<0.05$) (ANOVA table 10). Results obtained disagree with the findings of Atteh and Leeson (1983) who found that, increasing the vitamin D_3 content in the diet significantly improved feed efficiency.

Experimental intervals showed highly significant effect ($P<0.001$) on average feed conversion. Results obtained showed that average of feed conversion improved consistently after sexual maturity reaching its maximum value (2.10 kg feed/kg eggs) at the 18th week, (Fig 2).

The interaction effects between experimental intervals and either calcium or vitamin D levels was significant.

Table (9): Least square means and standard error for averages of feed conversion (kg ration/kg eggs) for experimental groups of Hisex and Shaver pullets.

Item	Feed conversion (kg ration/kg eggs)
Hybrid	
Hisex	2.83±0.16 a
Shaver	3.00±0.16 a
Calcium	
3.5%	2.74±0.20 a
4.5%	2.85±0.20 a
5.5%	3.13±0.20 a
Vitamin D3	
800 I.U.	2.70±0.20 a
1200 I.U.	2.93±0.20 ab
1600 I.U.	2.99±0.20 b

+ Means with the same letters in each column are not significantly different.

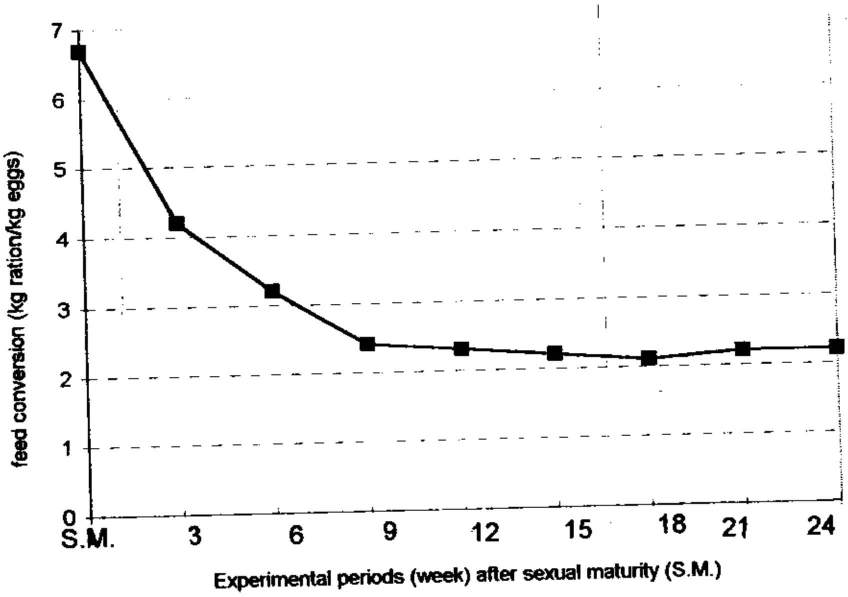

Fig (2) : Effect of experimental periods on average feed conversion (kg ration/kg eggs)

Table (10): Analysis of variance for data presented in table (9).

S.O.V.	d.f.	F-ratio
Hybrid (B)	1	0.041
Calcium (C)	2	0.174
Vitamin D (V)	2	2.767*
Period (I)	8	30.469***
B × C	2	2.020
B × V	2	0.040
B × I	8	0.362
C × V	4	0.595
C × I	16	2.506***
V × I	16	1.741*
Remainder d.f	1558	
Remainder MS	23.296	

* P<0.05 ** P<0.01 *** P<0.001

4.5. Rate of egg production:

Table (11) shows the effect of hybrid, dietary calcium and vitamin D_3 levels on egg production laid per hen per day.

From results obtained it could be concluded that Hisex pullets showed the highest egg production rate per pullet at all periods of estimation (62.23% hen/day) while Shaver pullets had the lowest rate (61.06%/ hen/day). Variation in the egg production due to the pullet's breed may be attributed to the genetic capacity characterized by each breed for egg production (El-Sayed, 1995). Rate of egg production was significant (P<0.01) different among the two hybrids at all experimental intervals. These results agree with the findings of Abd El-

Gawad and El-Ibiary (1971); Mohmoud et al., (1974); El-Labban (1977); El-Gendi (1985) and El-Sayed (1995) they found that pullet's breed has a remarkable effect on the rate of egg production.

Dietary calcium level showed highly significant effect ($P<0.001$) on egg production rate (ANOVA table 12). Rate of egg production per hen per day was 69.70; 60.87 and 54.38%/hen/day for pullets received diets containing 3.5; 4.5 and 5.5% calcium, respectively. The significant effect of dietary calcium level on egg production may be attributed to the difference existed in the rate of calcium absorption through the intestine and thus to its level in blood serum and in the uterine glands. These results agreed with those obtained by Wu and Vesonder (1997) who found that egg production of hens fed the low calcium diets was greater than that of hens fed the high calcium diets. On the other hand, Roland et al., (1996) reported that increasing the dietary calcium level up to 5% significantly increased egg production.

Highly significant variation ($P<0.001$) in the rate of egg production was found due to dietary vitamin D_3 level (ANOVA table 12). Rate of egg production was 65.15; 61.05 and 58.75%/ hen/day for pullets fed diets containing 800, 1200 and 1600 I.U. vitamin D_3, respectively. These results disagreement with those obtained by Abdulrahim et al., (1979); Harms et al., (1988 and 1990) and Soares et al., (1988) who reported no positive effect due to addition of vitamin D_3 on egg production. However, Randolph et al., (1997) reported that egg production positively correlated to vitamin D_3 level in a quadratic manner.

From results obtained it could be concluded that average rate of egg production consistently increased after sexual maturity reaching its maximum

Table (11) Least square means and standard error for average egg production %/hen/day as affected by pullet's hybrid, dietary calcium and vitamin D_3 levels.

Item	Average egg production (%/hen/day)
Hybrid	
Hisex	62.23±0.29 a
Shaver	61.06±0.29 b
Calcium	
3.5%	69.70±0.36 a
4.5%	60.87±0.36 b
5.5%	54.38±0.36 c
Vitamin D3	
800 I.U.	65.15±0.36 a
1200 I.U.	6105±0.36 b
1600 I.U.	58.75±0.36 b

+ Means with the same letters in each column are not significantly different.

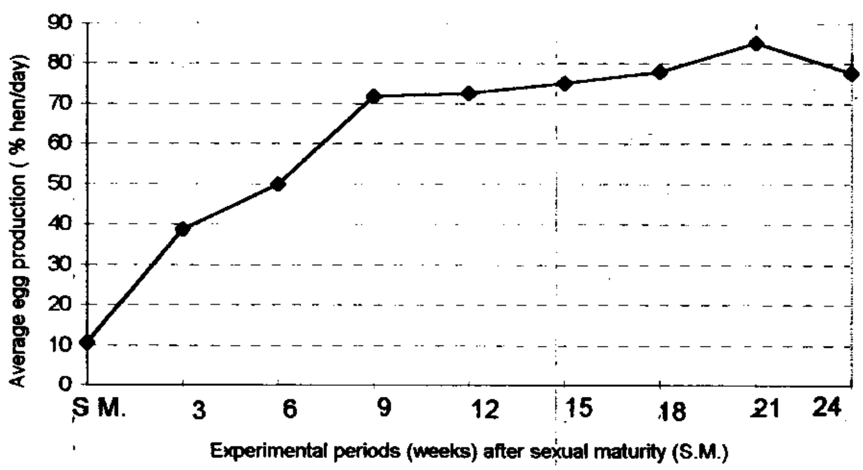

Fig (3): Effect of experimental periods (week) on the average egg production (%/hen/day)

value at the 21^{th} week after which it decreased towards the end of the experimental intervals (Fig 3). Highly significant (P<0.001) variation in averages rate of egg production was found due to the experimental intervals.

Interactions between all factors studied were highly significant (ANOVA table 10).

Table (12): Analysis of variance for data presented in table (11).

S.O.V.	d.f.	F-ratio
Hybrid (B)	1	7.651**
Calcium (C)	2	439.297***
Vitamin D (V)	2	78.039***
Period (I)	8	1602.074***
B × C	2	12.141***
B × V	2	6.398***
B × I	8	8,160***
C × V	4	41.286***
C × I	16	14.840***
V × I	16	4.041***
Remainder d.f	1558	
Remainder MS		72.856

* P<0.05 ** P<0.01 *** P<0.001

4.6. Egg weight:

Data concerning the effect of pullet's hybrid, dietary calcium and vitamin D_3 levels on egg weight laid during the experimental period are presented in table (13).

Averages of egg weight for Hisex pullets mounted 56.15 g and 56.14 g for Shaver pullets. Analysis of variance (ANOVA table 14) showed no significant effect in egg weight between the two hybrids. This result disagree with the finding of other investigators (Kotaiah et al., 1977; Benoff and Renden, 1983; Renden and McDonied, 1984; El-Gendi, 1985 and El-Sayed, 1995).

Average egg weight was found to be 56.22, 55.95 and 55.26 g, for pullets received 3.5, 4.5 and 5.5% calcium level in diet, respectively. Inspection of these data indicated that the lowest level of dietary calcium produced the heaviest egg weight, while the highest level of calcium produced the lowest egg weight. Analysis of variance (ANOVA table 12) showed insignificant effect on egg weight due to dietary calcium levels. These results agree with those reported by Summers et al., (1976); Holcomb et al., (1977); Kuhl et al., (1977); Holder and Huntley (1978) Brister et al., (1981); Rabon and Roland (1995); Roland et al., (1996), Kuchinski and Harms (1997); Scheideler and Robeson (1997) and Sohail and Roland (1997) they all reported that there is no differences in average egg weight due to dietary calcium levels.

Dietary vitamin D_3 level was found to have highly significant effect ($P<0.001$) on egg weight (ANOVA table 14). Averages of egg weight were found to be 56.09; 55.67 and 56.67 g for pullets fed 800; 1200 and 1600 I.U/kg diet of vitamin D_3, respectively. This result agree with the report of Turk and Mc Ginnis (1964) who found that the administration of vitamin D_3 stimulated a sustained increase in egg weight, while these results disagree with the findings of Soares et al., (1988) and Frost et al., (1990) who reported that the level of vitamin D_3 supplementation had no significant effect on egg weight.

The effect of either pullet's hybrid, calcium level or vitamin D_3 on egg weight varied from period to period during the whole period of egg production. It reached its maximum value at the 18th week after sexual maturity (59.74 g)

Table (13) Least square means and standard error for average egg weight as affected by pullet's hybrid, dietary calcium and vitamin D_3 levels.

Item	Average egg weight (g)
Hybrid	
Hisex	56.15±0.12 a
Shaver	56.14±0.12 a
Calcium	
3.5%	56.22±0.14 a
4.5%	55.95±0.14 a
5.5%	55.26±0.14 a
Vitamin D3	
800 I.U.	56.09±0.14 ab
1200 I.U.	55.67±0.14 b
1600 I.U.	56.67±0.14 a

+ Means with the same letters in each column are not significantly different.

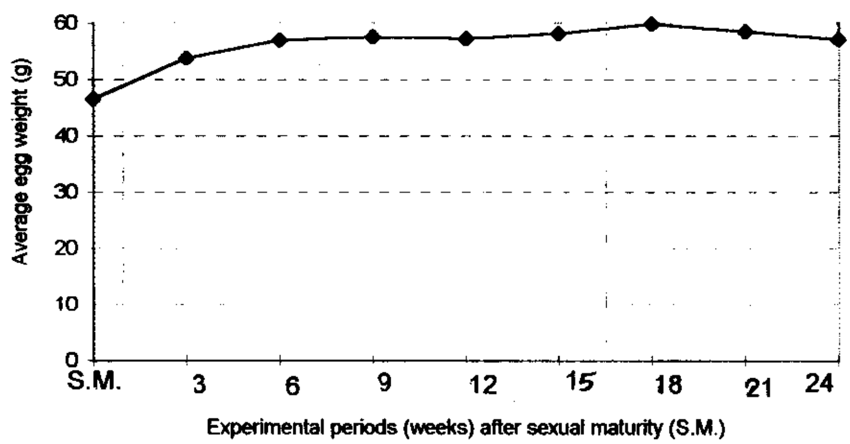

Fig (4): Effect of experimental periods on the average egg weight (g)

(Fig 4). This may lead to conclude that the effect of these factors on egg weight differed mainly according to the pullets age, which may be the result of modifying the response of the pullet to these factors (El-Gendi, 1985).

Interactions between all factors studied were of a highly significant value, except the interaction between breed×vitamin and calcium×vitamin D which showed insignificant effects on average egg weight. These results may lead us to conclude that hybrid and calcium levels effect did not add any beneficial effect to vitamin D_3 on egg weight.

Table (14): Analysis of variance for data presented in table (13).

S.O.V.	d.f.	F-ratio
Hybrid (B)	1	0.002
Calcium (C)	2	1.264
Vitamin D (V)	2	11.393***
Period (I)	8	232.804***
B × C	2	4.902**
B × V	2	0.493
B × I	8	7.447***
C × V	4	1.716
C × I	16	3.037***
V × I	16	3.977***
Remainder d.f	1558	
Remainder MS		12.05

* P<0.05   ** P<0.01   *** P<0.001

4.7. Egg mass:

Data presented in table (15) show the effect of pullet's breed dietary calcium and vitamin D_3 levels on the average of egg mass laid per hen per day during the whole experimental period.

Inspection of data showed that Hisex pullets showed the highest egg mass average during the whole experimental period (35.09 g/hen/day) when compared with Shaver breed (34.54 g/hen/day).

Analysis of variance for data obtained (ANOVA table, 16) showed significant ($P<0.05$) variation in average egg mass laid during the experimental period due to the pullet's hybrid. These results agree with those reported by Scheidler and Robeson (1997)who stated that strain had a profound effect on egg weight and mass. The significant variation in egg mass due to pullet's breed may be attributed to the variation found in both egg weight and egg production.

Dietary calcium level was found to have highly significant effect ($P<0.001$) on the average egg mass average (ANOVA table 16). Pullets fed 3.5% calcium had higher egg mass average (39.30 g/hen/day) followed by those fed 4.5% (34.36 g/hen/day) then by pullets fed 5.5% (30.77 g/hen/day). Variation in average egg mass found due to dietary calcium levels applied may be attributed to the availability of dietary calcium to be easily absorbed through the intestinal tract which may affect the level of serum blood calcium.

The sufficiency of calcium in the blood serum may accelerate the rate of calcium deposition existence of the egg in the uterus and correspondingly shorten the period needed for the complete shell formation. This may resulted in increasing the number of egg laid and thus increases the egg mass average. The results obtained agree with the findings of Keshavarz (1986) who stated that

Table (15) Least square means and standard error for average egg mass (g/hen/day) for experimental groups of Hisex and Shaver pullets during the whole period.

Item	Average egg mass (g/hen/day)
Hybrid	
Hisex	35.09±0.18 a
Shaver	34.54±0.18 b
Calcium	
3.5%	39.30±0.22 a
4.5%	34.36±0.22 b
5.5%	30.77±0.22 c
Vitamin D3	
800 I.U.	36.92±0.22 a
1200 I.U.	34.29±0.22 ab
1600 I.U.	33.23±0.22 b

+ Means with the same letters in each column are not significantly different.

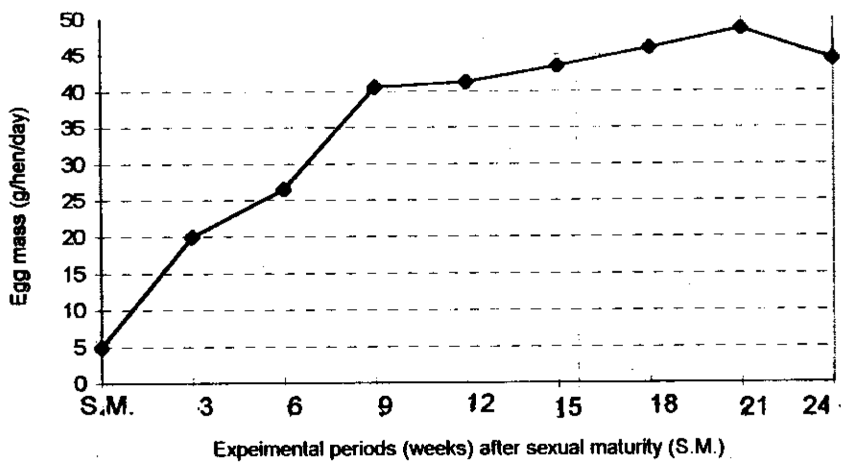

Fig (5): Effect of experimental periods on agerages of egg mass (g/hen/day)

egg mass was consistently lower for birds fed 5.5% calcium level compared to those fed 3.5%.

Highly significant variation ($P<0.001$) in average egg mass due to dietary vitamin D_3 levels was found (ANOVA table 16). Averages of egg mass were 36.92; 34.29 and 33.23 g/hen/day for pullets fed 800; 1200 and 1600 I.U vitamin D_3/kg, respectively. These results disagree with the findings of Soares et al., (1988) who reported no differences in egg weight, egg production or egg mass due to dietary vitamin D_3 levels.

Table (16): Analysis of variance for data presented in table (15).

S.O.V.	d.f.	F-ratio
Hybrid (B)	1	4.333*
Calcium (C)	2	351.335***
Vitamin D (V)	2	69.110***
Period (P)	8	1474.032***
B × C	2	15.478***
B × V	2	3.853*
B × P	8	6.459***
C × V	4	32.856***
C × P	16	13.406***
V × P	16	4.127***
Remainder d.f	1558	
Remainder MS		28.210

* $P<0.05$ ** $P<0.01$ *** $P<0.001$

Average egg mass, mostly increased consistently by advanced age and its maximum value occurred during the peak of egg production at the 21th week after sexual maturity (48.53 g/hen/day) Fig (5). I decreased threafter up to the end of the experimental period (Fig 5).

The effect of interactions between various factors studied were of highly significant values (ANOVA table 16).

4.8. Absolute weight of internal egg component:

4.8.1. Absolute albumen weight:

Data presented in table (17) show absolute albumen weight for eggs laid by Hisex and Shaver pullets during the experimental period.

Results obtained showed that Shaver pullets had almost the highest absolute egg albumen weight (34.63 g), while Hisex had the lowest weight (34.27 g). This result is closely related to that of the egg and body weights. Similar results were observed by El-Sayed (1985).

Analysis of variance showed that variation in albumen weight due to the pullet's breed was significant ($P<0.01$) (ANOVA table 18). These results are in agreement with those reported by Jain (1972) who found significant effect of layers line on absolute and relative albumen weights of egg.

Variation in the average of absolute egg albumen weight due to dietary calcium levels was of no significant value (ANOVA table 18). Averages of egg albumen weight were 34.61; 34.27 and 34.48 g for pullets received 3.5, 4.5 and 5.5% calcium level (table 19). These results are in agreement with those reported by Oliveria et al., (1996) who found that the internal egg quality was not affected by calcium level.

Regardless the effect of hybrid and calcium levels, egg albumen weight was affected by levels of vitamin D_3. Averages of absolute albumen weight were found to be 34.56, 34.20 and 34.59 g for pullets received 800, 1200 and

1600 I.U. vitamin D_3, respectively. Analysis of variance (ANOVA table 18) indicate that these differences are significant ($P<0.05$).

Results obtained Fig (6) showed that absolute weight of egg albumen increased consistently after sexual maturity reaching its maximum value (36.70 g) at the 18^{th} week then it decreased toward the end of the experimental period. The increase in averages albumen weight with advanced age may be attributed to the increase in egg size, which correspondingly led to albumen weight increment. This statement agree with the finding of Jain (1972) who reported significant positive correlation between egg weight and albumen weight.

All interaction effects between various factors studied on absolute albumen weight were of highly significant value ($P<0.001$) ,this was quite true except the interaction between Hybrid × Vitamin D (ANOVA table 18).

From the previously mentioned results, it could be concluded that variation found in average absolute weight of egg albumen due to hybrid or dietary vitamin D level may be attributed to the significant effect of these factors on average egg weight. It is well known that there is positive correlation between albumen weight and egg size (Gado, 1967 and El-Aggoury, 1974).

4.8.2. Absolute yolk weight:

Averages of absolute egg yolk weight for experimental groups of Hisex and Shaver pullets were listed in table (17).

Variation in average absolute egg yolk weight due to the pullet's hybrid was of significant value ($P<0.01$) (ANOVA table 18). It was found that Hisex breed mostly had the highest yolk weight averages (14.75 g) when compared with .. Shaver hybrid (14.56 g). This result agree with those reported by Mostager (1958); May and Stadelman (1960); Jain (1972); Polous et al., (1977); Choi et al., (1983) and El-Sayed (1995). They found that, the line of layers had a significant effect on absolute and proportional weights of egg yolk.

Variation in the average of absolute egg yolk weight due to pullet's breed may be attributed to the variation existed in egg weight.

The slight variation found in the absolute weight of the egg yolk due to dietary calcium level was found to be of no significant value (ANOVA table 18). Averages of absolute yolk weight were 14.63; 14.64 and 14.70 g for pullets received 3.5, 4.5 and 5.5% calcium, respectively.

Results obtained agreed with those reported by Oliveira et al., (1996) who found that the internal egg quality was not affected by calcium level, and disagree with the findings of Roland et al., (1973) who reported that yolk weight affected by dietary calcium level.

Dietary vitamin D level showed a significant effect ($P<0.001$) on absolute yolk weight. Pullets fed 1600 I. U. vitamin D laid eggs with higher average of absolute yolk weight (14.92 g) followed by those fed 800 I.U. (14.54) then by pullets fed 1200 IU (14.51 g), respectively.

Results obtained Fig (6) showed that absolute weight of egg yolk increased consistently after sexual maturity reaching its maximum value at the end of the experimental period. Highly significant effect ($P<0.001$) was found on average absolute yolk weight due to experimental interval. It is early stated that proportional weight of various egg components changes in relation to any change in the whole egg weight. The latter is greatly affected by the hen's age. As the laying hens grow older the whole egg weight increases, while the proportional weight of yolk decrease. In addition the proportional shell weight either still constant or slightly increases as the weight of egg increases (Green Wood and Bolton, 1956 and El-Sayed, 1995).

The interactions between the various factors studied showed highly significant effect on the absolute egg yolk weight, except the interaction between Breed × vitamin D and calcium × vitamin D which showed insignificant value (ANOVA table 18).

4.9. Proportional weights of internal egg component:

4.9.1. Albumen proportional weight:

Albumen weight percentage due to pullet's hybrid was found to be of significant value ($P<0.001$) (ANOVA table 18). Shaver pullets laid eggs of the highest proportional albumen weight average (61.67%), followed by Hisex pullets (61.10%) (Table 17). These results agree with that obtained by Jain (1972); Polous et al., (1977); Rao et al., (1978); Choi et al., (1983); El-Gendi (1985); Tharington et al., (1996) and Novak and Scheideler (1997).

Average of egg albumen percentage for hens received 3.5;4.5 and 5.5% levels of calcium were found to be 61.59; 61.29 and 61.28%, respectively. Analysis of variance (ANOVA table 18) showed insignificant effects of dietary calcium level on egg albumen weight percentage. These results are in agreement with those reported by Abu Egla (1995) and Oliveira et al., (1996) who found that the internal egg quality was not affected by calcium level. On the other hand, Novak and Scheideler (1997) reported that dietary calcium level significantly increased egg albumen percent in the Dekalb Delta strain and decreased it in the Hyline W-36 strain.

Egg albumen percentage mounted 61.64; 61.43 and 61.09% for pullets fed 800; 1200 and 1600 I.U level of vitamin D_3, respectively. Analysis of variance (ANOVA table 18) and Duncan test showed that this effect was highly significant between 1600 I.U. and the other levels of vitamin D_3. This result indicated that increasing dietary vitamin D_3 decreased albumen weight percentage.

Averages of proportional albumen weight of eggs laid by experimental groups of Hisex and Shaver pullets along the experimental period are presented in table (17) and Fig (6). It was found that proportion albumen weight was relatively higher at sexual maturity, then relatively declined towards the end of the experimental period with no recognized trend. It increased or decreased according to age after sexual maturity and experimental treatment, this variation in averages of proportional albumen weight due to experimental period was found to be of significant value ($P<0.001$) (ANOVA table 18). This result agree with the findings of El-Gendi (1985) and El-Sayed (1995).

The interaction between dietary vitamin D_3 and either pullets hybrid or experimental intervals only showed insignificant effect on proportional albumen weight while other interactions studied showed highly significant effect (ANOVA table 18). It may be somewhat true to attribute the significant interaction effect between dietary calcium level, and each of pullet's hybrid and dietary vitamin D_3 on albumen weight percent to their effects on the whole egg weight. As the egg weight increases the proportional albumen weight increases and vice virsa (May and Stadelman, 1960 and El-Gendi, 1985).

4.9.2. Proportional weight of egg yolk:

Data concerning the proportional weight of egg yolk for experimental groups of Hisex and Shaver pullets are presented in table (17). Variation in average egg yolk percentage due to pullet's breed was found to be of significant value ($P<0.01$) (ANOVA table 18). Hisex pullets laid eggs of the highest proportional yolk weight average (26.32%), while Shaver pullets had the lowest average (25.93%). These results are in agreement with those obtained by Polous et al., (1977); Ousterhout (1981); El-Gendi (1985)' El-Sayed (1995), Tharington et al., (1996) and Novak and Scheideler (1997) who reported that the line of layers had a significant effect on absolute and proportional weight of yolk.

Dietary calcium level showed no significant effect on proportional weight of yolk. Means of egg yolk percentage for hens received 3.5, 4.5 and 5.5% levels of calcium were found to be 26.02; 26.26 and 26.09%, respectively. These results are in agreement with those reported by Abu-Egla (1995) and Oliveira et al., (1996) who found that the internal egg quality was not affected by calcium level.

Averages egg yolk weight percentage were found to be 25.91; 26.18 and 26.29% for pullets received 800, 1200 and 1600 I.U. level of vitamin D_3, respectively. These results indicated that dietary vitamin D increased egg yolk weight percentage. Analysis of variance showed that effect of vitamin D_3 on egg yolk percent was not significant (ANOVA table 18).

Table (17): Least square means and standard error for factors affecting absolute and proportional weights of internal egg components.

Item	Albumen weight		Yolk weight	
	g	%	g	%
Hybrid				
isex	34.27±0.09 a	61.10±0.09 a	14.75±0.04 a	26.32±0.09 a
Shaver	34.63±0.09 b	61.67±0.04 b	14.56±0.04 b	25.93±0.09 b
Calcium				
3.5%	34.61±0.11 a	61.59±0.11 a	14.63±0.05 a	26.02±0.11 a
4.5%	34.27±0.11 a	61.29±0.11 a	14.64±0.05 a	26.26±0.11 a
5.5%	34.48±0.11 a	61.28±0.11 a	14.70±0.05 a	26.09±0.11 a
Vitamin D3				
800 I.U.	34.56±0.11 a	61.64±0.11 a	14.54±0.05 a	25.91±0.11 a
1200 I.U.	34.20±0.11 b	61.43±0.11 a	14.51±0.05 a	26.18±0.11 a
1600 I.U.	34.59±0.11 a	61.09±0.11 b	14.92±0.05 b	26.29±0.11 a

+ Means with the same letters in each column are not significantly different.

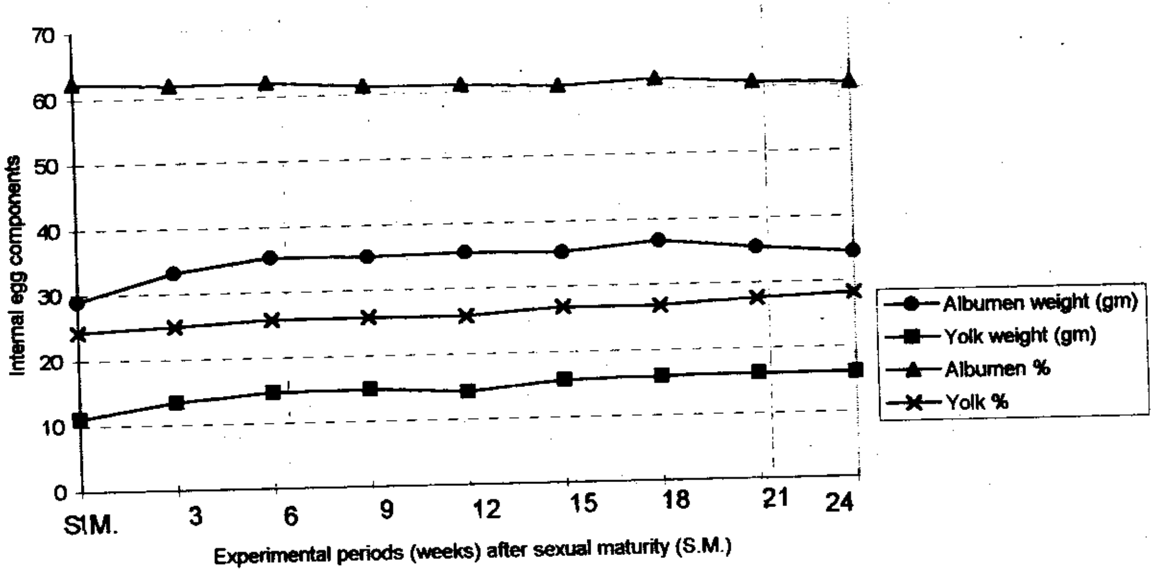

Fig (6): Effect of experimental periods on the absolute and proportional weights of internal egg components.

Table (18): Analysis of variance for data presented in table (17).

S.O.V	d.f.	F -ratio			
		Absolute weight (g)		Proportional weights (%)	
		albumen	yolk	albumen	Yolk
Hybrid (B)	1	7.925**	8.514**	17.881***	8.542**
Calcium (C)	2	2.420	0.450	2.184	1.179
Vitamin (V)	2	3.819*	16.606***	5.638**	2.974
Intervals (I)	8	134.940***	281.326***	12.552***	44.101***
B × C	2	15.315***	11.906***	25.496***	12.580***
B × V	2	0.494	0.012	0.149	0.091
B × I	8	5.238***	7.582***	3.425***	2.560**
C × V	4	6.215***	2.045	6.115***	3.590**
C × I	16	3.025***	2.572***	2.048***	1.093
V × I	16	3.566***	1.985**	1.593	1.049
Remainder d.f	1558				
Remainder MS		6.747	1.673	7.464	6.989

* P<0.05 ** P<0.01 *** P<0.001

Averages of proportional yolk weight of eggs laid by experimental groups (Fig 6) showed slight increase after sexual maturity reaching its maximum value at the end of the experimental period. Differences in yolk weight percentage due to experimental intervals were highly significant values (P<0.001) (ANOVA table 18).

The interaction between pullets hybrid and either dietary calcium level or experimental intervals and between dietary calcium level and vitamin D had highly significant effect (P<0.01) on the proportional yolk percent.

4.10. Egg shell quality:

4.10.1. Absolute egg shell weight:

Data concerning the effect of pullet's hybrid, dietary calcium and vitamin D_3 levels on absolute shell weight for eggs laid by the experimental hybrid are presented in table (19).

Results obtained showed that Hisex pullets had almost the highest absolute egg shell weight average (5.77 g) when compared to Shaver pullets (5.49 g).

Analysis of variance showed that variation in shell weight due to the pullet's hybrid was significant ($P<0.001$) (ANOVA table 20). This result agree with the findings of Marion et al., (1964 and 1966); Jain (1972); Polous et al., (1977); Ousterhout (1981) and Choi et al., (1983) which indicated that , breed differences in shell weight were significant.

Dietary calcium level seemed to have no significant effect on absolute egg shell weight (ANOVA table 20). Averages of egg shell weight were 5.63; 5.62 and 5.64 g for pullets fed diets containing 3.5; 4.5 and 5.5% calcium, respectively. These results agree with that reported by Hinners et al., (1963) who found no significant improvement in shell absolute weight as a result of feeding layers diets containing 2.25; 3.0 or 3.5% calcium. While disagree with the findings of Ousterhout (1981); Clunies et al., (1992) and Abou Egla (1995) who reported that egg shell weight was significantly affected by dietary calcium level.

Dietary vitamin D_3 levels also showed insignificant effect on egg shell weight (ANOVA table 20). Averages of egg shell weight were 5.64; 5.58 and 5.67 g for pullets fed diets containing 800, 1200 and 1600 I.U/kg from vitamin

D_3, respectively. These result agree with the findings of Hamilton (1980) and Frost et al., (1990) who reported that vitamin D_3 had no significant effect on either shell weight or thickness. On the other hand, Kaetzel et al., (1978) and Soares et al., (1988) reported that there is increasing in egg shell quality due to dietary vitamin D_3.

Results obtained showed that averages of absolute egg shell weight consistently increased after sexual maturity reaching its maximum value at the 9^{th}, 12^{th} and 15^{th} week, then slightly decreased towards the end of the experimental period (Fig 7a). These results agree with those findings of El Gendi (1985).

The interactions between various factors studied showed significant effects on egg shell absolute weight (ANOVA table 20).

4.10.2. Proportional egg shell weight:

Table (19) also shows the averages of proportional egg shell weight as affected by pullet's hybrid, dietary calcium, vitamin D_3 levels along the experimental period.

Inspection of data presented in Fig (7 a) did not show any characteristic trend concerning the effect of experimental period on egg shell percent. On the other hand, highly significant effect ($P<0.001$) was found in egg shell percent due to experimental intervals (ANOVA table 20).

Pullet's breed showed significant effect ($P<0.001$) on egg shell weight percent (ANOVA table 20). Hisex pullets laid eggs of almost higher proportional shell weight (10.37%) followed by Shaver ones (9.81%). These results agree with the findings of Kamar et al., (1976) ; El-Gendi (1985) and El-Sayed (1995).

Insignificant variation was existed in the proportional egg shell weight due to the dietary calcium, analysis of variance (ANOVA table 20). These results disagree with those of Sullivan and Kingan (1962); Hulan and Nikolaczuk (1972) and Miller and Sunde (1975) who stated that as dietary calcium level increased egg shell measures (thickness and shell percent) was improved.

Dietary vitamin D_3 level showed insignificant effect on proportional weight of shell. The value of egg shell percent were 10.09; 10.13 and 10.05% for pullets received diets supplemented with 800, 1200 and 1600 I.U/kg of vitamin D_3, respectively. This result are in agreement with the findings of Hamilton (1980) who reported that dietary vitamin D_3 source and level had no significant effect on egg shell percent.

All interactions between each two factors studied showed highly significant hybrid on shell weight percent, except the interaction between pullet's hybrid and either dietary calcium or vitamin D level which showed insignificant value on egg shell percent.

4.10.3. Shell thickness:

Averages of the shell thickness for all experimental groups of Hisex and Shaver pullets are listed in table (19). Averages of egg shell thickness were 0.403 and 0.358 mm for Hisex and Shaver pullets, respectively.

Analysis of variance (ANOVA table 20) highly significant variation (P<0.001) in shell thickness due to bird's hybrid. These result agree with the findings of Mostageer and Kammar (1961); Amer (1967), Kammar et al., (1976); Kotaiah et al., (1977), El-Gendi (1985) and El-Sayed (1995) who found breed differences in shell thickness. Variation in egg shell thickness due to the pullet's breed may be attributed to the variation existed in either egg weight and rate of egg production.

Dietary calcium level was found to have highly significant effect ($P<0.001$) on egg shell thickness (ANOVA table 20). Pullets fed 3.5; 4.5 and 5.5% calcium laid eggs with shell thickness averaged 0.387; 380 and 0.375 mm, respectively. The results obtained in agree with those of Sullivan and Kingan (1962); Hulan and Nikolaiczuk (1972) and Miller and Sunde (1975) who stated that as dietary calcium level increased egg shell measurements (specific gravity, egg shell thickness, strength and proportional weight) improved.

Pullets fed diet supplemented with 800; 1200 and 1600 I.U. vitamin D_3 laid eggs with shell thickness averaged 0.384; 0.379 and 0.380 mm, respectively. Variation found in shell thickness due to dietary vitamin D_3 level was of insignificant value.

These results are in agreement with those reported by Peter et al., (1964) and Frost et al., (1990) who reported that vitamin D_3 had no significant effect on shell weight and shell thickness.

Shell thickness consistently increased reaching its maximum value at the 9th week after maturity, after which it decreased towards the end of the experimental period (Fig 7b). Analysis of variance showed highly significant effect ($P<0.001$) due to experimental intervals on the average of egg shell thickness.

Highly significant effects were found due to the interaction between pullets hybrid and either calcium level or experimental interval. Interaction between dietary calcium level and either vitamin D_3 or experimental period were highly significant.

4.10.4. Shell weight per unit surface area (SWUSA):

Data concerning shell weight per unit surface area (SWUSA) for eggs laid by different experimental groups of Hisex and Shaver pullets are presented in table (19). SWUSA for Hisex and Shaver pullets average 68.35 and 68.36 mg/cm^2, respectively. Analysis of variance (ANOVA table 20) show that variation due to pullet's hybrid was of no significant value.

SWUSA values were found to be 68.38; 68.27 and 68.42 mg/cm^2 for eggs laid by pullets fed 3.5; 4.5and 5.5% calcium levels, respectively. Analysis of variance (ANOVA table 20) indicate no significant effect on SWUSA due to dietary calcium level. Results obtained disagree with those of Ousterhout (1980) who reported that egg shell weight, shell weight per unit surface area were significantly affected with dietary calcium levels.

Highly significant variations ($P<0.001$) were found in SWUSA due to dietary vitamin D_3 levels. Hens fed diet supplemented with 1600 I.U. vitamin D_3/kg feed had mostly the highest value of SWUSA (68.80 mg/cm^2) when compared with those receiving 800 I.U. (68.29 mg/cm^2) and 1200 I.U. (67.97) of vitamin D, respectively. These results are disagree with those of Hamilton (1980) who reported that dietary vitamin D_3 source and level had no significant effect on shell weight per unit surface area (SWUSA).

Table (19): Least square means and standard error for factors affecting shell quality.

Item	Shell weight		Shell quality	
	g	%	Shell thickness (mm)	SWUSA mg/cm^2
Hybrid				
Hisex	5.77±0.02 a	10.37±0.05 a	0.403±0.001 a	68.35±0.11 a
Shaver	5.49±0.02 b	9.81±0.05 b	0.358±0.001 b	68.36±0.11 a
Calcium				
3.5%	5.63±0.03 a	10.05±0.06 a	0.387±0.001 a	68.38±0.13 a
4.5%	5.62±0.03 a	10.15±0.06 a	0.380±0.001 b	68.27±0.13 a
5.5%	5.64±0.03 a	10.07±0.06 a	0.375±0.001 c	68.42±0.13 a
Vitamin D3				
800 I.U.	5.64±0.03 a	10.09±0.06 a	0.384±0.001 a	68.29±0.13 a
1200 I.U.	5.58±0.03 a	10.13±0.06 a	0.379±0.001 a	67.97±0.13 a
1600 I.U.	5.67±0.03 a	10.05±0.06 a	0.380±0.001 a	68.80±0.13 b

+ Means with the same letters in each column are not significantly different.

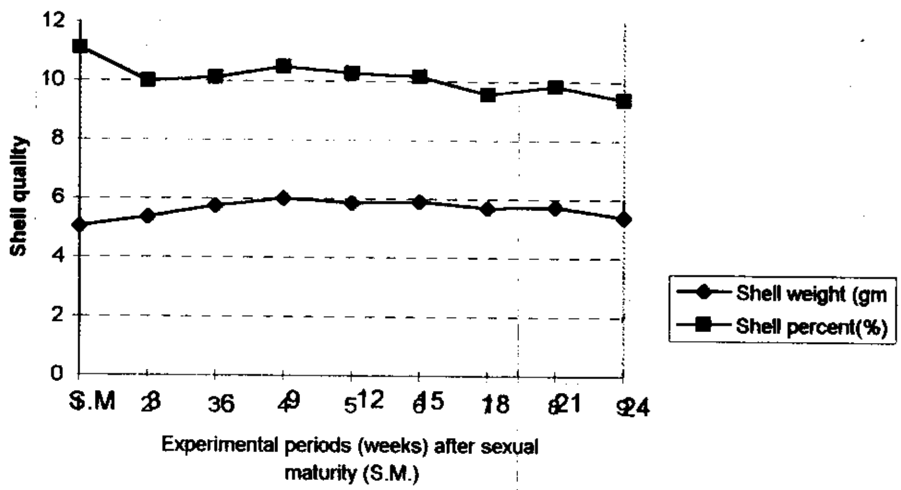

Fig (7 a) Effect of experimental periods (weeks) on shell quality.

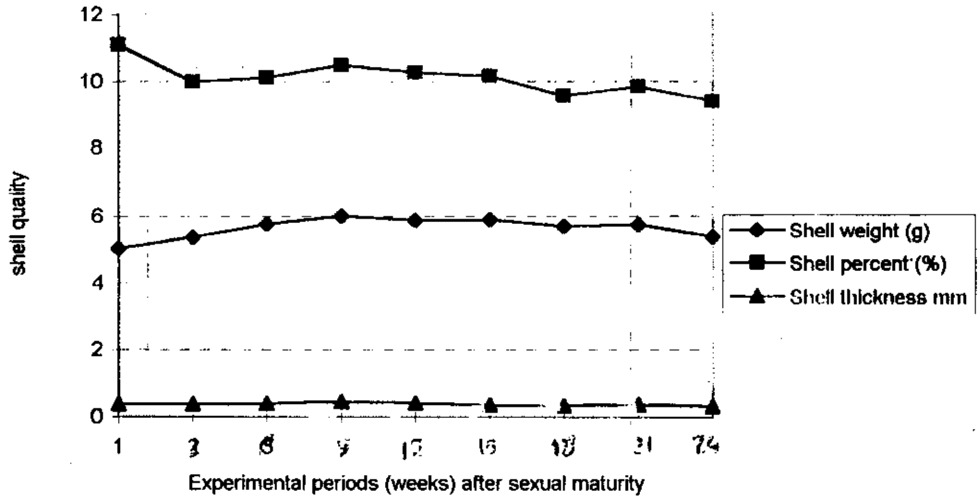

Fig (7 b): Effect of experimental periods (weeks) on shell quality

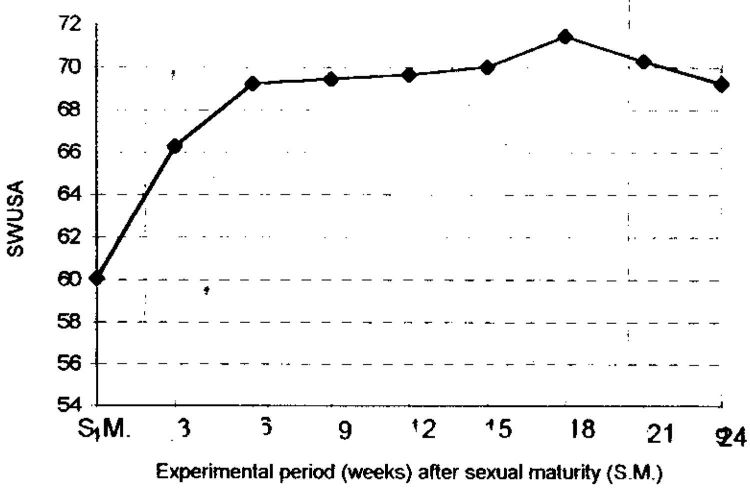

Fig (7c): Effect of experimental periods (weeks) on SWUSA

Table (20) Analysis of variance for data presented in table (19)

S.O.V	d.f	F-ratio			
		Shell weight		Shell quality	
		g	%	Shell thickness (mm)	SWUSA
Hybrid (B)	1	62.049***	59.813***	421.248***	0.010
Calcium (C)	2	0.146	0.817	9.612***	0.326
Vitamin (V)	2	2.614	0.408	1.570	9.363***
Interval (I)	8	33.794***	22.252***	270.580***	206.471***
B × C	2	5.603***	1.011	17.944***	4.859**
B × V	2	3.077	1.770	2.425	0.187
B × I	8	5.596***	3.5821***	18.206***	8.314***
C × V	4	2.701*	5.105***	7.545***	0.893
C × I	16	4.926***	3.254***	5.340***	2.880***
V × I	16	2.884***	2.302**	1.641	3.815***
Remainder d.f	1558				
Remainder MS		0.507	2.099	0.001	10.099

* $P<0.05$ ** $P<0.01$ *** $P<0.001$

SWUSA of egg was increased during the 18th week after sexual maturity, then decreased towards the end of the experimental period Fig (7 c).

Interaction between pullet's breed and each of dietary calcium level and experimental intervals showed highly significant effect ($P<0.01$) on SWUSA. Also highly significant effects ($P<0.001$) were found due to the interactions between experimental interval and either dietary calcium or vitamin D level (ANOVA table, 20).

4.11. Egg size classification:

Results presented in table (21) indicate that percentage of small, middle, large and Jumbo eggs were found to be 17.7, 42.8, 34.5 and 5.0%, respectively for Hisex hens, the corresponding values for Shaver hens were 13.5, 48.0, 34.0 and 4.5%, respectively.

Percentages of small eggs (grade S) were found to be 17.0%, 14.0% and 15.1% for hens receiving diet containing 3.5%, 4.5% and 5.5% calcium, respectively. Feeding hens diet containing 4.5 and 5.5% calcium increased middle (46.2) and large egg (36.3), respectively. However, the highest percentage of Jumbo eggs (5.4%) was observed in hens receiving 3.5% calcium level.

Regardless pullet's breed and dietary calcium level, percentage of small eggs (grade S) were found to be 17.0%, 17.4% and 11.4% for hens receiving diets supplemented with 800, 1200 and 1600 I.U. vitamin D_3, respectively. These results indicate that feeding high level of vitamin D_3 tend to decrease percentage of small eggs.

Percentage of middle eggs (class M) was found to be 42.8% for Hisex hens. While the corresponding values for Shaver was (48.0%).

Diets supplemented with 1200 I.U vitamin D_3/kg feed increased percentage of middle eggs (class M) (49.4%). On the other hand, large (38.4) and Jumbo (6.5%) grade eggs were found in hens fed 1600 I.U. vitamin D.

Data presented in table (22) showed that Shaver pullets decreased percentage of small eggs number (41.4%) and increased middle eggs (50.9%). However, Hisex pullets increased either large eggs (grade L, 52.2%) or Jumbo eggs (grade J, 54.2%) in each grade.

Table (21): Distribution of eggs according to percentage of eggs grade for different treatments per hen calculated according to the total number of eggs in each treatment.

Item	Character studied	Egg size				Total number
		S	M	L	J	of egg
Hybrid						
Hisex	Number	638	1547	1244	179	3608
	%	17.7	42.8	34.5	5.0	100
Shaver	Number	450	1606	1139	151	3346
	%	13.5	48.0	34.0	4.5	100
Calcium						
3.5%	Number	555	1492	1049	177	3273
	%	17.0	45.6	32.0	5.4	100
4.5%	Number	300	991	775	77	2143
	%	14.0	46.2	36.2	3.6	100
5.5%	Number	233	670	559	76	1538
	%	15.1	43.6	36.3	5.0	100
Vitamin D						
800 I.U	Number	461	1160	962	123	2706
	%	17.0	42.9	35.6	4.5	100
1200 I.U	Number	412	1171	700	85	2368
	%	17.4	49.4	29.6	3.6	100
1600 I.U	Number	215	822	721	122	1880
	%	11.4	43.7	38.4	6.5	100

S = Less than 49.6 g.
M = 49.6-56.6 g.
L = 56.7-63.7 g.
J = More than 63.7 g.

Table (22): Percentage of eggs in each grade of hens for different treatments per hen calculated according to the total number of eggs in each size

Item	Character studied	Egg size			
		S	M	L	J
Hybrid					
Hisex	Number	638	1547	1244	179
	%	58.6	49.1	52.2	54.2
Shaver	Number	450	1606	1139	151
	%	41.4	50.9	47.8	45.8
Calcium					
3.5%	Number	555	1492	1049	177
	%	51.0	47.3	44.0	53.7
4.5%	Number	300	991	775	77
	%	27.6	31.4	32.5	23.3
5.5%	Number	233	670	559	76
	%	21.4	21.3	23.5	23.0
Vitamin D					
800 I.U	Number	461	1160	962	123
	%	42.4	36.8	40.4	37.3
1200 I.U	Number	412	1171	700	85
	%	37.9	37.2	29.4	25.8
1600 I.U	Number	215	822	721	122
	%	19.7	26.0	30.2	36.9
	Number	1088	3153	2383	330
	%	100	100	100	100

Regardless pullets hybrid and dietary vitamin D_3 levels, high percentage of small (51.0), middle (47.3), large (44.0) and Jumbo eggs (53.7%) were observed in eggs laid by hens receiving 3.5% calcium, then by those produced from hens fed 4.5 and 5.5% calcium, respectively.

Feeding hens diet containing 800 I.U. vitamin D_3 produced high percentage of small (42.4%), large (40.4) and Jumbo eggs (37.3%). On the other hand, hens received 1200 I.U. vitamin D increased middle eggs (37.2%) followed by 800 I.U. (36.8%) then by those fed 1600 I.U. (26.0%), respectively.

4. 12. Economical efficiency:

Results of economical efficiency from hens fed the experimental layer diets are shown in Table (23). The results indicated that Hisex pullets showed slight economical efficiency by (3.9%) when compared with Shaver pullets.

Economical efficiency were found to be 33.6, 19.6 and 13.4% for pullets received 3.5, 4.5 and 5.5% calcium, respectively.

Regardless of pullet's hybrid and dietary calcium level, hens received diet containing 800 I.U. vitamin D increased economical efficiency by 7.9, and 13.0% when compared with those received 1200 and 1600 I.U./kg diet, respectively. The results obtained indicate that economical efficiency decreased as the level of either calcium or vitamin D increased, this may be due to the higher egg production rate for pullets received 3.5% calcium and 800 I.U. vitamin D compared with other levels of both calcium and vitamin D with

Table (23): Economical evaluation of dietary calcium and vitamin D supplementation to layer.

	Hybrid		Calcium %			Vitamin D I.U.		
	Hisex	Shaver	3.5	4.5	5.5	800	1200	1600
Fixed cost/hen L.E.	12	12	12	12	12	12	12	12
Managment/hen L.E.[1]	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total feed cost/hen L.E.	11.8	12.3	12.9	11.8	11.6	12.2	12.0	12.0
Total costs/hen L.E.	25.3	25.8	26.4	25.25	25.05	25.67	25.53	25.45
Total No. of egg /hen	112	110	131	106	97	121	110	103
Total egg price/hen L.E.[2]	22.4	22.0	26.2	21.2	19.4	24.2	22.0	20.6
Price of sold bird L.E.	9	9	9	9	9	9	9	9
Total revenue/hen L.E.	31.4	31.0	35.2	30.2	28.4	33.2	31.0	29.6
Net revenue/hen L.E.[3]	6.10	5.20	8.85	4.95	3.35	7.53	5.47	4.15
Economical efficiency (%)	24.1	20.2	33.6	19.6	13.4	29.3	21.4	16.3

1- Include medication, vaccines and sanitation

2- The price of an egg at time experiment = 20 p.t.

3- Net revenue per unit of total costs.

relatively constant of total costs / hen for different levels of calcium and vitamin D.

From the previously mentioned results it could be concluded that, the inclusion rate of calcium at a level of 3.5% and vitamin D_3 at 800 I.U./kg ration seemed to be adequate to achieve the favourable results and would be more economic.

4.13. Plasma level of calcium, inorganic phosphorus and alkaline phosphatase:

Plasma level of calcium, inorganic phosphorus and alkaline phosphatase were estimated for experimental groups of Hisex and Shaver pullets at four intervals: when the percentage of egg production reached 10% (at sexual maturity); 50% egg production; at the peak of egg production and at the end of the experimental period.

4. 13. 1. Plasma level of calcium:

From data obtained (Table 24) it was found that plasma level of calcium averaged (23.1 and 23.4 mg/100 ml) for Hisex and Shaver pullets, respectively. Variation in plasma calcium due to pullet's hybrid may be attributed to the differences found in the rate of egg production. However, this variation was of insignificant value (ANOVA table 25). Results obtained disagree with those of Taylor and Hertelendy (1961); Snapir and Perek (1970); El-Nadi et al., (1981); El-Gendi (1985) and El-Sayed (1995) who found significant breed differences in both plasma free calcium as well as the bound fraction.

Grand means of plasma calcium level mounted 20.5; 23.4 and 23.9 mg/100 ml, for pullets fed 3.5; 4.5 and 5.5% dietary calcium, respectively. This variation was highly significant ($P<0.001$) (ANOVA table 25). Results obtained agree with those of Bar et al., (1978); Thomason et al., (1978); Vohra et al., (1979); Stevens and Blair (1983) and Canter et al., (1997), who reported that increasing dietary calcium level had significant linear effect on plasma calcium. Contradictory results were found by Kemm (1972) who reported that dietary calcium does not effect serum calcium.

Analysis of variance (ANOVA table 25) showed no significant variation in plasma calcium content due to dietary vitamin D_3 level. Results obtained agreed with those of Roberson and Edwards (1994) who found that vitamin D_3 supplementation did not affect plasma calcium level. This may be due to the fact that the blood calcium concentration in laying hens is affected by the reproductive state of the bird and or the photoperiod and pattern of feed intake second (Parson and Combs, 1980). It could be also concluded that plasma calcium content is mainly affected by the dietary calcium content rather than the level of vitamin D_3.

Inspection of data presented in table (24) showed that plasma calcium level increased after sexual maturity reached its maximum value (26.6 mg/100 ml) at the peak of egg production. This may be attributed to the effect of sexual hormones output which increased after maturity with an increased rate towards sexual maturity. This may be a result of hormonal coordination in hypothalamic hypophyseal ovarian axis which may be attained during different period from sexual maturity. The hormonal coordination may effectively remain along the first year of egg production (El-Sayed, 1995). Analysis of variance showed highly significant effect (P<0.001) due to experimental intervals on plasma calcium level (ANOVA table 25). These results agree with those of Snapir and Perek (1970) who found positive correlation between egg production and total blood calcium.

The interaction effects of various factors studied (except hybrid × vitamin D) were found to be of highly significant value (P<0.001) (ANOVA table, 25). This may lead to conclude that changes in plasma calcium was more affected with dietary calcium level (Stevens and Blair, 1983, and Cantor et al., 1997) and egg production period rather than any other factor.

In addition, it could be stated that plasma calcium may be a function of variation in the rate of calcium absorption rather than the pullet's hybrid. This individual variation may be due to the individual differences in the hormonal regulation of blood calcium hemiostasis.

4. 13. 2. Plasma inorganic phosphorus:

Data concerning the effect of pullet's hybrid, dietary calcium and vitamin D_3 level, on the plasma inorganic phosphorus content were presented in table (24).

Inspection of data showed that serum inorganic phosphorus averaged 7.80 and 7.47 mg/100 ml for Hisex and Shaver pullets, respectively. Analysis of variance showed highly significant (P<0.01) breed variation (ANOVA table 25). It could be stated that the level of plasma inorganic phosphorus may be a function of genetic action on producing the enzymatic system responsible for the kidney hormonal activity in regulating the rate of phosphorus filtration and or reabsorption. This regulation may be affected with the status of blood calcium hemiostasis and mechanism of maintaining the electrical balance in the various compartments of the body fluids. The significant variation in plasma inorganic phosphorous due to the bird's breed is scientifically logic.

Theses results agree with those of Urist and Deutsch (1960); Edwards (1983) and El-Sayed (1995) who stated that, the effect of pullet's breed on inorganic phosphorus level was found to be highly significant.

As presented in table (24) plasma inorganic phosphorus content mounted 7.84; 7.82 and 7.24 mg/100 ml for pullets fed diet containing 3.5; 4.5 and 5.5% calcium, respectively. Analysis of variance indicated that these variations were highly ($P<0.001$) significant (ANOVA table 25).

From data obtained it could be noticed that increasing dietary calcium level decreased plasma inorganic phosphorus. These results agree with those of Mueller et al., (1970); Bar et al., (1972) and Stevens and Blair (1983).

Regardless of the effect of pullet's breed or dietary calcium level, it was found that pullets fed diet containing 800, 1200 and 1600 I.U of vitamin D_3 had (7.70; 7.26 and 7.95 mg/100 ml) plasma inorganic phosphorus, respectively. Analysis of variance showed highly significant effect ($P<0.001$) on plasma inorganic phosphorus due to dietary vitamin D_3 levels. These results agree with that of Stevens and Blair (1983). It could be suggested that vitamin D_3 accelerate calcium and inorganic phosphorus absorption in the intestine of laying chicken.

Plasma inorganic phosphorus level increased after sexual maturity reaching its maximum value (10.26 mg/100) at 50% rate of egg production after which it decreased towards the end of the experimental interval (Table 24). Experimental interval showed highly significant variation ($P<0.001$) in averages plasma inorganic phosphorus. These results agreed with the findings of Garlich et al., (1984) who reported that serum calcium and phosphorus contents of laying hens was influenced by age and production status.

Interaction between all factors studied (except the interaction between Hybrid×vitamin D and Hybrid×Intervals) had highly significant effect on plasma inorganic phosphorus. This may lead to conclude that, the effect of each pullets hybrid, dietary calcium and vit. D_3 on plasma seems to be dependent on and related to the effect of each other.

4. 13. 3. Plasma alkaline phosphatase:

Data listed in table (24) revealed that Hisex hens had the highest value of plasma alkaline phosphatase (429.53 U/100 ml) when compared with those of Shaver (401.95). However, the effect of pullet's hybrid on plasma alkaline phosphatase content was found to be insignificant (ANOVA table 25).

Pullets received diets containing 3.5, 4.5 and 5.5% calcium had 395.82; 411.76 and 439.66 U/100 ml alkaline phosphatase average, respectively. However, dietary calcium level showed insignificant effect on plasma alkaline phosphatase (ANOVA table 25). This result disagree with that of Stevens and Blair (1983) who reported that, the diets containing 0.6 and 3% calcium increased plasma alkaline phosphatase.

Regardless of pullet's breed and dietary calcium level, dietary vitamin D content had highly significant effect ($P<0.001$) on plasma alkaline phosphatase. Pullets fed diet supplemented with 800, 1200 and 1600 I.U of vitamin D_3 had 463.73; 386.04 and 397.80 U/100 ml alkaline phosphatase average, respectively. These results agree with those of Oser (1965) and Stevens and

Blair (1983) who reported that, increasing the level of vitamin D_3 in the diet decreased plasma alkaline phosphatase.

Table (24): Least square means and standard error for plasma calcium, inorganic phosphorus and alkaline phosphatase as affected by experimental factors.

Items	Plasma		
	Ca. Mg/100 ml	Ph mg/100 ml	Alk. Ph U/100 ml
Hybrid			
Hisex	23.1±0.18 a	7.80±0.07 a	429.53±13.27 a
Shaver	23.4±0.18 a	7.47±0.07 b	401.95±13.27 a
Calcium			
3.5%	20.5±0.22 a	7.84±0.09 a	395.82±16.26 a
4.5%	23.4±0.22 b	7.82±0.09 a	411.76±16.26 a
5.5%	23.9±0.22 b	7.24±0.09 b	439.66±16.26 a
Vitamin D3			
800 I.U	22.7±0.22 a	7.70±0.09 a	463.73±16.26 a
1200 I.U	22.9±0.22 a	7.26±0.09 b	386.04±16.26 b
1600 I.U	23.1±0.22 a	7.95±0.09 a	397.80±16.26 b
Intervals			
At sexual maturity	15.8±0.25 a	5.79±0.10 a	418.64±18.77 a
At 50% egg production	25.6±0.25 b	10.26±0.10 b	509.73±18.77 b
At the peak of egg production	26.6±0.25 c	8.08±0.10 c	657.37±18.77 c
At the end of the experiment	25.1±0.25 b	6.42±0.10 d	377.30±18.77 a

+ Means with the same letters in each column are not significantly different.

Table (25): Analysis of variance for data presented in table (24).

S.O.V	d.f.	F-ratio		
		Calcium	Inorganic phosphorus	Alkaline phosphatase
Hybrid (B)	1	1.444	9.307**	2.157
Calcium (C)	2	105.173***	12.775***	1.862
Vitamin (V)	2	2.112	13.705***	6.654***
Intervals (I)	8	263.883***	331.811***	118.394***
B × C	2	23.005***	9.151***	3.578*
B × V	2	1.322	1.862	0.049
B × I	8	7.885***	0.750	0.813
C × V	4	15.147***	35.135***	10.717***
C × I	16	42.883***	10.743***	7.278***
V × I	16	10.595***	4.281***	1.066
Remainder	1558			
Remainder MS		11.979	2.163	63477.083

* P<0.05 ** P<0.01 *** P<0.001

Data presented in table (24) shows that plasma alkaline phosphatase varied according to the period of egg production, it increase consistently after sexual maturity reaching its maximum value 567.37 I.U/100 ml at the peak of egg production. After which it decreased towards the end of the experiment. Analysis of variance revealed highly significant effect (P<0.001) on plasma inorganic phosphorus due to experimental intervals. These results agree with those of Wilcox et al., (1963 a, b) and Ali and Attia (1980) found that alkaline phosphatase level in the hen was significantly and positively correlated with both egg production and egg specific gravity during the season in which the blood was collected. Ali and Attia (1980) suggested that serum alkaline phosphatase is a reliable index for high egg production.

Interaction between Hybrid × Calcium level and between dietary calcium, level and either experimental interavl or vitamin D were found to be of significant value.

4.14. Mode of calcium absorption (in vitro) throughout the different parts of the small intestine:

Calcium absorption rate throughout the different intestinal regions was studied at sexual maturity and at the end of the experimental period for pullets of all experimental groups.

4.14.1. Total calcium absorption:

Inspection of data obtained (table 26) showed insignificant variation in total calcium absorption at sexual maturity and at the end of the experimental period due to the hen's hybrid (ANOVA table 27). The results obtained disagree with the finding of Radwan et al., (1984); El-Gendi (1985) and El-Sayed (1995).

It was found that the rate of total calcium absorption slightly increased as the dietary calcium contents increase. Total calcium absorption at sexual maturity averaged 19.8, 20.4 and 20.8 mg/hr, for pullets fed diets containing 3.5; 4.5 and 5.5% calcium, respectively. The corresponding values at the end of the experimental period were 20.0; 21.1 and 19.6 mg/hr, respectively. However, analysis of variance showed no significant variation in total calcium absorption due to dietary calcium level at either sexual maturity or at the end of the experimental period (ANOVA table 27).

Dietary vitamin D_3 levels showed significant effect ($P<0.05$) on the amount of total calcium absorption at sexual maturity only (ANOVA table 27). The grand means of total calcium absorption at sexual maturity were 20.0; 20.1 and 21.8 mg/hr for pullets received 800, 1200 and 1600 I.U vitamin D_3, respectively. The corresponding averages mounted 19.7, 20.2 and 20.8 mg/hr, respectively at the end of the experimental period. These results agree with the findings of Radwan (1990) who reported that level of vitamin D_3 showed a significant effect on total calcium absorption. This may be due to that vitamin D_3 treatment increased the rate of diffusion of calcium across the intestinal wall (Radwan, 1980).

Average of total calcium absorption mg/hr through ileum mounted 23.7 at sexual maturity and 24.1 mg/hr at the end of the experiment. The values was significantly ($P<0.001$) higher than the corresponding values concerning the absorption through jejunum (23.1; 21.6) and duodenum (14.1; 14.0 mg/hr). This was mostly quite true in all experimental groups. Similar results were observed by Radwan (1980), El-Gendi (1985); Radwan (1990) and El-Sayed (1995).

Highly significant variations ($P<0.001$) were found in total calcium absorption due to different intestinal parts (ANOVA table 27).

Significant variations were found also in total calcium absorption due to the interactions between Calcium × vitamin D at sexual maturity (ANOVA table 27).

4.14.2. Absorption per cm of the small intestinal length:

Inspection of data presented in table (26) indicate that the amount of calcium absorbed/cm length of the small intestine averaged 0.74 and 0.85 mg/cm/hr at sexual maturity and at the end of experimental period, respectively for Hisex pullets. The corresponding means were 0.79 and 0.81 mg/cm/hr, respectively, for Shaver pullets.

Variation in calcium absorption per cm length of the small intestine at sexual maturity due to the hen's hybrid were significant ($P<0.05$) (ANOVA table 27).

Dietary calcium level had significant effect ($P<0.001$) on calcium absorption/cm/hr at sexual maturity only (ANOVA table 27). The grand means of the amount of calcium absorption/ cm intestinal length/hr were 0.69; 0.80 and 0.80 mg/hr at sexual maturity while it mounted 0.83; 0.79 and 0.86 mg/cm/hr at the end of experimental period for pullets fed diet containing 3.5; 4.5 and 5.5% calcium, respectively. These results indicated that pullets fed 5.5% calcium level had higher rate for calcium absorption per cm length/hr, when compared with the other two dietary calcium levels.

Dietary vitamin D_3 levels had highly significant effect ($P<0.01$) on the rate of calcium absorption/cm length/hr at sexual maturity only (ANOVA table 27). These results disagree with the finding of Radwan (1990) who reported that there were no significant effects on the amount of calcium absorption per cm of small intestinal length per hour due to dietary vitamin D levels.

Highly significant variation ($P<0.001$) were found in calcium absorption/cm/hr due to different intestinal parts (ANOVA table 27). The grand means of calcium absorption/cm/hr at sexual maturity through duodenum, jejunum and ileum were 0.77; 0.55 and 0.97 mg/cm/hr at sexual maturity, respectively. The corresponding values were 0.83; 0.55 and 1.10 mg/hr, respectively at the end of the experimental period.

Interactions between all factors studied were insignificant except between Hybrid × Intestinal parts and calcium×intestinal part at sexual maturity and between calcium × vitamin D at the end of the experimental period (ANOVA table 27).

4. 14. 3. Absorption per g dry matter per hr:

Table (26) showed the rate of calcium absorption through the different intestinal parts (measured as mg/g dry matter/hr). The rate of calcium absorption per g dry matter per hr through the intestinal parts were obviously high in Hisex pullets and mounted 13.70 and 14.28 mg/g/hr at sexual maturity and at the end of experiment, respectively. It was found to be 14.0; and 12.28 mg/g/hr) at sexual maturity and at the end of experimental period, respectively for Shaver pullets. Variations between the two hybrids were highly significant ($P<0.001$) (ANOVA table 27). This result agree with the finding of El-Sayed (1995).

The grand means of the amount of calcium absorbed/g dry matter were 11.72; 16.39 and 13.59 mg/g/hr for hens received 3.5; 4.5 and 5.5% dietary calcium at sexual maturity, respectively. The corresponding values at the end of the experimental period were 12.22; 14.16 and 13.21 mg/g/hr; respectively. Analysis of variance showed that these results were highly significant ($P<0.001$) at sexual maturity, while were insignificant at the end of the experiment period.

These results disagree with finding of El-Gendi (1989) and Radwan et al., (1990) they reported that calcium absorption per g was not significantly affected by calcium level.

Dietary vitamin D_3 levels had significant effect on the amount of calcium absorption/g/hr at sexual maturity. Hens receiving 800, 1200 and 1600 I.U vitamin D had a values of 13.01, 15.16 and 13.53 mg calcium absorbed per g dry matter per hour, respectively at sexual maturity, while it were 14.23; 13.16 and 12.20 mg/g/hr, respectively, at the end of the experimental period. These results agree with the finding of Radwan et al., (1990) who reported that calcium absorption/g dry matter was significantly affected with the levels of vitamin D.

Calcium absorption per g dry matter of ileum was relatively higher than that of either duodenum or jejunum. This was quite true in all experimental groups. The least square means for calcium absorption per g dry matter per hour were 11.79; 10.80 and 19.12 mg/g/hr for duodenum; jejunum and ileum, respectively, at sexual maturity, while it was 11.46; 8.93 and 19.20 mg/g/hr for the same parts, respectively at the end of the experimental period. Similar results were observed by Radwan (1980); El-Gendi (1985) and El-Sayed (1995).

Highly significant variation ($P<0.001$) were found in the rate of calcium absorption due to different intestinal parts (ANOVA table 27).

Interactions between Hybrid×dietary calcium level and calcium with either vitamin D or intestinal parts had significant effects on the rate of calcium absorbed/g dry matter/hr at sexual maturity and at the end of the experimental period (ANOVA table 27)

Table (26) Least square means and standard error for calcium absorption of different experimental groups.

Item	Total calcium absorption mg/hr at		Calcium absorption mg/cm		Calcium absorption mg/g dry matter	
	Sexual maturity	The end of the experiment	At sexual maturity	At the end of the experiment	At sexual maturity	At the end of the experiment
Hybrid						
Hisex	20.1±0.31 a	19.9±0.47 a	0.74±0.01 a	0.85±0.02 a	13.7±0.42 a	14.28±0.49 a
Shaver	20.5±0.31 a	20.5±0.47 a	0.79±0.01 b	0.81±0.02 a	14.0±0.42 a	12.28±0.49 b
Calcium						
3.5%	19.8±0.38 a	20.0±0.57 a	0.69±0.02 a	0.83±0.02 a	11.72±0.51 a	12.22±0.60 a
4.5%	20.4±0.38 a	21.1±0.57 a	0.80±0.02 b	0.79±0.02 a	16.39±0.51 b	14.16±0.60 a
5.5%	20.8±0.38 a	19.6±0.57 a	0.80±0.02 b	0.86±0.02 a	13.59±0.51 c	13.21±0.60 a
Vitamin D3						
800 I.U.	20.0±0.38 a	19.7±0.57 a	0.71±0.02 a	0.85±0.02 a	13.01±0.51 a	14.23±0.60 a
1200 I.U.	20.1±0.38 a	20.2±0.57 a	0.78±0.02 b	0.82±0.02 a	15.16±0.51 b	13.16±0.60 a
1600 I.U.	21.8±0.38 b	20.8±0.57 a	0.81±0.02 b	0.81±0.02 a	13.53±0.51 a	12.20±0.60 a
Intestinal part						
duodenum	14.1±0.38 a	14.0±0.57 a	0.77±0.02 a	0.83±0.02 a	11.79±0.51 a	11.46±0.60 a
jejunum	23.1±0.38 b	21.6±0.57 b	0.55±0.02 b	0.55±0.02 b	10.80±0.51 b	8.93±0.60 b
ileum	23.7±0.38 b	24.1±20.57 c	0.97±0.02 c	1.10±0.02 c	19.12±0.51 c	19.20±0.60 c

+Means with the same letters in each column are not significantly different.

Table (27): Analysis of variance for data presented in table (26)

S.O.V.	d.f.	F-ratio					
		Total calcium absorption at		Absorption/cm at		Absorption/g dry matter at	
		Sexual maturity	The end of experiment	Sexual maturity	The end of experiment	Sexual maturity	The end of experiment
Hybrid (B)	1	0.747	0.897	4.521*	2.067	0.249	9.572**
Calcium (C)	2	1.673	1.749	8.454***	1.561	20.596***	2.574
Vitamin (V)	2	3.207*	0.883	5.332**	0.808	4.697**	2.825
Part (p)	2	197.951***	64.788***	89.618***	115.441***	77.029***	78.006***
B × C	2	1.286	2.012	12.104*	1.217	20.707***	0.950
B × V	2	0.506	0.475	0.999	0.325	0.596	0.241
B × P	2	0.557	0.569	5.678**	1.301	1.807	1.747
C × V	4	6.406***	2.340	1.566	3.964**	1.890	5.674***
C × P	4	1.017	1.250	2.788*	1.438	6.674***	1.509
V × P	4	0.513	2.140	1.803	0.899	1.720	1.319
Remainder	190						
Remainder MS		10.465	24.157	0.0356	0.0473	19.295	26.439

* $P<0.05$ ** $P<0.01$ *** $P<0.001$

From the previously mentioned results it could be concluded that ileum is the main site of calcium absorption since the amount of total calcium absorption and the rate of calcium absorption per 1 cm length and per 1 g dry matter were found to be higher in ileum portion when compared to the other two portions of the small intestine (duodenum and jejunum). This may be due to the relative higher number of villi found in ileum when compared with those in either duodenum or jejunum. These results agree with those of Radwan (1980); El-Gendi (1989) and El-Sayed (1995). They found that, the total calcium absorption varied significantly between different intestinal parts, being at a maximum in the ileum, jejunum and minimum in the duodenum.

Vitamin D and cortisol influence calcium transport by action on the permeability of cell surface to calcium (Harrison and Helenc, 1960 and Wasserman and Taylor, 1969). They stated that the main sites of vitamin D action on calcium and phosphate absorption were duodenum and upper Jejunum, respectively.