Alexandria Journal of Veterinary Sciences 2015, 46: 48-56
ISSN 1110-2047, www.alexjvs.com
DOI: 10.5455/ajvs.189814

Effect of weaning age and housing model on feed intake, growth performance, hemato-biochemical parameters and economic efficiency of post weaning New Zealand White rabbits

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Key words

Rabbits, weaning age, blood parameters, growth performance, welfare.

ABSTRACT:

The objective of this study was to evaluate the effect of different weaning times (at 25th, 30th and 35th day of age) and different housing models on feed intake, growth performance, some biochemical constituents, hematological parameters and economic efficiency of growing New Zealand White rabbits. One hundred and twenty New Zealand White rabbits were taken from multiparous does at the weaning age of 25, 30 and 35 days. They were allocated into six groups of 20 rabbits each (10 males and10 females) of similar body weight. Rabbits were housed in two different housing models with different environmental conditions (Building A and B).

The results showed that, rabbits that have been reared in building A have significantly higher final body weight than those reared in building B. There was a significant difference ($p<0.05$) for feed conversation ratio at the weaning age of 35 and 30 days. Plasma total protein, albumin, cholesterol, triglycerides, glucose and RBCs/ lymphocyte ratio were significantly increased ($P<0.05$) with increasing weaning age, while globulin was not significantly affected ($P>0.05$). White blood cells were significantly ($P<0.05$) decreased with increasing weaning age. The best value of relative revenue was found in the rabbits weaned at 35 days of age and reared in building A (1.53), followed by those weaned at 35 days of age and reared in building B (1.51), but the poorest value was recorded for those weaned at 25 days of age in both housing models (1.41).

In conclusion, housing conditions could affect growth performance of intensive rabbit production. While, late weaned rabbits (at 35 days of age) have reduced mortality rate, improved growth performance, economic efficiency and welfare under Egyptian environmental conditions.

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1. INTRODUCTION

The transition from nursing to pellet feed could be associated with considerable changes in the physiology of the digestive tract in early weaned rabbits (Padilha *et al.*, 1995; Piattoni *et al.*, 1995; Kovăcs *et al.*, 2008). It was noticed that, digestive enzymes of rabbits weaned between the 30th and 35th day of age are not fully developed (Gidenne and Fortun-Lamothe, 2002) and some nutrients pass undigested through the intestine into the caecum, where the microflora has recently colonized after the age of 14 days. With age, the number of bacteria gradually increases and reaches a steady level at weaning (Bennegadi *et al.*, 2003). Weaning is usually carried out between 28 and 35 days of age. Early weaning of rabbits would enable the provision of a diet suitable for young rabbits' requirements and limit the transmission of pathogenic agents between the mother and young rabbits. Kits begin to consume limited amounts of solid feed at 18 to 20 days of age (Maertens and de Groote, 1990; Scapinello *et al.*, 1999), then the microflora begins caecal colonization and fermentation develops soon afterwards (Gidenne, 1997), and some of the enzymatic digestive activities show important changes (Marounek *et al.*, 1995). Early weaning also reduces the incidence of digestive disorders and reduces pathogen transmission by limiting contacts between litters and does (Schlolaut, 1988).

Housing systems should be efficient in environmental thermoregulation to insure better rearing through good biological performance, thus high economic return. Housing livestock is designed to suit the prevailing climatic conditions, bearing in mind the availability and cost of materials and local construction worker's skills (Owen, 1994). Thermal stress would negatively influence animal welfare and productivity. Therefore this study aimed to investigate the effect of different weaning times (at 25th, 30th and 35th day of age) and different housing models on feed intake, growth performance, some blood biochemical constituents, hematological parameters and economic efficiency of growing New Zealand White rabbits.

2. MATERIALS AND METHODS

This study was carried out at Sakha Station rabbit farm, Animal Production Research Institute, Agriculture Research Center, Egypt, from March to July 2014.

For the purpose of this study, 120 New Zealand White rabbits were taken from multiparous does at the weaning age of 25, 30 and 35 days. They were allocated into six groups of 20 rabbits each (10 males and10 females) of similar body weight. Rabbits were housed in two different housing models with different environmental conditions (Building A and B) as shown in table 1. Building A was an open window with ventilator fans and the wall height was about 5 m. The floor was designed to have gradient, which permit get rid of water immediately and reduce air humidity of the building. The building was roofed by asbestos. Whereas, building B was an open window without ventilator fans and the wall height was about 2 m. The floor has not any gradient, which need handling to get rid of water every morning, so the air humidity of the building was slightly high. The building was roofed by 12 cm thick reinforced concrete. Ambient temperature and relative humidity were recorded daily (table 2).

Rabbits were housed in individual galvanized wire flat deck batteries (60 x 50 x 35 cm) with fodder and automatic nipple drinkers. The batteries were arranged in rows in a naturally ventilated house. A cycle of 16 hours of light and 8 hours of dark were used throughout the experiment. All rabbits were kept under the same managerial conditions. Feed and water were offered *ad libitum* throughout the experiment (5 to 13 weeks of age).

The diet was formulated to provide all essential nutrient requirements for growing rabbits according to De Blas and Mateos (1998). The diet was composed of 17.36% crude protein, 12.37% crude fiber, 2.23% ether extract and 2412 k cal/ kg digestible energy. Live body weight, feed intake and number of dead rabbits were recorded for all groups at the same age (5th -13th weeks). Daily weight gain, feed conversion ratio and mortality rate were calculated. The economic efficiency was calculated according to Raya *et al.* (1991). In addition, relative growth rate and performance index were calculated on a group basis:

Relative growth rate = [(W2 - W1) x100]/ [1/2 (W2+W1)]

Where: W1= the initial weight, and W2 = the final body weight

Performance index = (final live body weight (kg)/ feed conversion ratio) x 100 (North, 1981)

Blood samples were taken from six rabbits of each treatment group from marginal ear vein to determine some biochemical constituents at 13 weeks of age. From each rabbit, 2 ml blood was aspirated in EDTA vacuum tubes. Blood was centrifuged at 2500 rpm for 10 m for plasma separation (Burnett *et al.*, 2006).

Plasma was stored at -20 Ċ until used for assaying of total protein, albumin, glucose, triglycerides, cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), AST (aspartate aminotransferase), ALT (alanine aminotransferase), creatinine and urea were calorimetrically determined by using commercial kits (Bio-Diagonosis Co., Cairo, Egypt), following the same steps as described by manufacturers. Globulin values were calculated by difference.

For hematological parameters, six blood samples were taken at 13 weeks of age in EDTA vacuum tubes (1 ml). Blood samples were tested within 2 hrs. after collection for determination of blood picture including, red blood cells count (RBCs, $10^6/mm^3$), white blood cells count (WBCs, $10^3/mm^3$), differential of white blood cells count (lymphocytes, heterophils, monocytes, eosinophils, and basophils percentages), hemoglobin (Hb, g/dl) concentration, PCV, MCV, MCH and MCHC according to Drew et al. (2004).

Table 1. Experimental design.

Building	A			B		
Weaning age (days)	25	30	35	25	30	35
No. of rabbits	20	20	20	20	20	20

Table 2. Weekly means of ambient temperature (°C) and relative humidity (%) during the experimental period.

Weeks	Ambient temperature (°C)		Relative humidity (%)	
	Building A	Building B	Building A	Building B
1	24.5±2.0	27.0±1.8	66.0±4.3	71.5±4.1
2	23.0±2.2	26.5±2.1	68.0±4.3	73.0±4.2
3	22.0±2.2	25.0±2.0	69.0±4.6	74.0±4.4
4	26.5±2.4	29.0±2.3	69.5±4.0	75.0±3.8
5	28.0±2.4	30.0±2.5	73.0±4.7	78.0±4.8
6	28.5±2.5	30.5±2.5	74.5±4.6	77.5±4.7
7	27.0±2.6	28.0±2.7	71.0±5.0	76.0±5.1
8	26.0±2.6	29.0±2.6	70.5±5.2	75.0±5.1
Mean	25.7±2.4	28.1±2.3	70.6±4.6	75.0±4.5

Data were tested for distribution normality, linearity and homogeneity of variance. Data were statistically analyzed using two-way analysis of variance (ANOVA) in the General linear Model Program of SAS (2000). Duncan's multiple range test was performed to detect significant differences among means when appropriate. The significance level was set at (P<0.05).

3. RESULTS AND DISCUSSION

3.1. Feed intake and feed conversion ratio:

The effect of weaning age and housing models on feed intake and feed conversion ratio from 5th to 13th weeks of age are presented in table 3. During the first period (5-9 weeks), feed intake (g/ d) increased (P<0.001) from 59.88 g/d for rabbits weaned at 25 days of age to 62.78 g/d for those weaned at 35 days of age. The same trend was found in the second period (9-13 weeks of age). The highest value of feed intake was found in rabbits weaned at 35 days of age, while the lowest value was in those weaned at 25 days of age (105.4 *vs.* 101.2 g; P<0.001). During the whole period (5-13 weeks of age), feed intake was significantly increased (P<0.001) with increasing weaning age. Feed intake was higher in rabbits weaned at 35 days of age than those weaned at 25 and 30 days of age by 4.2% and 1.6%, respectively. On the other hand, feed intake was significantly higher in rabbits reared at building A than those reared at building B in the three periods.

During the first period (5-9 weeks of age), the best feed conversion ratio was observed for rabbits weaned at 35 days of age, while the worst value was recorded for those weaned at 25 days of age. No significant differences among treatments in the second period (9-13 weeks of age) were observed. During the whole experimental period (5-13 weeks of age), feed conversion ratio showed significant differences (P<0.01), where rabbits weaned at 30 and 35 days of age recorded the best values, while those weaned at 25 days of age recorded the poorest values (3.144 and 3.077 vs. 3.228, respectively). These differences may be due to the increase in daily weight gain. However, no significant differences in feed conversion ratio could be observed due to building type (A and B) in the three periods. The interaction between weaning age and housing model was not significant in feed conversion ratio. This was in accordance with data observed by Gallois *et al.* (2004). Moreover, Kovács *et al.* (2008) observed that late rabbits weaned (35 days of age) significantly increased daily feed intake, as compared with those weaned at 21 and 28 days of age.

3.2. Growth performance

3.2.1. Final body weight and daily weight gain

The effect of weaning age and housing models on growth performance from 5th to 13th weeks of age is presented in table 3. It is clearly shown that rabbits reared in building A had significantly (P<0.05) higher final body weight than those reared in building B. Rabbits weaned at 35 days of age have significantly high final body weight (P<0.001) than others weaned at25 and 30 days of age.

For daily weight gain in the first period (5-9 weeks of age), body weight was significantly increased with increasing weaning age. Rabbits weaned at 35 days of age had significantly higher (P<0.001) daily weight gain than other weaning ages at 25 and 30 days of age (26.61 *vs.* 23.68 and 25.52 g; respectively). The same trend was observed in the second period (9-13 weeks of age). During the whole experimental period (5-13 weeks of age), rabbits weaned at 35 days of age recorded the highest values of daily weight gain, followed by rabbits weaned at 30 days of age, while the lowest values were observed for rabbits weaned at 25 days of age (27.39 and 26.42 *vs.* 25.05 g, $P<0.001$, respectively). On the other hand, no significant differences were observed in daily weight gain between the two models of building (A and B), during the first and second period. While, rabbits reared at building A had significantly ($P<0.05$) higher daily weight gain than those reared at building B from 5 to 13 weeks of age. The interaction between weaning age and housing model was not significant in body weight and daily weight gain. Although the growth rate of early weaned rabbits was relatively more intensive, they showed a delay with regard to the buildup of muscle mass as compared to normally weaned rabbits (Vachkova, 2008). Furthermore, due to the higher mucous surface, corresponding to a higher absorption potential and higher digestive capacity (Gallois *et al.,* 2005).

the results of this study were similar to that by Zita *et al.*, (2012), who found that rabbits weaned at 21 days of age had significantly ($P<0.05$) lower live weight than those weaned at the age of 35 days, but at the end of the experiment they did not find any significant differences between groups.

3.2.2. Relative growth rate and performance index:

Relative growth rate was significantly increased by increasing weaning age during the first period (5-9 weeks of age), while no significant differences among treatments in the second period (9-13 weeks of age) or in the whole experimental period (5 to 13 weeks of age), table 3. There were no significant differences in relative growth rate due to building models (A and B) in the three periods. The interaction between weaning age and housing model was not significant in relative growth rate. The negative effect of early weaning on live weight was also found by Ferguson *et al.* (1997), Gidenne and Fortun-Lamothe (2001, 2003, 2004) and Gallois *et al.* (2003, 2004).

Rabbits weaned at 35 days of age recorded the best performance index, while those weaned at 25 days of age had the worst values (70.6% *vs.* 62.6%; $P<0.001$, respectively). The increase in performance index may not be only due to the increase in the final body weight, but also due to the improvement in the feed conversion ratio. There were no significant differences in performance index between housing models. The interaction between weaning age and housing models was not significant in performance index. According to Gallois *et al.* (2003, 2004) slight solid feed consumption led to the earlier development of digestive tract. On the other hand, Scapinello *et al.* (1999) reported that a lower milk intake in litters of 10 vs. 4 pups stimulated solid feed intake before weaning, but also led to lighter rabbits. Similarly, Xiccato *et al.* (2000) found the worse feed conversion ratio of rabbits weaned at 21 day when compared to that weaned at 32 days of age.

3.2.3. Mortality rate:

The lowest mortality rate was observed in rabbits weaned at 35 days of age compared with those weaned at 25 or 30 days of age (0% *vs.* 10 or 7.5%, $P<0.05$, respectively), table 3. Similar results were found by Gidenne and Fortun-Lamothe (2004) who found higher mortality rate in the early weaned rabbits. These results indicate that a late weaning at the age of 35 days is preferable in order to reduce mortality rate (Lebas, 1993). There were no significant differences in mortality rate due to housing models.

3.3. Biochemical constituents

Blood biochemical constituents of rabbits weaned in different age and reared in different housing models are shown in table 4. Plasma total protein and albumin were significantly increased ($P<0.05$) with increasing weaning age, while globulin was not significantly affected. The higher protein and albumin levels may be explained by the anabolic effect of androgens in males and increased feed intake in both males and females (Burnett *et al.,* 2006). Plasma cholesterol and triglycerides were significantly increased ($P<0.05$ and $P<0.01$, respectively) with increasing rabbits weaning age. Plasma high density lipoprotein (HDL) was significantly higher with late weaned rabbits, at 35 days of age, than those early weaned, at 25 days of age, (42.2 *vs.* 35.2 mg/ dl, respectively). While, plasma low density lipoprotein (LDL) was insignificantly increased with increasing weaning age. The higher cholesterol and triglycerides values may be related to dietary manipulation as female has the tendency to feed slightly larger quantities than male (Kaneko *et al.,* 1997). Plasma glucose was significantly increased ($P<0.01$) by increasing weaning age. Whereas, early weaned rabbits (at 25 days of age) significantly recorded the lowest plasma glucose as compared with those weaned later at 30 and 35 days of age (76.1 vs. 84.8 and 90.9 mg /dl, respectively). This increase in glucose level may be attributed to higher feed intake, improved absorption capacity and health status of late weaned rabbits (Bennegadi *et al.,* 2003).There were no significant differences among treatments in liver function indicators (AST, aspartate aminotransferase and ALT, alanine aminotransferase) or kidney function indicators (urea and creatinine). There was no significant effect due to housing model on all studied biochemical parameters. Likewise, the interaction between weaning age and housing model was not significant in all biochemical parameters.

3.4. Haematological parameters

The haematological values obtained for rabbits of different weaning age and reared under different housing models were presented in table 5. Haemoglobin (Hb) values varied but not significantly among different weaning ages. Values obtained were generally fall within normal range (9.4 -17.4) for rabbits (Ross et al., 1979; Mitruka and Rawnsley, 1997). The PCV percentage was significantly decreased (P<0.01) in early weaning rabbits (at 25 days of age), when compared with those weaned at 30 and 35 days of age. The PCV values for the treatment groups were at the lower level of normal range for rabbits (30.0-50.0), even though significant differences existed among treatment groups. PCV is an index of toxicity and its distribution vary with breeds. Reduction in the concentration of PCV in the blood may suggest the presence of a toxic factor (e.g. haemagglutinin) which had adverse effect on blood formation (Oyawole and Ogunkunle, 1998). This adverse effect usually appears as improper cell destruction, blood loss, and failure of bone marrow production.

Table 3. Effect of weaning age and housing model on growth performance of growing New Zealand White rabbits from 5 to 13 weeks of age.

	Weaning age (days)			**SEM**	**Building**		**SEM**	***P*-value**		
	25	**30**	**35**		**A**	**B**		**W**	**B**	**W x B**
No. of rabbits at 5 weeks of age	40	40	40	-	60	60	-	-	-	-
Final number at 13 weeks of age	36	37	40	-	57	56	-	-	-	-
Initial body weight at weaning (g)	411.1^{C}	516.4^{B}	631.9^{A}	4.780	519.1	520.5	12.36	***	NS	NS
Body weight at 35 days of age (g)	608.9^{B}	616.8^{AB}	631.9^{A}	6.626	621.5	616.8	5.101	*	NS	NS
Final body weight (g)	2009.3^{C}	2095.1^{B}	2165.5^{A}	12.65	2107.5^{A}	2077.7^{B}	12.96	***	*	NS
Daily weight gain (g):										
5-9 weeks	23.68^{C}	25.52^{B}	26.61^{A}	0.373	25.47	25.16	0.328	***	NS	NS
9-13 weeks	26.41^{B}	27.22^{AB}	28.16^{A}	0.487	27.68	26.98	0.321	*	NS	NS
5-13 weeks	25.05^{C}	26.42^{B}	27.39^{A}	0.260	26.57^{A}	26.07^{B}	0.227	***	*	NS
Feed intake (g/d):										
5-9 weeks	59.88^{C}	61.52^{B}	62.78^{A}	0.274	61.93^{A}	60.95^{B}	0.256	***	**	NS
9-13 weeks	101.2^{C}	104.1^{B}	105.4^{A}	0.301	104.2^{A}	103.1^{B}	0.295	***	**	NS
5-13 weeks	80.56^{C}	82.79^{B}	84.10^{A}	0.219	83.07^{A}	82.00^{B}	0.255	***	***	NS
Feed conversion ratio:										
5-9 weeks	2.548^{A}	2.429^{B}	2.371^{B}	0.034	2.451	2.441	0.028	**	NS	NS
9-13 weeks	3.882	3.857	3.773	0.078	3.792	3.879	0.043	NS	NS	NS
5-13 weeks	3.228^{A}	3.144^{B}	3.077^{B}	0.032	3.136	3.158	0.023	**	NS	NS
Relative growth rate:										
5-9 weeks	70.68^{B}	73.46^{A}	74.24^{A}	0.977	73.08	72.62	0.776	*	NS	NS
9-13 weeks	45.14	44.70	44.54	0.785	45.11	44.46	0.515	NS	NS	NS
5-13 weeks	107.2	109.2	109.7	0.877	109.2	108.3	0.697	NS	NS	NS
Performance index (%)	62.6^{C}	67.0^{B}	70.6^{A}	1.026	67.54	66.20	0.874	***	NS	NS
Mortality rate (%)	10^{A}	7.5^{AB}	0^{B}	-	5.0	6.7	-	-	-	-

SEM = Standard error of means, *** : Significant at 0.1% level of probability,
** : Significant at 1% level of probability, * : Significant at 5% level of probability, NS: Non-significant,
$^{A, B, C,}$ Means in the same row with different superscripts are significantly different.

Some hematological values (RBCs, MCV, MCH and MCHC) were not significantly differed among different weaning age of rabbits. There was no significant effect due to housing model on Hb, PCV, RBCs, MCV, MCH and MCHC. The values of haemoglobin, PCV and RBCs were increased in late weaned rabbits, which may be considered as an indicator of better health condition in these rabbits. White blood cells ($x10^3$) were significantly ($P<0.001$) decreased with increasing weaning age. Rabbits weaned early (at 25 days of age) recorded the highest values, while those weaned later (at 35 days of age) had the lowest values (9.58 *vs.* 7.57 $x10^3$/ µl, respectively). Also, white blood cells ($x10^3$) were significantly ($P<0.05$) higher for rabbits reared in building B than those reared in building A. High WBCs count is usually associated with microbial infection, the presence of foreign body or antigen (Ahamefule *et al.*, 2008). The total WBCs count may be increased by 15 to 30% in rabbits that reared under stress conditions (Campbell *et al.*, 2004; Poljičak-Milas *et al.*, 2009).

Table 4. Effect of weaning age and housing model on some biochemical parameters of New Zealand White rabbits.

	Weaning age (days)			SEM	Building		SEM	*P*-value		
	25	30	35		A	B		W	B	W x B
Total protein (g /dl)	6.15^{B}	6.51^{AB}	6.90^{A}	0.153	6.13	6.17	0.158	*	NS	NS
Albumin (g /dl)	3.37^{B}	3.66^{A}	3.81^{A}	0.085	3.37	3.38	0.162	*	NS	NS
Globulin (g /dl)	2.78	2.85	3.09	0.100	2.76	2.79	0.127	NS	NS	NS
Cholesterol (mg /dl):	86.5^{B}	90.9^{AB}	99.6^{A}	2.430	87.3	85.6	2.131	*	NS	NS
HDL	35.2^{B}	38.3^{AB}	42.2^{A}	2.371	34.8	35.5	0.562	*	NS	NS
LDL	51.3	52.6	57.4	2.711	52.5	50.1	3.353	NS	NS	NS
Triglycerides (mg/ dl)	116.6^{B}	119.8^{B}	139.6^{A}	1.885	117.4	115.8	2.124	**	NS	NS
Glucose (mg/ dl)	76.1^{B}	84.8^{A}	90.9^{A}	1.949	76.5	75.8	2.694	**	NS	NS
Kidney function:										
Creatinine (mg/ dl)	1.245	1.304	1.408	0.122	1.221	1.268	0.186	NS	NS	NS
Urea (mg/ dl)	10.60	11.01	11.91	0.674	10.40	10.80	0.942	NS	NS	NS
Liver function:										
AST (U/ml)	42.67	43.50	44.67	1.335	43.00	42.33	1.202	NS	NS	NS
ALT (U/ml)	24.33	25.33	26.17	1.022	24.33	24.33	1.453	NS	NS	NS

SEM = Standard error of means, **: Significant at 1% level of probability, * : Significant at 5% level of probability, NS: Non-significant $^{A, B,}$ Means in the same row with different superscripts are significantly different.

Table 5. Effect of weaning age and housing model on hematological values of New Zealand White rabbits.

	Weaning age (days)			SEM	Building		SEM	*P*- value		
	25	30	35		A	B		W	B	W x B
Hemoglobin (g/ dl)	9.38	9.40	9.65	0.381	9.27	9.69	0.133	NS	NS	NS
PCV [(1)] (%)	31.00^{B}	34.33^{A}	36.83^{A}	0.601	34.61	33.50	0.993	**	NS	NS
RBCs ($x10^6$/ µl)	3.62	6.69	3.62	0.131	3.55	3.73	0.037	NS	NS	NS
MCV[(2)] (fl)	88.00	86.00	84.33	1.476	86.78	85.44	0.997	NS	NS	NS
MCH[(3)] (pg)	22.50	22.92	24.00	0.611	23.39	22.89	0.470	NS	NS	NS
MCHC[(4)] (g/ l)	25.50	26.50	27.50	0.619	26.44	26.56	0.530	NS	NS	NS
WBCs ($x10^3$/ µl)	9.58^{A}	9.09^{A}	7.57^{B}	0.236	8.46^{B}	9.03^{A}	0.311	***	*	NS
Heterophil (%)	53.17	52.50	50.67	1.118	51.89	52.33	0.986	NS	NS	NS
Lymphocyte (%)	39.83^{A}	36.50^{AB}	35.67^{B}	1.335	36.33	38.33	0.943	*	NS	NS
RBCs/ Lymphocyte ratio	0.091^{B}	0.102^{A}	0.102^{A}	0.002	0.098	0.098	0.002	*	NS	NS
Monocyte (%)	4.50	4.00	3.83	0.365	4.33	4.89	0.261	NS	NS	NS
Eosinophil (%)	3.50	3.00	3.00	0.365	2.78^{B}	3.56^{A}	0.222	NS	*	NS
Basophil (%)	0.67	0.50	0.50	0.224	0.56	0.56	0.176	NS	NS	NS

SEM = Standard error of means, *** : Significant at 0.1% level of probability, **: Significant at 1% level of probability, * : Significant at 5% level of probability, NS: Non-significant

$^{A, B, C,}$ Means in the same row with different superscripts are significantly different.

[1] Packed cell volume [2] Mean corpuscular volume [3] Mean Corpuscular Hemoglobin [4] Mean Corpuscular Hemoglobin Concentrations

The heterophil, monocyte, eosinophil, and basophil percentage obtained did not significantly influenced by different weaning age. In addition, there was no significant effect due to housing model on heterophil, monocyte, basophil percentage, except for eosinophil value, which was higher in rabbits reared in building B than those reared in building A. The higher eosinophil count observed in building B may be related to a greater exposure to allergens. Rabbits at the building B were housed in an opened building, with other animal species such as poultry and goats in neighboring buildings. Allergens may therefore transfer and accumulate in the building and predispose to hypersensitivity reactions (Burnett *et al.,* 2006) especially under high environmental temperature and relative humidity. The increase of eosinophil, monocytes and basophils may indicate a lower state of health condition in early weaned rabbits as they are associated with parasitic infestation, chronic inflammation and stress conditions (Benson *et al.*, 1999). Lymphocyte percentage was influenced by weaning age. It was significantly ($P<0.05$) higher in rabbits weaned at 25 days of age than those weaned at 35 days of age. Although the late weaned rabbits (35 d) appear to be less stressed, the highest values of lymphocytes may be due to handling and restraint procedures during blood sampling (Harcourt-Brown, 2002). There was a significant ($P<0.05$) increase in RBCs/lymphocytes ratio with increasing weaning age. In addition, the values of heterophils / lymphocytes (H/ L) ratio for the treatment groups were at level of normal range (33:60) for rabbits (Poljičak-Milas *et al.*, 2009). It was determined that, the RBCs/ lymphocytes ratio and H/L ratio are changed during illness, stress, higher concentration of blood cortisol and due to a redistribution of cells (McLaughlin and Fish, 1994).The interaction between weaning age and housing model was not significant in all hematological values.

3.5. Economic efficiency

Some economical traits were affected by the weaning age and housing models (table 6). Total feed cost was increased by increasing rabbits weaning age, as a result of increasing of feed intake. In addition, selling price was increased by increasing rabbits weaning age. This increase in selling price may not be only due to the increase in average weight gain (kg /head), but also due to the reduction in mortality rate. The same trend was found in the net revenue and relative revenue, which were increased, by increasing rabbits weaning age.

Table 6. Economic impact of weaning age and housing model on 13 weeks New Zealand White rabbits.

	Building A			**Building B**		
	Weaning age (days)			**Weaning age (days)**		
	25	**30**	**35**	**25**	**30**	**35**
Average feed intake (kg /head)	4.549	4.432	4.733	4.474	4.606	4.687
No. of live animals	18	19	20	18	18	20
Total feed intake (kg)	81.882	84.208	94.660	80.532	80.908	93.740
Price /kg diet (L.E.)	2.583	2.583	2.583	2.583	2.583	2.583
Total feed cost (L.E.)	211.5	217.5	244.5	208.0	214.2	242.1
Average weight gain (kg/head)	1.413	1.389	1.546	1.392	1.460	1.521
Total weight gain (kg)	25.434	26.391	30.920	25.056	26.280	30.420
Selling price (L.E.) (1)	508.7	527.8	618.4	501.1	525.6	608.4
Net revenue (L.E.) (2)	297.2	310.3	373.9	293.1	311.4	366.3
Relative revenue (%)	1.41	1.43	1.53	1.41	1.45	1.51

- Other conditions like management are fixed.
- Ingredients price (L.E. per ton) at 2014 were: 3000 barley; 1500 berseem hay; 2000 wheat bran; 4000 soybean meal (44%) ; 250 limestone; 9000 premix; 40000 methionine; 1000 di-calcium phosphate; 1000 molasses; 250 salt; 10000 Anti-coccidia. - Adding 100 L.E. /ton for pelleting.

(1) Price of kg live body weight was 20 L.E.
(2) Net revenue = Selling price – total feed cost.

The best value of relative revenue was found in the rabbits weaned at 35 days of age reared in building A (1.53), followed by those weaned at 35 days of age reared in building B (1.51), but the poorest value was recorded with those weaned at 25 days of age in both types of building (1.41). **Ashour (2001)** studied the effect of three different housing models with different roof materials; concrete roof, double metal sheets with 40 cm apart roof and single metal sheet roof. He found that the feed cost (LE) decreased in model 2 than that in model 1 and 3 by 7.4% and 3.8%, respectively. Likewise, the economic efficiency in model 2 increased than that in model 1 by 14.3%.

4. CONCLUSIONS

We concluded that housing models could affect growth performance of intensive rabbit production. Correspondingly, early weaned (at 25 days of age) rabbits had reduced growth performance and increased mortality. Whereas, late weaned rabbits (at 35 days of age) had reduced mortality, improved growth performance, economic efficiency and welfare under Egyptian environmental conditions.

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