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The Seasonal Egg Production, Quality and Profitability of a Commercial Layer Farm with Different Cage Density in Subtropical Environment

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Abstract: The environmental conditions such as temperature, humidity and cage density in the hen house are the most important factors to provide a profitable egg production. The feed conversion increases, more eggs are produced when the environmental conditions in the hen house are set to provide a thermoneutral zone. The objective of this study is to determine effects of seasonal and cage density differences on profit of a commercial layer farm. This study was carried out for 8 weeks in Summer, 8 weeks in Fall and 8 weeks in Winter at a commercial layer farm in Bursa Province of Turkey. It has 5500 Isa Brown layers on a high-rise cage system. The seasonal production costs and entrepreneurial returns of the layer farm are calculated for each cage density. Significant differences among seasons are observed with different indoor environmental conditions, hen-day egg production, feed consumption, mortality and characteristics of egg quality ($p<0.01$). Feed and labor costs are the most important parts of the production cost. Feed costs change with seasons and cage densities. Feed costs for cages with 5 hens are higher than feed costs for cages with 4 hens. If eggs were sold with classification, the layer farm would gain approximately 10% more income in Summer. The benefit-cost ratios, calculated to determine economic efficiency, reach the highest level for cages with four hens in Fall. In this season, each $1 cost in the egg production brought $1.193 gross return for the layer farm.

Key words: Cost-benefit analysis, egg production, gross return, layer farm, seasonal variations

INTRODUCTION

Principal purpose in egg production facilities is to obtain the highest yield per input as in other commercial production activities. If suitable environmental conditions for laying hens is created for all seasons in the production cycle, the highest yield can be obtained. Laying hens are more sensitive than other animal species to environmental conditions in the hen house. Hence, environmental conditions in the hen house are the most important factors to provide a profitable egg production. If the environmental conditions in the hen house are set to provide a thermoneutral zone, feed conversion increases, more eggs are produced for a definite period and losses through mortality remain on a minimum level. Therefore, the profit of the egg producer increases.

In Turkey, high cage density in extensive production systems is a common practice for the egg industry because it allows for an increase of economic returns per unit of cage area. Worse environmental conditions within laying hen houses is one of the most important consequences of increasing cage density. Higher cage density usually results in increases in temperature, relative humidity and pollutant gases such as carbondioxide (CO_2) and ammonia (NH_3) levels (Estevez, 2002). Some of studies have been indicated that egg production parameters such as egg production, feed consumption and feed conversion in higher cage density are lower than those in lower cage density (Adams and Craig, 1985; Lee and Moss, 1995) but mortality is in higher cage density (Anderson *et al*., 2004; Carey *et al*., 1995). Also, changes in gross return of egg producers due to seasons and cage densities is fairly important.

The aim of this study is to determine the effects of seasonal and cage density differences on profit of egg production which are obtained by measurements for cage densities.

MATERIALS AND METHODS

Description of the study area, data collection and statistical analysis: This study was carried out for

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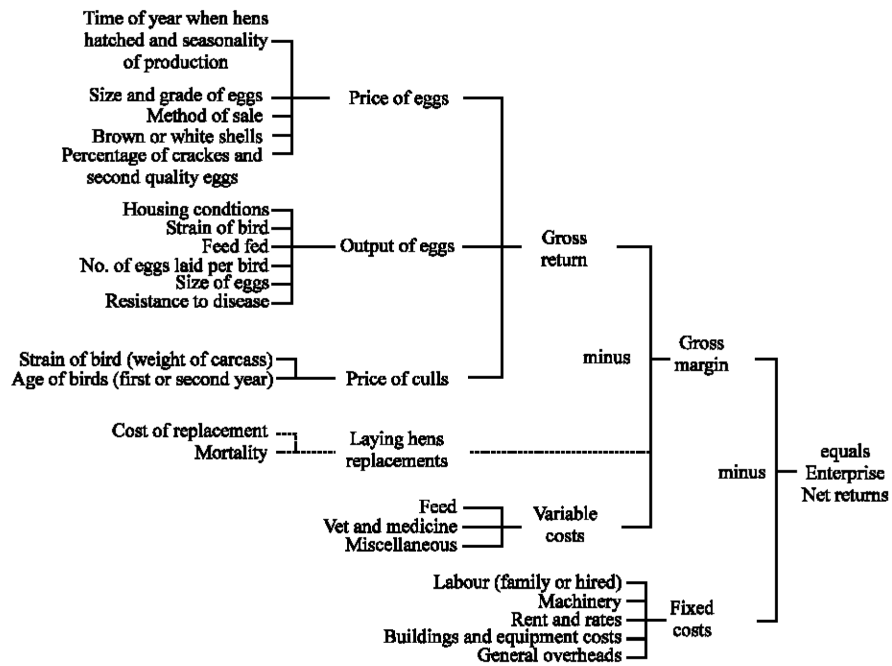

Fig. 1: Gross return and the factors affecting the profitability of a layer farm

8 weeks in Summer, 8 weeks in Fall and 8 weeks in Winter at a commercial layer farm in Bursa Province of Turkey. It has 5500 Isa Brown layers on a high-rise cage system. At the beginning of the study period, the birds were 22 weeks old. In the trial 36 cages, each of which are 50×45×40 cm, were used. About 4 or 5 birds were randomly located to each cage in 5 cage rows in the hen house.

Dead birds in the initial cages were replaced with new birds from other cages in the henhouse. The monitored house is mechanically ventilated. A minimum of 16 h of light per day was provided by natural and artificial light in the house during the laying period. All of the birds received the same feed according to starter, layer grower, pre layer and layer diets.

Indoor temperature and relative humidity in cages were measured in the whole study period to determine the differences between cage densities. Measurements were taken with a multi-function temperature and relative humidity meter with a hot-wire probe (Model 350 XL-454, Testo AG, Germany) for 24 h periods. Performance of the birds was examined daily by measuring the feed intake, feed conversion, egg production and mortality.

Conceptual framework of economic analysis: Figure 1 present culls the groups of production costs and gross output considered in the study design. Secondary return group is the output of cull hens while the main return group in the egg production activities is the output of egg and these return groups constitute the gross return in the layer farm. Gross return of an egg producer depends on the number of eggs, price of an egg, number of cull hens and price of a cull hen. The most important factor that affects the return from egg production is seasonal variations. Hence, an economic analysis is conducted to detect the effects of seasonal variation in this study. It is expected that the gross return of the layer farm differs in Summer, Fall and Winter seasons.

Eggs classified based on grades and sizes have different prices. Different grade eggs may be sold to different customers. Eggs with high quality may be sold to customers willing to pay more for higher quality and eggs with micro-cracks or small blood spots may be sold to bakeries. The examined layer farm does not classify eggs considering their size and quality. However, it is considered that egg prices change with seasons. The strain of layers, housing conditions, feed consumption and number of eggs produced per laying hens, egg size and resistance to disease impact egg production. The prices of culls are affected by the strains of birds (Weight of carcass) and ages of birds (1st or 2nd year). These factors are taken into account to calculate the gross return of the examined layer farm.

Neither fixed nor variable costs contain cost of laying hens replacement and mortality. Both of them are special cost groups that distinguish egg production activities from other production activities. The cost of laying hens replacement is not related to seasonal variation. Thus, the cost of laying hens replacement is neglected in calculating the seasonal profit for examined layer farm.

The feeding cost is calculated with feed consumption amount and seasonal price of feed. Because feed ingredients clearly differ between seasons, seasonal prices of feed was employed in the economic analysis. Also, the vitamin and water costs that change with seasons, are calculated through vitamin and water consumption and their prices. The examined layer farm has one vet and veterinary cost is constant all the seasons. The size of cartons are changed depending on the sizes of eggs. Therefore, carton costs vary between seasons. The cost of manure removal on the manure belt was constant for seasons and it only consists of electricity cost. The labour requirement in hours is multiplied by labour fee per hour to calculate the labour cost. Distribution and delivery costs consist of telephone and transport costs. Cage costs are amortized with an interest rate of 8% per annum for 12 years. Grade, yield and size loss are calculated by considering the deviation from maximum egg production in the season and the price changes. Administration and service costs are found by using working hours and hourly wages. Working capital interest costs are defined as 8% of the average cash balances needed for operating liquidity purposes. Mortality is thought as a part of the production cost for the present study since living laying hens at the other cages are placed instead of dead laying hens in the study.

Statistical analysis: The data were analysed using the General Linear Model (GLM) of Minitab 15. ANOVA was used in data analysis to account for variation in seasons and cage densities for environmental conditions in monitored house, egg production parameters and interior and exterior characteristics of egg quality. ANOVA reduces the within-group error variance and increases statistical power in the study. Significant treatment effects ($p<0.05$) were detected by the LSD test. The results were expressed as means with their standard errors.

RESULTS AND DISCUSSION

Seasonal performance parameters: The indoor environmental conditions and production parameters attained for seasons and cage densities are shown in Table 1. The average indoor temperature in monitored layer house was 15.69, 18.26 and 31.02°C for Winter, Fall and Summer season, respectively. Relative humidity in Winter season (86%) was higher than Fall (57%) and Summer seasons (44%). The differences between indoor temperature and humidity were statisticaly significant for seasons ($p<0.01$). The average daily indoor temperature in the Summer season exceeded the thermoneutral zone for laying hens. Appleby *et al*. (2004) reported that egg production in thermoneutral zone is relatively constant and therefore there is no need for artifical temperature control. The indoor temperature limits in the thermoneutral zone is estimated to be 15-27°C for laying hens. Lindley and Whitaker (1996) stated that hens housed in indoor temperatures between 13 and 24°C produced more jumbo eggs. The highest indoor relative humidity during study is obtained in Winter season due to lower airflow rate to maintain optimum indoor temperature. Seedorf *et al.* (1998) recommended that optimum relative humidity range is 50-90% at 0°C for laying hens. In this study, it is found that the differences between cage densities for indoor temperature and humidity are not significant. The indoor temperature for 5 birds per cage is lower than the expected value due to higher airflow rate at the level of these cages.

The average hen-day egg production for Winter, Fall and Summer season was about 81, 86 and 85%, respectively. Significant differences among seasons are observed for hen-day egg production and feed consumption ($p<0.01$). It is determined that seasonal fluctuations in environmental conditions played a very crucial role on such differences between seasons. Malau-Aduli *et al.* (2003) reported that season had a highly significant effect on egg production ($p<0.01$) and the number of eggs was the highest in the November to January period and lowest during August to October period. In this study, the hen-day egg production in Fall is higher than that in Summer and Winter seasons since, the most of daily average indoor temperatures measured in Fall season are in the thermoneutral zone (Table 1).

Marshaly *et al.* (2004) indicated that hen-day egg production significantly decreased through all 5 weeks for hens exposed to constant hot temperature compared with those in cyclic and control chambers. On the other hand,

Table 1: Seasonal indoor environmental conditions and egg production parameters (X±SE)

Environmental condtions	Temperature (°C)	Humidity (%)	Hen-day egg production (%)	Feed consumption (g/day.hen)	Mortality (%)
Season	**	**	**	**	**
Summer	31.02±0.611[a]	44.20±1.233[c]	84.73±0.310[a]	105.66±0.487[c]	6.80±0.389[a]
Fall	18.26±0.966[b]	56.76±1.950[b]	85.85±0.491[a]	116.34±0.770[b]	3.25±0.389[b]
Winter	15.69±0.683[c]	86.00±1.379[a]	80.99±0.347[b]	122.22±0.545[a]	3.52±0.389[c]
Density	NS	NS	**	NS	**
4	23.39±2.365	61.75±6.096	85.66±0.319	114.62±2.410	4.42±0.318[b]
5	22.86±2.365	61.62±6.096	82.04±0.319	112.63±2.410	4.63±0.318[a]

[a-c]Means with different superscripts for a trait differ ($p<0.05$); **($p<0.01$); NS = Non-Significant

hen-day egg production was not affected by cage density. This results are similar with findings of Bishop (1995). It reported that there were no significant effects of cage density on the 1st and 2nd year of lay for hen-day egg production.

Feed consumption varied from 60-170 g between seasons during the study. The daily average feed consumptions of laying hens in monitored house were about 106 g for Summer season, 122 g for Winter season and 116 g for Fall season. While feed consumption increases significantly in Winter season, it decreases significantly during Summer season ($p<0.01$). This reduction in feed consumption for Summer season may be attributed to unfavourably high indoor temperatures for laying hens. It reveales a decline in feed intake cost of 1.58% 1°C rise in temperature referenced to the intake value at temperatures in the 18-25°C range (NRC, 1981). Bell (1985) reported that feed consumption in the Winter season was higher than Summer and Fall. Hsu *et al.* (1998) indicated that higher indoor temperatures (29-32°C) significantly depressed egg production, feed consumption and egg size. Sterling *et al.* (2003) stated that significant ($p<0.05$) negative linear correlations were found between temperature and feed consumption, body weight gain, egg mass and egg production but not egg weight or body weight. It is determined that cage density did not have a significant effect on feed consumption. The highest feed consumption in this study is recorded in cages with 4 hens. This finding is in agreement with Lee and Moss (1995). In their study, feed consumption per bird is reduced by placing more than one bird per cage. However, Anderson *et al.* (2004) reported that feed consumption of layers was not affected by cage density.

In this study, it is found that season and cage density have a significant effect on mortality ($p<0.01$). The highest mortality value (6.8%) is obtained in Summer season and cage with 5 birds (Table 1). This result reflects that airflow rate in Summer season is inadequate to keep indoor temperature in the thermoneutral zone. The increasing indoor temperature due to insufficient airflow rate causes stress on laying hens and rises mortality in Summer season. Bell (1985) reported that findings obtained for seasons showed important variations in mortality. Malau-Aduli *et al.* (2003) indicated that season had a significant effect on mortality rate ($p<0.05$) and the highest mortality rate was recorded in the period when indoor temperature and humidity reached 36°C and 21%, respectively. The practice of 5 birds per cage tends to have a significantly higher mortality than the practice of four birds per cage ($p<0.01$). On the other hand, Guesdon and Faure (2004) stated that there was no difference in the rate of mortality between the practices of 5 and 6 hens per standard cage.

The effects of season and cage density on egg quality characteristics are presented in Table 2. It is determined in this study that the characteristics of egg quality such as egg weight, shape index, shell thickness, albumen index, yolk index and Haugh unit are significantly influenced ($p<0.01$) by season. The shape index (77%), shell thickness (0.34 mm), albumen index (9.9%), yolk index (47%) and Haugh unit (86) in Summer season are observed higher than those in Fall and Winter seasons. Average egg weight obtained for seasons increased approximately is 9.34 g from Summer season to Winter season. There is a decline in the shape index, shell thickness, albumen index, yolk index and Haugh unit. This decline and the increase in egg weight may be attributed to the age of laying hens and indoor environmental conditions. Egg quality is negatively impacted by hen age (Pandey *et al.*, 1989). Monira *et al.* (2003) reported that age of bird significantly affected egg weight and eggs after a week were more heavy than eggs before a week. The significant differences of egg weights among seasons can fairly influence seasonal income of enterprise. Because, egg prices alter due to egg weight and production season. It is observed in this study that cage density does not have a significant effect on egg quality. These findings of present study match with Bhat and Aggarwal (1989), Saylam *et al.* (1992) and Lee and Moss (1995).

The variations of hen-day egg production for season and cage density are given in Fig. 2. Egg yield per cage increases until the 26th week which is the first production cycle of the production period of laying hens in the Summer season. In the next weeks, it slowly decreases in this season while temperatures reach 33-34°C. It reaches the maximum point together with decreased temperatures in the Fall season. The indoor temperature below the

Table 2: Seasonal differences of characteristics of egg quality (X±SE)

Seasons	Egg weight (g)	Shape index (%)	Shell thickness (mm)	Albumen index (%)	Yolk index (%)	Haugh unit
Summer	57.33 ± 0.359^{c}	77.56 ± 0.457^{a}	0.34 ± 0.005^{a}	9.86 ± 0.203^{a}	47.37 ± 0.492^{a}	86.01 ± 0.955^{a}
Fall	63.74 ± 0.568^{b}	76.98 ± 0.722^{ab}	0.31 ± 0.008^{b}	4.31 ± 0.321^{b}	45.48 ± 0.778^{b}	66.95 ± 1.510^{b}
Winter	66.67 ± 0.402^{a}	75.36 ± 0.510^{b}	0.30 ± 0.006^{b}	3.81 ± 0.227^{b}	45.54 ± 0.550^{b}	64.24 ± 1.067^{b}
Density	NS	NS	NS	NS	NS	NS
4	61.88±1.396	76.54±0.528	0.32±0.007	6.80±0.946	46.32±0.542	75.56±3.403
5	61.89±1.396	76.77±0.528	0.31±0.007	6.50±0.946	46.40±0.542	73.69±3.403

$^{a-c}$Means with different superscripts for a trait differ ($p<0.05$); **($p<0.01$); NS = Non-Significant

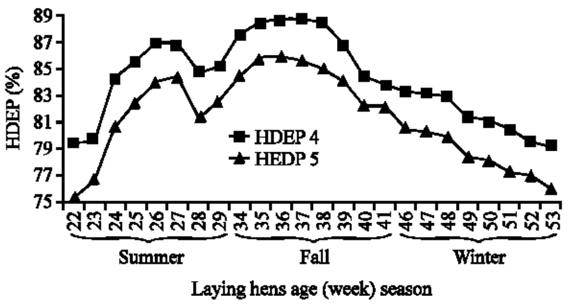

Fig. 2: The variation in Hen-Day Egg Production (HDEP) due to season and cage density

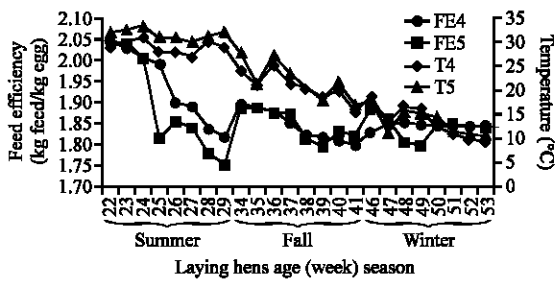

Fig. 3: The variation in Feed Efficiency (FE) and Temperature (T) due to season and cage density

thermoneutral zone causes a decrease in egg yield in the Winter season. Both the aging of birds and critical indoor temperature below 15°C reduce egg yield in Winter (Sainsbury, 1981).

Figure 3 shows the feed efficiency in the seasons, cage densities and indoor temperatures. While it is also stable at a certain level in the fall season, it increases again in with Winter season. An increase in the number of laying hens per cage means a decrease in feeder length per bird. Therefore, feed consumption in the cages with 4 hens is higher than that in the cages with 5 hens. On the other hand, feed conversion rate is higher in the practice of 5 hens per cage than the practice of 4 hens per cage during the study. The feed consumption is less with more laying hens per cage in the whole study period but feed efficiency increases for all seasons.

Seasonal egg production costs: The production costs in a commercial layer farm for seasons and cage densities are illustrated in Table 3. As the seasonal costs of egg production are distinguished in this study, it is necessary to consider varying factors that influence seasonal costs. These factors are feed intake, labour, mortality, carton, lighting, veterinary fee, manure removal, cage amortization, marketing, administer, grade and working capital interest. Feed, vitamin and water, carton grade, yield and size loss of production costs are assumed to be

Table 3: Seasonal costs by cage densities (4 and 5 birds per cage, $)

	Summer		Fall		Winter	
Cost parameters	4	5	4	5	4	5
Feeding	111.54	138.09	145.10	176.80	187.68	221.39
Vitamin and water	2.82	2.82	0.23	0.23	0.46	0.46
Lighting	1.48	1.48	1.73	1.73	1.98	1.98
Veterinary fee	6.56	6.56	6.56	6.56	6.56	6.56
Carton	11.35	14.16	12.17	15.20	13.00	16.23
Manure removal	0.52	0.52	0.52	0.52	0.52	0.52
Labour	60.87	60.87	60.87	60.87	60.87	60.87
Distribution/Delivery	0.50	0.50	0.50	0.50	0.50	0.50
Cage amortization	4.84	6.05	4.84	6.05	4.84	6.05
Grade, yield and size loss	35.26	51.43	42.95	85.81	42.80	76.87
Admin and services	16.40	16.40	16.40	16.40	16.40	16.40
Working cap. interest	6.74	8.21	8.34	10.08	10.54	12.38
Mortality	2.00	3.41	1.31	2.27	0.95	1.76
Total cost ($)	260.88	310.51	301.53	383.01	347.10	421.97

variable for seasons and cage densities. Labour, manure removal, distribution and delivery are not related to time but lighting, cage amortization, working capital interest are changing to some extent with time. The maximum total cost with $422 of monitored layer house was occurred in Winter season for cage density with 5 hens while minimum total cost with $261 was happened in Summer season for cage density with 4 hens.

Feed cost is the largest component of egg production costs and varies widely with both seasons and the number of hens within cages. In addition, the feed cost of experimental cage in monitored layer house ranged from $111 in Summer season for cage density with 4 hens to $221 in Winter season for cage density with 5 hens. The 3 main factors in this variation are temperature, activity and number of laying hens. Within cage, feed consumption per hen generally increases with decreasing cage density. Furthermore, the length of feeder per hen for cages with 4 hens is longer than feeder length per hen for cages with 5 hens. So, feed consumption is higher in the practice of 4 hens per cage than that in the practice of 5 hens per cage. Both lower temperature and higher activity are associated with higher feed consumption by laying hens.

Within the same season, in Summer, Fall and Winter, seasonal feeding cost of 5 hens was 23.8, 21.8 and 18.0% higher when compared to 4 hens, respectively. In this case, it is shown that feeding costs per birds increase with decreasing temperature. To obtain optimum body temperature, hens in cages with 4 hens consume more feed due to the lower temperature. Meanwhile, because hens are closer to each other, they conserve heat and do not need to consume more feed. Thus, the feeding cost of Fall and Winter seasons are respectively 30.1 and 68.3% higher than the feeding cost of Summer in the practice of 4 hens per cage. Also, the feeding cost of Fall and Winter seasons are respectively 28.0 and 60.3% higher than that in the Summer season in the practice of 5 hens per cage.

In brief, feeding costs in lower temperatures in proportion to feeding costs in higher temperatures for cages with 5 hens is less than that for cages with 4 hens. Vitamin cost for the Summer season is higher than that for the Fall and Winter seasons. This is because the vitamins' effects on egg quality were at minimum levels in high temperatures of the Summer season.

Labour is one of the most important cost factors. Labour cost is about $60.87 in each season. In the layer farm, labour cost does not vary seasonally because a worker is employed permanently for all works of the layer farm. Lighting cost also varies due to seasons as it changes depending on the availability and intensity of sunlight. Mortality cost is the highest in the Summer season; it reduces with decreasing temperatures. It is the highest in the practice of 5 hens per cage. Consequently, total cost increase in respect of seasons and the cost of 5 cage density production is higher than the cost of 4 cage density production in all seasons.

Cost-benefit analysis: The costs and returns of the egg productions are given in Table 4. Cost-benefit analysis is performed using the costs of egg productions, prices of eggs and numbers of egg produced. The results show that the highest production cost per egg is in the practice of 5 hens per cage production in the Winter season, which is $0.088. The net returns of egg productions are calculated by subtracting the total costs from the gross returns of the productions. As seen in Table 4, the highest net return ($58.29) is obtained from cages with 4 hens in the Fall season followed by cages with 4 hens in the Winter season. In this study, the benefit-cost ratios (B-C) of the egg productions are calculated by dividing the gross returns by the total costs to determine economic efficiency. The B-C ratios reveal that the highest B-C ratio was in the practice of 4 hens per cage production in the Fall season ($1.19) followed by 4 hens per cage production in the Winter season ($1.12). Also, the lowest B-C ratio was in Summer and the highest ratio was in Fall (Table 4). The reasons for such differences between benefit-cost ratios might be the egg prices, the numbers and weights of cull hens as well as the indoor environmental conditions.

Net return of five hens per cage is 85.1% higher than that of 4 hens per cage production in Summer season and the net returns of the Fall and Winter seasons for 5 hens per cage are 40.56 and 1.36% less than 4 hens per cage. Total cost was at maximum in the Winter season because feed consumption in the Winter season is more than that in other seasons and feed price was different due to changes in feed formula for seasonal hen demand. Also, the gross return was at the peak point for the Winter season. The egg prices are changed due to egg size and lack of eggs for Winter season. Net return per egg and per hen for 4 hens per cage production is at maximum in the Fall season. The highest cost per egg and per dozen is observed in the practice of 5 hens per cage production in the Winter season. Rahn (2001) reported that cost per dozen was $0.754 for 4 birds and $0.770 for 5 birds per cage. It found out that the cost per dozen is quite high all the seasons. The highest cost per hen is the cost of 4 hens per cage production in the Winter season.

In the monitored layer farm, all eggs are sold wholesale with seasonal prices and without being classified. It considered how the gross return would change if eggs were classified based on their weights in this study. Therefore, it performed a cost-benefit analysis with such classification. Returns obtained from each grade of eggs produced by seasons and cage densities are shown in Table 5. Under the circumstances, it estimates that gross return in the Summer season would be approximately 12% higher than that in the other season. Gross return of 4 and 5 cage density productions for Fall season would be about 8.05 and 7.21% higher, respectively, whereas gross returns of 4 and 5 hens per cage productions in the Winter season would be 7.78 and 6.13% higher, respectively. The Benefit-Cost ratio (B-C) reveals that the highest B-C ratio is of 4 hens per cage production in the Fall season.

Table 4: Net return and cost-benefit ratio of the egg production ($)

	Summer		Fall		Winter	
Parameters	4	5	4	5	4	5
Total cost (A)	260.880	310.510	301.530	383.010	347.100	421.970
Gross return (B)	274.570	335.850	359.820	417.660	390.580	464.860
Net return (C = B-A)	13.690	25.340	58.290	34.650	43.480	42.890
Benefit-cost ratio (B:A)	1.052	1.082	1.193	1.090	1.125	1.102
Egg price	0.069	0.069	0.090	0.090	0.097	0.097
Return per egg	0.003	0.005	0.015	0.007	0.011	0.009
Return per dozen	0.042	0.063	0.175	0.090	0.130	0.107
Return per hen	0.190	0.282	0.810	0.385	0.604	0.477
Cost per egg	0.066	0.064	0.076	0.083	0.086	0.088
Cost per dozen	0.791	0.770	0.907	0.993	1.035	1.058
Cost per hen	3.623	3.450	4.188	4.256	4.821	4.689

Table 5: Returns obtained from each grade of eggs produced by seasons and cage densities ($)

	Summer		Fall		Winter	
Grades	4	5	4	5	4	5
Small (45-55 g)	24.06	30.87	-	-	-	-
Medium (55-60 g)	289.24	353.97	36.42	37.13	28.69	31.69
Large (60-65 g)	-	-	211.86	312.84	79.12	140.99
Extra large (65-70 g)	-	-	143.04	100.14	246.07	254.62
Jumbo (70<)	-	-	-	-	69.65	67.92
Gross return with grade (b)	313.29	384.84	391.32	450.11	423.53	495.22
Gross return without grade (B)	274.57	335.85	359.82	417.66	390.58	464.86
Increased return (%)	12.36	12.73	8.05	7.21	7.78	6.13
Total cost (A)	260.88	310.51	301.53	383.01	347.10	421.97
Net return (c = b-A)	52.41	74.33	89.79	67.10	76.43	73.25
Cost benefit ratio (b:A)	1.20	1.24	1.30	1.18	1.22	1.17

-: There is not egg in this grade

CONCLUSION

In this study, data are collected from a layer house in Bursa in Northwest Turkey, during Summer, Fall and Winter. The following conclusions are drawn at the end of this study:

- In a poultry farm, feed and labour costs are the most important parts of the production cost. Feed costs differ between different seasons and cage densities. Feed costs increased with decreasing temperatures in other seasons when compared to Summer. Feed costs for cages with 5 hens are higher than feed costs for cages with 4 hens
- The benefit-cost ratios, calculated to determine economic efficiency, reach the highest level for cages with 4 hens in Fall. In this season, each 1$ cost in the plant return 1.193$ income in the layer farm. Gross return reaches maximum in Winter together with increasing egg prices
- If eggs were sold with classification, the layer farm would gain approximately 10% more income in Summer. The differences among the incomes that would be gained if the eggs were sold with classification and income gained without classification is less in Winter when compared to other seasons
- Significant differences among seasons are observed with different indoor environmental conditions, hen-day egg production, feed consumption, mortality and characteristics of egg quality ($p<0.01$). On the other hand, variation in cage density did not have significant impacts on environmental conditions and egg production parameters

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