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Production and egg quality traits of organic hens in a laying period under commercial conditions in Turkey

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Abstract: The productive performance and egg quality traits of hens in an organic production system in Turkey were executed in this paper. A total of 6000 hens were reared in an organic system for 72 weeks. Two organic certified houses each with a capacity of 3000 hens were used in the study. Mean egg production during the laying period was 303 eggs per hen. Laying rate was 80.24% for 72 weeks, while mortality was 8.85%. The internal and external egg quality traits were determined between 25 and 72 weeks. Mean egg weight was 63.03 g and shell thickness was 0.35 mm. Shape index was significantly decreased with age ($P < 0.01$). Mean shape index value was 76.34%. Shell breaking strength was highest (3.60 kg/cm^2) at peak production and decreased with age ($P < 0.01$). Haugh unit was 98.19 and highest at 25 weeks and significantly decreased with age ($P < 0.01$). Mean Haugh unit was 80.39. Albumen index was highest at 25 weeks and significantly decreased ($P < 0.01$). Conversely, yolk index significantly increased with age ($P < 0.01$).

Key words: Organic egg, organic hen, egg production, egg quality, brown layers, laying rate

1. Introduction

All animal and vegetative tissues are protein sources. Breast milk and eggs are known as "sample proteins" because protein inside these nutrients can convert completely to body proteins. Meat, fish, and milk can convert some of their proteins to body proteins; therefore, they are called "good quality proteins". The digestibility of animal proteins is 91–100%, while this ratio is 79–90% in cereal proteins and 69–90% in legume proteins. An average egg contains 6 g of protein and supplies 11% of an adult's daily protein need [1].

The egg is one of the cheapest and easy reachable protein sources in the world. There is not any culture or religion that inhibits or forbids the consumption of egg. Worldwide egg production was 78 million tons in 2018. Turkey is one of the ten largest egg producers in the world. Total production in 2018 was 1.25 million tons [2].

Since the 1960s, egg production was mostly performed in conventional cage systems. But in these cages the behavior of the hens is restricted, and this welfare issue spurred producers to find alternative systems. Besides noncage systems, free-range systems provide hens access to the outside [3]. On the other hand, there was increasing consumer demand for healthy products in recent decades [4]. The combination of a healthy product and an animal-friendly production system resulted in organic production. A limited number of birds, maximum space, use of an outdoor area, and prohibited use of genetically modified feedstuff and drugs are the advantages of organic production, both for hens and consumers. This could make production more difficult for producers, but in turn the higher income would be an advantage. Today the growth rate of the organic market is still increasing, mostly in the USA and EU [5]. In the EU,5.4% of laying hens were reared in the organic system in 2018 [6]. Denmark (31.1%), Sweden (16.1%), and Germany (12%) have the highest shares of laying hens kept in the organic system in the EU [7]. Turkey produced 161 million organic eggs from 1.2 million hens at 77 certified farms in 2018. This ratio equals to 0.72% of total egg production [2]. Organic egg production increased 60% in 2017, a share of 0.45% [2]. It is expected to increase in the coming years. There is a lack in the literature regarding the performance of hens in the organic system in Turkey. This study recorded the production traits of hens in a certified commercial farm during a laying period. Egg quality traits were also analyzed periodically to determine changes during the laying period.

2. Material and methods

The study was conducted at Yeşil Küre Organic Product located in Bafra, Samsun, Turkey (41°31′9.93N,

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36°0′11.94E) between November 2017 and November 2018. Two different ferroconcrete barns with dimensions of 12×42 m, each containing 3000 hens, were used in the study. The barns were designed according to EU organic production and labeling regulations (No: 889/2008). The products were certificated as organic by CERES certification and the controlling company. Lohmann Brown hens were the animals used in the study. Hens were 18 weeks old at the onset of the production. The pullets were reared in another unit of the same company and transferred to production units at 18 weeks. Organic rice hull was used as litter in the barns. Rice hulls were obtained from another farm of the company. Automatic floor feeding (1 pan for 12 hens) and drinking (1 nipple for 9 hens) line systems were used in the barns. The barns were ventilated via windows, vent stacks, and 2 fans. Sixteen hours of lighting was applied with white bulbs during production. Birds had access to the outdoor area from doors at 4 m for every 100 m² of the building. The total measurement of each building was 504 m², therefore there were 5 outdoor accesses in each building. The outdoor area was 12,000 m² (4 m² per hen) for each building. According to weather conditions, birds had access to the outdoor area for 130 days during the laying period.

2.1. Nutrition

Birds were fed with organic feed during both growing and laying periods. Some of the feedstuff used in the compound diet was grown in the farm's land or bought from an organic certificated company. Feedstuffs were analyzed for determining genetically modified organisms. The compound was mixed in the farm's mill. The laying period feed was based on organic soybean meal, organic corn, and organic bran. The nutritional value of the diets and the periods given are shown in Table 1. Feed and water were given adlibitum.

2.2. Egg production

Eggs were collected daily and recorded for each house. Total egg production was calculated according to the hen/house method. Total egg production and laying percentage were calculated according to the given logarithm. Mean egg production = total egg production in a week/total hens in the house during week. Mortality was also recorded daily for each house and given as the percentage to hen number at the start of the laying period.

2.3. Egg quality traits

From week 25 to 72, 30 eggs from each house for a total of 60 eggs were transferred to the laboratory of the Faculty

Table 1. Nutritional valueand ingredients of diets at different laying periods

	Egg starter diet	Laying period 1	Laying period 2
Periods (weeks)	17–20	21–55	56–72
Calculated values			
ME (Kcal/kg)	2750–2800	2750–2800	2500–2700
Crude Protein (%)	17.5	17	20
Ingredients (%)			
Corn	63.4	58.0	47.4
Soybean meal	14.2	22.0	35.0
Soybean (roasted)	15.0	9.00	5.15
Limestone	4.70	8.2	10.0
DCP	1.60	1.9	1.5
salt	0.25	0.25	0.25
Vit premix*	0.25	0.25	0.25
SodiumBicarbonate	0.20	0.20	0.25
Others**	0.40	0.20	0.20

*Vit premix: Vit A (4000000 IU/kg) , Vit D3 (1000000IU/kg), Vit E (12000 mg/kg),Vit K3 (1600 mg/kg), Vit B1 (800 mg/kg), Riboflavin (2800 mg/kg), Vit B6 (2000 mg/kg), Vit B12 (8 mg/kg), Vit B3 (12000 mg/kg), Vit B5 (4000 mg/kg), Folic acid (320 mg/kg), Biotin (24 mg/kg), CholinChloride (120000 mg/kg), Mn (40000 mg/kg), Fe (24000 mg/kg), Zn (32000 mg/kg), Cu (4000 mg/kg), I (400 mg/kg), Se (80 mg/kg) **Others: Enzyme (Composed of phytase plus carbohydrases) + Health additives (Ammonium format, Formic acid, Ammonium propionate and propionic acid for preventing Salmonella, Campylobacter and E.coli;Bentonite as Mycotoxin binder)

of Agriculture, Department of Animal Science, Ondokuz Mayıs University at 5-week intervals. Egg quality traits were analyzed on a total of 660 eggs to determine changes of quality traits at different ages. The eggs were transferred to the laboratory and then analyzed after 24 h. Egg weight, shape index, shell thickness, shell breaking strength, and shell ratio were determined as external quality traits. Albumen index, Haugh unit, albumen ratio, yolk index, yolk ratio, and yolk color were determined as internal quality traits using methods described by Stadelman [8] and Peebles and McDaniel [9].

2.4. Statistical analyzes

The normality test of the data was analyzed using the Kolmogorov-Smirnov test. The results showed that the data were normally distributed. The homogeneity of variances was analyzed with the Levene test and seen that variances were homogeny. Analysis of data was performed using the randomized block model, and comparison of means were analyzed using Duncan Multiple comparison test. SPSS software was used with an OMU license [10].

3. Results

Some production traits of organic hens during a laying period for two different houses are given in Table 2. Laying started with 3000 hens in both houses. Total mortality at the end of the laying period was 9.20% and 8.50% for two houses, with a mean of 8.85%. Laying started with a mean rate of 2.2% at 19 weeks and was around 75% at the end of 72 weeks. In both houses, egg production per bird was similar, and mean egg production was 303 eggs per bird at 72 weeks. The calculated mean laying rate of two flocks was 80.24% for the whole production period.

Egg quality traits were determined after 25 weeks. Some external egg quality traits are given in Table 3. Mean egg weight was lightest at 25 weeks and increased with age. The shape index was highest at 30 weeks (78.54%) and regularly decreased with age. Shell thickness was thinnest at 25 weeks (0.31 mm), reached 0.37 mm at 30 weeks, regularly decreased until 55 weeks of age, increased until the end of the laying period, and reached the thickest value (0.38 mm) at 72 weeks. The shell to egg weight ratio changed between 11.60% and 13.45%. Shell breaking strength was 2.76 kg/cm^{2}at 25 weeks and reached the maximum (3.60 kg/cm^2) at 45 weeks. The results of some internal egg quality traits are given in Table 4. Albumen (13.99%) and yolk (47.15%) indexes were highest at 25 weeks. Both indexes decreased with age ($P < 0.01$). The Haugh unit was highest at 25 weeks (98.19), regularly decreased with age, and was lowest at 72 weeks (69.65).The albumen ratio was highest at 25 weeks (68.60%) and lowest was at 72 weeks (61.09%, $P < 0.01$). Conversely, the yolk ratio was lowest at 25 weeks (19.80%) and highest at 70 weeks (25.97%, $P < 0.01$). Yolk color was highest at weeks 35 and 40 and lowest at 55 and 60 weeks ($P < 0.01$).

4. Discussion

Flock age at 50% productivity is accepted as the sexual maturity age [11]. Egg production was not given in days; therefore, it is not in the tables. But hens reached 50% productivity at 145 and 146 days in two houses. Similarly, Al-Nasser et al. [12] reported Lohmann Brown hens reach sexual maturity at 147 days. Rearing period practices affected sexual maturity age. Generally, both in organic and conventional production, pullets were reared with the same lighting program. Therefore, birds in organic systems had a similar sexual maturity age to reported conventional system hens. In this study, total egg production (hen-house) at 72 weeks was 303 eggs. Performance data for Lohmann Brown-Classic hens in alternative systems were 311–316 eggs [13]. In a study comparing the production performances of hens in free-range and organic systems in three European countries, Leenstra et al. [14] reported that Lohmann Brown hens produce 239 eggs at 60 weeks in the organic system. Similarly, in our study, egg production was 239 eggs at 60 weeks. On the other hand, the 80.24% mean laying rate of the hens was similar to the results of Türker and Alkan [15], who determined an 81.31% laying rate of Lohmann Brown hens in the free-range system. Also, in different studies, higher laying rates were obtained from Brown layers in free-range or organic production systems. Sardi [16] calculated the laying rate of 84.85% in Isa Brown layers, whereas Baykalır [17] had a rate of 86.16% in the same genotype. These differences could be related to diet, environmental differences, management, etc. We thought that the main reason for the difference between our results and literature findings was flock size. Most of the studies were conducted with a limited number of hens in experimental conditions. This study was in commercial conditions and a total of 6000 hens were used in two different houses. Therefore, it was normal to obtain a little bit lower laying rate in commercial conditions.

In our study, mean mortality of two houses during 19–72 weeks was 8.85%. The result was similar to the report of Burch [18], which showed mortality in organic hens to be 8.68% while it was 9.52% in free-range, 8.55% in barn, and 5.39% in cage flocks. Generally, mortality is lower in intensive systems [19]. There are various reasons for increased mortality affecting birds that had access to outdoors. Disease or parasites is the major reason, followed by cannibalism, panic reactions, outdoor challenges, etc. [20]. Literature findings showed that mortality was higher in a free-range system than in an organic system. This was mostly about better management and lower flock size [18]. In our study, it was concluded that mortality did not occur by cannibalism or disease. Giving birds the opportunity

Table 2. Production traits of organic hens in a laying period

			House 1				House 2	
Weeks	Hen number	Total mortality (%)	Egg / bird	Laying rate (%)	Hen number	Total mortality (%)	Egg / bird	Laying rate (%)
19	3000	-	0.17	2.43	3000	-	0.14	2.00
20	2998	0.07	2.18	28.73	2999	0.03	1.61	21.05
21	2994	0.20	6.40	60.26	2997	0.10	5.90	61.30
22	2989	0.37	12.48	86.89	2995	0.17	11.83	84.66
23	2983	0.57	18.64	87.93	2992	0.27	18.08	89.24
24	2976	0.80	24.93	89.91	2990	0.33	24.51	91.83
25	2970	1.00	31.29	90.91	2985	0.50	30.95	92.13
26	2966	1.13	37.80	92.91	2980	0.67	37.45	92.76
27	2961	1.30	44.27	92.49	2976	0.80	43.88	91.93
28	2956	1.47	50.54	89.60	2976	0.80	50.18	90.01
29	2950	1.67	56.75	88.72	2972	0.93	56.51	90.42
30	2945	1.83	63.02	89.45	2967	1.10	62.79	89.70
31	2931	2.30	69.28	89.49	2958	1.40	69.06	89.54
32	2928	2.40	75.58	90.02	2955	1.50	75.32	89.49
33	2923	2.57	81.88	89.98	2951	1.63	81.61	89.75
34	2915	2.83	88.18	90.08	2947	1.77	87.85	89.15
35	2910	3.00	94.55	90.87	2943	1.90	94.11	89.41
36	2904	3.20	100.90	90.81	2930	2.33	100.39	89.76
37	2904	3.20	107.24	90.52	2926	2.47	106.68	89.88
38	2901	3.30	113.57	90.46	2922	2.60	112.90	88.88
39	2898	3.40	119.89	90.31	2919	2.70	119.19	89.85
40	2896	3.47	126.25	90.86	2903	3.23	125.54	90.74
41	2893	3.57	132.61	90.86	2900	3.33	131.92	91.03
42	2890	3.67	138.94	90.36	2899	3.37	138.24	90.38
43	2888	3.88	145.27	90.47	2896	3.47	144.59	90.62
44	2883	3.90	151.58	90.08	2894	3.53	150.92	90.48
45	2883	3.90	157.88	90.04	2892	3.60	157.12	88.62
46	2881	3.97	164.12	89.21	2890	3.67	163.28	87.94
47	2878	4.07	170.35	88.90	2887	3.77	169.38	87.14
48	2876	4.13	176.46	87.32	2885	3.83	175.35	85.32
49	2871	4.30	182.38	84.54	2879	4.03	181.01	80.83
50	2865	4.50	187.92	79.13	2866	4.47	186.36	76.46
51	2857	0.49	193.26	76.35	2859	4.70	191.66	75.65
52	2856	4.80	198.51	74.93	2858	4.73	196.84	74.03
53	2848	5.07	203.86	76.54	2851	4.97	202.17	76.21
54	2843	5.23	209.38	78.79	2843	5.23	207.62	77.79
55	2836	5.47	214.92	79.14	2839	5.37	213.04	77.39
56	2824	5.87	220.41	78.46	2833	5.57	218.54	78.66
57	2820	6.00	225.61	74.27	2827	5.77	223.80	75.04
58	2820	6.00	230.69	72.59	2821	5.97	228.68	69.73

Table 2. (Continued).

59	2818	6.07	235.65	70.87	2819	6.03	233.63	70.74
60	2812	6.27	240.75	72.80	2819	6.03	238.67	71.96
61	2811	6.30	245.95	74.35	2819	6.03	243.82	73.68
62	2806	6.47	251.15	74.23	2816	6.13	249.39	79.44
63	2802	6.60	256.25	72.81	2814	6.20	254.57	74.02
64	2798	6.73	261.47	74.65	2810	6.33	259.73	73.82
65	2789	7.03	267.00	78.93	2803	6.57	264.95	74.51
66	2778	7.40	272.39	77.03	2792	6.93	270.21	75.16
67	2763	7.90	277.71	76.06	2785	7.17	275.60	76.99
68	2757	8.10	283.18	78.09	2776	7.47	280.95	76.42
69	2749	8.37	288.52	76.29	2767	7.77	286.33	76.88
70	2737	8.77	293.86	76.31	2754	8.20	291.63	75.73
71	2730	9.00	299.12	75.14	2750	8.33	296.91	75.32
72	2724	9.20	304.40	75.47	2745	8.50	302.21	75.77

Table 3. Some external egg quality traits of organic eggs at different ages

Age	N	Egg weight (g)	Shape Index(%)	Shell thickness (mm)	Shell ratio (%)	Shell breaking strength(kg/cm^2)
25	60	58.13± 0.65^{c}	77.87 ± 0.30^{ab}	0.31±0.01^{e}	11.60±0.12^{e}	2.76±0.12^{cd}
30	58	63.31±0.52^{b}	78.54 ± 0.29^{a}	0.37±0.00^{b}	12.45±0.10^{dc}	3.76± 0.11^{a}
35	59	65.44±0.52^{a}	78.04±0.36^{ab}	0.35±0.00^{c}	12.45±0.17^{dc}	3.13 ± 0.13^{bc}
40	57	64.29±0.69^{ab}	77.19 ±0.35^{b}	0.37±0.00^{b}	12.69±0.12^{cb}	3.41 ± 0.10^{ab}
45	59	62.76±0.52^{b}	77.03 ± 0.35^{b}	0.36±0.00^{bc}	13.45±0.19^{a}	3.60 ± 0.12^{a}
50	56	64.45±0.59^{ab}	76.90 ± 0.49^{b}	0.34±0.00^{d}	12.08±0.10^{d}	2.80 ± 0.12^{cd}
55	58	62.71±0.77^{b}	74.59 ±0.36^{c}	0.32±0.01^{e}	12.52±0.15^{dc}	2.26 ± 0.13^{e}
60	57	62.66±0.49^{b}	75.09 ± 0.34^{c}	0.33±0.01^{de}	13.30±0.20^{a}	2.55 ± 0.14^{de}
65	57	62.76±0.71^{b}	74.44 ± 0.35^{c}	0.33±0.00^{d}	12.50±0.17^{dc}	2.43 ± 0.12^{de}
70	56	63.85±0.67^{ab}	75.10 ± 0.42^{c}	0.36±0.00^{bc}	12.48±0.13^{dc}	2.81 ± 0.14^{cd}
72	57	63.19±0.64^{b}	74.95 ± 0.45^{c}	0.38±0.00^{a}	13.02±0.16^{ba}	2.95 ± 0.16^{c}
Overall Mean	634	63.03	76.34	0.35	12.59	2.95

$^{a,-e}$Means with different superscripts along the same column were statistically different ($P < 0.01$)

of free-range mobility could cause damage to and wounds on the body due to materials (woods, trees, fences, etc.) on the ground.

Egg weight is one of the most important quality traits of eggs directly affecting profitability in egg production. Regarding higher costs, egg weight becomes more important in organic production. Nevertheless, some studies showed that egg weight could be higher in cage systems [21,22]. But some studies found eggs to be heavier in free-range or organic systems [23,24]. Under any circumstances, it is important to produce eggs of acceptable marketing weight. In this study, the overall mean egg weight was 63.03 g, and these eggs were classified as large eggs per EU standards [25]. Age is an important factor in egg weight, and it was reported that egg weight increased with age in Brown layers [26].This is mostly related to increased body weight. But in our study, the heaviest eggs were obtained in the first period of laying (20–55 weeks) and egg weight did not increase significantly in the second period of laying. We thought that this was also related to body weight. We did not weigh bodies in the study but having access to the outdoors and increased physical activity could limit

Table 4. Some internal egg quality traits of organic eggs at different ages

Age (weeks)	N	Albumen Index (%)	Albumen ratio (%)	Haugh Unit	Yolk Index (%)	Yolk ratio (%)	Yolk Color
25	60	13.99 ± 0.42^{a}	68.60±0.65^{a}	98.19±0.91^{a}	47.15±0.54^{a}	19.80±0.63^{e}	5.22±0.13^{d}
30	58	12.15 ± 0.30^{b}	65.21±0.60^{b}	92.68±0.93^{b}	43.02±0.40^{b}	22.34±0.60^{cd}	5.57±0.13^{bc}
35	59	9.97 ± 0.22^{c}	64.10±0.58^{cb}	86.44±0.82^{c}	43.43±0.30^{b}	23.45±0.57^{bc}	6.02±0.09^{a}
40	57	9.10 ± 0.27^{d}	62.96±0.70^{dc}	82.67±1.17^{d}	41.42±0.31^{cd}	24.35±0.69^{ba}	6.21±0.10^{a}
45	59	8.53± 0.24^{de}	64.74±0.92^{cb}	80.47±1.08^{de}	40.62±0.37^{d}	21.80±0.90^{d}	5.47±0.12^{bc}
50	56	8.15 ± 0.28^{ef}	62.97±0.71^{dc}	78.25±1.16^{ef}	40.13±0.34^{d}	24.96±0.68^{ba}	5.63±0.11^{b}
55	58	7.60± 0.24^{fg}	63.03±0.87^{dc}	76.57±1.18^{fg}	38.90±0.47^{e}	24.45±0.83^{ba}	4.12±0.13^{f}
60	57	7.38 ± 0.29^{fg}	62.08±0.36^{ed}	74.06±1.75^{gh}	40.46±0.40^{d}	24.62±0.23^{ba}	3.89±0.12^{f}
65	57	6.90 ± 0.31^{gh}	63.42±0.73^{cb}	71.14±1.69^{hı}	42.23±0.68^{bc}	24.09±0.71^{ba}	4.67±0.14^{e}
70	56	7.33 ± 0.32^{gh}	61.55±0.39^{fe}	74.15±1.67^{gh}	40.92±0.37^{d}	25.97±0.36^{a}	5.45±0.12^{bc}
72	57	6.52 ± 0.27^{h}	61.09±0.62^{f}	69.65±1.58^{ı}	41.06±0.42^{cd}	25.90±0.56^{a}	4.72±0.11^{e}
Overall Mean	634	8.87	63.61	80.39	41.76	23.79	5.18

$^{a-e}$Means with different superscripts along the same column were statistically different ($P < 0.01$)

the increase in weight. Related to this, egg weight did not increase with age ($P > 0.05$).

The shape index is important for both incubation and marketing of table eggs. It is expected to be 72–76%, with a 74% shape index determined to be a perfect oval egg shape [11]. The shape index was significantly highest when flocks were younger, and shape index values were over 77% until 45 weeks ($P < 0.01$). This means that eggs were rounder, which could be a problem for the packaging of the eggs. After 45 weeks, shape index decreased and from 55 weeks there were no significant differences between values that were near-perfect egg shape. Similarly, Nikolava and Kocevski [27] showed that younger hens (up to 45 weeks) lay rounder eggs. This is mostly about the anatomical structure, particularly pelvic bone changes of the hen with increased age [28].

Eggshell thickness decreases with age [26]. This is normal because egg mass increases and body calcium reserves decrease. Therefore, the shell becomes thinner. This is common knowledge for cage eggs. But in organic or free-range systems, birds with access to outdoor eggshell thickness could remain constant or increase with age [29]. Also, in our study, shell thickness significantly but slightly decreased until 55 weeks and then started to increase ($P < 0.01$). Various factors affected this increase in eggshell thickness. Diet was changed at 55 weeks, which had higher calcium (3.60% vs. 3.85%). On the other hand, the second period of laying was in the spring and summer months, so the birds spent more time outdoors. They had the chance to consume additional calcium resources on pasture. Shell breaking strength is important for table eggs. The shell strength of eggs was higher in the first laying period (up to 55 weeks) and then decreased. This is mostly about the structure of the shell. The uterine tissue of the hens is damaged with age and decreases the secretion of gonadal hormones. Mineral levels decrease in the uterine tissue and shell quality deteriorates [30]. Our results were in parallel with the findings of previous studies [26,28].

Albumen height is reported to be the most effective internal egg quality trait [31]. It is also important for consumers because albumen height relates to egg freshness [32]. The albumen index is an indicator using albumen height, length, and width. In our study, the albumen index was highest at younger ages and significantly decreased with age ($P < 0.001$). This was an expected result because albumen height decreases and width increases with age [26]. Similarly, previous studies showed that the albumen index decreased with age [23,26,28]. Another important quality indicator using albumen height is the Haugh unit .Egg weight is also used to calculate the Haugh unit. Therefore, changes in the Haugh unit are also related to egg weight. The Haugh unit was the highest at the youngest age (98.19 at 25 weeks) and lowest at the oldest age (69.65 at 72 weeks), and significantly decreased with age ($P < 0.01$). The overall mean value of the Haugh unit was 80.39. According to Turkish standards, eggs that have a Haugh unit higher than 79 are classified as excellent, whereas eggs that have a Haugh unit between 55 and 78 are of good quality [11]. The results of this study showed that the quality of eggs was in perfect or good quality from beginning to the end of production. It is also reported

that eggs produced in the free-range system had a higher Haugh unit than cage systems [23]. But the strain is the most effective factor in the Haugh unit [21]. The albumen ratio of the eggs was highest at 25 weeks and lowest at 70–72 weeks. Conversely, the yolk ratio was lowest at 25 weeks and highest at 70–72 weeks. This was mostly about hen age and egg weight. Similar findings were reported by previous studies [23,26]. Yolk index is another quality trait of eggs and reported to be between 30 and 50 with a mean of 42% for fresh eggs [33]. In this study, the yolk index was highest at 25 weeks (47.15%) and decreased with age. But at all ages, the yolk index value was in the range of a good quality egg. Yolk color is important for consumers, particularly in organic eggs, because there is a demand that organic or free-range eggs have darker yolks [29]. The mean yolk color of the eggs during the production period was 5.18 in our study, which could be qualified as dark yellow. We thought that it was mostly about diet. There was no additive in the feed to affect yolk color. Therefore, yolk color was not as dark as expected.

5. Conclusion

Generally, production systems that had outdoor access are characterized by low productivity. But the results of this study showed that the productive performance of hens in the organic system was similar to cage systems. Birds reached sexual maturity at 21 weeks, and this was an ideal age for outdoor production. Egg quality traits were also in acceptable limits for Brown hens. Shell thickness did not decrease with age, and this is an advance for the marketing of eggs. It can be said that organic egg production has advantages for producers and could be profitable. Increase in the number of organic producers is related to consumer demand. The demand of consumers could increase by the increase of economic income as the prices of organic products are more expensive and by the increase in awareness of organic production.

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