Pakistan J. Zool., vol. 49(1), pp 129-137, 2017. DOI: http://dx.doi.org/10.17582/journal.pjz/2017.49.1.129.137

Effect of Carrot (*Daucus carota*) Leaf Powder on External and Internal Egg Characteristics of Hy-Line White Laying Hens

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Article Information
Received 18 July 2016
Revised 02 August 2016
Accepted 18 August 2016
Available online 10 November 2016

Authors' Contributions
MD, AAD and HC designed the experiments, collected and analysed data, and drafted the manuscript. EE statistically evaluated the data. KK and MMT have provided interpretation of data, drafting and carefully revising the manuscript for intellectual content. All authors read and approved the final manuscript.

Key words
Egg quality, Carrot leaf powder, Hy-line white laying hen, CHAID analysis, Data Mining, Production economics

ABSTRACT

This current work was conducted to determine the effect of dried carrot (*Daucus carota*) leaf powder at different amounts on some external and internal egg characteristics of Hy-line white laying hens as a commercial type through two-way ANOVA, to estimate the Pearson correlation between pairs of egg external and internal characteristics and to predict each of egg internal characteristics from egg external characteristics, treatment and week through CHAID analysis. A total number of eighty, 56 weeks old Hy-Line White laying hens (commercial type) of nearly similar initial body weight (1360.6±14.25 g) were assigned into 5 experimental groups (control group and 4 treatment groups) each including 16 and maintained individually in cages of 35 x 40 x 45 cm. The strongest correlations were found for egg weight-egg width (r=0.910, P<0.01), haugh unit-albumen index (r=0.876, P<0.01), egg weight-egg height (r=0.799, P<0.01), and egg shape index-egg height (r=0.693, P<0.01). ANOVA results revealed that treatment factor influenced only egg height among all the egg characteristics (P<0.05). The effect of treatment by week interaction on all the characteristics was non-significant. The significant differences in other egg characteristics between weeks were recorded except for egg shape index and egg height (P<0.05). Very strongly Pearson coefficient of 0.876 was estimated in egg shape index between predicted and actual values (P<0.01) in the CHAID analysis in comparison with other egg internal characteristics. The Nodes numbered 3, 4, 5, 8, 9 and 12 with the egg shape index of 72-76 in the CHAID analysis illustrated suitable eggs for egg cartons and shipment in poultry industry. As a result, it was determined in the study that CHAID analysis may be used to better prove relationship mechanism between egg quality characteristics which are of great importance for higher price and more income of fertile and table eggs.

INTRODUCTION

Poultry production is one of necessary animal activities not only for fulfilling essential food requirements of people but also for contributing to improving economy of the countries throughout the world. Among the animal products, egg is one of the cheapest protein sources for all consumers and its quality, which is important for higher price of fertile and table eggs, is substantially affected by internal and external egg characteristics (Hanusová *et al*., 2015; Orhan *et al*., 2016). Because of these, more qualified studies on being improved the egg characteristics are fundamental not only for sustainably producing more quality eggs but also for providing food safety in balanced diet for the poultry-based industry (Duru, 2013).

In recent years, use of growth promoters in poultry nutrition has not been given permission as a result of serious health problems encountered in the people. Instead of the detrimental promoters, more interest is growing for utilizing extracts or powder of vegetative parts of medicinal plants, some agricultural and endemic plants as alternative feeding supplements in terms of probiotics, organic acids,

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0030-9923/2017/0001-0129 $ 9.00/0

prebiotics, and essential oils (Kahraman, 2009; Demirözü, 2010). Aromatic and medicinal plants are alternative chiefly to growth promoter as antibiotics, but today they have been researched inadequately (Kutlu, 2007). In this regard, natural plants and agro-industrial by products may submit a good potential to poultry nutritionists.

Some earlier reports have already demonstrated the potential effects of alternative feed supplements in poultry feeding. Among them, Sahin and Duru (2010) evaluated the effect of *Tribulus terrestris* (TT) extract on digestive system and fattening performance of broiler chicks. Duru and Sahin (2012) assessed the potential effect of applying dietary puncture vine (*Tribulus terrestris*) powder together with various carriers on blood parameters, growth performance, and carcass characteristics of broiler chicks (Ross 308). Duru and Sahin (2015) focused on the effect of dietary puncture vine (*Tribulus terrestris*) powder with differential carriers on yield and egg quality in Super Nick white laying hens. Kaya and Yildirim (2011) researched the effect of dried sweet potato vines powder on several egg yield parameters and egg yolk color in hybrid layers (Super Nick). Duru (2013) comprehensively examined the influence of strawberry leaf powder as a supplement on yield, quality and yolk cholesterol in Lohmann Brown laying hens. To produce the better results in poultry feeding, researchers are still investigating new alternative feeding sources, such as lemon, olive, orange, strawberry, endemic plant species or agro-industrial by products of the plants cultivated for food industry (Duru, 2013). For instance, carrot (*Daucus carota*) leaves can possibly be a new feeding supplement in agro-industrial by-product (Hammershøj *et al*., 2010).

The production amount of carrots and turnips was 36.917.246 tons in the year 2012 in the World (FAO Stat, 2014). The carrot production was 557.977 tons in the year 2014 in Turkey (TUIK, 2016). Carrot cultivated all over the world is a root vegetable which is biochemically rich source of minerals, fiber, carbohydrates, antioxidant flavonoids, most of essential micronutrients, and especially beta-carotene (Sharma *et al*., 2012). Carrot leaves which are rich in calcium involve high amount of porphyrins stimulating the pituitary gland, and the leaves cause to the release of enlarged levels of sex hormones and the stimulation of the uterus. Carrot greens have antiseptic qualities and can aid a remedy of kidney disease and edema, heal injuries in the mouth, bad breath, gum bleeding and mouth ulcers and more significantly, the greeks evaluated carrot leaves in order to prevent cancer diseases in traditional medicine. In this regard, few related studies have been conducted in laying hens (Hammershøj *et al*., 2010; Kotrbáček *et al*., 2013; Alp *et al*., 2015). Because, carrot leaves are one of agro-industrial by products that cannot be evaluated in agricultural industry. Evaluation of the carrot leaves as an alternative feed supplement in animal nutrition is important for developing national economy. In poultry literature, much more documented information is still required on the determination of the effect of dried carrot leaf powder on internal and external egg characteristics in laying hens. The current investigation was therefore conducted (i) to determine the effect of dried carrot leaf powder at different amounts on some external and internal egg characteristics of Hy-line white laying hens as a commercial type through two-way ANOVA. We tried to provide evidence of the positive effect of carrot leaf powder on the egg characteristics, (ii) to estimate the Pearson correlation between pairs of egg external and internal characteristics, and (iii) to predict each of egg internal characteristics from egg external characteristics, treatment and week through CHAID analysis. Thus, CHAID analysis generated cut-off values of egg external characteristics, treatment and week in producing the best values for each of egg internal characteristics. The results recorded here are of note in practice for developing egg quality standards of Hy-Line White laying hens in the future.

MATERIALS AND METHODS

The experiment was conducted based on protocols by Mustafa Kemal University, Ethical Commission Report (Date: 30.04.2013 Decision Number: 2013-5/5).

Animals, diets and feeding treatments

A total number of eighty, 56 weeks old Hy-Line White laying hens (commercial type) of almost similar initial body weight (1360.6±14.25 g) were allocated into 5 experimental groups (control group and 4 treatment groups) each including 16 and kept individually in cages sized 35 x 40 x 45 cm.

Carrot (*Daucus carota*) leaves were supplied from the any farm in Kırıkhan / Hatay after fruit harvesting. These leaves were stored and maintained air drying in clean surface without any microbiological contamination and sunshine effect. Carrot leaves were assessed after dried and powdered with 1 mm sieve opening mill. Hens were fed basal diets (commercial) (171 g crude protein and 2817 Kcal ME kg^{-1}) supplement with 0 (control), 1, 2, 4 and 8 g kg^{-1} carrot leaves powder from 56 to 64 weeks age (Table I). Feed were offered limited (100 g/hen) and water were available *ad lib*. Birds were subjected to 16 hours day light, 19-22 °C ambient temperature in poultry house during the experimental period of 8 weeks.

Table I.- Experimental layer diet (Phase I).

Feed Ingredients, %	
Corn	47.8
Full fat soya	17.9
Sunflower meal	9.7
Barley	7
Corn gluten meal	7.6
$CaCO_3$	8.3
DCP (%17.5)	0.9
Methionine&Lysine	0.1
$NaHCO_3$ and NaCl	0.3
Mineral and Vitamin premix*	0.4
Calculated composition	
ME, kcal kg^{-1}	2817
Crude protein, %	17.1
Lysine, %	0.65
Methionine + systine, %	0.57
Ca, %	3
P (available), %	0.7

*Per kg diet included 7000 IU Vitamin A, 2000 IU Vitamin D_3, 15 mg Vitamin E, 2 mg Vitamin K_3, 4 mg Vitamin B_2, 10 mg Vitamin B_{12}, 60 mg Mn, 50 mg Zn, 25 mg Fe, 15 mg Cu, 0.25 mg Co, 1 g Iodine, 0.2 mg Se.

Egg parameters

In the study, 6 eggs for each group were collected biweekly (total 4 times during trial) from laying hens and their external and internal characteristics were determined. Eggs were weighted with a sensitive scale (±1 g) afterwards eggs were found in height and width using a calliper (0.01 mm, Mitutoyo, Japan). Eggs were broken on a flat glass surface for thick and height albumen and yolk. Yolk color was monitored using the Roche color fan (Vuilleumier, 1969). Then eggs yolk was weighted. The weight of the albumen was identified as the difference between the weight of whole egg and the weight of the yolk+weight of the shell.

Shape index, albumen index, yolk index, and Haugh unit were calculated by means of the following formulas:

Shape index = Maximum width (mm) / maximum height (mm) x 100 (Reddy *et al*., 1979),

Albumen index = Albumen height (mm) / [albumen height (mm) + albumen width (mm)] x 100 (Heiman and Carver, 1936),

Yolk index = Yolk height (mm) / yolk diameter (mm) x 100 (Sharp and Powell, 1930),

Haugh unit = 100 log (albumen height (mm) + 7.57 -1.7 x egg weight $(g)^{0.37}$) (Haugh, 1937).

Table II.- Internal and external characteristics of egg and results of descriptive statistics, ANOVA (F values) and Duncan test.

TRT	EW	EH	EWI	YC	ESI	YI	AI	HU
0 (Control)	60.37	57.60^{ab}	43.65	12.50	75.84	41.88	5.083	76.946
1 g	58.35	56.56^{b}	43.16	12.63	76.34	41.44	5.498	79.822
2 g	61.14	58.40^{a}	43.61	12.79	74.79	41.76	5.045	76.563
4 g	59.58	57.58^{ab}	43.27	12.67	75.18	40.20	5.544	79.840
8 g	61.45	58.39^{a}	43.72	12.63	74.97	42.64	5.492	78.977
SEM	1.0244	0.4591	0.2523	0.1498	0.5252	0.6928	0.2187	1.4908
WEEK								
58	61.60^{a}	58.27	43.98^{a}	12.83^{a}	75.53	38.72^{c}	4.377^{b}	71.304^{c}
60	61.81^{a}	57.95	43.86^{a}	12.27^{b}	75.76	43.77^{a}	5.644^{a}	77.450^{b}
62	58.79^{b}	57.57	43.16^{b}	12.87^{a}	75.05	43.38^{a}	5.542^{a}	80.405^{b}
64	58.50^{b}	57.02	42.92^{b}	12.60^{ab}	75.34	40.46^{b}	5.767^{a}	84.559^{a}
SEM	0.9162	0.4106	0.2257	0.1340	0.4697	0.6196	0.1956	1.3334
TRT	1.50^{NS}	2.73*	0.98^{NS}	0.49^{NS}	1.53^{NS}	1.64^{NS}	1.27^{NS}	1.11^{NS}
WEEK	3.74*	1.73^{NS}	5.28**	4.27**	0.40^{NS}	15.16**	10.83**	17.47**
TRT* WEEK int.	0.50^{NS}	0.61^{NS}	0.56^{NS}	0.59^{NS}	1.03^{NS}	0.48^{NS}	0.80^{NS}	0.71^{NS}

AI, Albumen index; EH, Egg height; ESI, Egg shape index; EW, Egg weight; EWI, Egg width; HU,Haugh units; TRT, Treatment; YC, Yolk color; YI, Yolk index; NS, Non-significant.
*P<0.05, **P<0.01
a, b: Averages with the same letter in a column are not significantly different for treatment and week main factors (P<0.05).

Statistical analysis

Firstly, descriptive statistics of egg internal (yolk height, albumen height, yolk color, egg shape index, yolk index, albumen index and haugh unit) and external characteristics (egg weight, egg height and egg width) were given as the least squares mean ± SE here. Secondly, two-way ANOVA (in the Factorial Design) has been used for testing hypotheses of treatment, week, and their interaction effects (Khan *et al*., 2014; Karaca *et al*., 2016). Thirdly, mean separation was obtained via Duncan test. Fourthly, Pearson correlation coefficient between pairs of egg internal and external characteristics was estimated (Orhan *et al*., 2016). It is easier to measure egg external characteristics compared to egg internal ones in regression analysis. Therefore, we fifthly targeted in the study to predict each of egg internal characteristics (dependent variables) from egg external characteristics (egg weight, egg height and egg width), treatment and week through the tree-based CHAID analysis. The non-parametric analysis technique assigns cut-off values of independent variables (egg external characteristics) that generate optimal results in dependent variables (egg internal characteristics) (Akin *et al*., 2016).

Egg external characteristics, treatment and week were independent variables in CHAID analysis, a non-parametric method. But, a treatment factor that was found non-significant was excluded in the CHAID analysis. Pearson correlation coefficient between predicted and actual variables was estimated as a predictive capability of the CHAID analysis for each of the egg internal characteristics (Ali *et al*., 2015). Bonferroni adjustment was made to derive adjusted P values in CHAID analysis. All statistical calculations were carried out through IBM SPSS ver.23.

RESULTS AND DISCUSSION

Results of descriptive statistics (least square means), ANOVA (F values) and Duncan test of the egg external and internal characteristics in laying hens are summarized in Table II. ANOVA results showed that treatment factor influenced only egg height among all the egg characteristics (P<0.05). No significant effect of treatment by week interaction on all the characteristics was found. When Table II was examined, the differences in egg shape index and egg height between weeks were found insignificantly (P>0.05). Sarica and Erensayin (2009) informed that a normal standard egg has between 72 and 76 in egg shape index. Egg shape index values for all the treatments tested in the study were within the interval reported by the authors. Our egg shape index values were found lower compared to those of Artan and Durmus (2015) for eggs produced in village, free range and cage systems. Similarly, Duru (2013) also recorded lower egg shape index values. Our present albumen index values were within values of Artan and Durmus (2015) (4.95-5.88) but lower than those declared by Duru (2013) (5.70-6.16). Although there were no significant differences in haugh unit among all the treatments, the 1 g carrot leaf powder group and 4 g carrot leaf powder group treatments produced haugh unit greater than 79, accepted as a marvelous quality. Other treatments had a good egg quality, whose haugh unit is between 58 and 78 as also informed by Sarica and Erensayin (2009). Our present findings in yolk index were found within those determined by Duru (2013). Kotrbáček *et al*. (2013) reported higher egg weight (63.8-65.8) and much lower yolk color (4.1-6.1), compared to the related values showed in Table II.

Pearson correlation coefficients between pairs of the characteristics are depicted in Table III. In line with the correlation of Alkan *et al*. (2013), we found the strongest correlation between egg weight and egg width (r=0.910, P<0.01). The strongest correlation between albumen index and haugh unit was estimated positively (r=0.876, P<0.01), which was in agreement with that informed by Sarica *et al*. (2012). Hanusová *et al*. (2015) highlighted that egg weight was genetically correlated with most important components like shell, albumen and yolk. The high correlation of 0.799 was obtained positively for the pair of egg height and egg weight (P<0.01). Egg height was positively correlated with egg width (r=0.533, P<0.01), which was in nearly agreement with that estimated by Alkan *et al*. (2013) (r=0.569, P<0.01). Egg height was negatively correlated with egg shape index (r= - 0.693, P<0.01), albumen index (r= -0.234, P<0.01), and haugh unit (r=-0.347, P<0.01), respectively, which was in definitely disagreement with the corresponding correlations estimated by Alkan *et al*. (2013) for Guinea Fowl eggs. Egg width was correlated with egg shape index (r=0.239, P<0.01), yolk index (r=0.199, P<0.05), and haugh unit (r=-0.369, P<0.01), respectively.

Aktan (2004) informed that egg weight was positively correlated with albumen quality. Orhan *et al*. (2016) recorded positive significant correlations between egg weight, albumen weight and shell weight. Duman *et al*. (2016) found that egg shape index, a key criterion in the identification of egg quality, was significantly correlated with albumen index (r=0.17, P<0.05) and haugh unit (r=0.24, P<0.05) but it was insignificantly with yolk index (r=-0.10), yolk color (r=0.08), which was in disagreement with those reported in Table III.

In a previous publication, Sarica *et al*. (2012) obtained that egg weight was significantly correlated with albumen index (r=-0.151, P<0.05), haugh unit (r=-0.178, P<0.05),

Table III.- Pearson correlations between pairs of the egg characteristics.

	EW	EH	EWI	YC	ESI	YI	AI
Egg Height (EH)	0.799**						
Egg Width (EWI)	0.910**	0.533**					
Yolk Color (YC)	0.022^{NS}	0.125^{NS}	0.029^{NS}				
Egg Shape Index (ESI)	-0.142^{NS}	-0.693**	0.239**	-0.122^{NS}			
Yolk Index (YI)	0.179^{NS}	0.072^{NS}	0.199*	-0.055^{NS}	0.090^{NS}		
AIbumen Index (AI)	-0.163^{NS}	-0.234**	0.159^{NS}	-0.158^{NS}	0.135^{NS}	0.343**	
Haugh Unit (HU)	-0.363**	-0.347**	0.369**	-0.162^{NS}	0.085^{NS}	0.227*	0.876**

*P<0.05, **P<0.01
For abrreviations, see Table II.

and yolk color(r=0.116, P<0.01), but it was insignificantly correlated with yolk index (r=0.032). Our present findings were not in line with those determined by Sarica *et al*. (2012). But, similar conclusions, were that a weakly correlation between egg shape index and albumen index was reported by Sarica *et al*. (2012) (r=0.087, P<0.01), and by Duman *et al*. (2016) (r=0.17, P<0.05). In disagreement with our finding and Duman *et al*. (2016), Sarica *et al*. (2012) found that egg shape index was correlated with yolk index (r=0.243, P<0.05). Our present findings were not consistent with those documented by Sekeroglu and Altuntas (2009) who found some positive significant correlations for egg weight-yolk index (r=0.283, P<0.01) and egg weight-yolk color (r=0.222, P<0.01). Egg weight can be affected by breed, strain, hen age, feed consumption, and disease (Sekeroglu and Altuntas, 2009). Our correlations between egg weight and egg shape index, yolk index and albumen index were not compatible with those found by Alkan *et al*. (2013). Duman *et al*. (2016) found that there exists a positive significant correlation between egg shape index and haugh unit (r=0.24, P<0.05), which was in disagreement with the present correlation submitted in Table III.

The difference in all the egg quality characteristics may be attributed to species, genotype and age of hen, feeding, oviposition time and rearing systems (Duman *et al*., 2016). It was reported that egg quality in poultry science affected the hatchability of fertile and incubated eggs, and especially chick's development (Obike and Azu, 2012). Yolk index and haugh unit are essential internal characteristics in poultry industry.

In literature, CHAID application has not yet been informed for the prediction of egg internal quality characteristics from egg external characteristics, treatment and week. Results of the CHAID analysis implemented in the prediction of yolk color among egg internal characteristics are depicted in Figure 1. A Pearson coefficient of 0.293 was estimated between predicted and actual yolk color values (P<0.01). This means that more predictive independent variables should be found. Figure 1 showed that only week factor had a statistically significant effect on the yolk color and all the eggs collected from the laying hens were partitioned by week factor into two subsets (Nodes 1 and 2), respectively. Node 1 was a subset of the 90 eggs collected in 58th, 62th and 64th weeks, and had an average of 12.767 (S=0.735) in the yolk color. Node 2 was a subset of the 30 eggs collected in only 60th week with the average of 12.267 (S=0.640). The remarkable difference was detected between both Nodes in yolk color (Adjusted P=0.008).

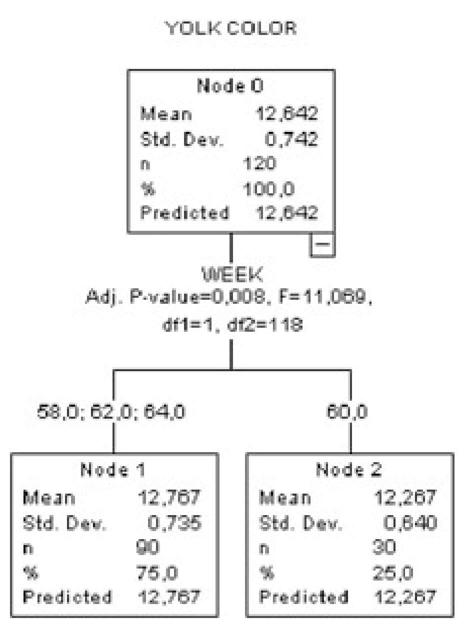

Fig. 1. The decision tree diagram constructed for yolk color.

Results of the CHAID analysis for the prediction of egg shape index were depicted in Figure 2. Very strongly Pearson coefficient of 0.876 was estimated in terms of egg shape index between predicted and actual values (P<0.01), which revealed that the tree based analysis had much higher predictive capability in egg shape index compared to the coefficients estimated for other egg internal characteristics. Average of egg shape index for all the eggs in Node 0 was estimated 75.422 as also seen in Figure 2. Egg shape index was mostly influenced by egg height, followed by egg width (Adj. P = 0.000). All the eggs in the CHAID analysis were partitioned into four subsets (Nodes 1-4) according to egg height, respectively. Node 1 was a subset of 12 eggs with 55.050 mm or shorter in egg height, and had the egg height average of 77.952 (S=2.085). Node 2 was a subset of 48 eggs with 55.050 < egg height ≤57.570 mm.

Node 2 was a subset of 48 eggs with 55.050 < egg height ≤ 57.570 mm, and divided into three new subsets (Nodes 5-7) in egg width, respectively (Adj. P=0.000). Node 5 was a subset of 26 eggs (75.378) whose egg width was 43.150 mm or narrower among 55.050 < egg height ≤ 57.570 mm. In the prediction of egg shape index, Node 6 was a subset of 9 eggs with 43.150 < egg width ≤ 43.850 mm and 55.050 < egg height ≤ 57.570 mm (77.035) and Node 7 was a subset of 13 eggs wider than 43.850 mm among 55.050 < egg height ≤ 57.570 mm (78.779).

Node 3 was a subset of 36 eggs with 57.570 < egg height ≤ 59.760 mm, and divided into three new subsets (Nodes 8-10) in egg width, respectively (Adj. P=0.000). Node 8 was a subset of 12 eggs (73.171) with 43.370 mm or narrower in egg width among the eggs with 57.570 < egg height ≤ 59.760 mm. Node 9 was a subset of 14 eggs with 43.370 < egg width ≤ 44.480 mm and 57.570 < egg height ≤ 59.760 mm with the average egg shape index of 75.357. Node 10 was a subset of 10 eggs wider than 44.480 mm among the eggs with 57.570 < egg height ≤ 59.760 mm with the average egg shape index of 77.027.

As a subset of 24 eggs longer in egg height than 59.760 mm, Node 4 was branched by means of egg width into two subsets (Nodes 11 and 12) with the egg shape index averages of 70.684 and 73.232, respectively. Among the 24 eggs longer than 59.760 mm, 9 eggs were 43.850 mm or narrower in egg width, whereas 15 of the 24 eggs were wider than 43.850 mm in egg width.

Duman *et al*. (2016) mentioned that egg shape index had a significant effect on several egg characteristics. CHAID analysis gave useful information about cut-off values of egg height and width providing normal standards in egg shape index. The normal standard eggs with the egg shape index of 72-76 (Sarica and Erensayin, 2009) were obtained from Nodes 0, 3, 4, 5, 8, 9 and 12, respectively. Average around egg (ESI >76) were obtained with Nodes 1, 2, 6, 7, and 10 respectively. Node 11 averagely produced sharp egg (ESI <72). Round and sharp eggs cannot be suitable for egg cartons and especially they can be easily broken during transportation in comparison with normal (standard) ones (Duman *et al*., 2016). With obtaining suitable eggs, unit cost per egg as well as economic losses of the produced eggs during transportation decrease. These mean that the profitability from egg production increase.

Results of the CHAID analysis for the prediction of yolk index are illustrated in Figure 3. Moderate Pearson coefficient of 0.512 was estimated in yolk index between predicted and actual values (P<0.01). Figure 3 revealed that merely week factor significantly affected on the yolk index and all the eggs taken from the laying hens were classified according to week factor into two subjects

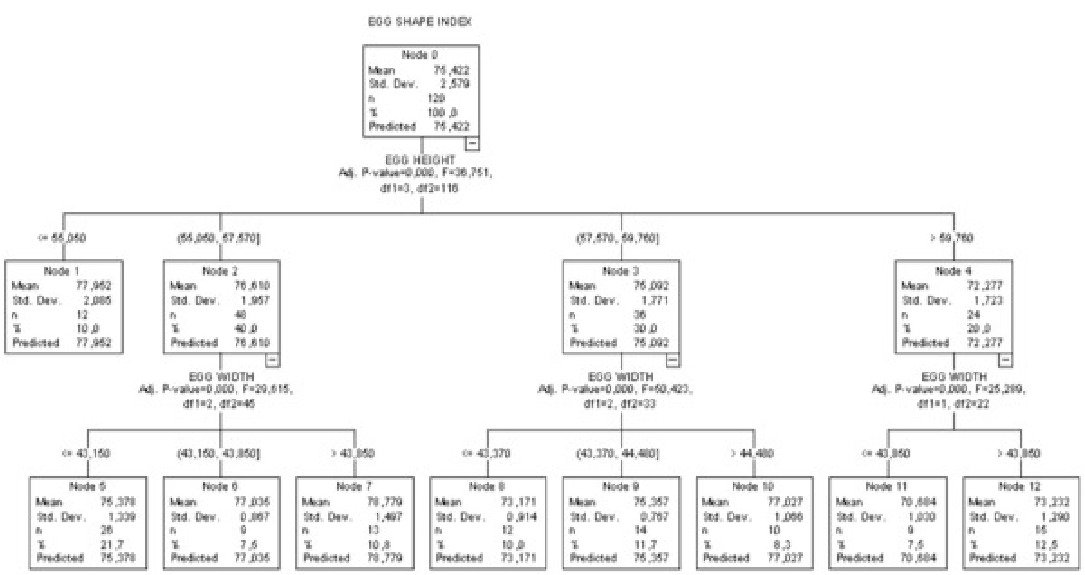

Fig. 2. The decision tree diagram constructed for egg shape index.

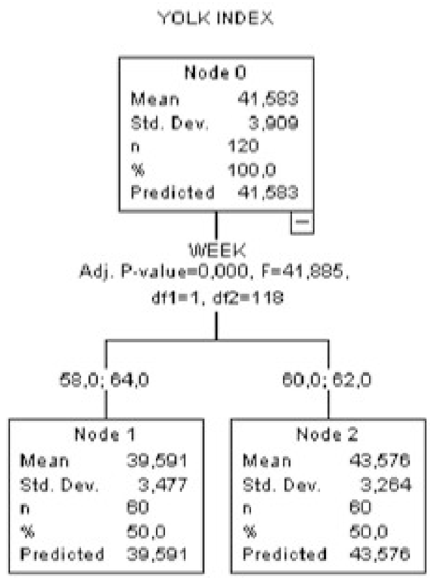

Fig. 3. The decision tree diagram constructed for yolk index.

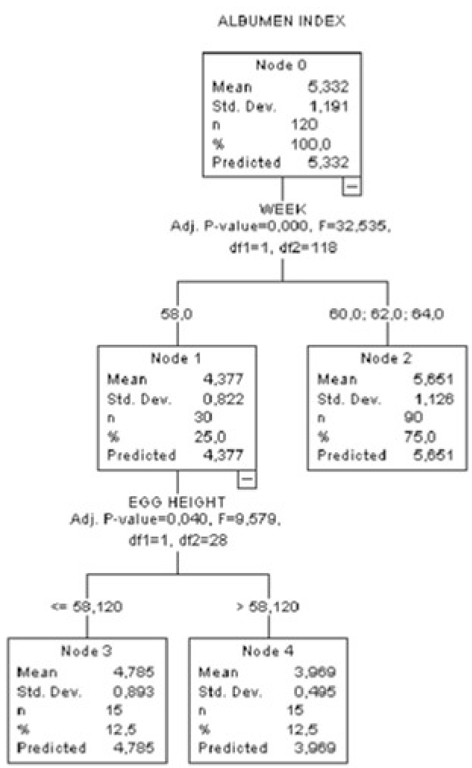

Fig. 4. The decision tree diagram constructed for albumen index.

(Nodes 1 and 2), respectively. With the average of 39.59 in the yolk index, Node 1 was a subset of the 60 eggs obtained in 58th and 64th weeks. Node 2 was a subset of the 60 eggs collected in only 60th and 62th weeks with the average yolk index of 43.58. The difference between both Nodes in yolk index was significant (Adj. P=0.000).

Results of the regression tree generated by CHAID analysis in the prediction of albumen index are depicted in Figure 4. The predicted albumen index values were calculated by means of the CHAID analysis, and then a moderately Pearson correlation (0.496) was obtained between actual and predicted albumen index values ($P<0.01$). In the tree graph, week (Adj. P=0.000) and egg height (Adj. P=0.040) significantly affected the albumen index. Whereas, the effect of treatment and other egg external characteristics on the index was non-significant. Node 0 was partitioned by week into two subsets (Nodes 1 and 2), respectively. Node 1 was a subset of 30 eggs collected in merely 58th week, but Node 2 was a subset of 90 eggs collected in subsequent weeks. Node 1 was statistically found lower in albumen index than Node 2, a terminal node (4.377 vs. 5.651). Node 3 was a subset of 15 eggs whose egg height was 58.120 mm or shorter in 58th week. Node 4 was a subset of 15 eggs whose egg height was taller than 58.120 mm in subsequent weeks.

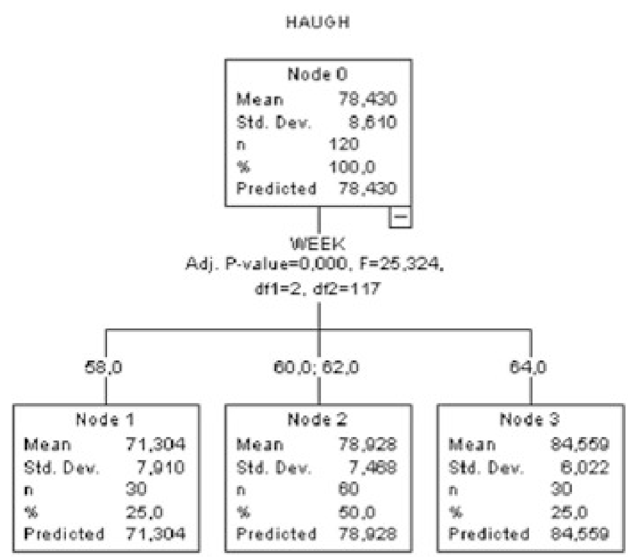

Fig. 5. The decision tree diagram constructed for Haugh unit.

Results of the regression tree constructed by CHAID analysis in the prediction of haugh unit are submitted in Figure 5. A moderately Pearson correlation of 0.550 was found significantly between actual and predicted haugh unit values, from the CHAID analysis ($P<0.01$). Among independent variables, only week factor had a significant influence on the Haugh unit (Adj. P=0.000). In the CHAID analysis, Node 0 was divided by week factor into three subsets, Node 1 (a subset of the 30 eggs collected in 58th week), Node 2 (a subset of the 60 eggs collected in 60th and 62th weeks) and Node 3 (a subset of the 30 eggs collected in 64th week), respectively with the Haugh unit averages of 71.304, 78.928 and 84.559. Node 3 produced the egg (in 64th week) in a marvelous quality since its haugh unit is greater than 79 (Sarica and Erensayin, 2009).

CONCLUSION

Egg quality characteristics of eggs consumed are important factors. Egg quality characteristics can be revealed with the measurements made on the egg quality. Being able to predict the egg internal quality external quality of the eggs from egg external characteristics will be able to give an idea to the consumers and will lead to results much more quickly. It is necessary to reveal the relationship between egg external and internal characteristics, indicators of egg quality, for achieving eggs better quality of Hy-line white laying hens. That is, egg quality is very important for succeeding in the hatchability of fertile and incubated eggs, and the development of chicks in poultry production and industry. Also, an increment in egg quality will enable egg producers to sell higher price compared to low quality. We summarized key results below:

1. The eggs suitable for marketing and shipment were provided by means of Nodes 0, 3, 4, 5, 8, 9 and 12 in the CHAID analysis of the egg shape index.
2. Very strongly Pearson coefficient of 0.876 was estimated in egg shape index between predicted and actual values (P<0.01). CHAID analysis produced much higher accuracy for egg shape index, compared to other egg internal characteristics.

In conclusion, CHAID analysis may be used to better prove relationship mechanism between egg quality characteristics.

ACKNOWLEDGMENT

The authors would like to thank Mustafa Kemal University for providing us oppertunity to conduct this study.

Conflict of interest statement

We declare that we have no conflict of interest.

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