Indonesian Journal of Agricultural Research Vol. 04, No. 02, 2021 | 130 – 141

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InJAR

Indonesian Journal of Agricultural Research

Breeds Characterization in Three Turkish Laying Chicken Breeds Based on Egg Characteristics

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Abstract. Breeds characterization can be performed based on their phenotypic traits. In poultry, the breeds characterization can be performed based on the egg characteristics. This study was carried out to characterize three Turkish laying chicken breeds (30-49 weeks of age) of White Leghorn (WL), Lohmann Brown (LB) and Ataks (AT) based on their egg characteristics. Total of 90 new stock eggs (30 eggs/breed) from Görukle market, Bursa city, Republic of Turkey were used for analysis. Three statistical analyses of principal component analysis (PCA), canonical discriminant analysis (CDA) and hierarchical cluster analysis (HCA) were used for breeds characterization. According to egg size index, most of eggs in this study had normal size type. The highest coefficient of correlation (0.99) value was showed between egg weight (EW) and specific gravity (SG). The PCA revealed that four principal components (4PC's) of egg characteristics capable to explain the total variance of egg characteristics in WL and LB hens about 83.10% and 78.95% respectively. Meanwhile, 3PC's of egg characteristic in AT were explained about 81.70% of total variance in egg characteristics. The Euclidean distance revealed that LB and AT hens were grouped into similar cluster and WL hen was grouped into different cluster. In conclusion, the egg characteristics in birds study can be used to characterize of WL (73.3%), LB (93.0%) and AT (76.7%) hens.

Keyword: CDA, HCA, PCA, phenotypic, Turkish laying hens

Received 05 May 2021 | Revised 12 August 2021 | Accepted 16 August 2021

1. Introduction

Breed characterization is important to determinate among breed of livestocks. Commonly, breeds characterization was performed based on qualitative and quantitative traits. Breed characterization with qualitative can be performed based on physical characteristic such as the body colour (skin, plumage, shank, hoof, horn, switch), humped or humpless, horness or hornless (polled), comb type, etc. Hence, breeds characterization with quantitative can be performed based on several body measurements and body weight [1]. In poultry, breeds characterization can be performed with body measurements, body weight and egg measurements [2], [3]. Breeds characterization can be performed based on three statistical

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p-ISSN: 2622-7681 | e-ISSN: 2615-5842 | DOI 10.32734/injar.v4i2.6210
Journal Homepage: https://talenta.usu.ac.id/InJAR

analyses of principal component analyses (PCA), canonical discriminant analysis (CDA) and hierarchical cluster analysis (HCA). The PCA is used as an interdependence technique to identify morphometric parameters that best serve as breed-specific markers. The CDA is a multivariate statistical technique used to descriminate two or more naturally occuring groups based on a suite of continous or discrimating variables. Thus, HCA can show relatedness and dissimilarity within and among items of a data set [4]-[6].

Three laying hen breeds of White Leghorn (WL), Lohmann Brown (LB) and Ataks (AT) were kept for egg production in Turkey. Ataks hen is a crossbred laying hen from Rhode Island Red × Plymouth Rock chickens [7]. The highest of egg production rate in White Leghorn hens at Turkey was reached of 100.0% (free-range) and 91.60% (indoor) [8]. Thus, the highest of egg production rate in Lohmann Brown and Ataks hens (housed in free-range) at Turkey were 95.70% and 95.20% respectively [9]. Three laying hen breeds of WL, LB and Ataks were easily to characterize with their phenotypic characteristics mainly in plumage colour. Moreover, WL hens had white colour of white and different to LB (dark grey) and AT (light grey) eggs. Recently, study in chicken characterization based on egg measurements is not reported. However, study in egg characterization based on egg measurements was performed in Isa Brown chickens in Nigeria [10], local chickens of Kurdistan [11] and local chickens of Zambia [12]. The objective of this study was to determinate among three Turkish laying chicken breeds based on egg characteristics.

2. Methods

2.1. Samples

Total of 90 eggs produced from three laying hen breeds of White Leghorn (WL), Lohmann Brown (LB) and Ataks (AT) were used in this study with ratio 30 eggs/breed. Eggs that used in this study was collected from Görukle market, Bursa city, Republic of Turkey. Eggs from two days after harvest were used for the analysis. The average age of layer chicken was about 30-49 weeks of age. Therefore, egg measurements were performed fom 28 February to 1 March 2020 in Training Education Center managed by Indonesian Student Association of Bursa - Turkey (PPI Bursa, Turki). The phenotypic characterisics of three Turkish laying hen breeds was presented in Figure 1.

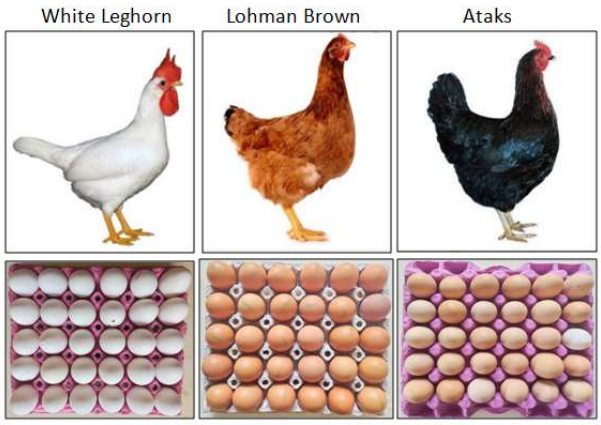

Figure 1. The Phenotypic Characteristics in Three Turkish Laying Chicken Breeds And Their Egg Colours

2.2. Egg Characteristics

Total of fifteen (15) egg measurements of weight of egg (WE), length diameter (LD), width diameter (WD), egg length (EL), egg width (EW), yolk weight (YW), yolk diameter (YD), yolk volume (YV), albumen weight (AW), long diameter of the thick diameter (AD), albumen volume (AV), shell weight (SW), specific gravity (SG), egg size index (EI) and surface area (SA) were performed in this study. Despite, PH of yolk and albumen were measured using PH meter (PH-009I, Canada). Data of EW, YW, AW and SW were weighed using digital weighing scale (TechFit, Hongkong). Data of YV and AV were measured with beaker glass. Data of LD and WD were measured as circumference using measuring tape. Data of EL, EW, YD and AD were measured using digital caliper (BTS, Germany). The egg measurements scheme in some egg measurements (WD, LD, EW, EL, YD and AD) were presented in Figure 2.

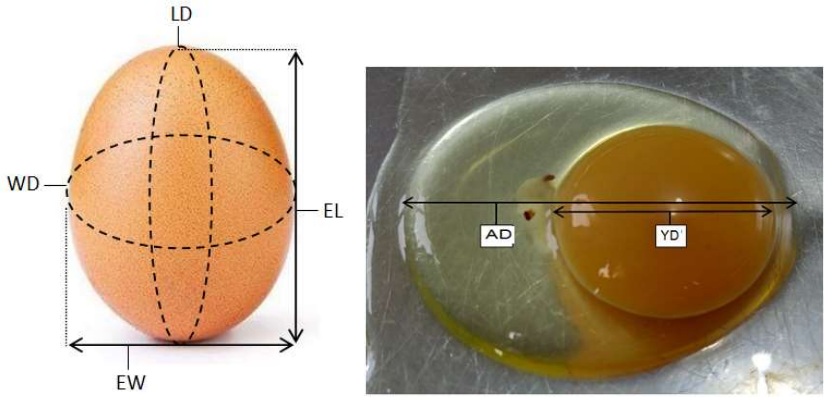

Figure 2. Egg Measurements Scheme for Width Diameter (WD), Length Diameter (LD), Egg Width (EW), Egg Length (EL), Long Diameter of the Thick Albumen (AD) and Yolk Diameter (YD).

Data of SG was obtained using mathematic formula [13]:

$$SG = \frac{WE}{V_2 - V_1} \quad (1)$$

where, SG is the specific gravity of egg (g/mL); WE is the weight of egg (g); V_2 is the water volume with egg (mL); V_1 is the initial water volume (mL). Total of 250 mL initial water volume were used in this study to measure SG of egg. Data of EI was obtained using mathematic formula [14]:

$$EI = \frac{EW}{EL} \times 100\% \quad (2)$$

Where, EW is the egg width (mm) and EL is the egg length (mm). Data of SA was obtained using mathematic formula [15]:

$$SA = 4\pi[0.25(EL + EW)]^2 \quad (3)$$

where, π is the constanta (3.14); SA is the space area (mm^2); EL is the egg length (mm); EW is the egg width (mm). Morever, the grading of eggs were performed based on WE, EI and SA. According to WE value, chickens egg had six types of peewee (< 45 g); small (45-50 g); medium (51-55 g); large (56-60 g); extra (61-65 g) and jumbo (>65 g) [16]. According to EI value, chickens egg had three types of elips (< 70 %); normal (70 - 79 %) and oval (> 79 %) [17]. According to SA value, egg had three types of narrow (66.94 - 74.58 cm^2); medium (74.59 - 84.85 cm^2) and large (84.86 - 110.70 cm^2) [18].

2.3. Data Analysis

The descripive statistic of mean and standard deviation in egg measurements were performed with mathematic model as follows [19]:

$$Y_{ij} = \mu + B_i + E_{ij} \quad (4)$$

whrere, Y_{ij} is the egg measurements; μ is the common mean; B_i is the effect of i^{th} laying hen breed; E_{ij} is the residual error. Hence, Pearson's correlation coefficient (r) was calculated to identify the relationship among egg characteristics from total sample. The characterization in birds study was performed using three analyses method such as Principal component analysis (PCA), canonical discriminant analysis (CDA) and hierarchical clustering analysis (HCA). The PCA was analysed to identify the first component of egg characteristics in each breed. The CDA was analysed to characterize eggs into their breeds with selected variable. The HCA was analyzed to classify breed into many clusters based on egg characteristics. All these analysis were performed using SPSS 16.0 computer program

3. Results and Analysis

3.1. Egg Characteristics

The descriptive statistic of egg characteristics in three Turkish laying chicken breeds were presented in Table 1. Overall, egg characteristics of WE, LD, EL, AD, SW, SG and SA of WL hens were highest than LB and AT hens. The WE of WL hens was closed to the Bovans White and Kurdistan laying hens as presented in Table 2.

Table 1. The Average of Egg Characteristics in Three Turkish Laying Chicken Breeds

Egg Characteristics	Laying Chicken Breeds		
	White Leghorn	Lohmann Brown	Ataks
Weight of egg (g)	59.70±4.15^{a}	53.70±2.42^{b}	55.86±4.89^{c}
Length diameter (mm)	148.35±3.24^{a}	145.43±2.32^{b}	145.26±5.71^{b}
Width diameter (mm)	147.62±5.03^{a}	165.52±2.58^{b}	169.39±5.03^{b}
Egg length (mm)	60.26±2.40^{a}	55.86±2.06^{b}	57.15±3.78^{b}
Egg width (mm)	43.97±1.02	43.18±0.81	43.56±3.51
Yolk weight (g)	16.13±1.94^{b}	37.87±1.92^{a}	41.31±1.39^{b}
Yolk diameter (mm)	43.50±1.98^{a}	11.96±1.35^{b}	15.66±1.74^{c}
Yolk volume (mL)	16.91±1.88^{b}	13.77±0.71^{a}	16.83±1.24^{b}
Albumen weight (g)	46.86±31.07^{a}	32.16±2.50^{b}	30.40±5.06^{b}
Long diameter of the thick albumen (mm)	101.58±12.27^{a}	91.00±9.23^{b}	89.72±11.31^{b}
Albumen volume (mL)	35.31±4.72^{a}	33.37±2.53^{ab}	32.61±5.49^{bc}
Shell weight (g)	8.76±0.89^{a}	7.36±0.80^{b}	7.50±1.40^{b}
Specific gravity (g/mL)	1.17±0.07^{a}	1.07±0.40^{b}	1.11±0.08^{c}
Egg size index (%)	73.06±2.92	77.38±2.74	77.00±13.75
Surface area (cm^2)	85.36±4.62^{a}	77.05±3.75^{b}	79.70±4.98^{c}
PH of yolk	6.29±0.19^{a}	6.61±0.34^{b}	6.76±0.39^{b}
PH of albumen	8.47±0.33^{a}	8.42±0.35^{ab}	8.24±0.51^{bc}

Superscript in the similar coloumn differ significantly ($P<0.05$)

According to Table 2, the EL and EW in bird studies were the highest than Denizli × Leghorn, Isa Brown and Lusaka laying hens. Meanwhile, YD in LB and AT hens were lowest than Denizli × Leghorn, Isa Brown and Lusaka laying hens. The EI of WL hens was closed to Denizli × Leghorn and Lusaka hens. Previous study reported that the WE and AW in WL hens were 50.48±0.42 g and 30.92±0.39 g, respectively [23] and lower than in this study. The average of PH albumen in Tanah Laut local hens was 8.28 [24] and close to this study. The WE and SG in Denizli × Leghorn crossbred hen were 47.81±0.38 g and 1.08±0.01 respectively [25] and lower than in this study. LB hens (50 weeks age) has egg characteristics of 65.40±0.42 g (WE); 7.16±0.12 g (SW) and 76.20±0.62 % (EI). Therefore, in AT hens (50 weeks of age) has egg characteristics of 61.80±0.38 g (WE); 6.71±0.15 g (SW) and 76.30±0.42 % (EI) [9]. The WE in LB and AT hens of this study were lower than [9] but SW and EI in both breeds of this study were higher than previous study.

Table 2. The Average of Egg Characteristics in Several Laying Chicken Breeds

Breed	WE	EL	EW	YD	YW	AW	AD	SW	EI	Reference
Denizli×Leghorn	-	54.07± 0.27	40.89± 0.16	38.17± 0.27	-	-	87.94± 1.03	-	75.70± 0.31	[3]
Isa Brown	52.75± 0.46	50.90± 0.02	38.60± 0.20	-	-	-	-	5.13± 0.06	-	[10]
Lusaka	49.72± 0.44	54.55± 0.17	40.31± 0.12	40.27± 0.30	16.55± 0.22	26.21± 0.30	-	6.34± 0.05	73.96± 0.23	[12]
Bovans White	59.54± 0.42	-	-	-	15.90± 0.16	34.80± 0.27	-	5.81± 0.03	74.33± 0.21	[20]
Kurdistan	59.16± 0.26	57.01± 0.14	-	-	-	-	-	-	75.82± 0.19	[21]
Red Balinese	40.67	-	-	-	16.00	19.87	-	4.13	-	[22]

WE: weight of age (g); EL: egg length (mm); EW: egg width (mm); YD: yolk diameter (mm); YW: yolk weight (g); AW: albumen weight (g); AD: long diameter of the thick diameter (mm); SW: shell weight (g); EI: egg size index (%)

Therefore, most of eggs in each breed had normal type of EI, medium type of WE and large type of SA as presented in Table 3. Thus, most eggs in AT hens had yellow color (score 6) and in WL and LB hens had orange colour (score 8) as presented in Figure 3. The different of yolk colour can be affected by xantophyl (carotenoid pigment) from corn diet feeds ration [26].

Table 3. Percentage (%) of Type of Eggs Based on Weight of age, Egg Index and Surface Area

Factor/Type	Laying Hen Breeds		
	White Leghorn (N)	Lohmann Brown (N)	Ataks (N)
Weight of egg			
Small	0.00 (0)	10.00 (3)	10.00 (3)
Medium	16.67 (5)	66.67 (20)	36.67 (11)
Large	40.00 (12)	23.33 (7)	40.00 (12)
Extra	36.67 (11)	0.00 (0)	10.00 (3)
Jumbo	6.67 (2)	0.00 (0)	3.33 (1)
Egg size index			
Elips	13.33 (4)	3.33 (1)	6.67 (2)
Normal	86.67 (26)	66.67 (20)	90.00 (27)
Oval	0.00 (0)	30.00 (9)	3.33 (1)
Surface area			
Narrow	0.00 (0)	20.00 (6)	13.33 (4)
Medium	43.33 (13)	6.67 (2)	76.67 (23)
Large	56.67 (17)	76.67 (23)	10.00 (3)

N: number of egg

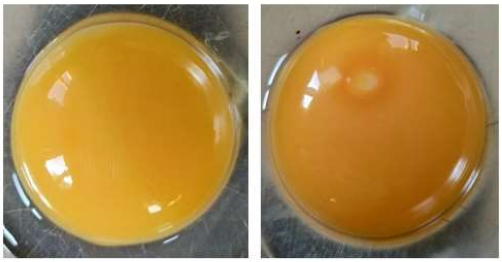

Figure 3. The common yolk colours in three Turkish laying chicken breeds

3.2. Phenotypic Correlations

The Pearson's coefficient of correlation (r) in egg characteristics of pooled birds was presented in Table 4. High category ($0.60 < r < 0.80$) to very high ($0.81 < r < 1.00$) of r values in this study were showed in WE-LD (0.82); WE-WD (0.89); WE-EL (0.71); WE-AV (0.72); WE-SW (0.67); WE-SG (0.99) and WE-SA (0.89). Local chicken of Lusaka had high to very high r value in WE-EL (0.72); WE-EW (0.83) and WE-YW (0.74) [12]. Kurdish local chicken had high of r value in WE-EL (0.76) [21] and close to this study. However, the very high of r value in Kurdish local chicken was showed in WE-YW (0.90) and WE-AW (0.85). Moreover, the local chicken of Nigeria had high to very high of r value in WE-EL (0.77) and WE-EW (0.84) [2]. The different of this study compared to previous studies can be caused by genetics (breed) and management system belonging to feed ration.

Table 4. Pearson's Coefficient Correlation of Egg Characteristics in Total Egg Samples

Egg characteristics*	WE	LD	WD	EL	EW	YW	YD	YV	AW	AD	AV	SW	SG	EI	SA
Weight of egg (WE)	-	0.82	0.89	0.71	0.34	0.45	0.46	0.46	0.56	0.39	0.72	0.67	0.99	-0.25	0.89
Length diameter (LD)		-	0.60	0.49	0.30	0.26	0.27	0.29	0.40	0.25	0.65	0.61	0.81	-0.18	0.66
Width diameter (WD)			-	0.73	0.35	0.54	0.56	0.55	0.50	0.43	0.55	0.56	0.89	-0.21	0.92
Egg length (EL)				-	-0.26	0.30	0.39	0.35	0.42	0.27	0.47	0.58	0.70	-0.77	0.80
Egg width (EW)					-	0.28	0.18	0.18	0.19	0.30	0.23	0.09	0.32	0.80	0.37
Yolk weight (YW)						-	0.72	0.86	0.15	0.27	0.05	0.36	0.45	0.01	0.46
Yolk diameter (YD)							-	0.66	0.22	0.25	0.04	0.37	0.45	-0.11	0.49
Yolk volume (YV)								-	0.15	0.23	0.08	0.29	0.46	-0.10	0.45
Albumen weight (AW)									-	0.32	0.68	0.40	0.56	-0.15	0.52
Long diameter of the thick albumen (AD)										-	0.30	0.37	0.39	0.04	0.44
Albumen volume (AV)											-	0.44	0.72	-0.18	0.60
Shell weight (SW)												-	0.66	-0.33	0.62
Specific gravity (SG)													-	-0.25	0.87
Egg size index (EI)														-	-0.24
Surface area (SA)															-

*(P<0.01)

3.3. Breed Characterization

The PCA resulted that four principal components was obtained in WL and LB hens and three principal components (3PC's) were obtained in AT hens (Table 5). The principal components in WL hens was consisted of PC1 (WE, WD, EL, SG, EI, SA), PC2 (LD, EW), PC3 (AW, AD, AV, SW) and PC4 (YW, YD, YV). The principal components in LB hens consisted of PC1 (WE, LD, WD, EW, AW, AV, SG), PC2 (EL, YD, EI, SA), PC3 (YW, YV) and PC4 (SW). Thus the principal component in AT hens consisted of PC1 (WE, LD, WD), PC2 (EL, YD, EI, SA) and PC3 (YW, YD, YV, AD, SW). The principal components in each breed were explained in total variance of WL, LB and AT about 83.10%; 78.95% and 81.70% respectively. The KMO

value in each breed more than 0.50 and indicated that the PCA results for each breeds were accurate.

Table 5. Rotated Component Matrix and Total Variance Explained by Different Components of Egg Characteristics in Three Turkish Laying Chicken Breeds

Egg characteristics	White Leghorn					Lohmann Brown					Ataks			
	PC1	PC2	PC3	PC4	EC	PC1	PC2	PC3	PC4	EC	PC1	PC2	PC3	EC
Weight of age	0.66*	0.61	0.36	0.18	0.97	0.92*	0.16	-0.09	0.01	0.87	0.97*	-0.08	0.22	0.99
Length diameter	0.11	0.94*	0.15	0.11	0.94	0.81*	-0.07	-0.08	0.25	0.72	0.87*	-0.12	0.28	0.85
Width diameter	0.83*	0.36	0.23	0.29	0.96	0.63*	0.43	0.07	-0.39	0.74	0.88*	0.09	0.18	0.81
Egg length	0.96*	0.09	0.22	0.10	0.99	0.15	0.93*	-0.23	0.07	0.95	0.54	-0.81*	0.06	0.95
Egg width	0.09	0.94*	0.16	0.19	0.95	0.92*	0.05	0.09	0.05	0.86	0.23	0.95*	0.16	0.98
Yolk weight	0.16	0.06	-0.02	0.90*	0.83	-0.07	-0.18	0.89*	0.06	0.84	0.10	0.26	0.87*	0.84
Yolk diameter	0.09	0.33	-0.35	0.54*	0.53	-0.10	-0.54*	-0.02	0.40	0.46	0.01	-0.02	0.66*	0.43
Yolk volume	0.09	0.07	0.11	0.88*	0.80	-0.18	-0.24	0.85*	0.16	0.84	0.22	-0.02	0.75*	0.61
Albumen weight	0.27	0.35	0.76*	-0.06	0.76	0.76*	0.02	-0.47	-0.18	0.83	0.93*	-0.04	0.00	0.86
Long diameter of the thick albumen	0.24	-0.28	0.61*	0.21	0.55	0.02	0.02	-0.25	-0.71	0.56	0.24	0.44	0.57*	0.58
Albumen volume	0.18	0.29	0.81*	-0.11	0.78	0.72*	0.23	-0.40	-0.33	0.84	0.93*	-0.03	-0.03	0.87
Shell weight	0.25	0.39	0.51*	-0.06	0.47	0.52	0.21	-0.04	0.55*	0.61	0.48	-0.35	0.51*	0.61
Specific gravity	0.66*	0.60	0.38	0.17	0.97	0.91*	0.03	-0.16	0.02	0.85	0.96*	-0.10	0.23	0.98
Egg size index	-0.88*	0.45	-0.12	0.01	0.98	0.32	-0.88*	0.28	-0.02	0.95	-0.12	0.98*	0.07	0.98
Surface area	0.85*	0.41	0.25	0.15	0.98	0.43	0.83*	-0.17	0.08	0.92	0.92*	0.08	0.25	0.92
Initial eigen value	6.99	2.37	2.06	1.04	-	6.21	2.94	1.62	1.08	-	7.34	3.19	1.72	-
Variance (%)	46.62	15.78	13.75	6.95	-	41.37	19.58	10.79	7.21	-	48.93	21.30	11.47	-
Cumulative (%)	46.62	62.40	76.15	83.10	-	41.37	60.95	71.74	78.95	-	48.93	70.23	81.70	-
KMO			0.614					0.574					0.706	
Bartlett's test			**					**					**	

PC: principal component; *main component; **(P<0.01)

According to CDA results, three egg characteristics of YD, YV and SA was selected as the describing variable to characterize three laying hen breeds in this study (Table 6). Hence, three selected egg measurement were reduced the F-remove from 23.11 to 9.85 and reduced Wilk's lambda from 0.34 to 0.27.

Table 6. Egg Characteristics Selected by Stepwise Discriminant Analysis to Characterize Three Turkish Laying Chicken Breeds

Variables Entered	Tolerance	F-remove	Wilk's Lambda
Yolk diameter	0.93	23.11	0.34
Yolk volume	0.90	14.08	0.30
Surface area	0.96	9.85	0.27

Total of two function (canonical) of function 1 (90%) and function 2 (10%) were obtained in this study with canonical correlation of 0.85 and 0.47 respectively (Table 7). In addition, total of 73.30% (WL), 93.0% (LB) and 76.7% (AT) of egg sample were classified into their original breed groups as presented in Table 8. The discriminant plot in three Turkish laying hen breeds was presented in Figure 4.

Table 7. Standardized Canonical Discriminant and Centroid Group Coefficients

Function	Selected Variable			Eigenvalue	Variance (%)	Canonical correlation	Centroid Group		
	YD	YV	SA				WL	LB	AT
1	0.71	0.39	0.35	2.52	90.0	0.85	1.70	-2.07	0.37
2	0.30	-0.89	0.70	0.28	10.0	0.47	0.47	0.26	-0.72

YD: yolk diameter; YV: yolk volume; SA: surface area; WL: White Leghorn; LB: Lohman Brown; AT: Ataks

Table 8. Mahalanobis and Euclidean Distances Among Turkish Laying Chicken Breeds Based On Selected Egg Characteristics

Breed	White Leghorn	Lohmann Brown	Ataks
White Leghorn	-	47.41	36.23
Lohmann Brown		-	6.36
Ataks			-

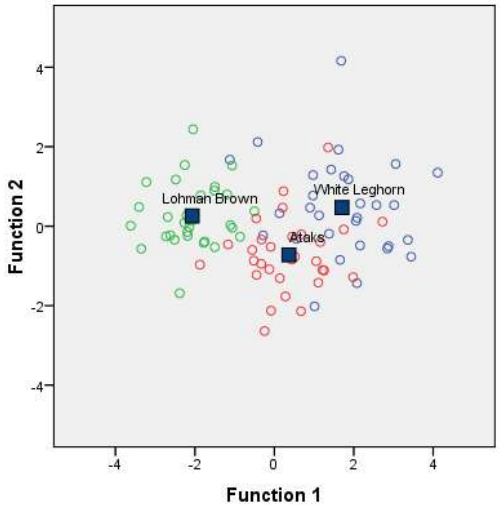

Figure 4. Canonical Discriminant Plot in Three Turkish Laying Chicken Breeds Characterization Based On Egg Characteristics

The HCA revealed that the lowest of Euclidean value was 6.36 (LB-AT) as presented in Table 9. It can be suggested that LB and AT were grouped in similar cluster and WL was grouped in separated cluster. The dendogram of Euclidean distance in three Turkish hen breeds was presented in Figure 5. Previous studies reported that PCA of egg measurements was explained in total variance about 75.80% (3PC's) in indigenous chickens of Lusaka [12], 85.80% (3PC's) in Isa Brown hens [10] and 76.40- 84.09% (2PC's) in indigenous chickens of Kurdistan [11]. Unfortunately, study of breed characterization based on egg characteristics with CDA and HCA analyses were not reported. Whereas, this study can be used as the early information to describe poultry animals based on their egg characteristics. In the future, a deeply study with large sample and similar of chicken age, storing time and management system are important to obtain the results accurately.

Table 9. Percentage (%) of Cross-Validated Eggs Classification Into Breed Based On Discriminant Analysis

Breed	Predicted group membership (N)			Total (N)
	White Leghorn	Lohmann Brown	Ataks	
White Leghorn	73.3 (22)	6.7 (2)	20.0 (6)	100.0 (30)
Lohmann Brown	0.0 (0)	93.0 (28)	6.7 (2)	100.0 (30)
Ataks	16.6 (5)	6.7 (2)	76.7 (23)	100.0 (30)

N: number of sample

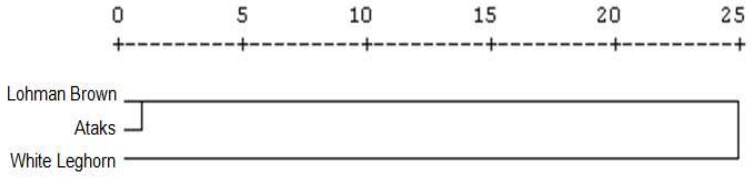

Figure 5. Dendogram of Euclidean Distance Among Three Turkish Laying Chicken Breeds Based On Egg Characteristics

4. Conclusion

Breed characterization using egg characteristics can be applied to the three Turkish laying chicken breeds of WL (73.3%), LB (93.0%) and AT (76.7%). Thus, three egg characteristics of YD, YV and SA were detected as the describing variable to classify three Turkish laying chicken breeds.

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