

Effect of level and source of dietary energy and/or enzyme additions on productive performance and egg quality of Japanese quail hens

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Abstract: The effect of inclusion 20% of rice bran (RB) or broken rice (BR) in all mash-vegetable diets containing either 2700 kcal/kg diet low energy (LE) or 2900 kcal ME/kg diet high energy (HE) without or with 1 g Avizyme-1500/kg, or phytase at 1000 /750 FYT/kg during growing/laying stage diet for Japanese quail (JQ) hens was undertaken. Thus, 2x3x3 factorial design was used. Diets were fed from day 14 to 98 of age. During the laying period nutrient profiles of the diets e.g. Ca, P and CP/amino acids were adjusted according to NRC (1994) to meet requirements for JQ breeding hens. There were 24 females/treatment allocated to 3 replications of 8 females/replicate.

Feeding HE increased ($p<0.05$) age at 40% egg laying rate (ELR), egg weight (EW) and BWG, while LE increased ($p<0.05$) ELR, egg mass (EM), feed intake (FI), and improved ($p<0.05$) feed conversion ratio (FCR), energy conversion ratio (ECR), and Haugh unit score. Including 20% RB or BR improved ($p<0.05$) ELR, EM and BWG, whereas RB or BR had no effect on EW. Including RB and BR improved FCR by 7.2 and 7.7%, respectively compared to the control diet. Yolk colour and Haugh unit score were decreased ($p<0.05$) due to dietary inclusion of RB and BR, with the effect of BR was more severe. Phytase and Avizyme improved ($p<0.05$) ELR, EW, EM, FCR and ECR, while decrease age at 40% ELR compared to control diet. Phytase ($p<0.05$) improved shell thickness compared to the control and Avizyme groups. Avizyme and phytase additions to the LE- and the HE-diet improved ELR and EM. There were interactions ($p<0.05$) between level and sources of dietary energy and enzyme additions, indicating that effect of enzymes depends on energy level and/or source. In conclusion, phytase and Avizyme supplementation improved productive performance, while the best performance was of phytase supplemented LE-corn-soybean meal diet and Avizyme supplemented-LE-BR diet and without negative effect on egg quality traits.

Keywords: Japanese quail hens; energy level and source; multienzymes and phytase; laying traits; egg quality.

Introduction

The optimum utilisation of RB and BR as potential feedstuffs has not been achieved and may be restricted by their NSP, phytin and low amino acids (Farrell, 2006; Attia *et al.*, 2001). For poultry, however, there are reports indicate that the inclusion of BR in the diets for laying hens at 20-26% (Chawla *et al.*, 1980), and at 50% (Jadhao *et al.*, 1999) decreased egg production. However, in literature, some successful studies are described in which RB (Ghazalah *et al.*, 1990; El-Full *et al.*, 2000; Attia *et al.*, 2001) and BR Tyagi *et al.* (1994) was included successfully in the laying hen diets to some extent. Enzymes, being multienzymes or phytase, may be a practical mean to improve poultry

diets containing higher levels of NSP and/or anti-nutritional factors (Attia *et al.*, 2001; Kies *et al.*, 2001; Choct, 2006). Attia *et al.* (2001) concluded that phytase and multienzymes mixture partially compensated for the negative effect of RB on performance of laying hens. The possibility of improving the nutritional value of all-mash vegetable diets containing 20% RB or BR in the HE or LE level by Avizyme and phytase addition for JQ hens was investigated herein from day 14 to 98 of age.

Materials and Methods

Four hundred and thirty two JQ pullets was assigned to (2×3×3) factorial design and fed from 14-98 d of age two energy levels (low 2700 and high 2900 kcal ME/kg diet), within each level, RB or BR was included at 0 or 20%, thus there were 6 main experimental diets. Each diet was fed without or with 1 g/kg of Avizyme 1500[®] (multienzymes containing 4000µ/g proteases, 300 µ /g of endo-1, 4- xylanase, and 400 µ /g of -amylase) or Ronozyme[™] P (CT)[®], or phytase at 1000/750 FYT during growing/laying period/kg diet (Table 1, Attia *et al.*, 2006). From 43 d of age, the experimental diets were adjusted to meet nutrient requirements for Japanese quail hens during the breeding period (NRC, 1994; Table 1). There were 24 females in each of the 18 dietary treatment groups distributed to 3 replicates with 8 females/replicate each. Pullets were fed *ad libitum* the tested diets in mash form and given free access to water. Pullets were kept on 16:8 light-dark cycle under similar condition. Available phosphorus and Ca of phytase supplemented-diets was adjusted by 0.10% diet according to phytase equivalent value.

Table (1) Composition of the diets fed during the laying phase (43-98 d of age)

Ingredients and composition, %	2700 kcal ME/kg diet			2900 kcal ME/kg diet		
	Yellow corn	RB	BR	Yellow corn	RB	BR
Yellow corn	54.93	37.20	32.10	50.22	32.09	29.37
Soybean meal (44% CP)	34.90	32.41	36.065	35.77	33.44	36.64
Rice bran	0.00	20.0	0.00	0.00	20.00	0.00
Broken rice	0.00	0.00	20.00	0.00	0.00	20.00
DL-methionine	0.14	0.13	0.12	0.14	0.13	0.13
Lime stone	6.14	6.21	6.14	6.14	6.20	6.13
Di-calcium phosphate	1.16	1.03	1.14	1.16	1.04	1.14
Vit.+Min Mixture*	0.30	0.30	0.30	0.30	0.30	0.30
NaCl	0.30	0.30	0.30	0.30	0.30	0.30
Palm oil	1.135	1.795	2.208	5.485	6.345	5.895
Sand	0.995	0.625	1.627	0.485	0.155	0.095
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated and analysed values (%)						
Dry matter ²	89.71	89.39	89.54	89.48	89.11	89.80
ME Kcal/kg ¹	2706	2703	2700	2903	2903	2905
CP ²	20.06	20.04	20.01	20.08	20.06	20.02
Methionine ¹	0.46	0.45	0.45	0.45	0.45	0.45
TSAA ¹	0.78	0.78	0.78	0.78	0.78	0.79
Lysine ¹	1.08	1.07	1.14	1.09	1.09	1.15
Calcium ¹	2.70	2.70	2.70	2.70	2.70	2.70
Av. P ¹	0.36	0.35	0.36	0.35	0.35	0.36
Crude fibre ²	2.74	4.46	2.50	2.74	4.46	2.54
Ash ²	10.36	10.11	10.51	10.22	10.44	10.36

¹Vit+Min mixture provides per kilogram of diet: vitamin A, 4,000,000 IU; Vit. E, 16.7g.; Vit. D3 500,000 IU; Vit. K, 0.67g.; Vit.B1, 0.67g.; Vit. B2, 2g.; Vit.B6, 0.67g.; Vit. B12, 0.004g.; Nicotinic acid, 16.7g.; Pantothenic acid, 6.67g.; Biotin, 0.07g.; Folic acid, 1.67g.; Choline chloride, 400g.; Zn, 23.3g.; Mn, 10g.; Fe, 25g.; Cu, 1.67g.; I, 0.25g.; Se, 0.033g.; Mg, 133.4g. * An antioxidant was added at the top of the diet at 125 g /ton. ¹ Calculated analyses ² Determined analyses.

Individual records for BWG (g), and pen basis records for ELR, EW, EM, FI, FCR, ECR and age at 40% ELR were maintained from day 43 to 98 of age. Egg laid in two successive d was used to determine egg quality at 56 and 85 d of age as cited by Attia *et al.* (2001). Data of the laying period (43-98 d of age) were analyzed using three way analyses of variance of the General Linear Model

(GLM) Procedure of the Statistical Analysis System (SAS[®], SAS Institute, 1990), and differences among means was compared using Duncan's New multiple Range Test (Duncan, 1955).

Results and Discussion

Laying performance: Body weight gain was increased ($p<0.05$) due to feeding HE, RB and with addition of either phytase or Avizyme (Table 2). Age at 40% production was increased ($p<0.05$) when HE was fed, while decreased ($p<0.05$) when either phytase or Avizyme was added compared to the control, with phytase was more efficient (Table 2). This may be due to the increase in nutrient availability due to enzyme supplementations (Kies *et al.*, 2001; Choct, 2006).

Females JQ fed LE increased ($p<0.05$) ELR by 12.5%, EM by 8.7% and FI by 4.0%, while decreased ($p<0.05$) EW by 2.1% and improved FCR by 4.4% and ECR by 11.1% compared to HE (Table 2). This may be due to higher nutrient intakes rather than ME due to higher FI, indicating that energy level of 2700 kcal ME/kg diet or ~73 kcal Me/d is adequate for JQ hens produced ~6.9 g egg/d during 43-98 d of age compared to level of 2900 kcal ME/kg diet cited in NRC (1994).

Inclusion of RB or BR in JQ hen diets improved ($p<0.05$) ELR by 8.5 and 8.0%, respectively, EM by 1.8 and 1.4%, respectively, while improved FCR by 7.2 and 7.7%, respectively and ECR by 7.2 and 7.4%, respectively, revealing the possibility of including 20% of RB or BR in JQ hen diets (Table 2). Also, Ghazalah *et al.* (1990), El-Full *et al.* (2000) and Attia *et al.* (2001) concluded that up to 40% RB could be included in laying hen diets without adverse effect on performance. However, inclusion of BR at 20-26% (Chawla *et al.*, 1980; Tyagi *et al.*, 1994) and at 50% (Jadhao *et al.*, 1999) decreased ($p<0.05$) LR of laying hens, and this was attributed to the decrease in energy utilization from BR-diets. This contradiction could be attributed to difference in strain tolerances and quality of BR.

The improvement in ELR, EM, FCR and ECR was 10.4 and 10.8%, 12.3 and 11.0%, 9.8 and 7.8% and 9.7 and 7.7% as a resulted of dietary inclusion of BR in the LE diet and RB in the HE-diet (Table 2). There was also an improvement in these criteria of less meaningful effect 6.5 and 5.3%, 7.9 and 4.6%, 6.6 and 5.4%, and 6.6 and 5.4% due to inclusion of RB and BR in the LE- and the HE- diet, respectively. Thus, inclusions of RB or BR at 20% in the LE diet for JQ hens yield better ELR, EW, EM, FCR and ECR than the control corn-soybean HE diet.

Phytase and Avizyme improved ($p<0.05$) ELR by 17 and 9.0, respectively, EM by 20.5 and 11.2%, respectively, FCR by 15.9 and 9.0%, respectively and ECR by 15.8 and 8.9%, respectively compared to the control diet, while only phytase improved ($p<0.05$) EW by 2.3% and increased FI by ~1%. The improvement due to Avizyme and phytase on performance of JQ hens was greater of phytase and in agreement with those reported by Attia *et al.* (2001), Um and Paik (1999), and might be due to the increases in the availabilities of nutrients. In conclusion Avizyme and phytase improved laying performance of Japanese quail hens and the effect depends on type of enzyme.

Avizyme and phytase addition to the LE and the HE diet improved ELR, EM, FCR and ECR by 8.8 and 17.9%, 9.1 and 16.2%, 10.4 and 21.1%, 12.0 and 20.1%, 8.4 and 17.7, 7.6 and 14.1%, 8.5 and 17.0, and 9.4 and 14.7%, respectively (data not shown). This indicates that LE or HE-phytase supplemented diet yield the highest LR and EM. Though, laying performance and nutrient utilizations was higher of LE diet supplemented with either phytase or Avizyme than the control LE-or HE-diet or enzymes supplemented-HE diet (data not shown). Similarly, Attia *et al.* (2001) showed enzymes improved performance of laying hens fed RB-diets.

Phytase addition to corn-soybean diet without or with RB or BR improved ELR by 28.7, 11.7, and 12.5%, respectively EM by 34.1, 13.2 and 13.5%, respectively FCR by 24.9, 10.2 and 11.1%, respectively and ECR by 24.6, 10.2 and 11.3, respectively of JQ hens compared to their respective controls (Table 2). Also, Avizyme improved LR, EM, FCR and ECR of corn-soybean diet without or with RB or BR compared to their negative controls, but to lesser extent than phytase.

Avizyme improved ELR by 10.0, 7.1 and 9.7%, and EM by 11.9, 9.1 and 10.1% of LE-corn-soybean diet without or with RB or BR, respectively, indicating an interaction ($p<0.05$) between energy level, rice by products and enzyme additions (Table 2). These improvements were 11.2, 4.9 and 11.4% for ELR and 12.8, 7.4 and 12.7% for EM of HE-corn-soybean diet without or with 20% RB or BR,

Table (2) Effect of energy level, and inclusion of 20 rice bran or broken rice and/or Avizyme or phytase additions on BWG, age at 40% laying, and laying performance and nutrient utilization of JQ hens during 43-98 d of age

Treatments	Laying performance during 43-98 d of age							
	Body weight Change, g	Age at 40% laying	Laying rate, %	Egg weight, g	Egg mass, g	Feed intake (g/h/d)	FCR (g/g)	ECR, kcal/g
2700	23.5 ^b	43.2 ^b	66.8 ^a	10.28 ^b	6.51 ^a	26.9 ^b	3.88 ^b	10.48 ^b
2900	26.0 ^a	43.7 ^a	59.4 ^b	10.50 ^a	5.99 ^b	25.9 ^a	4.06 ^a	11.79 ^a
SEM	0.56	0.09	0.24	0.050	0.067	0.049	0.015	0.073
P value	0.002	0.002	0.001	0.004	0.0001	0.0001	0.001	0.0001
Control	24.5 ^{ab}	43.3	59.8 ^b	10.28	5.83 ^b	26.0 ^c	4.18 ^a	11.70 ^a
RB-diet	26.1 ^a	43.6	64.9 ^a	10.46	6.44 ^a	26.8 ^a	3.88 ^b	10.86 ^b
BR-diet	23.6 ^b	43.4	64.6 ^a	10.42	6.47 ^a	26.4 ^b	3.86 ^b	10.83 ^b
SEM	0.68	0.12	0.29	0.062	0.082	0.061	0.018	0.051
P value	0.04	NS	0.001	NS	0.0001	0.0001	0.001	0.0001
No enzyme	21.6 ^c	44.2 ^a	58.1 ^c	10.26 ^b	5.65 ^c	26.2 ^b	4.33 ^a	12.13 ^a
Avizyme	25.3 ^b	43.3 ^b	63.3 ^b	10.42 ^{ab}	6.28 ^b	26.4 ^b	3.94 ^b	11.05 ^b
Phytase	27.2 ^a	42.8 ^c	68.0 ^a	10.50 ^a	6.81 ^a	26.5 ^a	3.64 ^c	10.21 ^c
SEM	0.68	0.12	0.29	0.062	0.082	0.061	0.018	0.051
P value	0.0001	0.0001	0.001	0.03	0.0001	0.01	0.001	0.0001
Low×control	22.6	43.3	63.2	10.06	6.03	26.4	4.10	11.08
Low×RB-diet	25.0	43.3	67.3	10.36	6.58	27.1	3.83	10.35
Low×BR-diet	22.8	43.0	69.8	10.41	6.91	27.3	3.70	10.00
High×control	26.4	43.3	56.4	10.51	5.64	25.7	4.25	12.33
High×RB-diet	27.1	43.9	62.5	10.56	6.30	26.5	3.92	11.38
High×BR	24.3	43.8	59.4	10.43	6.03	25.5	4.02	11.66
SEM	0.97	0.16	0.41	0.087	0.116	0.086	0.026	0.073
P value	NS	NS	0.0001	0.05	0.03	0.0001	0.0003	0.0005
Control×no enzyme	21.4	43.8	52.9	10.06	5.02	25.9	4.73	13.24
Control×Avizyme	24.9	43.2	58.5	10.26	5.66	26.1	4.25	11.89
Control×phytase	27.3	43.0	68.1	10.54	6.82	26.0	3.55	9.98
RB-diet×no enzyme	22.6	44.7	61.3	10.38	6.08	26.6	4.12	11.54
RB-diet×Avizyme	26.6	43.5	65.0	10.52	6.45	26.7	3.82	10.69
RB-diet×phytase	28.9	42.7	68.5	10.50	6.79	27.0	3.70	10.36
BR-diet×no enzyme	20.9	44.2	60.0	10.34	5.86	26.2	4.14	11.62
BR-diet×Avizyme	24.3	43.3	66.3	10.48	6.73	26.5	3.76	10.56
BR-diet×phytase	25.5	42.7	67.5	10.45	6.82	26.5	3.68	10.31
SEM	1.10	0.20	1.35	0.107	0.14	0.106	0.032	0.089
P value	NS	NS	0.01	NS	0.001	NS	0.0001	0.0001
Low ×control ×no enzyme	20.3	44.0	55.0	10.08	5.56	26.2	4.70	12.69
Low × control×Avizyme	22.1	43.0	60.5	10.25	6.22	26.7	4.30	11.61
Low ×control×phytase	25.5	43.0	74.0	10.68	7.94	26.3	3.31	8.93
Low × RB-diet×no enzyme	21.5	44.3	63.1	10.39	6.58	26.9	4.09	11.04
Low × RB-diet×Avizyme	25.6	43.3	67.6	10.59	7.18	27.0	3.77	10.17
Low × RB-diet×phytase	27.9	42.3	71.2	10.51	7.50	27.3	3.64	9.83
Low × BR-diet×no enzyme	19.8	43.3	65.7	10.51	6.91	27.3	3.93	10.62
Low×BR-diet×Avizyme	23.9	43.3	72.1	10.56	7.64	27.3	3.57	9.65
Low× BR-diet×phytase	24.7	42.3	71.7	10.55	7.58	27.3	3.61	9.74
High× control ×no enzyme	22.4	43.7	50.7	10.63	5.40	25.7	4.75	13.78
High× control ×Avizyme	27.8	43.3	56.4	10.76	6.09	25.6	4.20	12.18
High × control ×phytase	29.1	43.0	62.1	10.85	6.77	25.7	3.80	11.03
High× RB-diet×no enzyme	23.7	45.0	59.5	10.62	6.34	26.3	4.15	12.04
High × RB-diet×Avizyme	27.7	43.7	62.4	10.88	6.81	26.3	3.87	11.22
High × RB-diet×phytase	29.9	43.0	65.7	10.80	7.13	26.7	3.75	10.88
High× BR-diet ×no enzyme	22.1	45.0	54.3	10.57	5.77	25.1	3.36	12.63
High × BR-diet×Avizyme	24.7	43.3	60.5	10.70	6.50	25.7	3.95	11.46
High ×BR-diet×phytase	26.2	43.0	63.3	10.78	6.85	25.7	3.75	10.88
SEM	1.67	0.28	0.71	0.098	0.07	0.15	0.045	0.126
P value	NS	NS	0.001	NS	0.01	NS	0.001	0.0001

a-c means within a column within similar treatment with no common superscripts differ ($p < 0.05$). NS, ($p < 0.05$).

respectively. Phytase improved ELR by 34.5, 12.8, and 9.1%, and EM by 42.8, 14.0, and 9.2% of JQ-hens fed LE-corn-soybean diet without or with RB or BR, respectively. These improvements were 22.5, 10.4 and 16.6% for ELR and 25.4, 12.5 and 18.7% for EM of HE

diet corn-soybean diet without or with RB or BR, respectively. There were similar improvements in FCR and ECR, indicating that Avizyme and phytase improved performance of JQ hens with the effect depends on level and source of energy and type of enzymes (Table 2).

The best laying performance and feed utilization was achieved of groups fed phytase-supplemented LE-corn-soybean diet and Avizyme supplemented LE-BR.

Quality of eggs and shell: Shell quality, yolk colour, yolk and albumen (%) were not affected ($p>0.05$) by energy level, while rice by products had no effect on shell quality, yolk and albumen (%), also enzymes had no effects on shell (%), yolk color, yolk and albumen (%), and Haugh unit score (Table 3). However, Haugh unit score was better ($p<0.05$) of LE than HE. Similarly, Fathi (2002) found that yolk and albumen (%) and shell and yolk to albumen ratio and shell thickness were not affected ($p>0.05$) by energy level, meanwhile, Haugh unit score was ($p<0.05$) better of LE than HE. Inclusion of 20% RB or BR in the diets for JQ hens decreased ($p>0.05$) yolk colour and Haugh unit score, with the effect of BR was more severe (Table 3). These results in partial agreement with those reported by Ghazalah *et al.* (1990), Attia *et al.* (2001) and El-Full *et al.* (2000), they concluded that rice bran and enzymes did not affect most of egg quality traits.

Table (3) Effect of energy level and inclusion level of 20% rice bran or broken rice and/or Avizyme or phytase additions on egg quality criteria of Japanese quail hens during 43-98 d of age.

Treatments	Criteria of egg quality					
	Shell, %	Shell thickness (mm)	Yolk colour	Yolk,%	Albumen,%	Haugh Unit score
2700	10.9	0.221	3.3	33.9	55.2	82.0 ^a
2900	10.8	0.221	3.3	33.9	55.3	78.6 ^b
SEM	0.05	0.0005	0.041	0.12	0.13	0.17
P value	NS	NS	NS	NS	NS	0.0001
Control	10.9	0.221	3.7 ^a	33.8	55.3	81.5 ^a
RB-diet	10.9	0.221	3.2 ^b	34.1	55.0	80.0 ^b
BR-diet	10.8	0.221	2.9 ^c	33.8	55.5	79.3 ^c
SEM	0.34	0.0006	0.051	0.15	0.016	0.21
P value	NS	NS	0.0001	NS	NS	0.0001
No enzyme	10.8	0.220 ^b	3.3	33.8	55.4	80.4
Avizyme	10.9	0.220 ^b	3.3	33.9	55.2	80.4
Phytase	10.9	0.222 ^a	3.3	33.9	55.2	80.0
SEM	0.34	0.0006	0.051	0.15	0.016	0.21
P value	NS	0.03	NS	NS	NS	NS
Low× control	10.8	0.220	3.5	33.7	55.4	83.8
Low×RB- diet	10.9	0.220	3.3	34.3	54.7	81.6
Low×BR-diet	10.9	0.222	2.9	33.7	55.4	80.4
High×control	11.0	0.221	3.9	33.9	55.1	79.1
High×RB-diet	10.9	0.222	3.0	33.9	55.3	78.5
High×RB-diet	10.6	0.221	2.9	33.8	55.5	78.1
SEM	0.08	0.0009	0.07	0.21	0.23	0.29
P value	0.01	NS	0.0001	NS	NS	0.0002
Low×no enzyme	10.9	0.219	3.2	34.0	55.0	82.3
Low×Avizyme	11.0	0.221	3.1	33.9	55.1	82.1
Low×phytase	10.8	0.221	3.5	33.8	55.4	81.5
High×no enzyme	10.8	0.221	3.4	33.5	55.7	78.5
High×Avizyme	10.7	0.219	3.4	34.0	55.3	78.7
High×phytase	11.0	0.223	3.1	34.1	54.9	78.6
SEM	0.08	0.0009	0.07	0.21	0.23	0.29
P value	0.01	0.04	0.0001	NS	0.05	NS

a-c means within a column within similar treatment with no common superscripts differ ($p<0.05$). NS, ($p<0.05$).

There were interactions between energy level and inclusion of RB or BR was shown ($p<0.05$) in shell (%), yolk colour and Haugh unit score. Results showed that including RB or BR in the LE diet had no effect on shall (%), while including BR in the HE diet decreased shell (%) severely (3.6%), and this may be attributed to the negative relationship between increasing energy (fat) level and feed intake (Table 2), and the negative effect of BR in Ca and P retention (Tyagi *et al.*, 1993; Jadhao *et al.*, 1999). There were 5.7 and 17.1% decreases in yolk colour when RB and BR were included in the LE-diet, respectively. The corresponding values for HE- diet were 23.1 and 25.6%, respectively. There

were 2.6 and 4.1% decreases in Haugh unit score when RB and BR were included in the LE-diet, respectively. The corresponding values for HE- diet were 0.8 and 1.3%, respectively.

Avizyme increased shell (%) and shell thickness of LE diet, while phytase improved shell quality of HE-diet, showing the positive effect of Avizyme and phytase on mineral availabilities (Kies *et al.*, 2001; Attia *et al.*, 2001). Yolk colour and albumen (%) were increased due to phytase addition to the LE diet, while they were decreased when phytase was added to the HE- diet (Table 3). Avizyme had a small negative effect on shell quality of HE-diet (Table 3).

Phytase increased shell thickness by 1.8 and 1.4% of corn-soybean meal diet without or with BR while had a small effect on RB-diet (data not shown), showing the positive effect of phytase on mineral availabilities (Kies *et al.*, 2001), although, it contains 0.1% less Ca and non-phytate phosphorus. Avizyme increased yolk colour of LE-BR diet, and HE-corn-soybean diet (data not shown). However, Avizyme decreased yolk colour of LE corn-soybean diet without or with RB, and HE-BR diet. Yolk colour was increased due to phytase addition to LE corn-soybean diet without or with 20% RB or BR. Meanwhile, phytase decreased yolk colour when added to the HE diets, with the degree of response depends on dietary composition (data not shown).

Avizyme increased albumen (%) of only LE corn-soybean diet and Haugh unit of LE corn-soybean diet and HE-BR diet (data not shown), while it had a negative effect on albumen (%) of LE corn-soybean-BR diet, and HE-corn-soybean without or with BR. Albumen (%) was increased due to phytase to the LE-RB or BR diet, while it was decreased when phytase was added to HE corn-soybean diet without or with BR (data not shown). Also, Haugh unit score was improved due to phytase additions to the LE corn-soybean diet, and HE diet containing RB or BR. Phytase additions to the LE-RB or BR- diet, and HE- corn-soybean meal diet decreased Haugh unit score (data not shown). This results indicate that feeding LE-diet containing 20% RB or BR showed comparable egg quality to that of the HE-corn-soybean meal diet.

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