# Effect of energy level, rice by products and enzyme additions on carcass yield, meat quality and plasma constituents of Japanese quail

**F. S. A. ISMAIL[1], Y. A. ATTIA[2*], F. A. M. AGGOOR[1], E. M. A. QOTA[3] and E. A.SHAKMAK[1]**

**[1]Poultry Production Department, Faculty of Agriculture, Mansoura University, Egypt.**
**[2]Animal and Poultry Production Department, Faculty of Agriculture, Alexandria University Damanhour, 22516, Egypt, e-mail: yfat_alexu40@hotmail.com**
**[3]Animal Production Research Institute, Giza, Dokki, Egypt.**

**Abstract: The effect of inclusion 20% of rice bran (RB) or broken rice (BR) in all-mash vegetable Japanese quail (JQ) diets containing either 2700 kcal ME/kg diet low energy (LE) or 2900 kcal/kg diet high energy (HE) without or with 1 g/kg of Avizyme, or 1000 FYT of Ronozyme phytase was investigated using 2x3x3 factorial design during 14-42d of age with 51 chicks /treatment distributed to 3 replicates of 17 chicks each. Carcass yield, chemical and physical quality of meat and plasma constituents were studied with 6 samples/treatment as three of each sex of 42 d old chicks.**

**Feeding HE increased ($p$<0.05) dressing (%), proventriculus (%), meat DM (%), and EE (%), meat color, plasma total lipids and cholesterol, while decreased ($p$<0.05) meat CP (%) and thus decreased ($p$<0.05) water-holding capacity (WHC) of meat compared to the LE level. Plasma total lipids and cholesterol was increased ($p$<0.05) when HE diet was fed. Feeding diet containing 20% BR increased ($p$<0.05) proventriculus and testis compared with corn-soybean meal diet without or with 20% RB. Feeding RB-diet decreased proventriculus ($p$<0.05) compared to the control group. Meat color was decreased ($p$<0.05) upon the use of RB and BR, with the effect of BR was more severe. Phytase and Avizyme decreased ($p$<0.05) intestinal (%) compared to control. While, phytase increased ($p$<0.05) proventriculus (%). Plasma total lipids were increased ($p$<0.05) due to phytase, without adverse effect on plasma cholesterol. An interaction ($p$<0.05) between energy level and inclusion of 20% RB and BR and/or enzyme additions was observed, showing that the effect of enzyme depends on source and level of dietary energy. It could be concluded that energy level, inclusion of 20% RB or BR and enzyme additions had no negative effects on carcass yield and most of meat quality traits and plasma constituents.**

**Keywords**: Energy level and source; enzyme and phytase; carcass yield; meat quality and plasma constituents.

## Introduction

As reviewed in the combined paper (Attia *et al*., 2006) there are needs to seek the possibility of improving LE-diet and diets containing rice by-products by enzymes to overcame feed shortage and to improve economic returns for poultry producers. Kassim and Suwanpradit (1996), Badawy (1997) and Attia *et al*. (1998) found that increasing dietary ME level did not affect dressing and internal organs (%). Also, Aggoor *et al*. (2000) found that increasing ME content of the control diet with fat addition produced carcasses of higher dressing (%). Attia *et al*. (2003) found that dressing (%) was not affected ($p$<0.05) by RB level, while liver and pancreas (%) were ($p$<0.05) enlarged when RB was fed at 15% or more to broiler chicks. Raya and El-Shinnawy (1989) found that BR up to 100% of yellow corn had no adverse effect on carcass yield and body organs of broilers. However, Isshak (1990) found that

dressing (%) was not affected, meanwhile liver (%) was reduced, but heart and gizzard (%) were enlarged ($p$<0.05) of broilers due to dietary inclusion of 28% BR. El-Full *et al*. (2000), Kidd *et al*. (2001) and Attia *et al*. (2003) found that multienzymes and phytase had no effects on carcass yields and internal organs of broilers. The effect of 2700 vs. 2900 kcal ME/kg diet and 0 vs.20% RB or BR without or with Avizyme or phytase on carcass yield, meat quality and plasma constituents of JQ was studied herein.

## Material and methods

The experimental birds, handling protocols, design and diets were described in the combined paper (Attia *et al*., 2006). At 42 d of age, 6 JQ males were slaughtered after fasting overnight, processed and the weight of carcass, liver, intestinal, proventriculus, gizzard, heart, and testis were taken, and data were expressed as relative weight of live body weight. Meat cchemical composition and physical characteristics were done using a sample of 50 % of breast meat + 50 % of thigh meat. The DM, CP, EE and crude ash (CA) were determined according to AOAC (1995) and expressed in dry matter basis. Meat tenderness, water holding capacity (WHC), pH and color were carried out as cited by Aggoor *et al*. (2000), respectively. Six blood samples were collected in heparinized tubes of each treatment at 42 days of age. Plasma was separated by centrifugation at 3000 rpm for 10 minutes and stored at -18$^{o}$C until analysis. Plasma total protein, total lipids, total cholesterol, AST and ALT were determined as cited by Aggoor *et al*. (2000). Data were analysed using three way analyses of variance of the GLM of SAS (SAS Institute, 1990), while main differences were compared using Duncan's New multiple Range Test (Duncan, 1955).

## Results and discussion

Dressing (%) was higher and proventriculus was lower ($p$<0.05) of HE, while other body organs were not affected. Similarly, Al-Harthi (2002) reported that increasing energy level within the range of 2800-3400 kcal ME/kg diet for broiler improved dressing (%), whilst had no effect on gizzard, liver, giblets, heart and testis (Badawy, 1997; Aggoor *et al*., 2000). Proventriculus and testis (%) was increased ($p$<0.05) of BR-diet compared with corn-soybean meal diet without or with RB (Table 1). However, RB-diet had ($p$<0.05) small proventriculus (%) compared to that of the control group, but testis (%) was similar between these groups. The lack of significance in dressing, intestinal, gizzard, liver, giblets and heart (%) due to RB or BR and on dressing, gizzard, liver, giblets, heart and testis due to enzymes are in general agreement with those by Raya and El-Shinnawy (1989), El-Full *et al*. (2000) and Isshak (1990) for rice by products and by El-Full e*t al*. (2000), Kidd *et al*. (2001) and Attia *et al*. (2003) for enzymes. Phytase and Avizyme decreased ($p$<0.05) intestinal (%) compared to control (Table 2). However, phytase increased ($p$<0.05) proventriculus (%). Including RB or BR in the LE and RB in the HE-diet decreased proventriculus (%) by 10.1 and 13.6%, and 8.8%, respectively. Meanwhile, the contrary (+38.5%) was shown when BR was included in the HE-diet. Proventriculus (%) was decreased by 6.0 and 12.4% when Avizyme and phytase was included in the LE-diet, and increased by 32.4 and 10.8%, respectively when Avizyme and phytase were included in the HE-diet, These adaptation changes due to enzyme additions might be; however, reflect changes in intestinal function and enzyme secretions (Table 1).

Heart (%) was decreased by 8.6 and 9.5%, while increased by 7.8 and 1.0% when Avizyme and phytase were added to the LE-diet and the HE-diet, respectively. Avizyme increased proventriculus (%) by 15.4, 9.5 and 7.3% of corn soybean diet without or with RB or BR, respectively. Although, phytase increased proventriculus (%) by 6.1% of corn soybean diet, while decreased it by 10.0% of diets containing 20% BR. These changes may be affected by protease content of Avizyme and the positive effect of phytase on protein digestibility and their effects on digestive enzymes (Kies *et al*., 2001). Avizyme decreased heart (%) by 8.0, and 2.8% of corn soybean diet without or with BR, respectively but increased it by of 8.4% of RB-diet (Table 1). While, phytase decreased heart (%) by 8.8, and 6.5% of corn soybean diet without or with 20% RB, respectively, while increased it by 2.8%

of 20% BR-diet. Avizyme increased intestinal (%) by 5.5% of LE-corn-soybean diet, while decreased it by 19.2 and 1.9% of LE-corn soybean-RB, or -BR diet, respectively. The reductions due to Avizyme were 13.5, 2.5 and 16.6% of HE-corn-soybean diet without or with RB or BR, respectively (Table 1). Phytase decreased intestinal (%) by 8.1, 10.6 and 1.7% and by 6.6, 20.2 and 1.9% of LE and HE-energy corn-soybean diet without or with RB or BR, respectively (Table 1), showing that the changes in intestinal (%) to enzyme additions depend on level and sources of dietary energy.

**Table (1) Effect of energy level, rice by products and/or enzyme additions and their interactions on dressing and body organs (%)**

| Treatments | Dressing, % | Intestinal, % | Proventriculus, % | Gizzard, % | Liver, % | Heart, % | Testis, % |
|---|---|---|---|---|---|---|---|
| 2700 | 70.46[b] | 4.89 | 0.311[a] | 1.72 | 2.01 | 1.09 | 2.62 |
| 2900 | 71.73[a] | 4.81 | 0.286[b] | 1.77 | 1.90 | 1.06 | 2.49 |
| SEM | 0.391 | 0.080 | 0.0064 | 0.041 | 0.043 | 0.019 | 0.091 |
| P value | 0.02 | NS | 0.007 | NS | NS | NS | NS |
| Control | 71.46 | 4.80 | 0.299[b] | 1.74 | 1.96 | 1.07 | 2.41[b] |
| RB | 70.39 | 4.90 | 0.270[c] | 1.72 | 1.91 | 1.08 | 2.46[b] |
| BR | 71.44 | 4.84 | 0.326[a] | 1.78 | 2.00 | 1.08 | 2.80[a] |
| SEM | 0.478 | 0.099 | 0.0080 | 0.050 | 0.053 | 0.023 | 0.112 |
| P value | NS | NS | 0.0001 | NS | NS | NS | 0.03 |
| No enzyme | 70.59 | 5.13[a] | 0.290[b] | 1.77 | 2.00 | 1.09 | 2.56 |
| Avizyme | 71.80 | 4.71[b] | 0.284[b] | 1.75 | 1.91 | 1.09 | 2.61 |
| Phytase | 70.90 | 4.71[b] | 0.321[a] | 1.72 | 1.96 | 1.04 | 2.49 |
| SEM | 0.478 | 0.099 | 0.008 | 0.050 | 0.053 | 0.023 | 0.112 |
| P value | NS | 0.003 | 0.003 | NS | NS | NS | NS |
| Low × control | 70.67 | 4.91 | 0.338 | 1.79 | 1.97 | 1.12 | 2.61 |
| Low × RB | 69.34 | 5.01 | 0.304 | 1.69 | 1.96 | 1.07 | 2.46 |
| Low × BR | 71.38 | 4.76 | 0.292 | 1.69 | 2.10 | 1.08 | 2.77 |
| High × control | 72.25 | 4.70 | 0.260 | 1.70 | 1.95 | 1.02 | 2.20 |
| High × RB | 71.44 | 4.80 | 0.237 | 1.76 | 1.86 | 1.09 | 2.45 |
| High × BR | 71.50 | 4.93 | 0.360 | 1.86 | 1.90 | 1.08 | 2.82 |
| SEM | 0.677 | 0.139 | 0.011 | 0.070 | 0.075 | 0.032 | 0.158 |
| P value | NS | NS | 0.003 | NS | NS | NS | NS |
| Low×no enzyme | 69.91 | 5.11 | 0.331 | 1.77 | 2.05 | 1.16 | 2.52 |
| Low ×Avizyme | 70.54 | 4.82 | 0.311 | 1.67 | 1.97 | 1.06 | 2.71 |
| Low × phytase | 70.94 | 4.75 | 0.290 | 1.73 | 2.01 | 1.05 | 2.62 |
| High × no enzyme | 71.27 | 5.15 | 0.250 | 1.78 | 1.95 | 1.03 | 2.61 |
| High × Avizyme | 73.05 | 4.60 | 0.331 | 1.77 | 1.85 | 1.11 | 2.51 |
| High × phytase | 70.86 | 4.66 | 0.277 | 1.77 | 1.90 | 1.04 | 2.36 |
| SEM | 0.677 | 0.139 | 0.011 | 0.070 | 0.075 | 0.032 | 0.158 |
| P value | NS | NS | 0.0001 | NS | NS | 0.02 | NS |
| Control × no enzyme | 70.07 | 4.99 | 0.279 | 1.69 | 2.04 | 1.13 | 2.43 |
| Control × Avizyme | 73.07 | 4.79 | 0.322 | 1.70 | 1.91 | 1.04 | 2.44 |
| Control × phytase | 70.23 | 4.63 | 0.296 | 1.84 | 1.93 | 1.03 | 2.35 |
| RB × no enzyme | 70.36 | 5.37 | 0.263 | 1.76 | 1.89 | 1.07 | 2.41 |
| RB × Avizyme | 70.40 | 4.78 | 0.288 | 1.72 | 1.89 | 1.16 | 2.58 |
| RB × phytase | 70.40 | 4.56 | 0.261 | 1.69 | 1.96 | 1.00 | 2.38 |
| BR × no enzyme | 70.33 | 5.03 | 0.329 | 1.87 | 2.08 | 1.08 | 2.85 |
| BR × Avizyme | 71.93 | 4.56 | 0.353 | 1.75 | 1.93 | 1.05 | 2.80 |
| BR × phytase | 72.06 | 4.94 | 0.296 | 1.72 | 1.99 | 1.11 | 2.73 |
| SEM | 0.829 | 0.171 | 0.014 | 0.086 | 0.091 | 0.039 | 0.194 |
| P value | NS | NS | 0.001 | NS | NS | 0.04 | NS |

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

Avizyme increased proventriculus (%) by 2.6% of LE-corn soybean diet, while decreased it by 11.2 and 9.5% of the LE-RB or –BR diet (Table 1). Meanwhile, Avizyme increased it when added to HE-corn-soybean diet without or with RB or BR by 36.2, 40.4 and 24.8%, respectively. Phytase decreased proventriculus (%) by 9.0, and by 29.5% of LE-corn-soybean meal diet without or with BR, but increased it by 3.2% of LE-corn-soybean RB-diet (Table 1). Also, phytase decreased proventriculus (%) by 6.6% of HE-corn-soybean meal RB-diet, but increased it by 30.0 and 9.9% of HE-corn-soybean diet without or with BR. Avizyme decreased heart (%) by 13.8, 7.1 and 4.5% of LE-corn-soybean diet without or with 20% RB or BR, respectively (Table 1). Meanwhile, it was decreased

by 1.9% of HE-corn-soybean-BR diet, but it increased by 1.0 and 26.5% of HE-corn-soybean meal without or with RB, respectively. Phytase decreased heart (%) by 14.6, 7.1 and 4.5% and by 1.0 and 5.9% of LE-corn-soybean diet without or with RB or BR, and HE-corn-soybean diet without or with RB respectively (Table 1). Phytase increased heart (%) by 10.5% of HE-corn-soybean meal-BR-diet. It was concluded that energy level and source and enzyme additions did not negatively affect dressing, gizzard, liver and testis (%).

**Chemical composition and physical characteristics of meat, and plasma constituents**

Feeding HE increased ($p$<0.05) meat DM and EE (%) and meat color, plasma total lipids and cholesterol while decreased CP (%) of meat and consequent WHC compared to LE-diet (Table 2). These results are in line with the results by Aggoor *et al*. (2000), El-Naggar *et al*., 1997) and Gerken *et al*. (2003). Only, meat color was decreased ($p<0.05$) moderately (5.8%) upon inclusion of RB and severely (11.6%) upon inclusion of BR in JQ-diets. Similarly, El-Naggar *et al*. (1997) and Aggoor *et al*. (2000) found that increasing energy level by fat addition increased ($p$<0.05) plasma total lipid, triglyceride and cholesterol. Also, Raya and El-Shinnawy (1989) found that BR did not affect meat chemical composition and plasma total protein, total lipids, glucose and cholesterol. However, carotenoid content of carcass skin was linearly decreased with increasing BR level. This agrees with the decrease in meat color of BR groups (Table 2).

**Table (2) Mean effect of energy level, rice by products and/or enzymes additions on meat quality of 42 d old Japanese quail**

| Treatments | Chemical analyses of meat, % | | | | Physical criteria of meat | | | |
|---|---|---|---|---|---|---|---|---|
| | DM | CP | EE | Ash | pH | Color | Tenderness. | WHC |
| 2700 | 27.0$^{b}$ | 78.2$^{a}$ | 12.7$^{b}$ | 6.1 | 6.66 | 0.298$^{b}$ | 3.11 | 6.52$^{a}$ |
| 2900 | 27.9$^{a}$ | 76.6$^{b}$ | 15.4$^{a}$ | 6.0 | 6.68 | 0.321$^{a}$ | 3.09 | 5.75$^{b}$ |
| SEM | 0.224 | 0.107 | 0.099 | 0.08 | 0.02 | 0.002 | 0.046 | 0.030 |
| P value | 0.01 | 0.001 | 0.001 | NS | NS | 0.0001 | NS | 0.001 |
| Control | 27.2 | 77.5 | 14.1 | 6.1 | 6.68 | 0.329$^{a}$ | 3.084 | 6.186 |
| RB | 27.4 | 77.3 | 14.0 | 6.0 | 6.66 | 0.310$^{b}$ | 3.139 | 6.107 |
| BR | 27.7 | 77.3 | 14.1 | 6.1 | 6.66 | 0.291$^{c}$ | 3.088 | 6.118 |
| SEM | 0.229 | 0.131 | 0.122 | 0.09 | 0.02 | 0.002 | 0.056 | 0.037 |
| P value | NS | NS | NS | NS | NS | 0.0001 | NS | NS |
| No enzyme | 27.2 | 77.4 | 14.1 | 6.1 | 6.64 | 0.307 | 3.15 | 6.138 |
| Avizyme | 27.9 | 77.3 | 14.1 | 6.1 | 6.69 | 0.309 | 3.10 | 6.132 |
| Phytase | 27.3 | 77.4 | 14.1 | 5.9 | 6.68 | 0.312 | 3.06 | 6.141 |
| SEM | 0.229 | 0.131 | 0.122 | 0.09 | 0.02 | 0.0002 | 0.056 | 0.037 |
| P value | NS | NS | NS | NS | NS | NS | NS | NS |
| Low × control × no enzyme | 26.1 | 78.6 | 12.5 | 6.3 | 6.68 | 0.316 | 3.12 | 6.49 |
| Low × control ×Avizyme | 27.4 | 78.2 | 12.8 | 6.3 | 6.61 | 0.313 | 3.09 | 6.47 |
| Low × control × phytase | 26.6 | 78.1 | 12.8 | 6.0 | 6.72 | 0.316 | 3.09 | 6.60 |
| Low × RB × no enzyme | 25.7 | 77.8 | 13.1 | 6.0 | 6.61 | 0.304 | 3.22 | 6.44 |
| Low × RB × Avizyme | 28.0 | 77.8 | 12.8 | 6.2 | 6.77 | 0.298 | 3.03 | 6.60 |
| Low × RB × phytase | 26.5 | 78.7 | 12.2 | 6.0 | 6.60 | 0.302 | 3.19 | 6.52 |
| Low × BR ×no enzyme | 27.3 | 78.2 | 12.7 | 6.2 | 6.61 | 0.267 | 3.17 | 6.49 |
| Low×BR × Avizyme | 27.5 | 78.2 | 12.6 | 6.2 | 6.72 | 0.284 | 3.10 | 6.57 |
| Low× BR × phytase | 27.7 | 78.0 | 12.9 | 5.9 | 6.61 | 0.282 | 2.99 | 6.46 |
| High× control × no enzyme | 27.7 | 76.8 | 12.3 | 6.1 | 6.66 | 0.341 | 3.21 | 5.90 |
| High× control × Avizyme | 28.9 | 76.4 | 15.7 | 6.2 | 6.75 | 0.332 | 2.99 | 5.77 |
| High × control × phytase | 26.9 | 76.6 | 15.5 | 5.7 | 6.68 | 0.354 | 3.24 | 5.87 |
| High× RB × no enzyme | 28.2 | 76.5 | 15.4 | 6.1 | 6.61 | 0.317 | 3.06 | 5.70 |
| High × RB × Avizyme | 28.1 | 76.6 | 15.2 | 6.2 | 6.60 | 0.321 | 3.09 | 5.71 |
| High × RB × phytase | 27.8 | 76.5 | 15.5 | 5.5 | 6.76 | 0.313 | 3.15 | 5.66 |
| High × BR × no enzyme | 28.0 | 76.6 | 15.4 | 6.3 | 6.66 | 0.299 | 3.09 | 5.78 |
| High × BR × Avizyme | 27.9 | 76.5 | 15.4 | 5.8 | 6.66 | 0.307 | 3.15 | 5.67 |
| High ×BR × phytase | 28.0 | 76.5 | 15.5 | 6.0 | 6.71 | 0.306 | 3.02 | 5.72 |
| SEM | 0.731 | 0.321 | 0.298 | 0.229 | 0.047 | 0.006 | 0.138 | 0.091 |
| P value | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

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

Phytase increased plasma total lipids ($p$<0.05) without affecting plasma cholesterol. Also, Attia (2003) found that phytase had no adverse effects on plasma total protein, total lipids, cholesterol, ALT and AST. A small change in meat WHC were shown due to inclusion of RB or BR in the LE-diet, while including RB and BR in HE-diet decreased meat WHC ($p$<0.05). Meat WHC was not changed due to inclusion of RB or BR in LE-diet, while including RB- and BR in HE-diet decreased WHC of meat (data not shown). Obviously, inclusion of RB or BR in the LE-diet increased plasma ALT, meanwhile including RB and BR decreased plasma ALT of HE-diets (data not shown). Enzymes decreased plasma ALT considerably of LE-diet. While, phytase resulted in unexplained increase (6.7%) in plasma ALT of HE-diet (Table 3). Plasma ALT of only corn soybean-meal diet was ($p$<0.05) decreased due to phytase. However, Avizyme decreased plasma ALT of corn soybean meal without or with BR, whilst the contrary was shown of RB-diet. Plasma AST was not affected by level and source of energy and/or enzymes (Tables 3).

**Table (3) Effect of energy level, rice by products and/or enzyme additions on plasma constituents of 42 d old Japanese quail**

| Treatments | Total protein | Total lipid | Cholesterol | ALT | AST |
|---|---|---|---|---|---|
| 2700 | 4.05 | 6.51 [b] | 105.8 [b] | 12.1 | 23.77 |
| 2900 | 4.04 | 6.82 [a] | 116.5 [a] | 11.7 | 23.22 |
| SEM | 0.033 | 0.064 | 1.50 | 0.18 | 0.308 |
| P value | NS | 0.006 | 0.0001 | NS | NS |
| Control | 4.10 | 6.63 | 108.9 | 12.1 | 23.06 |
| RB | 3.99 | 6.73 | 111.3 | 12.0 | 23.73 |
| BR | 4.05 | 6.63 | 113.2 | 11.7 | 23.70 |
| SEM | 0.041 | 0.078 | 1.84 | 0.22 | 0.377 |
| P value | NS | NS | NS | NS | NS |
| No enzyme | 4.06 | 6.50[b] | 110.9 | 12.2 | 23.53 |
| Avizyme | 4.01 | 6.67[ab] | 110.3 | 11.5 | 23.80 |
| Phytase | 4.07 | 6.82[a] | 112.3 | 12.0 | 23.17 |
| SEM | 0.071 | 0.078 | 1.84 | 0.22 | 0.377 |
| P value | NS | 0.02 | NS | NS | NS |
| Low × control × no enzyme | 4.12 | 5.98 | 106.8 | 12.2 | 23.79 |
| Low × control ×Avizyme | 4.04 | 6.51 | 102.3 | 11.8 | 23.77 |
| Low × control × phytase | 4.01 | 6.73 | 106.0 | 11.1 | 22.51 |
| Low × RB × no enzyme | 4.14 | 6.52 | 103.0 | 13.1 | 22.34 |
| Low × RB × Avizyme | 4.00 | 6.58 | 108.3 | 13.0 | 26.18 |
| Low × RB × phytase | 4.00 | 6.82 | 104.7 | 10.8 | 21.82 |
| Low × BR ×no enzyme | 4.04 | 6.10 | 104.8 | 13.4 | 24.80 |
| Low×BR × Avizyme | 4.12 | 6.67 | 107.2 | 10.9 | 23.46 |
| Low× BR × phytase | 3.96 | 6.65 | 108.7 | 13.2 | 25.30 |
| High× control × no enzyme | 4.14 | 6.87 | 113.7 | 13.4 | 23.84 |
| High× control × Avizyme | 4.01 | 6.79 | 111.3 | 11.2 | 22.61 |
| High × control × phytase | 4.25 | 6.93 | 113.5 | 13.0 | 21.87 |
| High× RB × no enzyme | 3.85 | 6.76 | 118.6 | 10.6 | 24.80 |
| High × RB × Avizyme | 3.84 | 6.79 | 116.1 | 11.8 | 21.98 |
| High × RB × phytase | 4.16 | 6.89 | 117.1 | 12.7 | 25.27 |
| High × BR × no enzyme | 4.07 | 6.80 | 118.4 | 10.7 | 21.59 |
| High × BR × Avizyme | 4.05 | 6.70 | 116.6 | 10.7 | 24.79 |
| High ×BR × phytase | 4.03 | 6.88 | 123.6 | 11.2 | 22.25 |
| SEM | 0.10 | 0.191 | 4.51 | 0.55 | 0.923 |
| P value | 0.001 | 0.001 | 0.001 | 0.001 | 0.0001 |

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

Avizyme and phytase increased DM (%) by 4.9, 8.8 and 0.7% and by 1.9, 3.1 and 1.2% of LE-corn-soybean diet without or with RB or BR, respectively (Table 2). While, Avizyme resulted in an increase of 4.2% of HE-corn-soybean diet. Phytase decreased DM by 3.0, 1.5 and 0.2% of HE-corn-soybean meal diet without with RB and BR, respectively. Avizyme had a small effect on meat CP% of LE- or HE-diet without or with RB or BR. However, phytase had a positive impact on meat CP% of group fed LE-RB diet (1.2%), whilst other groups showed small negative effects. Avizyme increased (%) EE by 2.2 and 2.9% of LE- and the HE-corn-soybean diet, respectively. However, Avizyme decreased EE% by 2.0 and 1.2% of LE- and HE-RB diet, respectively. There was positive effect of

phytase on meat EE% of the LE-corn soybean diet without (2.4%) or with BR (2.1%), and of HE-corn soybean diet (3.1%). However, phytase decreased meat EE of LE-RB-diet (6.9%) and had small effect on other groups (Table 2). These changes in EE parallel the changes in meat dry matter. It interesting to report that Avizyme increased CA of meat of LE- and HE-diet containing RB by 4.0 and 2.8%, respectively. Meanwhile, a negative effect of Avizyme was shown of HE-BR-diet (7.8%). All in all, results showed that meat DM, CP and EE of phytase supplemented LE-diet without or with 20% RB or BR were comparable to those obtained of the unsupplemented HE-corn-soybean diet.

Avizyme increased pH by 2.4 and 1.7% of LE-diet RB- or BR-diet, respectively, and by 1.4% of HE-corn-soybean meal diet. Phytase increased meat pH by 2.3% of groups fed HE-RB diet, respectively. Yet, this was not supported by changes in EE and CP of meat. Avizyme increased color intensity of meat by 6.4 and 2.7% of LE-, HE- BR diet, respectively, and HE-RB diet (1.3%). Whilst, Avizyme decreased meat color of LE-corn-soybean meal diet fed without (1%) or with RB (2%) and HE corn soybean meal diet (2.6%). Phytase increased meat color of meat by 5.6% of the LE-BR, and by 3.8 and 2.3% of the HE-corn-soybean diet without or with BR, respectively, indicating an increase in pigmentations. Avizyme increased meat tenderness by 1.0 and 1.9% of HE-RB or BR-diet, respectively and decreased WHC by 2.2 and 1.9%of HE-corn-soy diet without or with BR, respectively (Table 2). Clearly, Avizyme decreased meat tenderness by 1.0, 5.9, 2.2, and 6.9% of LE-corn-soybean meal diet without or with RB or BR and HE- corn-soybean meal diet, respectively. Phytase had a negative effect on meat tenderness of LE-corn soybean-BR diet (5.7%) and HE-BR diet (2.3%), while increased meat tenderness of HE- RB diet (2.9%), while increased WHC of LE-corn soybean diet without or with RB by 1.7 and 1.2%, respectively, while the effect was ~1.0% in HE corn-soybean diet without or with RB or BR.

Avizyme increased plasma total protein by 2.0% of LE-BR diet, and this parallels the increase in protein digestibility. However, Avizyme decreased plasma total protein of LE corn-soybean diet without (1.9%) or with RB (3.4%) and HE-corn soybean diet (3.1%), but had small effect on HE-RB or BR-diets. Phytase increased plasma total protein of groups fed HE- corn-soybean diet without or with RB by 2.7 and 8.1%, respectively (Table 3), while the contrary was shown of LE groups (2%), HE-BR diet (1%), and corn-soybean diet without (2.7%) or with RB (3.4%). Avizyme increased plasma total lipids of corn-soybean meal diet without (8.9%) or with BR (9.0%), while the contrary was shown of HE-con-soybean diet without (1.2%) or with BR (1.5%), respectively (Table 3). Phytase increased plasma total lipids by 12.5, 4.6 and 9.0% of the LE-corn soybean diet without or with RB or BR, respectively, while the corresponding increase in HE-diet was small. Avizyme decreased plasma cholesterol of the most groups except those fed LE-RB or –BR diet, which was increased by 5.2 and 2.4%, respectively. Phytase increased plasma cholesterol of LE-RB or BR diets by 1.7, 3.8%, respectively, and by 4.4% of the HE-BR-diet, and this concurred with the increase in plasma total lipids. Avizyme increased plasma ALT by 12.1% of HE-RB diet, while decreased it when was added to the rest of treatment groups, being the most distinguish of those fed LE-BR diet (18.9%) and HE-corn soybean meal-diet (16.0%), other groups exhibited moderate reduction. In conclusion dietary 20% RB or BR in LE-phytase or Avizyme supplemented diet did not adversely affect carcass yield, quality of meat and plasma constituents.

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