# Effect of energy level, rice by products and enzyme additions on growth performance and energy utilization of Japanese quail

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**Abstract: The possibility of including 20% of rice bran (RB) or broken rice (BR) in all-mash vegetable Japanese quail (JQ) diets containing either 2700 kcal ME/kg low energy (LE) or 2900 kcal ME/kg diet high energy (HE) without or with addition of 1 g/kg of Avizyme 1500, or 1000 FYT of Ronozyme phytase was investigated using 2×3×3 factorial design during 14-42d of age. Feeding HE increased ($p$<0.05) BWG by 5.7%, and improved ($p$<0.05) feed conversion ratio (FCR) by 10.8%, and energy conversion ratio (ECR) by 4.0% compared to the LE. Apparent digestibility of crude protein (CP), either extract (EE), crude fibre (CF), crude ash (CA), organic matter (OM) and calculated metaboilzable energy (CME) were better ($p$<0.05) of HE-than LE. A 20% RB could be included in JQ diets without adverse effect on BWG, while improved ($p$<0.05) FCR and ECR compared to the control group and BR fed groups. Meanwhile, BR resulted in the opposite trend, and could not be included without enzyme additions. Inclusion of 20% RB and BR improved ($p$<0.05) digestibility of most of nutrient. Phytase improved BWG, FCR and digestibility of most of nutrients compared to the control and Avizyme-supplemented groups. Also, Avizyme improved ($p$<0.05) BWG, FCR and ECR compared to the control group, but of less extent than phytase. Phytase and Avizyme improved BWG, FCR and ECR of JQ fed LE-diet, however, the complete recovery was not obtained. Also, Phytase improved BWG and FCR and ECR greatly of corn-soybean meal without or with RB or BR. Phytase supplemented LE-RB diet showed comparable BWG to those fed the HE diet. In conclusion, phytase permits including 20% of RB or BR in the HE-diet for JQ, while Avizyme permits utilization of RB in HE-diet, and phytase and Avizyme improved energy utilization by 3.0 and 2.2%, respectively.**

**Keywords**: Japanese quail. energy level and source, enzyme and phytase

## Introduction

Rice by products such as RB and BR are rich sources of nutrients, and energy and protein contents of BR and RB compares well with those of maize. However, the optimum utilisation of these potential feedstuffs may be restricted by its NSP, phytin and low amino acid of RB and energy utilization of BR (Isshak, 1990; Jadhao *et al*., 1999; Attia *et al*., 2003; Farrell, 2006). However, some studies used these by products for formulating poultry diets to some extent e.g. RB (El-Full *et al.*, 2000; Attia *et al*., 2003) and BR (Raya, 1989). Multienzymes or phytase may be a practical mean to improve poultry diets containing higher levels of NSPand/or anti-nutritional factors (Attia *et al.*, 2003; Choct, 2006). They concluded that enzymes such as phytase and multienzymes mixture improved performance of poultry and this depends on dietary composition and type of enzyme. 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 was tested with Japanese quail during 14-42 d of age.

## Materials and methods

A factorial design (2×3×3) was used during 14-42 days of age, in which there were two energy levels e.g. (low 2700 and high level 2900 kcal ME/kg diet), within each level, RB or BR was included at 0 or 20%. Thus, there were 6 main experimental diets fed without or with 1 g/kg Avizyme 1500® (Avizyme containing 4000μ/g proteases, 300 μ /g of endo-1, 4-β- xylanase, and 400 μ /g of α-amylase) or 1000 FYT Ronozyme™ P (CT)®/kg diet. Available phosphorus and Ca of phytase supplemented-diets was adjusted by 0.10% diet according to phytase equivalent value. The nutrient profiles of feed ingredients as well as the analyzed values for RB (89.66% DM, 12.1% CP, 14.75% EE, 7.42% CF, 6.11% CA, and 49.28 %NFE) and BR (88.41% DM, 7.4% CP, 1.16% EE, 0.94% CF, 1.81% CA, and 77.1% NFE) and nutrients requirements (NRC, 1994) were used for dietary formulations of isonitrogenous diets (Table, 1). Each diet was fed to 51 wing banded JQ-chicks distributed randomly to 3 cages (replicates) of 17 chicks each. They were fed *ad libtium* the tested diets in mash form and given free access to water. Chicks were kept under 23:1 light-dark cycle under similar environmental and managerial condition during 14-42 d of age.

Table (1) Composition of the experimental diets fed to Japanese quail during 14-42 days of age.

| Ingredients and composition, % | 2900 kcal ME/kg diet | | | 2900 kcal ME/kg diet | | |
|---|---|---|---|---|---|---|
| | Yellow corn | RB | BR | Yellow corn | RB | BR |
| Yellow corn | 50.03 | 32.38 | 28.00 | 45.42 | 27.20 | 24.50 |
| Soybean meal (44% CP) | 45.00 | 42.43 | 45.96 | 45.77 | 43.44 | 46.63 |
| Broiler protein concentrate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| RB | 0.00 | 20.0 | 0.00 | 0.00 | 20.00 | 0.00 |
| BR | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 20.00 |
| Dl-methionine | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.12 |
| L-lysine-HCl | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lime stone | 1.40 | 1.40 | 1.34 | 1.35 | 1.40 | 1.35 |
| Di-calcium phosphate | 0.78 | 0.68 | 0.78 | 0.83 | 0.68 | 0.78 |
| 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 | 0.27 | 0.95 | 1.13 | 4.641 | 5.50 | 5.05 |
| Sand | 1.79 | 1.43 | 2.07 | 1.259 | 1.05 | 0.97 |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Dry matter[2] | 89.26 | 89.51 | 89.36 | 89.43 | 89.22 | 89.64 |
| ME kcal/kg[1] | 2700 | 2700 | 2700 | 2900 | 2900 | 2900 |
| CP[2] | 23.88 | 23.79 | 23.80 | 23.73 | 23.84 | 23.86 |
| Methionine[1] | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| TSAA[1] | 0.89 | 0.90 | 0.90 | 0.88 | 0.89 | 0.89 |
| Lysine[1] | 1.34 | 1.34 | 1.40 | 1.35 | 1.35 | 1.40 |
| Calcium[1] | 0.84 | 0.83 | 0.83 | 0.84 | 0.83 | 0.83 |
| Av. P[1] | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
| Crude fat[2] | 2.71 | 4.80 | 2.74 | 6.89 | 9.21 | 6.58 |
| Crude fibre[2] | 2.84 | 4.56 | 2.48 | 2.81 | 4.54 | 2.44 |
| Ash[2] | 9.91 | 9.43 | 9.86 | 9.50 | 9.32 | 9.31 |

*Vit+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.

Birds were weighed (g) individually and BWG (g/bird) was calculated. Feed intake was recorded for each replicate (g/bird) and thereby FCR (g feed/g gain) and ECR were calculated as kcal ME intake/g BWG. Apparent digestibility of CP, EE, CF, CA, and CME was done using three replicates of 4 males each/treatment using total collection method as cited by Attia *et al*. (2003). Nitrogen, EE and CF and CA content of the excrement as well as those of feed were determined according to AOAC

(1990). The metaboilzable energy value of the experimental diets was calculated using the digestible value of CP, EE and NFE according to Jager (1996). Statistical analyses was done using three way analyses of variance of the General Linear Model (GLM) of SAS® (SAS, Institute (1990), while main differences were compared using Duncan's New multiple Range Test (Duncan, 1955).

## Results and discussion

**Main effect of energy, rice by products and enzyme addition:** Growth was increased (5.7%; $p<0.05$) when HE-diet was fed compared to LE diet, and resulted in less ($p<0.05$) feed intake (5.8%) and better ($p<0.05$) FCR (10.8%) and ECR (4%; Table 2). The improvement in BWG, FCR and ECR could be due to the use of fat to increase energy level (Table 1) and the improvements ($p<0.05$) in digestibility of nutrients (Table 2).

**Table (2). Mean effect of energy level, and inclusion level of rice bran and broken rice and enzymes on growth performance and digestibility of nutrients.**

| Treatment | Growth performance parameters during 14-42 d of age | | | | Digestibility of nutrients (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | BWG,g | Feed intake, g /bird | FCR, g/g | ECR, kcal/g | CP | EE | CF | CA | Organic matter | ME value |
| 2700 | 134.4$^{b}$ | 498.8$^{a}$ | 3.72$^{a}$ | 10.04$^{a}$ | 82.11$^{b}$ | 69.32$^{b}$ | 22.62$^{b}$ | 32.01$^{b}$ | 64.73$^{b}$ | 2632$^{b}$ |
| 2900 | 142.0$^{a}$ | 471.3$^{b}$ | 3.32$^{b}$ | 9.64$^{b}$ | 82.97$^{a}$ | 84.31$^{a}$ | 25.96$^{a}$ | 32.88$^{a}$ | 69.50$^{a}$ | 2803$^{a}$ |
| SEM | 0.331 | 0.137 | 0.088 | 0.030 | 0.040 | 0.076 | 0.192 | 0.086 | 0.112 | 3.50 |
| P value | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Control | 139.8$^{a}$ | 491.5$^{a}$ | 3.52$^{b}$ | 9.85$^{b}$ | 82.56$^{b}$ | 73.23$^{c}$ | 22.76$^{b}$ | 32.61$^{b}$ | 65.73$^{c}$ | 2674$^{b}$ |
| RB-diet | 141.0$^{a}$ | 483.9$^{b}$ | 3.44$^{c}$ | 9.62$^{c}$ | 80.91$^{c}$ | 81.50$^{a}$ | 31.27$^{a}$ | 28.56$^{c}$ | 69.40$^{a}$ | 2799$^{a}$ |
| BR-diet | 133.8$^{b}$ | 479.8$^{c}$ | 3.59$^{a}$ | 10.04$^{a}$ | 84.16$^{a}$ | 75.71$^{b}$ | 18.84$^{c}$ | 36.18$^{a}$ | 66.22$^{b}$ | 2679$^{b}$ |
| SEM | 0.406 | 0.168 | 0.027 | 0.037 | 0.049 | 0.094 | 0.235 | 0.105 | 0.136 | 4.30 |
| P value | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| No enzyme | 134.2$^{c}$ | 488.2$^{a}$ | 3.65$^{a}$ | 10.19$^{a}$ | 81.73$^{c}$ | 74.95$^{c}$ | 19.50$^{c}$ | 31.07$^{c}$ | 65.21$^{c}$ | 2671$^{c}$ |
| Avizyme | 137.6$^{b}$ | 485.2$^{b}$ | 3.54$^{b}$ | 9.88$^{b}$ | 82.76$^{b}$ | 76.59$^{b}$ | 23.82$^{b}$ | 32.75$^{b}$ | 66.93$^{b}$ | 2731$^{b}$ |
| Phytase | 142.9$^{a}$ | 481.8$^{c}$ | 3.38$^{c}$ | 9.44$^{c}$ | 83.15$^{a}$ | 78.89$^{a}$ | 29.54$^{a}$ | 33.53$^{a}$ | 69.21$^{a}$ | 2750$^{a}$ |
| SEM | 0.406 | 0.168 | 0.049 | 0.037 | 0.049 | 0.095 | 0.235 | 0.105 | 0.136 | 4.30 |
| P value | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

$^{a\text{-}c}$ means within a column within similar treatment with no common superscripts differ significantly ($p< 0.05$), NS, ($p> 0.05$).

Dietary RB could be included at 20% in JQ diets while increased ($p<0.05$) BWG, and improved ($p<0.05$) FCR (1.42%) and ECR (2.33%), and decreased ($p<0.05$) feed intake (Table 2). The improved growth performance of RB-group was concurred with improved digestibility of EE (11.3%), CF (37.4%), OM (5.6%) and value of ME by 4.7% (Table 2). Whereas, BR decreased ($p <0.05$) BWG and feed intake and impaired ($P<0.05$) FCR and ECR, while improved digestibility of CP (1.9%), EE (3.4%), CA (10.4%) and OM (~1.0), with the impact of BR on EE, and OM was less than that of RB, while the opposite was shown in CP digestibility (Table 2). Similarly, El-Full *et al.* (2000) and Farrell (2006) indicated that RB could be included up to 20% in chicken diets without adverse effect on growth, which in contradictory to results by Attia *et al.* (2003). Whilst, the negative effect of BR on growth performance are in general agreement with the results by Isshak (1990) who found that BR at 28% in broiler diets decreased ($p<0.05$) broiler growth, and this may be due to the decrease in energy utilization of BR -diets (Tyagi *et al*., 1994; Jadhao *et al*., 1999).

Phytase and Avizyme improved ($p <0.05$) BWG (6.5 and 2.5%, respectively), while decreased ($P<0.05$) feed intake and improved ($p <0.05$) FCR (3.0 and 7.4%, respectively) and ECR (3.0 and 7.4%, respectively). The improved performance of enzymes supplemented groups was associated with increased ($p <0.05$) digestibility of CP, EE, CF, CA, OM and the value of ME, with phytase had greater effect (Table 2). Enzymes as either multienzymes or phytase (Kies *et al*., 2001, Attia *et al*., 2003) was found to increase availability of nutrients for broilers and resulted in improved ($p<0.05$) BWG and FCR of JQ (Bahtiyarca and Parlat, 1997), due to improve digestion of protein, starch, fat, and fibre, and eliminating the anti nutritional factors, improve heath of gut and immunity of birds (Choct 2006).

**Two-way interactions:** There was no significant interaction between energy level and enzymes in BWG, FCR and ECR (Table 2). However, phytase or Avizyme addition to the LE- or the HE-diets yields consistent improvements in BWG, FCR and ECR. Phytase and Avizyme improved BWG, FCR and ECR by 7.8% and 3.5%, 8.2 and 7.0%, and 7.8 and 3.7%, respectively of the LE-diet, thus BWG, FCR and ECR of phytase supplemented group was comparable to those fed unsupplemented HE-corn-soybean meal diet, indicates that phytase had greater effect on energy/nutrient utilization of LE diet (Table 3).

**Table (3) Effect of the interaction between energy level and rice by products and/or enzymes on growth performance and digestibility of nutrients.**

| Treatments | Growth performance | | | | Digestibility of nutrients (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | BWG, g | Feed intake, g/bird | FCR, g/g | ECR, kcal/g | CP | EE | CF | CA | OM | ME value |
| Low× control | 135.5 | 505.0 | 3.73 | 10.07 | 81.92 | 63.48 | 20.39 | 31.93 | 62.62 | 2559 |
| Low×RB | 137.0 | 498.0 | 3.64 | 9.82 | 80.45 | 77.20 | 28.24 | 27.62 | 67.41 | 2757 |
| Low×BR | 130.7 | 493.8 | 3.79 | 10.22 | 83.98 | 67.27 | 19.24 | 36.49 | 64.15 | 2580 |
| High×control | 144.1 | 472.9 | 3.32 | 9.62 | 83.21 | 82.97 | 25.13 | 33.28 | 68.84 | 2789 |
| High×RB | 145.0 | 470.7 | 3.25 | 9.42 | 81.37 | 85.80 | 34.31 | 29.49 | 71.38 | 2842 |
| High×BR | 137.0 | 465.7 | 3.40 | 9.87 | 84.34 | 84.15 | 18.43 | 35.86 | 68.29 | 2778 |
| SEM | 0.553 | 0.238 | 0.084 | 0.052 | 0.070 | 0.132 | 0.332 | 0.148 | 0.193 | 6.08 |
| P value | NS | 0.0001 | NS | NS | 0.001 | 0.001 | 0.001 | 0.001 | 0.0001 | 0.001 |
| Low×no enzyme | 129.5 | 500.8 | 3.89 | 10.44 | 81.47 | 66.76 | 17.65 | 30.45 | 62.52 | 2577 |
| Low×Avizyme | 134.0 | 497.9 | 3.72 | 10.05 | 82.24 | 69.21 | 22.67 | 32.26 | 64.86 | 2659 |
| Low×phytase | 139.6 | 497.7 | 3.57 | 9.63 | 82.64 | 71.99 | 27.54 | 33.33 | 66.82 | 2660 |
| High×no enzyme | 138.8 | 475.6 | 3.43 | 9.94 | 81.98 | 83.15 | 21.35 | 31.69 | 67.90 | 2765 |
| High×Avizyme | 141.2 | 472.6 | 3.35 | 9.71 | 83.28 | 83.98 | 24.98 | 33.24 | 69.00 | 2804 |
| High×phytase | 146.1 | 465.8 | 3.19 | 9.25 | 83.65 | 85.79 | 31.54 | 33.72 | 71.61 | 2839 |
| SEM | 0.552 | 0.239 | 0.084 | 0.052 | 0.070 | 0.132 | 0.332 | 0.148 | 0.193 | 6.08 |
| P value | NS | 0.0001 | NS | NS | 0.001 | 0.001 | 0.03 | 0.02 | 0.01 | 0.003 |
| Control×no enzyme | 137.1 | 494.3 | 3.62 | 10.10 | 81.97 | 70.22 | 17.38 | 30.22 | 63.52 | 2657 |
| Control×Avizyme | 139.2 | 492.8 | 3.54 | 9.91 | 82.81 | 73.83 | 22.28 | 31.69 | 65.61 | 2692 |
| Control×phytase | 143.0 | 489.4 | 3.41 | 9.54 | 82.92 | 75.63 | 28.61 | 30.56 | 68.07 | 2673 |
| RB×no enzyme. | 134.8 | 486.4 | 3.62 | 10.11 | 79.79 | 80.28 | 27.33 | 34.37 | 67.91 | 2721 |
| RB×Avizyme | 142.4 | 484.8 | 3.41 | 9.53 | 81.27 | 80.73 | 32.55 | 35.35 | 69.60 | 2820 |
| RB×phytase | 146.0 | 480.6 | 3.30 | 9.22 | 81.68 | 83.51 | 33.95 | 38.20 | 70.69 | 2858 |
| BR×no enzyme | 130.6 | 483.8 | 3.71 | 10.37 | 83.77 | 74.36 | 13.80 | 31.57 | 64.20 | 2636 |
| BR×Avizyme | 131.3 | 478.1 | 3.65 | 10.20 | 84.21 | 75.22 | 16.65 | 36.72 | 65.59 | 2682 |
| BR×phytase | 139.6 | 477.3 | 3.42 | 9.56 | 84.84 | 77.55 | 26.07 | 37.10 | 68.89 | 2720 |
| SEM | 0.702 | 0.291 | 0.103 | 0.063 | 0.086 | 0.162 | 0.407 | 0.181 | 0.236 | 7.44 |
| P value | 0.001 | 0.01 | 0.003 | 0.003 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.01 |
| Low×control×no enzyme | 131.8 | 507.9 | 3.86 | 10.41 | 81.52 | 59.24 | 15.4 | 30.30 | 60.00 | 2518 |
| Low×control×Avizyme | 135.8 | 506.3 | 3.73 | 10.07 | 82.03 | 64.89 | 21.6 | 32.58 | 63.57 | 2633 |
| Low×control×phytase | 138.8 | 500.9 | 3.61 | 9.74 | 82.20 | 66.29 | 24.2 | 32.91 | 64.31 | 2525 |
| Low×RB×no enzyme | 129.5 | 496.8 | 3.84 | 10.36 | 79.57 | 75.35 | 24.0 | 25.96 | 65.70 | 2660 |
| Low×RB×Avizyme | 140.0 | 497.6 | 3.55 | 9.60 | 80.55 | 75.92 | 29.4 | 28.92 | 67.39 | 2774 |
| Low×RB×phytase | 141.6 | 498.0 | 3.52 | 9.50 | 81.23 | 80.33 | 31.3 | 27.98 | 69.15 | 2836 |
| Low×BR×no enzyme | 127.4 | 497.7 | 3.91 | 10.55 | 83.33 | 65.67 | 13.5 | 35.09 | 61.85 | 2553 |
| Low×BR×Avizyme | 126.3 | 489.7 | 3.88 | 10.47 | 84.14 | 66.80 | 17.1 | 35.28 | 63.62 | 2568 |
| Low×BR×phytase | 138.4 | 494.2 | 3.57 | 9.64 | 84.48 | 69.35 | 27.2 | 39.09 | 67.0 | 2619 |
| High×control×no enzyme | 142.4 | 480.7 | 3.38 | 9.79 | 82.41 | 81.20 | 19.4 | 30.14 | 67.04 | 2795 |
| High×control×Avizyme | 142.7 | 479.2 | 3.36 | 9.74 | 83.58 | 82.79 | 23.0 | 34.37 | 67.64 | 2749 |
| High×control×phytase | 147.1 | 473.9 | 3.22 | 9.34 | 83.64 | 84.96 | 33.1 | 35.35 | 71.83 | 2820 |
| High×RB×no enzyme | 140.0 | 476.1 | 3.40 | 9.86 | 79.99 | 85.20 | 30.6 | 28.20 | 70.12 | 2781 |
| High×RB×Avizyme | 144.7 | 471.9 | 3.26 | 9.46 | 81.99 | 85.53 | 35.7 | 31.57 | 71.81 | 2864 |
| High×RB×phytase | 150.5 | 463.1 | 3.08 | 8.93 | 82.12 | 86.68 | 36.6 | 28.72 | 72.22 | 2879 |
| High×BR×no enzyme | 133.9 | 470.0 | 3.51 | 10.18 | 83.54 | 83.05 | 14.1 | 36.72 | 66.54 | 2719 |
| High×BR×Avizyme | 136.2 | 466.6 | 3.43 | 9.94 | 83.54 | 83.65 | 16.2 | 33.78 | 67.55 | 2796 |
| High×BR×phytase | 140.8 | 460.4 | 3.27 | 9.48 | 84.27 | 85.75 | 25.0 | 37.10 | 70.77 | 2820 |
| SEM | 1.012 | 0.412 | 0.032 | 0.089 | 0.121 | 0.229 | 0.58 | 0.257 | 0.335 | 10.5 |
| P value | 0.02 | 0.0001 | 0.04 | 0.04 | 0.001 | 0.001 | 0.01 | 0.001 | 0.003 | 0.001 |

NS, ($p > 0.05$).

Also, phytase and Avizyme improved BWG and FCR of HE-diet by 5.3% and 1.7% and 4.4 and 2.3%, respectively. These were associated with interactions ($p<0.05$) between energy level and enzyme additions on feed intake, showing that, phytase decreased feed intake by 0.6 and 2.1% of the LE- or HE-diet, respectively (Table 3). Attia *et al*. (2003) and Zanella *et al*. (1999) found that phytase or multienzymes could compensate for the reduced energy of the diet or inclusion of RB.

Phytase improved BWG, FCR and ECR by 4.3, 8.3, and 6.9%, 5.8, 8.8 and 7.8% and 5.5, 8.8 and 7.81% of groups fed corn-soybean meal diet without or with RB or BR, respectively (Table 3). Whilst, Avizyme improved BWG, FCR and ECR by 1.5, 5.6 and 0.5%, 2.2, 5.8 and 1.6% and 1.9, 5.7 and 1.6% of JQ fed corn-soybean meal diet without or with RB or BR, respectively. This suggested that phytase was more effective and had also greater impact on RB, a rich phytic acid feedstuffs. This could not be attributed only to phytase, but also to other enzymes from microbial body of phytase yielding organism (Ravindran *et al*., 1999; Attia *et al*., 2003). Results indicated that phytase and Avizyme decreased feed intake by 1.0, 1.2 and 1.3% and 0.3, 0.3, and 1.2%, of corn-soybean meal diet without or with RB or BR, respectively (Table 2). Also, Cabahug *et al*. (1999) concluded that the response of feed intake to phytase varied at different level of phytic acid.

There were interactions ($p<0.05$) between energy level and inclusion of RB and BR and energy level and enzymes on apparent digestibility of CP, EE, CF, CA, and OM and CME (Table 3). The results indicated that the impact of type of rice by product depends on dietary energy level. Also, Results indicated that phytase supplemented LE-diet yield comparable digestibility of CP, CF, and CA and OM of LE-diet to those of the control HE-diet. Also, phytase improved the digestibility of EE by 7.8% and CME by 3.2% of the LE-diet, and also improved apparent digestibility of CF by 56.0 and 47.7% of LE- and HE-diets, respectively. Thereby, the negative impact of feeding LE diet on growth performance was totally recovered, and consequences FCR and ECR were greatly improved by 8.2 and 7.8%, respectively (Table 3). It is clear also that Avizyme improved the digestibility of CP, EE, CF, CA, NFE and OM as well as CME of the LE- and the HE-diet, but the effect was small compared to that observed due to phytase, with the greatest improvement was of CF digestibility being 28.4% of LE-vs. 17.0% of HE- diet. Also, a similar trend of less extent was shown due to Avizyme on EE and OM digestibility in LE and HE-groups (3.7 and 3.7 vs. 1.0 and 1.6, respectively).

There were significant interactions between inclusion of RB or BR and enzyme additions on apparent digestibility of CP, EE, CF, CA, OM and CME (Table 3). Results indicated that phytase improved digestibility of CP, EE, CF, OM, CA and CME of corn-soybean diet without or with RB and BR by 1.2, 2.4 and 1.3%, 7.7, 4.0, and 4.3%, 64.6, 24.2 and 88.9%, 3.3, 4.1 and 7.3%, by 1.1, 11.1 and 17.5%, and 0.6, 5.0 and 3.2%, respectively. Meanwhile, the corresponding values for Avizyme supplemented groups were 1.0, 1.9 and 0.5%, 5.1, 0.6 and 1.2%, 28.2, 19.1 and 20.7%, 3.3, 2.5 and 2.2%, 4.9, 2.9 and 16.3%, and 1.3, 3.6 and 1.7%, respectively. This indicates that phytase improved digestibility of CP, OM and CME, and was more effective in RB diet.

**Three- way interactions:** There was a significant interaction between energy level, inclusion of rice-by products and enzymes in BWG, feed intake, FCR, ECR, and digestibility of nutrients (Table 3). Phytase improved BWG and FCR by 5.3, 9.3 and 8.6% and 6.5, 8.3 and 8.7% of LE corn-soybean meal diet without or with RB or BR, respectively. The corresponding values for HE were 3.3, 7.5 and 5.2% and 4.7, 9.4 and 6.8%, respectively. The improvements in ECR parallel that of FCR. Whilst, Avizyme improved BWG by 3.0 and 8.1% of LE corn-soybean diet without or with RB, respectively, and 3.4, and 1.7% of high-energy-RB or-BR diet, respectively (Table 3). The positive effect of Avizyme on FCR was 3.4, 7.6 and 0.8% of the LE corn-soybean meal diet without or with RB or BR, respectively. The corresponding values for FCR of HE-corn soybean diet were 0.6, 4.1 and 2.3%, respectively. These indicate that the effect of phytase and Avizyme on growth performance of JQ depends on energy level and composition of the diets, with enzymes was more effective on RB-diets than corn-soybean meal diet without or with BR. These could be elucidated based on higher NSP and phytic acid of RB containing-diet, which could furnish more substrates for phytase and Avizyme.

Phytase and Avizyme improved digestibility of CP by 0.8, 2.1 and 1.4% and 0.6, 1.2 and 0.9% of LE-corn-soybean diet without or with RB or BR, respectively. These improvements were 1.5, 2.7 and 0.9% and 1.4, 2.5 and 0.0% of HE diet corn-soybean diet without or with RB or BR, respectively (Table 3). Phytase and Avizyme improved digestibility of EE by 11.9, 6.6 and 5.6% and 9.5, 0.8 and 1.7%, respectively of LE-corn-soybean diet without or with RB or BR. These improvements were 4.6, 1.7 and 3.3% and 4.6, 1.7 and 0.7%, respectively of HE corn-soybean diet without or with RB or BR, respectively (Table 4). Phytase and Avizyme improved digestibility of CF by 56.9, 30.2 and 101.1% and 40.2, 22.1 and 26.4% of LE-corn-soybean diet without or with RB or BR, respectively. These were 70.9, 19.5 and 77.3% and 18.7, 16.7 and 15.2% of HE corn-soybean diet without or with RB or BR, respectively (Table 3). Phytase and Avizyme improved digestibility of OM by 7.2, 5.3 and 8.3% and 6.0, 2.5 and 2.9%, respectively of LE-corn-soybean diet without or with RB or BR, respectively. These were 7.1, 3.0 and 6.4% and 0.9, 2.4 and 1.5% of HE diet corn-soybean diet without or with RB or BR, respectively (Table 3). In general, results revealed that phytase had greater effect on OM digestibility of LE vs. HE-diet. However, this depends on dietary energy source and level as stronger impact was observed of corn soybean diet without or with BR. Phytase and Avizyme improved digestibility of CME by 0.3, 6.6 and 2.6% and 4.6, 4.3 and 0.6%, respectively of LE-corn-soybean diet without or with RB or BR. These were 0.9, 3.5 and 3.7% and 3.0, 2.8 and 2.8%, respectively of HE diet corn-soybean diet without or with RB or BR (Table 3). Phytase and Avizyme improved digestibility of CA by 8.6, 7.8 and 11.4% and 7.5, 11.4 and 0.5%, respectively of LE-corn-soybean diet without or with RB or BR. These ameliorations were 17.3, 1.8 and 1.0% and 14.0, 12.0 and 8.0%, respectively of HE diet corn-soybean diet without or with RB or BR (Table 3). The improvement in digestibility of nutrients and ME depends enzyme type, energy level and type of rice by product and was within the range cited in literature (Zanini and Sazzad, 1999; Attia *et al*., 2003) and this could be attributed to the improvement in digestibility of starch and amino acids (Ravindran, 1999; Kies et al., 2001; Choct, 2006).

All in all, phytase permits including 20% of RB or BR in the HE-diet for JQ, while Avizyme permits utilization or RB in HE-diet, and phytase and Avizyme improved energy utilization by 3.0 and 2.2%, respectively.

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