

EVALUATION OF EGG QUALITY TRAITS OF JAPANESE QUAILS (*Coturnix coturnix japonica*) FED ENZYME SUPPLEMENTED DIETS CONTAINING POULTRY OFFAL MEAL

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Accepted: 29th September 2009

ABSTRACT

The effects of substitution of poultry offal meal (POM) for soybean meal (SBM) and the effect of supplementation of POM by a mixture of solid state fermentation enzymes (SSF) and Lipase on egg quality traits of Japanese quails were studied in two experiments. Unsexed Japanese quails (13 days old; N=200) were randomly assigned to twenty groups of ten birds for each experiment. In experiment 1, POM was incorporated at 0, 2.5, 5, 7.5 and 10% in the diets to assess the maximum inclusion level of POM. In Experiment 2, the egg quality of Japanese quails fed diets containing 0, 5 and 10% POM was investigated. Enzyme effect was tested at 5 and 10% POM. The major egg quality traits and sensory qualities were assessed. Feeding POM at 10% rate significantly ($P<0.05$) lowered shell ratio, egg weights and unit surface shell weight (USSW) by 4.6, 4.2 and 5.6% respectively compared to the control diet. However, POM could be incorporated up to 10% with no detrimental effects on internal quality traits and consumer's preference. Experiment 1 concluded that, 2.5% POM is the best in terms of external quality traits. Enzyme supplementation did not affect egg quality traits except for the improvement of albumen index by 5.9% at 10% POM.

Key words: Dietary enzymes, Egg quality, Japanese quails, Poultry offal meal, Soybean meal

INTRODUCTION

Poor egg quality results significant losses annually to the world egg industry. Approximately, 7-8% of total amounts of the eggs are broken during the transfer of eggs from breeders to consumers. Especially, the amount of cracked and broken eggs produces a serious economical problem for both the breeders and dealers (Hamilton 1982). In egg processing enterprises the weight as well as the rates of the egg shell, albumen and the yolk affects the amount and the price of the product (Altan *et al.* 1998). Furthermore, the egg quality traits are important in poultry breeding since they influence the yield features of the future generations, breeding performances and quality and growth of the chicks (Kul and Seker 2004).

Japanese quails (*Coturnix coturnix japonica*), being the smallest farmed avian species (Panda and Singh 1990) is becoming popular in commercial poultry sector for meat and egg production. Quail eggs are extremely delicate and must be handled with a great care to minimize the losses from physical damages. Egg quality traits are influenced by many factors including nutrition (Roberts 2000). Therefore, enhancing the egg quality traits through cost effective nutritional manipulation is utmost

important. Even a small percentage improvement in the overall quality of eggs and egg shells could result in significant savings to the industry in an increasingly competitive environment (Roberts 2000).

In Sri Lanka, commercial broiler and layer rations are used for feeding Japanese quails which do not satisfy their nutritional requirements. These poultry rations consist of soybean meal (SBM) as the main source of protein which is mainly imported leading to drain foreign exchange reserves in Sri Lanka. SBM is a poor source of calcium and phosphorus and contains a heat stable anti-nutritive factor called phytic acid (Banerjee 1998).

Currently, huge quantities of poultry offal are wasted in Sri Lanka leading to environmental hazards. Poultry offal meal (POM) is the most common by-product meal derived from poultry processing in Sri Lanka (Samarasinghe 2007). Therefore, recycling of such non conventional, cheap feed ingredients and research to evaluate them generally focus on replacing conventional, expensive protein supplements.

Commercially available multi enzyme preparations were found to improve performance by facilitating utilization of higher levels of agro-industrial by products in monogastric nutrition and by over-

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coming anti-nutritional factors in feed stuffs (Attia *et al.* 2008).

Research were conducted in the past to investigate the effect of POM as a substitute to other animal originated protein supplements in the diets of different livestock and aqua species (Cheng *et al.* 2002; Zier *et al.* 2004). Though the feeding value of POM under different dietary conditions has been tested on chicken, reports on the feeding value of POM for Japanese quails are scanty (Samli *et al.* 2006; Samarasinghe 2007). Therefore, the study herein reported was designed to investigate the effects of POM as a substitute for dietary SBM with or without enzymes supplements on egg quality traits of Japanese quails.

MATERIALS AND METHODS

Experimental design

Two feeding trials were conducted each with two hundred, 12 days-old unsexed Japanese quail chicks. They were procured from a commercial quail breeder farm in Balangoda and transferred to battery cages installed in a shed at the University Farm, Sabaragamuwa University of Sri Lanka. On

the following day, they were divided in to twenty groups of ten in such a way that the average group weights were similar and then housed in 20 battery cages each having 40x 40x 25cm space (LxWxH). Feeds and water were given *ad libitum* during the experimental period. A lighting schedule of 16h light /day was applied.

Experimental diets

Dry rendered poultry offal meal derived from an industrial poultry slaughter house in Gampola, Sri Lanka was used for experiments. For the first experiment, five isoenergetic and isoproteic rations containing pre-analyzed POM at 0, 2.5, 5, 7.5 and 10% inclusion levels were produced for growers and layers separately (Table 1). Birds were fed on grower diets up to 35th day of age and thereafter on layer feeds until 15 weeks old.

For the second experiment, three isoenergetic and isoproteic grower and layer diets containing 0, 5 and 10% pre-analyzed POM without enzymes and both POM diets (5 and 10% POM) supplemented with a mixture of solid state fermentation enzymes (SSF) and Lipase at 200 ppm were prepared and fed until 16 weeks of age (Table 1). SSF possesses the activities of seven enzymes (phytase,

Table 1: Composition of the diets fed to Japanese quail growers and layers in experiments 1 and 2

Ingredients (%)	Experiment 1					Experiment 2								
	Grower (3- 5 weeks)					Layer (5-15 weeks)					Grower (3-5 weeks)		Layer (5-16 weeks)	
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T3 + E	T5 + E	T3+ E	T5 + E
Rice polish	20	20	20	20	20	15.9	15.9	16	16	16	20	20	16	16
Maize	45	45	45	45	45	43	43	44.7	45.9	47	43.5	42	43	44
Coconut oil	-	-	-	-	-	2	2	1.5	1	0.6	-	-	1.5	0.8
Soybean meal	20	17	13.7	10.4	7.0	27.2	24	21	18	14.9	13.3	7.0	21	15
POM	0.0	2.5	5.0	7.5	10	0.0	2.5	5.0	7.5	10	5.0	10	5.0	10
Coconut poonac	6.20	6.70	7.68	8.60	9.65	-	0.7	-	-	-	10.2	13.1	2	3.4
Shell grit powder	7.00	7.00	6.80	6.67	6.50	9.7	9.7	9.6	9.4	9.3	6.5	6.5	9.6	9.1
Dicalcium phosphate	0.75	0.75	0.75	0.75	0.75	1.35	1.35	1.35	1.35	1.35	0.43	0.3	1.1	0.9
Lysine HCl	0.15	0.15	0.17	0.18	0.20	-	-	-	-	0.02	0.17	0.20	-	-
DL Methionine	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25	0.23	0.30	0.30	0.25	0.20
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Cocciostats	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Zn Bacitracin	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin mineral premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
SSF (ppm)**	-	-	-	-	-	-	-	-	-	-	200	200	200	200
Lipase (ppm) Calculated com-- position:	-	-	-	-	-	-	-	-	-	-	200	200	200	200
ME (MJ/kg)	12.1	12.2	12.2	12.2	12.3	12.4	12.4	12.4	12.4	12.4	12.2	12.2	12.3	12.4
CP (g/kg)	170.3	170.6	170.8	170.8	170.8	180.7	180.5	180.2	180.7	180.7	170.6	170.6	180.5	180.5

T1= Control. T2= 2.5% POM diet. T3= 5.0% POM diet. T4= 7.5% POM diet. T5= 10% POM diet T3+E= Enzyme supplemented 5% POM diet. T5+E= Enzyme supplemented 10% POM diet

*Layer premix B; Each 2.5 kg Layer premix B contained: vitamin A 8 miu, vitamin D₃ 2 miu, vitamin E 4000 mg, vitamin K 1000 mg, vitamin B₁ 2000 mg, vitamin B₂ 3600 mg, vitamin B₆ 1000 mg, vitamin B₁₂ 10 mg, calcium pantothenate 6000 mg, choline chloride 150 000 mg, folic acid 500 mg, niacinamide 20000 mg, D. L methionine 250 000 mg. Trace mineral; Each 2.5 kg Layer premix B contained: Iron 20 000 mg, Manganese 40 000 mg, Copper 5000 mg, Zinc 50 000 mg, Iodine 500 mg and Cobolt 100 mg.

** SSF each 1.0 g contained: Alpha-amylase min. 30 FAU, beta-glucanase min. 200 BGU, cellulase min.10 CMC, pectinase min. 4000 AJDU, phytase 300 SPU, fungal protease min. 700 HUT, xylanase min. 100 XU.

protease, pentosanase, glucanase, cellulase, amylase and pectinase) which are capable of breaking down protein, cellulose, pentosans, phytate and starch.

All the diets were formulated to satisfy the nutrient requirements of growing and laying quails according to Leeson and Summers (2005). Metabolizable energy (ME) content of POM for ration formulation was calculated according to the formula described by Janssen (1989). The feed without POM (0%) was considered as the control feed while the others served as test feeds. In both trials, the experimental diets were randomly assigned to 20 groups of birds with four replicates.

Samples of experimental feeds were collected on every 4th day during feeding, pooled separately and composite samples made were analyzed in duplicate for proximate composition according to the procedures of the Association of Official Analytical Chemists (AOAC 2002) and for gross energy by bomb calorimetry (Harris 1966).

Sampling of eggs

In Experiment 1, the eggs laid on every 4th day of the week from 10th to 15th weeks of age were collected for laboratory analysis. In Experiment 2, three eggs per replicate group were sampled from every 4th day to 7th day of the week from 12th week till 16th week of age. The total number of eggs analyzed in Experiment 1 and 2 were 362 and 297 respectively.

Egg quality parameters studied

All analyses were carried out at the Livestock laboratory of the Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka. Each egg was labeled and assessed separately for internal and external egg quality traits. As external quality traits, egg weights, shape index, shell ratio, unit surface shell weight (USSW), shell strength and shell thickness were studied. Individual egg weight was measured

using a 0.0001g sensitive electronic balance (AR 2140 OHAUS Corp. USA) while egg length and width were measured using a vernier caliper sensitive to 0.01 mm. The egg shape index is the ratio of the length and width of the egg. The impact strength of egg shell was estimated by fall ball technique where a steel ball of known weight with a graduated glass tube was used (Frank *et al.*, 1964). Eggs were broken and the shells were air dried for 24 hours. The dried shells were weighed together with the shell membranes and the shell ratio was determined by relating the shell weight to the weight of the egg. USSW was estimated by relating egg shell weight to egg surface area. Average shell thickness was measured for individual dry egg shells to the nearest 0.001 mm using a digital micrometer screw gauge by using the samples obtained from blunt, sharp and equatorial parts (Kul and Seker 2004).

The interior egg quality traits were measured in terms of yolk index, yolk ratio, albumen ratio, albumen index and Haugh Unit as described by Kul and Seker (2004). The yolk index was calculated as the proportion of yolk height to diameter while the albumen index was calculated as the proportion of albumen height to averaged albumen length and width. Haugh unit was calculated from egg weight and albumen height where egg weight was measured using a 0.0001g sensitive electronic balance (AR 2140 OHAUS Corp. USA) and albumen height was measured using a three legged manual micrometer sensitive to 0.01 mm. The yolk was separated from the albumen and the yolk ratio was calculated in percentages by relating the yolk weight measured to the weight of that particular egg. The albumen weight was calculated by subtracting the yolk and dry shell weights from the whole egg weight. The albumen ratio relative to the individual egg weight was calculated as a percentage by relating the albumen weight measured to the weight of that particular egg.

Sensory evaluation

The eggs collected from 14 weeks old Japanese quails in Experiment 1 were boiled for 15 minutes and subjected for sensory evaluation by 32 untrained panelists from the Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka. The eggs from different treatments were evaluated separately for overall appearance, yolk color, smell, taste, albumen texture and general acceptability. The Hedonic Scale Test was used to rate the samples where the numerical values were ranged from 7 (Like very much) to 1 (Dislike very much).

Statistical analysis

The experiments were conducted in a completely randomized design (CRD) and the data were ana-

Table 2: Mean chemical composition and energy contents of poultry offal meal (as fed)

Component	Poultry offal meal	
	Experiment 1	Experiment 2
Dry matter (%)	90.80	85.27
Gross Energy (MJ/kg)	22.2	17.7
Metabolizable energy (MJ/kg)	15.0	14.5
Crude protein (%)	50.15	45.96
Crude fiber (%)	1.40	1.53
Ether extract (%)	25.9	25.71
Ash (%)	7.95	6.56
Calcium (%)	2.20	2.91
Phosphorous (%)	1.20	0.83

lyzed using GLM procedure of SAS (Version 9.0). Comparison of means was conducted by least square mean followed by GLM procedure. The sensory data were analyzed by Friedman test using Minitab (Version 14.0).

RESULTS

Average nutritive value of POM and experimental rations used in two experiments are presented in Tables 2 and 3, respectively.

Experiment 1

Effect of POM on egg quality traits

Significant differences (P<0.05) were observed between treatments for egg weights, shape index, shell ratio and USSW values (Table 4).

The highest value for mean egg weight was obtained with 2.5% POM diet which differed significantly from those with 5 (P=0.00), 7.5 (P=0.01) and 10% (P<0.00) inclusion rates. The average egg weight at 10% POM was significantly lower compared to those obtained with the control (P=0.01) and 2.5% (P<0.00) POM diets. Similar effects were found by Ertürk and Celik (2004) who reported that the egg weight of Japanese quails fed diets containing poultry by-product meal protein as a replacement of SBM protein at 0, 20, 40, 60 and 80% was significantly influenced by dietary treatments where the egg weight was reduced by feeding the diet containing 80% poultry by-product meal. The

shape index of eggs from the control group was significantly lower than the shape index of eggs from the birds fed diets contained 2.5% (P=0.00), 5% (P=0.03), 7.5% (P=0.02) or 10% (P=0.05) POM inclusion levels. There was no significant effect (P>0.05) due to different levels of POM. This finding however does not agree with the findings of Ertürk and Celik (2004).

The highest mean value for shell ratio was obtained from the group fed the diet with 5% POM, where the minimum was from the birds fed the diet having 10% POM. There was no significant (P>0.05) difference found between the control and 2.5, 5 and 7.5% POM diets in terms of shell ratio. The USSW of eggs from the groups fed 10% POM diet was significantly lower compared to all the other treatments (P≤0.00). However, USSW values were not significantly affected (P>0.05) by POM up to 7.5% inclusion level. The highest mean values for egg weight, shape index, USSW, shell thickness and shell strength were reported from the groups fed the diet containing 2.5% POM. The highest mean value for shell ratio was reported from the diet containing 5% POM which is not significantly (P=0.77) different from the diet with 2.5% POM. Inclusion of POM at 10% rate resulted poor shell ratio, egg weights and poor USSW. Feeding POM at 10% rate lowered shell ratio, egg weights and USSW significantly (P<0.05) by 4.6, 4.2 and 5.6% respectively as compared to the control diet. The shell thickness and shell strength were not affected (P>0.05) by dietary treatments.

Table 3: Mean chemical composition and gross energy contents of the experimental diets fed to Japanese quails

Component	Experiment 1									
	Grower					Layer				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
DM (%)	89.93	90.39	90.74	90.99	91.17	90.00	89.60	90.05	89.50	90.20
CP (%)	17.56	17.18	17.16	17.56	17.89	18.36	18.13	18.12	18.24	18.76
CF (%)	6.50	6.50	6.50	6.40	6.10	5.85	5.45	5.25	4.85	4.8
EE (%)	6.40	7.10	8.00	8.96	9.50	7.05	8.15	8.15	8.90	9.40
Ash (%)	17.56	17.18	17.16	17.56	17.89	17.5	17.05	16	15.8	16.7
NFE (%)	48.19	47.81	46.95	46.27	45.95	41.24	40.83	42.53	41.71	40.55
GE (MJ/kg)	18.16	16.63	16.64	17.65	16.64	16.13	15.12	16.63	15.62	15.63

Component	Experiment 2									
	Grower					Layer				
	T1	T3	T5	T3+E	T5+E	T1	T3	T5	T3+E	T5+E
DM (%)	89.05	90.14	89.21	89.05	89.84	88.56	88.70	88.84	88.36	88.27
CP (%)	17.80	17.93	17.21	17.82	17.70	18.27	18.08	18.13	18.13	18.87
CF (%)	4.99	5.76	5.41	6.06	6.16	5.15	5.26	5.20	5.85	5.76
EE (%)	7.63	6.78	8.03	8.13	6.96	7.65	7.70	8.21	8.29	8.08
Ash (%)	11.88	11.25	11.69	11.38	11.64	16.45	16.36	16.41	16.45	15.02
NFE (%)	46.75	48.42	46.87	45.66	47.38	41.04	41.30	40.89	39.64	40.54
GE (MJ/kg)	15.50	15.51	16.05	16.05	16.57	15.53	15.55	15.61	15.04	15.06

DM= Dry matter. CP= Crude protein. CF= Crude fiber. EE= Ether extract. NFE= Nitrogen free extract. GE= Gross energy
 T1= Control. T2= 2.5% POM diet. T3= 5.0% POM diet. T4= 7.5% POM diet. T5= 10% POM diet T3+E= Enzyme supplemented 5% POM diet. T5+E= Enzyme supplemented 10% POM diet

Table 4: Effects of poultry offal meal on egg quality traits of Japanese quails in Experiment 1 (Mean±SD)

Criteria	Treatments					P>F
	T1	T2	T3	T4	T5	
Egg weight (g)	11.09±0.39 ^{ac}	11.32±0.72	10.76±0.83 ^{ab}	10.85±0.67 ^{ab}	10.62±0.53 ^b	0.001
Shape index (%)	79.73±1.86 ^a	81.53±1.69	80.95±1.29 ^b	80.97±1.67 ^b	80.82±2.42 ^b	0.025
Shell ratio (%)	8.91±0.77 ^a	8.99±0.91 ^a	9.04±0.97 ^a	8.97±0.77 ^a	8.50±0.56 ^b	0.006
USSW* (mg/cm ²)	40.78±3.39 ^a	41.35±3.93	40.98±4.27 ^a	40.79±3.22 ^a	38.48±2.36 ^b	0.001
Shell thickness (mm)	0.225±0.02	0.229±0.02	0.228±0.02	0.227±0.02	0.227±0.02	0.819
Yolk index (%)	45.56±2.60	44.49±2.34	45.11±2.11	44.5±2.66	44.72±3.12	0.395
Yolk ratio (%)	33.42±1.38	33.15±1.91	32.31±1.04	33.46±2.35	32.63±1.94	0.115
Albumen index (%)	9.75±1.02	9.5±1.21	9.74±1.50	9.54±1.83	9.62±1.87	0.951
Albumen ratio (%)	57.67±1.91 ^{ad}	57.86±1.89	58.66±1.39 ^{bd}	57.57±2.69 ^{ac}	58.86±1.76 ^b	0.04
Haugh unit	86.19±2.28	86.48±2.84	85.99±3.29	84.96±3.42	85.66±3.34	0.341

^{a-d}Means within rows with no common superscripts are significantly different (P<0.05)

USSW*: unit surface shell weight

T1= Control, T2= 2.5% POM diet, T3= 5.0% POM diet, T4= 7.5% POM diet and T5= 10% POM diet

When internal quality traits are concerned, a significant (P<0.05) treatment effect was verified for the albumen ratio. The other internal quality traits assessed were not significantly (P>0.05) affected by dietary treatments. The maximum albumen ratio was obtained from the group fed the diet containing 10% POM which was however not significantly (P=0.69) different from the value obtained for 5% POM. The control feed and 7.5% POM feed resulted significantly lower albumin ratio as compared to 10% POM diet. A significant difference (P=0.04) was observed between the diets with 5% and 7.5% POM in terms of albumin ratio. Ertürk and Celik (2004) reported that there was no significant effect of the inclusion level of poultry by-product meal on yolk index, egg albumen index and Haugh Unit of Japanese quail eggs obtained from the birds fed 0, 20, 40, 60 and 80% poultry by-product meal protein as a replacement to SBM protein.

Effect of POM on sensory quality of eggs

No significant difference (P>0.05) was observed among treatments for taste, albumen texture, general acceptability and smell characters (Table 5). A significant difference (P<0.05) was found only between the control and the diet with 10% POM for yolk color (P=0.00) and overall appearance (P=0.00). Preference for general acceptability, overall appearance and egg yolk colour was minimum in birds fed the control diet.

This suggests that POM can be incorporated in quail rations up to 10% with no detrimental effects on consumer's preference on egg quality. The overall consumer preference increases along with the increasing level of POM in the diet.

Experiment 2

In the second experiment, the effect of enzyme supplements at 5 and 10% POM on egg quality was

tested. Results revealed that egg weight and shell thickness were affected by dietary treatments (Table 6). As compared to the control diet, 5% POM diet increased the egg weight but not the diet containing 10% POM. The egg weight with 10% POM was similar to that with the control diet. Enzyme supplements at any level of POM did not influence the egg weight. It should be noted here that in the 1st experiment, egg weight was increased only up to 2.5% POM which was decreased at higher levels of POM (Table 4). This difference may be due to the dietary differences in two experiments (Tables 2 and 3).

The average shell thickness was slightly but significantly increased at both levels of POM without a difference between two POM levels. Enzyme supplementation numerically increased the shell thickness at both levels of POM. The average shell thickness of eggs from the group fed control diet was significantly lower compared to all the other treatments (P≤0.00) at 12th week of age (Fig. 1).

The shape index, shell ratio, USSW and shell strength were not affected by dietary treatments in experiment 2. The control group had the numerically lowest mean values for USSW, shell thickness and shell strength and lied at the 4th place when ranked for egg weight, shape index and shell ratio. The control significantly differ (P<0.05) only for shell thickness with other four treatments and differ significantly with T3 for egg weight trait. Results of the experiment 2 suggest that 5% or 10% POM with or without enzymes can be successfully used to replace soybean meal in quail rations when external quality of eggs is concerned. This is in agreement with the findings of previous researchers (El-Deek *et al.* 2008; Elangovan *et al.* 2004) who reported that exterior egg quality was not affected by multi enzyme supplementation to layer diets. Of the internal quality traits assessed in experiment 2, egg yolk ratio, albumen index, albumen ratio and

Table 5: Effect of poultry offal meal inclusion level on sensory characters of Japanese quail eggs (Sums of ranks Vs sensory criteria)

Criteria	T1	T2	T3	T4	T5	S*	P**
Taste	94.0	84.0	94.5	104.0	103.5	4.39	0.36
Albumen texture	106	91.5	91.0	103.5	88.0	4.59	0.33
General acceptability	80.0	89.0	99.5	108.5	103.0	8.78	0.07
Overall appearance	68.5	99.5	104	95.0	113.0	19.74	0.00
Yolk color	70.5	97.0	98.0	93.5	121.0	23.23	0.00
Smell	94.0	89.0	92.5	105.5	99.0	2.67	0.62
N***	32	32	32	32	32	-	-

S*: sum of the squared deviation P**:. Probability adjusted for ties
 N***: number of panelists

Haugh Unit values were significantly affected by dietary treatments. Inclusion of POM in the diet at 5 or 10% reduced the yolk ratio of eggs while albumen ratio and Haugh Unit were increased by POM. Albumin index was increased only by 5% POM when diets were unsupplemented with enzymes. However the supplementation of both 5 and 10% POM diets with enzymes increased albumin index as compared to the control. The enzyme supplementation had numerically improved the values for yolk index, yolk ratio and albumen index at 5% POM inclusion rate. Enzyme supplementation to 5% POM did not contribute to establish any significant improvement in internal egg quality traits. Both, T3 and T3+E diets were significantly differed for yolk ratio, Haugh unit and albumen ratio compared to that of control with a positive improvement in Haugh unit and albumen ratio traits.

The enzyme supplementation at 10% POM numerically improved the values for yolk index, yolk ratio and Haugh unit. Albumen ratio was not affected by enzyme supplementation at 10% POM rate. An improvement due to enzyme supplementation was found only for albumen index at 10%

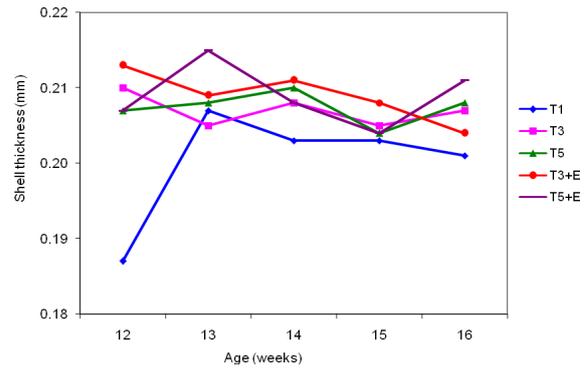


Figure 1: The effect of enzyme supplementation on egg shell thickness of Japanese quail eggs

T1= Control. T3= 5.0% POM diet. T5= 10% POM diet. T3+E= Enzyme supplemented 5% POM diet. T5+E= Enzyme supplemented 10% POM diet

POM inclusion rate by improving the albumen index by 5.9%. However, the albumen index was not significantly ($P>0.05$) affected by dietary treatments when each week of the experimental period concerned (Fig. 2).

Both T5 and T5+E diets were comparable to the control in terms of the major internal egg quality traits concerned in this study except for the yolk ratio and therefore, can be used in replacement to the control diet. This fact is in a close agreement to the finding reported by Yörük *et al.* (2006) who reported that, the interior or exterior quality traits of eggs were not affected by enzyme supplementation to corn-soybean meal diets.

CONCLUSIONS

The experiment 1 concluded that 2.5% POM is the best in terms of external quality traits of eggs. POM can be included in quail rations up to 10%

Table 6: Effects of poultry offal meal and enzyme supplementation on egg quality traits of Japanese quails in Experiment 2 (Mean±SD)

Egg parameter	Treatments					P>F
	T1	T3	T5	T3+E	T5+E	
Egg weight (g)	10.11±0.49 ^{ac}	10.49±0.50 ^b	10.21±0.61	10.43±0.56 ^{ab}	10.07±0.47 ^c	0.047
Shape index (%)	81.65±2.26	81.64±1.37	81.85±1.46	82.41±1.04	81.9±1.42	0.526
Shell ratio (%)	7.85±0.56	7.93±0.35	7.89±0.48	7.84±0.40	8.04±0.42	0.628
USSW* (mg/cm ²)	35.14±2.64	35.81±1.48	35.34±1.90	35.34±1.71	35.95±1.82	0.649
Shell thickness (mm)	0.200±0.01 ^a	0.207±0.01 ^b	0.208±0.01 ^b	0.209±0.01 ^b	0.209±0.01 ^b	0.016
Shell strength (Dynes)	141.34±4.78	141.94±3.36	142.03±2.72	141.57±3.43	142.24±3.89	0.890
Yolk index (%)	49.11±1.67	49.25±1.97	49.1±2.33	49.59±1.63	49.88±2.55	0.695
Yolk ratio (%)	33.21±2.53 ^a	31.43±1.18 ^b	31.89±1.74 ^b	31.77±1.35 ^b	32.47±1.79	0.014
Albumen index (%)	11.88±1.18 ^{ad}	12.35±1.09	11.79±1.36 ^{ac}	12.77±1.45 ^b	12.49±0.87 ^{bd}	0.028
Albumen ratio (%)	58.94±2.22 ^a	60.64±1.24 ^b	60.22±1.63 ^{bc}	60.31±1.28 ^{bc}	59.49±1.75 ^{ac}	0.007
Haugh unit	90.03±1.88 ^{ac}	91.48±1.76 ^b	90.27±2.02 ^{acd}	91.34±2.49 ^{bd}	90.84±1.42	0.045

^{a-d}Means within rows with no common superscripts are significantly different ($P<0.05$)

USSW* : unit surface shell weight

T1= Control, T3= 5.0% POM diet, T5= 10% POM diet, T3+E= Enzyme supplemented 5% POM diet and T5+E= Enzyme supplemented 10% POM diet

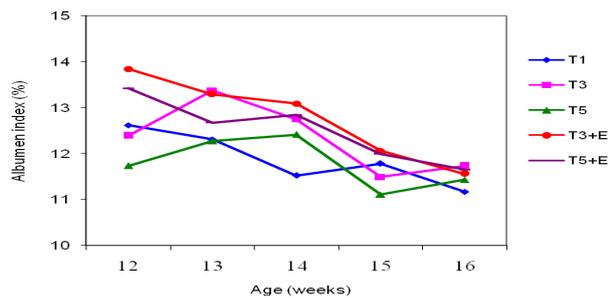


Figure 2: The effect of enzyme supplementation on Albumen Index (AI) of Japanese quail eggs

T1= Control. T3= 5.0% POM diet. T5= 10% POM diet. T3+E= Enzyme supplemented 5% POM diet. T5+E= Enzyme supplemented 10% POM diet

with no detrimental effect on internal quality traits and consumer's preference. The experiment 2 suggests that, dietary enzymes did not improve egg quality traits except for albumen index at 10% POM inclusion rate. The shell thickness was superior in birds fed with enzyme-supplemented diets than those fed with the control diet.

Therefore, the present study concludes that the POM can be successfully used to replace dietary SBM in quail rations and addition of dietary enzymes to the diets with POM does not exert a significant improvement in overall egg quality traits of Japanese quails.

ACKNOWLEDGEMENT

This investigation received the financial support from the Sabaragamuwa University of Sri Lanka (Grant No. SUSL/RG/2007/03). Authors wish to appreciate the assistance of the technical staff of the Department of Livestock Production, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, Department of Animal Science, Faculty of Agriculture, University of Peradeniya, C.G.E. (Pvt) Limited, Colombo 15 and Veterinary Research Institute Gannoruwa. The support of Dr (Mrs.) Lakmali Ranathunghe, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya and Mr DD Wickramanayake, Department of Livestock Production, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka is highly appreciated.

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