BENEFICIAL EFFECTS OF INSOLUBLE RAW FIBER CONCENTRATE ADDITION TO LAYER DIET

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ABSTRACT

A total of 144 Dekalb layers (19 weeks of age) were used to determine the effects of insoluble raw fiber concentrate (IRFC) addition to layer diet on production performance, egg quality, segments of the gastrointestinal tract (GIT) and economic parameters. The layers were randomly assigned to standard layer diet (SLD) and SLD + 0.80% IRFC. Each diet had six replications with 12 layers per replication. Results of the study showed that feeding diet with IRFC significantly (P<0.05) increased egg production by 3.43%, which was related to better efficiency of feed utilization (P<0.05). Feeding diet with IRFC did not influence egg quality parameters and size and weight of the GIT. The net benefit analysis showed an advantage of PhP 9.72 per layer (for 16 weeks) fed diet with IRFC compared with those fed without IRFC. The findings show that IRFC is a potential feed additive for layers' diet.

Keywords: egg production, gastrointestinal tract, insoluble raw fiber concentrate, layers

INTRODUCTION

Insoluble raw fiber concentrate (IRFC) is a functional fiber whose merits, as part of animal diet, are subject of research investigations today. Commercial preparations of this feed additive are already locally available and are now being used in the diet of animals in some farms. Functional fiber is an isolated, extracted or synthetic fiber that brings about health and physiological benefits (Bersamin *et al*., 2008). The feed grade IRFC is a concentrated fiber from lignified woody plant material that has a standardized fiber content of about 50-65% (Pottgüter, 2008). It is produced by extraction or isolation of polysaccharides and also by chemical, enzymatic or aqueous means (USDA, 2011). Chemically, it is composed of cellulose, hemicellulose and lignin which are non-viscous and non-fermentable under conditions that prevail in the intestinal environment.

It has been indicated that IRFC enhances physiological activity and health of the gastro-intestinal tract (GIT) and, thus, increase nutrient digestion and absorption (Svihus and Hetland, 2001; Hetland *et al.,* 2003). Its beneficial effects relate to the formation of fiber network in the intestinal tract which is responsible for the swelling

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and loosening of digesta for easier and faster penetration of digestive enzymes (Choct, 2001). The IRFC also stimulates the gizzard activity which results in increased digestion of nutrients (Hetland *et al*., 2005). Moreover, it has been pointed out that fiber is important for improving adaption of the gut of poultry to the current production systems and reducing digestive disturbances without the use of an antibiotic in feed (Montagne *et al*., 2003). Inclusion of IRFC in the diet has been reported to improve performance of broilers (Sarikhan *et al.,* 2010) and laying hens (Pottgüter, 2008). With these potentials, the inclusion of IRFC in layer's diet was examined in the present study. Specifically, its effects on production performance, gastro-intestinal tract and economic parameters were assessed.

MATERIALS AND METHODS

Experimental birds and treatments

A total of 144 Dekalb layers (19 weeks of age) were used in the study. The layers were randomly assigned to two dietary preparations, with six replications of 12 layers each. The first diet was a standard layer diet (SLD) without IRFC and the second was a SLD + IRFC. The SLD was least-cost formulated on digestible amino acids basis and contained the nutrient requirements of modern egg-type chickens recommended by Leeson (2006). The composition of the experimental diets is presented in Table 1; the calculated analysis of the diets is shown in Table 2. The IRFC is a commercial preparation made from lignocelluloses of woody plant with a crude fiber content of 65%. Its major components are cellulose, hemicelluloses and lignin. The methods involved in the manufacture of this feed additive are the debarking of wood (spruce), precutting it, and finally subjecting it to high pressure centrifugal fibrillation, which are technologies unique to the manufacturer of the additive. The IRFC was added to the SLD at the manufacturer's recommended inclusion rate for layer's diet of 0.80%, on add-on basis. The diets were mixed using electrically operated mixer on a biweekly basis.

Care and management of experimental birds

The layers were housed (open-sided house) in 36 two-tier wire laying cages in stair-step arrangement. The layers were allotted total photoperiod of 20 hr per day. The diets were offered, in mash form, on *ad libitum* basis. The disease and parasite prevention and control measures recommended for layers by PCARRD (2007) were followed.

Gathering and analyses of data

The feeding trial was conducted for 16 weeks. Hen-day egg production rate was calculated by dividing the total eggs produced in a week by the total hen-days for the week multiplied by 100. Daily feed intake per layer was calculated as the difference of the feed offered for the week and the feed remaining at the end of the week divided by the total hen-days for the week. The feed conversion ratio (FCR) was calculated by dividing the mean feed intake by the mean egg production (dozen eggs) for the same period. Egg mass was calculated by multiplying egg weight by

Table 1. Composition of standard layer diet (SLD) with or without insoluble raw fiber concentrate (IRFC).

Ingredient	SLD	SLD + IRFC
Yellow corn (Local)	57.61	57.61
Rice bran (Fine; D1)	7.00	7.00
Coconut oil (Crude)	0.00	0.00
Soybean meal (U.S.)	14.49	14.49
Full-fat soybean meal	7.30	7.30
Porcine meal (50% CP)	3.35	3.35
Limestone (Fine)	3.23	3.23
Limestone (Course)	5.30	5.30
Monodicalcium phosphate	0.10	0.10
Salt	0.40	0.40
DL-methionine	0.25	0.25
Lysine	0.14	0.14
Threonine	0.03	0.03
Poultry vitamin premix[1]	0.03	0.03
Poultry trace mineral premix[2]	0.15	0.15
Choline Chloride	0.10	0.10
Antioxidant	0.02	0.02
Toxin binder (HCAS)	0.20	0.20
Prebiotic	0.25	0.25
Phytase	0.01	0.01
Multi-enzyme	0.05	0.05
Raw fiber concentrate	0.00	0.8
Total	100.01	100.81
Cost/kg (Php)	17.18	17.62

[1]Each kg contains: 45,000,000 IU vitamin A, 9,000,000 IU vitamin D3, 200,000 g vitamin E, 15,000 g vitamin K3, 150,000 g niacin, 9,000g vitamin B1, 30,000 g vitamin B2, 19,500 g vitamin B6, 0.15 g vitamin B12, 81,522 g vitamin B5, 8,000 g vitamin B9, and 0.70 g vitamin H/H2.

the hen-day egg production. Percent livability of the layers was calculated as the birds remaining at the completion of the feeding trial divided by the initial number of birds multiplied by 100. Eggs were classified in accordance with the Philippine National Standards (2005).

The quality of eggs was determined weekly using two egg samples per replication taken at random. Albumen height was measured using a caliper. The yolk color was subjectively scored using a DSM yolk color fan (DSM Nutritional Products, 2003). Egg shells were weighed after drying them under the sun for a day.

A day following the end of the study, six layers per treatment were

Table 2. Calculated analysis of SLD with or without insoluble raw fiber concentrate (IRFC).

Item	SLD	SLD + IRFC
Metabolizable energy, kcal/kg	2,839	2,778
Crude protein, %	16.64	16.51
Crude fat, %	4.96	4.92
Crude fiber, %	3.86	4.34
Calcium, %	3.70	3.66
Phosphorus, available, %	0.40	0.39
Sodium, %	0.20	0.19
Chlorine, %	0.50	0.49
Linoleic acid, %	2.00	1.98
Choline, ppm	163.00	161.70
Digestible lysine, %	0.85	0.84
Digestible methionine, %	0.50	0.49
Digestible methionine+cystine, %	0.75	0.74
Digestible threonine, %	0.56	0.55
Digestible tryptophan, %	0.17	0.16

slaughtered. The weight of proventriculus, gizzard, liver, pancreas, small intestine, large intestine and ceca of the layers was determined. The weight of each segment of the gut and accessory organs of the birds was expressed relative to their body weight. The lengths of small intestine, large intestine and ceca were also measured.

The income over feed cost (IOFC) was determined as the difference of the sale value of eggs and cost of feeds consumed per hen-housed for a period of 16 weeks. The sale value of eggs was computed in accordance with the number of eggs per egg size/classification multiplied by their corresponding prices during the conduct of the feeding trial. Based on the IOFC data, incremental benefit analysis was done using the formula:

$$M_{\pi} = M_t - C_t$$

where:

M_{π} – incremental net benefit on production using IRFC
M_t – net benefit in production using IRFC
C_t – net cost in production using IRFC

Where applicable, data gathered were summarized on a weekly basis. Only the means for all periods were presented in this report. Significant differences between diets with and without IRFC were analyzed using *t*-test of Statistica (ver. 7). Probability for significant differences of treatment means was set at alpha 5.0%.

RESULTS AND DISCUSSION

Effects on egg production performance

Table 3 shows the mean production performance of layers as influenced by feeding diet with IRFC. The percent hen-day egg production and feed conversion ratio were significantly (P<0.05) better for layers fed diet with IRFC than those without. A tendency (P=0.10) for higher egg mass from the latter than the former was also noted.

Table 3. Mean (±SEM) effects of insoluble raw fiber concentrate (IRFC) addition to standard layer diet (SLD) on egg production performance.

Parameter	SLD	SLD+IRFC	Probability
Egg production (%)	83.51 ± 1.10	86.94 ± 0.59	0.02
Feed intake (g)/day	102.74 ± 1.29	102.02 ± 1.98	0.78
Feed conversion ratio	1.84 ± 0.09	1.56 ± 0.05	0.02
Egg weight (g)	54.81 ± 0.40	54.29 ± 0.51	0.43
Egg mass (g)	46.78 ± 0.60	48.06 ± 0.37	0.10
Livability (%)	97.22 ± 0.60	100 ± 0.00	0.34

The results demonstrated beneficial effects on production performance of layers fed diet with moderate amount of insoluble raw fiber concentrate. The finding supports the essentiality of insoluble fiber for improving production performance of laying hens (Pottgüter, 2008). The inclusion of IRFC to the SLD diluted the energy and nutrients present in the diet by about 0.80% (Table 2). On the contrary, the crude fiber content of the diet increased by 12.59%, about 0.50% of this fiber was pure ligno-cellulose contributed by the IRFC. It can be inferred that the added fiber was the primary dietary factor for the responses of the layers to IRFC. Apparently, the addition of IRFC to the diet enabled the layers to obtain optimal nutrients for egg production. It was noteworthy that this was attained by the layers without increasing their feed intake, resulting in improvement of their FCR. This was possibly associated with the fiber network formed by the IRFC which caused loosening and swelling of the digesta allowing easier and faster penetration of the digestive enzymes, due to increased substrate surface to enzyme action (Choct, 2001). It has also been reported that insoluble fiber increases retention time of digesta in the gizzard and gastro-intestinal reflux of bile salts resulting in increased digestion (Hetland and Choct, 2003). Likewise, insoluble fiber enhances proper development of intestinal villi which is necessary for efficient nutrient absorption (Sarikhan *et al*., 2010). The combined effects of these factors could have contributed to the favorable effects of IRFC inclusion to the layers' diet.

Effects on egg quality and classification

The data presented in Tables 4 and 5 show no significant differences (P>0.05) on the quality and classification of eggs from the birds fed diet with or

Table 4. Mean (±SEM) effect of insoluble raw fiber concentrate (IRFC) addition to standard layer diet (SLD) on egg quality.

Parameter	SLD	SLD+IRFC	Probability
Egg shell weight (g)	6.27 ± 0.09	6.29 ± 0.10	0.91
Albumen height (mm)	10.10 ± 0.17	10.29 ± 0.27	0.57
Yolk color, DSM yolk color	6.83 ± 0.24	6.79 ± 0.15	0.89

Table 5. Mean (±SEM) effect on egg classification of insoluble raw fiber concentrate (IRFC) addition to standard layer diet (SLD).

Egg classification	SLD	SLD + IRFC	Probability
Jumbo	0.76 ± 0.16	0.77 ± 0.20	0.98
Extra large	4.60 ± 1.18	4.39 ± 1.23	0.90
Large	4.37 ± 0.536	3.11 ± 0.53	0.12
Medium	60.37 ± 2.12	54.75 ± 2.33	0.11
Small	29.89 ± 2.86	36.97 ± 3.52	0.15

without IRFC. For egg classification, there were indications for reduced large (P=0.12) and medium (P=0.11) size eggs and preponderance of small (P=0.15) eggs with the inclusion of IRFC to the diet.

The results indicate that the amounts of the major dietary factors that affect egg quality and size parameters such as xanthophyll, amino acids, linoleic acid and energy (Leeson, 2006) were generally comparable between the two groups. The tendency, though, for increased number of small size eggs, at the expense of medium and large size eggs, with IRFC inclusion to the diet may have been the result of lesser amount of nutrients for synthesis of egg materials per egg concomitant with the increase in total egg mass.

Effects on different segment of gastrointestinal tract and accessory organs

The mean effects of feeding diet with or without IRFC on the relative weights of sections of the GIT and accessory organs as well size of some segments of the GIT are presented in Table 6. There were no significant (P>0.05) differences between the treatments in any of the parameters.

Contrary to the present findings, a number of reports indicated increased in weight of the GIT or some of its sections with increased consumption of dietary fiber. Feeding growing pullets (7-18 weeks) with a diet containing the same IRFC preparation used in the present study and at the same inclusion level (0.80%) resulted in increased gizzard weight of the birds (Pietsch, 2012). Also, it has been

Table 6. Mean (±SEM) effects of insoluble raw fiber concentrate (IRFC) addition to standard layer diet (SLD) on relative weight and size of different segments of the gut and accessory organs.

Parameter	SLD	SLD+IRFC	Probability
Relative weight (%)			
Liver	2.80 ± 0.23	2.25 ± 0.125	0.21
Pancreas	0.20 ± 0.009	0.21 ± 0.013	0.62
Proventriculus	0.35 ± 0.014	0.42 ± 0.023	0.18
Gizzard	1.44 ± 0.027	1.49 ± 0.06	0.57
Small intestine	2.96 ± 0.10	2.83 ± 0.05	0.46
Large intestine	0.17 ± 0.008	0.20 ± 0.006	0.14
Ceca	0.36 ± 0.007	0.43 ± 0.04	0.28
Size (cm)			
Small intestine	138.67 ± 5.96	136.40 ± 3.53	0.83
Large intestine	6.90 ± 0.33	7.53 ± 0.69	0.59
Ceca	13.43 ± 1.78	14.50 ± 1.45	0.76

demonstrated in laying hens that consumption of 4% feed as wood shavings resulted in a 50% heavier gizzard (Hetland *et al*., 2003). The observed favorable effects of IRFC on production performance, as highlighted above, were not associated with increase in size or weight of the GIT of the birds. However, it was probable that the IRFC elicited beneficial effects to GIT functions but these cannot be explicitly supported by the present data. It has been pointed out that certain amount of fiber is necessary for robust GIT to effect better health of the birds for more efficient digestion and utilization of nutrients (Choct, 2009). It was likely that these aspects were realized with IRFC inclusion in the diet, without concomitant increase in weight of the GIT.

Economic analysis

Table 7 shows the mean effect on IOFC of feeding laying hens of diets with or without RFC. A significant ($P<0.05$) difference was noted on sale value of eggs, in favor of the layers fed diet with IRFC. Such was associated with the significantly ($P<0.05$) higher number of eggs they produced (97 pcs.) than their counterpart (94 pcs.). Although feeding diet with IRFC numerically increased the cost of feeds consumed by the birds, IOFC remained higher for the birds fed diet with IRFC than those without.

The mean effect on net benefit of feeding laying hens of diets with or without IRFC is presented in Table 8. It can be noted that feeding laying hens with diet containing IRFC resulted in net increment benefit of PhP 14.74 per layer for 16 weeks production. The net incremental feed cost was PhP 5.02 per layer and a net benefit of PhP 9.72 per layer was realized for the same period of 16 weeks.

The results demonstrate that despite the increase in feed cost when IRFC was added in the diet of the laying hens, the marked increase in egg production offset such cost. Thus, net benefit from IRFC addition to the diet was still evident.

Table 7. Mean (±SEM) effects of insoluble raw fiber concentrate (IRFC) addition to standard layer diet (SLD) on income over feed cost (IOFC) .

Parameter	SLD	SLD+IRFC	Probability
Eggs produced, pcs	93.61 ± 1.20	97.38 ± 0.66	0.02
Sale value of eggs[1], pcs.	441.19 ± 5.52	455.93 ± 2.47	0.04
Total feed consumed, kg	11.43 ± 0.16	11.43 ± 0.22	0.99
Feed cost[2], Php	196.31 ± 2.72	201.33 ± 3.91	0.32
IOFC, Php	244.88 ± 6.04	254.59 ± 4.47	0.22

[1]Sale value per piece of jumbo, extra large, large, medium and small egg is PhP 5.50, 5.30, 4.90, 4.80 and 4.40, respectively.
[2]Cost/kg diet is PhP 17.18 for SLD and PhP 17.62 for SLD + IRFC.

Table 8. Net benefit cost of feeding diet with or without insoluble raw fiber concentrate (IRFC) to laying hens.

Item	SLD vs SLD+IRFC
Net increment benefit, PhP	14.74
Net increment cost, PhP	5.02
Net benefit, PhP	9.72

CONCLUSION

Results of the study revealed that IRFC inclusion in layers' diet improved egg production, which was related to improved efficiency of feed utilization. The diet with IRFC did not influence egg quality and classification nor the segments of the digestive tract and accessory organs. The IOFC and net benefit analysis revealed that IRFC inclusion to the diet resulted in economic advantage compared with feeding diet without IRFC, indicating that this feed additive has promising application in feeding laying hens.

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