Egyptian J. Anim. Prod. (1996) 33 (2): 163- 174

INFLUENCE OF ENZYME SUPPLEMENTATION OF BARLEY DIETS ON LAYING HENS PERFORMANCE AND EGG QUALITY

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SUMMARY

Four experiments were conducted to evaluate the performance of laying hens fed diets containing barley (Experiment 1) and the effects of a commercial enzyme mixture when supplemented to high barley diets (Experiment 2 and 3). The effects of the dose of the enzyme preparation were investigated in Experiment 4.

No significant effects of dietary treatments on overall productive hen performance were observed. As dietary barley levels increased, however, slight decreases resulted in daily feed intake, egg laying rate, egg and body weights with a deterioration in feed utilization. Yolk color scores were significantly increased as barley inclusion levels increased in the diets.

Enzyme supplementation to high barley diets did not have any significant effect on overall performance, yolk color scores, or excreta moisture content. There was a slight tendency for improved egg weight following enzyme addition. Increasing the dose of the enzyme mixture supplement to.05% improved hen performance although no significant effects were observed ($P < .05$). Doubling the dose did not further improve performance. Based on these results, enzyme supplementation of high barley diets does not significantly improve the overall performance of layers.

Keywords: Laying hens, barley, enzymes, , performance, yolk color

INTRODUCTION

The effects of enzyme supplementation of barley diets fed to laying hens remain inconsistent and inconclusive. Early studies from Berg (1959) used bacterial and fungal enzymes added to a barley diet, but were unable to obtain any significant improvement in laying rate or feed conversion ratio. Petersen and Sauter (1968) found a 5% improvement in laying rate with a bacterial amylase added to a high percent barley diet in one experiment but not in another Recent studies conducted by Näsi (1988), and Albustany and Elwinger (1988) have shown that the addition of a betaglucanase to barley diets had no significant effect on egg laying rate and feed conversion

Näsi (1988) reported however that a multienzyme preparation containing a variety of activities which degrade cell walls and liberate nutrients improved laying hen performance by 6% when supplemented to a high barley diet. Similarly, Aimonen and Näsi (1991) have shown that the addition of Avizyme^{R} to diets containing up to 67% barley, gave slightly better egg output and laying rate than the unsupplemented homologous diets. The inclusion of Avizyme to a 50% barley diet so tended to improve percent lay by 4,3% and feed conversion by 1.5% in a study by Graham (1991).

In an extensive review of the literature , Jeroch and Dänicke (1993) reported that the inclusion of barley in conventional dietary mixtures produced equal or similar performances and that enzyme supplementation effects remain contradictory. Soliman *et al.* (1993) showed however that pelleted barley diets with added fat and enzymes were able to sustain similar levels of egg production and egg quality scores to those of corn based diets.

Based on this knowledge, initial trials with barley based layer diets supplemented with commercial enzyme preparations were conducted (Benabdeljelil, 1991; Benabdeljelil and Arbaoui 1994) and failed to show constant and significant effects following enzymes addition. In view of these results, the present experiments were conducted to further test the effects of Avizyme[1] when added to local barley diets on hen performance and egg quality.

MATERIALS AND METHODS

General Procedure

Laying hens were obtained at peak of lay from a commercial producer and housed in an experimental room, two per cage offering 700 square centimeters per bird. Each cage was equipped with two nipple drinkers. Hens in five consecutive cages shared a common feeder. The hens were fed a commercial layer diet containing a minimum of 18% proteins before they were fed the experimental diets, *ad. libitum* in mash form. The birds had free access to water and a daily photoperiod of 16.5 hours was maintained. Environmental temperatures were maintained around 20^{o}C as shown in Table 1.

Table 1. Environmental temperatures ^{o}C recorded in the experimental rooms.

Experiment	Minimum	Maximum	Mean
1	18.0	26.0	23.5
2	13.4	23.0	18.4
3	21.5	27.5	24.0
4	12.7	35.0	18.6

[1] The use of trade names implies neither endorsement of the enzyme preparations named nor criticism of similar compounds not mentioned.

After all the hens were in production (92% had laid ≥ 10 eggs) hen performance and egg quality data were measured prior to the start of each experiment. The hens were thus selected on previous egg production and egg quality measurements so that average performance of the hens kept in five consecutive cages (i.e. a pen) was similar at the start of each experiment.

Egg production and mortality were recorded daily. Hen body weight was measured at the beginning and the end of each experiment and body weight change was calculated. Feed consumption was determined per pen weekly. Eegg weight and egg quality measurements were determined on all eggs laid during three consecutive days. Excreta moisture determinations were performed on samples that weighed approximately 100 g by drying the sample overnight at 105°C at the end of Experiments 1, 3 and 4. In the preparatory stages of the experiments barley was analyzed for proximate constituents (Table 2).

Table 2. Proximate composition of barley[1](%)

Experiment	Moistur	Crude Protein	Crude Fiber	Ash
1 and 3	8.83	13.65	7.19	3.96
2	11.80	11.10	7.00	2.70
4[2]	12.97	1150	5.05	2.27

[1] The metabolizable energy of barley was 2800 kcal/kg. When Avizyme was supplemented, a value of 3100 kcal/kg was used. Average betaglucans content of barleys were 3,0%.
[2] Calcium and phosphorus contents were .74 and .34% respectively.

The diets were isocaloric and isonitrogenous within each experiment and supplied 1,0% linoleic acid. Their composition is shown in Table 3.

The experimental unit for statistical analysis was the pen, i.e. a group of five consecutive cages sharing a common feeder. They were four dietary treatments within each experiment with three replicate pens each. All variables were analyzed using a one way analysis of variance for each period of measurement. Significant differences among dietary treatments means were determined ($P<.05$) using Duncan's multiple range test (Duncan 1955). Percentage data were transformed using arcsine of square root of percentage prior to the analysis of variance. However, percentage values are reported for ease of data interpretation.

Experiments 1, 2 and 3

One hundred and twenty Isa-brown laying hens were utilized in each experiment. The hens were 42 weeks old in Experiments 1 and 3 which lasted 8 weeks and 30 week old in Experiment 2 which was conducted for 9 weeks. In each experiment, the pens were randomly allocated to the dietary treatments based on barley contents. The inclusion levels were 10, 30, 35, and 40% for Experiment 1; 10, 40, 50, and 57% for Experiment 2 and 40 or 50% in Experiment 3. In the later trials 2 and 3,

Avizyme^{R} was supplemented at 0.5g/kg to the diets with 40, 50 and 57 and in two diets with 40 and 50% barley respectively for Experiment 3. In experiments 1 and 2, a 10% barley diet served as a control diet.

Table 3. Composition of experimental diets[1]

Diets	Barley (%)								
	10	30	35	40	40+	50	50+	57	65
Ingredient (%)									
Corn	52.03	41.24	38.24	34.23	26.89	26.20	19.26	22.42	-
Barley	10.00	30.00	35.00	40.00	40.00	50.00	50.00	57.00	65.18
Sunflower meal (34%)	5.00	5.00	4.63	3.15	5.00	0.15	5.00	-	-
Peas (26% CP)	14.00	2.27	-	-	8.39	-	5.49	-	-
Molasses	2.50	2.50	2.50	2.50	2.50	2.50	2.50	-	-
Fish meal (65% CP)	7.61	10.61	11.33	11.91	8.56	13.10	9.20	12.79	0.06
Calcium carbonate	6.86	6.92	6.77	6.94	6.90	6.95	6.91	6.99	8.15
Bone powder	0.76	0.32	0.40	0.15	0.58	-	0.48	0.02	1.66
DL-Methionine	0.05	-	-	-	0.01	-	-	-	0.08
Salt	0.19	0.14	0.13	0.12	0.17	0.10	0.16	0.11	0.30
Calculated analysis, (%)									
ME (kcal/ Kg)	2750	2750	2750	2750	2750	2750	2750	2750	2550
Proteins	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	17.00
Lysine	0.83	0.84	0.85	0.87	0.84	0.90	0.90	0.90	0.88
Methionine	0.36	0.36	0.37	0.37	0.34	0.38	0.38	0.38	0.36
TSAA	0.60	0.60	0.61	0.61	0.59	0.62	0.62	0.62	0.67
Calcium	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	4.00
P, nonphytate	0.42	0.42	0.45	0.42	0.42	0.42	0.42	0.42	0.42
Linoleic acid	1.27	1.20	1.14	1.12	1.00	1.01	1.01	0.99	1.00
Proximate analysis (%)									
Dry matter	91.91	92.06	92.33	92.20	91.91	92.03	92.21	93.35	99.10
Crude protein	18.97	20.15	20.94	20.48	19.02	19.26	19.26	19.43	18.20
Crude fiber	4.20	4.70	5.18	4.68	5.29	4.92	5.67	5.20	5.80
Ash	12.46	15.14	12.86	12.11	13.28	11.93	13.99	12.50	14.25

[1] All the diets had 1% of trace mineral and vitamins premix which supplied 10,000 IU vit A; 3000 IU vit D_3, 10 mg vit E, 1.8 mg vit K, 4 mg riboflavine, 10 mg panthotenate, 8 µg vit B_{12}, 24 mg nicotinic acid, 0.35 mg choline, and 0.6 mg folic acid, 0.4 ppm Co, 8ppm Cu, 25 ppm Fe, 1.1 ppm I_2, 80 ppm Mn, 0.2 ppm SE, and 50 ppm Zn.

Barley was formulated at 3100 kcal/kg in the diets marked with a + superscript.

In Experiment 2 barley was formulated at 2800 kcal/kg in all diets. 19.50% soybean meal (47% CP) and .003% L-lysine were added to the 65% basal barley diet in Experiment 4 to which Avizyme ref. lot 01920966 was supplemented at 0, 0.025, 0.05, and 0.10% respectively.

Avizyme^{R}: Multienzyme premix with cellulase, betaglucanase and protease activities supplied by Finnfeeds International Ltd., Market House, Ailsbury Court, High Street, Marlborough, Wiltshire, SN81AA, UK. Avizyme^{sx21} Ref batch #057-3128-4831. Avizyme^{R1}: Avizyme^{sx21} Ref batch #01920966.

Experiment 4

The trial was conducted for five periods of four weeks on Hissex laying hens housed 4 to a cage. The basal diet contained 65.2% barley to which Avizyme[R1] was added at 0; 0.025; 0.05; and 0.1% , respectively. Pre experimental data were collected during 4 weeks before the start of the experiment. The hens were 23 weeks old then and were kept on experimental diets until 42 weeks of age. Egg weight was measured every four weeks on all eggs laid during three consecutive days and egg mass was then calculated. Fecal output, ash and phosphorus content were determined at the end of the experiment.

RESULTS

The results of Experiments 1, 2, and 3 are respectively summarized in Tables 4, 5, and 6; those of Experiment 4 are reported in Tables 7 and 8.

Table 4. Effect of barley on the productive performance of laying hens and yolk color (Experiment 1)[1]

Measurements 42-50 weeks	Barley(%)				
	10	30	35	40	SEM[2]
Hen-day egg production (%)	69.7	69.4	65.7	64.1	5.66
Feed consumption (g/hen/day)	135	127	125	125	11.40
Egg weight (g)	64.4	62.8	62.1	60.8	1.77
Body weight change[3] (g)	80	-60	-120	-110	55
Yolk color scores[4]	6.37[a]	5.55[b]	5.36[b]	5.36[b]	0.17
Excreta moisture	68.1	71.3	69.5	71.1	7.23
Feed utilization[5]	3.01	2.91	3.06	3.21	0.22

1 The hens were 40 weeks-old at the start of the 8 weeks experiment.
2 SEM: Standard error of the means.
3 Body weight change (g) = final body weight - initial body weight.
4 Roche color scores (1 to 15)
5 Feed consumed (g)/egg mass (g).
a,b,c Means values within the same row without common supersctipts are significantly different (P<.05).

Experiment 1:

There were no significant differences between dietary treatments in weekly egg production, feed consumption, egg weight, body weight change, excreta moisture or feed utilization. As dietary barley levels increased, numerical reductions in egg production, feed consumption, egg weights were observed with a concomitant decrease in body weights and a slight deterioration in feed utilization values. Excreta moisture content increased, yolk color scores significantly decreased as barley inclusion in the diet increased (P<.05).

Table 5. Effect of dietary enzyme supplementation on the performance of laying hens and egg quality (Experiment 2)[1]

Measurements 30-39 weeks	Barley [2](%)				
	10	40+	50+	57+	SEM[2]
Hen-day egg production (%)	82.9[bc]	73.8[a]	78.9[ab]	78.5[ab]	4.28
Feed consumption (g/hen/day)	127[a]	121[c]	121[c]	124[b]	0.75
Egg weight (g)	61.2	61.5	61.7	61.9	1.30
Body weight change[4] (g)	190	190	110	190	99.00
Yolk color scores[5]	6.86[a]	5.97[b]	5.97[b]	5.48[c]	0.10
Specific gravity	1.096	1.095	1.096	1.096	.0013
Feed utilization[6]	2.50	2.49	2.66	2.55	0.16

1 The hens were 30 weeks-old at the start of the 9 weeks experiment.
2 Diets indicated with a superscript + had .05% of Avizyme[SX21]
3 SEM: Standard error of the means.
4 Body weight change (g) = final body weight - initial body weight.
5 Roche color scores (1 to 15)
6 Feed consumed (g)/egg mass (g).
a,b,c Means values within the same row without common supersctipts are significantly different (P<.05).

Experiment 2:

Enzyme supplementation to the high barley content diets did not have any significant effect on egg laying rate, egg weight, body weight change, shell quality or feed utilization. Significant decreases in feed consumption and yolk color scores were observed with a slight numerical improvement in egg weight (P<.05).

Experiment 3:

Avizyme supplementation to a 40 or 50% barley diets did not significantly affect egg production parameters, yolk color score or excreta moisture content. As in the previous experiment egg weight were slightly improved following enzyme addition (3.4% in the 50% barley diet) but feed consumption and yolk color scores were not drastically decreased. Increasing dietary barley levels to 50% significantly decreased egg laying rate, reduced overall hen performance and yolk color scores. Excreta moisture content increased.

Experiment 4:

Increasing the dose of Avizyme supplementation to 5% gradually improved hen performance although no significant effects were observed (P<.05). Doubling the dose was not concomitant with any additional effects. No significant differences were observed on all excreta measurements (Table 8)

Table 6. Effect of dietary enzyme supplementation on the color performance of laying hens and yolk color (Experiment 3)[1]

Measurements 42-50 weeks	Barley [2](%)				
	10	40+	50+	57+	SEM[3]
Hen-day egg production (%)	63.3[a]	59.1[ab]	53.0[bc]	57.1[ab]	4.96
Feed consumption (g/hen/day)	127	129	123	123	1.65
Egg weight (g)	60.6	61.0	59.4	61.4	0.64
Body weight change[4] (g)	-70	-110	-130	-110	53
Yolk color scores[5]	5.69	5.74	5.31	5.30	0.23
Excreta moisture	70.9	71.6	71.1	72.8	3.3
Feed utilization[6]	3.31	3.58	3.91	3.51	0.35

1 The hens were 42 weeks-old at the start of the 8 weeks experiment.
2 Diets indicated with a superscript + had .05% of Avizyme[SX21]
3 SEM: Standard error of the means.
4 Body weight change (g) = final body weight - initial body weight.
5 Roche color scores (1 to 15)
6 Feed consumed (g)/egg mass (g).
a,b,c Means values within the same row without common supersctipts are significantly different (P<.05).

Table 7 Effect of the dose of Avizyme[R1] supplimentation on laying hen performance[2] (Experiment 4)[1]

Measurements 23-42 weeks	Avizyme[SX21] g/ton					
	0	250	500	1000	Pvalue	SEM[3]
Hen-day egg production (%)	81.6	72.9	83.8	82.9	09749	6.66
Feed consumption (g/hen/day)	111	110	112	110	.9906	5.96
Egg weight (g)	58.8	58.9	59.1	57.8	.1302	0.74
Egg mass (g)	48.0	48.8	49.5	47.9	.9319	3.93
Feed utilization[3]	2.32	2.27	2.28	2.31	.8587	0.996
Body weight (g)						
23 weeks	1670	1694	1673	1698	.8447	55.08
42 weeks	1685	1740	1729	1707	.5755	59.27

1 Avizyme[SX21] Batch #01920966.
2 Overall means 22-42 weeks are presented. No significant differences were observed on all measurements.
3 Feed consumed (g)/egg mass (g).

Table 8. Effect of the dose of Avizyme[R1] supplementation on excreta output and composition[2] (Experiment 8)[1]

Measurements at 42 weeks	Avizyme[SX21] g/ton					
	0	250	500	1000	Pvalue	SEM[3]
Output g/hen/day	180	169	147	165	.0851	15.49
Moisture (%)	79.97	80.36	78.49	79.18	.973	5.95
Ash (%)	5.46	4.97	4.95	5.40	.603	.384
Phosphorus (%)	1.53	1.56	1.60	1.52	.3851	.057

1 Avizyme[sx21] Batch #01920966.
2 No significant differences were observed on all measurements.

DISCUSSION

Several recent studies on the use of barley in laying hen diets have been reported in various reviews. (Näsi 1988, Jeroch, 1991; Jeroch and Dänicke 1993; Wyatt and Goodman,1993). In contrast to earlier reports , it is now generally accepted that barley can be used in diets of laying hens with no detrimental effects on productive performance. Previous results from our laboratory have shown that barley can be included up to 62.4% in practical laying hen diets with no major effects on hen performance (Benabdeljelil and Arbaoui, 1994; Benabdeljelil 1992) The results of the study reported herein confirm further these findings with up to 65% barley in the rations (Tables 4, 6 and 7).

Although no significant differences were observed in egg and body weights, these parameters were numerically lower with the high barley diets (Tables 4 and 6) in contrast with recent results from Conrad and Carey (1993). These results were however in agreement with previous findings from Coon *et al.* (1988) who found no differences in egg production and egg weight between experimental diets in which corn was replaced by various barley cultivars. Early reports partially attributed the reduction in egg weight resulting from feeding high barley diets to a lower supply of linoleic acid (Jeroch and Dänicke 1993). The levels used in the experimental diets exceeded the recommended standard for laying hen diets (Table 3). Wyatt and Goodman (1993) found no differences in daily feed intake and egg weight for hens fed 65% barley diet for six-week period. Furthermore, the researchers determined that feeding high barley levels did not show any prevalence of wet droppings or dirty eggs as previously reported by Campbell (1984) and Graham (1991). These observations further confirm that barley can be used as a substitute for corn in diets for laying hens and may be beneficial under certain management programs to monitor egg and body weight.

Adult birds and laying hens appear to have the ability to utilize barley and adapt to rather high fiber diets as compared to younger birds which may be affected by barley ß-glucan content. Wyatt (1990) reported that the effect of feeding barleys containing

different total ß-glucan levels ranging from 4.3 to 7.9% were an increase in body weight gain and total egg production. Performance of hens fed barley with approximately 3.8% ß-glucan was not different than that of hens fed corn diets in this study. Similar findings were obtained in the present study. The effects of enzyme supplementation to barley diets fed to laying hens resulted in no further increase in performance in several studies (Benabdeljelil and Arbaoui, 1994; Wyatt and Goodman, 1993; Soliman *et al.* 1993; Jeroch and Dänicke 1993). Supplementation with Avizyme tended to improve however productive performance by about 3 to 4% to a level comparable to that of the corn control diet; the hens had a higher weight gain when fed the enzyme supplemented diet (Wyatt 1990). Wyatt *et al.* (1991) also reported significant improvements in egg production (4.3%) and feed conversion (2%) in another experiment with and increase in body weight gain. When the same diets were fed to adult roosters a 4% increase in TME_n was observed following enzyme supplementation. The inclusion of barley with added Avizyme sustained comparable performance to the control diets (Tables 6 and 7) which would suggest a 10% increase in ME content of barley fed to laying hens. Further studies may be warranted to determine if Avizyme supplementation substantially improves the metabolizable energy content of barley and further determine the mechanisms by which the enzyme mixture increases nutrients availability to the laying hens.

Enzyme supplementation of barley diets in the current study did not significantly improve egg yolk color. Berg (1959) reported that the addition of enzymes tended to increase yolk color. Aimonen and Rauva (1991) also found that enzyme supplementation slightly increased yolk color scores. Previous indications that Avizyme may improve egg yolk color (Graham 1991) are in contrast to our results and previous findings published with other commercial enzymes (Benabdeljelil , 1991). Yolk color was significantly reduced when high barley diets were fed. Enzyme additions also did not increase yolk color scores in experiments reported by Soliman *et al.* (1993).

In conclusion, barley can be used with no detrimental effects on hen performance. Various barley cultivars may respond differently. The variation in ß-glucans content and the other unknown factors may affect nutrient bioavailability and laying hen performance.

Enzyme supplementation to barley layer diets produce a positive response on nutrients bioavailability (Wyatt and Goodman, 1993) which may have beneficial effects for young birds, at production peak. The overall effect of feeding enzymes to barley diets on layer performance is not significantly improved under practical conditions.

Several recent trials such the experiments reported herein in which the energy values and the ß-glucans levels of barley have been determined prior to the start of the trials and where the diets were isonitrogeneous and iso caloric (with sufficient supply of linoleic acid) failed to show significant improvements on hen performance or efficiency of feed utilization.

Lastly further investigations, are needed to determine the efficiency of various enzyme mixtures in increasing nutrients availability to laying hens kept under different environmental and dietary conditions

ACKNOWLEDGMENTS

Support for this project was provided by the Ministry of Agriculture in Morocco and Cultor Company (Finland). Appreciation is extended to the personnel of Skikima Station for their technical assistance.

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إستخدام الإنزيمات فى علائق دجاج البيض المحتوية على الشعير وتأثيره على إنتاج وجودة البيض

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أجريت اربع تجارب لدراسة تأثير العليقة المحتوية على نسب عالية من الشعير (التجربة الأولى) وإضافه الإنزيمات (التجربة الثانية والثالثة) وتأثير نسبة الإنزيمات (التجربة الرابعة) على الإنتاج وجودة البيض. لم يظهر تأثير معنوى نتيجة لإختلاف العلائق المختبرة. بينما ظهر إنخفاض نسبى فى إستهلاك الغذاء و وزن الدجاج وإنتاج البيض مع زيادة كمية الشعير فى العليقة و على العكس لوحظ تحسن فى نسبة الإستفادة من الغذاء. كما لوحظ إنخفاض ملموس فى لون الصفار وزيادة رطوبة الزرق.

عند إضافة الإنزيمات الى العلائق المحتوية على نسبة عالية من الشعير لم يكن لها أى تأثير ملحوظ على الأداء الإنتاجى أو لون صفار البيض أو رطوبة الزرق. لوحظت زيادة فى وزن البيض عند إضافة الإنزيمات الى العلائق المختبرة . أدت زيادة منستوى الإنزيم حتى ٠,٠٥ ٪ الى تحسن ضئيل فى الأداء الإنتاجى، ولم يظهر أى تحسن إضافى عند مضاعفة نسبة الإنزيمات المضافة.

وأنتهت الدراسة الى أن إضافة الإنزيمات الى العلائق المحتوية على نسبة عالية من الشعير لم تؤثر على إنتاجية الدجاج البياض وكذلك جودة البيض الناتج.