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PERFORMANCE OF PEKIN DUCKLINGS AS AFFECTED BY MULTI-ENZYMES AND YEA SACC ADDITIONS TO BARLEY-CONTAINING DIETS

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SUMMARY

Eight diets were tested from 28 to 58 d of age in which there were three levels of barley at 0.0%, 50.0% and 100.0% of yellow corn, with the highest inclusion level being fed without or with poultry fat to equalize energy value to the control level. Each level was fed to three replicates without or with 0.075% Optizyme. In a second experiment, three levels of barley, 0.0%, 25.0% and 50.0% of the diet were fed from 1 to 42 d of age. The highest barley level was fed withoutor with fat to mimic energy differences from the control diet. Each diet was fed either with 0.075% Optizyme or 0.10% Yea Sacc or without either supplement. Nitrogen corrected apparent metabolizable energy (AME_n) and protein digestibility were measured in the 3rd Experiment.

The barley-containing diets had significant negative effects on growth and feed-to-gain ratio. Optizyme and Yea Sacc resulted in improved growth and feed-to-gain ratio of barley-containing diets. Feed consumption was affected insignificantly by barley and Optizyme. Optizyme improved AME_n of barley by 6.04% and crude protein digestibility by 2.36%. Barley slowed digesta passage significantly, with Optizyme relieve this effect.

Abdominal fat was decreased significantly with Optizyme addition and increased barley level. Sensory evaluations of breast meat were not affected significantly by barley level and Optizyme.

Keywords: Ducks, barley, multi-enzymes, Yea Sacc, growth, performance, carcass parts, sensory evaluations

INTRODUCTION

There are few experimental works testing the effects of barley and multi-enzymes on performance of waterfowl (Jeroch and Engerer, 1992; Jeroch *et al.*, 1995a; Schurz and Jeroch, 1995). However, utilization of enzyme-supplemented barley in broiler and layer diets has been increased in recent years due to advances in the commercial enzyme industry. Due to the similarity between ducks and chickens in the anatomy of gastrointestinal tract, physiological parameters of digestion and stomach pressure (Sturkie,1986), similar responses of waterfowl to barley could be expected (Jeroch *et al.*, 1995a).

There are accumulating evidences that the anti-nutritional activity of cell wall non-starch polysaccharide(s) (NSP) has impairing effects on growth and feed efficiency of birds (Choct and Annison, 1992). Mixed linked β-glucans of barley were shown to increase the viscosity of digesta and decrease the utilization of nutrients (Jeroch and Engerer, 1992; Jeroch *et al.*, 1995a; Schurz and Jeroch, 1995). Enzymes which decreased gut viscosity (Bedford and Sheppy, 1995), or acted on cell wall contents to make nutrients more available (Hesselman and Aman, 1986; Friesen *et al.*, 1992; Benabdeljelil, 1995; Jeroch *et al.*, 1995a) were found to improve bird performance (Jeroch *et al.*, 1995a; b). The anti-nutritional activity of NSP is directly or indirectly mediated by gut microflora (Misir and Marquardt, 1978a). With increasing human concern about using antibiotics in animal nutrition (Miles, 1993; Schurz and Jeroch, 1994, 1995; Osman *et al.*, 1996), probiotics such as a yeast culture may be an alternative pronutrient that could also control gut microflora resulting from feeding barley.

Barley may be an alternative feed resource in poultry feeding when corn is in short supply. Waterfowl meat can also provide an alternative animal protein source. This work aims to study the response of ducks to dietary barley and the effect of Optizyme or Yea Sacc on performance, carcass characteristics, sensory evaluations, AME_n and protein digestibility of ducks fed barley-containing diets.

MATERIALS AND METHODS

Local six-row barley was fed in the present experiments. Its chemical analysis (A. O. A. C.,1980) showed 90.80% DM, 11.26% CP, 1.85% EE, 6.50% CF, 4.56% ash and 66.63% NFE. Diet formulations as well as nutrient requirements for Pekin ducklings were based on tables by NRC (1994). Due to expected improvement in energy utilization resulting from multi-enzymes or Yea Sacc (Choct and Annison, 1992; Jeroch *et al.*, 1995b; Osman *et al.*, 1996; Kamra and Pathak, 1996), birds are also expected to compensate for the change in ME value of the diet (NRC, 1994; Leeson *et al.*, 1996), therefore some diets were iso-nitrogenous, but not iso-caloric. In addition to these diets, iso-caloric diets were also fed at the highest inclusion level of barley to distinguish between the effects of barley and that of dietary energy.

Experiment 1

Ducks were fed during the preliminary experimental period (1- 27 d of age) a commercial starter diet containing 20.0% CP and 2900 kcal ME/kg diet, 1.0% Ca, 0.4% available phosphorus, 0.80% TSAA and 1.0% lysine. Ducks were housed in Ducks floating units at El-Nozha Hydrome near Alexandria during the preliminary and the main (28-58 d of age) experimental periods. Four hundred and eighty, 28 d old Pekin ducklings were randomly distributed to 8 groups, with three replicates of 20 unsexed ducks each. During 28-58 d of age, barley was fed to replace 0.0%, 50.0% or 100.0% of yellow corn on weight:weight basis, that is equal to 0.0%, 33.93% and 67.85% of the diet. In addition, one treatment group 100.0% of the yellow corn was replaced by barley and the ration was supplemented with 5.54% poultry fat to mimic energy differences from the control diet (Table 1). Each diet was fed without or with Optizyme[1 ®] at 750g/ton diet (0.075%). Diets were formulated using corn-soybean meal and 5.0% of protein concentrate that contained 52.0% CP, 2200 kcal/kg diet, 1.8% Meth., 2.4% TSAA, 3.0% lysine, 9.0% calcium, 3.8% available phosphorus, 3.0% NaCl, 2.0% crude fiber, 2.2% crude fat and 1% vitamin and mineral mix.

Experiment 2

Corn-soybean meal diets containing 0.0%, 25.0% or 50.0% barley were used. In addition, one treatment group that was fed 50.0% barley supplemented with 3.10% poultry fat to equalize energy value to the control diet (Table 1). Each diet was fed without or with Optizyme at 750g/ton diet (0.075%) or Yea Sacc[2®] at 1000 g/ton diet (0.10%). There were four replicates in each group. Each replicate contained six unsexed ducks allocated to one unit of battery-brooders (40×45×60cm). The experimental period was from 1 to 42 d of age.

Experiment 3

The effect of Optizyme addition on AME_n and protein digestibility of barley was studied employing the total collection method. Two groups of 6 Pekin ducks, 35 d old were used, one of them was fed 6-row barley and the other was fed barley that was supplemented by Optizyme at 0.075%. Barley was crushed and vitamins and minerals mixture were supplemented at 0.3%. The

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[1] A product of Optivite International LTD, Main Street, Laneham, Retford, Nottinghamshire, DN22 ONA, England, and composed mainly of multi-enzyme systems proteases, amyloglucosidase, xylenase, β-gluconase, cellulases and hemicellulases.

[2] A product of Alltech, INC., Biotechnology, Nicholasville, KY 40356, USA. Yea Sacc is a biomass yeast culture containing different strains *of Saccharomyces cerevisiae* 10^6 cell/g, 28.0% CP, 6.0% EE, 14.0% CF and 8.0% ash.

procedure described by Jakobsen *et al.* (1960) was used for separating fecal nitrogen in dried excreta, followed by determination of nitrogen by method of A.O.A.C (1980) in feces and barley. Gross energy was determined for both barley and excreta by using Gallenkamp Ballistic Bomb Calorimeter (Catalog No CBB=330-0101).The quantitative difference between GE consumed and that excreted was corrected to a basis of nitrogen equilibrium to calculate AME_n according to Sibbald (1989).

Table 1. Composition of the experimental diets

Ingredients	Experiment 1				Experiment 2			
	%	%	%	%	%	%	%	%
Yellow corn	67.85	33.93	0.00	0.00	64.20	43.265	20.10	16.62
Barley	0.00	33.93	67.85	67.85	0.00	25.00	50.00	50.00
Soybean meal	21.95	19.60	17.30	17.30	30.80	28.60	26.80	27.18
Protein concentrate	5.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00
Vit & Min Mix[1]	0.20	0.20	0.20	0.20	0.30	0.30	0.30	0.30
Salt	0.45	0.45	0.45	0.45	0.30	0.30	0.30	0.30
Limestone	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
Bone meal	1.50	1.50	1.50	1.50	2.50	2.45	2.40	2.40
DL-methionine	0.055	0.070	0.083	0.083	0.078	0.085	0.095	0.10
Sand	2.495	4.820	7.117	1.577	1.822	0.000	0.005	0.00
Poultry fat	0.00	0.00	0.00	5.54	0.00	0.00	0.00	3.10
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated values								
ME kcal/kg diet	2872	2626	2384	2872	2838	2783	2663	2827
Crude protein,%	18.03	17.97	17.85	17.85	19.01	19.08	19.13	19.00
Crude fat,%	2.86	2.18	1.50	7.04	2.69	2.34	1.80	4.87
Crude fiber,%	3.13	4.42	5.72	5.72	3.57	4.57	5.57	5.57
Methionine,%	0.409	0.413	0.411	0.411	0.400	0.400	0.401	0.402
TSAA,%	0.700	0.706	0.709	0.709	0.703	0.712	0.720	0.718
Lysine,%	0.917	0.901	0.887	0.887	0.995	0.982	0.973	0.974
Ca,%	1.16	1.16	1.16	1.16	0.85	0.83	0.81	0.81
Ava. P, %	0.49	0.51	0.54	0.54	0.45	0.46	0.47	0.47

[1]Provides per kilogram of diet: vitamin A (as all-trans-retinyl acetate); 5,500 IU; vitamin E (all rac-â-tocopheryl acetate); 11 IU; menadione (as menadione sodium bisulfite); 1.1 mg; Vit.D_3, 1,100 ICU; riboflavin, 4.4 mg;Ca pantothenate,12 mg; nicotinic acid, 44 mg; choline chloride, 191 mg; vitamin B_{12}, 12.1 g; vitamin B_6, 2.2 mg; thiamine (as thiamine mononitrate); 2.2 mg; folic acid, .55 mg; d-biotin, .11 mg. Trace mineral (milligrams per kilogram of diet) : Mn, 60; Zn, 50; Fe, 30; Cu, 5; Se, .3.

Measurements

In all experiments feed and water were offered *ad libitum*. Ducks were weighed at 28, 42 and 58 d of age in the 1st Experiment, and biweekly in the 2nd Experiment. At the same ages, feed consumption was recorded and feed-to-gain ratio was calculated. At the end of the 1st Experiment (58 d of age), six ducks from each treatment were slaughtered for carcass evaluation according to the method of Saleh *et al.* (1996). Blood samples were also obtained from the slaughtered birds for total protein and cholesterol determinations. They were measured according to Weichselbaum (1946) and Ratllif and Hall (1973), respectively. Water holding capacity (WHC) as a bound water percentage and sensory evaluations (panel test) were determined by ten trained panelists to characterize color, flavor and consistency as described by El-Deek *et al.* (1997). Digesta passage was determined at five wk of age in the 1st Experiment and at 2nd, 4th and 6th wk in the 2nd Experiment, using the method of Almirall and Esteve- Garcia (1994).

Statistical analysis

Data from each experiment were subjected to analysis of variance using the GLM procedure of SAS® (SAS Institute, 1985) and Duncan's New Multiple Range Test (Duncan, 1955) at $P \leq 0.05$. All percentages were transformed to their corresponding angles arc sine before running the analyses.

RESULTS

1-Growth and mortality

Weight gains of 42 d old ducks were significantly decreased when barley was fed at 100.0% of yellow corn (67.85% in the diet) when compared to other barley levels in Experiment 1 (Table 2). Addition of poultry fat to the diet containing the highest level of barley increased weight gain at 42 and 58 d. There were also significant different responses of these two groups to Optizyme in the aforementioned periods. There was significant interaction between barley level and Optizyme, showing that Optizyme is more beneficial in barley-containing diets (Table 2).

In Experiment 2, there was a significant decrease in weight gains of 14 d old ducks fed 50.0% barley-containing diet, with the differences in total weight gains being significantly linear among the three groups fed without poultry fat addition (Table 3). There was no significant difference between the two groups fed 50.0% barley, however there was increase in weight gains due to poultry fat addition to the 50% barley- containing diet (Table 3). There was also significant interaction between Optizyme or Yea Sacc and barley levels, indicating that Optizyme improved weight gains of all the experimental groups, whileYea Sacc improved weight gains of only barley-containing diets.

Seven ducks died in Experiment 1 and 5 in Experiment 2, and mortality was not related to treatments (Tables 2 and 3).

Table 2. Effect of barley level and Optizyme addition on body weight gain, number of ducks dead and feed- and energy- to-gain ratios (Experiment 1)

Barley[1]	0.0%		50.0%		100.0%		100.0 %[2]		
Enzyme[3]	0.00	0.075	0.00	0.075	0.00	0.075	0.00	0.075	SEM
Body weight gain, g									
28-42 ,d	810.8^{a}	825.0	783.8^{a}	819.2	711.7_{x}^{b}	760.6	760.9^{ab}_{y}	786.4	12.9
43-58,d	687.7	673.4	640.0	679.2	620.2	667.8	646.3	675.2	24.5
28-58,d	1498.5^{a}	1498.4	1423.8^{b}	1498.4	1331.9_{x}^{c}	1428.4	1407.2^{b}_{y}	1461.6	23.9
Number of ducks dead									
28-58,d	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	......
Feed-to-gain ratio, g/g									
28-42, d	3.820	3.765	3.965	3.837	4.179	4.056	3.931	3.948	0.08
43-58,d	4.831	4.911	4.927	4.770	4.910	4.762	4.787	4.670	0.24
28-58,d	4.284^{c}	4.280	4.397^{b}	4.260	4.519^{a}	4.386	4.324^{b}	4.282	0.10
Energy-to-gain ratio, kcal/g									
28-58,d	12.30^{a}	12.29	11.55^{a}	11.19	10.77_{x}^{b}	10.46	12.42^{a}_{y}	12.30	0.28

[1] Barley content expresed as a percentage of yellow corn . [2] Fat added to equalize calorie values.

[3] 0.0 represents the control group for each barley level, 0.075 represents Optizyme addition at 0.75 kg/ton diet for each barley level. [abc] Means within a row with no common superscripts differ significantly ($P \leq 0.05$) when un-supplemented levels were compared. x,y Indicates significant difference ($P \leq 0.05$) between the 100% barley groups fed without and with poultry fat.

2-Feed-and energy-to- gain ratios

There was a significant linear impairment effect on feed-to- gain ratio when barley was fed, while the opposite is true for energy-to-gain ratio (Table 2), due to decreasing caloric consumption (Table 4). Equalize energy level of the 100.0% barley-containing diets improved feed-to-gain ratio, but impaired energy-to-gain ratio significantly (Table 2). There was an interaction effect due to barley level and addition of fat or Optizyme, indicating that enzyme being more efficiently in enhancing energy-to-gain ratio of low energy barley-containing diets.

There was a negative effect of barley on feed-to-gain ratio, with Optizyme improving it insignificantly in Experiment 2 (Table 3). There were no significant differences in feed-to-gain ratio between the two groups fed 50.0% barley

Table 3. Effect of barley level and Optizyme or Yea Sacc addition on body weight gain, number of ducks dead and feed- and energy- to gain ratios (Experiment 2)

Barley[1]	0.0%			25.0%			50.0%			50.0 %[2]			
Treatment[3]	0.00	0.075	0.10	0.00	0.075	0.10	0.00	0.075	0.10	0.00	0.075	0.10	SEM
Body weight gain, g													
1-14,d	268.3^{a}	271.3	278.7	271.6^{a}	273.6	269.6	242.8^{b}	266.0	246.7	258.1^{ab}	276.2	249.4	9.53
15-28,d	510.9	541.4	506.0	485.9	543.4	531.3	460.4	528.4	480.0	480.0	518.4	509.2	18.9
29-42,d	583.8	579.1	563.1	555.5	578.6	571.7	526.7	575.4	570.3	547.2	580.4	568.1	19.7
1-42,d	1363.0^{a}	1391.8	1347.8	1313.0^{b}	1395.6	1372.6	1229.9^{c}	1369.8	1279.0	1285.3^{bc}	1375.0	1326.7	24.7
Number of ducks dead													
1-42,d	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	......
Feed-to-gain ratio, g/g													
1-14,d	2.151	2.026	2.230	2.137	2.176	2.242	2.231	2.137	2.310	2.210	2.189	2.215	0.119
15-28,d	2.395	2.319	2.339	2.464	2.313	2.234	2.526	2.350	2.577	2.500	2.419	2.451	0.140
29-42,d	2.620	2.673	2.765	2.684	2.612	2.620	2.764	2.666	2.702	2.690	2.610	2.640	0.141
1-42,d	2.443	2.409	2.494	2.489	2.410	2.396	2.570	2.441	2 618	2.523	2.453	2.488	0.079
Energy-to-gain ratio, kcal/g													
1-42,d	6.93	6.84	7.08	6.93	6.71	6.67	6.84$_{x}$	6.50	6.97	7.14$_{y}$	6.95	7.04	0.23

[1] Barley content expressed as a percentage of the diet. [2] Fat added to equalize calorie values. [3] 0.00 represents the control group for each barley level, 0.075 represents Optizyme addition at 0.75 kg/ton diet for each barley level, 0.10 represents Yea Sacc addition at 1.0kg/ton diet for each barley level. [abc] Means within a row with no common superscripts differ significantly (P≤0.05) when un-supplemented levels were compared. [x,y] Indicates significant difference (P≤0.05) between the 50% barley groups fed without and with poultry fat.

levels, however energy-to-gain ratio showed significant negative effect of increasing caloric value of the diet containing 50.0% barley (Table 3).

Table 4. Effect of barley level and Optizyme addition on feed and energy consumptions and digesta passage (Experiment 1)

Barley[1]	0.0%		50.0%		100.0%		100.0 %[2]		
Enzyme[3]	0.0	0.075	0.0	0.075	0.0	0.075	0.0	0.075	SEM
Feed consumption, g/bird									
28-42,d	3097	3106	3108	3143	2974	3085	2991	3105	0.077
43-58,d	3322	3307	3153	3240	3045	3180	3094	3153	0.115
28-58,d	6419	6413	6261	6383	6019	6265	6085	6258	0.150
Energy consumed kcal/bird									
28-58,d	18435[a]	18418	16441[a]	16762	14349[b]$_x$	14936	17476[a]$_y$	17973	408.1
Digesta passage , Min									
35,d	74.0[b]	78.0	81.0[a]	79.0	82.0[a]	73.0	85.0 [a]	75.0	3.50

1 Barley content expressed as a percentage of yellow corn. 2 Fat added to equalize calorie values.
3 0.0 represents the control group for each barley level, 0.075 represents Optizyme addition at 0.75 kg/ton diet for each barley level. ab Means within a row with no common superscripts differ significantly (P≤.05) when un-supplemented levels were compared. x,y Indicates significant difference (P≤0.05) between the 100% barley groups fed without and with poultry fat.

3-Feed and energy consumptions

Feed consumption was unaffected by barley level or Optizyme (Table 4), although there was an obvious trend towards decreased feed consumption with increasing barley level and diminishing response when Optizyme was added in Experiment 1. There was no changes in feed consumption due to barley level in Experiment 2 (Table 5). However, at the highest inclusion level feed consumption declined by 5.10%, and this effect was diminished by Optizyme.

Yea Sacc increased feed consumption of all groups during 1-14 d of age except those fed iso-caloric-diet containing 50% barley (Table 5). Moreover, Yea Sacc stimulated feed consumption of low-energy diet containing 50.0% barley. Optizyme increased feed consumption of all groups compared with the controls. Feed consumption showed significantly different responses to Optizyme and Yea Sacc in the two groups fed the 50.0% barley level (Table 5). Optizyme increased feed consumption of all groups compared with the controls. A significant increase in feed consumption due to equalization of the energy value of the 50.0% barley during 15-28 d of age was also shown.

Energy consumption showed progressively significant decreases with increases in barley levels (Tables 4 and 5), due to low energy values of

Table 5. Effect of barley level and Optizyme or Yea Sacc addition on feed and energy consumptions and digesta passage (Experiment 2)

Barley[1]	0.0%			25.0%			50.0%			50.0 %[2]			
Treatment[3]	0.00	0.075	0.10	0.00	0.075	0.10	0.00	0.075	0.10	0.00	0.075	0.10	SEM
Feed consumption, g/bird													
1.14,d	577.2	549.6	621.4	580.4	595.4	604.5	541.8	568.4	570.0	570.4	604.6	552.4	17.2
15-28,d	1223.6	1255.6	1183.5	1197.2	1257.1	1186.8	1162.9_x	1241.7	1236.9	1200.0_y	1254.0	1248.0	27.2
29-42,d	1529.6	1547.8	1557.0	1490.8	1511.4	1497.6	1455.7	1533.8	1541.1	1472.0	1514.8	1500.0	67.2
1-42,d	3330.4	3353.0	3361.9	3268.4	3363.9	3288.9	3160.4	3343.9	3348.0	3242.4	3373.4	3300.4	82.9
Energy consumed kcal/bird													
28-58,d	9452^a	9516	9541	9096^a	9362	9153	8416_x^b	8905	8916	9179_y^a	9550	9343	260
Digesta passage, Min													
14,d	77.5^c	75.0	74.3	91.3^b	79.0	82.5	106.3^a	94.5	98.3	100.1^{ab}	92.8	91.2	4.9
28,d	75.0^c	76.3	76.3	82.5^b	75.0	80.0	101.3^a	91.3	96.1	91.8^{ab}	83.1	88.2	4.0
42,d	83.8^b	83.6	80.3	86.3^b	79.0	78.8	96.3^a	90.5	95.0	88.2^b	81.1	84.5	3.6

[1] Barley content expressed as a percentage of the diet. [2] Fat added to equalize caloric values. [3] 0.00 represents the control group for each barley level, 0.075 represents Optizyme addition at 0.75 kg/ton diet for each barley level, 0.10 represents Yea Sacc addition at 1.0 kg/ton diet for each barley level. [abc] Means within a row with no common superscripts differ significantly ($P \leq 0.05$) when un-supplemented levels were compared. [x,y] Indicates significant difference ($P \leq 0.05$) between the 50% barley groups fed without and with poultry fat.

barley-containing diets (Table 1). There were also significant increases in energy consumption due to added fats. The data indicate different degrees of response to Optizyme between the two groups fed 100.0% barley or yellow corn or between barley levels (Table 4). In the 2nd Experiment, energy consumption of the control and 50.0% barley diets was increased significantly to the same degree by Optizyme and Yea Sacc, while at other levels Optizyme had a greater influence, indicating significant interaction (Table 5).

4-Digesta passage

In the 1*st* Experiment, digesta passage was slowed significantly by inclusion of barley in the diet, and Optizyme accelerated it significantly only in the 100.0% barley fed group (Table 4). At any sampling time increasing barley level in the diet significantly slowed digesta passage, while Optizyme accelerated it (Table 5).

5-Nitrogen corrected apparent metabolizable energy (AME_n), protein digestibility, serum total protein and cholesterol

There was an increase in both AME_n and protein digestibility with Optizyme addition to barley in the diets of 35 d old Pekin ducks (Data were not presented). The value of AME_n increased by 6.04% from 2783 to 2951 kcal/kg and an increase by 2.36% in protein digestibility from 68.71% to 70.33%. Barley level showed significant effects on serum total protein and cholesterol, however, only serum protein was significantly increased by Optizyme addition (Fig. 1; 2)

6-Carcass characteristics and sensory evaluations

There were insignificant differences in carcass parts due to barley level and Optizyme (Table 6). Abdominal fat showed progressive significant decline with increasing barley level when compared to the corn-control group, and further significantly decreased by Optizyme (Table 6). Adding poultry fat to 100.0% barley diets increased abdominal fat deposition significantly. Data related to breast meat sensory evaluations exhibited insignificant effects of barley level and Optizyme supplementing (Table 6).

7-Internal organs

Gizzard percentage was increased significantly with increasing barley level, and Optizyme reduced it in all the experimental groups (Table 7). Pancreas percentage was increased significantly by 7.07% of ducks fed 100.0% barley when compared with the corn-control diet. Hence, Optizyme helped to decrease it in all experimental groups. Liver and spleen percentages were unaffected by the experimental treatments (Table 7). Percentages of intestinal weight and length and cecum length were increased ($P \leq 0.05$) by barley, while Optizyme overcame it.

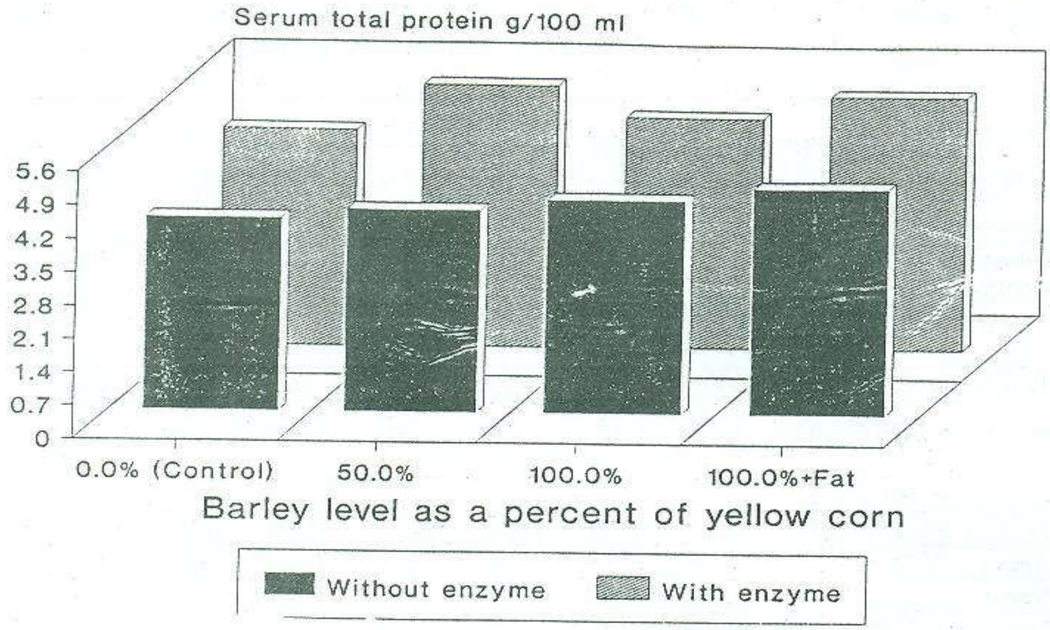

Fig. 1. Effect of Optizyme addition on serum total protein of Pekin ducklings fed diets -containing different barley levels (Experiment 1).

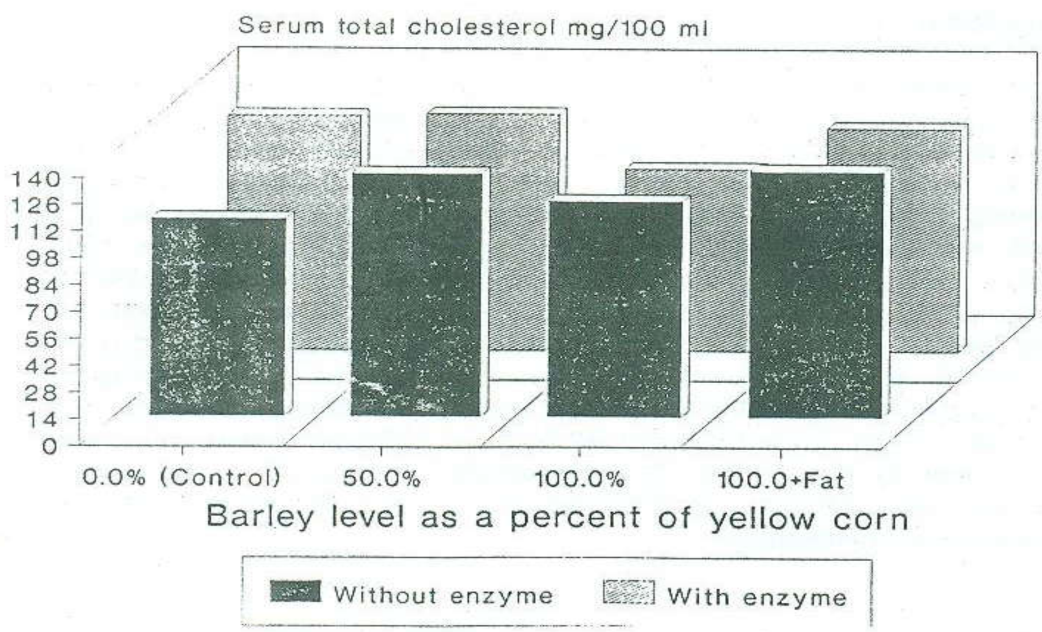

Fig. 2. Effect of Optizyme addition on serum total cholesterol of Pekin ducklings fed diets-containing different barley levels (Experiment 1).

Table 6. Effect of barley level and Optizyme addition on carcass parts as related to live body weight and sensory evaluations of breast meat (Experiment 1)

Barley[1]	0.0%		50.0%		100.0%		100.0 %[2]		
Enzyme[3]	0.0	0.075	0.0	0.075	0.0	0.075	0.0	0.075	SEM
Carcass parts[4],									
Breast+ wing,%	24.27	24.69	24.05	24.63	23.87	24.75	23.74	24.38	0.60
Thigh+ leg,%	21.16	20.06	19.59	19.50	19.98	19.14	19.79	19.34	0.77
Back,%	13.43	13.36	15.31	14.97	14.83	14.25	15.37	14.88	0.59
Abd. Fat[5], %	2.06^{a}	1.66	1.80^{b}	1.11	1.45_{x}^{c}	1.06	2.18_{y}^{a}	1.89	0.20
Sensory evaluations,									
WHC,%	96.95	96.80	98.10	96.30	96.60	96.70	97.40	96.38	2.90
Color	7.50	8.00	7.60	7.75	7.80	7.85	7.16	7.38	0.41
Flavor	7.55	7.70	8.15	7.60	7.50	7.55	7.40	7.38	0.41
Consistency	7.90	8.05	8.25	7.90	8.00	7.75	8.14	8.46	0.36

[1] Barley content expressed as percentage of yellow corn. [2] Fat added to equalize calorie values. [3] 0.0 represents the control group for each barley level, 0.075 represents Optizyme addition at 0.75 kg/ton diet for each barley level [4] Empty body weight without head, neck, feet+shanks, wings (the cut of wings were made at the end of humerus bone) and viscera . [5] Including abdominal and gizzard fats [abc] Means within a row with no common superscripts differ significantly ($P \leq 0.05$) when un-supplemented levels were compared. [x,y] indicates significant difference ($P \leq 0.05$) between the 100% barley groups fed without and with poultry fat.

DISCUSSION

The present results indicate that, growth and feed- to- gain ratio of Pekin ducks were hindered by including barley in their diets, and this seems to be related to the level of barley (Tables 2 and 3). Researchers compared the effect of barley with maize on growth of broiler chicks and found that barley-containing diets exhibited growth depression and poor feed efficiency of broilers and this depends on barley level (Aboud, 1988; Jeroch *et al.*, 1993; Gadallah, 1994; Saleh *et al.*, 1994), and chicks age (Salih *et al.*, 1991) as well as quality of barley (Classen *et al.*, 1988). In this concern, Jeroch *et al.* (1993) found that weight gains of broilers decreased by 4.0% and 10.0% when 50.0% and 100.0% of dietary corn were replaced by six-row barley. The 1st experiment revealed that 4.98% and 11.12% decreases when six-row barley fed in low-energy diet at 50% and 100% of dietary yellow corn (33.93% and 67.85% of the diet), respectively. In the 2nd experiment, the decreases were 3.67% and 9.77% when 25.0% and 50.0% barley were fed in low-energy diet, respectively.

Table 7. Effect of barley level and Optizyme addition on internal organs as related to live body weight of Pekin ducks (Experiment 1)

Barley[1]	0.0%		50.0%		100.0%		100.0 %[2]		
Enzyme[3]	0.0	0.075	0.0	0.075	0.0	0.075	0.0	0.075	SEM
Gizzard,%	3.19[b]	2.98	3.51[a]	3.02	3.60[a]	3.38	3.68[a]	3.41	0.15
Pancreas,%	0.396[b]	0.332	0.394[b]	0.326	0.424[a]	0.364	0.419[a]	0.354	0.012
Liver,%	2.43	2.49	2.31	2.47	2.38	2.48	2.41	2.54	0.15
Spleen,	0.056	0.058	0.061	0.057	0.054	0.065	0.058	0.061	0.007
Int. Wght[4],%	3.74[b]	3.72	4.41[a]	3.71	4.59[a]	3.83	4.48[a]	3.96	0.22
Int. Lg[5],%	8.41[b]	8.30	8.74[a]	8.03	8.88[a]	8.28	8.91[a]	8.18	0.24
Cecum Lg[5],	0.77[b]	0.76	0.86[a]	0.80	0.85[a]	0.77	0.86[a]	0.80	0.046

[1] Barley content expressed as a percentage of yellow corn . [2] Fat added to equalize calorie values.

[3] 0.0 represents the control group for each barley level, 0.075 represents Optizyme addition at 0.75 kg/ton diet for each barley level. [4] Empty intestinal weight, g. [5] Intestinal and cecum length, cm.

[ab] Means within a row with no common superscripts differ significantly (P<0.05) when un-supplemented levels were compared.

Equalization of energy value at the highest barley level relieved about 42% of the negative effect of barley. Even though, dietary barley at 50.0% and 67.85% in the iso-caloric diet for Pekin ducklings should also be neglected during 1-42 d and 28-58 d of age, respectively. This indicates that ducks and chicks are subjected to the anti-nutritive factors of barley with similar degree of response. Similarly, Jeroch *et al.* (1995a; b) reported that barley had negative effects on growth and feed-to-gain ratio of young birds and ducklings and this effect relieved with advanced age of birds due to higher adaptability of gastrointestinal tract microflora which form β-glucanase. They concluded that barley should be avoided in broiler starter diets, although older broilers could tolerate between 20-30% in the diet.

Optizyme ameliorated growth and feed-to-gain ratio of diets containing 33.93% or 25.0% barley in the 1st and 2nd experiments, respectively, so that there were no differences between these groups and the corn-control group. Similarly, Benabdeljelil (1995) found that broilers fed 25.0% enzyme-supplemented barley showed no difference from the corn-control group. Optizyme improved growth and feed-to-gain ratio in both experiments, with the responses being greater in high- barley low-energy diets (Tables 2 and 3). The response in growth to Optizyme decreases from 7.51% in low energy diet to 3.86% in their homologous groups fed iso-caloric diets in experiment 1. This decrease in experiment 2 was from 11.37% to 7.00%.

Feed-to-gain ratio exhibited similar response but of less degree. Also, Jeroch and Engerer (1992) and Jeroch *et al.* (1995a) reported that β-glucanase supplementing to barley-containing diets improved waterfowl growth by 2 to 7%, with the enzyme being more proficient in early ages than in the later stages of growth period, although feed-to-gain ratio was hardly affected by enzyme addition in iso-caloric, iso-nitrogenous diets. It is worth noting that the enzyme responses were more effective in early ages, indicating that the responses to the β-glucanase-containing multi-enzymes depends on age of ducks.

The influences of Optizyme (proteases, amyloglucosidase, xylenase, β-gluconase, cellulases and hemicellulases) on growth and feed efficiency could be due to overcome β-glucans of barley and improve digestibility of starch, fat and protein as well as hydrolysis of NSP to monomers D-glucose, D-xylose and L-arabinose (Almirall *et al.*,1993; Jeroch *et al.*, 1995 a, b). The results of the 3rd experiment indicate that, AME_n improved by 6.04% and protein digestibility by 2.36%, serum total protein was also increased as a result of Optizyme addition (Fig. 1). Similarly Rotter *et al.* (1990) found that energy value of two barley varieties increased by 3.0% as a result of enzyme (cellulase and β-glucanase) supplementation, while true protein digestibility was not influenced by enzyme supplementation.

In both experiments, there were progressive improvements in energy-to-gain ratio due to Optizyme supplementation in barley-fed groups (Tables 2 and 3). However, the reduction in ME contents of the diets could also be encountered. It is generally accepted that there is inverse relationship between energy value of the diet and its efficiency to some extent (Leeson *et al.*, 1996). The overall improvement in energy-to-gain ratio was 3.0% in experiment 1 and 5% in experiment 2 and is similar to the values reported by Friesen *et al.*(1992), Benabdeljelil (1995) and Jeroch *et al.* (1995b), who concluded that enzyme improved ME value of barley from 1.5 to 15%, and this depends on barley variety, NSP content and nature of feeds. Bedford (1997) reported that broilers fed six row barley-containing diets exhibited about 300 kcal improvement in AME value as a result of enzyme addition, such effect was found herein to be 168 kcal of AME_n. It is worth to note that, the uncompleted recovery in weight gains and feed-to-gain ratio of the 50.0% and 67.85% low-energy barley-containing diets could be partially due to caloric deficiency (Tables 4 and 5), and β-glucans of barley, as poultry fat recovered only 42% of the negative effect of barley.

The overall effect of Yea Sacc being only beneficial on growth and feed-to-gain ratio of ducks fed barley-containing diets, however compared to Optizyme, Yea Sacc was less effective in the 50.0% barley-containing diets (Table 3). This is most likely due to absence of specific enzyme (β-glucanase) of Yea Sacc. Although, similar mechanisms were exist between enzyme and Yea Sacc. Kamra and Pathak (1996) reported that yeast culture (*Saccharomyces cerevisiae*) increased the digestibilities of feeds, crude protein and fiber fractions thereby increasing the availability of nutrients for animal productivity (Krause *et al.*, 1989; Bradley *et al.*, 1994), or indirectly via change in the gut microflora in favour of the activities of fiber degrading micro-organisms especially cellulolytic bacteria and subsequently decreasing NSP contents in the gut (Miles, 1993).

The results reveal that the improvement which was shown in growth and feed-to- gain ratio of ducks fed enzyme-supplemented barley coincided with increasing nutrient consumptions. In accordance with the present results, Broz and Frigg (1986), Hesselman and Aman (1986) and Jeroch *et al.* (1995a) reported that feeding a barley-based diet reduced feed intake of broilers, and β-glucanase overcame it. Also, Noy and Sklan (1996) 0concluded that the intake of feed appears to be a major factor affecting growth of chicks. The lack of significance in the most of the feed consumption results might have been influenced by feeding behavior of ducks and thus, within treatments variations.

The results show that barley level and Optizyme had no effect on carcass parts (Table 6). These results are in general agreement with those reported by Emmanuel and Jeong (1989), Wyatt and Goodman (1992), Saleh *et al.* (1994) and Ghazalah *et al.* (1994). They found that barley and enzyme addition had no effects on dressing percentage of broilers. Nonetheless, Jeroch *et al.* (1995a) found that enzyme increased breast meat and decreased leg proportion of ducks.

Due to the decrease in energy level and thus energy consumption of barley-containing diets, abdominal fat was decreased (Table 6), and also serum total cholesterol only of the highest-barley level (Fig. 2). The increase in abdominal fat deposition and serum cholesterol of 100% barley iso-caloric-diet, indicated an increase in energy availability from added fats. In concert with the present results, Benabdeljelil (1995) found that barley-fed broilers had less abdominal fat. Likewise, Mohamed and Hamza (1991) found that increasing enzyme level decreased abdominal fat of broilers. Similar to the results reported by Jeroch (1995a) and Osman *et al.* (1996), it was found that barley level and Optizyme had no effects on sensory measurements of breast meat.

The significant effects of barley on gizzard, pancreas, intestinal weight and length and cecum length percentages may be related to increasing fiber and/or NSP contents of the experimental diets, with Optizyme resulted in restoring pancreas, intestinal length and weight percentages. In concern with the current observations, it was reported that broilers could adjust for changing in diet, particularly dietary starch, by altering the amount of amylase secreted from the pancreas and by altering intestinal surface area (Moran, 1985; Brenes *et al*., 1993; Attia and Abd El-Rahman, 1996). Moreover,the structure and function of the small intestine could be modified significantly by dietary manipulation (Dworkin *et al*., 1976; Benabdeljelil, 1995) and enzyme addition (Mohamed and Hamza,1991; Ritz *et al*., 1995 a, b). Furthermore, Isaksson *et al*. (1982) and Fengler *et al*. (1988) found that soluble fibers inhibited the activities of lipase, amylase and trypsin in *in vitro* studies, and lipase and protease additions to wheat-based diets improved performance of broiler chicks (Bedford and Sheppy, 1995).

In conclusion the results indicate that multi- enzymes containing β-glucanase added to iso-caloric diets containing barley up to 50% during 1-42 d, and 67.85% during 28-58 d periods improved growth and feed-to-gain ratio, indicating that barley could be utilized in iso-caloric duck diets when supplemented with β-glucanase-containing multi-enzymes. The economic consideration of using barley as an alternative grain component in duck diets will depend on its relative price to corn and the cost of multi-enzymes supplementation.

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تأثير إضافة المخلوط الإنزيمي (اوبتزيم) أو بيئة الخميرة على أداء البط البكيني المغذى على علائق تحتوى على الشعير

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نظراً لإفتقار المراجع للمعلومات عن تأثير الشعير و الإنزيمات علي البط علي الرغم مما هو معروف عن قدراته كطائر رعي من الاستفادة من مواد العلف المرتفعة في الألياف لذا فقد أجريت ثلاث تجارب لدراسة تأثير استخدام الأنزيمات أو بيئة الخميرة في علائق البط البكيني المحتوية على مستويات مختلفة من الشعير. في التجربة الأولي استخدم الشعير بنسب صفر٪، ٥٠٪ و ١٠٠٪ من نسبة الذرة الصفراء بالعلف وقد أضاف الي كل مستوي ٠,٠٧٥٪ من المخلوط الإنزيمي اوبتزيم أو ترك بدون إضافة وأجريت التجربة في الفترة من ٢٨-٥٨ يوم من العمر. في التجربة الثانية استخدم الشعير بنسب صفر ٪، ٢٥٪ و ٥٠٪ كنسبة من العلقية وأضاف الي كل مستوي ٠,٠٧٥٪ من المخلوط الأنزيمي اوبتزيم أو ٠,١٠٪ من بيئة الخميرة أو ترك بدون إضافة و أجريت التجربة خلال الفترة ١-٤٢ يوما من العمر وفي التجربة الثالثة درس اثر الإضافة الإنزيمية علي قيم الطاقة الممثلة الظاهرية والبروتين المهضوم من الشعير ودلت النتائج على الآتي:-

١- أدى استخدام الشعير في علائق البط البكيني إلي نقص معنوي في معدلات النمو والكفاءة الغذائية.

٢- أدت إضافة الأنزيمات في علائق البط المحتوية علي الشعير إلي تحسين معدلات النمو والكفاءة الغذائية وذلك بالاعتماد علي مستوي الشعير ومرحلة النمو كما حسن الأنزيم معدلات النمو والكفاءة الغذائية للمجموعة الخالية من الشعير.

٣- أدت إضافة الدهن لمعادلة مستوي الطاقة عند المستوي العالي من الشعير في كلتا التجربتين إلي تقليل التأثير الضار للشعير على النمو والكفاءة الغذائية المشاهد عند نفس المستوي من الشعير المغذي بدون إضافة الدهون.

٤- أدي استخدام بيئة الخميرة في علائق البط المحتوية علي الشعير إلي تحسين معدلات النمو والكفاءة الغذائية ولكن التأثير كان اقل عند مقارنته بالأنزيم.

٥- نقص معدل الإستهلاك الغذائي بإستخدام الشعير وبزيادة مستواه وأدت الإضافة الإنزيمية إلي تقليل تأثير الشعير على الإستهلاك الغذائي.

٦- أدت إضافة الأنزيم الي الشعير الي تحسين قيم الطاقة الممثلة الظاهرية للشعير بمقدار ٦,٠٤٪ و معامل هضم البروتين بمقدار ٢,٣٦٪.

٧- أدي استخدام الشعير والأنزيمات في علائق البط إلي تقليل ترسيب الدهن في منطقة البطن.

٨- لم تتأثر الصفات الحسية للحوم الصدر معنويا بالمعاملات التجريبية تحت الدراسة.

٩- أدي استخدام الشعير في علائق البط البكيني إلي تضخم معنوي في نسب أوزان البنكرياس والأمعاء والأعورين وساعد الأنزيم علي التقليل من تأثير الشعير.

١٠- أدي استخدام الشعير إلي بطئ في معدل مرور البلعه الغذائية وساعد الأنزيم علي تقليل تأثير الشعير معنويا.

و من هذا يمكننا التوصية باستخدام الشعير المضاف إليه الأنزيمات المحتوية علي β-glucanase في علائق البط البكيني التي تفي بحاجة الطيور من الطاقة حتى مستوي ٥٠٪ من العليقه في الفترة من ١-٤٢ يوم من العمر أو حتى مستوي ١٠٠٪ من الذرة الصفراء (٦٧,٨٥٪ من العليقه) في الفترة من ٢٨-٥٨ يوم من العمر وذلك حسب فرق السعر بين الشعير المضاف إليه إنزيم والذرة الصفراء.