



## Effect of Different Levels of Germinated Barley on Live Performance and Carcass Traits in Broiler Chickens

Dastar B<sup>1</sup>, Sabet Moghaddam A<sup>1</sup>, Shams Shargh M<sup>1</sup> & Hassani S<sup>2</sup>

<sup>1</sup>Department of Animal and Poultry Nutrition, Faculty of Animal Science, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran.

<sup>2</sup>Department of Animal and Poultry Breeding & Genetics, Faculty of Animal Science, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran.

*Poultry Science Journal 2014, 2 (1): 61-69*

### Abstract

#### Article history:

Received: August 27, 2013

Accepted: May 17, 2014

Available online: June 11, 2014

#### Corresponding author:

Behrouz Dastar, Ph.D

[dastar@gau.ac.ir](mailto:dastar@gau.ac.ir)

#### Keywords:

Barley

Enzyme

Performance

Broiler chickene

Germinated barley

An experiment was conducted to evaluate the effect of different levels of germinated barley (GB) on live performance and carcass traits in broiler chickens. The experiment lasted for 5 weeks starting from 7 days of age and ending at 42 days of age. Chicks (Ross 308) were fed six dietary treatments including a corn-soy diet (corn diet), a barley-soy diet (barley diet), a barley diet plus enzymes (enzyme barley diet), and 3 other diets in which GB was replaced with barley at levels of 33%, 66%, and 100% in the barley diet (33% GB diet, 66% GB diet, and GB diet, respectively). Data were analyzed in a completely randomized design. Results indicated that birds fed a barley diet had significantly lower performance than those fed other diets ( $P<0.05$ ). Supplementing of the barley diet with  $\beta$ -glucanase enzyme as well as replacing GB with barley improved the performance of broilers. Birds fed a GB diet had a significantly higher carcass yield those fed other diets ( $P<0.05$ ). The lowest abdominal fat percentage was observed in birds fed a barley diet or a corn diet. Thus, it is concluded that replacing GB with barley, especially at 33% level, is more effective than supplementing barley diets with  $\beta$ -glucanase enzyme in improving live performance of broiler chickens.

Please cite this article as: Dastar B, Sabet Moghaddam A, Shams Shargh M & Hassani S. 2014. Effect of different levels of germinated barley on live performance and carcass traits in broiler chickens. *Poult. Sci. J.* 2 (1): 61-69.

© 2014 PSJ. All Rights Reserved

## Introduction

Barley is an important cereal that has a lower energy value than corn, but higher crude protein (CP), lysine, tryptophan, methionine, and cysteine (Chensen, 1993). Studies indicate that broilers fed barley-based diets have lower growth rate and feed utilization, but higher sticky droppings (Almirall *et al.*, 1994; Nahas *et al.*, 2011; Svihus *et al.*, 1995). These negative effects have been generally attributed to the presence of non-starch polysaccharides (NSP), especially  $\beta$ -glucans that cause increased digesta viscosity and reduced nutrient availability. The identification of  $\beta$ -glucans as the main antinutritional factor in barley resulted to the use of  $\beta$ -glucanase enzymes in feeds (Ravindran *et al.*, 2006; Pertilla *et al.*, 2001). Esteve Garcia *et al.* (1997) and Pertilla *et al.* (2001) achieved beneficial effects when adding exogenous enzymes to barley-based diets.

Supplementing of broiler diets with dietary enzymes is a common practice. However, the process of producing germinated barley can be an alternative practice to improve the nutritive value of barley. The nutritive value of barley increases during the germination process because of producing and activating the internal enzymes such as amylases, proteases, phytases, and  $\beta$ -glucanases (Prentice *et al.*, 1981; Bartink and Szafranska, 1987). The polymer (1 $\rightarrow$ 3)(1 $\rightarrow$ 4)- $\beta$ -glucan 4-glucanohydrolase (lichenase) is the major  $\beta$ -glucanase produced in the endosperm of germinating barley (Woodward and Fincher, 1982). Therefore, germination decreases  $\beta$ -glucans that are responsible for the lower nutritive value of barley. While grains germinate, proteins are degraded into amino acids, transferred to embryos, and recombined into new proteins that have a higher quality and better amino acid balance (Gardner *et al.*, 1985). This process is important because cereal grains are usually poor in some indispensable amino acids, such as lysine and tryptophan. Svihus *et al.* (1997) showed that chickens fed barley, which had been soaked for 24 h and germinated for 48 h (DM = 60%), had higher weight gain and a lower feed conversion ratio. They found that the protein digestibility coefficient and the ileal digestible energy of the diets including germinated barley (GB) were higher than diets including barley. In their experiment, barley was treated daily during the feeding experiment and then mixed with other ingredients. Sabet Moghadam *et al.* (2009) recently conducted an experiment for determining the nutrient digestibility of GB in broilers. They found higher crude protein digestibility and ileal digestible energy in GB.

The present experiment was conducted to evaluate the effect of replacing barley with different levels of GB on the performance and carcass traits of broiler chickens.

## Materials and Methods

Before starting the experiment, adequate amounts of corn, soybean meal, barley grain (cultivar LB), germinated barley (GB), and other ingredients were collected. For obtaining GB, the barley (cultivar LB) was soaked for 48 hrs, germinated for 72

hrs, and finally the grains were dried to stop the seed internal enzyme activity (Briggs, 1998). A sample of barley and GB was analyzed for proximate composition based on the AOAC procedures (1990), whereas gross energy was determined using a Parr 1261-type adiabatic bomb calorimeter.

**Table 1. Composition of experimental diets in starter and grower periods<sup>1</sup>**

Ingredient, %	Starter period (7-21d)		Grower period (22-42d)	
	Corn diet	Barley diet	Corn diet	Barley diet
Corn	62.47	-----	67.07	-----
Barley	-----	57.63	-----	67.12
Soybean meal	34.05	32.14	27.04	23.68
Soybean oil	-----	6.80	-----	6.11
Limestone	1.07	1.15	1.35	1.45
Dicalcium phosphate	1.31	1.18	0.91	0.74
Vitamin permix <sup>2</sup>	0.25	0.25	0.25	0.25
Mineral permix <sup>3</sup>	0.25	0.25	0.25	0.25
Salt	0.39	0.37	0.27	0.24
DL-Methionine	0.14	0.16	0.05	0.09
Antioxidant	0.02	0.02	0.02	0.02
Salinomycin	0.05	0.05	0.05	0.05
Filler <sup>4</sup>	-----	-----	2.73	-----
<i>Calculated Composition<sup>5</sup></i>				
ME (Kcal/Kg)	2850	2850	2850	2850
CP (%)	20.48	20.48	17.80	17.80
Ca (%)	0.81	0.81	0.80	0.80
Available P (%)	0.40	0.40	0.32	0.32
Lysine (%)	1.09	1.09	0.91	0.91
Methionine+Cysteine (%)	0.81	0.81	0.67	0.67
Sodium (%)	0.17	0.17	0.13	0.13

<sup>1</sup>Enzyme barley diet was prepared by adding 0.05% Saffizyme enzyme to barley diet; 33% GB diet, 66% GB diet and GB diet was prepared by replacing of GB with barley in 33, 66 and 100%, respectively.

<sup>2</sup>Supplied the following nutrient per Kg: vitamin A, 3500000 IU; vitamin D3, 1000000 IU; vitamin E, 9000 IU; vitamin K3, 1000 mg; vitamin B1, 900 mg; vitamin B2, 3300 mg; vitamin B3, 5000 mg; vitamin B5, 15000 mg; vitamin B6, 150 mg; vitamin B9, 500 mg; vitamin B12, 7.5 mg; choline, 250000 mg; biotin, 0.1 mg.

<sup>3</sup>Supplied the following nutrient per Kg: manganese, 50000 mg; iron, 25000; zinc, 50000; copper, 5000 mg; iodine, 500 mg; selenium, 100 mg.

<sup>4</sup>Included rice hulls and sand as a same ratio.

<sup>5</sup>Based on NRC (1994) Tables.

360 day-old mixed-sex broiler chicks (Ross 308) were obtained from a local hatchery. Birds were raised on floor pens and received a pretest corn-soy starter diet that met or exceeded all of the nutrient requirements recommended by NRC (1994) during the first 7 days post-hatching. Following an overnight fasting, chicks were weighed and distributed randomly among 24 groups of 15 birds so that differences among groups were kept to a minimum. Six dietary treatments were formulated to meet or exceed the nutrients recommended by NRC (1994) for starter (7–21 d) and grower (22–42 d) periods. The dietary treatments were: corn–soy diet

(corn diet), barley-soy diet (barley diet), barley-soy diet plus Safizym GP 800 enzyme with  $\beta$ -glucanase activity (Enzyme barley diet), and three other diets in which GB replaced barley at levels of 33%, 66%, and 100% in the barley diet (33% GB diet, 66% GB diet, and GB diet, respectively). The composition of dietary treatments is shown in Table 1.

Birds had free access to feed and water throughout the experiment. Birds and feed intake were group weighed weekly. At the end of the experiment, one bird (male sex) from each replicate with a body weight close to its group's mean body weight was selected and killed for determining carcass traits.

### Statistical analyses

Analysis of variance was performed using the GLM procedure with SAS software (1998) based on a completely randomized design. Significant differences among treatment means were determined by Duncan's multiple range test at a 5% probability level.

### Results

The chemical composition of barley and GB used in the experiment is shown in Table 2. Gross energy and crude protein content were higher and crude fiber was lower for GB than for barley.

**Table 2. Chemical composition of barley and germinated barley**

Feedstuff	Moisture(%)	GE <sup>1</sup> (Kcal/Kg)	CP <sup>2</sup> (%)	EE <sup>3</sup> (%)	CF <sup>4</sup> (%)	Ash (%)
Barley	11.0	3906	10.3	1.9	5.0	2.5
GB <sup>5</sup>	8.0	3942	12.0	1.8	2.0	2.5

<sup>1</sup>Gross energy; <sup>2</sup>Crude protein; <sup>3</sup>Ether extract; <sup>4</sup>Crude fiber; <sup>5</sup>Germinated barley

The effects of dietary treatments on the body weight gain of birds are shown in Table 3. There was no significant difference between body weight gain in birds fed a corn diet or a barley diet, except for 35-42 days of age in which it was significantly higher in birds fed the corn diet than birds fed the barley diet ( $P<0.05$ ). However, birds fed a corn diet had numerically higher body weight gain than birds fed a barley diet throughout the experiment. Birds fed the enzyme-barley diet had very similar body weight gains compared with those fed a corn diet, and this was significantly higher than those fed a barley diet throughout the experiment ( $P<0.05$ ). Replacing barley with GB increased body weight gain as it was higher in birds fed a GB diet than in those fed a barley diet throughout the experiment. The highest increase in body weight gain among birds fed a GB diet was in the 33% GB diet. Birds fed GB diets had significantly higher body weight gain than those fed a barley diet or an enzyme-barley diet at 7-42 days of age ( $P<0.05$ ).

The effects of enzyme supplementation of the barley diet and replacing barley with GB on feed intake are shown in Table 4. There was not a significant difference between feed intake in birds fed a barley diet compared with those fed a corn diet throughout the experiment, except for 35 to 42 days of age. However, birds fed a barley diet always had a numerically lower feed intake than those fed a corn diet. Enzyme supplementation of the barley diet resulted in increased feed intake. This increase was significant at 21–28, 35–42, 21–42, and 7–42 days of age ( $P<0.05$ ). Replacing barley with GB increased feed intake. The increased feed intake was more pronounced when GB replaced 33% of barley, and it was significantly higher compared with the barley diet throughout the experiment ( $P<0.05$ ).

**Table 3. Effect of dietary treatments on body weight gain in broiler chickens (g)**

Rearing period	Corn diet	Barley diet	Enzyme Barley diet	33% GB diet	66% GB diet	GB diet
7-14d	147±2.24 <sup>c</sup>	162±3.33 <sup>bc</sup>	163±4.81 <sup>bc</sup>	200±8.38 <sup>a</sup>	171±3.72 <sup>b</sup>	164±8.57 <sup>b</sup>
14-21d	388±10.62	367±4.83	384±9.36	411±10.87	384±10.87	372±11.19
21-28d	447±12.85 <sup>bc</sup>	423±15.53 <sup>c</sup>	471±13.78 <sup>ab</sup>	507±21.3 <sup>a</sup>	495±16.72 <sup>a</sup>	464±10.11 <sup>abc</sup>
28-35d	549±20.40	549±17.55	560±19.35	592±15.71	567±8.30	598±6.66
35-42d	642±23.84 <sup>ab</sup>	485±31.50 <sup>c</sup>	565±35.43 <sup>b</sup>	640±14.07 <sup>ab</sup>	650±18.11 <sup>a</sup>	685±27.74 <sup>a</sup>
7-21d	535±10.81 <sup>b</sup>	529±3.61 <sup>b</sup>	547±6.56 <sup>b</sup>	611±17.56 <sup>a</sup>	555±12.69 <sup>b</sup>	536±16.49 <sup>b</sup>
21-42d	1639±18.83 <sup>bc</sup>	1457±27.16 <sup>d</sup>	1596±29.17 <sup>c</sup>	1739±34.48 <sup>a</sup>	1712±32.55 <sup>ab</sup>	1709±18.72 <sup>ab</sup>
7-42d	2174±22.77 <sup>dc</sup>	1986±27.23 <sup>e</sup>	2142±26.94 <sup>d</sup>	2350±35.87 <sup>a</sup>	2266±43.40 <sup>ab</sup>	2245±18.68 <sup>bc</sup>

Data are expressed as the mean ± SEM.

<sup>a-c</sup>Means in each row with no common superscripts differ significantly ( $P<0.05$ ).

**Table 4. Effect of dietary treatments on feed intake in broiler chickens (g)**

Rearing period	Corn diet	Barley diet	Enzyme Barley diet	33% GB diet	66% GB diet	GB diet
7-14d	234±4.63 <sup>b</sup>	229±2.49 <sup>b</sup>	239±5.78 <sup>b</sup>	256±6.28 <sup>a</sup>	243±6.32 <sup>ab</sup>	237±7.23 <sup>b</sup>
14-21d	508±8.69 <sup>c</sup>	509±4.29 <sup>c</sup>	519±5.05 <sup>bc</sup>	556±10.34 <sup>a</sup>	538±4.38 <sup>ab</sup>	517±13.39 <sup>bc</sup>
21-28d	855±16.10 <sup>abc</sup>	812±3.48 <sup>c</sup>	881±30.01 <sup>ab</sup>	902±15.52 <sup>a</sup>	837±27.21 <sup>bc</sup>	837±11.78 <sup>bc</sup>
28-35d	1050±23.34	1045±18.01	1100±35.73	1133±25.26	1077±15.51	1048±16.93
35-42d	1315±20.69 <sup>a</sup>	1191±27.84 <sup>b</sup>	1291±40.01 <sup>a</sup>	1315±20.82 <sup>a</sup>	1284±24.75 <sup>a</sup>	1279±26.89 <sup>a</sup>
7-21d	742±11.25 <sup>c</sup>	738±5.65 <sup>c</sup>	758±10.80 <sup>bc</sup>	812±16.01 <sup>a</sup>	781±9.22 <sup>ab</sup>	854±19.85 <sup>bc</sup>
21-42d	3221±55.41 <sup>ab</sup>	3048±45.71 <sup>b</sup>	3273±50.03 <sup>a</sup>	3349±60.57 <sup>a</sup>	3199±63.51 <sup>ab</sup>	3164±36.79 <sup>ab</sup>
7-42d	3962±55.31 <sup>bc</sup>	3786±40.14 <sup>c</sup>	4031±70.97 <sup>ab</sup>	4161±69.51 <sup>a</sup>	3980±67.11 <sup>abc</sup>	3918±48.31 <sup>bc</sup>

Data are expressed as the mean ± SEM.

<sup>a-c</sup>Means in each row with no common superscripts differ significantly ( $P<0.05$ ).

The effects of dietary treatments on the feed conversion ratio of birds are shown in Table 5. Birds fed a barley diet had a significantly higher feed conversion ratio than those fed a corn diet during 35–42, 21–42, and 7–42 days of age ( $P<0.05$ ). Enzyme supplementation had no significant effect on the feed conversion ratio compared with the barley diet. Replacing barley with GB at all three levels of 33%, 66%, and 100% improved the feed conversion ratio, and this improvement was

significantly higher at 21–42 and 7–42 days of age compared with the barley diet as well as the enzyme–barley diet ( $P<0.05$ ).

The effects of dietary treatments on carcass traits of birds are shown in Table 6. Birds fed a GB diet had a significantly higher carcass yield than those fed other diets ( $P<0.05$ ). Dietary treatments had no significant effect on breast relative weight. The highest tight relative weight was found in birds fed a GB diet. This was significantly different compared with other treatments, except the enzyme–barley diet ( $P<0.05$ ). Birds fed a corn diet or a barley diet had a significantly lower abdominal fat relative weight than those fed GB at 33%, 66%, and 100% ( $P<0.05$ ).

**Table 5. Effect of dietary treatments on feed conversion ratio in broiler chickens**

Rearing period	Corn diet	Barley diet	Enzyme Barley diet	33% GB diet	66% GB diet	GB diet
7-14d	1.50±0.03 <sup>a</sup>	1.40±0.03 <sup>b</sup>	1.47±0.01 <sup>b</sup>	1.29±0.03 <sup>c</sup>	1.42±0.02 <sup>b</sup>	1.45±0.04 <sup>b</sup>
14-21d	1.31±0.04	1.39±0.02	1.35±0.04	1.35±0.02	1.40±0.04	1.39±0.03
21-28d	1.91±0.04 <sup>a</sup>	1.92±0.08 <sup>a</sup>	1.86±0.02 <sup>a</sup>	1.78±0.05 <sup>ab</sup>	1.69±0.06 <sup>b</sup>	1.80±0.02 <sup>ab</sup>
28-35d	1.91±0.05	1.90±0.03	1.96±0.01	1.91±0.02	1.90±0.02	1.87±0.01
35-42d	2.05±0.09 <sup>bc</sup>	2.47±0.14 <sup>a</sup>	2.32±0.21 <sup>ab</sup>	2.05±0.06 <sup>bc</sup>	1.97±0.03 <sup>c</sup>	1.87±0.05 <sup>c</sup>
7-21d	1.39±0.04	1.39±0.02	1.38±0.03	1.33±0.01	1.41±0.03	1.40±0.02
21-42d	1.96±0.03 <sup>bc</sup>	2.09±0.04 <sup>a</sup>	2.05±0.06 <sup>ab</sup>	1.93±0.03 <sup>dc</sup>	1.87±0.01 <sup>dc</sup>	1.85±0.02 <sup>d</sup>
7-42d	1.82±0.01 <sup>bc</sup>	1.90±0.02 <sup>a</sup>	1.88±0.04 <sup>ab</sup>	1.77±0.01 <sup>dc</sup>	1.75±0.01 <sup>d</sup>	1.74±0.01 <sup>d</sup>

Data are expressed as the mean ± SEM.

<sup>a-d</sup>Means in each row with no common superscripts differ significantly ( $P<0.05$ ).

**Table 6. Effect of dietary treatments on carcass traits in broiler chickens (as % live body weight)**

Rearing period	Corn diet	Barley diet	Enzyme Barley diet	33% GB diet	66% GB diet	GB diet
Carcass Yield	64.42±0.54 <sup>b</sup>	64.28±0.59 <sup>b</sup>	63.73±1.00 <sup>b</sup>	64.36±0.96 <sup>b</sup>	62.56±0.80 <sup>b</sup>	66.78±0.72 <sup>a</sup>
Breast	21.13±0.51	21.01±0.67	20.57±0.62	20.54±1.29	20.51±0.20	21.03±0.60
Tight	20.14±0.44 <sup>b</sup>	19.91±0.39 <sup>b</sup>	20.44±0.44 <sup>ab</sup>	19.41±0.96 <sup>b</sup>	19.42±0.15 <sup>b</sup>	21.41±0.04 <sup>a</sup>
AF <sup>1</sup>	1.63±0.05 <sup>b</sup>	1.72±0.14 <sup>b</sup>	2.22±0.12 <sup>a</sup>	2.15±0.06 <sup>a</sup>	2.15±0.12 <sup>a</sup>	2.08±0.23 <sup>a</sup>

<sup>1</sup>Abdominal Fat.

Data are expressed as the mean ± SEM.

<sup>a-b</sup>Means in each row with no common superscripts differ significantly ( $P<0.05$ ).

## Discussion

Previous studies indicated that the replacing of corn with barley resulted in a decrease of performance in broiler chickens (Almirall *et al.*, 1994; Nahas and Lefrancois, 2001; Svihus *et al.*, 1995). Barley has a higher CP but lower metabolizable energy and nutrient digestibility (Chesson, 1993; Rotter *et al.*, 1990), which may be related to a higher NSP content. It is clearly shown that the use of barley in broiler diets results in a decrease of feed intake because of elevated digesta viscosity and a decrease in passage rate (Almirall *et al.*, 1994; Nahas and Lefrancois, 2001). Present results indicate that birds fed a barley diet had a relatively lower feed intake those fed other diets. Supplementing the barley diet

with Safizym enzyme and also replacing of barley with GB increased broilers' feed intake. Similarly, Brenes *et al.* (1993), but not Esteve Garcia *et al.* (1997), reported an increase of feed intake by supplementing broiler diets with enzymes. The reduction of barley  $\beta$ -glucans and viscosity of the digestive tract by adding enzymes to a barley diet or replacing of barley with GB resulted in an increase in passage rate that likely explains the increased feed intake. This finding is in agreement with the results of Svihus *et al.* (1997). The higher live body weight observed in the diets containing different levels of GB and the enzyme supplemented diet may be due to the decrease of intestinal viscosity and the increase in nutrient digestibility in the gastrointestinal tract (Sabet Moghaddam *et al.*, 2009). This finding is similar to the results of Svihus *et al.* (1997). Birds fed a diet containing 33% GB had higher weight gain than those fed diets containing 66% and 100% GB. The reason for this improvement could be due to the increase in feed intake. The addition of Safizym enzyme to the barley diet resulted in a significant improvement in the live body weight gain as well as a numerical improvement of the feed conversion ratio. The reason for these observations may be due to the higher nutrient digestibility values in the enzyme supplemented diet than in the barley diet.

The carcass and thigh weight as a percentage of live weight were higher in birds fed a GB diet than those fed other diets. These findings were expected due to the higher nutrient digestibility values in GB diets compared with those of a barley diet.  $\beta$ -glucans in barley decreases the absorption of nutrients, particularly fats, due to the increase of intestinal viscosity (Almirall *et al.*, 1995; Pasquier *et al.*, 1996). The abdominal fat percentage was increased in birds fed different levels of GB or the enzyme-supplemented diet compared with those fed a barley diet. This can be related to the decrease of  $\beta$ -glucans (Svihus *et al.* 1997; Ouhida *et al.* 2000) and subsequent increase of digestibility and absorbance of fats in GB and enzyme supplemented diets.

### Conclusion

In conclusion, the results of this experiment indicate that replacing barley with GB is more effective than supplementing the barley diet with enzymes for improving growth performance of broiler chickens. Additionally, the best level of GB replacement in the barley diet is 33% because of the higher broiler performance.

### References

- Almirall M & Esteve-Garcia E. 1994. Rate of passage of barley diets with chromium oxid: Influence of age and poultry strain and effect of  $\beta$ -glucanase supplementation. *Poultry Science*, 73: 1433-1440.
- Almirall M, Francesch M, Perez-Vendrell AM, Brufau J & Esteve-Garcia E. 1995. The differences in intestinal viscosity produced by barley and  $\beta$ -glucanase alter

- digesta enzyme activities and ileal nutrient digestibilities more in broiler chicks than in cocks. *Journal of Nutrition*, 125: 947-955.
- AOAC (Association of Official Analytical Chemists). *Official Methods of Analysis*. 15<sup>th</sup> Ed. Washington, DC.
- Bartnik M & Szafranska I. 1987. Changes in phytate content and phytase activity during the germination of some cereals. *Journal of Cereal Science*, 5: 23-28.
- Brenes A, Smith M, Guenter W & Marquardt RR. 1993. Effect of enzyme supplementation on the performance and digestive tract size of broiler chickens fed wheat and barley based diets. *Poultry Science*. 72: 1731-1739.
- Briggs DE. 1998. *Malts and Malting*. 1<sup>st</sup> Ed. Blackie Academic and Professional. London. 780 Pages.
- Chesson A. 1993. Feed enzymes. *Animal Feed Science and Technology*, 45: 65-79.
- Esteve-Garcia E, Brufau J, Perez-Vendrell A, Miquel A & Duven K. 1997. Bioefficiency of enzyme preparation containing  $\beta$ -glucanase and xylanase activities in broiler diets based on barley or wheat in combination with flavomycin. *Poultry Science*, 76: 1728-1737.
- Gardner FP, Pearce RB & Mitchell RL. 1985. *Physiology of Crop Plants*. 2<sup>nd</sup> Ed. Iowa State University Press. Ames. 327 Pages.
- Nahas J & Lefrancois MR. 2001. Effects of feeding locally grown whole barley with or without enzyme addition and whole wheat on broiler performance and carcass traits. *Poultry Science*, 80: 195-202.
- NRC (National Research Council). *Nutrient Requirements of Poultry*. 9<sup>th</sup> Rev. Ed. National Academy Press. Washington, DC. 176 Pages.
- Ouhida I, Perez JF, Gasa J & Puchal F. 2000. Enzymes ( $\beta$ -glucanase and arabinoxylanase) and/or sepiolite supplementation and nutritive value of maize-barely-wheat based diets for broiler chickens. *British Poultry Science*, 41: 617-624.
- Pasquier B, Armand M, Castelain C, Guillon F, Borel P, Lafont H & Lairon D. 1996. Emulsification and lipolysis of triacylglycerols are altered by viscous soluble dietary fibre in acidic gastric medium *in vitro*. *Biochemistry Journal*, 314: 269-275.
- Perttila S, Valaja J, Partanen K, Jalava T, Kiiskinen T & Palander S. 2001. Effects of preservation method and  $\beta$ -glucanase supplementation on ileal amino acid digestibility and feeding value of barely for poultry. *British Poultry Science*, 42: 218-229.
- Prentice N & Faber S. 1981. Beta-D-glucan in developing and germinating barley Kernels. *Cereal Chemistry*, 58: 77-79.
- Ravindran Z, Tilman ZV, Morel PCH, Ravindran G & Coles GD. 2007. Influence of  $\beta$ -glucanase supplementation on the metabolizable energy and ileal nutrient digestibility of normal starch and waxy barleys for broiler chickens. *Animal Feed Science and Technology*, 134: 45-55.

- Rotter BA, Friesen OD, Guenter W & Marquardt RR. 1990. Influence of enzyme supplementation on the bioavailable energy of barley. *Poultry Science*, 69: 1174-1181.
- Sabet Moghaddam A, Mehdipour M & Dastar B. 2009. The determining of digestible energy and digestibility coefficients of protein, calcium and phosphorus of malt (Germinated Barley) in broilers. *International Journal of Poultry Science*, 8: 788-791.
- SAS (Statistical Analysis System). 1998. SAS/STAT® 6.1 User's Guide. SAS Institute Inc. Cary, NC.
- Svihus B, Selmer-Olsen I & Brathen E. 1995. Effect of different preservation methods for high moisture barley on feeding value for broiler chickens. *Acta Agriculturae Scandinavica*, 45: 252-259.
- Svihus B, Newman RK & Newman CW. 1997. Effect of soaking, germination and enzyme treatment of whole barley on nutritional value and digestive tract parameters of broiler chickens. *British Poultry Science*, 38: 390-396.
- Woodward JR & Fincher GB. 1982. Substrate specificity and kinetic properties of two (1→3), (1→4) -β-D-glucan endo-hydrolases from germinating barley (*Hordeum vulgare*). *Carbohydrate Research*, 106: 111-122.