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The Determining of Digestible Energy and Digestibility Coefficients of Protein, Calcium and Phosphorus of Malt (Germinated Barley) in Broilers

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Abstract: This experiment was conducted to determinate digestible energy and digestibility coefficients of protein, calcium and phosphorus of malt (germinated barley) and barley in broilers nutrition. Four dietary treatments included barley diet (96.24% of diet) and three other diets which malt was replacing with barley as 32.08, 64.16 and 96.24% (malt diet) were fed from 18-25 days of age. Experimental data were analyzed in a completely randomized design. Results of experiment indicated that digestible energy value and nutrient digestibility coefficients were significantly increased with replacing of malt with barley in experimental diets ($p<0.01$). Digestibility coefficients of protein, calcium and phosphorus in malt diet were significantly higher 16, 4.5 and 4% respectively, than barley diet ($p<0.01$). Digestible energy value determined for malt and barley using the regression analysis was 3213.34 and 2848.3 Kcal/Kg, respectively.

Key words: Digestible energy, digestibility, barley, malt, broiler

INTRODUCTION

Barley is one of the most cereals widely cultivated in the world. It has high concentration of starch, protein, vitamin and other important nutritive compounds. The utilization of barley in poultry feeds is limited because of low energy value as well as high concentration of non Starch Polysaccharides (NSPs) and phytate (the important phosphorus stock resource in plants). β-glucans are the major NSP in barley cause reduction in protein and carbohydrate digestibility by increasing intestinal viscosity and also by reducing contact of enzymes and substrate (Annison, 1993; Fuente *et al*., 1998). Phytate decreases the bio-availability of necessary mineral elements by phytate-mineral element complex formation in physiological pH and thus decreases their absorption. Supplementing of dietary enzymes to barley diets is a common practice in order to improve its nutritive value and performance of broilers (Villamide *et al*., 1997). Germination of barley can be another practice for improving its nutritive value, but little information is available. Germination of barley degrades phytate (Briggs *et al*., 1981; Briggs, 1992) and so increases mineral elements digestibility. In previous studies, soaking of barley improved its nutritive value due to activation of inner seed enzymes (Fry *et al*., 1958; Willingham, 1959; Adams and Naber, 1969). During germination, cereal endosperm includes starch and protein is used for energy and protein production. Thus, the important event during germination is starch endosperm cell wall degradation. Germination process is referred to malting process is divided into 3 steps: steeping, germination, kilning. The aim of kilning step is suspension of embryo growth and inner enzyme activities (Bamforth and Martin, 1983). Svihus *et al*. (1996) showed that after germination of barley for 24 h, β-glucans and then intestinal viscosity were decreased. During barley steeping some enzymes like Amylase, protease, phytase and β-glucanse are produced and activated in seed (Prentice and Faber, 1981; Bamforth, 1982; Woodward and Fincher, 1982).

According to Svihus *et al*. (1997) experiment, barley soaked 24 h in the room temperature and then germinated 48 h in the same temperature. In their experiment, germinated barley was used daily then was mixed with other dietary nutritive materials including soybean meal and oil. They reported germinated barley diet had higher digestible energy (3964.84 versus 3745.1 kcal/kg feed), higher protein digestibility (73 versus 63%) and ash digestibility (35 versus 20%) rather than barley diet.

The objective of this experiment was to determine nutritive value of malt included digestible energy value and digestibility coefficients of crude protein, calcium and phosphorus.

MATERIALS AND METHODS

A batch of malt was obtained from local malt producing factory (Mazrae Nemmone, Gorgan-Agh Ghala, Km 24). Briefly, the barley (cultivar Reyhaneh) was soaked 48 h and then germinated 72 h, finally the grains were dried to stop the seed internal enzymes activity (Briggs, 1998). One day old Ross 308 broiler chicks were purchased

from a local hatchery. The chicks were raised from 1-17d of age on floor pens and received a pretest corn-soy bean meal diet contained 2900 Kcal/Kg ME and 20.84 % CP and minimum nutrient requirements for starter broiler chicks (0-21d of age) recommended by NRC (1994).

On day 18, birds after overnight fasting were weighted individually and wing banded. 24 chicks with similar live body weight was selected and distributed randomly to 12 groups of 2 birds to provide approximately equal starting weight. Four dietary treatments included barley diet (96.24% of diet) and three other diets which malt was replacing with barley as 32.08, 64.16 and 96.24% (malt diet) were prepared according to Applegate (2005) procedure in order to determine Digestible Energy (DE) and nutrients digestible coefficients of barley and malt. Dietary treatments were formulated to meet minimum nutrient requirements recommended by NRC (1994), except energy and protein levels, as well as barley and malt was as the sole source of energy and CP (Table 1). Dietary treatments were fed ad-libitum to birds from 18 -25 days of age. On day 26, birds were scarified and the intestinal contents of the lower half of the ileum were collected.

Table 1: Composition of experimental diets

	Diet			
Ingredient, %	1 (Barley diet)	2	3	4 (Malt diet)
Barley	96.24	64.16	32.08	-
Malt	-	32.08	64.16	96.24
Limestone	1.29	1.29	1.29	1.29
Dicalcium phosphate	1.31	1.31	1.31	1.31
Broiler premix[1]	0.50	0.50	0.50	0.50
Salt	0.36	0.36	0.36	0.36
Cr_2O_3	0.3	0.3	0.3	0.3
Determined analyses (%)				
GE (Kcal/Kg)	3745	3767	3790	3812
CP	10.11	10.63	11.16	11.69
Ca	0.95	1.04	1.14	1.23
P	0.71	0.74	0.78	0.81

[1]Broiler premix contained 50% vitamin and 50% mineral premix. Each Kg of vitamin premix contained: 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 and each Kg of mineral premix contained 50000 mg; iron, 25000; zinc, 50000; copper, 5000 mg; iodine, 500 mg; selenium, 100 mg.

Protein Digestible Coefficient (PDC) was calculated as a ratio between crude protein and chromium oxide in the feed and the ileal contents (Williams *et al*., 1962). Ileal Digestible Energy (IDE, kcal/kg of diet) evaluated by following formulation.

Gross energy diet- [Gross energy ileal contents × (M diet/ M ileal contents)]

M is the percentage of Chromic oxide added in diet and measured in excreta.

Chemical and statistical analyses: For analysis of feed (barley and malt) and digesta contents of intestine, samples were oven- dried and ground in electrical household- type coffee mill. Dry Matter (DM), Crude Protein (CP), Ether Extracts (EE), Crude Fiber (CF) and ash contents of feed and digesta were measured according to AOAC (1990). Gross energy was determined using a PARR-1261 adiabatic bomb calorimeter. Calcium (Ca) and Phosphorus (P) were measured by Inductively Coupled Plasma-emission Spectroscopy. Chromic oxide was determined according to the method of Williams *et al*. (1962). Analysis of variance was performed using the GLM- procedure of Statistical Analysis System (SAS, 1998) according to a completely randomized design. Significant differences among treatment means were determined by Duncan's multiple-range test. A statement of statistical significance was based on a 5% level of probability. Linear regression procedure of SAS (1998) was used for determining DE of barley and malt by extrapolation to 100% of inclusion of barley or malt.

RESULTS AND DISCUSSION

Proximate composition: The proximate composition and gross energy value of barley and malt are shown in Table 2. The nutrient content of barley in this experiment

Table 2: Proximate composition of barley and malt (as %)

Nutrient	Barley	Malt
GE (Kcal/Kg)	3891	3961
DM	89	92
CP	10.5	12.15
EE	2.5	2.3
CF	5.2	2.5
Ash	2.6	2.6
Ca	0.18	0.48
P	0.48	0.59

Table 3: Nutrients digestibility of dietary treatments

Treatments	DE (Kcal/Kg)	CP (%)	Ca (%)	P (%)
1 (Barley diet)	2860.9^{b}±54.13	56.5^{c}±1.5	88.5^{c}±0.5	83.5^{b}±0.5
2	2945.49^{b}±7.87	63.2^{c}±1.0	91.1^{c}±0.1	84.5^{b}±0.5
3	3084.64^{a}±31.34	67.5^{b}±0.5	92.7^{b}±0.1	87.9^{a}±0.1
4 (Malt diet)	3207.79^{a}±30.41	72.5^{a}±0.6	93.8^{a}±0.1	87.5^{a}±0.5

Means ± SEM within a column with different superscript differ significantly ($p < 0.01$).

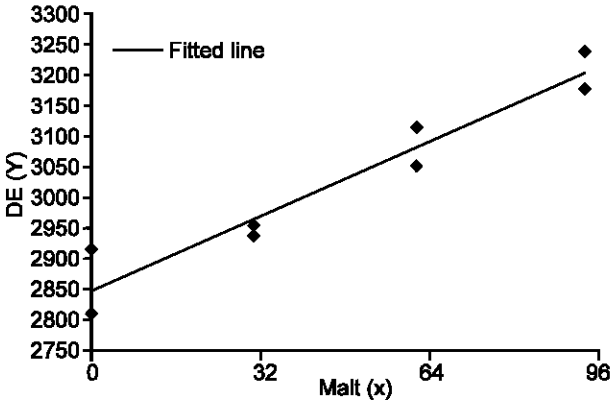

Fig. 1: Digestible energy value versus different levels of malt in experimental diets (Y= 2848.3 + 365.04X R^2=0.92)

was within the range reported by NRC (1994) and Villamide *et al*. (1997). As expected, malt had 1.80% higher energy and 1.65% CP content, but 2.7% lower CF than barley. During malting process fermentation occurs and cell wall degrades. Adeyemi and Familade (2003) also reported that fermented product have higher protein content.

Digestible energy: DE value for experimental diets is shown in Table 3. The lowest and highest DE value was related to barley and malt diets (3207.8 versus 2860.9 Kcal/Kg), respectively. DE value was increased by replacing of malt with barley in dietary treatments. DE value of malt and barley were estimated 3213.34 and 2848.3 Kcal/Kg, by extrapolation to 100% of inclusion of the linear regression equation between dietary DE and malt level (Fig. 1). The effects of NSPs on amylase activity (Ikeda and Kusano, 1983) and reduction of digestion and retention of dietary fat and starch (White and Bird, 1981; Lee and Campbell, 1983) led to decrease of barley digestible energy, but this problem was decremented by degrading NSPs breakage during germination (Woodward and Fincher, 1982). In Svihus *et al*. (1997) experiment, replacing barley with germinated barley led to increase of DE which is similar to finding of this experiment.

Nutrient digestibility: Nutrient digestibility coefficients for diets are shown in Table 3. The highest nutrients digestibility was related to malt diet and was significantly more than barley diet ($p<0.01$). Replacing of barley with malt led to increase of CP digestibility in diets. This is because of decreasing of intestinal viscosity and increasing of protein digestion and absorption while germinating (Annison, 1993; Bamforth, 1982).

Ca digestibility of malt diet was 4.5% more than barley diet. This improvement was 4% for P. When malt was replaced with barley, digestibility coefficient of Ca and P increased. β-glucans, by increasing intestinal viscosity and also phytate by producing mineral-phytate complex increase Ca and P of excretion and decrease their digestion and absorption (Larsson and Sandberg, 1992). Increase of Ca and P digestibility observed in this experiment may be related to reduce of β-glucans (Loi *et al*., 1987; Brunswick *et al*., 1987) and activating of enzyme phytase during germinating (Prentice and Faber, 1981; Bartnik and Szafranska, 1987; Rimsten, 2003).

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