

EFFECT OF REMOVAL OF LARGE PARTICLES FROM MILLED BARLEY ON GROWTH PERFORMANCE IN BROILER DURING GROWING STAGE

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By

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ABSTRACT

This investigation was conducted to study the influence of separating and regrinding the large particle size of barley as compared to the barley ground coarse feeds on improving overall broiler performance and possible change associated with morphology in the digestive system. Thirty chicken were used in the experiment. They were brooded for 21 days and thereafter divided into two groups of treatment. The two diet treatments were coded for particle size, ground barley diet GBD (control), and reground coarse-fraction barley diet (RBD). Each treatment was applied on 15 birds. The experimental period was 21 days (from day 21 to 42 day old). The performance of the broilers was monitored on daily basis. At the end of week six, all birds in each treatment were slaughtered via neck slit, defeathered and eviscerated for carcass and intestinal morphology analysis (i.e., relative length of digestive). The results showed that RBD reduced feed intake and improved feed conversion ratio and changed gastrointestinal morphology of broilers during the growing stage. From the processing prospective, regrinding coarse fraction reduced average particle size without producing excess of fines. Regrinding coarse particles of barley could be also an approach to reduce production cost of broiler feed through minimizing feed intake without producing excess of fines.

Key words: *barley, broiler, digestive system, feed intake, particle size.*

1. INTRODUCTION

Grain grinding is the first step in feed processing where particle size is reduced to facilitate further steps such as mixing of other feed ingredients (Koch, 1996), increase surface area of grain particles to increase digestibility (Al-Rabadi *et al.*, 2009). For example, for each 100 μm increase in particle size in ground maize grains, the degree of starch access by alpha-amylase was found to decrease by 26.8 g/kg starch (Blasel *et al.*, 2006). Reduction of particle size of corn from 900 to 300 μm can increase the surface area more than double (Healy *et al.*, 1994). However, fine milling has been reported to cause logistical problems such as feed handling difficulties, capacity reduction of the mill and increased energy consumption during milling (Goodband *et al.*, 1995; Al-Rabadi 2013). This work describes an experiment which separated the large particles in barley and then reground it to reduce their size,

to investigate whether this procedure will improve broiler performance and possible changes associated to morphology in the digestive system. This is a novel alternative to grind large particles and turn them into a smaller size in the first place. The proposed methodology was designed to achieve the benefit of removing large particles without the drawback of generating excessive amounts of dust and fine particles.

2. MATERIALS AND METHODS

2.1. Barley grinding and sieving analysis

Barley grains were hammer milled (Model No. M.K. 11R180, Kteingesellschaft, Germany) by using 4 mm screen size. Ground barley (around 100 kg) was collected at steady state during milling (constant motor load indicated by constant ammeter reading). Approximately, half the quantity of ground barley was sieved manually used a rectangular 2 mm sieve (50 cm

x 60 cm) to separate fine particles (approximately 45%) and coarse fractions (approximately 55%). The ground-coarse fractions of barley grains were stored in separate containers and then re-milled using the hammer mill fitted with a 4 mm screen size and then mixed with fine fractions.

To evaluate the processes of grinding, sieving and regrinding, 100 g sample from each treatment were sieving using a sieve shaker for 15 min. according to ASAE (2003). The particle size distribution of the ground-coarse and the coarse fraction after re-milling and mixing with the fine fraction were determined by size segregation using vertical multiple sieving under gravity with mechanical agitation using a sieve shaker (Model No. SV001, Impact Test Equipment Ltd, UK). Eight screen sieve (Impact Test Equipment Ltd, UK) sizes were selected to give a broad spectrum of particle size ranging from 2.8 mm to 0.045 mm (pan). Moreover diameter geometric mean (d_{gw}) and geometric standard deviation (S_{gw}) and particle size distribution (fraction yield percentage) were estimated (Table 1).

In this paper, the term particle size refers to particles that were retained on a particular sieve. Thus, a particle size of 0.5 mm means that the particles in that fraction passed through the 1.0

mm sieve, and were retained on the 0.5 mm sieve. A particle size of <0.125 mm means the material passed through the 0.125 mm sieve and was collected on the pan. The diet treatments were coded for particle size: ground barley diet (GBD) (control) and reground coarse-fraction barley diet (RBD).

2.2. Birds and diets formulation

Thirty Hubbard broilers were raised from 21 to 42 day old according to general commercial husbandry. They were raised in floor cages and equipped with a trough drinker and feeder. Feed and water were given *ad lib* and broilers had a continuous light. Barley (with different level of particle size) based diets were formulated to be iso-caloric and iso-nitrogenous by mixing with other feed ingredients as shown in (Table 2).

2.3. Data measurements

At the end of the experimental period (day 42), all broilers in each experimental treatment (15 birds) were weighed for carcass and digestive system evaluation. The birds were slaughtered by cutting the jugular veins, scalded in hot water for about a minute, and the feathers were removed by defeathering machine. The birds were eviscerated and weighed to obtain their dressed carcass weights. The heart, gizzard, liver, spleen, abdominal fat, small intestine, and large intestine were removed and weighed using

Table (1): Means of particle size distribution, geometric mean (d_{gw}) and geometric stranded deviation (S_{gw}) of particle size of milled barley grains at different hammer mill screen size (values are represented as means ± SE).

Sieve size (mm)	Barley particle size	
	Control	Reground coarse fraction
	Fraction yield (%)±SE	Fraction yield (%)±SE
4	0 ± 0.00	0 ± 0.00
2.8	24.3 ± 0.77	6.6 ± 0.66
2	29.6 ± 0.61	19.9 ± 0.21
1	31.7 ± 0.4	47.0 ± .04
0.5	9.2 ± 0.82	15.4 ± 0.18
0.25	3.9 ± 0.04	7.2 ± 0.37
0.125	1.2 ± 0.02	3.8 ± 0.45
0.045	0.1 ± 0.00	0.1 ± 0.00
Particle size parameters		
d_{gw} (mm)	1.72	1.25
S_{gw} (mm)	1.89	1.97

Table (2): Ingredients (%) and calculated analysis (%) of the experimental diet.

Ingredient	%
Barley	45.0
Corn	13.8048
Soybean meal (44% CP)	26.3752
Soybean oil	6
^a DCP (Dicalcium phosphate)	2.5987
Salt (NaCl)	0.1607
^b Vit.+Min premix	0.2
^c Myco Curb [®]	0.1
^d Brocon Concentrate [®] (35% CP)	4.9605
Methionine	0.3
Lysine	0.3
Enzyme	0.05
Calcium carbonate	0.1
^e Calculated analysis	
AMEn (kcal/kg)	2900
Crude protein	20.0
Crude fibre	4.86
Methionine	0.65
Lysine	1.35
Meth + Cys	0.88
Calcium	0.9
Non-phytat phosphorous	0.78
Sodium	0.15
Chloride	0.184

^a Dicalcium phosphate Contained 21% calcium and 20% phosphorous.

^bVitamin premix provided per kilogram of premix including : Vitamin A,700,000 IU; vitamin D3, 150,000 IU; vitamin E, 75mg; vitamin B1, 100 mg; vitamin K, 175 mg; vitamin B5, 600 mg; manganese oxide, 4000 mg, ferrous sulphate, 9000 mg, zinc oxide, 6000 mg, magnisum oxide, 2500 mg, potassium iodide, 70 mg, sodium selenite, 125 mg, copper sulphate, 100 mg, cobalt sulphate, 50 mg, dicalcium phosphate, 7000 m, sodium chloride, 10000 mg.

^c Mold inhibitor for animal feed (Kemin Industries, U.S.A)

^dBrocon Concentrate[®] (Wafa, B. V., Ablasserdam, Holland)

^eCalculated based on analyzed values of feed ingredients (feed composition tables) from NRC (1994).^fβ- Glucanase level was 500 gram/ ton following the company's (Novo Nordisk, Denmark) recommended level.

a sensitive electronic scale. The dressed carcass and digestive system organ weights were expressed as percentages of the live weights. In addition, the length of the digestive system parts was measured using a tailor's tape. From each bird, pH measurements were obtained directly from the digesta contents in the lumen of gizzard and proventriculus using a digital pH meter (Model PL-600, EZDO, Taiwan).

2. 4. Experimental design

Statistical analysis was carried out using Statistic Software, Version 9.0 (SAS Institute, Cary, NC). The Student t test at 5% level of significance was used to compare the measured means between the two treatments (15 broilers

for each treatment. All data were presented as means (± Standard error (SE)).

3. RESULTS

The effect of hammer mill screen size on the average particle size (d_{gw}), geometric standard deviation (S_{gw}) and the fraction yield on each sieve after sieving for GBD and RBD diets are shown in Table (1). As expected, regrinding coarse fraction of milled barley reduced d_{gw} by 0.5mm. The influence of regrinding coarse fraction of barley grains on d_{gw} is attributed to reducing fraction yield of coarse fractions after being milled again Table (1). In this study, regarding coarse fraction reduced the percentage

of coarse fractions retained on sieves 4 mm and 2.8 mm from 54 to 27%.

Influence of barley particle size on broiler performance over the growing period (week 4 - week 6) is shown in (Table 3). Particle size of

the different diets particle size (Table 4). However, relative weight of heart was significantly higher for broilers fed RBD compared to broilers fed GBD. The mechanism behind the influence of regarding coarse

Table (3): Influence of barley particle size on broiler performance during 4 to 6 week old.

	Particle size		P value
	GBD*	RBD**	
Initial body weight (g)	712.3 ± 22.36	667.7 ± 19.43	0.17
Final body weight (g)	2476.5 ± 49.63	2323.5 ± 86.41	0.16
Week 4			
ADG (g/day)	67.83 ± 3.8	59.31 ± 2.4	0.10
FCR (g/g)	1.82 ± 0.1	1.94 ± 0.08	0.37
CFI (g)	842.77 ± 9.83	797.95 ± 33.89	0.26
Week 5			
ADG (g/day)	70.37 ± 4.53	65.57 ± 4.76	0.48
FCR (g/g)	2.26 ± 0.13	2.27 ± 0.12	0.92
CFI (g)	1114.9 ± 21.65	1027.4 ± 37.99	0.08
Week 6			
ADG (g/day)	88.5 ± 5.12	69.57 ± 5.86	0.48
FCR (g/g)	2.47 ± 0.11	2.14 ± 0.16	0.10
CFI (g)	1499.1 ± 25.18	1370 ± 38.03	0.02
Whole period (Week 4-week 6 old)			
ADG (g/day)	81.1 ± 4.17	78.69 ± 5.12	0.51
FCR (g/g)	1.95 ± 0.08	1.85 ± 0.10	0.09
CFI (g)	3456.8 ± 39.05	3195.3 ± 88.	0.03

*Ground barley diet

** reground coarse-fraction barley diet

Table (4): Influence of barley particle size on broiler dressing percentage and relative organ weight (as a percentage of live weight (± SE)).

Item	Particle size		P value
	GBD*	RBD**	
Dressing %	72.73 ± 1.41	73.66 ± 2.07	0.66
Gizzard relative weight (g/g)	1.70 ± 0.07	1.56 ± 0.08	0.21
Abdominal fat relative weight (g/g)	0.37 ± 0.05	0.48 ± 0.07	0.23
Heart relative weight(g/g)	0.45 ± 0.01	0.52 ± 0.02	0.04
Spleen relative weight(g/g)	0.11 ± 0.006	0.14 ± 0.02	0.14

*Ground barley diet

** reground coarse-fraction barley diet

barley did not significantly affect broiler's average daily gain (ADG), feed conversion ratio (FCR) and cumulative feed intake (CFI) during week 4 and week 5 although there was a tendency for lower CFI for broiler's fed RBD at the end of week 5 (P=0.08). By the end of week 6, CFI was lower in broiler's fed RBD (1027.4 gm) compared to broilers fed GBD (1114.9 gm). Generally, bird group fed RBD recorded better values of FCR and lower values for CFI throughout the experimental period (4-6 week old) compared to group fed GBD.

Dressing percentage, gizzard (as a percent of live weight), abdominal fat weights and spleen relative weight (g/g) were not affected by

particles on the relative relative weight of heart is unclear. It has been reported that different grain particles sizes have different kinetics of starch digestion; smaller particles have a higher starch digestion rate (Al-Rabadi *et al.* 2009). Synchronous absorption of glucose and amino acids by poultry can increase metabolizable energy delivery and may reduce amino acid oxidation and thus enhance protein retention (van den Borne *et al.*, 2007). Consequently, the possible synchronous in amino acid and glucose absorption may increased heart relative weight in broilers fed RBD.

Results in (Table 5) showed insignificant differences in gizzard pH and proventriculus pH between the two bird group feds RBD and GBD.

particle size when broiler feed wheat-corn (Nir *et al.*, 1994) or sorghum (Nir *et al.*, 1990) based diets. The reduction in feed intake between the two groups may be attributed to that the

Table (5): Gizzard and proventriculus pH (± SD) in broiler chickens at 42 days of age fed diets with different particle sizes.

Item	Particle size		P value
	GBD	RBD	
Gizzard pH	4.09 ± 0.08	4.23 ± 0.06	0.24
Proventriculus pH	5.08 ± 0.09	4.98 ± 0.06	0.40

The influence of barley particle size on conformational characteristics (length of digestive system organs) of broiler digestive system is shown in Table (6). The obtained results revealed that conformational characteristics were significantly affected by particle size of barley grain fragment in the diets. In all measured digestive components (small intestine, large intestine, and ceca), the length was significantly lower for broilers fed RBD compared to broilers fed GBD.

digestive system of poultry fed RBD became impacted as a result of viscous digesta from finely ground barley. Barley is well known to have beta-glucan which is responsible for increasing digesta viscosity (Smith *et al.*, 2008, Fincher, 1975). High viscosity profiles have been reported to characterize fine barley fractions compared to coarse fractions (Al-Rabadi 2013). Viscosity caused by beta glucan in barley has been reported to decrease endogenous enzyme activity and to induce

Table (6): Length of digestive system parts (± SE) of 42 day-old broilers fed diet with different particle size.

Item	Particle size		P value
	GBD	RBD	
Pancreas Length (cm)	12.84 ± 0.47	11.67 ± 0.18	0.04
Small intestine length (cm)	179.49 ± 2.73	162.41 ± 1.98	0.001
duodenum length (cm)	29.24 ± 0.46	27.28 ± 0.52	0.02
Jejunum length (cm)	87.59 ± 1.66	80.17 ± 1.60	0.01
Ileum length (cm)	62.66 ± 2.31	54.97 ± 0.95	0.02
Large intestine (cm)	32.52 ± 0.64	29.43 ± 0.87	0.02
Ceca length (cm)	23.09 ± 0.84	20.67 ± 0.34	0.03

4. DISCUSSIONS

The regrinding approach of coarse fractions of barley grains did not increase the amount of very fine particles which are associated with potential handling in feed mills, under development of gizzard and enlargement proventriculus (Taylor and Jones, 2004). There was only a modest increase in particles of <0.5 mm considered to be the cut-off for causing handling problems at feed mill and improper function in digestive system in poultry and thus over all bird performance (Amerah *et al.*, 2007 a & b). Fine particles have been reported to cause a bridging problem in bins and feeder and increase dustiness of the feed (Goodband *et al.*, 1995).

Reduction in feed intake has been previously reported to be associated with reduction in feed

morphological changes in the digestive system (Jacob and Pescatore, 2012). Highly viscous digesta have been reported to decrease feed intake when poultry fed finely ground wheat (Amerah *et al.*, 2007a). However, no influence of particle size has been reported to affect poultry feed efficiency (Amerah *et al.*, 2007b).

Many researchers reported that feeding coarse feed particles can stimulate gastric secretion and reduce proventriculus and gizzard pH (Cumming, 1994; Gabreial *et al.*, 2003). However, the differences in this study were not significant (Table 5).

Feed particle has been shown to affect the development of the digestive system segments in poultry fed mash diets (Nir *et al.*, 1995; Gabriel *et al.*, 2003). It could be notice that the digestive system of poultry fed RBD became more

impacted as a result of viscous digesta when fed RBD. Recent study showed that fine fragments of barley have a higher viscosity compared to coarse particles (Al-Rabadi 2013). Previous research of Amerah *et al.* (2007a) showed that fine particles can cause viscous digesta and consequently shortened the length of the digestive system. In this study, the relative length of pancreas was higher in GBD compared to RBD. Coarse particles have been reported to increase cholecystokinin release (Svihus *et al.*, 2004), which stimulates and enhanced the secretion of pancreatic enzymes (Duke, 1992; Li and Owyang, 1993).

In conclusion, the outcomes of this study suggest that regrinding coarse particles reduced the percentage of coarse fractions retained on sieves 2.8 mm and 2.0 mm without increasing the amount of very fine particles which have potential application in feed industry. Regrinding coarse particles of barley could be an approach to reduce the production cost of broiler feed through minimizing feed intake without producing excess of fines.

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تأثير عملية ازالة حبيبات الشعير الكبيرة بعد طحنها على نمو الدجاج اللاحم خلال فترة النمو

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ملخص

يهدف هذا البحث لدراسة تأثير عزل حبات الشعير المجروش الكبيرة ومن ثم إعادة طحنها على نمو التغيرات المصاحبة في الجهاز الهضمي للدجاج اللاحم. تم في هذه التجربة استخدام 30 طائر حيث تم تربيتها حتى عمر 21 يوم ومن ثم توزيعها على مجموعتين (معاملتين) تم ترميز المعاملتين على النحو التالي بناء على حجم حبات الشعير المستخدم: 1- حبات شعير مجروش (GBG)، 2- حبيبات شعير مجروش بعد إعادة طحن حبات الشعير الكبيرة (RBG). أحتوت كل معاملة على 15 طائر. وكانت مدة التجربة 21 يوم (من عمر 21 يوم إلى 42 يوم). عند نهاية الأسبوع السادس تم ذبح جميع الطيور بقطع الرأس وإزالة الريش والجهاز الهضمي للتعرف على خصائص الذبيحة والجهاز الهضمي. اوضحت نتائج الدراسة ان إعادة طحن حبيبات الشعير الكبيرة قللت من كمية الغذاء المأكول واحسنت من معدل التحويل الغذائي اثناء مرحلة النمو. كما بينت التجربة من الناحية التصنيعية أن إعادة عملية طحن حبيبات الشعير الكبيرة لم تزيد من نسبة الحبيبات الناعمة والتي لها آثار سنية. يمكن الاستنتاج من هذه الدراسة أن عملية إعادة طحن حبيبات الشعير الكبيرة يمكن أن تستخدم كطريقة لتخفيض كلفة الانتاج من خلال تقليل كمية العلف المتناول بدون إنتاج حبيبات شعير ناعمة.

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