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Use of Untreated and Autoclave-Treated Wheat Germ Meal in Growing Rabbit Diets

Walaa Attia Salama*, Amira Mahmoud Refaie, Hamdy Farouk Amin and Lamiaa Fathy Abdel-Mawla

Animal Production Research Institute, Agricultural Research Center, Giza, Egypt.

*Corresponding author's Email: dr.walaa..attia@gmail.com; ORCID: 0000-0002-1854-1986

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ABSTRACT

The present study was intended to investigate the influence of using 20% and 40% treated or untreated wheat germ meal in growing New Zealand rabbit diets. A total of 75 weaned New Zealand White rabbits aged six weeks old, with an average initial weight of 659.60±18.84g were divided into five groups with five replicates in each group (three rabbits per replicate). The first group was fed on a basal diet (T_1), second and third groups received diets containing Wheat Germ Meal (WGM), as replacement of soybean meal protein, at levels of 20% and 40% and were labeled as T_2, T_3, respectively. Fourth and fifth groups were fed with 20% and 40% autoclave-treated WGM (T_4 and T_5, respectively). The trial was continued until 14 weeks of age. The present study was evaluated growth performance, blood parameters, carcass traits, meat quality in different groups and also economic efficiency was calculated. There were insignificant differences in terms of live weight, daily weight gain, carcass weight and dressing percentages among rabbits in groups of T_1, T_2, and T_4. Rabbits in the group of T_4 achieved the best feed conversion ratio. Digestion coefficients of crude protein, crude fiber, ether extract, nitrogen-free extract, and nutritive value in terms of digestible crude protein, total digestible nutrition, and digestible energy did not significantly differ between T_1 and T_4. However, these factors significantly decreased in T3 and T_5 compared to T_1. Plasma total protein and globulin significantly increased in rabbits of T_2 and T_4 compared to those fed in T_1 group. A significant decrease in total cholesterol and total lipid for rabbits in groups of T_4, T_5, and T_2 was observed. Moreover, rabbits fed on T_4 or T_2 diets had the highest economic efficiency. Conclusively, the untreated or autoclaved WGM can be used in growing rabbit diets up to 20% for replacing the soybean meal protein, which caused low feed costs without adverse effects on the growth performance of rabbits.

Key words: Rabbits, Soybean meal, Wheat germ meal

INTRODUCTION

Wheat, maize, rice, oats, barley, millets, sorghum, and rye are important cereals for human nutrition, either for cooking or as raw material for obtaining flour for baking (De Vasconcelos et al., 2013). Wheat is one of the important cereals and food ingredients around the world due to its ability to be converted to flour. Wheat flour is produced by milling wheat and extraction rate varies from 73% to 77%, depending on the variety of wheat and the production conditions (Elliott et al., 2002). Therefore, in the milling process, by-products such as wheat germ, wheat bran and parts of the endosperm comprise 23 to 27% of the production.

The wheat germ as a significant by-product of the cereal industry accounts for 2.5 to 3.8% of the total grain weight (Brandolini and Hidalgo, 2012). The wheat germ oil is the richest natural source of vitamin E (α-tocopherol) (Gerald et al., 2017). Hafez et al. (2019) found that rats received 3g/kg wheat germ oil had a non-significant increase in Malondialdehyde (MDA) levels of serum at the 15th day of study as compared to control group. Saleh (2016) found that oral administration of wheat germ oil (1400 mg⁄kg) to mice for eight days improved the liver and small intestine damage induced by carbon tetrachloride.

The Wheat Germ Meal (WGM) is produced when the oil is extracted from the wheat germ. WGM is high in protein content and rich in carbohydrates which could be processed further into livestock feeds. WGM as a good source of water-soluble vitamins also has a high content of lysine, threonine, and histidine (Barton and Monr, 1946). In addition, Moran and Summers (1967) reported that WGM contains 29% Crude Protein (CP), 2.1% Crude Fiber (CF), 10.3% Ether Extract (EE). Moreover, it contains gluten and antinutritional factors such as hemagglutinins and trypsin inhibitor, which inhibit enzymatic digestion of proteins (Creek and Vasaitis, 1962). Therefore, methods such as autoclaving or biological treatment are essential for improving the nutritive value of WGM. Autoclaving destroys the activity of these factors (Creek et al., 1962). Moran and Summers (1967) demonstrated the Autoclaved Wheat Germ Meal (AWGM) at 121 °C for 20 minutes, incorporated to chicken diets at the level of either 47% or 63.8% improve growth performance and feed utilization compared to groups fed WGM autoclaved for 90 min and control group. Hence, the objective of the present

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study was to investigate the effects of partial replacement of soybean meal protein with autoclave treated WGM protein on feed cost and growth performance of rabbits.

MATERIALS AND METHODS

The experiments were conducted at Borg-El Arab, located in Alexandria governorate, Egypt. The autoclave treatments were performed at the laboratories of By-Products Research Department, Animal Production Research Institute, Agriculture Research Center, Giza, Egypt.

Ethical approval

The study was carried out after obtaining the ethical approval from the Animal Production Research Institute, Egypt.

Wheat germ meal processing

WGM was obtained from the processing and extraction unit of natural oils, National Research Center, Giza, Egypt. It was ground by a hammer mill and stored in an air-tight condition then kept for further processing.

Autoclave treatment

WGM was treated with an autoclave at 121 °C for 20 minutes as recommended by Moran and Summers (1967). After treatment of the WGM, the drying was done in the air for 10 min and then kept for chemical analysis before mixing to the diets. Dry gluten content was determined according to Haraszi et al. (2011) and trypsin inhibitor activity was assessed as defined by Makkar et al. (2008). These measurements were performed before and after treatment.

Animal management and feeding

Seventy-five weaned New Zealand White rabbits of both sexes (six weeks old, the average body weight of 659.60±18.84 g) were allocated to five dietary treatments of 15 rabbits per treatment. Each treatment was replicated 5 times (three rabbits per replicate). The T_1 was fed the control diet, the T2 and T3 received 20% and 40% untreated WGM in replacing of soybean meal protein, respectively (6.12 and 12.31% of the whole diet, respectively). The T4 and T5 were fed on 20% and 40% autoclave-treated WGM, which consisted of 6.20 and 12.41% the whole diet, respectively. The ingredients and chemical composition of diets are presented in table 1. All the experimental diets were formulated to be isonitrogenous and isocaloric, to meet all the essential nutrient requirements of growing rabbits according to (Egyptian Agriculture Ministry Decree, 1996). The animals were reared in metal battery cages equipped with separated feeders and automatic nipple drinkers. All animals were receiving control diet for one week before the start of the experimental period and vaccinated against diseases during the veterinary examinations. Feed and water were offered *ad libitum*. The management and hygienic conditions were identical for all groups.

Table 1. Ingredients and chemical composition of experimental diets

Ingredients (%)	T_1	T_2	T_3	T_4	T_5
Barley	30.26	27.48	25.93	27.48	25.83
Clover hay	26.74	27.05	26.05	27.05	26.05
Wheat bran	18.40	18.40	18.40	18.40	18.40
Soybean meal (44%)	18.10	14.47	10.86	14.47	10.86
Wheat germ meal	--	6.15	12.31	6.20	12.41
Molasses	3.00	3.00	3.00	3.00	3.00
Di calcium phosphate	2.20	2.20	2.25	2.20	2.25
Sodium chloride (NaCl)	0.30	0.30	0.30	0.30	0.30
Vit.& min. mix[1]	0.30	0.30	0.30	0.30	0.30
Lime stone	0.35	0.35	0.35	0.35	0.35
DL-Methionine	0.30	0.25	0.20	0.25	0.20
Anticoccidia (Diclazuril)	0.05	0.05	0.05	0.05	0.05
Total	100	100	100	100	100
Chemical analysis[2]					
Crude protein (%)	17.70	17.37	17.04	17.36	17.06
Crude fiber (%)	12.87	12.64	12.08	12.65	12.08
Ether extract (%)	2.17	2.44	2.70	2.39	2.70
Nitrogen-free extract (%)	59.22	59.88	58.98	58.39	59.16
Digestible Energy (kcal/kg)	2533.35	2515.5	2512.5	2515.6	2512.4
Methionine+ cysteine (%)	0.55	0.54	0.54	0.54	0.54
Lysine (%)	0.91	1.10	1.28	1.09	1.28

T_1: control diet, T_2: 20% untreated wheat germ meal, T_3: 40% untreated wheat germ meal, T4: 20% autoclave -treated wheat germ meal, T_5: 40% autoclave-treated wheat germ meal. [1]Vitamins (Vit.) and minerals mixture; each 3 kg contains: Vit. A 6000.000 IU, Vit.B_1 2000mg, Vit.B_2 4000mg, Vit.D_3 900000 IU, Vit E 40000mg, Vit. K_3 2000 mg, Pantothenic acid 10000mg; Nicotinic acid, 50000g; Vit. B_6 2000 mg; Vit. B_{12} 10 mg, Folic acid 3.0g, Biotin 50 mg, choline 250000mg, Cu 5g, Mn85g 60g, Fe 50g, , Co 0.1 g, Se 0.1 g, Zn 50 g, I 0.2 g and Antioxidant 10000mg. [2]Chemical analysis of ingredients according to AOAC, 2000.

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Experimental parameters

Growth performance

Feed Intake (FI, g/ rabbit/ day) and Body Weight Gain (BWG, g/ rabbit/ day) were recorded weekly. Moreover, the Feed Conversion Ratio (FCR) was calculated as FI/BWG over an experimental period of 8 weeks.

Digestion trial

Digestibility test was carried out using five male rabbits from each experimental group in the last week of the experiment (14 weeks of age). The feces were daily collected separately for six days. The feces were sprayed with 2% boric acid solution for trapping released ammonia and dried at 60^{o} C for 48 hours (until constant weight). Feces were ground and stored for subsequent chemical analysis. Samples of WGM, diets, and feces were analyzed for moisture, ash, Nitrogen-Free Extract (NFE), EE, CF, and CP according to AOAC (2000).

Carcass traits

At 14 weeks of age, 25 rabbits (five rabbits per treatment) were slaughter to determine carcass traits according to Biasco and Ouhayoun (1996).

Chemical meat measurement

Longissimus dorsi muscles from 25 samples were frozen at -20 ºC for determination of total cholesterol, MDA and Total Antioxidant Capacity (TAOC) by colorimetric methods using analytical kits (Bio Diagnostic Company, Egypt)

Blood parameters

Blood samples were taken from the five rabbits per treatment at the time of slaughter and were collected in dry clean tubes containing heparin and centrifuged at 3000 rpm for 20 minutes. Then plasma was separated and stored in a deep freezer at approximately -20ºC till the time for determining total lipids, total cholesterol, total protein, and albumin. Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT) were colorimetrically determined using commercial kits, according to the manufacturer's instruction (purchased from Bio Diagnostic, Cairo, Egypt). The concentration of globulin (g⁄ dl) was calculated by subtracting albumin from total protein values.

Statistical analysis

The experimental data were subjected to using analysis of variance (ANOVA) in the general linear model using SAS version 9 (SAS Institute Inc.) by the following model:

$Y_{ij} = \mu + T_i + e_{ij}$

Where μ was overall mean of $Y_{ij;}$ T was the effect of treatment; i was (1, 2…, etc.), and e_{ij} was experimental error. The Significant differences between treatments means were separated by Duncan's multiple range test (1955).

Economic efficiency

Economic efficiency was calculated using the following equation: Economic efficiency = Net revenue / total costs

Total cost was calculated in Egyptian pound according to the price at the time of the experiment.

RESULTS

Chemical composition

Chemical analysis of WGM and AWGM in comparison to soybean meal are shown in table 2. The CP was higher in soybean meal (44 %) compared to WGM (25.83%) and AWGM (25.62%). Also, the CF was higher in soybean meal (7.3 %) compared to WGM (1.28 %) and AWGM (1.22%). However, the EE of soybean meal was lower (1.50%) in comparison to WGM (6.02%) and AWGM (5.30%). On the other hand, DE of soybean meal was 3200 kcal/ kg closed with WGM (2900 kcal/kg) and AWGM (2901 kcal/ kg). WGM contained 4% dry gluten and trypsin inhibitor activity was 2.817 mg⁄g, while autoclave treatment reduced dry gluten by 50% and trypsin inhibitor activity by 62.4% compared to WGM.

Growth performance

The results of final body weight, daily BWG, FI, and FCR are presented in table 3. Rabbits fed either T_1 or T_4 showed significantly higher final body weight followed by group fed T_2 compared to T_3 and T_5. While groups fed T_3 and T_5 had the lowest values. Rabbits fed control diet and T_4 recorded insignificantly higher BWG compared to T_2 and T_5. While the lowest values were recorded for T_3. The FI was not significantly affected by any of the tested diets. Regarding FCR, the group fed T_4 recorded the higher value without significant differences with T_1 group. Whereas, the lowest values were found in groups fed T_3 and T_5.

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Table 2. Chemical analysis of soybean meal, wheat germ meal and autoclave-treated wheat germ meal based on dry matter percentage

Items	Soybean meal*	WGM	AWGM
Organic matter (%)	93.50	93.40	93.48
Crude protein (%)	44.00	25.83	25.62
Crude fiber (%)	7.30	1.28	1.22
Ether extract (%)	1.50	6.02	5.30
Nitrogen-free extract (%)	40.7	60.27	61.34
Ash (%)	6.50	6.60	6.52
Digestible energy** (Kcal/kg)	3200	2900	2901
Anti-nutritional factors			
Dry gluten (%)	-	4.00	2.00
Trypsin inhibitor activity (mg/g)	21.00	2.817	1.058

WGM: Wheat Germ Meal, AWGM: Autoclave-treated Wheat Germ Meal. *Chemical analysis according to Feed composition for animal and poultry feedstuff used in Egypt (2001). **Digestible energy calculation was performed according to (Cheeke, 1987).

Table 3. Growth performance of New Zealand White rabbits (six weeks old) fed diets containing untreated or treated wheat germ meal

Items	T_1	T_2	T_3	T_4	T_5	SEM
Initial body weight (g)	645.00	668.00	671.00	641.00	673.00	18.84
Final body weight (g)	2143.3^{a}	2031.7^{ab}	1872.0^{c}	2108.0^{a}	1965.0^{bc}	30.56
Daily body weight gain (g)	26.76^{a}	24.35^{ab}	21.44^{b}	26.20^{a}	23.07^{ab}	0.70
Daily feed intake (g)	103.59	94.59	94.27	99.33	95.00	3.80
Feed conversion ratio (g feed/ g gain)	3.87^{bc}	3.88^{bc}	4.39^{a}	3.79^{c}	4.11^{ab}	0.10

Different superscript letters within the same row mean significant differences ($P<0.05$). T_1: control diet, T_2: 20% untreated wheat germ meal, T_3: 40% untreated wheat germ meal, T_4: 20% autoclave-treated wheat germ meal, T_5: 40% autoclave-treated wheat germ meal. SEM: Standard error of the mean.

Digestion coefficient

According to results shown in table 4, AWGM increased nutritive values for the rabbit compared with 40% untreated WGM. These results indicated that CP digestibility was significantly higher in T_1 and T_4 groups in comparison to other groups. Digestibility of CF, EE, and NFE were significantly improved in T_1, T_2, and T_4. Digestible CP values were significantly increased in T_1 and the lowest values were found with inculcation untreated or treated WGM at the level of 40%. Feeding with T_4 and T_1 diets enhanced total digestible nutrients, digestible crude protein and digestible energy compared to other treatments.

Carcass characteristics

The results of carcass characteristics are presented in table 5. Carcass and dressing percentage were significantly higher in T_1, T_2, and T_4 in comparison to other groups. While T_3 and T_5 were significantly decreased in the carcass weight and dressing percentage compared to T_1. However, the percentage of liver, kidney, heart, and giblets were not significantly affected by any treatments.

Meat quality

Table 6 shows that the T_1 and T_5 recorded the highest TAOC value values in rabbit meat followed by T_2 and the lowest values were recorded for T_3 and T_4. The highest MDA value was recorded for T_2 followed by T_5 .While T_1 group was found to have the lowest value. Regarding total cholesterol in rabbit meat, T_2 recorded significantly the highest level. The lowest level was found in the groups of T_5 and T_3.

Blood constituents

The plasma concentration of total protein, albumin, globulin, total cholesterol, and lipids are shown in table 7. The obtained values of blood parameters were within the normal range. Insignificant differences were found in the concentration of plasma albumin, ALT and AST in different tested treatments. Plasma total protein increased significantly in T_2 and T_4 compared to control and T_5 groups. Globulin values were significantly higher in rabbits fed T_2 and T_4 compared to other groups. The concentration of total cholesterol and lipid in plasma were significantly higher in T_1 and T_3 compared to control group.

Economic efficiency

Effects of replacement of treated or untreated WGM on economic efficiency are shown in table 8. The results indicated that inclusion 20 or 40% treated or untreated WGM decreased total feed cost /rabbit as a result of decreasing FI compared to control group. Growing rabbits fed diets either T_4 or T_2 recorded high economic efficiency followed by T_1. Also, selling price increased in T_4 than control (71.88 and 73.40 LE, respectively). The same trend was found in relative economic, where the best values were recorded in T_4 and T_2 groups (109.19 and 105.6 %, respectively), while the poorest value was recorded in T_3 group.

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Table 4. Digestion coefficient of New Zealand White rabbits (six weeks old) fed on autoclave-treated or untreated wheat germ meal.

Items	T_1	T_2	T_3	T_4	T_5	SEM
Organic matter (%)	64.05	60.60	58.67	61.44	58.81	1.18
Crude protein (%)	74.31^{a}	65.94^{b}	60.67^{b}	71.80^{a}	61.34^{b}	1.62
Crude fiber (%)	40.85^{a}	33.99^{ab}	27.18^{b}	42.39^{a}	30.75^{b}	1.80
Ether extract (%)	80.77^{a}	77.09^{ab}	68.27^{c}	78.15^{ab}	73.82^{bc}	1.33
Nitrogen-free extract (%)	76.89^{a}	72.79^{ab}	68.68^{b}	75.41^{a}	71.73^{ab}	0.96
Digestible crude protein (%)	13.15^{a}	11.37^{ab}	10.33^{b}	12.46^{a}	10.46^{b}	0.41
Total digestible nutrients (%)	58.33^{a}	54.61^{b}	48.80^{c}	57.00^{ab}	50.66^{c}	1.03
Digestible energy*(kcal/kg)	2584.01^{a}	2419.22^{b}	2161.84^{c}	2525.1^{ab}	2244.23^{c}	45.59

T_1: control diet, T_2: 20% untreated wheat germ meal, T_3: 40% untreated wheat germ meal, T_4: 20% autoclave-treated wheat germ meal, T_5: 40% autoclave-treated wheat germ meal. SEM: Standard error of the mean. Different superscript letters within the same row mean significant differences ($p< 0.05$). * Digestible energy = Total digestible nutrients* 44.3, according to Schneider and Flatt (1975).

Table 5. Carcass traits of New Zealand White rabbits (six weeks old) fed on autoclave-treated or untreated Wheat germ meal

Items	T_1	T_2	T_3	T_4	T_5	SEM
Carcass weight (%)	56.69^{a}	55.43^{a}	53.29^{b}	55.69^{a}	53.74^{b}	0.37
Dressing (%)	60.38^{a}	58.89^{ab}	56.80^{c}	59.52^{a}	57.59^{bc}	0.39
Liver (%)	2.91	2.42	2.60	2.91	2.89	0.09
Heart (%)	0.275	0.293	0.269	0.273	0.267	0.01
Spleen (%)	0.035	0.048	0.055	0.036	0.053	0.003
Kidney (%)	0.706	0.705	0.588	0.614	0.645	0.01
Giblets (%)	3.69	3.46	3.51	3.83	3.85	0.08

T_1: control diet, T_2: 20% untreated wheat germ meal, T_3: 40% untreated wheat germ meal, T_4: 20% autoclave-treated wheat germ meal, T_5: 40% autoclave-treated wheat germ meal. SEM: Standard error of the mean. Different superscript letters within the same row mean significant differences ($p<0.05$)

Table 6. Meat quality of New Zealand White rabbits (six weeks old) fed on untreated or autoclave-treated wheat germ meal

Items	T_1	T_2	T_3	T_4	T_5	SEM
TAOC (mM⁄g)	1.025^{ab}	0.3800^{ab}	0.465^{c}	0.9200^{b}	1.25^{a}	0.085
MDA(mg⁄g)	1.26^{d}	3.17^{a}	1.835^{c}	1.815^{c}	2.445^{b}	0.162
Total cholesterol(mg⁄g)	13.50^{c}	25.95^{a}	12.85^{c}	22.15^{b}	12.85^{c}	0.922

TAOC: Total Antioxidant Capacity MDA: Malondialdehyde.T_1: control diet, T_2: 20% untreated wheat germ meal, T_3: 40% untreated wheat germ meal, T_4: 20% autoclave-treated wheat germ meal, T_5: 40% autoclave-treated wheat germ meal. Different superscript letters within the same row mean significant differences ($P<0.05$). SEM: Standard error of the mean.

Table 7. Blood constitutes of New Zealand White rabbits (six weeks old) with treated or untreated wheat germ meal

Items	T_1	T_2	T_3	T_4	T_5	SEM
Total protein (g/ dl)	5.44^{b}	6.10^{a}	5.59^{ab}	6.10^{a}	5.46^{b}	0.10
Albumin (g/ dl)	2.82	2.96	2.90	2.69	2.75	0.05
Globulin (g/ dl)	2.62^{b}	3.14^{a}	2.69^{b}	3.41^{a}	2.71^{b}	0.09
Total cholesterol (g/ dl)	83.75^{a}	57.90^{b}	75.17^{a}	58.16^{b}	53.56^{b}	3.46
Total lipid (g/ dl)	311.90^{a}	254.33^{b}	290.87^{a}	190.45^{c}	187.49^{c}	14.13
ALT(U/ L)	12.73	12.48	12.32	13.02	12.54	0.12
AST(U/ L)	16.22	15.01	14.70	15.44	15.02	0.25

T_1: control diet, T_2: 20% untreated wheat germ meal, T_3: 40% untreated wheat germ meal, T_4: 20% autoclave-treated wheat germ meal, T_5: 40% autoclave-treated wheat germ meal. SEM: Standard error of the mean. Different superscript letters within the same row mean significant differences ($p<0.05$).

Table 8. Economic efficiency of New Zealand White rabbits (six weeks old) fed on diets with treated or untreated wheat germ meal

Items	T_1	T_2	T_3	T_4	T_5
Total weight gain (kg)	1.498	1.363	1.200	1.467	1.292
Price of 1kg body weight	49	49	49	49	49
Selling price/rabbit (LE) (A)	73.40	66.78	58.85	71.88	63.31
Total feed intake	5.801	5.297	5.279	5.562	5.320
Price/kg feed (LE)	4.44	4.27	4.16	4.28	4.17
Total feed cost/rabbit (LE) (B)	25.75	22.61	21.96	23.80	22.18
Net revenue(LE)[1]	47.65	44.17	36.89	48.08	41.13
Economic efficiency[2]	1.85	1.953	1.679	2.02	1.854
Relative economic efficiency[3]	100	105.60	90.80	109.19	100.23

T_1: control diet, T_2: 20% untreated wheat germ meal, T_3: 40% untreated wheat germ meal, T_4: 20% autoclave-treated wheat germ meal, T_5: 40% autoclave- treated wheat germ meal. LE: Egyptian pound. 1: Net revenue = A – B. 2: Economic efficiency = (A-B/B). 3: Relative Economic Efficiency= Economic efficiency of treatments other than the control/ Economic efficiency of the control group.

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