



The Effect of Fermented Wheat Germ Extract on Biochemical, Physiological and Performance Parameters of Broiler Chickens

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ABSTRACT

Fermented wheat germ extract (FWGE) is a multisubstance composition contains 2-methoxy benzoquinone and 2, 6-dimethoxy benzoquinone which are likely to exert some of its biological effects as well as it is a concentrated source of vitamins, minerals, and protein. An experimental trial of FWGE supplementation to broiler feed from one day old with a rate of 0.5, 1.5 and 3 g/kg feed was tried. Results revealed that all doses of FWGE increased body weight significantly ($p \leq 0.05$), especially with the dose of 3 g/kg feed. Also, FCR values decreased significantly ($p \leq 0.05$) in the FWGE treated groups. Regarding biochemical analysis at 35 days old, the most significant results obtained with the doses of 1.5 and 3 g FWGE/kg feed especially in SGOT, SGPT, creatinine, uric acid, total protein, glucose, and triglycerides levels. Physiologically, FWGE only increased hemoglobin concentration significantly ($p \leq 0.05$) without alteration of red blood and white blood cells counts. There was also a significant increase ($p \leq 0.05$) in the intestinal weight in relation to carcass weight% and a significant decrease ($p \leq 0.05$) in the liver and total body fat weights in relation to carcass weight%. At 45 days (10 days after vNDV challenge), the mortality rates were 60% in the non-treated non-vaccinated challenged chicken group 5 and 4% in the non-treated vaccinated challenged chicken group 4 without appearance of any mortality in the 3 FWGE treated groups. Also, addition of FWGE had a positive effect on HI titers for NDV in the collected serum samples at 45 days old. Finally, it was concluded that FWGE improved the general health condition of broilers regarding biochemical and physiological parameters and immune response to NDV vaccination.

Key words:

Fermented Wheat
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challenge

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1. INTRODUCTION

In the last decades; fermented wheat germ was found to be a good therapy for human and experimental animal cancer and for treatment of human arthritis (Telekes *et al.*, 2007). Also, it had a growing interest in the poultry and other farm animals as an immunostimulant as well as to maximize their potential output (Mueller & Voigt, 2011).

The wheat germ constitutes approximately 2.5% of the total weight of the wheat kernel, the production of FWGE involves fermenting wheat germs of the genus *Triticum vulgare* by adding baker's yeast (*Saccharomyces cerevisiae*) (Hidvégi *et al.*, 1999).

Administration of FWGE proved to be effective as supportive therapy to surgery plus chemotherapy for a colorectal cancer patient without any toxic effects (Jakab *et al.*, 2003).

Fermented wheat germ extract (FWGE, Avemar pulvis) was invented by Hungarian biochemist Mate Hidvégi in the early 1990s. In the United States, FWGE is marketed as a dietary supplement, Avé[®], by American BioSciences, Inc. (Blauvelt, NY). FWGE is manufactured as Avemar[®] in Hungary, where it is approved as a "medical nutriment" for cancer patients (Illmer *et al.*, 2005).

Stipkovits *et al.* (2004) found that immunomodulators such as FWGE were effective against *M. gallisepticum* infection, similar to the well-known antimycoplasmal drug, tiamulin. FWGE could be used to reduce the economic losses caused by mycoplasma infection.

Also, Kósa and Bajcsy (2008) used another product (Immunovet HBM[®]) in laying parents from the 2nd week to the end of the laying period with 1 kg/t commercial layer diet and noted that the average

numbers of laid eggs were increased significantly by 9.8% than control group with a lower feed amount/egg by 10% (0.36 kg vs. 0.40 kg of the control one) and declared that the long term use of Immunovet HBM® in the diet had high metabolic rate results and improved the layer performance.

In addition, the incorporation of FWGE into pig feeds at 1 g/kg level improved the weight gain of the pigs by average 6% (Rafai et al., 2011).

This study was designed to validate the fermented wheat germ efficacy on broiler biochemical, physiological, performance parameters and immune response.

2. MATERIAL AND METHODS:

2.1-Preparation of fermented wheat germ extract:

2.1.1. Yeast strain

Dry active baker’s yeast *Saccharomyces cerevisiae* provided from local market was used as a producing microorganism. Yeast was activated through suspension in 0.1% sterile peptone water pre warmed to 38°C. The yeast cell count was determined in Neuburger’s counting chamber and finally the amount of inoculum needed to obtain 30-35 X 10⁶ viable cells per g of the fermentation medium was taken from the yeast solution.

2.1.2. Enzymes

All enzymes Novozymes (A heat-stable a-amylase from *Bacillus licheniformis*) and gluco-amylase from (*Aspergillus niger*)) (Denmark) were handled and stored according to the manufacture’s recommendations was used for wheat meal liquefaction.

2.1.3. Pre-treatment of wheat samples for fermentation

FWGE was prepared by mixing of mashed wheat samples with water enzyme mixture (1:3) in metallic jars. The jars were held in shaker water bath (150 rpm) for 30 min at 50 °C. After that wheat samples were heated up to 65 °C for 60 min. Then temperature was lowered to 53-55 °C and gluco-amylase was added and kept for 30 min.

Temperature was lowered to 30 °C. Mashers were transferred to 1 L glass bottles and the prepared yeast was added; the bottles were closed with foam burls to allow venting of the Co2 produced during fermentation. Fermentation was conducted in thermostat with 30 °C (Pejin et al., 2009).

2.2. Experimental birds

The present study was affirmed by the Committee on the Ethics of Animal Experiments of Damanhour University, Egypt, and all mandatory laboratory health and safety procedures had been complied. All killed birds were euthanized by chloroform at high dose to induce respiratory failure.

300 Cobb broiler chickens were bought from a local hatchery at the age of 1-day old.

Chickens were divided into 6 experimental groups. Groups from 1 to 3 included 75 birds in 3 replicates, 25 each and groups from 4 to 6 included 25 birds each (Table, 1).

The addition of fermented wheat germ extract was done from the first day of age till the end of the experimental (45 days of age).

Vaccination program:

- Hitchner B1 at 7days old via eye drop
- Avian Influenza subtype H5N2 inactivated vaccine at 8 days old via S/C route
- Newcastle disease inactivated vaccine at 10 days old via I.M. route
- IBD, LaSota and another IBD live vaccines were applied at 12, 18 and 22 days old respectively, via eye drop.

2.4.Biochemical and Physiological analysis of serum samples collected at 35 days old before NDV challenge:

Ten serum samples were collected for determining Liver function test (SGOT, SGPT), Kidney function test (Creatinine, Uric Acid and Total protein levels), Glucose, and Triglycerides levels and physiological analysis for total RBCs count, total WBCs count, Hemoglobin concentration.

Table 1: Experimental Design

Chicken Groups	Treatments	No. of birds	Vaccination for NDV	Challenge
1	0.5 g FWGE/kg feed	75	√	√ (for 25 out of 75 birds)
2	1.5 g FWGE/kg feed	75	√	√ (for 25 out of 75 birds)
3	3 g FWGE/kg feed	75	√	√ (for 25 out of 75 birds)
4	No FWGE	25	√	√
5	No FWGE	25	×	√
6	No FWGE	25	×	×

2.3. Feed formulation:

Ingredient	Starter	Grower	Finisher
Yellow corn	578	600	651
Soyben meal 46%	292	219	158
full fat soy	50	100	120
Corn gluten 60%	35	40	35
MCP	13	10	9
Limestone	19	19	16
Nacl	3	3	3
Sod. Bicarbonate	1	1	2
Broiler premix	3	3	3
Methionine liquid	2.75	2	1.93
Lysine	2.65	2.6	1.65
Diclazoril	0.63	0.63	0.63
Lysoforte	0.25	0.25	0.25
Kemzyem	0.05	0.05	.05
Mycotoxin binder	0.5	0.5	0.5

Feed and water were provided ad-libitum, chickens were weighted weekly and the feed conversion was calculated.

2.5. Challenge with Newcastle disease virus (NDV):

Twenty-five birds from each group of 1, 2 and 3 and all birds of groups 4-6 were experimentally infected at 35 days old through I.M. (intra muscular) route with a dose of 0.2 ml/bird (containing 10^6 ELD₅₀/ml) of velogenic strain of NDV (GenBank accession no. KU377781) kindly provided from the department of Poultry and Fish Diseases, Faculty of Veterinary, Damanhour University.

The chickens were observed for 10 days post-infection for clinical signs, daily mortality and P.M. lesions was recorded.

2.6. Carcass traits monitored at 45 days old:

Relative intestine, liver, gizzard, spleen, body fat, bursa of Fabricius weights to body weight ratio were calculated.

2.7. Serum Samples collected at 45 days old after NDV challenge:

Ten serum samples were collected for determining HI titers for NDV, which was carried out according to (Alexander, 2000). The used antigen was LaSota.

2.8. Statistical analysis

The analysis of variance (ANOVA) for the obtained data was performed using statistical program (IBM, SPSS.20[®]) to assess the significant differences using Duncan's multiple range test.

3. RESULTS

3.1. Biochemical analysis of serum samples collected at 35 days old (Table, 2)

3.1.1. Liver enzymes

SGOT: Only the dose of 1.5 g/kg feed decreased significantly ($p \leq 0.05$) SGOT level in blood of treated broiler chickens, from 20.655 (control) to 17. SGPT: The doses of 1.5 and 3 g/kg feed decreased significantly ($p \leq 0.05$) SGPT level in blood of treated broiler chickens and the higher significant difference was to the addition of FWGE with 1.5 g/kg feed.

3.1.2. Kidney function tests

Creatine level: A dose of 0.5 g/kg feed in chicken group no. 1 increased significantly ($p \leq 0.05$) the creatinine level in blood of broiler chickens from 0.840 (control) to 1.11. But doses of 1.5 and 3g/kg feed were non significantly ($p \geq 0.05$) different from control groups.

Uric Acid: All doses decreased significantly ($p \leq 0.05$) uric acid level in blood of treated broiler chickens, but the higher significant difference was to the addition of FWGE with 1.5 g/kg feed.

Total Protein level: The dose of 0.5 g/kg feed dose increased significantly ($p \leq 0.05$) the total protein level in blood of treated broiler chickens, from 4.950 (control) to 5.45. But the doses of 1.5 g/kg feed decreased significantly ($p \leq 0.05$) the total protein level in blood to 4.833.

3.1.3. Glucose level: All FWGE doses increased significantly ($p \leq 0.05$) the sugar level in blood of broiler chickens in comparison with the control. But there was no significant difference among the different treatments ($p \geq 0.05$).

3.1.4. Triglycerides level: All doses decreased significantly ($p \leq 0.05$) the level of triglycerides in blood of treated broiler chickens, but the higher significant difference was to the addition of FWGE with 3 g/kg feed.

3.2. Physiological analysis of serum samples collected at 35 days old (Table, 3).

3.2.1 Red and white blood cell counts: There was no significant differences ($p \geq 0.05$) among different FWGE treatments and control group regarding the RBCs and WBCs counts in blood.

3.2.2 Hemoglobin concentration: Chickens of group no. 2 and 3 had significant increase ($p \leq 0.05$) in hemoglobin conc. compared to control group no. 6 although chickens of group 3 which fed on 3 g/kg feed was observed as significantly the highest value.

3.3. Body weight, Feed intake and FCR at 35 days age (Table, 4).

FWGE improved significantly ($p \leq 0.05$) the Bwt. and FCR values than the other control groups (4, 5 and 6). There was no significant difference ($p \geq 0.05$) between the 3 doses of treatment but the highest dose of addition in group 3 gave the highest Bwt. as 2051.3 g and the best FCR values as 1.546. Regarding the feed consumption, there were no significant differences ($p \geq 0.05$) in feed consumption among different groups.

3.4. Mortality % after NDV challenge:

After challenge, chicken group no. 5 had 60 % mortality (15/25 birds) and group no. 4 (vaccinated and challenged and non-treated with FWGE) had 4 % mortality (1/25 birds), while all the vaccinated challenged and treated groups with FWGE and group no. 6 had 0% mortality after challenge.

3.5. Carcass traits monitored at 45 days old (Table, 5).

3.5.1. Intestine weight relative to body weight %. It was observed that the relative weight of intestine to body weight ratio increased significantly ($p \leq 0.05$) in group 2 by 0.518% and in group 3 by 0.951% compared with group no. 6.

3.5.2. Liver weight relative to body weight. The highest Liver relative to body weight ratio was in chicken groups no. 4, 5 and 6. There was a significant decrease ($p \leq 0.05$) in the relative liver to body weight ratio with the addition of FWGE. The least ratio was in group 1 received 0.5 g/kg feed dose. This decreased liver weight in relation to body weight ratio in the FWGE treated groups may be due to the higher increase in body weight rather than the increase in the liver weight.

Table 2): Effect of FWGE on some biochemical parameters as SGOT, SGPT, Creatinine, Uric Acid, Glucose, Total Protein, Triglycerides, in blood of broiler chickens at 35 days old.

Chicken group no.	SGOT (mg/DCL)	SGPT (mg/DCL)	Creatinine (mg/DCL)	Uric Acid (mg/DCL)	Total Protein (mg/DCL)	Glucose (mg/DCL)	Triglycerides (mg/DCL)
1	20.000 ^a	27.333 ^a	1.110 ^a	14.666 ^{ab}	5.453 ^a	169.167 ^a	135.000 ^{ab}
2	17.000 ^b	22.000 ^b	0.750 ^b	11.200 ^b	4.833 ^b	164.733 ^a	123.333 ^{ab}
3	20.000 ^a	25.666 ^{ab}	0.756 ^b	12.666 ^{ab}	4.916 ^{ab}	171.500 ^a	113.667 ^b
4, 5 & 6	21.867 ^a	27.666 ^a	0.866 ^b	16.000 ^a	4.950 ^{ab}	134.267 ^b	149.333 ^a

Means within a column under similar letter (Super scripts) are significantly different as $p \leq 0.05$

Table 3): Effect of FWGE on some physiological parameters as total RBCs WBCs counts, and Hemoglobin % in blood of broiler chickens at 35 days old

Chicken group no.	Total RBCs count ($\times 10^6 \mu l$)	Total WBCs count ($\times 10^3 \mu l$)	Hemoglobin concentration %
1	2.850 ^a	24.583 ^a	23.500 ^c
2	3.566 ^a	25.023 ^a	26.250 ^b
3	3.243 ^a	25.926 ^a	28.883 ^a
4, 5 & 6	2.676 ^a	22.890 ^a	21.777 ^c

Means within a column under similar letter (Super scripts) are significantly different as $p \leq 0.05$

Table 4): Effect of FWGE on Body weight (Bwt.), Feed Intake (FI) and Feed Conversion Rate (FCR) at 35 days old

Chicken group no.	Bwt. (g)	FI (g)	FCR
1	1974.3 ^a	3.154 ^a	1.597 ^a
2	1990.3 ^a	3.108 ^a	1.561 ^a
3	2051.3 ^a	3.173 ^a	1.546 ^a
4, 5 & 6	1782.0 ^b	3.226 ^a	1.810 ^b

Means within a column under similar letter (Super scripts) are significantly different as $p \leq 0.05$

3.5.3. Body fat weight relative to body weight %.

There was a direct relationship between FWGE treatment and the body fat relative weight, as it caused a significant decrease ($p \leq 0.05$) in body fat compared to the control group no. 6 and this indicated the higher lean meat of the FWGE treated groups.

Regarding the gizzard, spleen and bursa of Fabricious, there was no any significant difference between their weights and the control chicken group no. 6.

3.5.4. HI titers (Geometric mean) for detection of serological response at 45 days old. The treated vaccinated and non-challenged gave higher titers than challenged one and group 3 gave the highest titer. Also, all the FWGE treated groups (1, 2 and 3) gave higher NDV HI titers than other groups no. 4, 5, and 6 (Fig. 1).

4. DISCUSSION

EU has banned AGP-s (antibiotic growth promoters) in 2006 and researches has been carried out to find alternatives to control and prevent colonization of pathogen bacteria e.g. Salmonellas in the intestines modulating gut microbiota. Prebiotics are non-digestible carbohydrates containing feed ingredient a substrate for multiplication of useful bacteria in microbiota, prevent or at least suppress colonization

of pathogen microflora including Salmonellas (Ribeiro et al., 2007).

FWGE is a prebiotic reproductive part of grain kernels that concentrates high protein essential vitamins and minerals, such as potassium, iron, zinc, D, E and B vitamins, and essential fatty acid. It was recognized as early as at the beginning of the 1950's and that fermentation of the germ cells using *Saccharomyces cerevisiae* glycosides split it into benzoquinones (Cosgrove et al., 1952, cit. (Johanning & Wang-Johanning, 2007).

Due to fermentation process of wheat germ, the digestibility of the fibrous fraction of feed ingredients is improved thereby contributing to higher energy digestibility and also, this fermentation resulted in lower NSP (Non Starch Polysaccharides) content amounting to 104 g/kg compared to 120 g/kg in non-fermented wheat, which may explain the slight increase in crude protein content of fermented wheat (Patel, 2014), this higher protein content had no drawback on the kidney function tests as the added doses of 1.5 and 3g/kg feed were non significantly ($p \geq 0.05$) different in creatine level from control groups although all doses decreased significantly ($p \leq 0.05$) uric acid level in blood of treated broiler chickens, with higher significant difference by

Table 5): Effect of FWGE on intestine, liver, gizzard, spleen, body fat, bursa of Fabricious weights (%) in relation to body weight ratio of broiler chickens at 45 days old.

Chicken group no.	Intestine	Liver	Gizzard	Spleen	Body Fat	Bursa of Fabricious
1	2.876 ^b	1.723 ^b	1.240 ^a	0.127 ^a	1.700 ^{ab}	0.054 ^a
2	3.350 ^b	2.116 ^{ab}	0.951 ^a	0.078 ^a	1.550 ^b	0.046 ^a
3	3.783 ^a	1.426 ^b	0.928 ^a	0.066 ^a	1.583 ^b	0.051 ^a
4	2.841 ^b	2.566 ^a	1.251 ^a	0.211 ^a	2.227 ^a	0.031 ^a
5	2.792 ^b	2.518 ^a	1.239 ^a	0.222 ^a	2.213 ^a	0.027 ^a
6	2.832 ^b	2.598 ^a	1.246 ^a	0.240 ^a	2.216 ^a	0.029 ^a

Means within a column under similar letter (Super scripts) are significantly different as $p \leq 0.05$

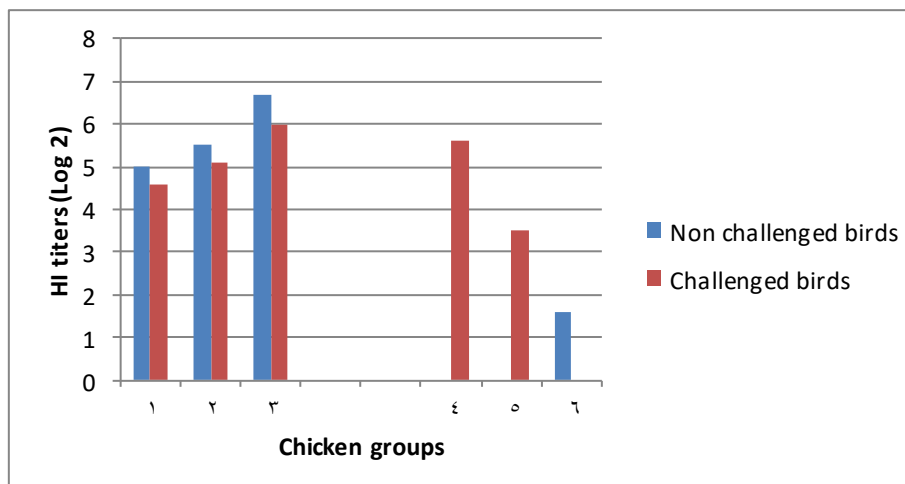


Figure 1. HI titers for NDV in the collected serum samples at 45 days old.

the dose of 1.5 g/kg feed. Only the dose of 1.5 g/kg feed decreased significantly ($p \leq 0.05$) the total protein level in blood.

Regarding, liver enzymes as SGOT, only the dose of 1.5 g/kg feed decreased significantly ($p \leq 0.05$) SGOT level in blood of treated broiler chickens, while both doses of 1.5 and 3 g/kg decreased significantly ($p \leq 0.05$) SGPT level in blood of treated broiler chickens with higher difference to 1.5 g/kg feed. This may indicate the better liver function with the two doses regarding detoxification and bile secretion leading to higher nutrient absorption.

In addition, a significant higher glucose level ($p \leq 0.05$) appeared in all FWGE doses with significant decreased ($p \leq 0.05$) triglycerides level in blood of treated broiler chickens leading to significant decrease ($p \leq 0.05$) in body fat with higher lean meat of the FWGE treated groups, while there was no significant differences ($p \geq 0.05$) among different FWGE treatments and control group regarding the WBCs and RBCs counts in blood, although doses of 1.5 and 3 g/kg feed had significant increase ($p \leq 0.05$) in hemoglobin conc. compared to control group no. 6. These results agreed with Hasan *et al.* (2014) who recorded a significantly reduced ($p < 0.05$) serum cholesterol level and significantly increase ($p < 0.05$) in the erythrocyte count, hemoglobin concentration and haematocrit values of broiler chickens fed mannanoligosaccharide supplemented diet at 35 days old compared with the control non treated ration,

FWGE improved significantly ($p \leq 0.05$) the Bwt. and FCR values than the non treated groups (4, 5 and 6) without significant differences ($p \geq 0.05$) between the 3 doses of treatment. The highest Bwt. and the best FCR values were obtained in group 3 treated by FWGE 3 g/kg feed and this may be related to the increased intestinal weight relative to body weight ratio compared with group no. 6.

There are many reports on the growth promoting, immune modulating and antioxidant effect of FWGE as Rafai *et al.* (2011) who conducted a growing pig experiment with fed diets containing zero or two levels (1 or 2 g/kg) of fermented wheat germ extract (FWGE). In the first part of the experiment (19 days between 49 and 68 days of age) weight gain and feed conversion were tested. The 2nd part of the experiment (21 days between 68 and 89 days of age) served to measure the effect of FWGE on some compartments of the immune system. In the first part of the experiment supplementation of the starters' diet with FWGE yielded 7.8 and 14.2% additional daily weight gain in the 1st and 2nd experimental groups, respectively

($P < 0.05$). Important in vitro and in vivo compartments of the cellular immunity were also enhanced which might indicate improved disease resistance against facultative pathogenic microorganisms.

Also, in another study of broiler chickens fed with FWGE (Immunovet HBM[®]), there was a significantly higher average villus depth in the duodenum, jejunum and ileum with 10-33% on day 10, 21 and 42, as compared with the control ones of the same ages. This nourishment of the intestinal villi, increases their surface, and enhances the absorption of alimentary substances. FWGE acts also, as an antioxidant / free radical scavenger, activates immune mechanisms and normalizing of the immune regulating system (Kósa *et al.*, 2011).

Velogenic NDV challenge, resulted in 60 % mortality in chicken group 5 and decreased to 4 % vaccinated, challenged and non-treated with FWGE group no. 4, while all the vaccinated challenged and treated groups with FWGE and group no. 6 had 0% mortality after challenge. Similar results were obtained by Stipkovits *et al.* (2004) regarding *M. gallisepticum* infection as they concluded that FWGE as well as tiamulin were able to protect birds from infection without development of clinical signs, and mortality. Absence of pathological lesions as catarrhal pneumonia, pleuritis in the slaughtered birds, was recorded. Also, no mycoplasma was re-isolated from brain, liver, spleen, heart, or kidneys of the FWGE-treated birds, and the number of mycoplasma isolations from the respiratory tract samples was less frequent than from the infected untreated birds.

On other hand, an investigation of *Salmonella infantis* infection in cloacal swabs in broiler chickens proved that FWGE in the feed did not influence neither of dynamics nor intensity shedding of this bacteria, as the flock remained salmonella positive till the end of experiment at 37th days old (Nagy *et al.*, 2011).

Immunologically, the serological response to NDV vaccination and challenge at 45 days old using HI titers indicated that the treated vaccinated and non-challenged group gave higher titers than challenged one and group 3 gave the highest titer. This may indicate the beneficial effect of FWGE on immune response of broiler chickens. Also, Nagy *et al.* (2011) concluded that humoral immune response after vaccination had been positively influenced by FWGE as in case of IBD vaccination till the 28th, IBV and NDV till the end of experiment at 42th days old. They found that FWGE increased the NDV haemagglutination inhibition geometric mean titers to be higher by 100% and also, IBV ELISA

mathematical mean titers higher by 180% in the FWGE treated group on the 42th day of rearing. While, IBD virus neutralization geometric mean titers increased 7 days post-vaccination by 26% compared to the control group.

There was also an obvious beneficial effect of FWGE as immunomodulator against *Mycoplasma gallisepticum* infections in domestic poultry, which was similar to the well-known antimycoplasmal drug, tiamulin, probably due to activation of macrophages, the induction of transcription of cytokine genes, the release of inflammatory cytokines, the increase of blastic transformation of lymphocytes and the reduction of MHC class I expression, thus exposing mycoplasmas to natural killer cell activity, which has been demonstrated in various tumor experiments. The use of FWGE seeks to reduce its use of use of antibiotics (Stipkovits *et al.*, 2004).

In addition, Mueller and Voigt (2011) recorded that FWGE modulates immune response by down-regulation of MHC-I complex and the induction of TNF- α and various interleukins which may provide evidence for a colon cancer preventing effect of FWGE.

CONCLUSION:

FWGE is economically efficient treatment for chickens and it has a positive effect on general health condition regarding biochemical and physiological parameters and immune response to NDV vaccination. The best treatment of FWGE was 3 g/kg ration as it improved feed conversion ratio and increased body weight by 269.3 g over Bwt. of chickens in control group at 35 days.

REFERENCES

Alexander, D.J. 2000. Newcastle disease and other avian paramyxoviruses. *Rev Sci Tech*, 19, 443-462.

Hasan, S., Hossain, M.M., Miah, A., Bhuiyan, M.E.R. 2014. Influences of Prebiotic on Growth Performance and Hemato-Biochemical Parameters in Broiler During Heat Stress. *Bangladesh J. Vet. Med.* 12.

Hidvégi, M., Rásó, E., Farkas, R.T., Lapis, K., Szende, B. 1999. Effect of MSC on the immune response of mice. *Immunopharmacol.* 41: 183-186.

Illmer, C., Madlener, S., Horvath, Z., Saiko, P., Losert, A., Herbacek, I., et al. 2005. Immunologic and biochemical effects of the fermented wheat germ extract Avemar. *Exp Biol Med (Maywood)*, 230: 144-149.

Jakab, F., Shoenfeld, Y., Balogh, Á., Nichelatti, M., Hoffmann, A., Kahán, Z., et al. 2003. A medical nutriment has supportive value in the treatment of colorectal cancer. *Brit. J. Cancer*, 89: 465-469.

Johanning, G.L., Wang-Johanning, F. 2007. Efficacy of a medical nutriment in the treatment of cancer. *Altern Ther Health Med*, 13:56-63; quiz 64-55.

Kósa, E., Bajcsy, E. 2008. Feeding experiment on layer-parents, production and immunology with wheat germ extract (trade name: ImmunovetHBM™). *World's Poult. Sci. J. Book of Abstracts* 64: 436.

Kósa, E., Glávits, R., Ózsvári, L., Jurkovich, V., Brydl, E. 2011. Effect of fermented wheat germ extract (FWGE) on the intestinal morphology. In *Animal Hygiene and Sustainable Livestock Prod.* pp. Poster Presentations, 1301). Vienna, Austria.

Mueller, T., Voigt, W. 2011. Fermented wheat germ extract--nutritional supplement or anticancer drug? *Nutr J*, 10: 89.

Nagy, G., Könyves, L., Jurkovich, V., Kovács, P., Kósa, E., Brydl, E. 2011. Effect of fermented wheat germ extract (FWGE) on shedding *Salmonella infantis* and immunreactions of broilers. In J. Köfer, H. Schobesberger (Eds.), *XVth International Congress of the International Society for Animal Hygiene*, pp. 711-713 ref.718). Vienna, Austria.

Patel, S. 2014. Fermented wheat germ extract: a dietary supplement with anticancer efficacy. *Nut. Therapy Metabolism* 32: 61-67.

Pejin, D., Mojović, L.J., Vučurović, V., Pejin, J., Denčić, S., Rakin, M. 2009. Fermentation of wheat and triticale hydrolysates: A comparative study. *Fuel*, 88, 1625-1628.

Rafai, P., Papp, Z., Jakab, L., Tuboly, T., Jurkovich, V., Brydl, E., et al. 2011. The effect of fermented wheat germ extract on production parameters and immune status of growing pigs. *J. Animal and Feed Sci.* 20, 36-46.

Ribeiro, A.M.L., Vogt, L.K., Canal, C.W., Cardoso, M.R.I., Labres, R.V., Streck, A.F., et al. 2007. Effects of prebiotics and probiotics on the colonization and immune response of broiler chickens challenged with *Salmonella Enteritidis*. *Revista Brasileira de Ciência Avícola*, 9, 193-200.

Stipkovits, L., Lapis, K., Hidvegi, M., Kosa, E., Glavits, R., Resetar, A. 2004. Testing the efficacy of fermented wheat germ extract against *Mycoplasma gallisepticum* infection of chickens. *Poult Sci.* 83: 1844-1848.

Telekes, A., Resetar, A., Balint, G., Blazso, G., Falkay, G., Lapis, K., et al. 2007. Fermented Wheat Germ Extract (Avemar) Inhibits Adjuvant Arthritis. *Annals of the New York Academy of Sciences*, 1110: 348-361.