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PROCEEDINGS BOOK

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Prof. Dr. Uğur USLU
Assist. Prof. Dr. Deniz ULUKUŞ

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PALET YAYINLARI
Mimar Muzaffer Caddesi Rampalı Çarşı No. 42 Konya
Tel. 0332 353 62 27
e-mail: paletyayinevi@gmail.com
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İÇİNDEKİLER

PROCEEDINGS

DETERMINATION OF HEAT TRANSFER AND FLUID FLOW CHARACTERISTICS IN A PARALLEL PLATES CHANNEL WITH V SHAPE CORRUGATION

Mustafa Noaman Shareef Shareef İlker Göktepeli Ulaş Atmaca*

Konya Technical University, Faculty of Engineering and Natural Sciences,
Department of Mechanical Engineering, Konya
**Corresponding author: uatmaca@selcuk.edu.tr, +903322232735*

Abstract

The heat transfer and fluid flow characteristics are determined in a V shape corrugated parallel plate in turbulent flow. The channel assumed to be at constant wall temperature of 400K while water enters to system with 300K temperature. The results are given for three different Reynolds number values (10000, 15000 and 20000) and for three corrugated tile angel values (60°, 100° and 140°) while the height of corrugation kept constant at 15mm. In turbulent flow solutions various turbulent flow models are used and a comparison is also presented in solutions. The results of parallel plate without corrugation are also found for comparison. The effects of different geometrical parameters of the corrugated structure on heat transfer and fluid flow characteristics are discussed. The corrugated surfaces has a significant effect on the enhancement of the heat transfer and pressure drop. The heat transfer coefficients obtained from the results with the corrugated surface are higher than those of the plain surface since the presence of the recirculation zones. The heat transfer coefficient, the pressure drop values increases as the angle of V corrugation decreases. As the Reynolds number values increases the heat transfer coefficient and pressure drop values increases due to secondary flow.

Keywords: Blockage, CFD, Heat transfer, Nusselt number, Parallel plate, Reynolds number, Turbulent flow, V shape corrugation.

Introduction

Turbulence promoters in form of ribs, corrugations and blockages are commonly used in various thermal equipments such as turbine cooling channels, heat exchangers, nuclear reactors and solar air heaters. Different types of methods are used for increasing the heat transfer in various processes. These methods are grouped as active and passive techniques in general. If energy is needed to increase the heat transfer it can be called as active method. However, it is possible to enhance the heat transfer by using the passive methods without requiring any energy source. The passive methods used to increase heat transfer by enlarging the heat transfer area or breaking and destabilizing the thermal boundary layer by artificial surface elements.

One of the mechanisms used for the heat transfer enhancement is to provide the flow separation. It is observed that the heat transfer is significantly affected by flow stagnation, separation and reattachment regions.

Corrugated plates is used as a turbulence promoters to enhance the thermal performance of many thermal device. In previous experimental and/or numerical works various shapes of the ribs are investigated. In the literature, a common shape is the triangular cross-sectional ribs. A detailed literature survey is given in [1]. The arrangement of the ribs influences the amount of the heat transfer enhancement also. The staggered arrangement [2] and the unstaggerred arrangement [3, 4] for the triangular cross-sectional ribs have been given. A numerical work considering flow of nanofluid in a corrugated channel is given [5]

The application of rectangular cross-sectional ribs on heat transfer is considered for the staggered arrangement in [6-12] and unstaggerred arrangement [13-16]. The comparison, of staggered and unstaggerred arrangements is given for the rectangular cross-sectional ribs in some studies like [17-20]. Moreover, the specific geometrical shapes for the ribs are also encountered such as convex-concave [21], semi-circular cross-sectional [22], sinusoidal [23], diamond-shaped [24], trapezoidal [25] in the previous studies.

As can be seen there are numerous experimental and theorical studies that reported the heat transfer and pressure drop in various configurations. The heat transfer and fluid flow characteristics is determined in V shaped corrugated channels. The temperature contours,

streamwise velocity component, pressure distribution, streamline patterns and normalized mean Nusselt numbers are obtained.

Methodology

The V shape corrugated ribs are symmetrically placed on the top and bottom plates of a horizontal channel. A schematic diagram of the model is shown in Fig.1.

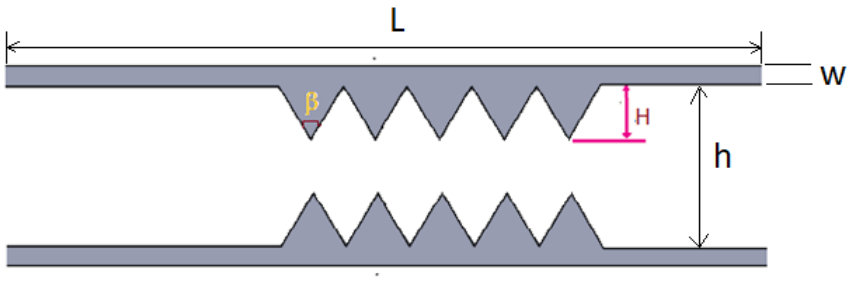

Fig. 1. The schematic of the model for $9.5 \leq L' \leq 18.5$

The heat transfer problem is solved with a software program FLUENT-18 by using k-ω SST turbulence model and then compared with the smooth plate.

The height of the duct, h, is taken as 0.05 m and kept constant for the whole system. All dimensions have been normalized with the height, L' = L/h = 20, for the length of the channel. The height of the corrugation is indicated as H' = H/h = 0.3 which has been kept constant for all numerical analyses. The corrugation angle β is taken three different values as 60°, 100° and 140°. The corrugation starts after the point of L' = 10 where the length is sufficient for the development of flow [26]. Heat transfer and flow characteristics are analyzed for Reynolds numbers of ($Re = U_\infty D_H / \nu$) 10000, 15000 and 20000. The thermophysical properties of the fluid is taken as constant in the solutions.

The boundary conditions for numerical solution taken as: uniform velocity inlet and pressure outlet have been defined at the inlet and the outlet of the duct, respectively. wall boundary conditions have been used in the regions where the fluid contacts the parallel plates. For the corrugated plate, the same boundary condition has been applied.

For deciding whether the solution is independent from the grid structure a correlation- which is given in Eq. 1 for the smooth parallel plate has been used for comparison of Nusselt numbers [27].

$$Nu = 0.021\ Pr^{0.5}\ Re^{0.8} \quad (1)$$

Table 1. Nusselt numbers obtained from different turbulence models at Re = 10000

Turbulence model	Nu
k-ε Realizable	97.63
k-ε Re-Normalisation Group (RNG)	115.37
k-ω Shear Stress Transport (SST)	86.43
k-ω Standard	87.55

It is very important to select a turbulence model for a simulation [28]. Different Nusselt numbers have been found by using k-ω SST turbulence model in the numerical analyses depending on the grid numbers as indicated in Table 2. The nearest result is obtained with the grid number of 6.6 x 10^5 when compared with the correlation.

Table 2. Nusselt numbers attained for different grid numbers via k-ω SST turbulence model at Re = 10000

Grid number	Nu
3 x 10^5	87.01
4.3 x 10^5	86.46
6.6 x 10^5	86.43
8.6 x 10^5	86.52
1.16 x 10^6	86.53

The skewness (maximum value ≤ 0.95) and the orthogonal quality (minimum value≥0.15) values have been obtained in the recommended intervals [29].

For the incompressible flow condition, the continuity and the momentum equations are given with Eqs. (2) and (3), respectively:

$$\frac{\partial \bar{u}_i}{\partial x_i} = 0 \tag{2}$$

$$\frac{\partial \bar{u}_i}{\partial t} + \frac{\partial (\bar{u}_i \bar{u}_j)}{\partial x_j} = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x_i} - \frac{\partial \tau_{ij}}{\partial x_j} + \frac{\partial}{\partial x_j}\left(\nu \frac{\partial \bar{u}_i}{\partial x_j}\right) \tag{3}$$

Energy equation, presented in Eq. (4), is solved for the heat transfer problems [29]:

$$\frac{\partial}{\partial t}(\rho E) + \frac{\partial}{\partial x_i}[u_i(\rho E + p)] = \frac{\partial}{\partial x_j}\left[\left(k + \frac{C_p \mu_t}{\mathrm{Pr}_t}\right)\frac{\partial T}{\partial x_j} + u_i(\tau_{ij})_{eff}\right] + S_h \tag{4}$$

Additional terms are expressed as the turbulent stresses that have to be included in the solution process enabled by the turbulence model. The equations of the turbulence model used is given in Eqs. (5) and (6) [29]:

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho k u_i) = \frac{\partial}{\partial x_j}\left[\Gamma_k \frac{\partial k}{\partial x_j}\right] + \tilde{G}_k - Y_k + S_k \tag{5}$$

$$\frac{\partial}{\partial t}(\rho \omega) + \frac{\partial}{\partial x_i}(\rho \omega u_i) = \frac{\partial}{\partial x_j}\left[\Gamma_\omega \frac{\partial \omega}{\partial x_j}\right] + G_\omega - Y_\omega + D_\omega + S_\omega \tag{6}$$

In these equations, k is the turbulent kinetic energy and ω is the specific dissipation rate. Moreover, $\tilde{G}_k$ stands for the generation of the turbulent kinetic energy owing to the average velocity gradients while G_ω is the generation of the specific dissipation rate. The effective diffusivity values of k and ω are represented via Γ_k and Γ_ω terms. Also, Y_k and Y_ω are the dissipation of k and ω because of turbulence. The cross-diffusion term is given by D_ω while S_k and S_ω are the user-defined source terms.

In the numerical analyses, the time step is taken as 0.0068 seconds and maximum twenty iterations per time step have been performed. However, the total number of the

iterations changes with the required analysis duration depending on the residuals of the equations as 10^{-8} for all analyses. As a result, the dimensionless wall distance has been found as $y^+ = u_* y/\nu \cong 1$ and matched with the criteria.

Results and Discussion

Turbulent flow and heat transfer characteristics, temperature contours, streamwise velocity component, pressure distribution, streamline patterns and normalized mean Nusselt numbers are obtained by numerical analyses between corrugated parallel plates are given for Reynolds number 10000, 15000 and 20000.

Time-averaged temperature (T) distributions have given obtained from numerical analyses. Although the numerical analyses have been performed for all Reynolds numbers in the present study, the temperature distribution inside the duct has been given for only Re = 10000 as an example in Fig. 2. Legend is changed between since it is assumed that fluid enters to the system at 300K while the walls are kept at 400K. It can be seen that temperature contours effected from the corrugations. The corrugations affect the temperature pattern just form the upstream of the first corrugation and continuous thorough the downstream of the last obstacle. It can be also seen from the Fig. 2 that the higher temperature values between corrugations are obtained for lower tile angle corrugations. As the angle increases fresh and cold inlet fluid get into gaps between corrugations. The temperature field gets similar pattern for all Reynolds numbers.. Time-averaged stream wise velocity components<u> have been given in Fig. 3 for only Re = 10000. As can be seen from the chart, the cross-sectional flow area of the duct is minimized due to the obstacles mounted on the plates. Therefore, there is an increase for the stream wise velocity components. This phenomenon is explained by ascending flow separation owing to the first rib on both top and bottom plates. Decrement of the corrugation angle causes flow separation and flow distortion affecting heat transfer since more chaotic flow structure is achieved by increasing the flow mixing. Axial velocity gets negative values between the corrugations due to flow circulation zones. Flow separation is more dominant on lower tile angles. Similar flow patterns are observed for the same corrugation angles for different Reynolds numbers.

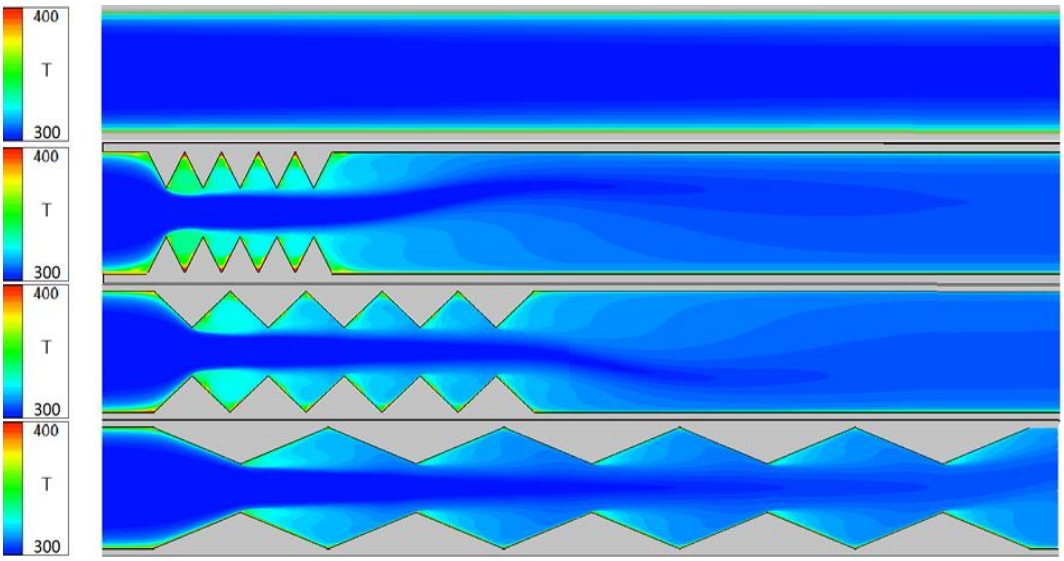

Fig 2. Temperature (T) contours for the channel at Re = 10000

Time-averaged streamline patterns have been given in Fig. 4 for only Re = 20000 as a result of the numerical analyses performed. Chaotic flow structure has been observed in the presence of the corrugation. Because of the obstacles for the flow the stream lines are destroyed and flow circulations can be seen between corrugations. While two discrete circulation zones can be seen for the corrugation angle of 60^{o} there are only one circulation zone for the other corrugation values. Effect of corrugation also continuous after the last obstacle at downstream region.

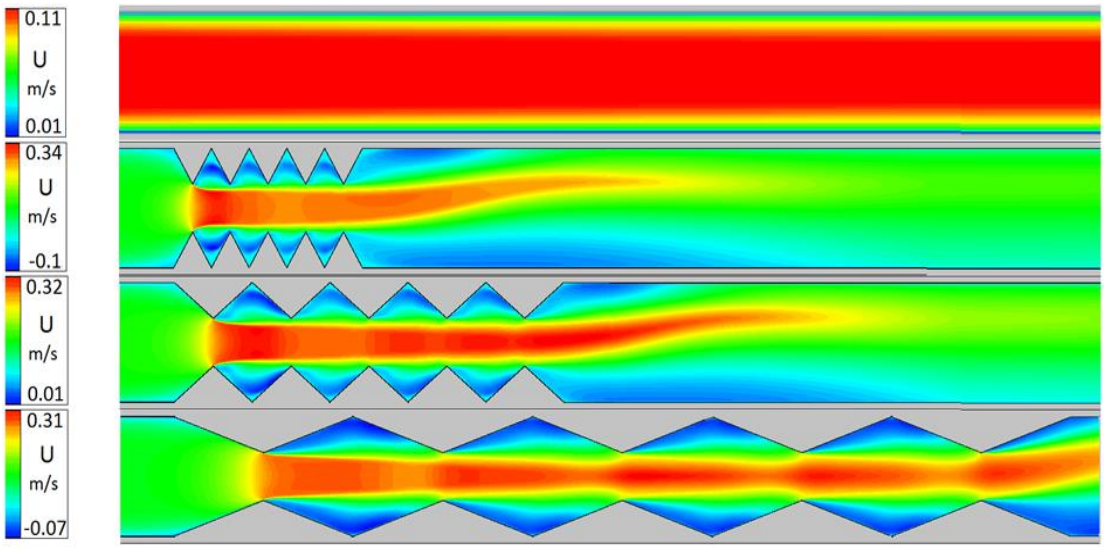

Fig 3. Axial velocity (U) contours for the channel at Re = 10000

Time-averaged pressure (P) distributions have been given in Fig. 5 for only Re = 15000 as a result of the numerical analyses performed. Pressure loss for the smooth plate has been attained less than the ribbed model as expected for all Reynolds numbers. There is an increase for pressure loss when Reynolds number is increased. Placing the corrugations on the plates also causes pressure loss. In lower corrugation angles the effect of the first obstacles is much dominant than the others. As the corrugation angle increases the pressure decreases gradually.

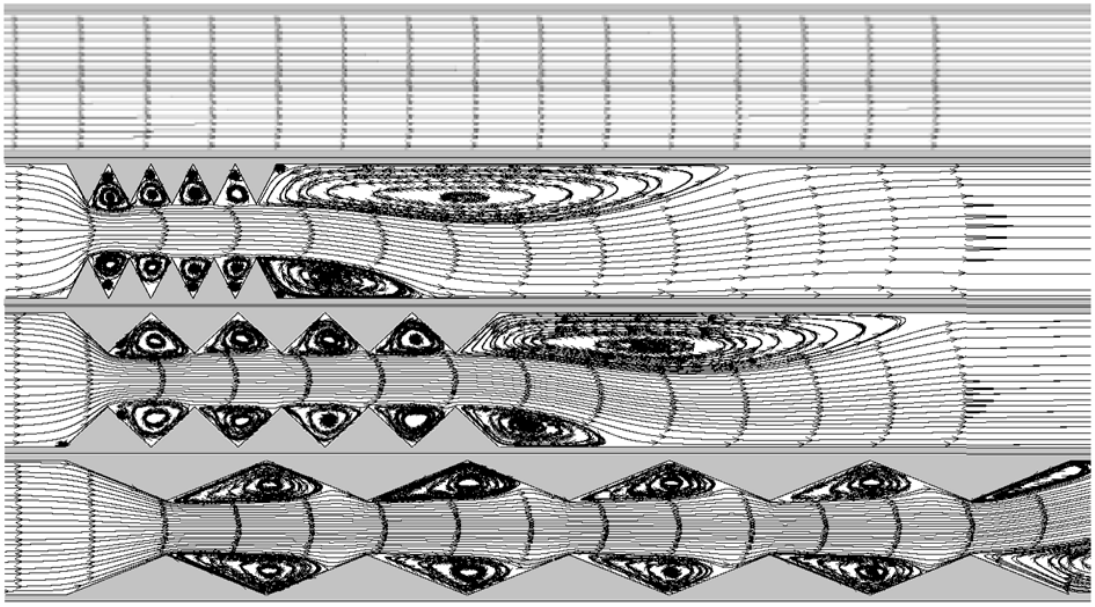

Fig 4. Stream lines for the channel at Re = 20000

Mean Nusselt numbers for Re = 15000 have been given in Fig. 6 for the ribbed plates and normalized with the ones of the smooth plates. Nusselt numbers are increased by mounting the corrugations on the internal sides of the plates when compared to the smooth plates. The level of the heat transfer increases as the angle of the corrugation increases. And the Nusselt values are increases as the Reynolds number values are increases.

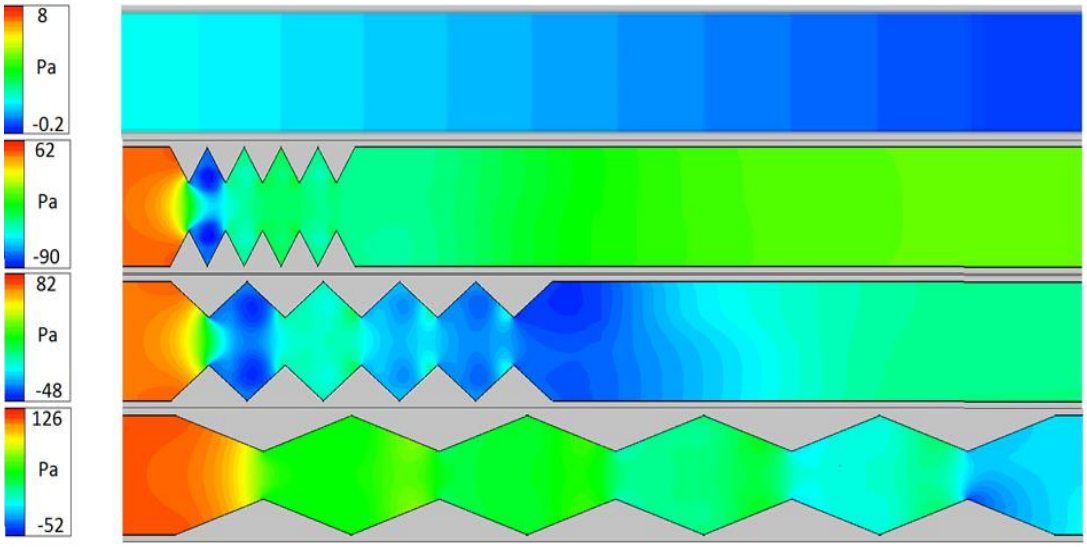

Fig 5. Pressure distributions (P) for the ribbed plates at Re = 15000

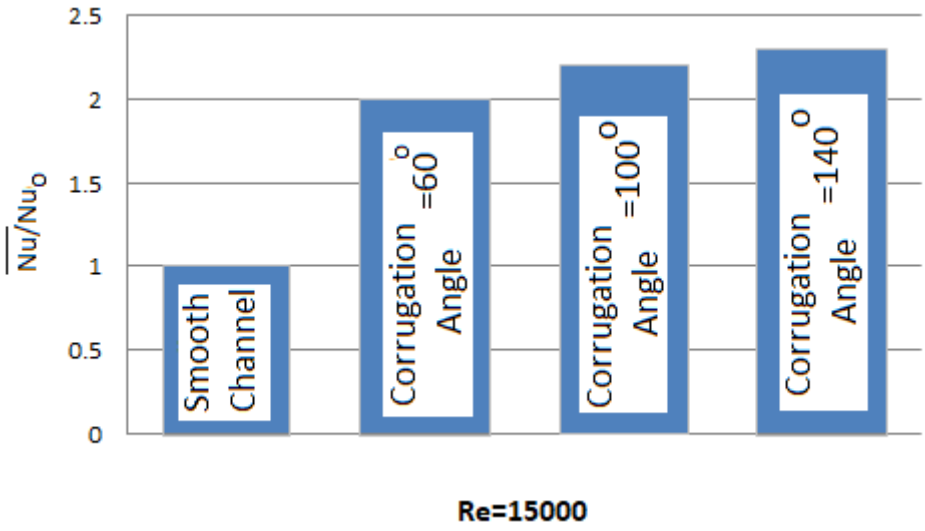

Fig 6. Normalization of mean Nusselt numbers($\overline{Nu}$) at Re = 15000

Conclusions

In the present study, the two dimensional turbulent flow and temperature fields in a channel with V-shape corrugations on the top and bottom walls are investigated by using k-ω SST turbulence model. The obstacles on the channel result in radical changes in the flow pattern. The flow being deflected from its own way. Major recirculation zones are occurs between corrugations as the corrugation angle decreases. As the corrugation angle increases smaller there can be seen smaller eddies and flow separations.

It is found that the V shape corrugated channel provides higher Nusselt number than the smooth plate. And as the corrugation angle increases the value of the Nusselt number increases. It is also found that the required pumping power increases than to the smooth plate. The pressure loss increases as the Nusselt number increases and also pressure loss increases as the corrugation angle decreases.

Nomenclature

CFD : Computational Fluid Dynamics
D_H : Hydraulic diameter [m]
D_ω : Cross-diffusion term
E : Energy [J]
G_k : Generation of turbulence kinetic energy
G_ω : Generation of dissipation rate
h : Distance between the plates [m]
h' : Dimensionless distance between the plates
H : Height of the corrugation [m]
k : Thermal conductivity coefficient [W/mK], turbulence kinetic energy [m^2/s^2]
L : Length [m]
L' : Dimensionless length
Nu : Nusselt number
P : Pressure [Pa]
Pr : Prandtl number
RANS : Reynolds-Averaged Navier-Stokes
Re : Reynolds number
RNG : Re-Normalization Group

SST	:	Shear Stress Transport
t	:	Time [s]
T	:	Temperature [K]
u	:	Streamwise velocity component [m/s]
U_∞	:	Free-stream velocity [m/s]
w	:	Thickness [m]
w'	:	Dimensionless thickness
y^+	:	Dimensionless wall distance
Y	:	Dissipation due to turbulence
Γ	:	Effective diffusivity
ΔP	:	Pressure loss [Pa]
μ	:	Dynamic viscosity [Pas]
ν	:	Kinematic viscosity [m^2/s]
ρ	:	Density [kg/m^3]
τ	:	Stress [Pa]
Ψ	:	Streamline pattern
ω	:	Specific dissipation rate, vorticity [s^{-1}]

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THE RUTTING PERFORMANCE OF ASPHALT SURFACE COURSE AND ASPHALT BINDER COURSE OF HIGHWAY

Dr. Mehmet Ali LORASOKKAY

Selcuk University, Higher School of Vocational and Tech. Sci., Konya, Turkey
E-mail: mlorasokkay@selcuk.edu.tr

Abstract

Highways are transport heavy and moveable loadings more than another engineering structures. Rutting settlements are occure in hot mix asphalt pavement layers and resistance against deformations is in decrease with the effect of hight temperatures and long loading periods by indicating a viscous behaviour. Height quality and durable road a pavement constructing was become compulsory in order to supply with recently rapid increasing in traffic volume and increase the life service of the pavements. In-situ rutting performance of asphalt surface course and asphalt binder course that frequently used in highways as types of hot bituminous mixture pavement is determined with Hamburg Wheel Tracking Test in laboratory.

Keywords: Hot mix asphalt, Permanent deformation, Hamburg wheel tracking test.

INTRODUCTION

Rutting is defined as the accumulation of small amounts of unrecoverable strain resulting from applied wheel loads to HMA pavement. This deformation is caused by consolidation or lateral movement, or both, of the HMA under traffic. Rutting not only decreases the useful life of a pavement but also creates a safety hazard for the traveling public (Cooley vd., 2000).

The Hamburg Wheel Tracker Device has been used for over thirty years to evaluate the performance of asphalt pavements in terms of rutting susceptibility and moisture damage (Cox vd., 2013). In 1970, Esso A.G. developed by Hamburg in Hamburg, measures the combined effects of a steel wheel motion and water damage along the surfaces of asphalt concrete samples immersed in hot water. After the number of wheel passages was 10,000,

some blend samples were damaged due to water (Romero ve Stuart, 1998).

In a 1993 study in Colorado, Hamburg reported that the results of the wheel traces best reflect the wheel track that has taken place due to moisture sensitivity (Izzo ve Tahmoressi, 1999).

In-situ rutting performance of asphalt surface course and asphalt binder course that frequently used in highways as types of hot bituminous mixture pavement is determined with Hamburg Wheel Tracking Test in laboratory.

MATERIAL AND METHOD

In the scope of the study, cored specimens of 150 mm diameter were taken from certain places of the traffic lanes in the Wear and Binder layers on some main arteries in Konya.

Figure 1. Obtaining the asphalt coring samples

The AASHTO T324 test procedure is used to test the hardness and fatigue resistance of hot mix asphalt samples in the Hamburg tire tracker.

Wear resistance of the core samples of the Wear and Binder Layer were made according to AASHTO T324 method. In this study limestone aggregate and 50/70 penetration grade bitumen were used (Table 1).

Table 1. Properties of binders used

Properties	Standard	Experimental Results
Penetration (25 °C, 1/10 mm)	ASTM D 5	54
Softening Point (°C)	ASTM D 36	44
Ductility (25 °C, 5 cm/min)	ASTM D 113	>100

In Table 2. aggregate grading, bitumen content and bitumen grades used in the experiments are given.

Table 2. *Mix Gradations and Asphalt Cement Contents*

Sieve Sizes mm	Wearing course % passing	Binder course % passing
25.0	100.0	100.0
19.0	100.0	91.5
12.5	92.2	69.7
9,5	84.0	57.6
4.75	49.5	39.1
2.0	31.0	25.2
0.425	14.5	13.4
0.18	10.3	9.1
0.075	4.5	4.2
Asphalt Cement Grade	**PG 64-22**	**PG 64-22**
Asphalt Content (%)	**4.48**	**3.92**

hamburg wheel-track testıng

Experimental study was carried out by using Controls brand "77-PV31A05 PAVELAB DWT Hamburg Type double wheel tracker" type test device in Selçuk University, Faculty of

Engineering, Civil Engineering, and Transport Laboratory.

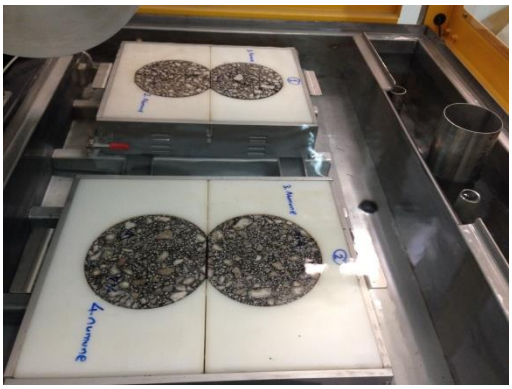

Figure 2. Hamburg Type double wheel tracker

Abrasion and core samples of 150 mm in diameter taken from the bedding asphalt layer were first cut to 60 mm thickness on the asphalt cutting machine and 7.5 mm from the sample edges for the wheel test to bring the reference mold to the appropriate dimensions.

The experimental study was conducted at a temperature of 50 °C as the medium and service temperature that can be seen in the roads.

Initially 100 cycles were applied at 25 °C to reinforce the core specimens and to have a smooth surface.

Abrasion and Binder layer were conditioned by holding the core samples in water for 30 minutes at the test temperature before starting the experiment. 705 N loads were applied to the wheels with a speed of 26 rpm.

In the experimental study, 20.000 wheel passes were applied to the core specimens in another 10.000 cycles.

The depths of the wheel traces in the samples are instantly measured by the automatic sensor. In PAVELAB DWT Hamburg wheel track device, the pre-test and post-test conditions of the cored specimens of the wear and layer are given in the form.

Figure 3. Appearance of samples after experiment

Traffic and water effects are the most important factors in the deterioration of asphalt concrete coatings. Table 3. shows the mean wheel trace depths at 50ºC of the core samples taken from the automatic sensor at 100, 300, 500, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000 and 10000 cycles after the start of the test.

Table 3. *Wheel Depths (mm)*

Number of Cycles	Wearing course Rut Depth (mm)	Binder course Rut Depth (mm)
100	1.683	1.452
300	2.631	2.627
500	3.196	3.370
1000	4.492	4.736
2000	6.059	5.921
3000	7.382	6.641
4000	8.521	7.130
5000	9.462	7.428
6000	11.022	8.066

7000	13.032	8.431
8000	13.838	8.807
9000	14.839	9.119
10000	15.709	9.516
Max. Relative Density	2.415	2.391
Air voids (%)	4.92	4.58

In the Hamburg wheel test, the test results of the cored specimens of the Wear and Binder layer are evaluated and the depths of the wheel traces in 20000 passages are shown in Figures 3.7 to 3.9. The wheel trace resistances of the Wear and Binder Layer core samples, which were realized using Controls brand "77-PV31A05 PAVELAB DWT Hamburg Type double wheel tracker" type test device, were made according to AASHTO T324 method. At the end of 10.000 cycles (20.000 wheel passes) of the core samples; Asphalt Wearing Layer **15,709 mm** and asphalt Binder layer **9,166 mm** have undergone permanent deformation.

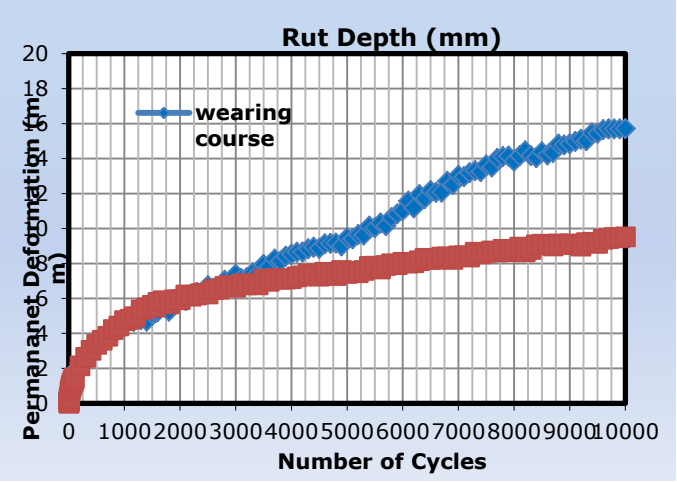

Figure 4. *Wear and Binder Layer Wheel Track Depth*

CONCLUSIONS AND RECOMMENDATIONS

The tendency of cities to develop continuously is increasing the speed of roads and their usage. Flexible superstructure road coverings are deteriorated by exposure to wear and tear, which is caused by time, weather conditions and repetitive traffic.

Wheel tracks seen in road asphalt coatings are caused by insufficient or weak base layers of asphalt layer.

Binder asphalt layer has been observed to be less affected by temperature and water effects, and is more resistant to plastic deformation and peeling.

In the wheel trail test, water damage along with wheel passages was also effective in increasing deformation. Water weakens adhesion between bitumen and aggregate and accelerates deformation.

While the Binder Layer core samples reached 9,516 mm deformation at 20,000 wheel passes, the wear layer core deformation showed 15,709 mm deformation at 20,000 wheel passes. Binder asphalt layer samples, according to asphalt wear layer samples; 65% better wheel track performance.

The main reasons why more tire tracks are seen on asphalt wear layer samples are; The higher percentage of bitumen compared to the binder layer, the excess of fine material, heavy and high number of repetitive loads can be counted.

The use of the Binder layer in road work improves the wheel track performance of the flexible top structure.

Durable aggregates should be used in roads with heavy vehicle traffic and high bituminous binders with performance class should be preferred.

In Bituminous Hot Mixtures, the use of the Wear layer as Modified Wear will provide significant economic benefits in the long run in roads with heavy vehicle traffic.

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EFFECTS OF APPLICATIONS OF ARBUSCULAR MYCORRHIZAL FUNGUS SPORES AND K-HUMATE ON THE DEVELOPMENT OF ONION PLANT

Emel ATMACA[1] Ummahan ÇETİN KARACA[2]

[1,2] *Selcuk University Agriculture Faculty, Soil Science and Plant Nutrition Department Campus/Konya/TURKEY*
[1]: Corresponding Author: *ekaraarslan@selcuk.edu*.tr
Mobile: +905392828292

Abstract

It is crucial to investigate the mechanisms, that are in nature and harmless to the nature, for ensuring the continuity of the cultivated soil in sustainable form. The present study aims to determine the effects of K-Humate, lack of harmful compound, and arbuscular mychorrizal fungus (AMF) spore, a microbial fertilizer and can be found in nature, on certain growth parameters of onion plant, which has an important cultivation area. The application of K-Humate and AMF spores addition single and binary was conducted on a total of 24 pots in laboratory conditions and in a randomized plot design with six replications. The plant growth chambers are used in the Laboratory of Plant Physiology of Soil Science and Plant Nutrition Department.

Shoot ratio, shoot length, leaf number and leaf chlorophyll content were obtained from the plants before harvesting. After cultivation of 40 days, the biomass, shoot wet-dry weights, root length, root wet-dry weight and ratio of mycorrhizal infections in plant roots are determined from harvested plants. Microbial respiration and mycorrhizal spore number are also determined in the trial soils of harvested plants. Generally the inspected parametric values are found to be highest according to the correlation of dual combination application. However, the values obtained were found to be statistically significant in some applications, whereas they were not found to be significant in some others ($P<0.01$).

Keywords: Arbuscular mycorrhizal fungus (AMF) spore, onion, K-Humate, sustainability.

INTRODUCTION

The mycorrhiza fungi can be benefit to plants by enhancing the availability of soil water and nutrients (Smith and Read 1997). The inoculation may improve crop yield by increasing the capacity of plant to obtain nutrients that are relatively immobile in the soil such as phosphorus (Rhodes 1980; Jansa et al. 2003). Humic acid is an organically charged bio-stimulant that significantly affects plant growth and development and increase crop yield. It has been extensively investigated (Nardi et al. 2004). Humic acid improves physical (Varanimi et al. 1995), chemical and biological properties of soil (Keeling et al. 2003; Mikkelson 2005). The role of humic acid is well known in controlling soil borne diseases and improving soil health and nutrients uptake by plants, and increasing mineral availability (Mouromical et al. 2011).

It is known that in the whole region of Turkey the soil is deficient from organic matter.

And it is impossible to apply of sufficient amount of organic manure to whole country region. Instead of this, less amount of humic and fulvic acide, that are activated fraction of organic matter and humus, can be used. Thus the fertility potential of the soils of Turkey can be improved (Gezgin et al. 2012).

Organic matters can be converted to non-humic matters as; carbohydrate, aminoacide, proteins, lipids, nucleic acide and lignin and humic matters as; fulvic, ulmic, humic acides, humin by chemical and biological decomposition and degradation (Gezgin et al. 2012). Humified organic matter is also known to increase microbial growth and activity.

This study is made in order to examine the application of single and binary combinations of K-Humate, that is a soil regulator and source of organic matter, and arbuscular mycorrhiza, which is a life form of a biotrof, on onion plant grown.

MATERIAL AND METHODS

100% locally grown pearl onion, also known as shallot (marketed with the code TR-45-K-006049 in 500-gram packages, grown in Acıpayam) was used in the experiment. Microbial fertilizer produced under license by the Ministry and marketed under the trade name of Shubhodaya containing $1x10^5$ Glomus spp. (propagule/kg) was applied as 4g per pot (approximately 100 spores) based on the advised dose. A mixture of (turf : river sand : perlite)

was used on a (1:1:1) unit volume basis. Transparent plastic pots with a capacity of 500 g were used.

In the trial the source of K-Humate, fluid and natural organic soil amendments is used which is produced by TKİ (The *General Directorate* of *Turkish Coal* Mining Administration) (12% Humic+Fulvic and 5% organic matter and pH=11) (Mtua et al. 2015).

Before the experiment was set up, the pots were cleaned by washing with tap water and distilled water to prevent any contamination, and the transparent pots were covered with aluminum foil to protect the plant roots from sunlight. After the pots were filled with the abovementioned mixture, spores were applied under the shallots in the applications with AMF spore inoculation, and the sludge was applied as 10% of the pot soil under the shallots in S.S. applications. A suitable humidity level was maintained for the soil in the pots and 3 onion shallots were planted per each pot. The experiment involved the application of K-Humate (KH) and AMF spores in single and binary combinations, one type of plant (onion) and 6 replications in a total of 24 pots, and conducted in a randomized plot design in the plant growth chamber of the Plant Physiology Laboratory of our Department. The experiment was set up on March 5, 2018 and finalized on April 25, 2018.

Certain parameters determined in the plant

Pre-harvest Procedures

Shoot length (cm), plant off shoot number (item), leaf number (item), leaf chlorophyll content (SPAD reading)

Post-harvest Procedures

Shoot fresh-dry weight (g), root length (cm), root fresh-dry weight (g), biomass (g), microbial respiration value ($mgCO_2$/100g FKT/24hrs) (Isermayer, 1957), mycorrhizal spore number (items/10 g soil) (Gerdeman and Nicolson, 1963), root staining for determining mycorrhizal infection (Koske and Gemma, 1989), mycorrhizal infection rate (%) (Giovannetti and Mosse, 1980).

RESULTS AND DISCUSSION

In this study on determining the effects of mycorrhizal spore and K-Humate (KH) application in single and binary combinations on certain growth parameters of onion plant; the highest values for onion plant shoot length, shoot fresh-dry weight, biomass value, root fresh weight, leaf chlorophyll content, mycorrhizal spore number and mycorrhizal infection rate (47.17 cm, 15.16 g, 2.03 g, 18.44 g, 4.11 g, 51.00 spad reading, 14.00 spore number/10 g soil, 36.67% respectively) were obtained through the binary application of arbuscular mycorrhizal spores with KH. Of these parameters the effect of the application mycorrhizal spore number and mycorrhizal infection rate were found to be statistically significant ($P<0.05$), whereas the findings were not statistically significant for the others (plant shoot length, shoot fresh-dry weight, biomass value, root fresh weight, leaf chlorophyll content) (Table 1.).

The highest root length and microbial respiration values in the plants (18.28 cm, 29.04 mg CO_2/100 g dry soil) were observed with AMF spore inoculation. The effect of the applications on root length and microbial respiration values were found to be statistically significant ($P<0.05$) (Table 1.).

While the highest value in leaf number and root dry weight (6.33 item, 0.53 g) were obtained from the control, the effect of the applications on this value was not found to be statistically significant ($P<0.05$ or $P<0.01$) (Table 1.).

Table 1 *The effects of mycorrhizal spore and K-Humate application in single and binary combinations on certain growth parameters of onion plant.*

Application	Shoot length (cm)	Shoot fresh weight (g)	Shoot dry weight (g)	Biomass (g)	Plant off shoot number (item)	Leaf number (item)	Root length (cm)	Root fresh weight (g)	Root dry weight (g)	Chlorophyll content (spad reading)	Microbial respiration $mgCO_2/100g/DS$	Mycorrhizal spore number item/10g soil	Mycorrhizal infection rate (%)
CONTROL	40.50	12.29	1.79	15.79	2.00	6.33	16.27B	3.49	0.53	49.88	13.13B	0.00C	0.00C
AMF	45.67	9.11	1.49	12.68	1.67	4.17	18.28A	3.61	0.40	50.28	29.04A	5.33B	10.00B
K-Humate	37.83	9.75	1.73	14.33	2.00	5.50	13.47C	3.28	0.46	46.38	4.18C	0.00C	0.00C
AMF+ K-Humate	47.17	15.16	2.03	18.44	2.00	6.00	17.00AB	4.11	0.46	51.00	16.09AB	14.00A	36.67A
Significance LEVEL	NS	NS	NS	NS	NS	NS	P<0.05	NS	NS	NS	P<0.05	P<0.05	P<0.05
LSD	---	---	---	---	---	---	**1.557**	---	---	---	**7.219**	**1.718**	**5.434**

While extensive amounts of Fusarium spp. were observed particularly in the petri media planted with KH dilution and Penicillium spp. were extensively observed in the petri media planted with soils in which AMF spores were applied, correlatively Fusarium spp. and Penicillium spp. were extensively observed in binary combinations (Photo 1).

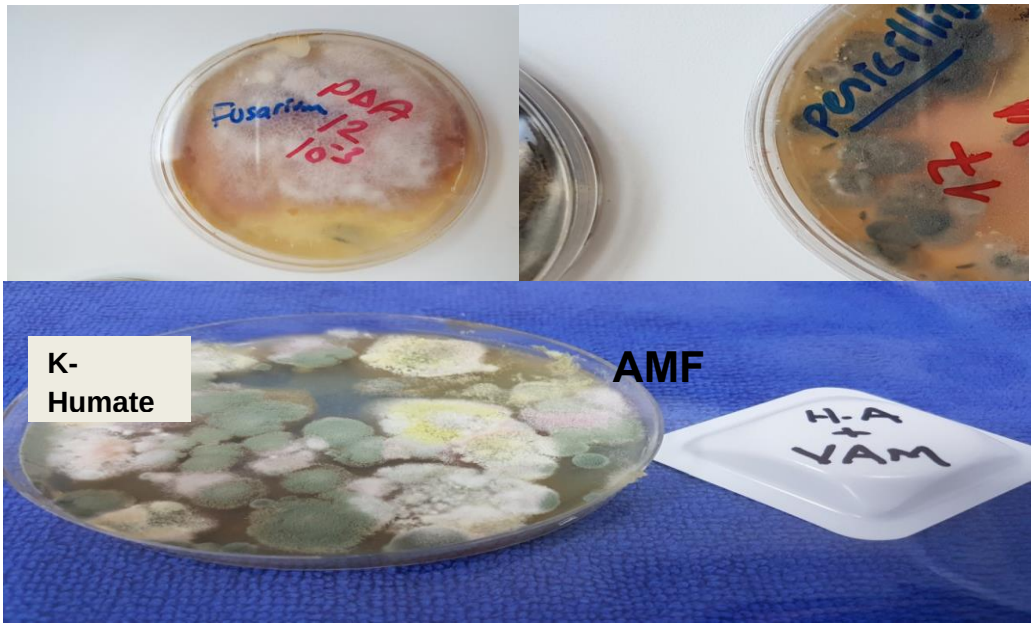

Photo1. *The view of Arbuscular mycorrhiza, KH and their binary combinations diluted petri media planted*

That the onion plant grown in a turf : river sand : perlite medium without any fertilization in a vegetation period of approximately 40 days did not show any nutrient element deficiency could indicate that the nutrient element content of KH is suitable for plant production. Obtaining the highest values for several parameters in the plant with the AMF spore +KH application could result from that KH is not toxic for AMF spores, or the elements it contains are at a level that can activate AMF spores. Many different organic amendments have been reported to influence AM fungal root colonization. For example, chitin (Gryndler et al. 2003) and humic substances (Gryndler et al. 2005) enhanced colonization levels, whereas cellulose reduced colonization by the AM fungus (Avio and Giovannetti 1988; Gryndler et al. 2003). Gryndler et al. (2003) also observed neutral to positive effects of chitin amendment on the spore production of various Glomus species.

Compared to the single application of AMF spores, the high AMF activity observed in the binary combination with KH could be because KH eliminated the firming effect on the soil caused by the heavy clay structure of the commercial mycorrhizal fertilizer used in the study. Many authors have reported that humic substances positively affect plant growth by increasing soil aggregation, aeration, and permeability (Tan and Nopamornbodi 1979a; Mylonas and McCants 1980; Rauthan and Schnitzer 1981; Mt~ller-Wegener 1988). Humic substances were found to stimulate plant growth since they increased the absorption of soil nutrients (Vaughan and McDonald 1971), allowed a greater distribution of metal ions (i. e., heavy metals) as chelates within the plant (Kononova et al. 1966; Weber 1988), and affected metabolic reactions (Flaig 1970; Cacco and Dell'Agnola 1984).

Extensive fungal and bacterial colonies were observed in the media prepared with KH, AMF spores, and their combinations. Humified organic matter is also known to increase microbial growth and activity. Visser (1985 a) pointed out that humic acids, if added to selective media, could increase the growth of a wide range of taxonomic and functional groups of soil bacteria and he hypothesized that a modification of cellular activity and growth might be promoted by humic substances through their influence on cell membrane permeability or on nutrient absorption (Visser 1985 b).

CONCLUSIONS

In conclusion, it can be said that during the inoculation of any microbial fertilizer such as AMF spores in greenhouse and field plants, the medium should have a particularly good air and water composition for better activation of spores, which can be maintained by the addition of an organic matter to the soil. In the future works, we will try to examine the interactions among various doses of KH, with different rhizospheric microorganisms, with different plants and with various growth media.

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DETERMINATION OF THE EFFECTS OF FREE-RANGE RAISING SYSTEM ON THE HISTOLOGY OF ILEUM IN BROILER CHICKENS FED WITH DIFFERENT PLANTS

Emrah SUR[1] Tahir BALEVİ[2] Banu KANDİL[3]
Özcan ÇİTİL[2] Oğuzhan KAHRAMAN[2]

[1]*Dep. of Histology and Embryology, Faculty of Vet. Med., Selçuk University, 42031, Campus, Konya, Turkey*
[2] *Dep. of Animal Science, Faculty of Veterinary Medicine, Selçuk University, 42031, Campus, Konya, Turkey*
[3] *Dep. of Histology and Embryology, Faculty of Vet. Med., Siirt University, 42031, Siirt, Turkey*
**corresponding/presenting author: tbalevi@gmail.com*

Abstract

This study was carried out to determine the effect of free-range raising system on the histology of ileum in broiler chickens fed with different plants.

Each group consisted of 4 main groups and also 4 subgroups. Group 1 control group and groups 2 (Clover), 3 (Bromus Inermis) and 4 (Clover and Bromus Inermis) were designed astrial groups. All the chickens in any subgroups will also be fed *Origanum vulgare L.*. The first group was fed as a control group only in closed mobile poultry. The second group was fed with concentrated feeds, clover and thyme. Besides, the third group wasfed with concentrated, blanched bromine and thyme. The fourth group was fed with concentrated feed, clover, free bromine and thyme. The first 4 subgroups (as control group) were grown only in closed mobile poultry. The mobile poultry (5-6; 7-8; 9-10 and 11-12) was placed horizontally in the cultivated areas located in the second and third groups. In the last group, the mobile poultry (13-14 and 15-16) were placed vertically for consuming both clover and free bromine and thyme by broilers. Each mobile poultry was divided into two sections (totaling 16 subgroups). In the experiment, totally 480 chicks and so 30 broiler chicks were used in each subgroup. Broiler chickens were placed in subgroups approximately two square meters for 15 animals to per m^2. It allowed to growth of coarse feeds in trial sites. Mobile clusters which were used for groups 2, 3 and 4 were replaced once a month. In the control group, only the broilers fed in the poultry were cut at the end of the 6th week (42th day). The experiment was

carried out 42 days. At the end of the trial villus height were found to be 564.33, 636.30, 705.82 and 583.08 µm; Thickness of tunica muscularis 274.47, 349.68, 360.81 and 281.53 µm.

Conclusion: Although the clover and *Bromus inermiş* supplementations effected the histology of ileum in concentration dependent manner, the most desirable results for all evaluated parameters were obtained from animals supplemented alone *Bromus inermiş* compared to the other groups.

Keywords: Free range system, *Bromus inermis,* chicken, clover, histology, ileum.

* This work is a part of the project supported *by The Scientific and Technological Research Council of Turkey* (TUBİTAK) (Project No: 114O753).

MATERIAL AND METHODS

The project was carried out in Hümeyra Özgen Research and Application Farm in Selcuk University Veterinary Faculty. Clover, Bromus inermis, clover + free bromineand also thyme *(Origanum vulgare L.)* were planted to test area for feeding each subgroup.

Feeding Material

First of all, ration was prepaired for broiler chicks. The feedstuffs were obtained fromthe market and prepared in a special feed factory. The broilers were fed with starter broiler feeds as ME of 2900 kcal and an HP of 23% during the first 4 weeks. Nutrient content of the rations was prepared taking into account the nutrient levels determined by NRC (1994) used in the experiments. In addition, lysine amino acid addition was performed to fix the needing of broiler chickens. After 28 days, broilers were picked up to mobile poultry and fed with 3200kcal of ME and 20% of HP until day 42. Likewise, the ration food content was prepared taking into account the nutrient levels determined by NRC (1994) used in the experiments. Before the chicks arrived, one mobile house was prepared. Feeders and syringes were passed through by the eye, and the osmolality and the degree were set. The heaters mounted on the wall of themobile clusters and temparature was set as 35 ° C.

Animal Material

One daily 480 slow-growing male Hubbard Isa Red-JA broiler chicks were purchased from Ankara for using in the research. Male Hubbard Isa Red-J broiler chicks were weight done by one and was placed in to the mobile pens. Firstly, sugary water were given to broilers. Approximately 2 hours later, meat chick powder feeds which had been prepared before were placed on feeders (table chick). Broilers were fed with these prepared rations in *Manas J. Agr. Vet. Life Sci, 2017, 7 (1), 80-88*3 the mobile poultry for 0-14 days. At the 14th day, male Hubbard Isa Red-JA chicks were weighed and feed consumption were determined.

Experimentation

Each group consisted of 4 main groups and also 4 subgroups. Group 1 control group and groups 2 (Clover), 3 (Bromus İnermis) and 4 (Clover and Bromus İnermis) were designed astrial groups. The first group was fed as a control group only in closed mobile poultry. The second group was fed with concentrated feeds, clover and thyme. Besides, the third group wasfed with concentrated, free bromine and thyme. The fourth group was fed with concentrated feed, clover, free bromine and thyme. The first 4 subgroups (as control group) were grown only in closed mobile poultry. The mobile poultry (5-6; 7-8; 9-10 and 11-12) was placed horizontally in the cultivated areas located in the second and third groups. In the last group, the mobile poultry (13-14 and 15-16) were placed vertically for consuming both clover and free bromine and thyme by broilers. Each mobile poultry was divided into two sections (totaling 16 sub-groups). In the experiment, totally 480 chicks and so 30 broiler chicks were used in each subgroup. Broiler chickens were placed in subgroups approximately two square meters for 15 animals to per m^2. It allowed to growth of coarse feeds in trial sites.

Mobile pens which were used for groups 2, 3 and 4 were replaced once a month. In the control group, only the broilers fed in the poultry were cut at the end of the 6th week (42th day).

At the end of the study (42th day), the birds were killed by cervical dislocation. The ileum samples were collected. After routine hitological process, the serial sections were stained with Crossmon's trichrome (Culling et al, 1985). All sections were evaluated under the light microscope and were photographed by digital camera and were recorded. Villus height,

villus width (Figure 1), crypt depth (Figure 2), and thickness of tunica muscularis (Figure 3) were measured.

Statistical analysis: The data obtained from this study were analyzed by using one-way analysis of variance and followed by post hoc Duncan multiple comparisons test using the Statistical Package for Social Sciences (SPSS version 15.0; SPSS Inc. Corp., USA). Results were considered at significant at P<0.05.

Table 1. *The villus height, villus width, crypt depth and thickness of tunica muscularis of ileum.*

Groups	Villus height±SE (µm)	Villus width±SE (µm)	Crypt depth±SE (µm)	Thickness of tunica muscularis ±SE (µm)
Control	564,33±23,45^{c}	153,16±6,89^{b}	128,82±4,53^{b}	274,4720±10,16^{b}
Clover	636,30±22,54^{b}	151,73±4,51^{b}	141,15±4,97^{b}	349,6840±14,24^{a}
Bromus inermis	705,82±25,26^{a}	183,54±5,85^{a}	162,79±6,70^{a}	360,8060±14,57^{a}
Clover + bromus inermis	583,08±14,34b^{c}	160,66±6,08^{b}	134,56±5,33^{b}	281,5340±10,35^{b}
	P<0,001	P<0,001	P<0,001	P<0,001

a–c: Values within a column with no common superscripts are significantly different (P<0,001).

Results: The average villus height and thickness of tunica muscularis were increased in clover and *Bromus inermis* groups where as the crypt depth and villus width were increased in only *Bromus inermis* group (P<0,001). In clover+*Bromus inermis* group, all data were higher than control group but the differences were not statistically important (P>0,05). The most higher results were found in *Bromus inermis* group (P<0.001, Table 1).

DISCUSSION

The ileum is the last segment of the small intestine and it may play crucial role for digestion and absorption of important nutrients such as starch in fast-growing broilers (Shivus, 2014). Also, ileum is widely known as the local site of immune activation (Simon et al, 2014). The height of intestinal villi is related to absorption capacity because of higher villi represents the greater villus surface area and the greater absorption of available nutrients (Jazideh et al, 2014). Greater villus sizes increase the activities of some digestive enzymes secreted from the intestinal epithelial cells, resulting in improved digestibilty and better growth performance (Muthusamy et al, 2011). Moreover, because the intestinal crypts is

accepted as cell factory, deeper crypts mean a fast cell renewal. This cell turnover is very important especially when animals are suffered from intestinal infections because it is necessary for the intestinal improvement in these animals as soon as possible for normal growth (Ahmed et al, 2016). The layer of tunica muskularis, which is located in the intestinal mucosa and consists of smooth muscles, is responsible for intestinal motility and contraction which plays a vital role in terms of enhancing the contact of nutrients with the absorbent surface, as well as mixing intestinal content (Çetingül et al, 2015, Sur et al, 2017). Therefore, the thickness of this muscle layer is thought to be positively related to the absorption processes. These data obtained from this study may be important for newly hatching animals, because their digestive and immune system sare not well developed and these animals are more sensitive to some certain young avian diseases. It was concluded that although the clover and *Bromus inermis* supplementations effected the histology of ileum in concentration dependent manner, the most desirable results for all evaluated parameters were obtained from animals supplemented alone *Bromus inermis* compared to the other groups.

Figure 1. *A section from ileum of a control group animal. Black bar: Villus height, Red bar: Villus width. Crossmon's trichrome stain.*

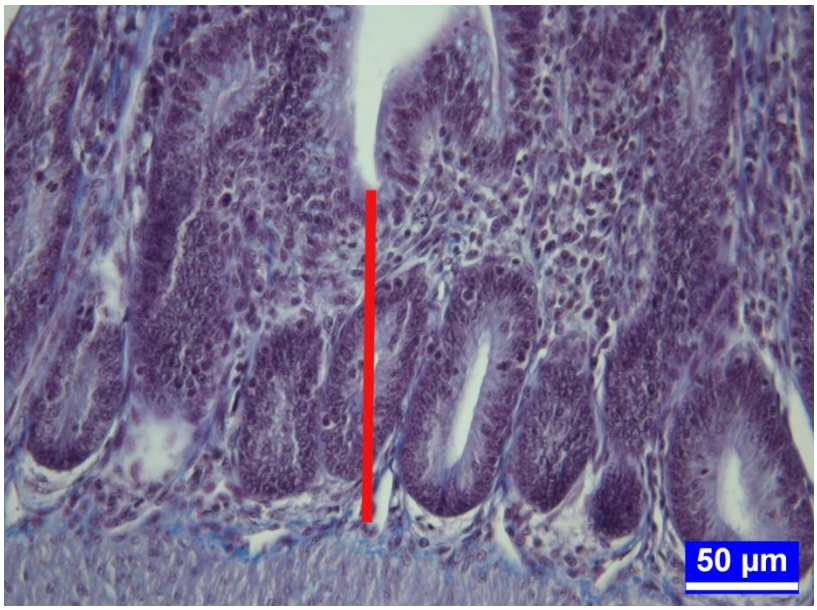

***Figure 2**. A section from ileum of a control group animal. Red bar: Crypt depth. Crossmon's trichrome stain.*

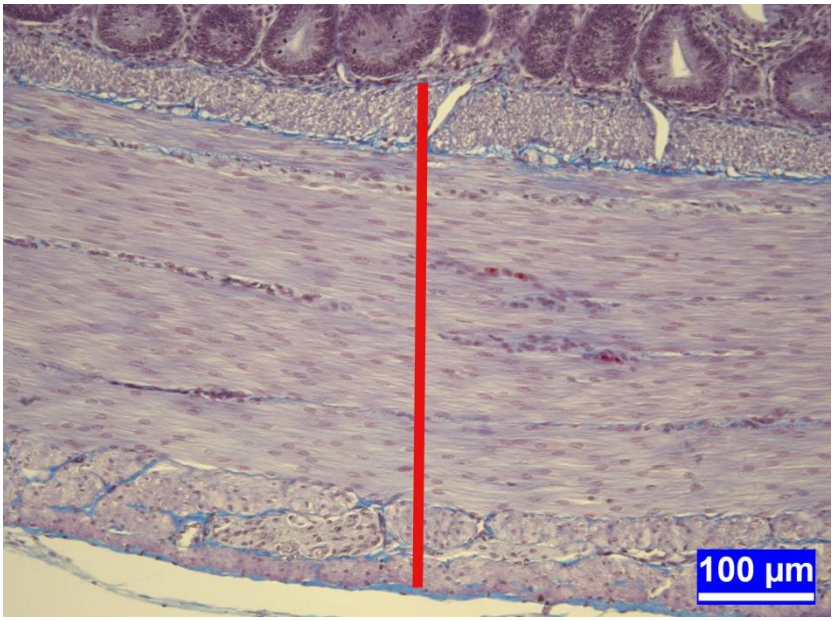

***Figure 3**. A section from ileum of a control group animal. Red bar: Thickness of tunica muscularis. Crossmon's trichrome stain.*

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DETERMINATION OF THE EFFECTS OF FREE-RANGE RAISING SYSTEM ON THE HISTOLOGY OF ILEUM IN BROILER CHICKENS FED WITH RESTRICTED FEED*

Emrah SUR[1], Tahir BALEVİ[2], İlknur Tekdemir ÜNDAĞ[1]
Derya ARIK[2, 3] Abdullah ÖZBİLGİN[2]

[1]*Dep. of Histology and Embryology, Faculty of Vet. Med., Selçuk University, 42031, Campus, Konya, Turkey*
[2]*Department of Animal Nutrition and Nutritional Disorders, Faculty of Veterinary Medicine, Selçuk University, 42031, Campus, Konya, Turkey*
[3]*Department of Animal Nutrition and Nutritional Disorders, Faculty of Veterinary Medicine, Near East University, Nicosia, Cyprus*
**corresponding/presenting author; tbalevi@gmail.com*

Aim

This study was performed to determine the effects of concentrate feed restriction on the histology of ileum in broiler chickens.

Abstract

The study was carried out in order to reveal the effects of carcass production on the free carbohydrate breeding of the free system broiler chickens. Approximately 4 decares of clover, *Bromus inermis* or clover + *Bromus inermiş f*ound in the Research and Application Farm of the Veterinary Faculty of the University of Selcuk, It was made in the field surrounded by mobile wires. All the chickens in any subgroups will also be fed *Origanum vulgare L.*. In the experiment, 480 slow-growing male Hubbard Isa Red-J broiler chicks were divided into 4 main groups and 4 subgroups in each main group. At the end of the 28th day, the broods outside the control group were opened at 7:00 am and released to the mountains. The broodsters who graze in grassland were taken back into the mobile poultry at 19:00 hours before the evening weather. In the experiment, feed was kept in front of the control group (group 1). In the second group, 75% of the first group consumed the food, 50% in the third group and 25% in the fourth group. Groups 2, 3 and 4 also fed alfalfa, unbranched bromine and thyme grass. The concentrate feed consumption of the first group was determined on a daily basis and this value was based on the amount of daily feed to be given to the other groups the next day. The control group was sent on the 42nd day. At the end of the experiment, theaverage villus height, villus width and the crypt depth were increased in

restriction percentage dependent manner (P<0,001). In 75% restriction group, all data were higher than the other groups (P<0,001). The thickness of tunica muscularis was higher in 25% and 75% groups (P<0,001).

As a result, Although the concentrate feed restrictions effected the histology of ileum in restriction percentage dependent manner, the mostremarkable results for all evaluated parameters were obtained from animals 75% restricted group compared to the other groups.

Keywords: Broiler, Free range, restricted feed, histology, ileum.

*This work is a part of the project supported *by The Scientific and Technological Research Council of Turkey* (TUBİTAK) (Project No: 114O753).

MATERIAL AND METHOD

The project was carried out at Hümeyra Özgen Research and Application Farm of Selçuk University Veterinary Faculty. All procedures in the study were approved by Ethics Committee of Selcuk University Veterinary Faculty.

The experiment was conducted in a field with approximately 5 decares. The field was planted with clover, bromine (*Bromus inermis*), clover + clover-free bromine and thyme (*Origanum vulgare L.*) for each subgroup. After planting, the field was irrigated twice a day by sprinkler system depending on the temperature.

The broilers were raised in mobile poultry pens (polyurethane) roof and outer cover of which consists of galvanized static painted sandwich panel were used. Areas around each group were 9 x 9 m sizes. Each mobile poultry pens were divided into 2 sections with 1 m high wires and tulles up to the ceiling. Thus the size of each compartment was 4.5 m² (2.25 x 2 m). The base of pens (40 x 60, 2 mm thick) were covered with 2 cm thick pleymite material. Beside the front and rear main doors; there were also two entrances which was openable and closeable from the sides so that broilers able to access pasture easily. Two rows of automatic nipple systems was placed inside and a plastic water tank of 300 liters was placed on the top of the mobile pens for inside watering of broilers. The bottom of the mobile pens were covered with sawdust approximately 5 cm thick. Moisture and ambient temperature of mobile

pens were adjusted and monitored daily. Plate-shaped table feeder were used for chicks. As the chicks grew, the feeders were replaced by hanging feeders.

To prevent subgroup mixing; the mobile pens were surrounded by wires (1.5 m length, 1.5 m height). Area of mobile pens for each group were 81 m² (9 x 9 m) sizes and surrounded by wire plates to prevent mixing of groups. 72 m² of areas were planted clover or free bromine (*Bromus inermiş,* clover + free bromine and thyme *(Origanum vulgare L.).* Total experimental area of farm were covered with 3.30 m long wires and canopies to prevent from other wild animals and predators.

Before the experiment, all parts of mobile pens, outside area, feeders, water bottles were disinfected with ozone.

Table 1. *Composition of rations used in the experiments,%*

	PERIOD, day	
Ingredients, %	**1-28**	**28-84**
Corn	55.99	55.13
Corn gluten, 43% CP	6,10	6.10
SBM 48% CP	26,10	13.67
Whole Fat Soybean	-	9.80
SFM, 36% CP	5.75	5.85
Fish flour, 64% CP	1.10	1.10
Vegetable oil	1.10	4.00
DCP	1.90	2.00
Limestone	1.30	1.30
Salt	0.25	0.25
Mineral mix[1]	0.10	0.10
Vitamin mix[2]	0.25	0.25
Coccidiostats	0.05	0.05
DL-Methionine	-	0.20
Lysine	0.01	0.20

[1] Per 2.5 kg of vitamin premix contains 3.6 mg vitamin A, 0.05 mg vitamin D_3, 30 mg vitamin E, 3 mg vitamin K_3, 3 mg vitamin B_1, 6 mg vitamin B_2, 5 mg vitamin B_6, 0.015 mg vitamin B_{12}, 25 mg niacin, 0.04 mg biotin, 8 mg carotenoid, 1 mg folic acid, 300 mg choline chloride, 50 mg vitamin C.

[2] Per kg of mineral premix contains 80 mg Mn, 35 mg Fe, 50 mg Zn, 5 mg Cu, 2 mg I, 0.4 mg Co, 0.15 mg Se.

In this study, 480 slow-growing male Hubbard Isa Red-JA broiler chicks were used. The trial lasted between 3th October and 20th December 20, 2016. The chicks were raised in

2 mobile pens in first 28 days and fed *ad libitum*. On the 28th day, 480 chicks were distributed to subgroups each of which consisted of 30 chicks. The experiment was carried out 42 days.

Table 2. *Chemical composition of rations and feeds used in the experiments,*

	1-28th. days	28-42th days	Clover	Free Bromine
ME, kcal*	2910	3190	-	-
Crude protein, %	23.06	20.36	24.16	16.41
Dry matter, %	91.29	91.84	17.00	20.34
Ash, %	5.67	5.38	13.20	11.81
Crude fibre, %	5.54	5.80	21.38	29.18
Ether extract, %	8.27	9.76	1.99	2.94

*Obtained by calculation.

The broilers were fed with starter broiler feeds during the first 4 weeks and then they were fed to the end of the experiment with finisher broiler feeds (Table 1, 2). Methionine and lysine-producing amino acids were added to meet the needs of the animals.

Trial groups were designed as 4 groups each of which consisted of 2 subgroups. First group was determined as control group in which chicks were fed ad-libitum and not free range access. As for experimental groups; the amount of feed given to chicks were based on the amount of feed consumed by contol group. So 2st, 3th, 4th groups fed %75, %50, %25 *ad libitum*. When mortality was seen in any each group, Concentrated feed amounts were rearranged according to groups. Freshly cut coarse (clover, free bromine and thyme) baits were placed in broiler pens. The control group was terminated on the 42nd day of the experiment. However, at other times of the experiment, a certain number of broiler chickens continued to be fed as a control group in order to detect feed consumption of broiler chickens and to determine feeds to be given to experimental groups. The feed consumption of broiler chicks fed in the control group was calculated weekly. At the trial, the all groups was terminated on the 42nd.

Table 3. Daily feed amounts given to broiler chickens in trial, g / day

	GROUPS			
Days	**1 (Control)**	**2**	**3**	**4**
28-35	110.0	82,5	55.0	27,5
35-42	120.0	90.0	60.0	30.0
42-49	130.0	97,5	65.0	32,5
49-56	140.0	105.0	70.0	35.0
56-63	147.0	110.0	73,5	37.0
63-70	160.0	120.0	80.0	40.0
70-80	160.0	120.0	80.0	40.0

At the end of the study, the birds were killed by cervical dislocation. The ileum samples were collected. After routine histological process, the serial sections were stained with Crossmon's trichrome (Culling et al, 1985). All sections were evaluated under the light microscope and were photographed by digital camera and were recorded. Villus height, villus width (Figure 1), crypt depth, and thickness of tunica muscularis (Figure 2) were measured.

Statistical Analysis: The data obtained from this study were analyzed by using one-way analysis of variance and followed by post hoc Duncan multiple comparisons test using the Statistical Package for Social Sciences (SPSS version 15.0; SPSS Inc. Corp., USA). Results were considered at significant at $P<0.05$.

RESULTS

The data obtained from slaughter house on the 42nd day of the experiment were presented on the tables.

The average villus height, villus width and the crypt depth increased in restriction percentage dependent manner ($P<0.001$). In 75% restriction group, all data were higher than the other groups ($P<0,001$). The thickness of tunica muscularis was higher in 25% and 75% groups ($P<0.001$, Table 1).

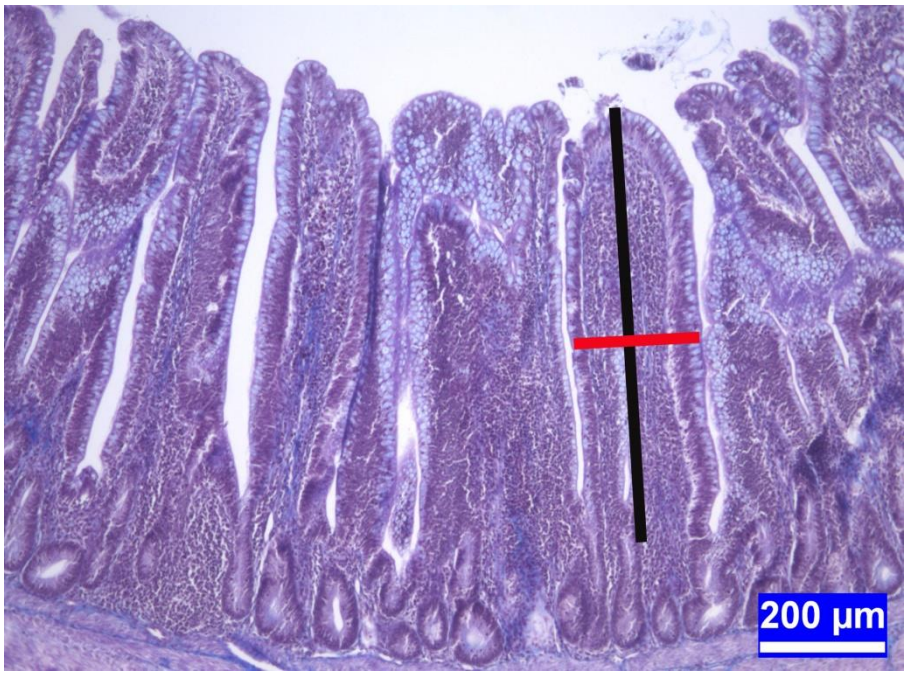

Figure 1. *A section from ileum of a control group animal. Black bar: Villus height, Red bar: Villus width. Crossmon's trichrome stain.*

Table 4. *The villus height, villus width, crypt depth and thickness of tunica muscularis of ileum.*

Groups	Villus height±SE (µm)	Villus width±SE (µm)	Crypt depth±SE (µm)	Thickness of tunica muscularis ±SE (µm)
1 (Control)	308,50±6,20^{d}	54,57±1,57^{c}	72,17±2,35^{c}	108,08±3,98^{c}
2	611,98±15,58^{c}	116,56±2,98^{b}	165,54±4,13^{b}	278,35±5,17^{a}
3	538,47±14,91^{b}	109,75±3,38^{b}	172,63±4,41^{b}	238,00±5,88^{b}
4	711,23±22,51^{a}	132,75±3,84^{a}	225,28±5,32^{a}	280,39±4,40^{a}
	P<0,001	P<0,001	P<0,001	P<0,001

a–c: Values within a column with no common superscripts are significantly different (P<0.001).

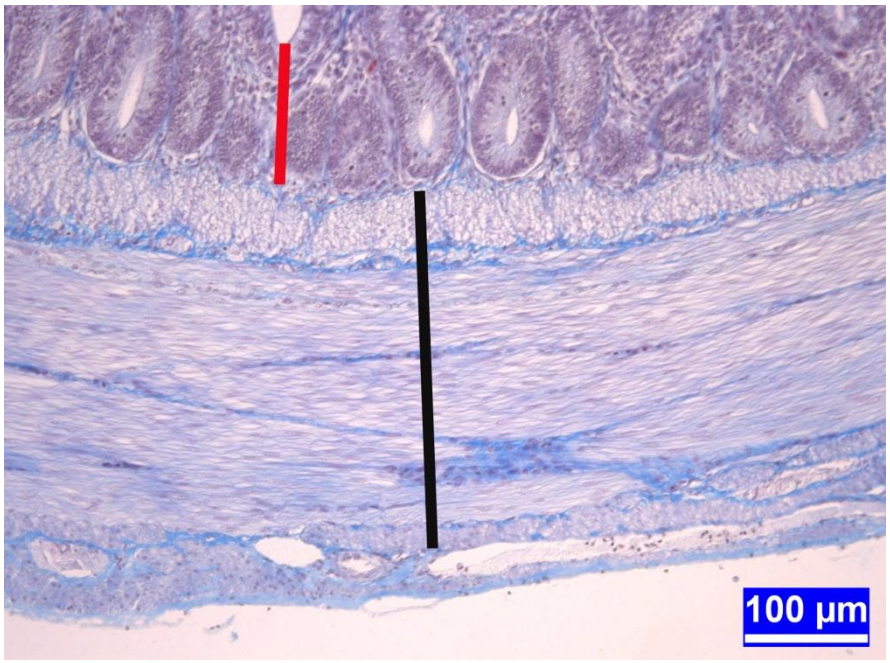

Figure 2. *A section from ileum of a control group animal. Red bar: Crypt depth, Black bar: Thickness of tunica muscularis. Crossmon's trichrome stain.*

DISCUSSION

The ileum is the last segment of the small intestine and it may play crucial role for digestion and absorption of some certain nutrients such as starch in fast-growing broilers (Shivus, 2014). Also, ileum is known as an important member of the gut associated lymphoid tissue (GALT), a local site of immune activation (Simon et al, 2014). The intestinal villus height is positively related to absorptive capacity because of increased villus sizes represents the greater villus surface area and the greater absorption of available nutrients (Jazideh et al, 2014). Thus, increased surface area results in improved growth performance. Moreover, because the intestinal crypts is accepted as cell factory, deeper crypts mean a fast cell renewal. This cell turnover is very important especially when animals are suffered from intestinal infections because it is necessary for the intestinal improvement in these animals as soon as possible for normal growth (Ahmed et al, 2016).The layer of tunica muskularis, which is located in the intestinal mucosa and consists of smooth muscles, is responsible for intestinal motility and contraction which plays a vital role in terms of enhancing the contact of nutrients with the absorbent surface, as well as mixing intestinal content (Çetingül et al, 2015, Sur et al, 2017). Therefore, the thickness of this muscle layer is thought to be positively related to the

absorption processes. These data obtained from this study may be important for newly hatching animals, because their digestive and immune systems are not well developed and these animals are more sensitive to some certain young avian diseases.

Conclusion: Although the concentrate feed restrictions effected the histology of ileum in restriction percentage dependent manner, the most remarkable results for all evaluated parameters were obtained from animals 75% restricted group compared to the other groups.

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