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Nutrient digestibility and serum biochemistry of laying quails (*Cortunix cortunix japonica*) fed sugarcane scrapping meal-based diets supplemented with exogenous enzyme

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Abstract: *The study was carried out to investigate the effect of Maxigrain® enzyme supplementation of sugarcane scrapping meal-based diets on the nutrient digestibility and serum biochemical variables of laying Japanese quails (Coturnix coturnix japonica) in ant 8 week experiment. Six experimental diets tagged* $T10_0$*,* $T10_{100}$*,* $T10_{200}$*,* $T15_0$*,* $T15_{100}$ *and* $T15_{200}$ *were formulated to be isonitrogenous (20%CP) and isocaloric (2786.72 Kcal/kg ME). Diets* $T10_0$*,* $T10_{100}$ *and* $T10_{200}$ *contained 10% crude fibre and 0, 100 and 200 ppm enzyme while* $T15_0$*,* $T15_{100}$ *and* $T10_{200}$ *contained 15% crude fibre and 0, 100 and 200 ppm enzyme, such that* $T10_0$ *and* $T15_0$ *function as the control for* $T10_{100}$ *and* $T10_{200}$*, and* $T15_{100}$ *and* $T15_{200}$*, respectively. Three hundred and sixty 6 weeks old laying quails were randomly allocated to the dietary treatments at the rate of 60 birds per diet. Each treatment was replicated 4 times in a 3 x 2 factorial arrangement having 15 birds per replicate. The results showed that enzyme supplementation improved (P<0.05) significantly the digestibility of dry matter (62.21 vs.63.03 and 63.28%), crude protein (67.25 vs. 67.87 and 69.14%), crude fibre (70.19 vs.78.14 and 81.66%), ether extract (65.37 vs.67.28 and 665.29%), nitrogen free extract (43.77 vs.43.65 and 43.18%), neutral detergent fibre (43.76 vs.55.35 and 56.34%), acid detergent fibre (57.33 vs.48.85 and 48.20%), acid detergent lignin (39.40 vs.48.34 and 48.31%), hemicellulose (55.66 vs. 57.24 and 67.57%), glucose (20.15 vs.19.15 and 16.18 g/dl), protein (31.25 vs.30.25 and 30.75 g/dl), cholesterol (7.78 vs.7.38 and 8.55 mg/dl) and creatinine (39.47 vs.37.82 and 39.15 mg/dl) for no enzyme, 100 ppm and 200 ppm enzyme supplemented diets, respectively. Similarly, dietary fibre depressed the digestibility of dry matter (66.79 and 53.77%), crude protein (68.80 and 52.22%), nitrogen free extract (43.76 and 39.80%), neutral detergent fibre (58.42 and 45.44%), acid detergent fibre (57.14 and 44.36%), hemicellulose (64.45 and 50.43%) and glucose (18.88 and 18.10g/dl) but improved (P<0.05) those of acid detergent lignin (43.55 and 54.54%), protein (30.33 and 31.17 g/dl), cholesterol (7.70 and 8.10 mg/dl) and creatinine (37.85 and 39.78 mg/dl). The interactive effects of enzyme and dietary fibre influenced (P<0.05) neutral detergent fibre and cellulose only. In view of the outstanding performance of the quails fed the high fibre-high enzyme supplemented diets, quail farmers can use the combination for compounding laying quail diets.*

Keywords: *Laying quails, sugarcane scrapping meal, fibre, enzyme supplementation, carcass characteristics, blood parameters and nutrient digestibility*

I. Introduction

The use of unconventional feedstuffs as substitutes for grains and other feedstuffs have been suggested thus, the search for non-conventional feedstuffs has been the most active area of animal nutrition research in the tropical world (Ikani and Adesehinwa, 2000). The search for cheaper sources of animal protein brings poultry birds into focus. Yakubu *et al.*, (2010) suggested that the quickest potential for bridging protein supply-demand gap lies in the production of highly prolific animals that are efficient converters of feed to flesh, have short generation interval such as poultry birds which includes quails and the integration of the wide array of cheap and locally available non-conventional feedstuffs at our disposal into well-defined feeding systems to reduce cost. One of such agro-industrial waste products is sugarcane scrapings.

According to Ayoade *et al.* (2007), sugarcane scrapping is obtained by scraping the outer part of the stem (rind) with a sharp knife to remove the bark on the stem that affords protection to the underlying cells. The scraping is done to remove the wax-covered epidermis and prepare the stem for chewing. The scrapings consist of the wax, pigments and fibrous materials of the rind, and a small quantity of the underline parenchyma cells. After scrapping, the material lies waste littering in both urban and rural settlements hereby constituting environmental pollution. It is heaped and burnt from time to time. Livestock such as cattle, goat and sheep scavenge these residues. Possible uses of the scrapings include feed for livestock and fuel for cooking. This could translate to substantial savings of money in this era of exorbitant prices of kerosene. The scrapping could also be used as mulching material for plants and when decayed could constitute a source of manure for the soil.

The proximate and energy composition of SCSM, according to the findings of Ayoade *et al.* (2007)

indicates that dry matter is about 87.6%, crude protein 3.2%, crude fibre 12.7%, Ether extract 2.8%, ash 12. 8%, NFE 77.1%, and gross energy of about 2.84 Mcal/kg. Augustine (2005) investigated the effect of replacement of maize with graded levels of sugarcane scraping meal (SCSM) on the performance and carcass characteristics of growing rabbits where SCSM replaced maize completely (100%) observed that the rabbits gained weight in all the treatments throughout the period of study while the digestibility of various nutrients and dressing percentages were high. These are indications of good nutritive value of SCSM in rabbit's rations. The author also reported that replacement of maize with SCSM reduced the production cost and could make rabbit available to the general public at lower cost. This is attributed to the fact that SCSM is very cheap compared to maize. Since body weight gain, and feed conversion ration were similar among treatments and there is reduction in production cost and profit increased as a result of the inclusion of SCSM, the author concluded that SCSM could replaced up to 100% of the maize in the diets of grower rabbits without adverse effect on performance.

Hastings (1946) and Allen *et al.* (1997) both observed that enzyme addition to monogastric animal feed reduced viscosity of ingesta in the intestine and showed a marked improvement on the various morphological effects of feeding fibrous materials to non-ruminant animals. Strategies for ensuring adequate nutrition of animals must be based on optimizing overall agricultural and livestock productivity from available resources, improving existing technologies and integrating technology that employs multipurpose crops and animals, and recycling of crop residues and by –products as feeding stuffs for animals (Njwe, 1990).

Maxigrain® enzyme is a multi-enzyme compound of β-glucanase, xylanase, phytase, arabinoxylanase and a mixture of yeast and minerals produced by the Bio-Organics Ltd. It is originates from the bacteria *Aspergillus oryzae.* Esuga *et al.* (2008) reported in an experiment to investigate the effects of feeding graded levels of palm kernel meal (PKM) in broiler chicken diets supplemented with Maxigrain® enzyme where PKM treated with Maxigrain® was included at 10, 20, 30, and 40% levels and observed a significant ($P<0.001$) difference in protein, fat, NFE and metabolizable energy retention in birds fed the control and Maxigrain® treated diets than those on diets without Maxigrain®. The objective of this study is therefore, to evaluate the effect of replacing maize with sugarcane scraping meal supplemented with exogenous enzyme on nutrient digestibility, blood constituents and meat quality of laying Japanese quails (*Coturnix coturnix japonica*).

II. Materials and Methods

Study area

The experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University, Keffi, Shabu – Lafia Campus. It is located in the Guinea Savanna zone of North Central Nigeria. It is located on latitude 08^0 35'N and longitude 08^0 33' E. The mean maximum and minimum temperatures are 35. 06 and 20.16^0C respectively while the mean relative humidity is 74 %. The annual rainfall is about 1168. 90mm (NIMET, 2008).

Maxigrain® enzyme

Maxigrain® enzyme, a multi-enzyme which contains β-glucanase, xylanase, phytase, arabinoxylanase, yeast and minerals was purchased from a vendor (Animal Care Ltd, Abuja).

Sugarcane scrapping

Sugarcane scrapings was sourced from local sugarcane marketers within Lafia metropolis, sun-dried and milled to form the sugarcane scrapping meal (SCSM).

Source of Maxigrain® enzyme

Description and preparation of experimental diets for layer quails

Six (6) experimental diets $T10_0$, $T10_{100}$, $T10_{200}$, $T15_0$, $T15_{100}$ and $T15_{200}$ were compounded to be isonitrogenous (20% crude protein) and isocaloric (2650Kcal/Kg ME) with two levels of crude fibre. Three hundred and sixty 9-weeks old layer quails were randomly allocated to the treatments at rate of 60 birds per diet in an experiment that lasted for 8 weeks. Each treatment was replicated 4 times in a 2x3 factorial arrangement having 15 birds per replicate. Treatments T_{10}, $T_{10}100$ and $T_{10}200$ contained 10% crude fibre (normal fibre level) while treatments $T15_0$, $T15_{100}$ and $T15_{200}$ contained 15% crude fibre level (high fibre level). The exogenous enzyme (Maxigrain®) was included at 0, 100 and 200ppm thus, treatments $T10_0$ and $T15_0$ contained 0ppm, $T10_{100}$ and $T15_{100}$ contained 100ppm while $T10_{200}$ and $T15_{200}$ contained 200ppm of the Maxigrain® enzyme supplementation such that treatment $T10_0$ and $T15_0$ served as the control for treatments $T10_{100}$ and $T10_{200}$ and $T15_{200}$ and $T15_{200}$ respectively. Other ingredients were included at the recommended levels to meet the nutrient requirements of the birds. The analyzed experimental diets for layer quails are presented in Table 2.

III. Data collection

Digestibility trial

During the last 7days of the trial, faeces were collected from the 6 treatments of 4 replicates which were previously fasted for 12hours to empty the birds' gut to mark the beginning and end of faeces collection. The faeces collected were oven-dried for a period of 18 hours at a temperature of about 105^0C and weighed daily. At the end of the collection period, the faecal samples collected from each treatment per day were bulked, ground and thoroughly mixed to obtain a homogenous mixture. Samples of the faeces were taken for proximate analysis according to standard methods outlined (AOAC, 1984) and the results obtained used to calculate the apparent digestibility using the formula below:

Apparent nutrient digestibility was determined using the formula:

$$\text{Apparent digestibility coefficient} = \frac{\text{Nutrients in feeds} - \text{Nutrients in faeces}}{\text{Nutrients in feeds}} \times 100$$

Serum biochemistry

Blood samples were collected in sample bottles without anti-coagulant to allow for clotting for serum biochemical analysis. Serum protein, creatinine, triglyceraldehyde and cholesterol were analyzed using sigma kits. Glucose was analyzed according to Feteris (1965) and Roschlan *et al.* (1974).

IV. Results and Discussion

Chemical composition of sugarcane scrapping

The chemical composition of the test ingredient (sugarcane scrapping) is presented in Table 1.The calculated metabolizable energy from the proximate composition data using the formula described (Pauzenga, 1985) ME (kcal/kg) = 37x % cp x 81.1 x % EE + 35.5 x % NFE was about 2970.45. The test ingredient contain low (8.25%) crude protein, high crude fibre and low (3.36%) either extract. The dry matter was about 90.67% while ash and nitrogen free extract were about 9.98 and 67.40% respectively. This composition suggests that sugarcane scrapping, being a fibrous feed material, will require some level of processing or pre-digestion if must be fed to monogastric animals.

The levels of these minerals were adequate for quails in this age group (Musa *et al.*, 2007). The fibre fraction, NDF (neutral detergent fibre), ADF (acid detergent fibre), ADL (acid detergent lignin), hemicelluloses and cellulose were within the range of 39.96 - 56.38%, 19.21 - 38.21%, 5.92 - 6.37%, 18.17 - 24.90% and 13.12 - 25.84% respectively.

Analyzed and energy composition of experimental diets

The chemical composition of the experimental diets for layer quail is presented in Table 2. The diets were formulated such that they were isonitrogenous (about 19.00%CP). The calculated metabolizable energy from the proximate composition data of the diets using the formula as described by Pauzenga (1985), ME (kcal/kg) = 37 x % CP + 81.1 x % EE + 35.5 x % NFE, was isocaloric (2900 kcal/kg ME) and it is adequate for layer quails (Musa *et al*., 2007 and Bawa *et al*., 2012). The crude fibre values were about 10% for diets $T10_0$, $T10_{100}$ and $T10_{200}$ while diets $T15_0$, $T15_{100}$ and $T15_{200}$ was about 15%. The crude fibre level increased with increasing level of sugarcane scrapping meal in the diets. The values obtained for ether extract were less than 4% ranging from 3.68-3.91% Ash value was between 5.26-5.73% the NFE was within the range of 59.07-61.32% fibre traction NDF, ADF, ADL hemicellulose and cellulose were within the range of 49.65-55. 69%. 27.29-33.96%, 10.67-17.15%, 20.80-23.36% and 16.62-18.59% respectively calcium and phosphorus of the diets were calculated from NRC (1979) and were within the range of 2.99-3.14% and 1.61-1.71% respectively. The levels of these minerals were adequate for layer quails in this age group (Musa *et al*., 2007).

Nutrient digestibility by laying quails (Cortunix cortunix japonica)

The result of the effect of Maxigrain® enzyme supplementation or dietary fibre on the nutrient digestibility by laying quails is presented in Table 3.The improvement in the digestibility of crude protein, crude fibre, ether extract, nitrogen free extract and fibre fraction components such as neutral detergent fibre, acid detergent fibre, acid detergent lignin and hemicellulose due to enzyme supplementation supports the general assertion that exogenous enzyme supplementation improves digestibility of nutrient (Adeola and Olukosi, 2008). Furthermore Omole *et al*. (2011) investigated the performance and nutrient digestibility of broiler birds fed diets containing exogenous Hamecozyme® observed significant improvement in crude protein and crude fibre digestibility as the level of Hamecozyme increased in the diets. Similarly, Alu *et al*. (2009) conducted an experiment using weaner pigs to investigate the effect of Nutrase Xyla® enzyme supplementation on nutrient digestibility where high and low fibre diets were fed to weaner pigs also noted significant improvement in the digestibility of neutral detergent fibre and hemicellulose.

Dietary fibre significantly depressed the digestibility of nutrient except for crude fibre, ether extract and cellulose which is in consonance with the report of Olomu (2011), McDonald *et al*. (1995) and Atteh

(2002). Reports (Woodman and Evans, 1947b and Crampton and Harris, 1954) suggest that older animals utilize fibrous diets more than the young ones. The test ingredient used in this experiment was sourced from matured sugarcane ready for consumption. The degree of lignifications of fibre also affects it digestibility (Mecy, 1942). The most important anti-nutritional NSPs are the arabinoxylans and these are recognized to increase the viscosity of digesta by their water binding capacity which means the animals own enzyme are constrained or limited in catalyzing the digestion of dietary nutrients (Van de Mierop, 2001 and Graham, 1996). The observation could also be attributed to the fact that non-starch polysaccharides, by their gel-forming property, encapsulate or enclose the nutrients and thus make them unavailable to animals for absorption.

The report of this experiment is also in line with the earlier findings (Alu *et al.*, 2009), which reported significant reduction in the digestibility of dry matter, neutral detergent fibre and hemicellulose when Nutrase xyla® was supplemented in low and high fibre diets of weaner pigs. The values obtained in this experiment are close to 71.92 - 85.15% for crude protein and 83.93 -97.60% for ether extract reported by Ijaiya *et al.* (2012). There was improvement in the digestibility of nutrients due to the interaction of dietary fibre and enzyme supplementation in the diets and this agrees with the findings of Adeola and Olukosi (2008) who observed that high dietary fibre can only be properly digested and utilized in monogastric animals if exogenous enzymes are added to the diets. The authors maintained that when enzyme is added to feed, they break down the anti-nutritional factors that are present, many of which are not susceptible to digestion by the animals endogenous enzymes.

The result of the effect of Maxigrain® enzyme supplementation and dietary fibre on the nutrient digestibility by laying quails is presented in Table 4.The non-significant variation in the nutrient digestibility except for neutral detergent fibre and cellulose due to the interaction of dietary fibre and enzyme suggests that the supplemented enzyme in the low and high fibre diets leveled the performance of birds in terms of digestibility. The result of these findings is supported by the earlier works (Feng *et al*., 1996; Oduguwa *et al*., 2001 and Petty *et al*., 2000).

Blood parameters of layer quails (Cortunix corturnix japonica).

The result of the effect of Maxigrain® enzyme supplementation or dietary fibre on serum metabolites of laying quails is presented in Table 5. Supplementation of Maxigrain® enzyme and the interaction of enzyme and dietary fibre in the diets of laying quails did not influence triglyceraldehyde. Dietary fibre reduced significantly ($P<0.05$) glucose, but improved protein, cholesterol and creatinine. The observations in the present study which are within the normal values for mature laying quails (Edache *et al.,* 2003), support the earlier works of Bawa *et al.* (2012c) and Ojebiyi *et al.* (2009). Bawa *et al.* (2010) investigated the effect Maxigrain® in broilers chickens and reported a significant increase in some of the serum variables. These observations could be an indication that the birds were in good health throughout the experimental period while the non-significant variation in most of the haematological parameters due to enzyme supplementation supports the earlier report of Ojebiyi *et al.* (2009) who evaluated the growth, haematological and serum biochemical responses of broilers chickens fed graded levels of kola husk meal and observed that white blood cells, lymphocytes and eosinophils only were significantly affected by the level of Kola husk inclusion in the diets.

The significant variations in most of the serum biochemical parameters (glucose, proteins, cholesterol, creatinine, uric acid and triglyceraldehyde) due to Maxigrain® enzymes supplementation or dietary fibre support the earlier reports of Ojebiyi *et al.* (2010) who observed significant reduction in some serum parameters (total protein) of broilers birds when they used graded levels of kola husk meal at 0, 10, 20 and 30% in the diets of broilers.

V. Conclusions And Recommendations

The findings of this study revealed that sugarcane scrappings is high in energy content (2970.45 Kcal/kg ME) implying that the test ingredient can support growth and meat production in the diets of laying quails. Nutrient digestibility was influenced due to the enzyme, fibre and the interactive effect of the two. Similarly, most of the haematological and serum biochemical parameters evaluated were affected by the enzyme supplementation, dietary fibre but the interaction of the enzyme supplementation and dietary fibre did not have any effect while some of the visceral organs were influenced by the interactive effects of enzyme and fibre.

In view of the outstanding performance of the quails fed the high fibre-high enzyme supplemented diets, quail farmers can use the combination for compounding laying quail diets without affecting the meat quality, health status or impairing the availability of nutrients to the birds.

Table 1. Proximate and energy composition of sugarcane scrapping

Nutrient	CP	EE	CF	Ash	DM	NFE	[a]Energy (Kcal/kgME)

%	8.25	3.36	36.48	9.98	90.67	67.40	2970.45

[a]Calculated from Pauzenga (1985)

Table 2. Proximate and chemical composition of layer quails (*cortunix cortunix japonica*) diets (%)

Nutrients	T10$_{0}$	T10$_{100}$	T10$_{200}$	T15$_{0}$	T15$_{100}$	T15$_{200}$
DM	89.65	89.79	89.96	89.71	89.71	89.87
CP	19.68	19.37	19.49	20.13	20.58	20.29
CF	10.75	10.26	10.19	10.84	10.96	10.70
EE	3.86	3.79	3.68	3.91	3.83	3.89
Ash	5.67	5.26	5.43	5.73	5.56	5.47
NFE	60.04	61.32	61.21	59.39	59.07	59.56
NDF	49.65	51.06	55.69	52.69	54.12	53.86
ADF	27.29	29.87	33.96	31.89	32.67	31.95
ADL	10.67	11.28	17.15	13.38	15.86	14.79
Hemicellulose	23.36	21.19	21.73	20.80	21.45	21.91
Cellulose	16.62	18.59	16.81	18.51	16.81	17.16
[a]Calcium	3.14	3.14	3.14	2.99	2.99	2.99
[a]Phosphorus	1.71	1.71	1.71	1.61	1.61	1.61
[b]Energy (Kcal/kg ME)	2972.63	2900.92	2992.53	2970.26	2969.06	2978.46

NFE-Nitrogen-free extract**, NDF-**Neutral detergent fibre**, ADF-**Acid detergent fibre**, ADL-**Acid detergent lignin**,** [a]calculated from NRC (1979), [b]calculated from Pauzenga (1985).

Table 3. Effect of Maxigrain® enzyme supplementation or dietary fibre on coefficient of nutrient digestibility by laying quails (*Cortunix cortunix japonica*) (%)

Nutrients	Enzyme Treatment Means					Fibre Treatment Means			
	No Enzyme	100ppm Enzyme	200ppm Enzyme	SEM	LOS	Low Fibre	High Fibre	SEM	LOS
DM	62.21^{b}	63.03^{a}	63.28^{a}	2.51	*	66.79^{a}	53.77^{b}	1.47	*
CP	67.25^{b}	67.87^{a}	69.14^{a}	2.87	*	68.80^{a}	52.22^{b}	1.29	*
CF	70.19^{b}	78.14^{a}	81.66^{a}	3.77	*	70.43	76.65	2.90	NS
EE	65.37^{b}	67.28^{a}	65.29^{b}	2.66	*	75.05	62.32	2.25	NS
NFE	43.77^{b}	43.65^{b}	43.18^{a}	2.23	*	43.76^{a}	39.80^{b}	1.92	*
NDF	43.76^{b}	55.35^{a}	56.34$^{a\,b}$	2.67	*	58.42^{a}	45.44^{b}	1.66	*
ADF	57.33^{a}	48.85^{b}	48.20^{b}	4.11	*	57.14^{a}	44.36^{b}	3.55	*
ADL	39.40^{b}	48.34^{a}	48.31^{a}	3.12	*	43.55^{b}	54.54^{a}	2.69	*
Hemicellulose	55.66^{b}	57.24^{b}	67.57^{a}	2.09	*	64.45^{a}	50.43^{b}	3.12	*
Cellulose	43.66	44.38	46.40	3.52	NS	46.47	49.35	2.46	NS

DM-Dry matter, **CP-**Crude protein, **CF-**Crude fibre**, EE-**Ether extract, **NFE-**Nitrogen-free extract**, NDF-**Neutral detergent fibre**, ADF-**Acid detergent fibre**, ADL-**Acid detergent lignin**, a, b-** Means on the same row bearing different superscript differ significantly ($P < 0.05$), **NS-** No significant difference ($P > 0.05$), **LOS-** Level of significant difference.

Table 4. Effects of Maxigrain® enzyme supplementation and dietary fibre on coefficient of nutrient digestibility by laying quails (*Cortunix cortunix japonica*) (%)

Nutrients	Main Treatment Means							
	T10	T10$_{100}$	T10$_{200}$	T15	T15$_{100}$	T15$_{200}$	SEM	LOS
DM	56.33	59.47	60.27	47.49	52.66	53.28	2.12	NS
CP	65.59	68.76	69.21	61.30	55.24	55.20	2.24	NS
CF	67.41	68.43	65.30	62.74	67.53	65.72	3.87	NS
EE	65.73	65.65	66.29	62.34	63.70	64.63	3.63	NS
NFE	43.13	43.20	43.35	43.28	42.49	42.34	1.46	NS
NDF	53.57^{a}	53.64^{a}	53.40^{a}	45.14^{b}	53.60^{a}	46.80^{c}	2.56	*
ADF	45.13	44.68	45.12	46.64	45.87	45.55	1.09	NS
ADL	32.66	32.42	46.32	46.72	45.34	52.76	3.10	NS
Hemicellulose	52.34	54.70	58.63	47.31	45.22	51.39	1.34	NS
Cellulose	54.14^{a}	49.35^{b}	55.71^{a}	53.42^{ab}	56.73^{a}	56.33^{a}	4.28	*

DM-Dry matter, **CP-**Crude protein, **CF-**Crude fibre**, EE-**Ether extract, **NFE-**Nitrogen-free extract**, NDF-**Neutral detergent fibre**, ADF-**Acid detergent fibre**, ADL-**Acid detergent lignin**, a, b-** Means on the same row bearing different superscript differ significantly (P < 0.05), **NS-** No significant difference (P > 0.05), **LOS-** Level of significant difference.

Table 5. Effect of Maxigrain® enzyme supplementation or dietary fibre on serum metabolites of laying quails (*Cortunix cortunix japonica*)

Parameters	Enzyme Treatment Means					Fibre Treatment Means			
	No Enzyme	100ppm Enzyme	200ppm Enzyme	SEM	LOS	Low fibre	High fibre	SEM	LOS
Glucose (g/dl)	20.15 [a]	19.15 [a]	16.18 [b]	1.66	*	18.88 [a]	18.10 [b]	1.35	*
Protein (g/dl)	31.25 [a]	30.25 [b]	30.75 [a]	1.48	*	30.33 [b]	31.17 [a]	1.21	*
Cholesterol (mg/dl)	7.78 [a]	7.38 [b]	8.55 [a]	0.92	*	7.70 [b]	8.10 [a]	0.75	*
Creatinine (mg/dl)	39.47 [a]	37.82 [b]	39.15 [a]	1.41	*	37.85 [b]	39.78 [a]	1.15	*
TGR (mg/dl)	0.83	0.87	0.83	0.01	NS	0.81	0.88	0.01	NS

TGR- Triglyceraldehyde, **a, b-** Means on the same row bearing different superscript differ significantly (P < 0.05), **NS-** No significant difference (P > 0.05), **LOS-** Level of significant difference

Table 6. Effect of Maxigrain® enzyme supplementation and dietary fibre on serum metabolites of laying quails (*Cortunix cortunix japonica*)

Parameters	Main Treatment Means							
	T10	$T10_{100}$	$T10_{200}$	T15	$T15_{100}$	$T15_{200}$	SEM	LOS
Glucose (g/dl)	18.15	16.70	13.12	12.27	18.67	12.20	0.63	NS
Protein (g/dl)	26.75	24.50	26.25	27.50	27.00	25.00	1.31	NS
Cholesterol (mg/dl)	8.85	8.90	7.35	8.97	8.95	6.50	1.74	NS
Creatinine (mg/dl)	35.60	34.17	36.07	33.43	36.45	33.13	2.01	NS
TGR (mg/dl)	0.97	1.02	1.02	0.88	0.90	1.04	0.10	NS

TGR- Triglyceraldehyde, a**, b-** Means on the same row bearing different superscript differ significantly (P < 0.05), **NS-** No significant difference (P > 0.05), **LOS-** Level of significant difference.

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