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تأثير استبدال دريس البرسيم بمخلف فطر المشروم (*Pleurotus osteratus*) المستنبت على قش الأرز على الأداء التناسلي لإناث الأرانب وبعض تحاليل الدم

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Effect of replacing dietary berseem hay with mushroom by-product (*Pleurotus osteratus*) growing on rice straw on female rabbit reproductive performance and some blood analysis

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الملخص:

أجريت هذه الدراسة في محطة بحوث الانتاج الحيواني بالنوبارية، معهد بحوث الانتاج الحيواني مركز البحوث الزراعية ، تم إجراء الدراسة في الفترة من سبتمبر 2022واستمرت التجربة لمدة 16 أسبوع وبحثت الدراسة في تأثير كل من استبدال مخلف فطر المشروم المستنبت على قش الارز بنسب مختلفة (0-20 - 40 -60 %) محل دريس البرسيم وتأثير عدد البطون ما بين نسب استبدال المشروم محل دريس البرسيم وعدد البطون على الأداء التناسلي وبعض صفات الدم لأمهات الأرانب النيوزيلاندى.

يمكن تلخيص الٌنتائج كما يلى:

أظهر التحليل الإحصائي لهذه الدراسة أن استبدال مخلف فطر المشروم المستنبت على قش الارز بنسب مختلفة (0-20 - 40 -60 %) محل دريس البرسيم كان له تأثيرًا معنويا على كل من استهلاك العلف (أثناء الرضاعة 14-28 يومًا) ، وانتاج الحليب ، نسبة الرضاعة ، كفاءة الحليب ومتوسط الحليب / المجموعة ، متوسط وزن الجسم للخلفة عند الفطام ، ومتوسط وزن الجسم المكتسب للخلفة، ومعدل الحمل، ونسبة الخلفة الاحياء قبل الفطام، بالإضافة الى صفات الدم مثل (RBC، WBC، HCT، MCV، MCH، MCHC في منتصف اليوم الرابع عشر من الرضاعة) أو الدم البيوكيميائي (البروتين الكلي) ، الألبومين ، الجلوبيولين ، نسبة الألبومين / الجلوبيولين والجلوكوز في منتصف الرضاعة اليوم الرابع عشر).

وأما تأثير عدد البطون كان له تأثير معنوي كبير على وزن جسم امهات الارانب (عند التزاوج أو قبل الولادة) ، واستهلاك العلف (خلال 14-28 يومًا من الحمل أو 0-14 يومًا من فترات الرضاعة) ، ونسب الخلفة الاحياء قبل الفطام ، كما ان كان له تأثير معنوي على عدد كرات الدم البيضاء و(MCV ميكرومتر لكرات الدم3).

وأظهرت الدراسة ايضا ان التفاعل مابين استبدال مخلف فطر المشروم المستنبت على قش الارز بنسب مختلفة (0-20 - 40 -60 %) محل دريس البرسيم وعدد بطون امهات الارانب كان له تأثيرًا معنويا على استهلاك العلف (خلال فترات الحمل والرضاعة) وانتاج الحليب خلال الاسبوع الاول من الرضاعة، نسبة الرضاعة ، كفاءة الحليب ومتوسط الحليب / المجموعة، بالاضافة الى صفات الدم أو الدم البيوكيميائي (البروتين الكلي) ، الألبومين ، الجلوبيولين ، نسبة الألبومين / الجلوبيولين والجلوكوز عند منتصف الرضاعة (اليوم الرابع عشر).

الكلمات الدالة: مخلف فطر المشروم، أمهات الأرانب، الصفات الانتاجية للأمهات،صفات الدم الهيماتولوجى.

Abstract

The aim of the present study was to investigate the effects of replacing berseem hay (BH) with different levels of waste mushroom substrate (WMS) and the impact of three parities on the reproductive performance and blood traits of doe rabbits. Forty-eight New Zealand White (NZW) doe rabbits, approximately 6-7 months old and weighing 3.100-3.110 kg, were randomly assigned to four experimental groups, with 12 rabbits in each group. The groups were as follows: Treatment 1, which served as the control diet with 32 Kg/100Kg BH (0% WMS); Treatment 2, with 6.4 WMS + 25.6 BH Kg/100 Kg (20% WMS); Treatment 3, with 12.8 WMS + 19.2 BH Kg/100 Kg (40% WMS); and Treatment 4, with 9.2 WMS + 12.8 BH Kg/100Kg (60% WMS). The experimental period lasted for three parities.

Statistically analyzed by two-ways system revealed that the main effect of WMS replacement with BH cause a significant effect on FI (during lactation 14-28days), MY, Lactation ratio, milk efficiency and average milk/ kit, ALW at weaning, ALWG, Pre-weaning SR%, CR % and hematological as (RBC, WBC, HCT, %), MCV, μm^3, MCH, pg, MCHC, g dL^{-1} at mid lactation 14^{th} day) or biochemical blood as (total protein, albumin, globulin, albumin/globulin ratio and glucose at mid lactation 14^{th} day).The main effect of parity has a significant effect on LBW (at mating or pre-partum), FI (during 14-28 day of pregnancy or 0-14 day of lactation periods), pre-weaning SR%, hematological (WBC 10^3/ mL and MCV μm3). The interaction between WMS addition and parity orders had a significant effect on FI (during pregnancy and lactation periods), the first week of MY, Lactation ratio, milk efficiency and average milk/ kit, CR, %, hematological and biochemical blood at mid lactation of NZW Does rabbits.

Keywords: Waste mushroom substrate, does rabbit, reproductive performance, hematological, biochemical blood.

INTRODUCTION:

The scarcity of the animal production sector in Egypt is a major obstacle to the growth of livestock wealth. This shortage leads to an increase in animal feed prices, which in turn raises the cost of animal production and the prices of animal and food items needed to feed the citizens of Egyptian society (Shoukry 2021). Egypt produces about 25 million tonnes of plant byproducts each year, including wheat straw, rice straw, and maize stalks. However, many farmers are not fully utilizing these byproducts, either for bedding aviary hens or feeding livestock (Ministry of Agriculture and Land Reclamation 2008). Straw and sugarcane bagasse have been successfully used as substrates for growing mushrooms. Implementing waste recycling and supplementation techniques in the mushroom industry, particularly for Pleurotus species, could provide pollution management benefits (Onokpise et al., 2007). Growing mushrooms is an economically feasible way to convert rice straw into a protein-rich food. Mushroom cultivation enhances the degradation of lignocellulosic compounds and the nitrogen content in rice straw, making the spent mushroom substrate an alternative substrate for microorganisms in the anaerobic environment (Karimi et al., 2015; Kuijk et al., 2015). P. Ostreatus has been shown to have a high relative selection for lignin degradation of soft wood substrates due to the presence of enzymes like laccase, Mn-peroxidase, and lignin peroxidase (Hou et al., 2004; Isikhuemhen et al., 2009). These mushrooms have various biological properties, including anti-oxidative and immune-stimulating properties, as well as antiviral, anti-carcinogenic, anti-hypercholesterolaemic, and blood lipid and glucose level-controlling capacities (Wasser and Weis 1999; Lakhanpal and Rana 2005). Bioactive constituents found in these species include oligosaccharides, polysaccharides, dietary fibers, glycoproteins, proteins, peptides, amino acids, triterpenoids, alkaloids, alcohols, phenols, polyphenols, vitamins, and minerals such as zinc, copper, iodine, selenium, and iron (Villas-Boas et al., 2002). Many by-products undergo biological treatment to increase their nutritional value, as they contain significant amounts of simple carbohydrates such as mono and disaccharides (Abdel-Aziz et al., 2014). Hasniyati et al. (2015) found that using mushroom stalk as an agricultural waste and soybean meal as a partial or complete replacement of fish meal protein at different levels produced good growth performance in broiler chickens. Shad et al. (2019) also found that the use of mushroom stem waste (MW) at a 2% level as a potential phytogenic feed supplement affected broiler chickens' serum cholesterol levels, immunological state, and growth performance. This study aims to examine the impact of using Pleurotus ostrateus mushroom by-products, grown on rice straw, on the productive performance and blood constituents in female rabbit diets.

MATERIALS AND METHODS

The experimental work took place at El Nobaria Animal Production Research Station in Behera Governorate, Egypt, starting in September 2022 and lasting for 16 weeks. Forty-eight (NZW) does, aged 6-7 months and weighing 3.100-3.110 kg, were equally divided into 4 treatment groups, with 12 does in each group. The basal diet was formulated and pelleted to meet the nutrient requirements of rabbits, following the guidelines of De Blas and Wiseman (1998) as shown in Table 1.

Table 1. The ingredients (g/kg) of the experimental diets used in the doe rabbits study.

Ingredients	WMS 0%	WMS 20%	WMS 40%	WMS 60%
Berseem hay (BH)	320.0	256.0	192.0	128.0
Mushroom waste (WMS)	-	64.0	128.0	192.0
Barley	182.0	182.0	182.0	182.0
Corn yellow	134.0	134.0	134.0	134.0
Wheat bran	120.0	120.0	120.0	120.0
Soybean meal 44%	190.0	190.0	190.0	190.0
Molasses	30.0	30.0	30.0	30.0
Di-Ca-Ph	15.0	15.0	15.0	15.0
Salt	4.0	4.0	4.0	4.0
Vit-min permix1	3.0	3.0	3.0	3.0
Lysine	0.8	0.8	0.8	0.8
Methionine	1.2	1.2	1.2	1.2

1= containing vitamin A, 12,000 IU; vitamin D3, 2000 IU; vitamin E, 11 IU; vitamin K, 2 mg; pantothenic acid (d-Ca pantothenate), 10 mg; folic acid, 1 mg; choline (choline chloride), 250 mg; Mn (manganous oxide), 60 mg; Fe (ferrous sulfate), 30 mg; Zn (zinc oxide), 50; Cu (copper sulfate), 10 mg; iodine (ethylenediamine dihydroiodide), 1 mg; cobalt (cobalt sulphate heptahydrated), 0.1 mg; and Se (sodium selenite), 0.1 mg.

Waste mushroom substrate (WMS) consisted of a mixture of the stem base of oyster mushroom (*Pleurotus osteratus)* and rice straw. After harvesting, the mushrooms were weighed, placed in net bags, dried firstly in air/sundrying until loss a substantial volume of water. Then, WMS was further exposed to oven drying at a consistent temperature of 60 C° to eliminate water thoroughly. The oven-dried WMS was mashed using a feed grinder to a small size resembling the commercial feed particles. The WMS was then stored in a sealed storage container before being mixed into the basal feeds.

The experimental groups were divided into four categories: Treatment 1 had a control diet with 32% Berseem hay (BH) and no wheat middlings (WMS). Treatment 2 had a diet with 6.4% WMS and 25.6% BH (20% WMS). Treatment 3 had a diet with 12.8% WMS and 19.2% BH (40% WMS). Treatment 4 had a diet with 9.2% WMS and 12.8% BH (60% WMS). All animals had access to feed and water, except for does with reproductive issues and those outside the lactation period, which received only 120 g of feed daily to prevent overweight.

The rabbits were housed in a windowed building in cages with nest boxes, feeders, and water nipples. The lighting followed a 16:8 h light–dark cycle. The male to female ratio was 1:5, and females were bred in the morning and, if necessary, in the late afternoon. If a female did not accept the male, mating was forced. Females were checked for pregnancy 10 days after breeding, and those that were not pregnant were bred again.

The study evaluated various reproduction-related traits in does, including live body weight at mating and pre-parturition, total feed intake during pregnancy and lactation, number and weight of kits born and weaned per doe, litter body weight at weaning, and total number and weight of kits at kindling and weaning over three reproductive cycles. Milk yield was estimated by measuring the difference in doe weight before and after suckling, and litter size, litter weight at birth and weaning, average total litter weight gain, and pre-weaning survival rate were also recorded.

The conception rate (CR) was calculated as the number of does conceived divided by the total number of does mated, multiplied by 100. Gestation length (GL) was recorded as the time between conception and kindling.

The blood samples of five doe rabbits each group, at mid lactation period, were collected from the ear vein of with a sterile syringe. Xylol was applied to increase blood flow (Hoppe et al., 1969). Three ml of the blood samples was added to a Bijon bottle containing ethylenediaminetetraacetic acid (EDTA) as an anticoagulant for the hematological assay. Other three ml of the blood sample was placed into a sterile vacutainer tube without an anticoagulant. The samples were centrifuged (700 × g, 15 min.) and the serum was carefully decanted into serum vials and stored at -20 °C until being used for the serum biochemical analysis. Red blood cell counts (RBC) were estimated according to Perkins (2009). Hemoglobin concentration (Hb) was determined colorimetrically using commercial kits (Bio-diagnostic Co., Cairo, Egypt) according to the cyanmethemoglobin procedure (Van Kampen and Zijlstra, 1983). As well as hematocrit (HTC) value was measured according to Provan et al. (2009).

The mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) was calculated according to Feldman et al. (2000) using the following equations

MCV (μm^3) =HCT (%) × 10/ RBCs (10^6/ mL)

MCH (pg) =Hb (g/ dL) ×10/RBCs (10^6/ mL)

MCHC (g/ dL) =Hb (g/ dL) × 100/ HCT (%)

The serum protein profile, lipid profile and urea were calorimetrically estimated by using commercial kits produced by Bio diagnostic, Egypt. Serum total protein level was determined according to (Gornal et al., 1949). Serum albumin level was determined according to (Doumas et al., 1971). Serum globulin concentration was calculated by the difference between total protein and albumin (Coles, 1974). Serum glucose level was measured by means of spectrophotometer according to Trinder (1969).

Statistical analysis

Data were statistically analyzed using the General Linear Model procedure of the Statistical Analysis System (SAS, 2008). Data of the doe rabbits study were statistically analyzed by two-ways analysis of variance to test the treatment (waste mushroom substrate replacement 0-60%), parities (1^{st} , 2^{nd} and 3^{rd} parities) and their interaction as follows:

$Y_{ijk} = \mu + T_i + P_j + TP_{ij} + A_k + e_{ijk}$

where μ represents the overall mean, Ti is a fixed effect of the waste mushroom substrate replacement, Pj is the fixed effect of the parities, TPij is the interaction between the waste mushroom substrate replacement and parities, Ak is a random effect of the rabbit in each treatment, and eijk is the random error assumed to be independent and normally distributed with mean = 0 and variance = $\sigma 2$.

Values were given as a means. Multiple comparisons among the means were carried out by (Duncan, 1955) considering $P \leq 0.05$ as significant.

RESULTS AND DISCUSSION

Live Body weight of does (LBW)

Table 2 displays the effect of substituting BH with various WMS concentrations and their interactions on the change in LBW of female (NZW) rabbits. The beginning LBW of female NZW rabbits ranged from 3005 to 3185 g, and there were no appreciable changes between treatments. This implies that the rabbits were divided up between the treatments at random. Regardless of parity, the results demonstrated that substituting WMS for BH at different levels (0, 20, 40, and 60%) in rabbit diets led to non-significant (P=0.319 and 0.243) differences in LBW at mating and pre-partum. Research on the LBW of female rabbits fed rice straw treated with *P. ostreatus* is scarce. In a study by Ali et al. (2017), it was found that replacing 15% and 30% of BH with biologically treated conocarpus using Effective Microorganisms in rabbit diets resulted in significantly higher pregnancy weights compared to control diets ($P \leq 0.05$). Similarly, Sarker et al. (2016) found that using 10% rice straw as bedding material for mushroom cultivation as cattle feed did not significantly affect the live body weight (LBW) when compared to other replacement diets.

The results showed that LBW was significantly (P=0.002 and 0.001) impacted by the first, second, and third parities during mating and pre-partum, respectively, when the effect of replacing WMS with BH was disregarded. A doe's parity is the quantity of ignitions she has had. When compared to individuals in the second and third parities, does rabbits were heavier at first parity following mating and at pre-partum. In this connect, Parity order affected female LBW at parturition (P=0.0001) and at 21 days of nursing (P=.0001), and doe LBW at 35 days postpartum was 154 g greater in the intense rhythm group ($P<0.05$) compared to the semi-intensive rhythm group, (Rebollar et al 2008). According to Dalle Zotte and Paci (2013), multiparous does have LBW that was significantly higher than nulliparous does (4,352 vs. 4,122 g; $p<0.05$). The interaction between WMS addition and three parity orders had no effect on the change in LBW of NZW female rabbits during mating and pre-partum.

Table 2. Live body weights (g) (LBW) of doe rabbits as affected by feeding diets replaced with WMS through three parities.

Items	The live body weight does (LBW)		
	Initial	At mating	Pre-partum
Main effect of WMS replacement			
0% WMS	3100	3135	3295
20% WMS	3075	3157	3321
40% WMS	3105	3163	3348
60% WMS	3050	3117	3304
SEM	25.77	22.23	25.59
P-value	0.786	0.319	0.243
Main effect of parity			
1st parity	3160	3201[a]	3389[a]
2nd parity	3185	3118[b]	3334[b]
3rd parity	3163	3111[b]	3228[c]
SEM	31.65	26.61	30.90
P-value	0.836	0.002	0.001
Interaction effect WMS × parity			
P-value	0.434	0.176	0.263

[a, b, c] different superscripts within a column indicate significant differences.

Feed Intake (FI):

Table 3 provides information on the impact of adding WMS, parity order, and their interactions on FI throughout pregnancy and lactation. From the first day of pregnancy through the 14th day of lactation, FI was found to be unaffected (P=0.874, 0.594, and 0.616) by the substitution of various levels of WMS (20, 40, and 60% WMS) with BH. Feeding 60% WMS-containing meals to rabbits exhibited a detriment (P=0.05) effect during the 14-28-day lactation period. The decrease in feed intake could be negatively affected by the high concentration of ash and acid insoluble ash, which may limit minerals in the feed (Gerrits, 1994). El-Badawi et al. (2007) found that adding treated sugar beet-root pulp to the meal did not affect feed intake, while adding untreated sugar beet-root pulp resulted in a significantly lower feed intake (P<0.05). In line with EL-Marakby (2003), rations comprising (25% CFM+fungally treated wheat straw ad libitum) had a mean value of dry matter intake as g kg−1 $W^{0.75}$ that was considerable (P<0.05) lower than those containing (50% concentrate feed mixture+fungally treated wheat straw). The presence of inhibitory substances like phenolic compounds in spent mushroom wheat straw, which are produced as a result of lignocellulose degradation through solid state fermentation by fungi, may also have a negative impact on voluntary intake, (Bonnen et al., 1994). When spent mushroom wheat straw made up 10% of the ruminant diet, Fazaeli and Masoodi (2006) found that the voluntary intake of dry matter and organic matter did not differ, but that increasing the amount of spent mushroom wheat straw in the diet resulted in a significant decrease in DM and OM intake. Kholif et al. (2014) revealed that replacing mushroom-spent rice straw for 50% of the clover hay in the diets of Baladi nursing goats resulted in a substantial (p=0.0114) decrease in overall DM consumption as well as DM intake from forages (p=0.0061) when compared to the control. The research of Badarinaa et al. (2015), supplementing nursing goats with fermented coffee husk had no effect on the goat milk production. The DM intake of beef calves fed on four diets as (rice straw and purple field corn stove) fermented with *Pleurotus ostreatus and Volvariella volvacea* did not vary ($p>0.05$), according to Khonkhaeng and Cherdthon (2019).

Table 3. Feed intake (g/d) FI of doe rabbits as affected by feeding diets replaced with WMS through three parities.

Items	FI during pregnancy		FI during lactation	
	0–14 days	14–28 days	0–14 days	14–28 days
Main effect of WMS replacement				
0% WMS	178.62	188.70	202.24	219.15[a]
20% WMS	177.83	189.76	202.67	217.45[ab]
40% WMS	177.88	191.83	204.80	217.73[ab]
60% WMS	176.08	189.75	202.07	214.05[b]
SEM	1.05	0.78	0.46	0.46
P–value	0.874	0.594	0.616	0.050
Main effect of parity				
1st parity	178.1	191.9[a]	204.7[a]	217.2
2nd parity	177.2	190.8[ab]	203.5[ab]	216.2
3rd parity	178.1	187.2[b]	200.5[b]	217.8
SEM	1.54	1.17	0.68	1.10
P–value	0.838	0.050	0.0102	0.679
Interaction effect WMS × parity				
0% WMS × 1st parity	187.2[a]	204[a]	219.3[a]	233.8[a]
0% WMS × 2nd parity	174.7[bc]	188.2[c]	200.5[c]	213.3[bc]
0% WMS × 3rd parity	174.0[c]	174[d]	187[d]	210.3[c]
20% *WMS* × 1st parity	176.1[b]	189.3[c]	201.7[c]	215.4[bc]
20% *WMS* × 2nd parity	175.2[bc]	188.2[c]	200.3[c]	211.2[c]
20% *WMS* × 3rd parity	182.0[ab]	191.7[b]	205.8[b]	225.1[ab]
40% *WMS* × 1st parity	172.9[d]	185.8[c]	197.3[cd]	208.8[d]
40% *WMS* × 2nd parity	181.9[ab]	196.6[ab]	210.0[ab]	222.9[ab]
40% *WMS* × 3rd parity	178.7[b]	193.0[b]	207.1[b]	221.3[ab]
60% *WMS* × 1st parity	176.1[b]	188.7[c]	200.7[c]	210.7[c]
60% *WMS* × 2nd parity	176.9[b]	190.04[bc]	203.3[c]	216.8[b]
60% *WMS* × 3rd parity	177.7[b]	190.3[bc]	202.2[c]	214.4[bc]
SEM	1.56	1.15	0.68	0.68
P–value	0.003	0.001	0.001	0.001

[a, b, c, d] different superscripts within a column indicate significant differences.

The results showed that during the pregnancy (14–28 days) and lactation (0–14 days) periods, the parity order had a substantial impact on FI even when the effect of WMS level was disregarded. FI FI of the rabbits in the second and third parities was lower during the 14–28 day period of pregnancy (190.8 and 187.2 g/d vs 1st

Parity=191.9, P=0.05). Additionally, FI of female rabbits in the first parity was lower (204.7g/d, P=0.05) than it was in the second and third parities (203.5 and 200.5g/d) during the lactation period (0–14 days).

Tables 3 provide information on the effects of 20, 40, and 60% WMS levels of a form of parity order on doe rabbits' FI. Feeding BH solely to the basal diet devoid of WMS during the pregnancy and lactation phases of female rabbits led to larger increases in FI than other experimental groups.

Milk yield (MY)

Table 4 shows the impact of substitute WMS, parity order, and their interactions on milk production throughout lactation. It was observed that the levels of WMS had a detrimental effect on milk supply from the first day of lactation to the last 28 days of lactation (P=0.0032, 0.0201, 0.0148, and 0.0277). The higher milk yield with 0% WMS-diet may be due to the higher CP content of the control diet and higher CP digestibility and/or higher TVFA levels in the diets rabbits. These results conflict with Ali et al (2017) who found that feeding does diets containing 15% Conocarpus + Effective microorganisms and with 15 or 30% Conocarpus + Trichoderma reesi fungi replacement of BH significantly ($P \leq 0.05$) gave the highest milk yield and content of dry matter, crude protein, and fat compared to the other dietary treatments. Kholif et al (2014) recorded that replacing 45% of clover hay rations of Baladi lactating goats with WMS caused a significant reduction in milk and energy corrected milk yield compared to the control and the group of animals which received 25% WMS (p= 0.0330 and p = 0.0290, respectively).

The results showed that the parity order had no discernible impact on MY supply during lactation periods (1–28 days) when the effect of WMS level was disregarded. When compared to the female rabbits in the first and third parities, the second parity females did not produce significantly more milk during lactation. In this connect, Rebollar et al (2008) who found that the lowest milk production was obtained at 1^{st} parity of does ($P < 0.0001$), and the highest in rabbit does with the advance of parity ($P<0.0001$). Intesar et al (2021) demonstrated that the quantity of milk produced is significantly influenced by the day of lactation, with milk production increasing steadily up to the 4th parity order.

Table 4. Milk yield (g/d) (MY) of doe rabbits as affected by feeding diets replaced with WMS through three parities.

Items	7^{th} day	14^{th} day	21^{st} day	28^{th} day
Main effect of WMS replacement				
0% WMS	144.4^{a}	192.6^{a}	212.2^{a}	177.1^{a}
20% WMS	132.528^{b}	183.1^{ab}	201.2^{ab}	164.4^{b}
40% WMS	130.3^{b}	179.3^{b}	196.3^{b}	163.2^{b}
60% WMS	132.4^{b}	177.6^{b}	196.0^{b}	164.6^{b}
SEM	3.19	3.23	3.08	3.00
P-value	0.0032	0.0201	0.0148	0.0277
Main effect of parity				
1^{st} parity	135.0	182.6	201.1	166.8
2^{nd} parity	135.9	185.2	203.6	169.3
3^{rd} parity	133.7	181.4	199.4	165.9
SEM	3.4	3.7	4.0	3.8
P-value	0.8153	0.6884	0.6938	0.7412
Interaction effect WMS × parity				
0% WMS × 1^{st} parity	150.6^{a}	197.6	218.9	193.4

0% WMS × 2nd parity	137.2^{b}	191.5	208.3	191.5
0% WMS × 3rd parity	146.0^{ab}	189.1	210.0	189.1
20% *WMS* × 1st parity	137.2^{b}	184.0	203.8	184.0
20% *WMS* × 2nd parity	127.4^{c}	177.8	196.4	177.8
20% *WMS* × 3rd parity	133.0^{bc}	187.4	203.4	187.4
40% *WMS* × 1st parity	128.1^{c}	183.1	196.8	183.1
40% *WMS* × 2nd parity	136.6^{b}	181.6	200.3	181.6
40% *WMS* × 3rd parity	126.3^{c}	173.2	192.0	173.2
60% *WMS* × 1st parity	125.4^{c}	166.8	186.4	166.8
60% *WMS* × 2nd parity	142.3^{ab}	190.1	209.4	190.1
60% *WMS* × 3rd parity	129.3^{c}	176.0	192.3	176.0
SEM	5.2	6.40	7.03	6.41
P-value	0.0437	0.1446	0.2423	0.3478

$^{a, b, c}$ different superscripts within a column indicate significant differences.

Table 4 includes data concerning the effects of the WMS type on parity order at levels 20, 40, and 60% on the milk production of doe rabbits. When compared to other experimental groups during the first week of lactation periods in this study, BH alone in the basal diet free of WMS led to larger (P=0.0437) increases in milk supply. However, the findings demonstrated that the MY in the second, third, and fourth lactation periods was not significantly equivalent.

Lactation ratio, milk efficiency and average milk/ kit during lactation period of the doe rabbits:

Data regarding the effect of substitute WMS, parity order and their interactions on MY during the lactating periods are shown in Table 5. It was shown that the levels of WMS had a negative (P=0.0232 and 0.0243) impact on the average milk production per kit and lactation ratio, respectively. However, compared to rabbits fed diets containing 20 or 40% WMS, the milk efficiency value was significant (P=0.0319) greater in those fed diets containing BH alone or 60% WMS substituted with BH.

When the effect of WMS levels was overlooked, the results showed that during lactation periods (1−28 days), the parity order had no appreciable impact on the lactation ratio, milk efficiency, or average milk/kit. Comparing the average milk/kit milk yield values of the female rabbits in second parity with those of the doe rabbits in first and third parities, there was no discernible difference. As compared to 2nd and 3rd parity, the data also show that the lactation ratio and milk efficiency were at their greatest in the first parity.

During the lactation phase, the interaction between the WMS addition and the three parity orders significantly affected the lactation ratio, milk efficiency, and average milk/kit. The group that received 40% and 60% WMS during the second or third pregnancy and the first or third pregnancy recorded the highest lactation ratio. However, the group of female rabbits fed 40% WMS at the first parity and the group of doe rabbits fed BH exclusively at the second and third parities both had a considerably higher milk efficiency. Through the three parities of the experimental diet, the average milk/kit was considerably lower in the group of doe rabbits fed varied doses of 20, 40, and 60% WMS.

Table 5. Lactation ratio, milk efficiency and average milk/ kit during lactation period of the doe rabbits as affected by feeding diets replaced with WMS through three parities

Items	The total feed intake during lactation/total milk yield per lactation ratio	Milk efficiency (total milk yield per lactation/litter gain 1-28-day)	Average milk yield/ kit (the average daily milk yield/ litter size of the doe)
Main effect of WMS replacement			
0% WMS	1.160^{b}	2.641^{a}	29.59^{a}
20% WMS	1.234^{a}	2.267^{b}	26.66^{b}
40% WMS	1.262^{a}	2.427^{ab}	27.78^{b}
60% WMS	1.241^{a}	2.592^{a}	27.43^{b}
SEM	0.091	0.49	1.19
P-value	0.0232	0.0319	0.0243
Main effect of parity			
1^{st} parity	1.231	2.520	27.99
2^{nd} parity	1.210	2.433	28.16
3^{rd} parity	1.230	2.475	27.41
SEM	0.02	0.56	1.21
P-value	0.5491	0.6512	0.3592
Interaction effect WMS × parity			
0% WMS × 1^{st} parity	1.192^{ab}	2.877^{a}	32.13^{a}
0% WMS × 2^{nd} parity	1.136^{b}	2.430^{b}	29.31^{b}
0% WMS × 3^{rd} parity	1.082^{c}	2.813^{a}	29.29^{b}
20% *WMS* × 1^{st} parity	1.177^{b}	2.442^{b}	29.06^{b}
20% *WMS* × 2^{nd} parity	1.211^{ab}	2.267^{c}	25.87^{c}
20% *WMS* × 3^{rd} parity	1.212^{ab}	2.285^{c}	27.35^{b}
40% *WMS* × 1^{st} parity	1.175^{b}	2.306^{c}	28.79^{b}
40% *WMS* × 2^{nd} parity	1.237^{a}	2.860^{a}	29.51^{b}
40% *WMS* × 3^{rd} parity	1.289^{a}	2.353^{c}	27.09^{b}
60% *WMS* × 1^{st} parity	1.275^{a}	2.761^{ab}	24.95^{c}
60% *WMS* × 2^{nd} parity	1.148^{b}	2.465^{b}	30.85^{ab}
60% *WMS* × 3^{rd} parity	1.237^{a}	2.743^{ab}	28.39^{b}
SEM	0.11	0.66	1.28
P-value	0.0034	0.0176	0.0263

[a, b, c] different superscripts within a column indicate significant differences.

Litter performances of does rabbits:

Table 6 presents the performance and survival rate (%) of litters affected by the replacement of WMS with BH. The results show that substituting WMS for BH did not have a significant impact on LS at birth or weaning. However, there was a significant difference (P=0.05) in ALW at weaning, ALWG (g), and SR between doe rabbits fed a diet containing 20% WMS and those fed diets containing 40%, 60%, or 100% BH. These findings are consistent with those of Szendro et al. (2002), who suggested that milk production per offspring may have a significant effect on the mortality of young rabbits. Additionally, a decrease in mortality rate may indicate an improvement in milk quality due to biological treatments in the diets.

Irrespective of WMS levels, the results showed that LS, ALW (g) and ALWG (g), respectively were not affected significantly by parity order. Nevertheless, there were changes in the pre-weaning SR (%) of doe rabbits in the second parity that was statistically significant (P=0.01). However, the litter size gradually increased as parity increased, peaking at the third parities, (Mahmoud, 2013). Additionally, with a mean of 6.08, the LS at birth was significantly ($P<0.05$) larger in the third parities (6.80) than the first and second parities. Das and Yadav (2007) and Rabie et al. (2019) attribute this improvement to the maturity of the doe, as more ova were released from the ovary in the third parities, which increased the likelihood of increasing LS at birth. As reported by Zerrouki et al. (2004), immature first parity does have smaller overall LS and mean kit birth weights than older multiparous does. The lowest LS was discovered in the first kindling, and LS gradually grew until the fifth kindling, as demonstrated by Tuma et al. (2010), who also explained that the parity order had no discernible effect on LS. Brahmantiyo and Raharjo (2008) found that the number of newborns in a litter is also determined by genetics, the breeding season, the age of the doe, the number of previous litters, and the degree of nutrition. Weaning LS is affected by a variety of parameters, but the two most important ones are the mothering ability and milk secretion efficiency, which are strongly influenced by breed and parity, (Yamani et al., 1991; Tawfeek, 1995). The impact of parity, however, is not always positive. For instance, Singh et al. (2004) found that in German Angora rabbits, parity did not significantly improve the parameters of litter birth and weaning. Contrary to Das and Bujarbarua's (2005) assertion that parity had a substantial ($P<0.05$) impact on LW at birth, there was no discernible relationship between parity order and LW. According to Tuma et al. (2010) and Rabie et al. (2019), the LW at day 21 grew up until the third kindling before declining. Parity order has a significant ($P<0.05$) influenced on LS at birth and weaning, bunny weight at birth and weaning, LW at birth and post-weaning growth rate, (Apori et al 2014).

The interaction between WMS addition and three parity orders had no effect on LS, ALW (g), ALWG (g) and Pre weaning SR (%) of NZW rabbits.

Table 6. The Effect of nutritional interventions on Litter performance of does rabbits over the course of the three reproductive cycles.

Items	LS		ALW (g)		ALWG (g)	SR, (%)
	Birth	Weaning	Birth	Weaning		
Main effect of WMS replacement						
0% WMS	6.83	5.81	347.7	2273.0^{ab}	1925.3^{b}	85.07^{b}
20% WMS	6.97	6.14	327.2	2430.3^{a}	2103.1^{a}	88.09^{a}
40% WMS	6.78	5.61	322.6	2252.4^{ab}	1929.8^{b}	82.74^{c}
60% WMS	6.89	5.64	332.4	2143.7^{b}	1811.3^{c}	81.86^{c}
SEM	0.26	0.21	11.6	70.0	39.21	15.22
P-value	0.9797	0.4508	0.6726	0.05	0.003	0.02
Main effect of parity						
1^{st} parity	6.88	5.65	331.9	2236.3	1904.4	82.12^{b}

2nd parity	6.79	5.98	330.4	2327.5	1997.1	88.07^{a}
3rd parity	6.94	5.77	335.2	2260.7	1925.5	83.14^{b}
SEM	0.32	0.25	14.2	85.4	45.09	28.01
P–value	0.9376	0.5676	0.9668	0.6671	0.3249	0.01
Interaction effect WMS × parity						
P–value	0.8373	0.9886	0.9673	0.1522	0.0923	0.9430

$^{a, b, c}$ different superscripts within a column indicate significant differences.

LS=Litter Size; ALW=Average Litter Weight; ALWG= Average Litter Weight; SR=Pre–weaning Survival rate.

Conception rate (CR %) and Gestation length (GL–days)

Data regarding the effect of substitute WMS, parity order and their interactions on CR (%) and GL (days) during the experimental period are shown in Table 7. When compared to doe rabbits fed diets containing BH alone, it was observed that does fed diets with various amounts 20%, 40%, and 60% of WMS had a positive (P=0.0001) influence on CR (%).Different amounts of (20, 40, and 60% WMS) substituted for BH had no appreciable impact on gestational duration (days; P=0.7020).

When the effect of WMS level was overlooked, the results indicated that during three parities, the parity order had no a significant (P=0.9961 and 0.3371) effect on CR (%) and GL (days). The work of Tuma et al. (2010), there was no discernible effect of the season or parity order on gestation time, and the gestation period was typically greater than 31 days in rabbit does the fourth or fifth kindling. Also, Apori et al (2014) showed that there were however no significant effect of parity on GL (days) and the value was within the ranges (30–32 days for GL).

In Table 7, data are provided for the interaction between the 20, 40, and 60% levels of WMS by type of parity order at the CR (%) and GL (days) for doe rabbits. According to the findings, the group that received 20 and 40% WMS during the third and second parities had the highest conceiving rate (83.19 and 82.86%, respectively) with a *P*–value = 0.0001. The findings, however, demonstrated that gestational duration was unaffected by the substitution of various amounts of WMS during three parities.

Table 7. Conception rate (CR, %) and gestation length (GL, days) of doe rabbits as affected by feeding diets replaced with WMS through three parities.

Items	CR (%)	GL (days)
Main effect of mushroom replacement		
0% WMS	66.87^{d}	30.17
20% WMS	74.43^{a}	30.39
40% WMS	72.17^{b}	30.22
60% WMS	69.23^{c}	3031
SEM	0.43	0.21
P–value	0.0001	0.7020
Main effect of parity		
1st parity	70.63	30.35
2nd parity	70.71	30.31
3rd parity	70.69	30.15
SEM	0.73	0.22

P-value	0.9916	0.4471
Interaction effect WMS × parity		
0% WMS × 1st parity	75.78[b]	30.25
0% WMS × 2nd parity	58.33[d]	30.08
0% WMS × 3rd parity	66.50[c]	30.17
20% *WMS* × 1st parity	66.39[c]	30.17
20% *WMS* × 2nd parity	74.23[b]	30.58
20% *WMS* × 3rd parity	82.68[a]	30.42
40% *WMS* × 1st parity	74.92[b]	30.17
40% *WMS* × 2nd parity	83.19[a]	30.25
40% *WMS* × 3rd parity	58.39[d]	30.25
60% *WMS* × 1st parity	65.45[c]	30.83
60% *WMS* × 2nd parity	67.09[c]	30.33
60% *WMS* × 3rd parity	75.17[b]	29.75
SEM	0.852	0.245
P-value	0.0001	0.1362

a, b, c, d different superscripts within a column indicate significant differences.

Gestation length (GL): the interval between conception and kindling.

Conception rate (CR) = number of does that conceived / total number of does mated ×100

Blood Hematological Parameters

Table 8 presents data on the impact of substitute WMS, parity order, and their interactions on various blood parameters at mid lactation (14th day) of the experimental period. Increasing the amount of WMS in the diet led to a significant decrease in RBC (106/ mL) and WBC (103/mL) levels (P= 0.0001 and 0.002). However, Hb (g/dL) and HCT (%) did not show significant differences compared to the control group of doe rabbits (fed 0% mushroom) (P= 0.4396 and 0.5298).

Table 8. Hematological parameters of doe rabbits at mid lactation as affected by feeding diets replaced with WMS through three parities.

Items	Hb (g/dL)	RBC (10^6/mL)	WBC (10^3/mL)	HCT (%)	MCV (μm3)	MCH (ρg)	MCHC (g/dL)
Main effect of WMS replacement							
0% WMS	11.27	6.94[a]	9.11[a]	30.67	44.19[c]	16.24[c]	36.75[b]
20% WMS	11.97	6.96[a]	9.47[a]	28.56	41.03[c]	17.2[c]	41.91[a]
40% WMS	10.89	5.56[b]	7.68[ab]	31.44	56.55[b]	19.59[b]	34.64[b]
60% WMS	11.17	5.20[b]	5.88[b]	32.11	61.75[a]	21.48[a]	34.79[b]
SEM	0.77	0.17	2.06	2.19	2.01	0.62	2.77
P-value	0.4396	0.0001	0.0020	0.5298	0.0001	0.0005	0.0257
Main effect of parity							
1st parity	11.68	6.31	6.38[b]	31.71	50.25[ab]	18.51	36.84

2^{nd} parity	11.48	5.68	9.99^{a}	30.08	52.96^{a}	20.21	38.17
3^{rd} parity	10.81	6.50	7.73^{b}	30.29	46.6^{b}	16.63	35.69
SEM	1.20	0.22	1,81	2.29	2.08	0.71	2.82
P-value	0.3156	0.058	0.04	0.7215	0.05	0.057	0.0934
Interaction effect mushroom × parity							
0% WMS × 1^{st} parity	13.23	6.76^{b}	7.99^{c}	32.00	47.34^{cd}	19.57^{b}	41.34^{ab}
0% WMS × 2^{nd} parity	11.25	6.73^{b}	12.46^{a}	24.67	36.66^{e}	16.72^{c}	45.6^{a}
0% WMS × 3^{rd} parity	9.31	7.32^{a}	6.87^{cd}	35.33	48.27^{cd}	12.72^{d}	26.35^{d}
20% *WMS* × 1^{st} parity	11.64	6.95^{a}	8.36^{c}	28.17	40.53^{d}	16.75^{c}	41.32^{ab}
20% *WMS* × 2^{nd} parity	11.85	7.03^{a}	9.64^{b}	29.00	41.25^{d}	16.86^{c}	40.86^{ab}
20% *WMS* × 3^{rd} parity	12.43	6.90^{a}	10.41^{b}	28.50	41.3^{d}	18.01^{b}	43.61^{a}
40% *WMS* × 1^{st} parity	11.48	6.74^{b}	4.18	36.67	54.41^{c}	17.03^{c}	31.31^{c}
40% *WMS* × 2^{nd} parity	10.41	5.02^{c}	9.32^{b}	32.67	65.08^{b}	20.74^{b}	31.86^{c}
40% *WMS* × 3^{rd} parity	10.78	4.92^{c}	9.54^{b}	25.00	50.81^{c}	21.91^{b}	43.12^{a}
60% *WMS* × 1^{st} parity	10.37	4.78^{c}	4.98^{d}	30.00	62.76^{b}	21.69^{b}	34.57^{bc}
60% *WMS* × 2^{nd} parity	12.42	3.96^{d}	8.55^{bc}	34.00	85.86^{a}	31.36^{a}	36.53^{b}
60% *WMS* × 3^{rd} parity	10.72	6.86^{b}	4.12^{d}	32.33	47.13^{cd}	15.63^{c}	33.16^{c}
SEM	0.829	0.328	1.094	3.074	6.125	1.817	4.332
P-value	0.0706	0.0001	0.0211	0.0650	0.0013	0.0004	0.0314

a, b, c, d different superscripts within a column indicate significant differences.

Hb, hemoglobin; RBCs, red blood cells; WBCs, white blood cells; HCT, haematocrit

MCV: mean corpuscular volume (μm^3) =HCT (%) × 10/ RBCs (10^6/ mL)

MCH: mean corpuscular hemoglobin (*ρ*g) =Hb (g/ dL) ×10/RBCs (10^6/ mL)

MCHC: mean corpuscular hemoglobin concentration (g/ dL) =Hb (g/ dL) × 100/ HCT (%),

The maximum hemoglobin concentration, which fell within the range of 9.4 -17.4g/dl reported by Mitruka and Rawnsley (1977), was found in the female rabbits fed 60% WMS with BH diet. The (RBC) observed in this investigation was within the levels suggested for healthy rabbits by Hewitt et al. (1989). This suggests that up to 60% WMS may not negatively impact rabbit erythropoiesis. There is a small variation in RBC and WBC counts when WMS is consumed at greater doses, which may be caused by improper nutrient absorption and lingering anti-nutrients. The effects of 60% WMS-diets on MCH and MCV were substantial (P= 0.0001 and 0.0005). The levels of MCH and MCHC increased by 28.44% and 24.09% respectively, surpassing the control. However, at this level, MCHC significantly decreased (P=0.0257), while the group of doe rabbits fed 20% WMS in their diets showed a high value of MCHC. The decrease in HB, RBCs, and PCV of rabbits could indicate anemia, as evidenced by a significant increase in MCV and a significant decrease in MCHC values (Al-Redhaiman et al., 2003). The MCH values in this study at 40% and 60% WMS-diet were within the normal range of 19.2-29.5 pg reported by Hewitt et al., (1989). MCHC values at 20%, 40%, and 60% WMS-diets fell within the normal range of 31.1-37.0 g/l reported by Hewitt et al. (1989), even though the rabbits did not show any obvious signs of abnormality. MCHC values are known to be the most accurate and absolute index indicating the anemic condition in animals (Thompson, 2006).

Irrespective of WMS levels, the results showed that the 1st, 2nd and 3rd parities of female rabbits age had no significant effect on Hb (g/ dL), RBC (10^6/ mL), HCT (%), MCH (ρg) and MCHC (g/ dL); However, it had a significant effect on WBC (10^3/mL) and MCV (μm3), it was observed that WBC and MCV tend to increase in second parity of female rabbits age than in 1st and 3rd parity.

WMS levels and parities interaction had no any significant effect of HB and HCT. However, RBCs (10^6/ mL), WBC (10^3/mL), MCV (μm3), MCH (ρg) and MCHC (g/ dL) were significantly affected by the interaction and the rabbits fed on 20% WMS-diet recorded the highest value of RBCs (10^6/ mL). Also, significant effect due to the interaction was observed in MCH and MCV, since feeding 60% WMS-diet at 2nd parity when compared to the other experimental groups showed the highest values. As a general trend, feeding 20 and 40% WMS-diets to the female NZW rabbits at 3rd parity resulted in increasing MCHC.

Blood biochemical

Serum total protein, albumin and globulin concentrations

The values for total protein, albumin, globulin, albumin/globulin ratio, and glucose can be found in Table 9.

The results indicate that including WMS in the diets of female NZW rabbits at the studied levels, regardless of parity, affects serum total protein, albumin, globulin concentrations, albumin/globulin ratio, and glucose. When 20% WMS with BH was substituted for the control group, the levels of serum total protein and globulin were significantly altered (P=0.0111 and 0.00008). Serum albumin was higher (P=0.05) in the rabbits fed diets containing 40% mushroom waste compared to the control group, possibly due to improved albumin synthesis in the liver from diets containing treated rice straw. Kholif et al. (2005) and Allam et al. (2006) reported that biological treatments increased serum total protein and glucose. Additionally, the albumin/globulin ratio and glucose were higher (P=0.0052 and 0.0001) than the control and other treated groups when rabbits received a diet containing 60% WMS. The higher serum glucose with 60% WMS may be due to higher organic matter digestibility and higher TVFA in the rabbits. In contrast, Hassan et al. (2020) found no statistically significant differences in blood total protein, total albumin, and globulin concentrations at day 42 between chickens fed 1 and 2% WMS in the basal diet with Enramycin (125 g/kg) added as an antibiotic and those fed on a basal diet without supplementation.

The results also showed that total protein, albumin, globulin, albumin/globulin ratio, and glucose were not impacted by the order of the three parities in the experimental investigations when the influence of (20, 40, and 60% WMS) levels was disregarded

Table 9. Serum protein profile and glucose of doe rabbits at mid lactation period affected by feeding diets replaced with WMS through three parities.

Items	Total protein (g/dL)	Albumin (g/dL)	Globulin (g/dL)	A/G ratio	Glucose (mg/dL)
Main effect of WMS replacement					
0% WMS	5.327^{b}	3.24^{b}	2.08^{b}	1.56^{ab}	70.40^{c}
20% WMS	6.33^{a}	3.38^{ab}	2.95^{a}	1.15^{b}	80.16^{bc}
40% WMS	5.71^{ab}	3.66^{a}	2.06^{b}	1.78^{ab}	83.55^{b}
60% WMS	5.27^{b}	3.58^{ab}	1.69^{b}	2.12^{a}	97.51^{a}
SEM	037	0.041	0.046	0.748	2.34
P-value	0.0111	0.05	0.0008	0.0052	0.0001
Main effect of parity					

1st parity	5.85	3.50	2.34	1.50	81.34
2nd parity	5.79	3.57	2.22	1.61	81.41
3rd parity	5.34	3.31	2.03	1.63	85.98
SEM	0.055	0.064	0.056	0.028	2.49
P-value	0.1586	0.2162	0.4093	0.9657	0.4530
Interaction effect WMS × parity					
0% WMS × 1st parity	5.65^{b}	3.40^{c}	2.25^{bc}	1.51^{c}	80.89^{c}
0% WMS × 2nd parity	5.74^{b}	3.68^{b}	2.06^{c}	1.79^{b}	56.35^{d}
0% WMS × 3rd parity	4.56^{bc}	2.63^{d}	1.93^{c}	1.36^{cd}	73.98^{c}
20% *WMS* × 1st parity	5.79^{b}	2.95^{d}	2.84^{a}	1.04^{d}	58.80^{d}
20% *WMS* × 2nd parity	6.92^{a}	3.69^{b}	3.24^{a}	1.14^{d}	91.50^{b}
20% *WMS* × 3rd parity	6.26^{ab}	3.49^{c}	2.78^{a}	1.26^{d}	90.19^{b}
40% *WMS* × 1st parity	6.63^{a}	4.12^{a}	2.51^{b}	1.64^{c}	91.58^{b}
40% *WMS* × 2nd parity	5.18^{c}	3.42^{c}	1.77^{cd}	1.93^{b}	80.40^{c}
40% *WMS* × 3rd parity	5.33^{c}	3.44^{c}	1.89^{c}	1.82^{b}	78.67^{c}
60% *WMS* × 1st parity	5.31^{c}	3.54^{bc}	1.77^{cd}	2.00^{b}	94.08^{ab}
60% *WMS* × 2nd parity	5.31^{c}	3.51^{bc}	1.80^{c}	1.95^{b}	97.38^{a}
60% *WMS* × 3rd parity	5.20^{c}	3.68^{b}	1.51^{d}	2.44^{a}	101.07^{a}
SEM	0.394	0.212	0.330	0.316	5.87
P-value	0.0464	0.0069	0.0478	0.0381	0.0015

a, b, c, d different superscripts within a column indicate significant differences.

A/G ratio: albumin/globulin ratio.

WMS levels and parities interaction had a significant effect on serum total protein, albumin, globulin, albumin/globulin ratio and glucose. Total protein was significantly affected by the interaction and the group fed 20% WMS × 2nd parity and 40% WMS × 1st parity recorded the highest value of total protein. As well as, significant effect due to the interaction was observed on albumin, since feeding 40% WMS × 1st parity when compared to the other experimental groups showed the highest values. Besides, Globulin was significantly affected by the interaction and the group fed 20% WMS in diets rabbits during three parities recorded the highest value of Globulin. The opposite trend observed in A/G ratio and glucose, which were (P= 0.0381 and 0.0015) higher value since feeding 60% WMS × 3rd parity than the other treated groups.

Conclusion, The study found that using 20% waste mushroom substrate as a feed supplement with Berseem hay improved productivity in rabbits, including litter body weight at weaning, average litter weight gain, pre-weaning survival rate, and blood constituents.

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