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EFFECT OF SUBSTITUTING LENTIL SCREENING BY-PRODUCT FOR SOYBEAN MEAL ON GROWTH PERFORMANCE, NUTRIENTS DIGESTIBILITY AND CARCASS PARAMETERS OF GROWING RABBITS

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ABSTRACT: The objective of this study was to evaluate the nutritional impacts of the inclusion of different levels of lentil screening by-product (LSB) as unconventional ingredient of protein source as a replacement of soybean meal (SBM) on the growth performance, nutrients digestibility, carcass parameters and plasma constituents and of growing rabbits as well economic efficiency of the diets. Sixty New Zealand White (NZW) growing rabbits, 6 weeks age with an average live body weight 617.9 ±62.4 g were randomly assigned to four dietary treatments as follows: the first used as control diet while the other three diets were formulated to replace LSB for SBM at levels of 25, 50 and 75% (which is equal to 5, 10 and 15% LSB). The results showed that LSB contained 26.6% CP and 12.4% CF on DM basis. LSB was superior in gross energy content than SBM. Lentil screening by-product contains higher concentrations of phytochemicals such as saponnin (26.3 mg/100gDM), phytic acid (610 mg/100g DM), phenolic content (21.01 mg GAE/g DM) and tannins (840 mg catechin equivalent/100 g DM). The rabbits group fed 5% LSB achieved significantly (P<0.05) higher digestibility of CP and value of DCP compared to the control group. Moreover, the same group was higher (P<0.05) in TDN and DE values than the rabbits group fed 15% LSB. They also recorded the highest (P<0.05) final live weight. Daily gain significantly (P<0.05) increased in the groups fed 5, 10 and 15%LSB. The group fed the diet contained 15% LSB achieved the highest (P<0.05) hot carcass weight (g), dressing% and total edible parts%. The group fed 5%LSB recorded the highest (P<0.05) level of globulin. The total cholesterol content, ALT and AST levels tended to be lower (P<0.05) for both groups fed 10 and 15% LSB. Since the use of up to 15% of LSB didn't have a detrimental effect on productive performance, carcass characteristics and plasma constituents as well as economic efficiency in growing rabbit diets; therefore, lentil screening by-product can be recommended as replacement up to 75% of SBM in growing rabbits diets.

Keywords: Lentil screening, rabbits, growth, digestibility

INTRODUCTION

The most effective way to reduce the feed cost is to use the non-traditional feeds instead of relatively expensive conventional feeds especially for feeding rabbits which are becoming widespread in the developing countries. Environmental sustainability increased interest in seeking new protein sources as alternatives to replace soybean meal that is widely used as source of protein in rabbit's diets. However, it is highly expensive compared to other protein sources. Lentil screenings are promising good substitute for soybean meal in rabbit feeds, which are the by-products of cleaning lentil seeds. Lentil screenings consist of whole and broken lentils, cereal grains, weed seeds, haulm and dust (Stanford *et al*., 1999), these agro-industrial by-products may have potential value as animal feedstuffs (Andrade *et al*., 2019). Therefore, alternatives are required for the production of balanced pelleted feeds using local raw materials, available at a lower price (Kadi *et al*., 2018).

Lentil (*Lens culinaris Medik*) is one of the most important food legumes in the world. Lentil is an edible pulse. It is considered a major dietary protein source in developed countries (Rochfort *et al*., 2019 and Daniela *et al*. 2020). Lentil ranks the fifth among the most the world's most productive pulses and is grown in Egypt on 235,000 hectares, producing approximately 480,000 tons (FAOSTAT, 2017). Pulses like lentils are the edible seeds of legumes. Lentil seeds are also a good source of protein, fiber, essential minerals like calcium, phosphorous, iron and vitamin B (Joshi *et al*., 2017 and Khazaei *et al*., 2017). In addition, lentil contains phytochemicals including phenolic acids, flavanols, saponins, phytic acid, condensed tannins and has excellent antioxidant properties (Jamdar *et al*., 2017 and Campos-Vega *et al*., 2020). Lentils are a leguminous seed with high natural antioxidants content (Amarowicz *et al*., 2010). Moreover, lentil is a rich source of protein, ranging from 20.6% to 31.4% proteins (Urbano *et al*., 2007) and Lentil proteins are consisting of around 16% albumins, 70% globulins, 11% glutelins and 3% prolamins (Boye *et al*., 2010). Accordingly, good quality of lentil screenings by-product can be used as useful protein and energy-rich feeds because of the competitive price (Lardy and Anderson, 2009).Therefore, this study was conducted to investigate the potential use of lentil screenings by-product as an alternative protein source for growing rabbits and its effect on growth performance, nutrients digestibility, carcass parameters and plasma constituents.

MATERIALS AND METHODS

The experiment was conducted at Borg El-Arab experimental station, Animal Production Research Institute (APRI), Agricultural Research Center, Egypt.

Animals, experimental design, diets and management

Sixty New Zealand White (NZW) growing rabbits, 6 weeks age with an average live body weight 617.9±62.4g were allotted randomly to four experimental groups each of three replicates (five rabbits per replicate). Four experimental diets were formulated as follows: the first was used as control diet while, the other three diets were formulated to replace lentil screenings by-products for soybean meal at levels of 25, 50 and 75%. All experimental diets (Table 1) were formulated to be iso-nitrogenous, iso-caloric and to meet all the essential nutrient requirements of growing rabbits in accordance with De Blas and Mateos (1998). Feed composition and chemical analysis of the experimental diets are presented in Table 1.

The diets and fresh water were offered *ad libitum.* All rabbits were kept under the same management. The experimental period lasted for 8 weeks from 6 to 13 weeks of age. Animals were individually weighed every week, consumption of feed was recorded weekly, while feed conversion ratio (FCR) was calculated as gram feed per gram gain.

Digestibility measurements

At the end of the experimental period, a digestion trial was conducted to determine the digestion coefficient of the nutrients and the nutritive values of the experimental diets according to European reference methods (Perez *et al*., 1995). Twelve adult male New Zealand rabbits were allotted randomly to four groups of three rabbits each. Rabbits were housed in an individual metabolic cages and fed the experimental diets and then, feces were collected every 24 hours for 4 consecutive days weighed fresh and after dried at 60ºC for 24 h in air-drying oven . Data of feed intake and dried feces as well as chemical analysis of feed and dried feces were used to calculate the nutrients digestion coefficients and nutritive values for each dietary treatment, as described by Fekete (1985). Digestible energy (DE, Kcal/Kg diet) was calculated as follow: DE=TDN × 44.3 according to Schneider and Flatt (1975).

Chemical analysis

Chemical analysis of LSB, diets and feces were performed as recommended by A.O.A.C (2000) for determining moisture, crude protein (CP), crude fiber (CF) and ether extract (EE). Amino acids (Methionine and lysine) were determined using Beckman Amino Acid Analyzer (model 6300; Beckman Coulter Inc., Fullerton, Calif., USA). Amino acid hydrolysis was carried out according to the method of (AOAC, 2012).

Calcium was determined by an atomic absorption spectrophotometer and phosphorous was determined colorimetrically using spectrophotometer. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined sequentially according to Van Soest *et al*., (1991). Gross energy was determined by Isoperibol bomb calorimeter. Tannins were determined using vanillin hydrochloric acid method as described by Burn (1971) saponins were determined by using the method of Shany *et al.*, (1970) and phytic acid was determined colorimetrically using DU 7400 spectrophotometer according to A.O.A.C (2000). Phenolic compounds were determined by HPLC according to Goupy *et al*., (1999).

Slaughter trial, Blood collection and analysis

At the end of the experimental period (14 weeks of age), three rabbits from each treatment were randomly taken, individually weighed and slaughtered. After complete bleeding, pelt and viscera were removed and then carcass was weighed.The empty carcass was weighed without head and giblets. The giblets (liver, heart and kidneys) were separated and weighed. The edible giblets percentage, total edible parts and dressing percentage were calculated according to Blasco *et al.,* (1993).

Blood samples were collected at slaughtering time in heparinized glass tubes. Blood plasma was separated by centrifugation at 3,000 rpm for 15 minutes. The collected plasma was stored at -20°C until being assayed. Plasma total protein, albumin, creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT) and total cholesterol were measured by colorimetric methods using commercial kits supplied by Bio-diagnostic, Egypt. All measurements were performed according to the manufacturer's instructions. Total protein was determined according to Gornall *et al*., (1949), albumin was estimated according to Doumas and Waston, (1971), Plasma globulin concentration was calculated by the difference between total protein and albumin. Creatinine was assayed according to Young (2001), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined according to Henry, (1964), and plasma total cholesterol according to the method of Lopez-Virella *et al*., (1977).

Economic efficiency

Economic efficiency was calculated as the ratio between the return of weight gain and the cost of consumed feed. The cost of the experimental diets was calculated according to the price of different ingredients prevailing at local market as well as the price of tested materials at the time of experimentation, 2019. The price of one kg live body weight was 50 LE., at time of experiment.

Statistical analysis

The obtained data were statistically analyzed by using the GLM (General Linear Model) procedure of SAS software (2004) by one-way ANOVA, using the following model: $Y_{ij} = \mu + T_i + E_{ij}$, Where, Y_{ij} = An observation; μ = Overall mean; T_i = the effect of treatment groups; E_{ij} = experimental random error. Differences between treatment means were performed using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition of lentil screening by-product

The chemical composition of lentil screening by-product compared to soybean meal is presented in Table 2. LSB was higher in DM, CF, ADL, EE, NFE and ash contents. However, soybean meal contained more OM, CP, NDF, ADF and ash than LSB. Regarding the minerals content, soybean meal contained higher calcium and phosphorus concentrations than LSB. LSB was superior in gross energy content than soybean meal. Furthermore, lentil screenings by-products are relatively lower in lysine, methionine, and cystine concentrations than SBM.

In the present study, CP content of LSB is lower and fat content is higher than values recorded by Ganesan and Xu (2017) who mentioned that LSB contained 24.44 to 25.71 g/100g DM for CP and 0.92 to 1.06 g /100gDM for fat. While, the CF content of LSB was within the same range (10.7-31.4g/100g) as reported by the same authors. Furthermore, total carbohydrates averaged 51g /100 g for lentils (Siva *et al*., 2019) were lower than the value mentioned in the present study. Additionally, Daniela *et al*., (2020) demonstrated that Lentils (*Lens culinaris L*.) are a protein-rich plant, which is also enriched with fiber source. As well as, Chen *et al*. (2016) reported that lentils are significant worldwide legumes, providing excellent dietary sources of protein, fiber and micronutrients.

Phytochemical compounds of lentil screening by-product are shown in Table (3). Lentil screening by-product showed a significant amount of total phenolic and tannins content. Similar phenolic content of lentil (21.90 mg GAE/g DM) was reported by Tijana *et al.*, (2011)**,** while, higher total phenolic content (26 mg GAE/100 g fresh wt) was found by Ganesan and Xu (2017).

phenolics have recently been reported to be high antioxidants and have been shown to be more effective because of their scavenging ability due to their hydroxyl groups (Uddin *et al.*, 2014 and Zhang *et al*., 2018). Lentils contain higher concentrations of phytochemicals especially phenolic compounds (Oomaha *et al.,* 2011; Zhao *et al*., 2014). In this direction, the effectiveness of tannins as natural antioxidants is due to their complex combinations of decreasing and redox activities, which also allows them to scavenge radicals (Ricci *et al*., 2016). Therefore, many of *in vitro* studies have been identified the tannins ability as biological antioxidants (Barreira *et al*., 2008; Peng *et al.,* 2016; Huang *et al*., 2018). With regard to the phytic acid content, lentils contain (610 mg/100g DM) which is higher than the content reported by Ayet *et al.,* (1997) who found that lentils have 4.91 mg phytic acid/g DM . Besides, the lower saponin content was observed in Ganesan and Xu (2017) than saponin content in the present study. Zhang *et al*., (2018) further reported that lentils are considered the best source of saponins.

Concisely, the current study suggests that LSB is a potential functional dietary ingredient that has nutritive composition and a diverse profile of phytochemicals categorized into phenols, saponins, phytic acid and tannins that exhibit enhanced anti-oxidant activity as demonstrated by Zhang *et al*., (2018), Chen *et al*., (2016) and Daniela *et al*., (2020). Collectively, these findings indicate that lentil screening by-product is considered to be one of the best dietary feed sources in rabbit's diets.

Digestibility of nutrients

Digestibility of nutrients for the experimental diets is presented in Table (4). The obtained results showed that the differences were not significant in DM, OM, CF and NFE digestibility. Meanwhile, the group fed 5%LSB achieved significantly (P<0.05) higher digestibility of CP compared to the control group. Moreover, data of nutritive values illustrated that the group fed 5 and 10% LSB recorded higher (P<0.05) values of DCP than the rabbits group fed 15% LSB and the control group. While, TDN and DE values were higher (P<0.05) with rabbits group fed 5% LSB than those fed 15% LSB. This finding agreed with those reported by Suliman *et al*., (2019) who stated that no significant changes were noticed in all nutrients digestibility of DM, OM, CP, CF, EE and NFE between groups of rabbits fed 15 and 30%LSBP.

This study reveals that the enhanced digestibility in the groups fed diets contained different levels of LSB can be attributed to protein structures and energy content of LSB as it was mentioned in Table (2) that lentil screening by-product have a relatively high protein (26.60%) and gross energy content (4400 kcal/kg) and low digestive inhibitors. However, the main antinutritional factors in LSB are polyphenols, phytic acid, sapoinin and particularly tannins, but these are not present in considerable amounts to depress animal performance (Mavromichalis, 2013). Also, lentils had a high content of DE 3180 kcal/kg as fed and 3600 kcal/kg on DM for rabbits (Feedinamics, 2020). It is worthy to mention that the digestion coefficients of DM, OM, CP, CF and NFE were higher with the group fed 5% than the group fed 10 and 15% LSB diets. It should be taken into consideration that LSB contained anti-nutritional factors such as α-galactosides and trypsin inhibitor in substantial quantities. These compounds are responsible for decreasing the digestibility of protein by inhibiting protease activity (Vidal-Valverde *et al*., 1993). Digestibility of CP improved (P<0.05) by 6.00% in the group fed 5% LSB compared to the control group. These findings confirmed those of Ciurescu *et al*., (2017) who found that lentil seeds represent an interesting alternative protein source. Lentil protein has high nutritional value and high digestibility (Jarpa-Parra, 2018). Additionally, Lentils seeds had an intestinal health promoting effects that may be attributed to the quality of prebiotic carbohydrates (Genesan and Xu, 2017).

Growth Performance

The effect of LSB incorporation at different levels in rabbit's diets on their performance is presented in Table (5). Results indicated that there was a significant difference in final live body weight (P<0.05) between the group fed 5% LSB and the control group. While, insignificant differences were observed between the rabbits group fed 5% LSB and those fed 10% and 15% LSB. At the same time, the group fed 5%LSB recorded the highest final live weight while, the control group recorded the lowest one. It is worth noting that average daily gain of the groups fed 5, 10 and 15%LSB significantly (P<0.05) increased during the experimental period compared to the control group. Also, the average daily feed intake of the group fed 5%LSB diet was higher (P<0.05) than those fed 10%, 15%LSB diets and the control diet during the experimental period. However, the inclusion of LSB at the tested levels of 5, 10 and 15% had no significant impact on FCR.

Nevertheless, the findings of the current study are in line with those of Suliman *et al*. (2019) who stated that lentil screening by-product protein could be used up to 30% substitution level for soybean meal protein without any adverse effects on rabbit's performance. Ayaşan *et al*. (2018) published similar findings, and found that lentil by-products could be added into quail diets up to 15% with no negative impact on live body weight. Likewise, Farhoomand (2006) revealed that lentil seeds have the potential to be used in broiler diets up to 20% but not as the sole source of protein. Kara (2016) also stated that lentil bran, due to its high fiber content and low fermentation ability, may be recommended for the growing rabbit. In addition, Rossi *et al*., (2020) reported that lentil by-producrs may be satisfactorily used as a dietary feedstuff for rabbits due to improved growth performance.

In the sight of these results, up to 15% of LSB could be included in the rabbit's diets without any adverse effects on growth performance. This may be attributed to the nutritive composition of lentils which is a rich source of bioactive and non-bioactive nutrients. Moreover, lentils have the highest starch content and insoluble dietary fiber content and high quantities of prebiotic carbohydrates that sustain the gut microbiota (Ganesan and Xu, 2017). Lentils are known to be a good source of prebiotics and have nutritionally significant quantities of prebiotic carbohydrates (12.3–14.1 g/100 g of dry lentils) that help maintain the intestinal microbial environment and prevent intestinal diseases (Dwivedi *et* *al*., 2014 and Chen *et al*., 2016). Importantly, Lentils are not only an excellent source of macronutrients such as protein, fatty acids, fibers, and carbohydrates but also contain phytochemicals including phenolic acids, saponins, phytic acid and condensed tannins as presented in Table (3) and have strong antioxidant properties (Xu and Chang. 2010, Jamdar *et al*., 2017 and Campos-Vega *et al*., 2020). Condensed tannins have both positive with low levels of <3% and negative with high levels of >5% effects on nutrients digestibility and animal performance, depending on both the amount and biological activity of the condensed tannins (Schofield *et al*., 2001). However, several recent reports showed that several low-level tannin sources have improved health status and animal performance of monogastric farm animals (Brus *et al*., 2013; Starcevic *et al*., 2015; Ricci *et al*., 2016 and Huang *et al*., 2018).

Carcass characteristics

Carcass characteristics of the growing rabbits are summarized in Table (6). The present results revealed that the inclusion of LSB affected significantly (P<0.05) hot carcass weight, dressing %, heart % and total edible part %. The increasing of the incorporation levels of LSB in diets gradually increased (P<0.05) the hot carcass weight, dressing %, heart % and total edible parts %. It is worthy to mention that the group fed diet contained 15%LSB achieved the highest (P<0.05) hot carcass weight (g), dressing % and total edible part % compared to the other tested groups. On the other hand, the control group recorded the lowest (P<0.05) hot carcass weight, dressing %, and total edible parts %. Whereas, liver%, kidneys% and edible giblets % were not statistically affected by the inclusion of LSB in rabbit's diets. The results are inconsistent with previous studies (Suliman *et al*., 2019) who suggested that the inclusion of lentil screening by-product protein at a level of 15% significantly decreased (P<0.05) total edible parts % compared with the control group. Moreover, Ayaşan *et al*., (2018) found that the use of lentil by-products in quail's diets at levels of 5, 10, 15 and 20% reduced the dressing percentage than in the control group, even though the reduction was significant in 5 and 10% of lentil by-products fed groups.

The improvement of hot carcass weight (g), dressing %, heart % and total edible parts % of rabbits fed diets contained LSB may be partially explained by the tendency of enhancement in growth performance as well as by the superior feed efficiency for experimental diets included LSB at levels of 25, 50 and 75% of soybean meal, also the nutritive and potential functional composition of lentil screening by-product as presented in Tables (2) and (3). The present study suggests that faster growth shows better carcass characteristics.

Plasma constituents

The effect of feeding rabbits diets containing LSB on plasma constituents is shown in (Table 7). Data illustrated significant (P<0.05) higher levels of plasma total protein for rabbits fed diets contained 5 and 10% LSB than rabbits fed 15% LSB and the control group. Moreover, there was no significant difference in albumin level among all the experimental groups. While, rabbits group fed 5%LSB had the highest (P<0.05) concentration of globulin. The group fed 15%LSB was the highest (P<0.05) in A/G ratio compared to the other tested groups. Both groups fed 10 and 15% LSB diets had lower (P<0.05) values of total cholesterol, the inclusion of LSB decreased (P<0.05) the creatinine level of plasma. These results are in agreement with the observations of Suliman *et al*., (2019) who reported significantly higher (P<0.05) levels of plasma total protein and albumin concentrations for rabbits fed diets contained 30% lentil screening by-products protein than the control group. Also, there was a significant decrease (P<0.05) in AST level with rabbits fed 30% lentil screening by-products protein. The current results inconsistent with those reported by Ciurescu *et al*., (2017) who stated that broiler chickens fed 20 and 40% lentil seeds substitutes soybean meal had insignificant differences in plasma protein, cholesterol, creatinine, AST and ALT. In the current study, all values of plasma biochemical parameters were within the normal physiological ranges according to Harcourt-Brown (2002).

The decrease of total cholesterol may due to mixture of soluble and insoluble fibres derived from lentil screening by-product, the addition of soluble fiber could be the reason for the decreased serum cholesterol levels observed in rabbits fed diets contained LSB, as soluble fiber has been reported to be associated with lower circulating cholesterol levels (Abeysekara *et al*., 2012). According to previous studies, another reason is that lentil screening by-product contained anti-nutritional compounds such as saponins that have been reported to exert a positive effect by reducing cholesterol levels in the tissue and serum of experimental animal (Vinarova *et al*., 2015; Bera *et al*., 2019a). The lower serum cholesterol levels have also been observed in broiler chicken (Chaudhary et al., 2018; Bera *et al*., 2019b) due to the supplementation of dietary saponins from different sources. Similar findings have been found with rats fed diets containing 30% lentil and had lower level of plasma total cholesterol (Hanson *et al*., 2014).

Economical efficiency

The economic efficiency of dietary treatments is summarized in Table 8. The present results indicated that the best economic efficiency and net revenue were recorded by 25% LSB diet and the lowest values were for the control group. As well, the economic efficiency and net revenue improved with the dietary inclusion of LSB at levels of 5, 10 and 15%. It is clear to notice that replacement of soybean meal with LSB appears to be economically feasible because soybean has high price, besides it is an ideal feed for rabbits, so it has seriously affected the economic benefits of rabbit's production. In this trend, Gidenne *et al*., (2017) stated that feeding represents the majority of production costs and feed efficiency is a key criterion to improve the economic as well as environmental sustainability of the farm. The reduction of feed cost was explained by the low and competitive price of LSB compared to soybean meal, additionally, the improvement of the growth performance for LSB groups compared with the control group. These results are in agreement with those obtained by Suliman *et al*., (2019) who stated that the inclusion of lentil screenings by-products protein at a level of 30% of soybean protein in growing rabbits has the best net revenue and economical efficiency. It can be concluded that lentil screenings by-products can be economically used as a sole protein and energy source in diets for growing rabbits.

CONCLUSION

In conclusion, lentil screening by-product can serve as suitable alternative protein and energy source for growing rabbits, furthermore, lentil screenings by-products could be used in the rabbit diet up to 15 % to maintain the performance without any detrimental effects on the digestion coefficients of nutrients, carcass characteristics and plasma constitutes. Consequently, it can be considered that lentil screening by-product is a cheap source of ingredients that can be used economically in rabbit diets.

Table (1): Ingredients and chemical composition of the experimental diets**.**

Ingredient	**Experimental diets**			
	Control diet	**25%LSB[1]**	**50%LSB**	**75%LSB**
Soybean meal (44% CP)	20	15	10	5
Lentil screening by-product (LSB)	-	5	10	15
Barley	20	19	19	15
Wheat bran	24	25	25	26
Clover hay	30	30	30	33
Molasses	3	3	3	3
DL-methionine	0.4	0.4	0.4	0.4
Dicalcium phosphate	2	2	2	2
Sodium chloride (NaCl)	0.3	0.3	0.3	0.3
Vitamins and minerals primix[2]	0.3	0.3	0.3	0.3
Total	100	100	100	100
Chemical composition (DM basis)				
DM%	87.98	88.78	87.68	88.66
OM%	95.13	95.08	95.05	94.99
CP%	17.70	17.50	17.23	17.21
CF%	13.30	13.51	13.78	14.58
EE%	2.00	2.13	2.41	2.33
NFE%	62.13	61.94	61.63	60.87
Ash%	4.87	4.92	4.95	5.01
Calcium[3]	1.01	1.01	1.02	1.02
Total Phosphorus[4]	0.65	0.65	0.66	0.66
Methionine[5]	0.64	0.64	0.64	0.64
Lysine[6]	0.80	0.81	0.82	0.82
DE kcal/kg[7]	2707.56	2697.73	2685.09	2638.76

[1]LSB= Lentil screening by-product

[2]Each kg of vitamins and minerals mixture contains: Vit. A 2.000.000 IU, Vit.B_1 0.33g, Vit.B_2 1.0g, Vit.D_3 150.000 IU, Vit E 8.33g, Vit. K 0.33 g, Pantothenic acid 3.33g; Nicotinic acid, 30.00g; Vit. B_6 2.00g; Vit. B_{12} 1.7 mg, Folic acid 0.83g, Biotin 33 mg, Cu 0.5g, choline choloride 200mg,Mn 5.0g, Fe 12.5g, Mg 66.7mg, Co 1.33 mg, Se 16.6 mg, Zn 11.7g,Iodine 16.6 mg and Anti-oxidant 10.0g.

[3,4,5,6] Calculated on the basis of the ingredients composition.

[7]DE kcal/kg DM=3330 - 46.8 (%CF) according to Lebas and Gidnne (2000).

Table (2): Chemical composition of LSB compared to SBM (on DM basis)

Item (%)	**SBM[1]**	**LSB[2]**
DM	87.0	89.20
OM	95.69	93.80
CP	44.0	26.60
CF	7.30	12.40
NDF[3]	15.0	14.1
ADF[4]	10.0	5.2
ADL[5]	1.51	1.6
EE	1.50	2.20
Ash	4.31	6.20
NFE	42.89	52.60
Calcium	0.30	0.18
Phosphors	0.63	0.46
GE (Kcal/kg)[6]	3200	4400
Lysine	29.5	17.6
Methionine	6.5	2.2
Cystine	4.01	2.10

SBM[1]: Soybean meal*;* LSB[2]: Lentil screening by-product; NDF[3]: Neutral detergent fibre; ADF[4]**:** Acid detergent fibre**;** ADL[5]**:** Acid detergent Lignin**;** GE[6] (kcal/kg): Gross Energy.

Table (3): Phytochemical compounds of lentil screening by-product (on DM basis).

Item %	**LSB**
Total phenolic content (mg GAE/g DM)	21.01
Tannins (mg catechin equivalent/100g DM)	840
Phytic acid (mg/100g DM)	610
Saponin (mg/100g DM)	26.3

LSB: Lentil screening by-product

Table (4): Effect of inclusion of lentil screening by-product on digestibility and nutritive values of the experimental diets

Item	Experimental diets					
	Control	**25% LSB**	**50% LSB**	**75% LSB**	**±SEM[1]**	***P*-value**
Digestibility (%)						
DM	67.96	71.47	68.48	69.26	1.26	0.286
OM	70.53	78.20	71.18	71.37	1.28	0.284
CP	70.37^{b}	74.59^{a}	73.02^{ab}	72.14^{ab}	1.20	0.017
CF	54.16	57.47	54.95	51.44	3.39	0.672
EE	73.20	72.83	70.33	74.95	1.49	0.261
NFE	74.12	77.64	74.33	75.13	1.15	0.196
Dietary nutritive values[2]						
DCP[3]%	12.12^{b}	13.05^{a}	12.92^{a}	11.76^{b}	0.20	0.006
TDN[4]	69.68^{ab}	72.79^{a}	69.93^{ab}	67.78^{b}	1.27	0.011
DE(kcal/kg)[5]	3086.84^{ab}	3224.78^{a}	3097.93^{ab}	2999.94^{b}	56.17	0.011

a,b,c--- Means in the same row with different superscripts are significantly different ($P<0.05$).
[1]SEM: standard error of the mean.
[2]Dietary Nutritive values of experimental diets were calculated from digestibility coefficients (Table 4)
[3]DCP**:** Digestible crude protein; [4]TDN: Total digestive nutrients**;**
[5]DE: Digestible energy (kcal/kg)

Table (5): Growth performance of growing rabbits fed on the experimental diets

Item	Experimental diets					
	Control	**25% LSB**	**50% LSB**	**75% LSB**	**±SEM**	***P*-value**
Initial live body weight, (g)	618.33	617.92	617.91	617.50	18.01	1.000
Final live body weight, (g)	2042.92^{b}	2240.42^{a}	2174.12^{ab}	2164.12^{ab}	44.07	0.023
Average daily weight gain (g/rabbit/day)	25.44^{b}	28.97^{a}	27.78^{a}	27.62^{a}	0.61	0.002
Average daily feed intake (g/rabbit/day)	97.45^{b}	111.42^{a}	102.06^{ab}	98.46^{b}	3.95	0.065
FCR (g feed/g gain)	3.83	3.85	3.67	3.56	0.15	0.487

a and b means within the same row with the same letter are not significantly different ($p>0.05$).

Table (6): Carcass characteristics of growing rabbits fed the experimental diets.

Item	Experimental diets					
	Control	25% LSB	50% LSB	75% LSB	±SEM	*P*-value
Pre-slaughter weight (g)	2051.66	2063.33	2059.33	1971.66	48.04	0.518
Hot carcass weight (g)	1081.67^{b}	1186.67^{a}	1203.33^{a}	1226.67^{a}	24.38	0.013
Dressing %	52.79^{c}	57.49^{b}	58.43^{b}	62.29^{a}	1.13	0.002
Liver %	2.77	3.35	2.65	3.43	0.27	0.176
Heart %	0.31^{b}	0.39^{ab}	0.38^{ab}	0.43^{a}	0.03	0.011
Kidneys%	0.81	0.88	0.87	0.99	0.05	0.258
Edible Giblets[1] %	3.89	4.62	3.90	4.48	0.28	0.092
Total edible parts[2] %	56.69^{c}	62.11^{b}	62.33^{b}	67.14^{a}	1.22	0.002

a, b and c Mean values with the same letter within the same row did not differ significantly (P>0.05).
[1]Edible Giblets %= (liver+ kidney + heart) / Pre-slaughter weight (g)*100
[2]Total edible parts %= (carcass wt. + edible giblets wt.) / Pre-slaughter weight (g)*100.

Table (7): Plasma constituents of growing rabbits fed the experimental diets.

Item	Experimental diets					
	Control	25% LSB	50% LSB	75% LSB	±SEM	*P*-value
Total protein,g/dl	6.81^{b}	7.66 ^{a}	7.37^{a}	6.48^{b}	0.16	0.003
Albumin, g/dl	3.62	4.05	4.24	4.12	0.18	0.1658
Globulin, g/dl	3.19^{b}	3.61^{a}	3.13^{b}	2.36^{c}	0.13	0.0008
A/G ratio	1.14^{b}	1.12^{b}	1.37^{b}	1.75^{a}	0.12	0.014
Total cholesterol,mg/dl	102.76^{a}	95.52^{ab}	87.93^{bc}	82.76^{c}	2.41	0.0018
Creatinine, mg/dl	2.16^{a}	1.47^{c}	1.54^{bc}	1.63^{b}	0.02	0.0001
AST,u/l	39.60^{ab}	40.70^{a}	38.00^{b}	34.80^{c}	0.622	0.0008
ALT, u/l	46.00^{a}	43.67^{b}	42.08^{c}	41.00^{d}	0.22	0.0001

a, b,…ect mean values with the same letter within the same row did not differ significantly (P>0.05).

Table (8): Economic efficiency of the experimental diets.

Item	Experimental diets			
	Control	**25%LSB**	**50%LSB**	**75%LSB**
Average body weight gain (kg)	1.424	1.622	1.556	1.546
Price of 1 kg body weight (L.E.)	50	50	50	50
Selling price/rabbit (L.E.) (A)	71.20	81.10	77.80	77.30
Total feed intake/ rabbit (kg)	5.457	6.239	5.715	5.513
Price of feed/kg (LE)	4.77	4.523	4.235	3.928
Total feed cost/rabbit (LE) (B)	26.030	28.219	24.203	21.655
Net revenue/ rabbit (LE)[1]	45.170	52.881	53.597	55.645
Economic efficiency[2]	1.735	1.874	2.214	2.570

[1]Net revenue/ rabbit =A - B
[2]Economical efficiency = Net revenue / Total feed cost / rabbit (LE).

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الملخص العربي

تأثير إحلال مخلف غربلة العدس محل كسب الصويا علي اداء النمو وهضم العناصر الغذائية وقياسات الذبيحة للارانب النامية

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هدفت هذه الدراسة إلى تقييم التأثيرات الغذائية لإحلال مستويات مختلفة من مخلف غربلة العدس كمصدر للبروتين والطاقة علي أداء النمو وهضم المركبات الغذائية وقياسات الذبيحة ومكونات البلازما والكفاءة الاقتصادية للأرانب النامية. ستون ارنبا ابيض نيوزلندي نامي عمر 6 اسابيع بمتوسط وزن حي 617.9 ± 62.4 جم وزعت عشوائيا إلي اربعة مجموعات كالاتي: الاولي هي مجموعة الكنترول والثلاثة الاخري تم احلال مخلف غربلة العدس لكسب الصويا عند مستويات 25و50و75% من الكسب بما يوازى 5 ، 10 ، 15% مخلف غربلة العدس من العليقة. أوضحت نتائج الدراسة الحالية ان مخلف غربلة العدس يحتوي علي 26.6% بروتين خام، 12.4% الياف خام علي اساس المادة الجافة. مخلف غربلة العدس عالي في محتواه من الطاقة الكلية عن كسب الصويا ويحتوي علي تركيزات عالية من المواد الفيتوكيماوية مثل الصابونين (26.3 ملجم/100 جم ماده جافة)، حامض الفيتك (610 ملجم/100 جم ماده جافة)، المحتوي الفينولي (21.01 ملجم / حامض الجاليك) والتانين (840 ملجم مكافئ كتاشين/ 100 جم ماده جافة). حققت مجموعة الارانب التي تغذت علي 5% مخلف غربلة العدس اعلي معامل هضم بروتين واعلي قيمة للبروتين الخام المهضوم مقارنه مع مجموعه الكنترول، وايضا نفس المجموعه كانت اعلي معنويا في قيم مجموع المركبات الغذائية المهضومه والطاقة المهضومه من مجموعه الارانب المغذاه علي 15% مخلف غربلة العدس و سجلت ايضا اعلي وزن حي نهائي معنويا عند عمر 13 اسبوع وزادت الزياده الوزنية معنويا اثناء فتره التجربة مع مجموعات الارانب المغذاه علي 5 و 10و 15% مخلف غربلة العدس مقارنة مع العليقة الكنترول. لم يكن لاحلال مخلف غربلة العدس لكسب الصويا بمستويات 25و50و75 % تأثير معنوي علي معامل التحويل الغذائي. وحققت مجموعه الارانب المغذاه علي عليقة تحتوي علي 15% مخلف غربلة العدس اعلي وزن للذبيحة ونسبة التصافي و الاجزاء الكلية المأكولة. سجلت مجموعه الأرانب المغذاه علي 5% مخلف غربلة العدس اعلي مستوي من الجلوبيولين وكانت مستويات الكوليسترول الكلي وانزيم ALT , AST اقل لكلا من مجموعه الارانب المغذاه علي 10 و15% مخلف غربلة العدس. حيث ان استخدام مخلف غربلة العدس حتى مستوى 15% لم يكن له اي تأثيرات ضاره علي اداء النمو وصفات الذبيحة ومكونات البلازما وكان اكثر كفاءة اقتصادية في علائق الارانب النامية. فعلي ذلك يمكن أن يوصي باحلال مخلف غربلة العدس حتي 75% من كسب الصويا في علائق الارانب النامية.