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Evaluation Canola Meal on Growing Rabbits; Nutritionally and on Their Nutritional Meat Quality

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Abstract An experiment was conducted with 45 males growing New Zealand White (NZW) rabbits, four weeks old with an average initial body weight 480g were used in the study to assess their growth performance; meat quality and nutritional meat quality when fed a graded level of canola meal in the ration. The experimental diets had inclusion levels of 0%, 5% (5CM) and 10% (10CM) canola meal in treatments 1 (control), II and III respectively, with fifteen rabbits per every treatment diet and for an eight week feeding trial. During the experiment, growth body weight gain (BWG) was assessed daily and serum lipid profile was withdrawnby the end of 8 weeks. The canola meal at the level of 10 % and 5% of diet reduced both plasma triglycerides and cholesterol value as compared with the control group. The differences between groups were significant in high-density-lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C). While, there is no significant effect on Atherogenic lipoproteins (AL) in blood rabbit samples. At 12 weeks of age fifteen animals from each group were slaughtered for carcass evaluation, meat quality and frozen storage of meat. Results showed that the effect of treatments on body weight gain was insignificant. Average daily gains during the study were 27.42,28 and 28.78 gm, for the control group, fed 5% canola meal and fed 10% canola meal respectively. The produced group of rabbits meat contains of vitamins E was enhanced by feeding with canola meal. Thiobarbituric acid (TBA) levels of meat was significantly ($P<0.05$) lowered by supplemented with canola meal in a rabbit diet. Chemical composition of produced rabbit meat that is introduced, there were no difference ($P>0.05$) in moisture and crude protein ratio, the lipid and ash in all rabbit meat fed on 0, 5 or 10%. Physicochemical characteristics of fresh rabbit meat fed on canola meat and frozen storage, pH, water holding capacity (WHC) and cooking loss were investigated in this study. The effect of 5CM and 10CM supplemented in rabbit meal were occurred a significant ($P<0.05$) increase in PUFAs not only but also increase in total unsaturated fatty acids of produced rabbit meat. A significantly ($P<0.05$) higher monounsaturated being in 10CM meat after freeze storage period. C18:2 ω 6 is one of the most abundant PUFAs fatty acid in rabbit meat 10CM and follows by 5CM and control basal diet meat, these fatty acids include a conjugated linoleic fatty acid CLA. In terms of a nutritional treatment, which can be beneficial in improving meat and eating quality, special attention in recent years has been paid to conjugated linoleic acid (CLA). At 10CM meat of rabbit meat was significantly decreased atherogenicity index (AI) and Thrombogenicity index (TI) in nutritional quality. Amino acid profile and nutritional quality, the produced rabbit meat control dietary fed contains a low ratio of sulfur containing amino acids (1.89± 0.15). While, after supplemented the dietary of rabbit by 5 and 10%, the meat containing an appreciable amount of essential amino acid of sulfur contain amino acid and lysine. Essential amino acid index (EAAI) of four investigated samples were ranged 1.508 to 2.041. Corresponding to EAAI was recording a high value in 10CM meat (2.041) followed by 5CM (1.995) and zero canola rabbit meat group (1.534).Compared to the control diet better lipid stability (DPPH activity scavenging) was only found for 5CM and 10CM level in the meat produced. Its presence in the canola meal have probably contributed largely to its high antioxidant activity (phenolic compounds) and DPPH scavenging activity. Sinapic acid is the most abundant phenolic compound in canola meal, it appears in the meat of 10% group canola meal (6.01%) and (3.7%) in the meat of 5CM. Generally in the profile GC-MS showed that, 10CM meat extract containing appreciable amounts of phenolic and antioxidant material than identified in 5CM meat extract and control diet meat. In conclusion: these antioxidantsmay improve storage and nutritional quality of diet rabbit and its meat. A supplementation, diet of rabbit with canola meal was improved meat stability and nutritional quality. Reveled to the results that using canola meal up to 10% in growing NZW rabbit diets had improved on productive performance meat quality and nutritional meat quality in either fresh rabbit meat or storage rabbit meat moreover improve the economical parameter of by-product canola and rabbit meat.

Keywords: *rabbits, canola meal, growth performance, thrombogenicity index, fatty acid, nutritional meat, meat quality, serumbiochemistry, dpph, phenolic compound, CLA*

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1. Introduction

Rabbit meat is considered a Mediterranean food, especially in Egypt in last dedicate. Rabbit meat is flavorful and easily digested, with high nutritional and dietetic properties: this meat contains 20–21% of proteins, unsaturated fatty acids (oleic and linoleic; 60% of all fatty acids), potassium, phosphorus, and magnesium, it has low concentrations of fat, cholesterol, and sodium [1]. Rabbit meat is, to a great extent, compliance with the requirements for a complete protein diet and a reduction of fat content of foods. According to [2] 100 g of rabbit meat contain 25 mg cholesterol, which is very close to its content in the meat of wild animals. Moreover, the energy value of rabbit meat (427–849 kj/100 g of fresh meat) is comparable to various commonly consumed sorts of red meat [1].Complete meat proteins contain sufficient amounts of essential amino acids, yet the quality of a protein, as a primary food component depends on its amino acid composition [3].The most important attributes of rabbit meat to consumers are color, texture and flavor[1].

Food manufacturers use food-grade commercial antioxidants to prevent deterioration of products and to maintain their nutritional value. Lipid oxidation is a major problem in rabbit meat due to the high content of polyunsaturated fatty acids (PUFA), which can lead to oxidation reducing the shelf life due to rancidity and color deterioration. [4] reported that oat in rabbit diets decreased oxidation in the Longissimus dorsi muscle.

Antioxidants have also drawn attention from biochemists and health professionals for their beneficial health aspects. The use of extracts with antioxidative compounds from plant extracts instead of the commercial antioxidants like BHT and BHA has been discussed in the recent years.

Rapeseed (*Brassica napus* L.) is an important source of edible oil in many countries. In Egypt, it was introduced as an oil crop which may reduce the gap between local production and the consumption of edible oil. It might also provide a low-cost renewable resource of high value-added compounds such as tocopherol and phytosterols [5].Canola seed production in Egypt is about 1-1.2 Ton /Fadden and annual production 0.5 million ton/year (2012).

Canola meal is only second to soybean meal as the most commonly fed protein feedstuff in animal diets around the world [6].Canola is now the third most widely grown genetically modified crop after soybean and maize [6].Introduction Canola, after soy, is the second largest oilseed crop produced worldwide [7]. It was bred from rapeseed and it differentiates from the latter by its low content in erucic acid; an anti-nutritive fatty acid, which compromised the value of rapeseed oil for years [8]. Defatted canola (rapeseed) meal has been considered as a potential source of food-grade proteins because of its well-balanced amino acid composition [9].Canola mealcontents and a relatively high content of minerals, especially potassium, sulfur, calcium and iron and an especially good source of selenium and phosphorus [10]. Moreover, it is rich in choline, biotin, folic acid, niacin, riboflavin and thiamin [11]. Like many plant protein sources, canola meal is limiting in lysine but noted for having high levels of Met and Cys [12]. Canola protein is of high quality because of its good balance of essential amino acids and the highest protein efficiency ratio (PER= 3.29) of all plant based proteins. Therefore, rapeseed protein has a high biological value that could be sufficient to meet human requirements for essential and non-essential amino acids. The meal after oil extraction is used primarily as a protein source for animal feed; other uses for canola protein are very limited. Canola protein has a very complicated composition [13]. Two major storage canola proteins are cruciferin and napin, accounting for 60% and 20%, respectively, of the total protein in mature seeds [14]. The production of canola in Egypt is about 1-1.2 Ton /Fadden and annual production 500 million tons/year (2012).

These by-products of oil processing are normally referred to as meals. Meals contain after the extraction of oil , large amounts of phenolic compounds. The meals have a significant phenol content, which implies their antioxidative power [15]. However, the content of phenolics in rapeseed flour is nearly 30 times higher than that of soybeans. Among these, glucosinolates are the most important anti-nutritional compounds. The glucosinolates are important in cancer prevention agents and crop protectants [16]. Sinapic acid, the main phenolic compound of canola constitutes over 73% of free phenolic acids and about 80–99% of the main phenolic acids mainly occurring as esters and glucosides. The development and utilization of more effective antioxidants of natural origin could, therefore, afford potential benefits for the optimization of human health [17].

Other prospects for use of the meal include extraction of proteins fit for human consumption, since the meal contains normally around 50% protein content [18].Indeed, oil-free rapeseed meal contains 38-40% of crude proteins that display a well-balanced aminoacid composition with high levels of essential sulfur containing amino acids [19].

Normal diet contains soybean meal is considered the major protein source for animal nutrition, in some parts of the world, the whole soybean grain is used to increase the dietary lipid contents, and may be an option to improve the fatty acid profile of ruminant products [21].

Numerous animal feeding trials have been carried out using different species and breeds aiming at bringing the polyunsaturated fatty acid/saturated fatty acid (P/S) ratio of meat closer to the recommended value (>0.7), as well as for the n-6/n-3 ratio (<5). Besides the beneficial effects of PUFA for human health [22].

The ability of fresh meat to retain moisture is arguably one of the most important quality characteristics of raw products. It has been estimated that as much as 50% or more of the pork produced have unacceptably high purge or drip loss [23]. The majority of water in muscle is held either within the myofibrils, between the myofibrils and between the myofibrils and the cell membrane (sarcolemma), between muscle cells and between muscles bundles (groups of muscle cells). Once the muscle is harvested the amount of water and location of that water in meat can change depending on numerous factors related to the tissue itself and how the product is handled [24]. Water holding capacity is centered in the proteins and structures that bind and entrap water, specifically the myofibrillar protein. There is a great body of evidence that demonstrates a direct effect of pH, ionic strength, and

oxidation on the ability of myofibrillar protein and myofibrils and muscle cells to entrap water. Independent of these effects, it is clear that the same factors (pH decline, ionic strength, and oxidation) also affect proteolysis of key cytoskeletal proteins in postmortem muscle [25].

This present study was aimed at evaluating the effect canola meal by-product sources on growing rabbits and quality of their produced meat using biological treatment, nutritional and performed of physico-chemical qualities. In addition, this study was to investigate how supplementation rabbit diet on sheep canola meal in improve nutritional and storage its rabbit's meat quality.

2. Material and methods

2.1. Chemicals, Solvents, Reagents

2.2-Diphenyl-1-picrylhydrazyl (DPPH•), butylated hydroxyl Toluene (BHT) and Folin–Ciocalteu reagents were obtained from Sigma Chemical Co. Methanol (HPLC grade) was purchased from Aldrich Co. All other solvents and chemicals were of analytical grade.

2.2. Materials

Egyptian canola meal (*Brassica juncea*) was obtained from the El-Barka for Natural Oils, EL-Gurghada, Egypt. The meal was used to study. Canola meal was milled using an electric miller (Coffee grinder, Moulinex,France), sieved through the 841 mm screen, and kept Frozen in polyethylene bags until used.

2.2.1. Lipid Extraction

The total lipid was extracted with chloroform / methanol (2:1 v/v) as described by after lipid ex- traction [26]. Briefly, the rabbit meat samples were homogenized; 3 g of each homogenates was taken and mixed with chloroform / methanol (2:1 v/v) in solvent blander.

2.2.2. Proximate Chemical Composition

The proximate composition of canola meal and rabbit meat and their storage were determined according to [27] in twice. Caloric contents of seeds were calculated from crude fat, crude protein, fiberand ash.

2.3. Experimental Site and Management of Rabbit Animals

2.3.1. Animals and Diets

The experiment was carried out at the rabbit farm belonged to an intensive rabbit production unit; Faculty of Agriculture; Ain Shams University. Forty five male New Zealand white rabbits, of four weeks of age and 480 gm average live body weight were randomly distributed into three comparable groups; each of 15 cadges. All experimental animals were housed in individual cages provided with continued feeders and automatic waters during the experimental period lasted for 8 weeks. As shown in Table 1. Rabbits groups were fed diet without canola meal (control, group 1), or with 50 g canola meal /kg diet (5% canola meal (5CM)) group 2 or with 100 g canola meal /kg diet (10% canola meal (10CM)) group 3. Chemical analysis showed that the canola meal contained 8.5 % moisture, 36 % crude protein, 3.7 ether extract, 12 % crude fiber, 33.1 % nitrogen free extract (NFE) and 6.7 % ash. The experimental diets covered nutrients requirements for growing rabbits as recommended by [28]. Animals were weighed individually at weekly intervals.

Table 1. CompositionOf Diet Supplemented With Canola Meal For Three of Rabbit Group.

Nutrients	Control Diet Group (0CM) ** (N=15 per group)	Diet Contain 5% Canola Meal Group (5CM)(N=15 per group)	Diet Contain 10% Canola Meal Group (10CM) (N=15 per group)
Barley	33%	33%	33%
Alfalfahay 12% CP	28 %	26 %	25.5 %
Soybeans 44%	16 %	10 %	5 %
Canola meal	0	5%	10%
Wheat bran	15.5 %	17.5 %	17 %
Corn gluten	1%	2%	3%
Molasses	3%	3 %	3 %
Di calcium phosphate	2.2 %	2.2 %	2.2 %
Calcium carbonate	0.4%	0.4%	0.4%
Premix *	0.3%	0.3%	0.3%
Na cl	0.3%	0.3%	0.3%
Methionine	0.1%	0.1%	0.1%
Anti-fungi	0.1%	0.1%	0.1%
Anti-toxin	0.05%	0.05%	0.05
Anti coccidia	0.05%	0.05%	0.05%
Total	100%	100%	100%
Protein cp %	17.4	17.3	17.4
Cf%	12.9	12.9	12.9
Energy	2513	2500	2500

*Premix: Supplied per kg. of diet: 12000 IU vit.A; 2200 IU vit. D3; 10 mg vit. E; 2.0 mg vit. K3; 1.0 mg vit. B1;4.0 mg vit. B2; 1.5 mg vit. B6; 0.0010 mg vit. B12; 6.7 mg vit. PP; 6.67 mg vit. B5; 0.07 mg B8; 1.67 mg B9; 400 mg Choline chloride; 133.4 mg Mg; 25.0 mg Fe; 22.3 mg Zn; 10.0 mg Mn;1. 67 mg Cu; 0.25 mg I and 0.033 mg Se

** Number of each group was 15 rabbit animal.

2.3.2. Blood Sample Collection

Blood samples were withdrawnby the end of 8 weeks, from the ear vein of animal in a heparinzed syringe and put in a vacationer tube under cooling until reaching to the laboratory. The plasma was carefully separated after centrifugation and stored at -20°C for biochemical analysis. Total cholesterol and Triglyceride were determined according to [29]. Cholesterol LDL was determined according to [30] and Cholesterol HDL was determined according to [31]. Calculated atherogenic lipoproteins according formula described by [32]:

$$\textbf{Atherogenic lipoproteins} = \textbf{Total cholesterol / HDL ratio } (\textbf{TC / HDL}) \quad (1)$$

2.3.3. Slaughter and Carcass Traits

At the end of the experimental period (at 12 weeks of age) animals from each experimental group selected at random and slaughtered according to the Islamic rolls using the procedure described by [33]. Rabbits were weighed just before slaughter and carcass after complete bleeding, then the head, giblets (heart, liver and kidneys) and hot carcasses were weighed. And the dressing percentage was calculated. For meat composition traits, all

carcasses were divided longitudinal to two similar halves. Lean samples from different carcass parts as a percentage of the carcass of the animal are mixed for chemical analysis, physicochemical analysis, and storage.

2.4. Evaluation of Rabbit Meat Quality Parameters

2.4.1. Chemical Composition of Rabbit Meat Fed on Basal Diet with Zero Canola Meal and at Different Ratios of Canola Meal

Proximate analyses of muscles were carried out according to the Association of Official Analytical Chemists [34]. In particular, moisture, ash, and total nitrogen content were obtained using the N. 950.46B, 920.153, and 928.08 methods, respectively. The total protein content was calculated using Kjeldahl nitrogen and a conversion factor of 6.25.

The water holding capacity (WHC) describes the ability of meat to resist the removal of liquid that could result from squeezing the beef or from gravity [35]. The water holding capacity (WHC) was estimated [36] by centrifuging 1 g of whole muscle placed on tissue paper inside a tube for 4 min at 1500×g. The remaining water after centrifugation was quantified by drying the samples at 70 °C overnight. The WHC was calculated as follows: (weight after centrifugation−weight after drying) /initial weight×100.

Malondialdehyde: was determined in rabbit meat samples after sacrifice (zero time) and different storage days at 5 °C according method described by [37].

2.4.2. Determination of Vitamin E

Vitamin E (α–tocopherol) in rabbit meat were assayed using HPLC, according to [38].

2.5. Determination Fatty Acid Profile in Extracting Rabbit Meat

The fatty acid (FA) profile of extracted lipid from diets and meats on the second day of slaughter and after 45 days of freezing storage (-20°C). It's been determined by gas-chromatography (Shimatzu 2010 *plus* equipped with a flame ionization detector; Japan) according to the method by [34]. Separation of the resulting fatty acid methyl esters (FAME) was carried out on an Agilent (J&W) capillary column (60 m×0.25 mm I.D.) coated with a DB-Wax stationary phase (film thickness of 0.25 mm). The individual FA methyl esters (FAME) were identified by reference to the retention time of authentic FAME standards. The relative proportion of each FA in the samples was expressed as a percentage of total FA and calculated by GC software.

2.5.1. Calculated Nutritional Indices

From the fatty acid profile, the Atherogenicity Index (AI) and Thrombogenicity (TI) Indices were calculated, as proposed by [39] to relate the profile of fatty acids with the risk of cardiovascular disorders, through the equation:

$$IA = \begin{bmatrix} C12:0 \\ +(C14:0\times 4) \\ +C16:0 \end{bmatrix} / (Total\ unsaturated\ fatty\ acids) \quad (2)$$

Where: C12 = the percentage of lauric acid in relation to TFA; C14 = the percentage of Myristic acid in relation to TFA; and C16 = the percentage of palmitic acid in relation to TFA.

$$TI = \Sigma(C14:0 + C16:0 + C18:0) / \begin{pmatrix} 0.5\times C18:1 \\ +0.5\times \Sigma\ MSFA \\ +0.5\ \times\ \Sigma\ (\omega - 6) \\ +0.5\times\ \Sigma\ (\omega - 3) \\ +(\omega - 3/\omega - 6) \end{pmatrix} \quad (3)$$

Where: ω-6 is fatty acids containing omega-6 and ω-3 is fatty acids containing omega-3.

2.5.2. The Peroxidizability Index (PI) of the Lipids

PI was calculated on the basis of the number of methylene groups between the double bonds, according to the following equation reported by [40]:

$$\begin{aligned} PI = {} & (\%\ \text{dienoic}\times 1) + (\%\ \text{trienoic}\times 2) \\ & + (\%\ \text{tetraenoic}\times 3) + (\%\ \text{pentaenoic}\times 4) \\ & + (\%\ \text{hexaenoic}\times 5). \end{aligned} \quad (4)$$

2.6. Determination of Amino acids

Amino acids determination for canola meal and rabbit meat fed on canola meal were performed according to the method of the [34]. Oxidation with performic acid, to protect methionine and cysteine from destruction during acid hydrolysis with (6 M HCL) was carried out in closed conical flask for determining all amino acid other than tryptophan. A sample of 20-30 mg weighted in conical flask and 5 ml of performic acid was added. The flask was closed and placed in ice water bath for 16 hours. Sodium metabisulfate and 25 ml HCL 6 N were added to the oxidized mixture. The flask was placed in an oven at 110 °C for 24 hours. The flask was then opened and all removed from evaporating samples to dryness in a rotary evaporator. A suitable volume of sodium citrate buffer (pH 2.20) was added to the dried film of hydrolyzed sample. After all soluble material completely dissolved, the samples analyzed for amino acids using Eppendorf LC 3000 (EZ Chrom, software used for data collection and processing). The results were calculated as percentage of total crude protein. For tryptophan determination, an alkaline hydrolysis with lithium hydroxide under oxygen exclusion was undertaken according to [41] and [42].

2.6.1. Protein and Nutritional Qualityparameter

2.6.1.1. Protein Chemical Score (PCS)

An amino acid score was computed for each essential amino acid by the following formula.

$$PCS = \text{Min}\{(a\ a\ AA)1\ldots\ (a\ a\ /\ AA)k\} \quad (5)$$

Where a - amino acid in meat sample; b - essential amino acid in meat sample; n - the number of amino acids; m - the number of essential amino acid; AA - the content of amino acid in [43]. The lowest amino acid score was used as the chemical score for the protein and also predicted the first-limiting amino acid. The reference patterns used were those established by [43].

2.6.1.2. Essential Amino Acid Index

Amino acid results were expressed as µmoles of amino acid per gram of diet (µmolg–1) and as grams per 100g determined amino acid for protein. The essential amino acid (A/E) ratio [44] of each essential amino acid (EAA) was calculated as the percentage of the total EAA. The essential amino acid index (EAAI) of the two diets was determined from the formula:

$$\mathbf{EAAI} = \sqrt[n]{aa1/AA1 \times aa2/AA2 \ldots\ldots\ldots \times aa11/AA11} \quad (6)$$

Where: aa1 is the A/E ratio in the protein sample [(EAA/total EAA+tyrosine) ×100], AA1 is the A/E ratio in the egg [(EAA/total EAA+tyrosine) ×100]. The EAAI is patterned after the formula for [45] using as the reference protein. In this study, whole Egg was used as the reference protein, following the hypothesis that an efficient diet should have a similar amino acid profile to that of the experimental rats [46].

2.6.1.3. Protein Efficiency Ratio (P-PER)

PER values were calculated from the regression equations proposed by [47] depending on the Leu, and Tyrcontents (g/100 g protein).

$$P-PER = -0.468 + 0.454\ (Leu) - 0.105\ (Tyr) \quad (7)$$

2.7. Antioxidant and Phenolic Compound Profile

Extraction and identification of phenolic compounds by GC–MS. Phenolic compounds of extractingrabbit meat fed on 5% canola meal and rabbit meat of feeding control diet according to the method described by [34] and [48]. One gram of oil was extracted three times with methanol2 ml. The extracted was combined and methanol evaporated under reduced pressure. The residue was dissolved in acetonitrile (2ml) and washed two times with hexane (3ml). Acetonitrile was evaporated under vacuum and the residue was dissolved in methanol (1ml). Injections of 10µl from this dissolve extracted lipid in methanol, were performed into using a GC/MS (Agilent Technologies 6890N computerized system coupled to an MSD, Agilent 5973B mass spectrometer).

2.7.1. Total Phenolics

Total phenolics were determined according to the Folin–Ciocalteu method [49]. This protocol gave a good idea of the total phenolic content. Appropriately diluted extracts (3.6 ml) were mixed with 0.2 ml of Folin–Ciocalteu reagent (Sigma) and 3 min later, 0.8 ml of sodium carbonate (20% w/v) was added. The mixture was heated at 100°C during 1 min. After cooling, the absorbance at 725 nm was measured. Phenolic contents were calculated on the basis of the standard curve for Gallic acid (GAL). The results were expressed as mg of Gallic acid equivalent per g of dry extract. Analyses were performed in duplicate on each extract.

2.7.2. DDPH activity Scavenging Activity

DDPH activity Scavenging activity was determined by radical 2, 2-diphenyl-1-picryhydrazyl (DPPH˙), as described by [50]. A stock solution was prepared by stirring 75 mg of DPPH˙to 1 L of methanol overnight. In the assay, 0.75 ml of extract, blank (methanol), and 1.5 ml of DPPH solution were mixed. The absorbance at 517 nm of samples, standards and blanks was determined after 5 min. For each extract, a blank with 1.5 ml of methanol, instead of DPPH˙ reagent, was included to correct for any sample absorbance at 517 nm. The DPPH radical scavenging activity materials were compared with the activity of synthetic butylated hydroxytolulene (BHT).

The percentage inhibition was calculated as follows:

$$1\% = \frac{\left[\begin{array}{l}\text{absorbance of control} \\ -\text{absorbance of sample} \\ (\text{CD, and rabbit meat fed on5 and 10\%})\end{array}\right]}{\text{absorbance of control}} \times 100 \quad (8)$$

2.8. Statistical Analysis

Data were subjected to a one-way analysis using [51]. Variables having significant differences were compared using Duncan's Multiple Range Test [52].

Table 2. Effect of Canola Meal Supplemented Rations on Body Weight and Daily Gain In Male NZW Rabbits

Items	Control Group (0CM)	Fed Canola Meal 5% (5CM)	Fed Canola Meal 10% (10CM)	SE	Probability
Animal Number	15	15	15		
Initial Body Weight (gm) (4th Weeks Of Age)	484	482	478	23.4	NS
Final Body Weight(gm) (12th Weeks Of Age)	2020	2050	2090	60.3	NS
Total Body Gain (From 4th To 12th Week)	1536	1568	1612	38.2	NS
Daily Gain (gm)	27.42	28.0	28.78	1.2	NS

Nearly similar for the different groups. The dressing percentage revealed the same, n=15 rabbit per each group.

3. Results and Discussion

3.1. Growth Performance Traits

Data in Table 2. Showed that, there were no significant differences between the body weights of the experimental groups. The final body weights were 2020, 2050 and 2090 gm for the control group (0CM), fed 5% Canola meal (5CM), and fed 10% canola meal (10CM), respectively. It could be noticed that average daily gains followed the same trend of the body weight being higher for rabbits fed canola meal than the control group. The highest improvement in average daily gains during the present study was 4.3 % in those fed 10% Canola meal group followed by 2.22% in the group fed 5% canola meal, as compared with the control group. For comparison, similar results were recorded by [53] reported that finishing steer calves fed canola meal increased average daily gain as compared with control group. However, the highest

improvement found in feeding canola meal may be due to its contains of free fatty acids, unsaturated fatty acids (such a linolenic acid) and omega-3 fatty acids with has a main effect on optimum lipid metabolism and subsequent body weight [54]. Moreover, [55] found that the highest level of essential fatty acids, unsaturated fatty acids and malabsorption of fatty acids in canola can play a major role in feed conversion ratio with reduces the rate of feed passage through the digestive system, which allows a better absorption of all nutrients in the diet.

3.2. Carcass Characteristics

Carcass traits of rabbits for different groups are shown in Table 3. There were in significant differences in the final live body slaughter and carcass weights among the different groups. It could be noticed that, the canola meal 10% group showed the highest final live body slaughter and carcass weights (2070 and 1306 gm, respectively), in the other side the control group showed the lowest final live body slaughter and carcass weights (2010 and 1245 gm respectively). Also, the carcass traits of Fore part, Middle part, Hind part, liver, kidneys, hearts, lungs and heads were trend of final live body slaughter and carcass weight, when showed higher dressing percentage of canola meal 10% group followed by canolameal 5% and the control group had the lowest percentage, nearlysimilar results were obtained from [55] that dietary supplementation with canola meal improved the performance and carcass traits in broiler chicks. However [56] they reported that canola meal improved feed intake and feed conversion ratios in the broiler chicks.

Table 3. Effect of Canola Meal on Carcass Traits in Male NZW Rabbits

Carcass Traits	Control Group (0CM)	Fed Canola Meal 5% (5CM)	Fed Canola Meal 10% (10CM)	SE	Probability
Animal Number Slaughters Body Weight (g)	5 2010	5 2030	5 2070	64.3	NS
Hot Carcass Weight (g)	1245	1265	1306	45.2	NS
Dressing (%)	61.9	62.2	63.1	1.2	Ns
Fore Part (%)	16.7	16.6	16..8	0.41	NS
Middle Part (%)	12.1	12.3	12.25	0.32	Ns
Hind Part (%)	20.2	20.1	20.8	0.36	Ns
Head (%)	9.8	10.2	10.06	0.19	Ns
Liver (%)	3.1	3.02	3.2	0.11	Ns

Nearly similar for the different groups. The dressing percentage revealed the same, n=15 rabbit per each group.

3.3. The Blood Plasma Biochemical Response of Rabbits Fed on Canola Meal

The results of biochemical blood plasma of New Zealand White male rabbits are presented in Table 4. Plasma cholesterol level was significantly decreased by 19.7 and10.4 % in group fed canola meal 10% and 5%, respectively, related to control group. Similar result, both of the triglyceride and cholesterol concentration were decreased when reaching diet of rabbit with canola meal [57] and [58]. The improvement cholesterol level in the feeding canola meal was explained by the effect of components of canola meal including fatty acids, triterpene alcohols, phytosterols, tocotrienols, and α-tocopherol [59].

In addition to these components, the phytosterols including gamma oryzanol are thought to be responsible for changes in blood cholesterol concentrations [60]. Generally the blood plasma triglyceride concentration followed the same trend of cholesterol concentration to be lower for rabbits fed diet with canola meal thanthe control group. Blood plasma LDL concentrations (Table 4) were 47.8, 38.2 and 30.5 mg /dl for control group, canola meal 5% and canola meal 10% The highest decrease of LDL cholesterol concentration in blood plasma in the case of feeding diet with canola meal 10% group, to the effect of canola meal prevent the accumulation of LDL cholesterol by enriching the monounsaturated fatty acid (oleic acid) as well the unsaturated fatty acids (61%) which consider to heart-friendly acids [60]. The effect feeding diets with examined on HDL were significant (Table4). The present results showed that, the difference between groups was insignificant in the case of HDL and VLDL cholesterol content (Table 4).

Table 4. Effect of Canola Meal on Blood Parameters of NZW Rabbits

Plasma Parameters	Control Group (0CM)	Fed Canola Meal 5% (5CM)	Fed Canola Meal 10% (10CM)	SE	Probability
Triglyceride (mg/dl)	96^{a}	91.4^{c}	87.5^{b}	2.22	P<0.05
Total Cholesterol (mg/dl)	86^{a}	77^{c}	69^{b}	1.83	P<0.05
HDL-C (mg/dl)	36^{c}	34.6^{a}	31^{b}	0.81	P<0.05
LDL-C (mg/dl)	45.8^{a}	38.2^{c}	32.5^{b}	0.87	P<0.05
VLDL(mg/dl)	4.2	4.3	4.2	0.12	NS
Atherogenic lipoproteins (AL)	2.39	2.23	2.23	0.16	NS

Nearly similar for the different groups. The dressing percentage revealed the same, n= Three mixed samples from each group of rabbit.

Atherogenic lipoproteins (AL) composition of fed on canola meal rabbit is reported in Table 4. There were no significant treatment differences ($p > 0.05$) observed in the AL level in blood of feeding rabbit on either 5 or 10% canola meal in the current study (Table 4). With an enormous decrease in the AL was accompanied with a

significant decrease occurred in triglycerides, total cholesterol, HDL-C, LDL-C when compared to the control rabbit group. These results are caused a significant improvement in rabbit blood lipid profile, these parameters its hypolipidemic and anti-atherogenic effects (Table 4). These were atherogenic events, compelling evidence that nutrition can affect the genesis of Atherogenesis by modulating functional properties of vascular endothelial cells [61].

3.4. Chemical Composition of Rabbit Meat Fed on Basal Diet with Zero Canola Meal and at Different Ratio of Canola Meal

The chemical composition of rabbit meat after feeding on a normal diet and canola meal with 5 and 10% diet are reported in Table 5. The crude protein and lipid contents in rabbit meat are important nutritional parameters. The canola meal protein (Table 8) has been contained 35.1%. Crude protein proximate composition demonstrates its rich in protein rages 21.7 -23.21 (g/100g) in Table 5. Along with high protein content, rabbit meat also contains high essential amino acid level. The rabbit meat also fed on canola meal (moisture) is relatively contained 74.70, 74.15 and 72.81 (g/100g) in a diet containing 0, 5 and 10% canola meal.

There were no difference (P>0. 05) in moisture and the crude protein ratio in all rabbit meat fed on 0, 5 or 10% (Table 5). Similar finding in the lipid and ash ratio were none significantly different (P>0. 05) in the zero canola meal diet and either 5 or 10% canola meal enrichment. The vitamin E in rabbit meat in all ratio canola meal diet were similar (P>0.05). These results are consistent with the research of [1].Vitamin E is essential for growth, immune function, enhancement tissue integrity, reproduction, disease preventative and antioxidant function in biological systems. Muscle food such as rabbit meat are important in vitamin E ratio ranged 2.85 -3.13 (mg /kg) in rabbit fed on canola meal 5 and 10% diet, rabbit meat is the most important sources (Table 5). The enormous is enhanced with vitamin E in rabbit meat after feeding rabbit on canola meal (5 and 0%) with non-significantly different (P>0. 05) between rabbit meat in the experiment. This increase in Vit E extends meat shelf live and improve quality of meat characteristics and improve water holding capacity in rabbit meat [61] and [62]. The canola diet (0, 5 and 10%) was formulated to have a similar protein and energy content. The inclusion of canola meal in the diet did not significantly (P>0.05) influence on the protein, moisture, lipid, ash and Vit E content in produced rabbit meat.

Table 5. Composition Rabbit of Meat Samples Fed a Control or Supplemented Diet With Canola Meal*

Variable	Rabbit Meat Fed on Basal Diet (Zero Canola Meal)	Rabbit Meat Fed on Canola Meal 5%	Rabbit Meat Fed on Canola Meal 10 %	P-Value	SED
Meat Composition (g/100 g)					
Moisture	74.70	74.15	72.81	0.358	2.26
Protein	21.31	21.72	23.21	0.098	0.78
Lipids	2.64	2.72	2.56	0.261	0.49
Ash	1.35	1.36	1.45	0.075	0.30
Vitamin E (mg /kg)	2.60	2.85	3.13	0.120	0.09

n=5 halve rabbit carcass per group**;** SED: standard deviation, *Values expressed on samples basis and average of five analysis.

3.5. Physicochemical Characteristics of Fresh Rabbit Meat Fed on Canola Meat and Frozen Storage

Results for physical characteristics of fresh and frozen produced rabbit meat are presented in Table 6. The effect of dietary supplementation with canola meal PH were significantly differed (p<0.05) in comparison to control rabbit meat fed on basal diet without canola (zero %).

Table 6. Physicochemical Characteristics of Fresh Rabbit Meat Fed on Canola Meal Compared With Control Diet and Effect of Frozen Storage*

Physical Characteristics	Control Rabbit Meat Fed On Basal Diet	Control After Storage Period	Rabbit Meat Fed on 5% Canola Meal	Rabbit Meat Fed on 5% Canola Meal Storage	Rabbit Meat Fed on 10 % Canola Meal	Rabbit Meat Fed on 10 % Canola Meal Storage	LSD	Probability
PH	5.44^{a}±0.01	5.77^{bc}±0.03	5.76^{b}± 0.02	5.84^{c}±0.17	5.74^{bc}±0.03	6.05^{d}±0.20	0.13	P<0.05
WHC (%)	32.98^{a}±0.17	38.17^{c}±0.15	37.34^{b}±0.40	42.70^{e}±0.54	39.10^{d}±0.07	44.14^{f}±0.14	0.53	P<0.05
Cooking Loss (%)	34.65^{c}±0.05	39.73^{d}±0.05	28.47^{b}±0.66	43.09^{e}±0.10	21.69^{a}±0.07	45.10^{f}±0.21	0.44	NS

n=5 halve rabbit carcass per group

$^{a\,b\,\ldots f}$ Within a row, means lacking common superscript letters differ (P < 0.05)

*Values expressed on samples basis and average of five analysis with ± SD.

PH was varied from 5.44 in the control group up to 5.74 in 10CM (group 3) in fresh status. The pH values of rabbit meat in different canola meal ratio (5 and 10%) meat ,increased significantly (P < 0.05) during the frozen storage from 5.44 to 5.77 in the control meat, 5.76 to 5.84 in rabbit meat fed on 5% canola meal and 5.74 to 6.05 rabbit meat fed on 10% canola meal. During storage time, pH values of which might be attributed to delay production of lactic and lipolysis [64]. Generally, the decline in the pH value is very important as it inhibits growth of undesired bacteria, rates of conversion of color, and formation of undesired flavor rabbit meat products. The pH values of rabbit meat were significantly affected by the addition of the plant polyphenols from canola meal during storage, being effective in decreasing pH values (P <0.05).This obtained result is agree with [65] 5.58-5.61 in fresh rabbit meat. Whereas, after 2 months of deep frozen storage, the pH of rabbit meat were significantly increased 5.84 and 6.05, respectively in 5 and 10% meat of canola meal rabbit. The pH measurements were taken in meat that had been frozen higher than those of fresh rabbit meat fed on either canola meal or control fed on basal diet. The

average pH value in rabbit meat fed on canola meal was greater than found in fresh, similar to study by [66], 5.96 - 6.02. The pH was decreased by animal's weight increases as found by [67].

Table 6 described, that the administration of 5CM or 10CM for rabbit have a significant ($p < 0.05$) increase in WHC of rabbit meat. By increasing the WHC led to produce an excellent rabbit meat quality and improvement in the juiciness of rabbit meat even after a storage period. The technological quality of rabbit, especially the water-holding capacity (WHC) of meat during storage, retail display and processing, is substantial for the meat industry due to its economic consequences. The water holding capacity (WHC) of the meat might also influence the juiciness independent of pH, but this is not quite clear [68]. Similar results indicated by [69]concentration of glycogen could also influence the juiciness as an increased concentration of glycogen will increase the juiciness in beef with a normal pH (between 5.5 and 5.75). Water-holding capacity of fresh meat (ability to retain inherent water) is an important property of fresh meat as it affects both the yield and the quality of the end product. This characteristic can be described in several ways, but in fresh products that have not been extensively processed, it is often described as drip loss or purge. The mechanism by which drip or purge is lost from meat is influenced by both the pH of the tissue and by the amount of space in the muscle cell and particularly the myofibril that exists for water to reside. Water-holding capacity of meat can also influence processing characteristics. Meat with low water-holding capacity often tends to produce inferior processed products.

Data demonstrated in Table 6 indicated that, the cooking loss % of rabbit meat fed on canola 5 and 10%. The cooking loss was significant ($P < 0.05$) lower in these fed group than the control group which fed on basal diet. Regarding to the storage period in freeze condition, these meats of canola group (5 and 10%) were significantly higher than freeze control of meat basal diet rabbit. These results were validated that, the storage meat of canola meal, rabbit were in improved quality towards tenderness and juiciness, as well as flavor. Cooking of meat is essential to achieve a palatable and safe product [70]. In addition, Parameters related to WHC of the meat (cooking loss and pH) showed the same pattern as in rabbit meat of canola meal group with increase pH had a significantly higher cooking loss. This was true for both treatment of canola meal fed rabbit meat group (5 and 10%).

Tenderness of meat products, together with juiciness, flavor and color are the main eating quality characteristics that do influence the consumers' overall judgment of quality [71]. They can be influenced by several production factors (genetics, feeding systems, etc.) and processing techniques (chilling, marinating, cooking).

3.6. Fatty Acid Composition and Nutritional Quality Parameter of Rabbit Meat

Table 7 shown data on fatty acid composition of rabbit meat fed on basal diet and different ratio of canola meal before and after storage. Herein, the study occurred a tendency of total SFA to be lower in meat from 10% supplemented canola meal. On 5CM meat and control basal diet had a significantly ($P<0.05$) higher in C16:0, C18:0 and C14:0 before storage and similar trend was found after storage with a little increase in Total of SFA. On 10CM meat had a significantly lower ($P<0.05$) in total SFA (3.10±0.05) either before or after storage with a little increase occur in SFA (5.23±0.06). The profile of the long chain fatty acids of 5CM meat shows oleic acid (C18:1), to be the most abundant, with C20:1ω9 and C16:1 ω7 being relatively high. While, C18:0 and C22:0 were definitely disappeared in meat of 10CM. Significant ($P<0.05$) effects were observed in MUFA among dietary treatments as influenced by days of storage. The monounsaturated fatty acids of C18:1ω 9, C20:1 ω 9 and C16:1 ω 7 were abundant fatty acid in 5CM meat and control basal diet rabbit meat. There were no significant changes in MUFA after storage in basal control rabbit meat group. While after storage evoke some modification in total MUFA among meat of rabbit fed on a 5 % canola meal. In rabbit meat 10 canola meal fed storage has been occurring a little bed similar to 5CM meat except for their fatty acid profile. In 10CM meat group C16:1 ω 7 follows by C18:1 ω9 and C20:1 ω9 were the abundant MUFA fatty acids. A significantly ($P<0.05$) higher monounsaturated being in 10CM meat after freeze storage period.

The effect of 5CM and 10CM supplemented in rabbit meal was occurring a significant ($P<0.05$) increase in PUFAs not only, but also increase in total unsaturated fatty acids of producing rabbit meat shown in Table 7.

In 10CM meat containing a higher ratio of PUFAs compared to basal diet rabbit meat and even stable fatty acid profile after freeze storage. Polyunsaturated fatty acids in 10CM meat containing a precious amount of linoleic acid (C18:2 ω 6) and linolenic acid (C18:3 ω 3). Therefore, 5CM meat containing in the abundance ratio of C18:2 ω 6. Unfortunately, in the 5CM meat and control basal rabbit meat were similar fatty acid profile, except for C18:3 ω 3 was drastically reduced after the storage process in control 5CM meat. Dietary canola at 10% has significantly increased the PUFAs in fresh slaughter rabbit meat and rabbit meat. The effect of canola meal supplementation at 10% on PUFAs and SFA was more pronounced than on MUSFA proportion. Canola meal supplementation at 10% has significantly increased PUSFA concentration in meat, rabbit fed on this ratio. C18:2 ω 6 is one of the most abundant PUFAs fatty acid in rabbit meat 10CM and follows by 5CM and control basal diet meat, these fatty acids include a conjugated linoleic fatty acid CLA. In terms of a nutritional treatment, which can be beneficial in improving meat and eating quality, special attention in recent years has been paid to conjugated linoleic acid (CLA). CLA revealed impressive protective effects against tumor- genesis in animal studies. Because of the unique chemo protective properties of CLA numerous studies were carried out to investigate the background of CLA. [72] studied the effect of CLA on the inhibition of development of mammary tumors induced by 7, 12-dimethylbenz (a) anthracene (DMBA). Also, in human medicine a recent scientific study shows the ability of CLA to inhibit lipoproteinlipase, which can result in reduced fat deposition. Because of this, in recent years CLA has been used to help reduce human body weight [73]. Several experiments on laboratory animals in human medicine, indicate that CLA has beneficial effects in improving the immune function, preventing cancer,

reducing the incidence of heart disease and improving blood sugar level [74]. Other studies have demonstrated an advantageous influence of CLA on the content of cholesterol in human blood [75].

Table 7. Fatty Acid Composition (% of Total Fatty Acids), Dietary Indexes and Oxidative Status of Rabbit Meat Fed With Canola Meal and Control Diet[a]

Fatty Acids Composition	Rabbit Meat Fed On Basal Diet (Zero Canola)	Control After Storage Period	5% Canola Meal	5% Canola Meal Storage	10 % Canola Meal	10 % Canola Meal Storage	LSD[b]	Probability
C10:0	-	1.2±0.030	0.61±0.080	-	0.15±0.03	1.28±0.14	0.080	NS
C12:0	0.16±0.007	0.58±0.20	0.34±0.007	-	0.16±0.021	0.36±0.014	0.030	NS
C14:0	2.19±0.040	2.39±0.071	1.36±0.042	1.63±0.106	-	-	0.030	P<0.05
C15:0	0.55±0.007	0.22±0.014	1.04±0.014	0.77±0.007	0.72±0.021	0.85±0.035	0.040	NS
C16:0	28.13±0.007	29.59±0.60	23.37±0.30	23.71±0.07	0.76±0.021	0.71±0.014	0.610	P<0.05
C17:0	0.86±0.020	-	1.33±0.014	1.24±0.021	1.32±0.035	2.04±0.007	0.045	P<0.05
C18:0	8.30±0.050	13.15±0.107	7.24±0.021	8.28±0.071	-	-	0.130	P<0.05
C22:0	1.62±0.007	2.145±0.021	0.97±0.028	1.46±0.007	-	-	0.033	P<0.05
Total SFA	**41.79±0.085**	**49.27±0.61**	**36.25±0.24**	**37.07±0.25**	**3.10±0.05**	**5.23±0.06**	**0.650**	P<0.05
C14:1ω5	0.25±0.021	-	-	-	2.54±0.014	2.04±0.007	0.026	P<0.05
C16:1ω7	3.55±0.14	1.17±0.021	0.63±0.007	0.54±0.0	23.22±0.007	23.83±0.69	0.690	P<0.05
C16:1ω9	0.31±0.36	-	0.72±0.14	0.83±0.007	0.67±0.050	0.57±0.36	0.053	P<0.05
C18:1ω 9	23.75±0.29	27.27±0.13	26.50±0.028	30.24±0.078	5.65±0.014	7.28±0.077	0.170	P<0.05
C18:1ω 7	-	0.33±0.007	2.18±0.007	1.84±0.021	-	-	0.023	NS
C18:1ω 5	0.86±0.028	0.25±0.007	0.56±0.007	0.37±0.035	-	-	0.046	P<0.05
C20:1ω9	4.25±0.021	3.66±0.007	3.01±0.014	3.76±0.014	2.46±0.042	2.84±0.035	0.063	P<0.05
C22:1ω9	0.26±0.014	0.36±0.021	-	-	0.23±0.021	0.53±0.08	0.034	NS
Total MUFA	**33.17±0.14**	**33.02±0.064**	**33.59±0.064**	**37.56±0.071**	**34.76±0.078**	**37.07±0.76**	**0.780**	P<0.05
C18:2ω6	20.15±0.021	16.64±0.22	23.87±0.077	21.62±0.063	28.11±0.27	27.29±0.106	0.380	P<0.05
C18:2ω5	0.44±0.01	0.105±0.021	0.54±0.035	0.18±0.035	1.86±0.028	1.69±0.0	0.062	P<0.05
C18:2ω4	-	0.33±0.021	-	-	-	0.28±0.028	0.035	P<0.05
C16:3ω4	-	-	-	-	0.32±0.01	0.75±0.28	0.029	P<0.05
C18:3ω6	0.27±0.014	0.115±0.01	0.60±0.05	0.25±0.021	0.53±0.021	0.41±0.22	0.062	P<0.05
C18:3ω3	3.36±0.20	0.45±0.035	2.49±0.20	2.58±0.021	24.21±0.035	23.73±0.0	0.284	P<0.05
C18:3ω4	0.33±0.021	0.16±0.014	-	-	0.83±0.021	0.74±0.05	0.060	P<0.05
C20:4ω6	0.34±0.021	-	2.31±0.014	0.43±0.021	1.25±0.028	1.42±0.12	0.130	P<0.05
C18:4ω3	-	-	-	-	2.67±0.014	3.07±0.08	0.079	P<0.05
Total PUFA	**25.03±0.014**	**18.12±0.15**	**29.97±0.021**	**24.61±0.72**	**59.81±0.29**	**58.96±0.49**	**0.930**	P<0.05
TUSAT	**58.29±0.36**	**50.81±0.24**	**63.38±0.28**	**62.60±0.23**	**97.06±0.23**	**98.37±0.93**	**1.12**	**P<0.05**
Saturated/unsaturated	0.72±0.006	0.97±0.017	0.57±0.001	0.59±0.002	0.032±0.00	0.053±0.001	0.018	P<0.05
PUFA (n−6/n−3)	6.19±0.37	37.74±2.52	10.79±0.86	8.65±0.03	1.11±0.012	1.11±0.004	2.68	P<0.05
PUFA (n−3/n−6)	0.16±0.01	0.026±0.002	0.093±0.007	0.12±0.00	0.90±0.01	0.90±0.40	0.016	P<0.05
Dietary Indexes and Oxidative Status								
Atherogenicity index (AI)	0.88±0.002	0.81±0.004	0.81±007	0.81±0.008	0.29±0.018	0.20±0.003	0.022	P<0.05
Thrombogenicity index(TI)	0.95±0.006	1.16±0.017	0.71±0.006	0.72±0.003	0.015±0.00	0.014±0.00	0.019	P<0.05
Peroxidability index(PI)	29.51±0.39	18.52±0.35	37.50±0.50	28.71±0.25	93.47±0.45	93.77±0.64	1.09	P<0.05
TBA	7.51±0.50	65.13±1.004	7.21±0.95	52.77±0.76	6.29±0.16	47.14±0.86	1.53	P<0.05

[a] All values are expressed as Mean ± SD (n = 5).

[b] Differences between means within the same row exceeding the LSD value are significant (P < 0.05).

In addition, canola meal has been reported to have a several beneficial physiological effects, e.g. been antiadipogenic, antidiabietogenic, anticarcinogenic and antiatherosclerotic [76]. Short -term health promoting effects of canola meal are in conclusive in humans [77]. So the incorporation of canola meal into tissue lipids could mean potentially healthier their rabbit products.

Regarding results from total unsaturated fatty acid the dietary canola meal at 10% for the rabbit was observed with an increase in C18:3 ω 3 and C18:2 ω 6 in fresh rabbit meat. In contrast 5CM dietary of rabbit showed a higher ratio in C18:2 ω 6 not for C18:3 ω 3 and with a higher ratio of C18:1 ω 9 in their rabbit meat compared to control group meat and 10CM meat. In Table 7 shown that diet affected in all percentage and ratio studies by canola meal, Thrombogenicity index favored a decrease (P < 0.05) by increase PUFAs. At 10% canola meal dietary rabbit was significantly decreased atherogenicity index (AI) and Thrombogenicity index (TI). Expecting that increase PUFAs in 10CM meat was favored to be more Peroxidability index (PI) when PUFAs was increased in comparison to control dietary meal or 5% canola meal dietary rabbit.

Relation between fatty acid profile and the nutritional quality of rabbit meat:

Table 7 shows that, the AI and TI were decreased significantly (P < 0.05) with the inclusion of canola meal 10% of the fresh rabbit meat, whereas, there was a significant increase (P < 0.05) occurred in PUFAs ratio,

especially in PUFA (n−3/n−6) up to 0.90±0.01 in fresh and 0.90±0.40 in storage 10CM meat.

The lipid from rabbit meat fed on 5CM and control diet had a higher ratio of n−6/n−3 fatty acid compared to 10CM meat lipid. Regarding the saturated/ unsaturated ratio, this ratio increase in control diet rabbit meat and 5CM meat compared with 10CM meat lipid. These two indexes (n−6/n−3 and sat/unsat) representational approach commonly used to describe the amount of dietary fat [71]. While, PUFA (n-3/n-6) was significantly increased by decrease sat/unsat, AI and TI indexes.

A lower ratio of omega-6/omega-3 fatty acids in fat or lipid in meat are more described in reducing the risk of many chronic diseases of high prevalence in Western societies as well as in developing countries that are being exported to the rest the world [78]. Omega -3 fatty acids increase bleeding time, decrease platelet aggregation, blood viscosity and fibrogen; increase erythrocyte deformability, thus decreasing the tendency to thrombus formation. Also omega-3 PUFAs which possess the most potent immune modulatory activity and management inflammatory diseases [78].

From these results, it can be concluded that the supplement canola meal in a rabbit diet at a level 10 % should be enough to improve meats rabbit fatty acid profile and their rabbit meat nutritional quality.

Table 8. Amino Acid Composition of Raw Canola Meal Protein and Rabbit Meat Fed on (5 and 10% Canola Meal) and Their Nutritional Quality Parameters for Compared With FAO/WHO/UNU (1985) Provisional Reference and Egg Amino Reference [a]

Parameter	Canola Meal	Rabbit Meat Fed On Basal Diet (Zero Canola) (Control Dietary)	Rabbit Meat Fresh Fed On Canola Meal 5% (5CM Meat)	Rabbit Meat Fresh Fed On Canola Meal 10 % (10CM Meat)	LSD[b]	Probability	FAO/WHO UNU (1985) Provisional Pattern	Egg Amino Acid Reference**
Crude Protein (g/100)	35.61±0.55	21.30±0.07	21.72±0.07	23.21±0.04	0.78	NS		
EssentialAmino Acid								
Histidine	3.35±0.07	3.24±0.06	4.26±0.06	4.46±0.08	0.19	P<0.05	2.4	2.1
Isoleucine	3.93±0.07	5.49±0.08	5.47±0.14	5.34±0.01	0.25	P<0.05	4.0	6.3
Leucine	7.07±0.06	8.21±0.04	8.04±0.05	8.01±0.01	0.13	NS	7.0	8.8
Lysine	6.23±0.11	8.36±0.06	8.23±0.02	8.13±0.08	0.20	NS	5.5	7.0
Methionine +cystine	7.43±0.16	1.89±0.15	4.03±0.00	6.47±0.01	0.30	P<0.05	3.5	5.8
Phenylalanine	5.40±0.02	4.30±0.00	3.94±0.10	4.38±0.08	0.18	P<0.05	6.0	5.7
Threonine	3.68±0.14	4.05±0.10	4.09±0.01	4.15±0.04	0.23	P<0.05	4.0	5.1
Tryptophan	2.13±0.04	1.10±0.01	1.20±0.3	1.09±0.20	0.08	P<0.05	1.0	1.5
Valine	5.32±0.03	5.11±0.13	5.21±0.01	4.78±0.17	0.30	P<0.05	5.0	6.8
∑ EssentialAmino Acid	44.52±0.64	41.74±0.35	44.46±0.06	46.80±0.30	1.09	NS	38.4	49.1
NonessentialAmino Acid								
Alanine	4.64±0.014	6.76±0.014	6.09±0.01	5.78±0.18	0.25	NS		
Aspartic acid	7.24±0.03	9.31±0.13	9.15±0.22	9.17±0.10	0.38	P<0.05		
Glutamic acid	17.68±0.14	20.39±0.58	19.75±0.04	19.03±0.01	0.23	P<0.05		
Glycine	5.12±0.02	4.79±0.02	4.45±0.45	4.26±0.06	0.83	NS		
Proline	6.09±0.02	0.82±0.1	0.87±0.10	0.83±0.06	0.63	P<0.05		
Serine	3.51±0.10	4.23±0.03	4.09±0.01	3.63±0.33	0.15	P<0.05		
Tyrosine	3.71±0.01	3.96±0.06	3.89±0.01	3.79±0.15	0.08	NS		
Arginine	6.75±0.014	7.11±0.01	6.79±0.01	6.54±0.08	0.12	NS		6.4
∑ Nonessential Amino Acid	54.73±0.41	57.36±0.93	55.07±0.61	52.84±0.21	1.67	NS		
Protein Chemical Score (PCS)%	90.00	54.00	65.66	73.00				
Limiting Amino Acid First	Phenylalanine	Meth +Cys	Phenylalanine	Phenylalanine				
Essential Amino Acid Index (EAAI)	1.508	1.534	1.995	2.041				
Protein Efficiency Ratio (PER)	2.35	2.84	2.77	2.79				

** According to [78].

[a] All values are expressed as Mean ± SD (n = 5).

[b] Differences between means within the same row exceeding the LSD value are significant (P < 0.05).

3.7. Amino Acid Composition and Nutritional Protein Quality

Amino acid composition of raw canola meals and rabbit meat fed on dietary containing canola meal 5 and 10% is shown in Table 8. Sulfur containing (methionine and cystine) were the major amino acids in raw canola meal investigated 7.43± 0.106 %. Soya is one of legumes which considered as a common protein add into the dietary of rabbit, it is reported to be rich in lysine but deficient in tryptophan and sulfur containing amino acids (methionine and cysteine).The produced rabbit meat controls dietary

fad contains a low ratio of sulfur containing amino acids (1.89± 0.15). While, after supplemented the dietary of rabbit by 5 and 10%, the meat containing an appreciable amount of essential amino acid of sulfur contain amino acid and lysine. Also, it could investigate that total indispensable amino acid was increased after dietary contained a canola meal. The sulfur containing were found to be the most limiting amino acids in all studies. There were a significant ($P<0.05$) increase in sulfur contain, threonine and histidine amino acid in the meat contain after dietary on canola meal (5 or 10%).

Generally, the essential amino acids histidine, Isoleucine, leucine, lysine, sulfur containing, phenylalanine, tryptophan and threonine ratios were higher in rabbit meat fed on dietary containing 5 or 10% canola meal than their corresponding content in the provisional protein pattern [43].

Glutamic acid followed by aspartic and arginine were abundant nonessential amino acids in either canola meal or their produced rabbit meat 5 CM or 10CM. Proline is the lowest ratio of nonessential amino acids in the meat of rabbit fed on free canola meal and 5 , 10% CM ranging from 0.82 to 0.87%.

3.8. Calculated Nutritional Quality Parameter of Canola Dietary Rabbit Meats

Canola meal had been the highest protein chemical score (PCS) (90 %) followed by rabbit meat of 10CM (73%) while the lowest value was in rabbit meat fed on free canola (54%). Sulfur containing amino acids is the most limiting amino acids in the rabbit meat from group fed on basal diet free from canola meal.

Meanwhile, both of canola meal or their produced meat (5 or 10%) dietary CM were limiting in phenylalanine. Essential amino acid index (EAAI) of four investigated samples were ranged 1.508 to 2.041.

Corresponding to EAAI was recording a high value in 10CM meat (2.041) followed by 5CM (1.995) and zero canola rabbit meat group (1.534). This result indicated by [79] who reported that, High digestibility of rapeseed protein was found in rats. In human food, rapeseed protein (both isolates and hydrolyzate) having a high nutritional quality and can be considered to be as efficient as soy protein for a postprandial amino acid response Generally feeding rabbit on canola meal at different supplements ratio was the precious value of EAAI than found in the dietary group of rabbit fed on a basal canola free diet. There is no obvious increase in PER value after feeding rabbit on the diet containing canola meal.

However, results are indicated that, the PER of canola meal in the diet has similar to the basal normal diet in feeding rabbits. From these obtained results could be pronounced that canola protein has a high biological value that could be sufficient to meet human requirements for essential and non-essential amino acids [80]. Furthermore, due to the high content of bioactive compounds in vegetable proteins, there are other beneficial effects, e.g., on some cardiovascular risk factors by improving the lipid profile, reducing the serum low-density lipoproteins and preventing hypertension [81].

3.9. Total Phenolic and Scavenging Activity of Rabbit Meat Fed with and without Canola Meal

The antioxidant activity of each extract was based on its ability to prevent the formation of thiobarbituric acid reactive species (TBARS) in a linoleic acid oxidation system. In the present study dietary treatment with canola meal had effects on total phenolic and scavenging activity of rabbit meat fed with and without canola meal (Table 9). Supplementation of canola meal by feeding at a level of 5CM and 10CM have increasedlevel of total phenolic from 37.25± 0.19 in control rabbit meat fed on a basal free canola diet to 40.23± 0.23 in 10CM. A high level of canola meal at 10% in feed was able to increase anti-oxidative capacity. Table 9 shows the mean DPPH scavenging activity ratio with groups fed the higher concentrations canola meal at 10% (58.90± 0.03) and 5% CM (49.51± 0.03). However, The DPPH activity in control rabbit meat fed onbasal diet free canola has observed a higher DPPH activity % 50.03± 0.03. The difference between meats as canola meal dietary were different when compared with the control. This is in agreement with [82] who reported that the concentration of test material that reduced 50% of the DPPH$^{\cdot}$ radical concentration (IC50) was 0.3 mM for sinapic acid. Sinapic acid showed good scavenging activity in reducing the activity of DPPH in producing meat near to activity of standard BHT. The radical-scavenging activity decreased with increasing amounts total phenolic in fresh 10CM and 5CM meat except for storage meat 10CM. The fed rabbit on canola meal were found to be moderately in scavenging activity by DPPH than in standard BHT.

Table 9. Total phenolic and scavenging activity of rabbit meat fed with and without canola meal

Type of sample	Total phenolic (mg/g dw)	DPPH• Scavenging activity %
BHT (control)	-	83.18±0.10
Control Rabbit meat Fed on basal diet	38.3±0.28	50.03±0.03
Control Rabbit meat Fed on basal diet (Zero canola) storage	37.25±0.19	43.18±0.03
Rabbit meat 5% canola meal	36.3±0.47	49.51±0.03
Rabbit meat 5% canola meal Storage	32.4± 0.45	42.14±0.03
Rabbit meat 10 % canola meal	40.23±0.23	58.90±0.03
Rabbit meat 10 % canola meal Storage	28.00 ± 0.20	57.12±0.03

N= 5sample from each diet group.

This is mean that dietary rabbit on canola meal which containing anappreciable amount of phenolic compound found in produced meat. Scavenging activities of extracting material from 10CM meat contain the necessary compounds for radical elimination. In the present study carried out on a feeding canola meal. This result is indicated by [83] determined the contents of sinapic acid derivatives in canola (an edible variety of rapeseed

characterized by low erucic acid content) extracts. Sinapine was the major phenolic constituent in canola seeds and press cake extracts, representing 70% to 87% of the total phenolic content of different canola fractions.

After storage period rabbit meat both total phenolic and DPPH activities were decreased in all investigated three types of meat groups. At 5% level of canola feeding rabbit meat their total phenolic was decreased from 36.3 % before storage into 32.4% after storage period. While a higher decrease could be occurred in total phenolic compounds in 10CM meat from 40.23 in fresh meat into 28.00% in 10CM after storage. Similar finding by [84]. Compared to the control diet better lipid stability (DPPH activity scavenging) was only found for 5CM and 10CM level in the meat produced. Its presence in the canola meal have probablycontributed largely to its high antioxidant activity and DPPH scavenging activity.

Table 10. GC-MS chemicalcomponents in rabbit meat fed with and without canola meal

Compound	Ratio of Antioxidant and phenolic compound in meat extracted from Control diet	Ratio of Antioxidant and phenolic compound in meat extracted fed on canola meal 5%	Ratio of Antioxidant and phenolic compound in meat extracted fed on canola meal 10 %
4-Methylcatechol	18.3	12.9	11.53
3,4-Dihydroxyhydrocinnamic acid	22.9	27.9	25.50
Sinapic acid	-	3.7	6.01
Benzoic acid, 3-hydroxy-	7.0	5.5	4.86
3-Carene	6.2	3.8	2.43
1, 8-CINEOL	1.5	1.0	0.87
4-Hydroxyphenylpyruvic acid	4.3	2.9	2.34
(+)-BETA-PINEN	1.6	1.1	0.95
1,2-Benzenediol, 4-(2-amino-1-hydroxyethyl)-, (R)-	25.3	22.1	21.77
Etilefrine	1.6	2.7	4.16
(+)-BORNEOL	1.8	1.9	2.86
α-Terpinol	1.6	1.1	0.78
Isobornyl acetate	-	1.1	0.95
β-Guaiene	-	1.1	0.87
Ylangene	-	1.1	1.56
Copaene	1.4	1.0	1.30
γ-HIMACHALENE	1.1	1.0	0.87
Apigenin 7-β-rutinoside	-	1.0	1.04
5-Hydroxy-L-tryptophan	-	1.0	2.43
Isolongifolene	1.2	1.0	1.73
(-)-GUAIOL	1.0	1.1	0.99
α-Elemene	0.9	1.1	0.99
Levobunolol	0.9	1.3	1.17
3-Acetylindole	0.2	1.3	1.17

3.10. GC-MS Chemical Components in Rabbit Meat Fed with and without Canola Meal

The chemical composition and the yield of the three rabbit meats produced after dietary on the control diet, 5CM and 10CM analyzed by GC and GC–MS techniques are reported in Table 10. Twenty five compounds were identified in extracts meat of control diet, 5CM and 10CM, its main compounds were 3, 4-Dihydroxyhydrocinnamic acid identified in 22.9 % for control meat diet, 27.9% in 5CM meat and 25.50% in 10CM meat extract. 1,2-Benzenediol, 4-(2-amino-1-hydroxyethyl) -, is the second abundant phenolic compounds in extracting material from control rabbit meat (25.3%), 22.1% in 5CM meat and 21.77% in 10CM meat. Sinapic acid is the most abundant phenolic compound in canola meal, it appears in the meat of 10% group canola meal (6.01%) and (3.7%) in The Meat of 5CM.

Generally in the profile GC-MS could be notice that, 10CM meat extract containing appreciable amounts of phenolic and antioxidant material than identified in 5CM meat extract and control diet meat. This result indicated by [85] and [86] Sinapine is the main phenolic ester in canola seeds and constitutes about 80% of the total phenolics. Sinapine and sinapic acid were reported to be the main phenolics in rapeseed press cake .Their contribution to the total phenolic content of rapeseed press cake was 4% and 45%, respectively. This indicates that canola meal when received into rabbit animal provide with a natural bioactive material and improve nutritional status of producing meat and decrease oxidation [85]. Not only, but also, this bioactive material is provided human body with natural antioxidant and phenolic compounds, which protect from aging and cancer. This is also indicated by [87] that, the phenolic compounds derived from rapeseed

as freesinapic acid is able to effectively prevent lipid oxidationin bulk rapeseed oils, comparable to the tocopherols. Therefore, extracts from by-products of rapeseed oil processing, irrespective of the processing, could be used to stabilize rapeseed oils, especially with low amounts ofendogenous phenols, or as antioxidants for various food and non-food applications.

4. Conclusion

From this study, it was concluded that canola meal did not affect the biochemical blood profile or the hematology and serum biochemistry of rabbits. Canola meal was improved the amino acid profile and increase the nutritional quality of meat. The polyunsaturated fatty acid and omega -3 was improved in producing meat in fresh status and after the storage period. The antioxidant activity was generally improved after using canola meal in dietary rabbit. Sinapic acid is the one of most phenol compounds in canola meal, it was observed in producing meat after dietary. This phenolic is able to improve storage period of rabbit meat. It may be recommended as good feeding stuff for concentrate feed formulation for rabbits when further results will be obtained on intake, growth and health performances on a larger number of animals. Also feeding rabbit on canola meal has improved quality and nutritional properties of rabbit meat and improve nutritional status in the human diet.

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