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# Using dried kitchen food wastes as untraditional feed in growing rabbit's diets

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## Abstract

**Background:** Kitchen food wastes (KFW) are food lost from human especially from hotels, hospitals, cafeterias and home, could be alternative feed resources and create the attention of researchers to process these wastes and recycling it as animal feeding not only to reduce the use of expensive feed ingredients but also to decrease the environmental pollution. The main objective of this study was conducted to investigate the effect of dietary KFW inclusion on growth performance, digestibility, carcass traits, and some blood biochemical parameters of growing New Zealand White rabbits.

**Results:** The results showed that rabbits fed on diets containing 30% KFW achieved significantly ( $P < 0.05$ ) higher daily weight gain (22.61 g) than the control (20.79 g) and there were no difference between diets 10% and 20%, and the lowest daily gain was with diet 40%. The highest organic matter (OM) and crude protein (CP) digestibility were recorded in rabbits fed on a diet containing 30% KFW (64.08 and 64.29%, respectively), while the lowest was observed in 40% group (61.11 and 55.54%, respectively). Diets containing KFW decreased caecal ammonia nitrogen ( $\text{NH}_3\text{-N}$ ) and increased propionate up to 30% substitution. The addition of KFW to rabbits diets had no significant effect ( $P < 0.05$ ) on serum globulin, glucose, ALT, and AST values and increased significantly ( $P < 0.05$ ) serum total protein, albumin, triglycerides, cholesterol and creatinine.

**Conclusion:** It can be concluded that the best growth performance and economical feed efficiency was observed in rabbits fed on a diet containing 30% KFW and surpassing all treated groups and achieved the best body weight gain.

**Keywords:** Rabbits, Kitchen food wastes, Performance, Digestibility, Caecal, Carcass and blood parameters

## Background

Livestock production in many developing countries is constrained because of poor quality and the short supply source of animal feeds (International Atomic Energy Agency, IAEA 2011). In livestock production systems, the cost of animal feed represents about 70–85% of the total recurring cost (FEFAC 2015), therefore, it is necessary to find low cost feeds incorporated in the rations of animals and poultry. Therefore, Kim (1995), Kim et al. (2001) and Yang et al. (2001) demonstrated that dried leftover

feed could be used as feed ingredient or supplement for poultry and swine, not only to reduce the use of shortage and expensive feed ingredients, but also to decrease the environmental pollution. Food wastes may save the cost of feeding by substituting 25% (Sehgal and Simmi 1993). It is important to put in our mind selection and handling of unconventional feed sources, that some studies reported the nutritional efficiency of leftover food which can be superior or comparable to traditional feedstuffs (Kawashima 2002). The chemical composition of food wastes is 21–29% CP, 11–15% EE, 2–4% CF and 6–12% ash as DM basis (Kim 1995). Gustavsson et al. (2011) reported that about 30–50% of food waste discarded and considered uneaten for humans (Dou et al. 2016) especially from hotels, hospitals, restaurants and homes.

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Meanwhile, Truong et al. (2019) and Luciano et al. (2020) suggested that food wastes could be used successfully for monogastric animals and must mitigate the environmental pollution by utilized food wastes through recycling, and used it in animal feeding which reduce the cost of livestock production.

**Methods**

The current study was carried out at the Experimental Farm Station of the by-product Utilization Department, Animal production Institute, Agriculture Research Center, Nubaria Area and Animal Production Department, National Research Center, Dokki, Giza.

**Experimental rabbits and housing**

Fifty males growing New Zealand White rabbits (NZW) aged 6 weeks old with an average body weight of 650.5 ± 3.61 g were blocked by weight into five equal groups (10 animals each) in a growth trial lasted 70 days. Growing NZW rabbits were obtained from a commercial farm (Agri-Feed farm, Buheira governorate, Egypt). All the experimental rabbits were healthy and clinically free from parasites and were kept under the same hygienic conditions. Experimental rabbits were housed individually in galvanized metal wire cages equipped with feeding and water troughs. Clean drinking water was freely available at all times.

**Diets and feeding**

The experimental diets were formed in a pelleted form to cover nutrient requirements of the breeding phase of rabbits according to NRC (1994) recommendations. Composition and chemical analysis of the feed ingredients and tested pelleted diets are shown in Table 1. The first group of rabbits was fed control diet, while 2nd, 3rd, 4th and 5th groups were fed basal diet replacement with 10, 20, 30 and 40% kitchen food wastes (KFW) respectively, so that the chemical composition of all diets is almost same. Experimental diets were offered daily at 8.30 a.m. Feed refusals were daily collected, weekly weighed and recorded.

**Collection processing of kitchen food wastes**

Kitchen food wastes were collected from houses and some small restaurants, and then it was minced and dried by solar cells in National Research Centre Labs. And analyzed for its chemical composition and essential amino acid profile is shown in Table 2.

**Digestibility trials**

At the end of the feeding trial, five digestibility trials were carried out over a period of seven days; where three days were for adaptation and the other four days

**Table 1** Composition and chemical analysis of experiment diets

	Control	kitchen food wastes			
		10%	20%	30%	40%
<i>Ingredients (%)</i>					
Alfalfa hay	30.0	30.0	30.00	30.00	30.0
Barley grain	22.5	22.5	19.0	12.5	6.50
Soybean meal (44%)	20.5	17.0	13.5	10.0	6.00
Yellow corn	11.5	6.50	5.00	5.00	5.00
Wheat bran	8.00	6.5	5.00	5.00	5.00
KFW	0.00	10.0	20.0	30.0	40.0
Molasses	4.50	4.5	4.50	4.50	4.50
Calcium carbonate	1.35	1.35	1.35	1.35	1.35
Calcium di-phosphate	0.65	0.65	0.65	0.65	0.65
Sodium chloride	0.50	0.50	0.50	0.50	0.50
DL-methionine	0.10	0.10	0.10	0.10	0.10
Premix*	0.40	0.40	0.40	0.40	0.40
<i>Chemical analysis as dry matter basis (%)</i>					
DM	89.83	89.22	89.63	89.81	89.74
OM	93.04	92.84	92.76	92.70	92.56
CP	16.97	17.02	17.11	17.07	16.99
CF	13.96	12.98	12.89	13.03	13.11
EE	2.43	02.85	03.07	03.22	03.47
NFE	59.68	59.99	59.69	59.38	58.99
Ash	6.96	07.16	07.24	07.30	07.44
NDF	37.87	37.22	36.99	36.89	36.12
ADF	19.43	19.37	19.11	19.09	19.02
ADL	4.98	05.11	05.14	05.19	05.23

\*Vitamins and mineral premix at 0.4% of diet supplies the following per kg. of diet: vit. A 1200 IU; 500,000 IU, T3; 0.67 mg vit. K3; 0.67 mg vit. B1; 2.0 mg B2; 0.67, h/vit B6; 0.004 mg. vit B12; 16.7 mg. Folic acid; 400 mg. choline chloride; 22.3 mg. Zn; 10 mg Mn; 25 mg Fe' 1.67 mg. cu' 0.25 mg I; 0.033 mg. Se and 133.4 mg. Mg

**Table 2** chemical analysis and essential amino acids of kitchen food wastes (KFW)

Essential amino acids (g/100 g sample)	Chemical analysis (%)
Arginine	DM 92.2
Leucine	OM 87.0
Valine	CP 25.1
Histidine	EE 15.3
Lysine	CF 10.3
Threonine	Ash 15.2
Phenylalanine	NFE 36.3

\*Value of the previous samples are the average of three samples of three batches on the dry-matter bases

for quantitative collection of feces and urine. Three random rabbits from each group were individually confined in stainless-steel metabolic cages, where feces and urine

could separately be collected. Daily amounts of feed intake, feces and urine out-put were determined and daily recorded during the collection period.

#### Slaughter technique and caecum parameters

After termination of the feeding trial, three representative rabbits randomly chosen from each group were fasted for 12 h, weighed and hand slaughtered animals were de-skinned, dressed out and the hot carcass without head was weighed and recorded. Edible offals (liver, Heart, Spleen and kidneys) were separately weighed and recorded. The whole carcass of each rabbit was de-boned and the meat of each rabbit was minced and oven dried for 72 h weighed to determine body water content and the dry meat was finally ground to determine protein, fat and ash.

Gastrointestinal tracts were individually removed from three slaughtered rabbits from each experimental groups, the caecal content was measured to the pH by using digital pH meter. Another sample of caecal content was filtered through four folds of faux leather for determine total and molar percentages of ammonia nitrogen and volatile fatty acids.

#### Blood samples

Blood samples were collected from the three slaughtered rabbits in heparinized tubes. Plasma samples were obtained by centrifugation of samples at 4000 r.p.m for 20 min and stored at  $-20^{\circ}\text{C}$  for later assay. Total plasma protein, albumin, globulin, glucose, total lipids, total cholesterol, triglycerides, HDL, LDL, urea, creatinine, AST and ALT were determined using colorimetric methods (Biodiagnostec, Egypt).

#### Chemical analysis

Chemical composition of feeds, KFW, feces and rabbit's meat including dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), ash, neutral detergent fiber (NDF) and acid detergent fiber (ADF) were estimated according to the methods of Association of Official Analytical Chemists (AOAC 2005). Nitrogen free extract (NFE) and acid detergent lignin (ADL) were calculated by difference. And essential amino acids according to method described by Spackman et al. (1958). Urinary nitrogen (UN) was determined by the microkjeldahl method. Concentration of ammonia nitrogen was determined calorimetrically according to Searle (1984). Total volatile fatty acids (TVFA's) and its fraction content was determined using a gas chromatograph (GC-2010, Shimadzu, Kyoto, Japan) equipped with a flame Ionization detector and a capillary column (HP-INNO-WAX, 1919N-133, Agilent Technologies, Santa Calra, CA, USA), as described by Hu et al. (2005).

#### Statistical analysis

Raw data were subjected to statistical analysis as one-way analysis of variance according to SAS (2002). The model used to analyze the different treatments studied for rabbits was as follows:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where  $Y_{ij}$ =observation,  $\mu$ =Overall mean;  $T_i$ =Effect of  $i$ th treatments and  $e_{ij}$ =Experimental error. Duncan's Multiple range test was used to detect differences between means of the experimental groups (Duncan 1955).

#### Results

##### Chemical analysis

Data of chemical composition of dried kitchen food wastes (KFW) and its essential amino acids profile, as well as the tested diets which containing different levels of KFW are presented in Tables 1 and 2. It is clear from results that dried KFW are rich in both CP and EE beside its valuable content of essential amino acids which considered a good feedstuff in animal feeding.

##### Growth performance

Growth performance evaluation of the rabbits fed varying levels of kitchen food waste during the whole experimental period are presented in Table 3 which indicated that there was no significant difference in initial body weight among groups, however rabbits receiving 40% (FKW) substitution recorded the lowest final body weight and daily weight gain ( $P < 0.05$ ). There were insignificant differences among the testing groups (control, 10 and 20% substitution) for both final body weight and daily weight gain, whereas the highest daily weight gain ( $P < 0.05$ ) recorded with rabbits fed 30% KFW.

Concerning daily feed intake, the addition of (KFW) to rabbits diets had no significant differences among the experimental groups.

According to data of feed conversion ratio (g. feed/g. gain) of group five which receiving 40% KFW recorded the lowest value ( $P < 0.05$ ) compared to the other groups, whereas no significant differences among the other groups. There was a tendency that increasing KFW in the diet of growing rabbits decreased feed conversion until 30% substitution.

##### Digestibility and nutritive values

Nutrients digestion, nutritive value and nitrogen utilization of rabbits fed experimental diets were presented in Table 4. Rabbits who received diet of 40% (KFW) recorded the lowest DM, OM, CP and CF digestibility ( $P < 0.05$ ) compared to those fed the other tested diets and there were no significant differences in DM and CF

**Table 3** Effect of dietary containing kitchen food wastes (KFW) on growth performance of growing rabbits

Items	Control	KFW				SEM	P value
		10%	20%	30%	40%		
IBW (g)	646.89	650.33	646.89	654.11	647.22	10.66	0.649
FBW (g)	1811.41 <sup>b</sup>	1835.00 <sup>b</sup>	1847.22 <sup>b</sup>	1920.00 <sup>b</sup>	1631.88 <sup>c</sup>	24.84	0.018
DWG (g)	20.79 <sup>b</sup>	21.15 <sup>b</sup>	21.43 <sup>b</sup>	22.61 <sup>a</sup>	17.58 <sup>c</sup>	0.29	0.037
DFI (g)	91.67	92.33	92.78	93.17	89.76	0.37	0.641
Feed conversion ratio (g. feed/g. gain)	4.41 <sup>b</sup>	4.37 <sup>b</sup>	4.33 <sup>b</sup>	4.12 <sup>b</sup>	5.11 <sup>a</sup>	0.15	0.009

<sup>a,b,c</sup> Means with different superscripts in the same row differ significantly ( $P < 0.05$ )

**Table 4** Effect of feeding different levels of kitchen food wastes (KFW) on nutrients digestibility and nutritive values of diets by rabbits

Items	Control	KFW				SEM	P value
		10%	20%	30%	40%		
<i>Digestibility coefficient (%)</i>							
DM	63.63 <sup>a</sup>	63.40 <sup>a</sup>	63.56 <sup>a</sup>	65.46 <sup>a</sup>	60.16 <sup>b</sup>	0.07	0.016
OM	64.43 <sup>a</sup>	63.72 <sup>b</sup>	63.88 <sup>b</sup>	64.08 <sup>a</sup>	61.11 <sup>c</sup>	0.07	0.011
CP	58.79 <sup>c</sup>	62.30 <sup>b</sup>	62.46 <sup>a</sup>	64.29 <sup>a</sup>	55.54 <sup>d</sup>	0.05	0.001
CF	44.78 <sup>a</sup>	45.75 <sup>a</sup>	45.67 <sup>a</sup>	45.66 <sup>a</sup>	40.58 <sup>b</sup>	0.37	0.048
EE	68.72 <sup>c</sup>	71.33 <sup>b</sup>	75.43 <sup>b</sup>	75.37 <sup>a</sup>	70.55 <sup>bc</sup>	0.29	0.039
NFE	70.32 <sup>a</sup>	67.65 <sup>b</sup>	67.62 <sup>b</sup>	67.46 <sup>b</sup>	66.72 <sup>b</sup>	0.43	0.044
<i>Nutritive values</i>							
TDN	61.30 <sup>c</sup>	61.63 <sup>c</sup>	62.15 <sup>b</sup>	64.29 <sup>a</sup>	59.28 <sup>a</sup>	0.14	0.035
DCP	9.98 <sup>b</sup>	10.60 <sup>a</sup>	10.69 <sup>a</sup>	10.97 <sup>a</sup>	09.44 <sup>c</sup>	0.04	0.017
<i>Nitrogen utilization</i>							
NI	2.49	2.51	2.54	2.54	2.44	0.44	0.533
NB	1.03 <sup>b</sup>	1.15 <sup>b</sup>	1.18 <sup>b</sup>	1.25 <sup>a</sup>	0.79 <sup>c</sup>	0.08	0.012
NB/NI	41.37 <sup>b</sup>	45.82 <sup>a</sup>	46.46 <sup>a</sup>	49.21 <sup>a</sup>	32.38 <sup>c</sup>	0.54	0.033

<sup>a,b,c</sup> Means with different superscripts in the same row differ significantly ( $P < 0.05$ )

digestibility among the other groups, while rabbits fed a diet containing 30% (KFW) substitution showed the highest OM, CP and EE digestibility ( $P < 0.05$ ) compared with the other groups.

Meantime, insignificant differences were observed in CF digestibility among control, 10% and 20% KFW substitution, also there was no significant difference in CP digestibility between rabbits receiving diets containing 10% and 20% (KFW) but they were significantly ( $P < 0.05$ ) higher compared with the control group.

The highest EE digestibility ( $P < 0.05$ ) was recorded with 20% and 30% KFW substitution and the lowest EE value ( $P < 0.05$ ) showed with the control group. In addition, rabbits fed control diet recorded the highest NFE digestibility compared with other groups which recorded no significant differences among them.

The lowest nutritive values as TDN and DCP recorded with the 40% KFW, while the 30% KFW recorded the best TDN ( $P < 0.05$ ), followed by 20% then the control

and 10% KFW. DCP values were significantly higher ( $P < 0.05$ ) for 10, 20 and 30% of substitution comparing with the other two tested groups (Table 4). Rabbits fed diets of 40% KFW recorded the lowest nitrogen utilization ( $P < 0.05$ ) as nitrogen intake (NI), nitrogen balance (NB) and NB/NI, meantime there was no significant difference in NI among all groups.

#### Caecal liquor parameter

Data in Table 5 elucidated that there was no significant difference in caecal pH values among all tested groups. Rabbits fed 0, 10, 20 and 30% of KFW substitution showed significant low values ( $P < 0.05$ ) of caecal ammonia nitrogen ( $\text{NH}_3\text{-N}$ ) mmol/l comparing with 40% of KFW diet. On the other hand, volatile fatty acids (VFA's) values were significantly higher ( $P < 0.05$ ) with rabbits groups fed control, 10, 20 and 30% KFW substitution compared with 40% substitution group which recorded the lowest estimate.

**Table 5** Effect of dietary containing kitchen food wastes (KFW) on caecal pH, ammonia nitrogen (NH<sub>3</sub>-N) and volatile fatty acids (VFA's) of growing rabbits

Items	Control	KFW				SEM	P value
		10%	20%	30%	40%		
pH	6.25	6.24	6.31	6.33	6.39	0.28	0.663
NH <sub>3</sub> -N <sub>3</sub> (mmol/l)	5.45 <sup>b</sup>	5.58 <sup>b</sup>	5.69 <sup>b</sup>	5.81 <sup>ab</sup>	5.97 <sup>a</sup>	0.13	0.032
TVFA's (mmol/l)	62.87 <sup>a</sup>	62.83 <sup>a</sup>	62.89 <sup>a</sup>	63.07 <sup>a</sup>	61.22 <sup>b</sup>	0.47	0.001
VFA's percentage (%)							
Acetate	74.85 <sup>b</sup>	74.63 <sup>b</sup>	74.49 <sup>b</sup>	74.33 <sup>b</sup>	76.94 <sup>a</sup>	0.87	0.016
Propionate	08.56 <sup>b</sup>	08.81 <sup>a</sup>	08.95 <sup>a</sup>	09.37 <sup>a</sup>	06.88 <sup>c</sup>	0.22	0.037
Butyrate	14.07	14.22	14.31	14.52	14.96	0.87	0.672

<sup>a,b,c</sup> Mean in the same row bearing different superscripts are significantly different

As for VFA's fractionation, the highest acetate % was recorded with the 40% KFW substitution comparing with other experimental groups, while propionate % was significantly high ( $P < 0.05$ ) for groups 10, 20 and 30% (KFW) substitution followed by the control group, whereas, the lowest percentage of propionate recorded with 40% substitution. In addition, there was no significant difference ( $P < 0.05$ ) with butyrate molar fraction among all groups.

#### Carcass characteristics

The effect of KFW inclusion on the carcass characteristics of the experimentation rabbits are shown in Table 6. The obtained data revealed that the pre-slaughter weight was an insignificant difference among all groups, while hot carcass weight was nearly similar among the tested groups, hence the highest hot carcass weight ( $P < 0.05$ ) was recorded for 30 and 40% KFW substitution compared with control group and without significant difference between groups of 10 and 20% substitution.

Dressing percentage was significantly high ( $P < 0.05$ ) for 40% KFW substitution and without significant difference with groups of 20 and 30% KFW followed by 10% KFW,

the lowest dressing percentage ( $P < 0.05$ ) was recorded for the control group. And there was no significant effect for liver and heart among the tested groups. Meanwhile, kidney and lung recorded the highest weight ( $P < 0.05$ ) for control compared with 40% of KFW, while the other levels recorded moderate weights.

Chemical composition of rabbit's meat was shown in Table 7 and represents that moisture and CP % of meat were nearly similar among all tested groups except the 30% substitution, which recorded the highest percentages ( $P < 0.05$ ). As for EE % of meat was ( $P < 0.05$ ) high for 20% KFW followed by the other experimental groups which showed similar results, however ash percentages were varied among groups hence it was significantly ( $P < 0.05$ ) high for control and the lowest ash % ( $P < 0.05$ ) was recorded for the meat of 40% KFW substitution.

#### Blood biochemical parameters

Plasma biochemical values demonstrated some significant differences ( $P < 0.05$ ) among the experimental groups by adding different levels of KFW in rabbit's diets (Table 8). The concentration of total plasma protein (g/dl) was significantly high ( $P < 0.05$ ) for KFW of 20 and

**Table 6** Effect of diet containing different levels of kitchen food wastes (KFW) on carcass characteristics of growing rabbits

Items	Control	Kitchen food wastes (KFW)				SEM	P value
		10%	20%	30%	40%		
Pre slaughter weight (g)	1761	1786	1743	1872	1562	8.60	0.644
Hot carcass weight (g)	851.00 <sup>b</sup>	887.00 <sup>ab</sup>	896.20 <sup>ab</sup>	909.20 <sup>a</sup>	914.00 <sup>a</sup>	7.55	0.049
Dressing %	54.53 <sup>c</sup>	55.93 <sup>bc</sup>	58.07 <sup>ab</sup>	57.85 <sup>ab</sup>	58.53 <sup>a</sup>	0.42	0.003
Liver (g)	53.82	54.96	50.98	58.36	49.69	1.25	0.845
Kidney (g)	14.24 <sup>a</sup>	13.31 <sup>ab</sup>	13.02 <sup>b</sup>	14.10 <sup>a</sup>	10.82 <sup>c</sup>	0.19	0.028
Spleen (g)	1.03 <sup>a</sup>	0.99 <sup>ab</sup>	0.88 <sup>b</sup>	1.20 <sup>a</sup>	1.02 <sup>a</sup>	0.03	0.062
Heart (g)	5.43	5.38	4.86	5.63	4.77	0.20	0.934

<sup>a,b,c</sup> Means with different superscripts in the same row differ significantly ( $P < 0.05$ )

**Table 7** Chemical composition of rabbit's meat (on fresh basis) fed experimental rations

Items	Control	KFW				SEM	P value
		10%	20%	30%	40%		
Moisture (%)	68.82 <sup>ab</sup>	68.62 <sup>ab</sup>	68.44 <sup>ab</sup>	69.04 <sup>a</sup>	68.35 <sup>b</sup>	0.10	0.172
CP (%)	19.70 <sup>b</sup>	19.56 <sup>b</sup>	19.53 <sup>b</sup>	20.18 <sup>a</sup>	19.97 <sup>ab</sup>	0.09	0.036
EE (%)	4.73 <sup>b</sup>	4.81 <sup>ab</sup>	4.95 <sup>a</sup>	4.69 <sup>b</sup>	4.68 <sup>b</sup>	0.03	0.024
Ash (%)	1.78 <sup>a</sup>	1.63 <sup>b</sup>	1.34 <sup>c</sup>	1.12 <sup>d</sup>	1.05 <sup>d</sup>	0.08	0.000
Others (%)	3.97	4.38	4.73	3.96	4.95	0.16	0.1422

<sup>a,b,c</sup> Means with different superscripts in the same row differ significantly ( $P < 0.05$ )

**Table 8** Effect of dietary containing different kitchen food wastes levels on some blood biochemical parameters of growing rabbits

Items	Control	KFW				SEM	P value
		10%	20%	30%	40%		
Total protein (g/dl)	06.37 <sup>b</sup>	06.68 <sup>b</sup>	06.71 <sup>a</sup>	06.88 <sup>a</sup>	06.16 <sup>c</sup>	0.27	0.021
Albumin (g/dl)	03.27 <sup>a</sup>	3.33 <sup>a</sup>	03.39 <sup>a</sup>	03.79 <sup>a</sup>	02.93 <sup>b</sup>	0.11	0.014
Globulin (g/dl)	03.10	03.35	03.32	03.39	03.23 <sup>c</sup>	0.42	0.642
Glucose (mg/dl)	81.34	81.28	81.41	81.49	80.52 <sup>a</sup>	0.73	0.591
Total lipids (g/l)	03.05 <sup>c</sup>	03.23 <sup>bc</sup>	03.52 <sup>b</sup>	03.89 <sup>a</sup>	04.52 <sup>a</sup>	0.33	0.001
Cholesterol (mg/dl)	189.66 <sup>c</sup>	204.24 <sup>bc</sup>	221.31 <sup>b</sup>	239.55 <sup>b</sup>	284.62 <sup>a</sup>	16.63	0.001
Triglycerides (mg/dl)	67.45 <sup>c</sup>	69.33 <sup>bc</sup>	70.17 <sup>b</sup>	72.66 <sup>b</sup>	75.33 <sup>a</sup>	1.79	0.001
HDL (mg/dl)	32.63	32.68	32.73	32.98	33.02	0.51	0.522
LDL (mg/dl)	81.43 <sup>b</sup>	82.14 <sup>b</sup>	82.69 <sup>b</sup>	82.93	84.08 <sup>a</sup>	0.27	0.31
Urea (mg/dl)	35.53 <sup>b</sup>	35.89 <sup>ab</sup>	36.15	36.31	37.33 <sup>a</sup>	0.16	0.007
Creatinine (mg/dl)	00.76 <sup>c</sup>	00.81 <sup>b</sup>	00.82 <sup>b</sup>	00.88	00.96 <sup>a</sup>	0.06	0.002
AST (U/L)	31.77	32.53	31.94	32.07	31.35	0.62	0.662
ALT (U/L)	15.74	15.87	15.66	15.69	15.47	0.59	0.721

<sup>a,b,c</sup> Mean in the same row bearing different superscripts are significantly different

30% substitution followed by zero and 10% of KFW, whereas the lowest concentration ( $P < 0.05$ ) was recorded with 40% KFW. Plasma albumin (g/dl) was significantly low ( $P < 0.05$ ) with 40% level of KFW compared with the other groups which showed insignificant difference.

Moreover, there were no significant differences in plasma globulin, glucose, HDL, AST and ALT among all the experimental groups. Total plasma lipids concentration was significant ( $P < 0.05$ ) high with groups 30 and 40% KFW followed by groups of 10 and 20% KFW, while the lowest concentration ( $P < 0.05$ ) was for the control group. Concerning plasma cholesterol and triglycerides content revealed that, addition of kitchen food wastes to rabbit's diets had different significant effects, which recorded the highest values with 40% group, while the lowest concentrations ( $P < 0.05$ ) were recorded for control followed by groups 10, 20 and 30% KFW, but without any significant difference between zero and 10% of KFW.

Also, there was significant increase ( $P < 0.05$ ) in plasma LDL level with 40% KFW, but there were no significant differences among the other groups. Plasma urea

concentration was significantly low ( $P < 0.05$ ) for groups zero and 10% KFW, while the other three tested groups recorded ( $P < 0.05$ ) high significant values. The concentration of plasma creatinine was significantly ( $P < 0.05$ ) high for groups of 30 and 40% of KFW substitution, while the lowest content recorded by the control group.

## Discussion

Data of Table 2 showed that the value of CP is comparable to the range recorded by Kim (1995) and Cho et al. (2004).

The results of Table 3 agree with Westendorf et al. (1998) who reported that weight gains of pigs fed 50% of cafeteria food waste (CFW) substitution from soybean meal were not different compared with 0% CFW diet. Also, there were insignificant differences in daily weight gain among steers fed substitution level of dried leftover food (DLF) 0, 25, 50, 75% of diet (Paek et al. 2005). Meanwhile, Farhat et al. (2001) and Enasa et al. (2018) reported improvements in body weight gain of ducks fed diets containing 30% DLF. In addition,

increased level of kitchen food wastes to 40% substitution in the diet decreases daily weight gain because of low nutritive value of KFW, particularly in TDN and DCP values.

Daily DM intake was comparable among groups, these results are in agreement with McClure et al. (1970) who demonstrated that daily feed intake of sheep and beef cattle fed DLF was similar to those fed control feed and with Summers et al. (1980) who indicated that sheep fed 30% DLF substitution of diet has similar feed intake with control group. Also, daily dry matter intake in this study was insignificant increase up to 30% KFW substitution, these results agree with Maeng et al. (1997) and Amene et al. (2016) who recorded increasing feed intake of hens fed DLF, and with Pigs fed dried cafeteria leftover (DCL) respectively.

Data of Table 4 showed that rabbits fed diet containing 30% KFW substitution showed the highest OM, CP and EE digestibility ( $P < 0.05$ ) compared with the other groups, and those agreed with Chae et al. (2000) who reported that CP and EE digestibility were increased with increasing levels of dried food waste in the diets of pigs. The high CP content of KFW may be enhancing the efficiency of rumen microflora such as proteolytic bacteria and cellulolytic bacteria which leads to increase nutrients digestibility (Dawson et al. 1990). Also, Kil et al. (1999) recorded that incorporating DLF in ruminant diets increased the generation of rumen ammonia which increase the absorption of nitrogen through stomach walls. Meanwhile, pigs fed diets consisted of DCL showed higher DM digestibility (Almeida et al. 2014) and higher CF and EE digestibility (Amene et al. 2016), may be due to the existence of soluble components in DCL or exposed food to heat treatment during cooking which increase food digestibility.

As shown in Table 5 there were insignificant differences observed in pH of caecal contents and slightly like obtained with Garcia et al. (2002) (pH 5.4–6.8). The caecal TVFA's concentration increased with diets containing KFW could be due to high digestible DM (Allam et al. 1984), high digestible OM (El-Ashry et al. 2003) and high digestible CF of KFW resulted from the activity of microbial population (Doane et al. 1997), which could be well utilized by rabbits since they have hind gut fermentation. Besides, fermentation process which is performed by microflora enables rabbits to obtain protein and energy from feed with moderate fiber materials.

Data of Table 6 of dressing % agree with Cho et al. (2004) who revealed that increasing the level of DLF in the diet affected significantly on dressing percentage and carcass weight of hens. And were not in agreement with that reported by Chen et al. (2007) and Mousa et al.

(2018) who found that duck's diets contain DLF had no significant effect ( $P < 0.05$ ) on dressing %, carcass weight and relative weights of liver and heart.

Table 7 represents that chemical analysis of meat were nearly similar among all tested groups which reflect that KFW has not any adverse effect on meat that it is food wastes of human and agree with found by Westendorf et al. (1998) who reported that meat quality of pigs fed CFW similar with those fed 0 CFW.

Blood parameters of Table 8 showed insignificant differences in plasma globulin, glucose, HDL, AST and ALT among all the experimental groups and this mean that inclusion of KFW in the diets had no adverse effect on rabbits health. While, Chen et al. (2007) showed higher value of serum AST with increasing dried food waste in chickens diets up to 20%. However, Hassanien et al. (2020) found no significant concentrations of blood total protein, globulin, cholesterol, AST, ALT, urea and creatinine for cows fed dried leftover up to 40% of diets. Concerning plasma total cholesterol and triglycerides content, substitution of KFW of rabbit's diets recorded the highest values with 40% group, while the lowest concentrations ( $P < 0.05$ ) were recorded for other diets. Cho et al. (2004) found that feeding dried leftover food to broilers had no significant effect on blood total cholesterol concentrations and Mousa et al. (2018) reported that triglyceride increased with increasing the level of leftover in duck diets up to 30% of diet. According to several researchers, one of the factors affecting content of cholesterol in the blood was fiber content in animal feed. Palmer and Zilversmit (1974) and Adams et al. (2018) suggested that cellulose as an indigestible material controlled the cholesterol metabolism and affected cholesterol concentration in blood and cholesterol turnover rate.

The overall conclusion from the feeding trials through several places demonstrated that kitchen food wastes are nutritionally suitable for use as animal feed, however, the recommend approach is to use it in a combined feed, in order to ensure that a nutritionally balanced feed can be safety provided (Westendorf et al. 1998).

## Conclusion

Results of the current study concluded that the best growth performance, feed conversion and meat quality was observed clearly for rabbits fed diets containing 30% of kitchen food wastes which surpassing all the tested groups.

The reasonable growth performance obtained in this study could encourage the researcher to recommend the use of kitchen food wastes at 30% in replacement of expensive normal diet as a non-conventional cheap

## feedstuff in warning rabbit's diets without any disorders effects on growth performance or hygiene.

### Abbreviations

KFW: Kitchen food wastes; NZW: New Zealand White rabbits; g: Gram; DM: Dry matter; OM: Organic matter; CP: Crude protein; CF: Crude fiber; EE: Ether extract; NFE: Nitrogen free extract; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Acid detergent lignin; UN: Urinary nitrogen; TVFA: Total volatile fatty acids; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; HDL: High density lipoprotein; IAEA: International Atomic Energy Agency; LDL: Low density lipoprotein; SAS: Statistical Analysis System; IBW: Initial body weight; FBW: Final body weight; DWG: Daily weight gain; DFI: Daily feed intake; TDN: Total digestible nutrients; NI: Nitrogen intake; NB: Nitrogen balance; CFW: Cafeteria food waste; DLF: Dried leftover food.

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### Authors' contributions

Conceptualization, FH and AE; Data curation, SE, MMB and EE; Investigation, FH, AE and SE; Methodology, FH, MMB, EE and SE. Supervision, FH and AE; Validation, FH and SE. Visualization, Writing—original draft FH, AE and SE. Writing—review and editing, AE and SE. All authors have read and agreed to the published version of the manuscript.

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### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on request.

### Declarations

#### Ethics approval and consent to participate

The experimental design and all the research protocols were approved by the Medical Research Ethics Committee (MREC) of the National Research Center with ethical approval code 20/189.

#### Consent for publication

"Not applicable".

#### Competing interests

The authors declare that they have no competing interests.

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