Nutritional Value and Quality Profile of Fresh Rabbit Meat in Assiut City, Egypt

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ABSTRACT

Nutritional value and safety have gained great importance among the factors that determine meat quality. In the present study thirty rabbits were randomly bought from retail rabbit slaughterhouses in Assiut city, Egypt. They were slaughtered and divided into two halves and each half was further subdivided into fore and hind quarter for chemical and microbiological assessments. The samples were assessed chemically for the proximate composition (moisture, protein, fat, carbohydrate and gross energy content), thiobarbituric acid reactive substances (TBA), total cholesterol (Chol), triglycerides (TGs), high-density lipoprotein (HDL) cholesterol and low-density lipoptotein (LDL) cholesterol. For microbiological assessment the total aerobes, Enterobacteriaceae, *E. coli, Staphylocooccus aureus*, mold and yeast counts (cfu/ml) as well as incidence of *Salmonella* spp were assessed in the rinse of the fore and hind quarters. The mean values of moisture, protein, fat, ash, and carbohydrate were 75.2±0.48 and 76.13±0.26; 19.81±0.22 and 20.59±0.18; 3.54±2.39 and 1.78±0.19; 1.12±0.03 and 1.17±0.03; and 0.33±0.03 and 0.33±0.03 for fore and hind quarter samples, respectively. The protein and fat means were significantly different (P<0.05), while those for moisture, ash and carbohydrate were not (P>0.05). The gross energy (Kcal/100g) mean values were 112.42±4.04 and 99.67±1.82, respectively, and the TBA (mg malonaldehyde/kg flesh) values were 0.3±0.03 and 0.19±0.02, respectively, with a significant difference (P<0.05). For Chol, TGs, HDL, and LDL, the mean values were 59.13±4.4 and 54.97±3.9; 19.04±1.56 and 25.9±2.77; 22.36±1.17 and 21.95±1.47; and 32.96±4.4 and 27.85±3.74 mg/100g, respectively. No significant difference (P>0.05) was observed for Chol, HDL, and LDL means value. The LDL % was higher in fore (49.11±3.58) than in hind (46.33±3.37) quarter samples. The mean value of total aerobes, Enterobacteriaceae, *Staphylococcus aureus*, mold and yeast counts for positive samples were 2.7±0.82 $x10^6$ and 4.2±1.57 $x10^6$; 3.56±2.10 $x10^5$ and 9.53±4.97 $x10^5$; 3.63±2.48 $x10^5$ and 1.59±1.53 $x10^5$; 1.29±1.25 $x10^5$ and 1.25±0.84 $x10^5$; and 3.2±0.98 $x10^6$ and 4.6±1.95$x10^6$ cfu/ml, respectively. No significant difference for the previous counts between fore and hind quarters was found. *E. coli* couldn't be detected in any of the fore quarter samples, but it in only one hind quarter sample with a count of 5$x10^2$cfu/ml. *Salmonella* spp were detected in percentage of 23.3 and 20% in fore and hind quarter samples, respectively. It could be concluded that nutritional properties of fresh rabbit meat is healthier over other meats (high in protein and low in fat).Hind quarters meat was found to be superior to fore quarters from the nutritional and public health points of views (higher in protein, lower in fat, Chol, LDL%, and TBA as well in incidence of salmonellae).

Key words: Fresh Rabbit Meat, Proximate Composition, Microbial Quality, TBA, Total Cholesterol, HDL, LDL.

INTRODUCTION:

Rabbit (*Oryctolagus cuniculus*) is a versatile animal has been encouraged for meat production for its small body size, shorter generation interval, high prolificacy and early marketability (Haque et al., 2016). Today, rearing rabbits for meat is an established industry in many countries of the world. The global rabbit meat production had reached up to 1. 8 million tonnes/ year, with the leading producer is China (735,021 tonnes/year), while in Egypt the production is only 56,338 tonnes/year (FAOSTAT, 2012).

Currently nutritional value and safety have gained great importance among the factors that determine meat quality. The close relationship between diet and health has led to changes in consumer habits, demanding products that meet their dietary and nutritional preferences (Hernandez, 2008).Recommended by nutritionists over other meats, rabbit meat is valued for it is being lean, rich in proteins of high biological value, minerals, and vitamins. Besides, it has low concentrations of saturated fatty acids, cholesterol and sodium (Frunza et al., 2014).

In addition, nutritional quality of rabbit meat is superior to other species because its lipid has high content of monounsaturated fatty acids and being rich in polyunsaturated fatty acids, thus plays a vital role in the prevention of vascular diseases with positive influences on the health state of humans (El-Medany and El-Reffaei, 2015).The ash content of rabbit meat is similar or higher than that of other livestock. Its calcium and phosphorus contents are higher than in other meats (Hermida et al., 2006and Williams, 2007). It also considers a source of B vitamins "B2, B3, B5, B12"and lipid soluble vitamins A and E (Combes, 2004). As well, rabbit meat is characterized by its lower energetic value compared with red meats (Dalle Zotte, 2004) due to its low fat content. Another advantage of rabbit meat is its very low content in uric acid, being recommended even to people with gout, besides it has low contents of purines (Hernández et al., 2007).

Rabbit meat is wholesome, tasty and protective food. It is considered a traditional food in Egypt and the Sudan (Bora, 1995; FAO, 1997; El-Medany and El-Reffaei, 2015). Rabbit meat is flavorful and easily digested, with high nutritional and dietetic properties being indicated in feeding children and old people (Dalle Zotte, 2000; Dalle Zotte, 2002). However, microbial quality of fresh rabbit meat is an influence factor.

Rabbit carcasses can be easily contaminated during slaughtering. This contamination can accessed from hide, intestine, processing equipment, air, water or human. Microbial contamination of fresh rabbit meat gives indication about processing practice, shelf life of that meat and hazards might be caused to consumer. Total aerobes count is used as an indicator of contamination of rabbit meat after processing. Rabbit meat can be contaminated with fecal coliform which is an indicator of good manufacturing practice (GMP), *Staphylococcus aureus* which signifies poor personal hygiene, and also it might be polluted with pathogenic microorganisms as *Salmonella* (Rodriguez-Calleja et al., 2004; Cwikova and Pytel,2017).

Recently, the nutritional value of rabbit meat has been reviewed by several authors (Hernández and Gondret, 2006; Ghosh and Mandal, 2008; Nistor et al, 2013; Dalle zotte, 2014; Frunza et al., 2014; Swami et al., 2014; El-Medany and El-Reffaei, 2015; Haque et al., 2016). However, data regarding the chemical composition of rabbit meat is greatly variable, depending on the part of the carcassstudied (Pla et al., 2004) and also on the different productive factors (Dalle Zotte, 2002), especiallyfeeding. As well, microbiological quality of rabbit meat is still questionable.

The present study was undertaken to assess the fresh rabbit meats' quality (nutritional and microbial) in Assiut city, Egypt, comparing the quality of the fore quarters to that of the hind quarters, so as to help consumers to choose what is suitable for their health and preferences.

MATERIALS AND METHODS

1- Collection and preparation of samples:

Thirty rabbits of different ages, sex, breeds and weights were randomly bought alive from retail slaughterhouses in Assiut city, Egypt at varying intervals over a period of 2 months (October/November 2017). They were slaughtered manually according to Islamic procedure, de-skinned and eviscerated on spot, kept separately in polyethylene bags and transported with a minimum of delay to the laboratory of Meat Hygiene, Faculty of Veterinary Medicine, Assiut University. Carcasses were inspected visually for the presence of any obvious pathological lesions, and affected ones were removed from assessments. Each visually sound carcass was divided into two halves for microbiological and chemical assessments. Each half was further divided into fore and hind quarters. The samples were kept overnight in the refrigerator (4°C).

2- Chemical (nutritional quality) assessments

For chemical assessment each sample was dissected from the fat surface, hand-boned and the lean part was then finally cut and thoroughly mixed for the following analyses.

2.1.Nutritional proximate composition

The proximate analysis (moisture, protein, fat and ash) was carried out on meat of the fore and hind quarters according to the procedures of AOAC (2012). Moisture content was determined in 20g sample using hot air oven at 65°C for 24h then at 105°C for 6h. Protein content was calculated as nitrogen percentage multiplied by 6.25. The nitrogen percentage in dried sample (0.5g) was determined using Kjeldahl procedure. Fat from the sample was extracted by Soxhlet method using petroleum ether (60/80) for 16-18h, where the loss in sample (1g dry sample weighed and wrapped in filter paper) weight was calculated as the fat percentage. For ash content, dried sample (1g) was ignited in muffle furnace at 600°C for 4-6h. Analysis was made in duplicate.

N.B. The obtained results on dry weight basis were converted on wet weight basis using the following equation according to Jurgens and Bregendahl (2007):

$$\text{Nutrient wet basis\%} = \frac{\text{nutrient dry basis\% X dry matter \%}}{100}$$

Total carbohydrate content was calculated by difference as following:

Total carbohydrate % = 100 – (moisture % + protein % + fat % + ash %)

The gross energy value (Kcal/100gm) related to fresh rabbit meat was calculated according to the equation of Merrill and Watt (1973):

Gross energy (Kcal/100g) = (protein% x 4) + (fat% x 9) + (carbohydrate% x 4)

The energy related to each of protein (protein%x4), fat (fat%x9) and carbohydrate (carbohydrate%x4) was also calculated separately.

2.2.TBA, Chol, TGs, HDL and LDL

2.2.1. Thiobarbituric acid reactive substances (TBA) value (mg malonaldehyde/kg flesh)

The TBA value in the fresh rabbit meat samples was determined according to the method of Buege and Aust (1978) and using the spectrophotometer at 531nm

2.2.2. Total Cholesterol (Chol) content (mg/100g flesh)

Lipid was first extracted from rabbit meat sample (1.25g) according to Bligh and Dyer (1959) using chloroform/methanol mixture (1:2), extracted lipid was then saponified according to Naeemi et al. (1995) using saturated methanolic potassium hydroxide. The upper layer after centrifugation was used for the assessments using Spectrum diagnostic kits.

According to Pasin et al (1998) Chol was assessed using diagnostic kits (Spectrum IFUFCC08).

2.2.3. Triglycerides (TGs), High Density Lipoprotein (HDL) Cholesterol, Low Density Lipoprotein (LDL) Cholesterol content (mg/100g flesh)

The TGs were assessed in the saponified lipid extract using diagnostic kits (Spectrum IFUFCC39).

The HDL was assessed using diagnostic precipitant kits (Spectrum IFUFCC26) with the cholesterol reagent of the kit "Spectrum IFUFCC08".

The LDL was calculated according to the equation of Spectrum HDL precipitant kits

$$\text{LDL Cholesterol} = \text{Total Cholesterol} - \frac{\text{Triglyceride}}{5} - \text{HDL Cholesterol}$$

All spectrophotometric measurements of Chol, TGs, and HDL were at 546 nm.

3. Microbiological analysis

A total of 60 samples (30 of each of fore and hind quarters of rabbit carcasses) were analyzed separately using rinsing method. Sterile buffered peptone water (BPW) in sterile bags was used for rinsing (100mls) and serial dilutions (9mls). The dilutions (0.1mls) were used for seeding of Plate Count Agar (PCA), Violet Red Bile Glucose Agar (VRBG), Eosin Methylene Blue Agar (EMB), Mannitol Salt Agar (MSA), Sabouraud Dextrose Agar (SDA). The plates incubated at 35±2°C for 24-48h for detection of total aerobes, Enterobacteriaceae, *E. coli*, and *Staphylococcus aureus* (*Staph aureus*) counts, and at 25°C for 5 days for yeast and mould counts, respectively (Rodriguez-Calleja et al., 2004; Thomas et al., 2006; Avila et al. 2013)

For detection and isolation of *Salmonella* spp., buffered peptone rinses were incubated at 37°C for 18±2 hours, enrichment on Selenite Cystine broth which incubated at 37°C for 24 hours, plating on Xylose Lysine Desoxycholate (XLD) and incubated at 37°C for 24-48 hours. *Salmonella* spp. isolates were confirmed biochemically "TSI, sucrose, lactose, H2S and urease" (Thomas et al., 2006).

4. Statistics

All obtained data were statistically processed using the Statistical Software Package SPSS (2001). One way ANOVA test was applied and significance was assessed at P<0.05.

RESULTS

The data in table 1 represent the proximate composition (%) and the gross energy content of the examined fresh rabbit fore and hind quarter's meat samples. The composition of the fore and hind quarters meat ranged from 69.55 to 79.07 and 73.76 to79.28; 16.54 to 21.82 and 18.18 to 22.12; 0.81 to 8.78 and 0.46 to 3.73; 0.81 to 1.52 and 0.83 to 1.52; and from 0.11 to 0.6 and 0.06 to 0.59 with mean values of 75.2 ± 0.48 and 76.13 ± 0.26; 19.81 ±0.22 and 20.59 ± 0.18; 3.54 ± 2.39 and 1.78 ±0.19; 1.12 ±0.03 and 1.17 ± 0.03; and 0.33 ±0.03 and 0.33 ± 0.03 for moisture, protein, fat, ash, and carbohydrate, respectively.

Table 1: Proximate composition (%) and caloric content (Kcal/100g) of fresh rabbit fore and hind quarter's meat samples

Categories		Min	Max	Mean ±SEM
Moisture (%)	**F**	69.55	79.07	75.20^{a}± 0.48
	H	73.76	79.28	76.13^{a}± 0.26
Protein (%)	**F**	16.54	21.82	19.81^{a}± 0.22
	H	18.18	22.12	20.59^{b}± 0.18
Fat (%)	**F**	0.81	8.78	3.54^{a}± 0.44
	H	0.46	3.73	1.78^{b}± 0.19
Ash (%)	**F**	0.81	1.52	1.21^{a}± 0.03
	H	0.83	1.52	1.17^{a}± 0.03
Carbohydrate (%)	**F**	0.11	0.60	0.33^{a}± 0.03
	H	0.06	0.59	0.33^{a}± 0.03
Gross energy (Kcal/100gm)	**F**	86.35	161.31	112.42^{a}± 4.04
	H	85.81	118.89	99.67^{b}± 1.82
E Ptn (Kcal/100gm)	**F**	66.16	87.29	79.25^{a}± 0.88
	H	72.72	88.48	82.37^{b}± 0.72
E Fat (Kcal/100gm)	**F**	7.29	79.02	31.87^{a}± 3.93
	H	4.14	33.57	15.99^{b}± 1.73
E Cho (Kcal/100gm)	**F**	0.45	2.41	1.30^{a}± 0.11
	H	0.22	2.38	1.30^{a}± 0.11

F=fore quarter, H=hind quarter, n= 30 for each of fore and hind quarters

E Ptn = energy related to protein E fat = energy related to fat E Cho = energy related to carbohydrate

Within the same category, means with different superscripts are significantly different (P<0.05)

Table 2: TBA (mg malonaldehyde/kg flesh), Chol (mg/100g), TGs (mg/100g), HDL (mg/100g), and LDL (mg/100g) contents of fresh rabbit fore and hind quarter's meat samples

Categories		Min	Max	Mean ±SEM
TBA	F	0.07	0.56	$0.30^{a} \pm 0.03$
	H	0.04	0.43	$0.19^{b} \pm 0.02$
Chol	F	24.22	110.26	$59.13^{a} \pm 4.4$
	H	25.00	121.83	$54.97^{a} \pm 3.9$
TGs	F	8.70	40.00	$19.04^{a} \pm 1.17$
	H	6.09	56.52	$25.90^{b} \pm 1.47$
HDL	F	5.70	33.06	$22.36^{a} \pm 1.56$
	H	5.70	39.90	$21.95^{a} \pm 2.77$
LDL	F	4.38	88.00	$32.96^{a} \pm 4.4$
	H	3.32	101.50	$27.85^{a} \pm 3.74$
LDL (%)	F	12.01	88.10	$49.11^{a} \pm 3.58$
	H	13.28	87.39	$46.33^{a} \pm 3.37$

F=fore quarter, H=hind quarter, n= 30 for each of fore and hind quarters
Within the same category, means with different superscripts are significantly different ($P<0.05$)

Table3: Total aerobes, Enterobacteriaceae, *E. coli*, *Staph aureus*, mold and yeast counts (cfu/ml) in the rinse of fore and hind quarters of examined rabbit carcasses'

Categories		Positive NO (%)	Min	Max	Mean ±SEM
Total aerobes count	F	30(100)	$1x10^{2}$	$2x10^{7}$	$2.7 \pm 0.82\ x10^{6}$
	H	30(100)	$1x10^{2}$	$3x10^{7}$	$4.2 \pm 1.57\ x10^{6}$
Enterobacteriaceae count	F	25(83.3)	$1x10^{2}$	$5x10^{6}$	$3.56 \pm 2.10\ x10^{5}$
	H	22(73.3)	$5x10^{2}$	$1x10^{7}$	$9.53 \pm 4.97\ x10^{5}$
E. coli count*	F	0	-	-	-
	H	1(3.3)	-	-	-
Staph. aureus count	F	14(46.7)	$1x10^{2}$	$3x10^{6}$	$3.63 \pm 2.48\ x10^{5}$
	H	13(43.3)	$1x10^{2}$	$2x10^{6}$	$1.59 \pm 1.53\ x10^{5}$
Mold count	F	16(53.3)	$1x10^{2}$	$2x10^{6}$	$1.29 \pm 1.25\ x10^{5}$
	H	14(46.7)	$1x10^{2}$	$1x10^{6}$	$1.25 \pm 0.84\ x10^{5}$
Yeast count	F	30(100)	$2x10^{2}$	$3x10^{7}$	$3.2 \pm 0.98\ x10^{6}$
	H	30(100)	$1x10^{2}$	$5x10^{7}$	$4.6 \pm 1.95\ x10^{6}$

F=fore quarter, H=hind quarter, n= 30 for each of fore and hind quarters
**E. coli* count found in one hind quarter sample at $5x10^{2}$cfu/ml.

Table4: Frequency distribution and frequency distribution percent of microbial counts (cfu/ml) in the rinse of fore and hind quarters of examined rabbit carcasses'

Category		$<10^2$	%	10^2-$<10^3$	%	10^3-$<10^4$	%	10^4-$<10^5$	%	10^5-$<10^6$	%	10^6-$<10^7$	%	10^7-$<10^8$	%
Total aerobes count	**F**	-	-	2	6.7	1	3.3	5	16.7	8	26.7	10	33.3	4	13.3
	H	-	-	4	13.3	5	16.7	1	3.3	7	23.3	10	33.3	3	10
Enterobacteriaceae count	**F**	5	16.7	5	16.7	8	26.7	6	20	4	13.3	2	6.7	-	-
	H	8	26.7	4	13.3	5	16.7	5	16.7	3	10	5	16.7	-	-
***E. coli* count**	**F**	30	100	-	-	-	-	-	-	-	-	-	-	-	-
	H	29	96.7	1	3.3	-	-	-	-	-	-	-	-	-	-
***Staph aureus* count**	**F**	16	53.3	5	16.7	5	16.7	2	6.7	-	-	2	6.7	-	-
	H	17	56.7	5	16.7	5	16.7	2	6.7	-	-	1	3.3	-	-
Mold count	**F**	14	46.7	9	30	5	16.7	1	3.3	-	-	1	3.3	-	-
	H	16	53.3	6	20	4	13.3	2	6.7	1	3.3	1	3.3	-	-
Yeast count	**F**	-	-	4	13.3	1	3.3	3	10	7	23.3	11	36.7	4	13.3
	H	-	-	5	16.7	1	3.3	5	16.7	6	20	9	30	4	13.3

F=fore quarter, H=hind quarter, n= 30 for each of fore and hind quarters
Frequency distribution percent= (frequency/n) x 100

Table 5: Incidence of *Salmonella* spp. in the rinse of fore and hind quarters of examined rabbit carcasses'

Type of samples	No. of samples	positive samples		Negative samples	
		No.	%	No.	%
Fore quarter	30	7	23.3	23	76.7
Hind quarter	30	6	20	24	80

The means value for protein and fat were significantly different (P<0.05), while those for moisture, ash and carbohydrate were not (P>0.05). The gross energy content (Kcal/100g) ranged from 86.81 to 118.89 and from 66.16 to 87.29 for fore and hind quarter samples with mean value of 112.42 ± 4.04 and 99.67 ± 1.82, respectively. The energy value (Kcal/100g flesh) related to each of protein, fat, and carbohydrate were in the range of 66.16 to 87.29 and 72.72 to 88.48; 7.29 to 79.02 and 4.14 to 33.57; and 0.45 to 2.41 and 0.22 to 2.38 for fore and hind quarter samples with mean value of 79.25 ± 0.88 and 82.37 ± 0.72; 31.87 ± 3.93 and 15.99 ± 1.73; and 1.3 ± 0.11 and 1.31 ±0.11, respectively. The gross energy means value for fore and hind quarters were all significantly different (P<0.05) except in the case of carbohydrate (P>0.05).

The TBA (mg malonaldehyde/kg flesh) content of fresh rabbit meat showed a minimum value of 0.07 and 0.04, a maximum of 0.56 and 0.43, and a mean of 0.3 ± 0.03 and 0.19 ±0.02 for fore and hind quarter samples, respectively, with a significant difference (P<0.05) in between. For Chol, TGs, HDL, and LDL the minimum values were 24.22 and 25.0; 8.7 and 6.09; 5.7 and 5.7; and 4.38 and 3.32, while the maximum values were 110.26 and 121.83; 40.0 and 56.52; 33.06 and 39.9; and 88.0 and 101.5 with mean value of 59.13 ± 4.4 and 54.97 ± 3.9; 19.04 ± 1.56 and 25.9 ± 2.77; 22.36 ± 1.17 and 21.95 ± 1.47; and 32.96 ± 4.4 and 27.85 ± 3.74 mg/100g for fore and hind quarter samples, respectively. A significant difference (P<0.05) was observed between the means value of TGs, while for Chol, HDL, and LDL the means value not differ significantly (P>0.05). The LDL % showed a minimum of 12.0 and 13.28, a maximum of 88.1 and 87.39, and a mean of 49.11 ± 3.58 and 46.33 ± 3.37 for fore and hind quarter samples, respectively, with insignificant difference (P>0.05) between them (Table 2).

The count and frequency distribution of the tested microorganisms were shown in tables 3 and 4, the mean values of total aerobes, Enterobacteriaceae, *Staph aureus*, mold and yeast counts for positive samples were $2.7\pm0.82x10^6$ and $4.2\pm1.57x10^6$; $3.56\pm2.10x10^5$ and $9.53\pm4.97x10^5$; $3.63\pm2.48x10^5$and $1.59\pm1.53x10^5$; $1.29\pm1.25x10^5$and $1.25\pm0.84x10^5$; and $3.2\pm0.98x10^6$and $4.6\pm1.95x10^6$cfu/ml, for fore and hind quarters, respectively. *E. coli* count couldn't be detected in any of the examined fore quarter samples, but it was found in only one sample of hind quarters with a count of $5x10^2$ cfu/ml. Of the examined fore and hind quarter samples, 33.3 and 33.3% showed total aerobes count in the range 10^6-$<10^7$; 26.7 and 26.7% Enterobacteraceae count in the range 10^3-$<10^4$ and $<10^2$, respectively; 100 and 96.7% *E. coli* count in the range $<10^2$ and 10^2-$<10^3$, respectively; 53.3 and 56.7% *Staph aureus* count in the range $<10^2$; 46.7 and 53.3% mold count in the range $<10^2$; and 36.7 and 30.0% yeast count in the range 10^6-$<10^7$ cfu/ml. *Salmonella* species were detected in percentage of 23.3 and 20% in fore and hind quarters, respectively (Table 5).

DISCUSSION

Nutritional Quality

The nutritive value of meat has an increasing importance among the factors determining meat quality and consumer acceptability (Hernandez, 2008). Rabbit meat is of high nutritional value, recommended by nutritionists over other meats and can be used to replace red meat for it is being healthier and cheaper in price. It is used as functional food where its consumption could be a good way to provide bioactive compounds (essential amino and fatty acids) to human consumers; also, it is low in uric acid, cholesterol and saturated fatty acid contents. Additionally, rabbit meat is an important source of highly available micronutrients, such as vitamins and minerals (Hernández, 2007; Hernández et al., 2007 and Kone et al., 2016).

Rabbit meats nutritional quality currently received a great concern. The results of the current study (Table 1) declared that the mean moisture content (%) of the hind quarters (76.13) was higher than that of the fore quarters (75.20) with no significance difference (P>0.05). Nearly similar mean value of 75.97 was recorded by Simonova et al. (2010) in muscles *Longissimus dorsi* of rabbit, and Haque et al. (2016) found moisture mean values of 76.19 in meat of New Zealand White and a higher moisture content of 77.17 in Soviet Chinchilla rabbit meat. Lower values were obtained by Dalle zotte (2014) of 69.5 and 73.8 for fore and hind quarters, respectively. Elamin et al. (2011), Kowalska et al. (2011), Nistor et al. (2013), Dalle zotte et al. (2014), Belichovska et al. (2017), Mattioli et al. (2017), and Pavelkova et al. (2017) found lower moisture mean values for hind quarter rabbit meat of 73.96, 72.25, 68.5, 73.6, 74.49, 74.3 and 75.14, respectively. Mean values of71.5, 72.16, 72.69, 74.7 and 64.8 were reported by Polak et al. (2006), Swami et al. (2014), Attai et al. (2015), El-Medany and El-Reffaei (2015) and Maikanov et al. (2017) for rabbit meat; and of 68.32, 73.9, 74.25,75, 73.5 by Omojola and Adesehinwa (2006), Peiretti and Meineri (2011), Mertin et al. (2012), Dalle zotte et al. (2014) and Kowalska (2015) for muscles *Longissimus* of rabbit, respectively. Besides, Ghosh and Mandle (2008) found values of 69.6 and 70 for Soviet Chinchilla and Grey Giant male and female rabbits, respectively, while Mattioli et al. (2017) reported a value of 74.1 for lion muscles of New Zealand White rabbits. Moisture mean values ranged from 72.5 to 76.1 and from 74.1 to 75.2 were recorded by Metzger et al. (2011) for hind leg and Logissimus dorsi meat of the Pannon White rabbits of different ages and weights, respectively. Frunza et al. (2014) reported values ranged from 63.6 to 75.93 for rabbit meat of males and females. Moisture content of rabbit meat significantly decreased with the increase in animal age(as the animal become mature) with no significant effect for the breed or sex (FAO, 1997;Polak et al., 2006;Ghosh and Mandal, 2008; Haque et al., 2016;Belichovska et al., 2017).

Compared with the meat of other species, rabbit meat is richer in proteins (FAO, 1997). Protein mean value (%) of 18.6 was recorded by Dalle Zotte (2014) for fore quarters' rabbit meat, seemed lower than the current result (19.81), while a value of 21.7 was recorded for the hind quarters' which was higher than the current result (20.59). Protein content of the hind quarters was significantly ($P<0.05$) higher than that of the fore quarters. Higher mean percentages of protein for hind leg rabbit meat were obtained by Kowalska et al. (2011), Nistor et al. (2013), Tumova and Hrstka (2013), Dalle Zotte et al. (2014), Belichovska et al. (2017), Mattioli et al. (2017) of 23.41, 21.2, 22.39, 22, 21.79 and 22, respectively, and lower percentage of 19.6 was recorded by Marounek et al. (2007), while nearly similar percentages were obtained by ELamin et al. (2011) and Pavelkova et al. (2017).Protein contents of 21.05, 21.63, 24.3, 22.2 and22.9were detected by Omojola and Adesehinwa (2006), Simonova et al. (2010), Peiretti and Meineri (2011), Mertin et al. (2012) and Dalle Zotte et al. (2014), respectively for *Longissimus* muscles. Kowalska (2015) detected a value of 19.8 for *Longissimus dorsi* muscle. Mean values of 22, 20.21, 21.64, 21.31 was obtained for rabbit meat by Polka et al. (2006),Swami et al. (2014), Attia et al. (2015) and El-Medany and El-Reffaei (2015), respectively. Frunza et al. (2014) recorded mean values of 16.65 – 21.7 for males and females' rabbit meat, but values of 20.4 and 20.3 were recorded by Ghosh and Mandal (2008) for Soveit Chinchilla and Grey Giant males and females rabbit meat, while Haque et al. (2016) recorded values of 18.63 and 18.86 for New Zealand White and Soviet Chinchilla *Longissimus dorsi* rabbit meat, and Metzger et al. (2011) recorded values of 22.7 – 23.8 and 20.7 – 21.7 for *Longissimus dorsi* and hind leg meats of Pannon White rabbit of different ages and weights, respectively. Marounek et al. (2017) registered protein mean value of 21.6 for loin meat of rabbits, and a value of 24 reported by Mattioli et al. (2017). Protein content of rabbit meat showed a significant increase with the age of the animal (FAO, 1997; Haque et al., 2016)), with variation between sex(Polaket al., 2006) orcarcass portions (Marounek et al., 2007; Metzger et al., 2011; Dalle Zotte et al., 2014; Mattioli et al., 2017), but no significant effect for diet or genotype (Polak et al., 2006; Ghosh and Mandal, 2008; Peiretti and Meineri, 2011; Belichovska et al., 2017). Ghosh and Mandal (2008) recorded no significant effect for sex.

Compared with the meat of other species, rabbit meat has less fat (FAO, 1997). The result of the current study showed significant ($P<0.05$) lower fat mean content (%) of hind quarters (1.78) rabbit meat than that of the fore quarters (3.54). Dalle Zotte (2014) recorded higher mean fat content for fore (8.8) and hind (3.4) legs rabbit meat. Higher fat contents for hind leg rabbit meat were obtained by Bianchi et al. (2006),Marounek et al. (2007), Nistor et al. (2013), Tumova and Hrstka (2013), Dalle Zotte et al. (2014), Belichovska et al. (2017) and Mattioli et al. (2017) of 2.96, 3.93,9.2, 2.84, 2.9, 2.78 and 2.41, while nearly similar contents of 1.66, 1.52 and 1.44 was found by Elamin et al. (2011), Kowalska et al. (2011) andPavelkova et al. (2017), respectively. Fat contents for *Logissimus* muscles of 1.49, 1.4, 2.55, 0.9 and 2.11 were registered by Omojola and Adesehinwa (2006), Simonova et al. (2010), Mertin et al. (2012),Dalle Zotte et al. (2014)and Kowalska (2015), respectively. Lower fat content for *Logissimusdorsi* muscle of 0.57 was found by Peiretti and Meineri (2011), while fat contents of 5.4, 6.4, 4.13 and 2.64 were found by Polak et al. (2006), Swami et al. (2014), Attia et al. (2015), El-Medany and El-Reffaei (2015) for rabbit meat, respectively. Frunza et al. (2014) reported mean fat content values of 1.69–18.1 for Belgian Giant males and females rabbits, while Ghosh and Mandal (2008) documented fat content of 8.08 and 7.81 for Soviet Chinchilla and Grey Giant male and females rabbits, respectively. Metzger et al. (2011) recorded contents of 0.53-1.27 and 1.51–5.58for *Longissimus dorsi* and hind leg meat of Pannon White rabbits of different ages and weights, respectively, besides Haque et al. (2016) calculated contents of 5.82 and 4.8 for *Logissimus dorsi* muscle of New Zealand White and Soviet Chinchilla rabbits, respectively. Marounek et al. (2007) and Mattioli et al. (2017) estimated mean values of 0.85 and 0.46 for fat in lion meat. Fat content of rabbit meat showed significant increase with the age and significant variation with the type of cut, diet, sex and breed (FAO, 1997; Polak et al., 2006; Marounek et al.; 2007; Peiretti and Meineri, 2011; Metzger et al., 2011; Haque et al., 2016 and Mattioli et al., 2017). Non-significant effect of sex or genotype on fat content of rabbit meat was noted by Ghosh and Mandal (2008) and Belichovska et al. (2017).

The ash content of rabbit meat is similar or higher than that of other livestock (Williams, 2007).Ash mean value content (%) of rabbit meat in the present work showed no significant ($P>0.05$) variation between fore (1.21) and hind (1.17) quarters despite slightly higher for fore quarters. Parallel mean values were recorded by FAO (1997), Kowalska et al. (2011), Nistor et al. (2013), Dalle Zotte (2014), Mattioli et al. (2017) and Pavelkova et al. (2017), while higher values by Dalle Zotte et al. (2014) and Belichovska et al. (2017),and lower values by Elamin et al. (2011) for hind leg rabbit meat. Mean ash values of 1.17 and 1.39 were registered by Polak et al. (2006) and Attia et al. (2015) for fresh rabbit meat, but values of 2.03, 1, 1.25 and 1.35 by Omojola and Adesehinwa (2006), Simonova et al. (2010), Peiretti and Meineri (2011) and Dalle Zotte et al. (2014), for *Longissimus* muscles of rabbit, respectively. Frunza et al. (2014) found mean ash values of 1.01-1.21 for males and females Belgian Giant rabbits, Ghosh and Mandal (2008) values of 1.08 and 0.93 for males and females Soviet Chinchilla and Grey Giant rabbits, Haque et al. (2016) of 1.15 and 1.18 for *Longissimus dorsi* muscle of New Zealand White and Soviet Chinchilla rabbits,and Metzger et al. (2011) of 1.25 and 1.16 for *Longissimus dorsi* and hind leg meat of Pannon White rabbits of different ages and weights, respectively. El-Medany and El-Reffaei (2015) recorded mean value of 1.35 for lean rabbit meat, and Mattioli et al. (2017) of 1.35 for loin meat of New Zealand White rabbits. FAO (1997), Ghosh and Mandal (2008), Metzger et al. (2011), Peiretti and Meineri (2011), Belichovska et al. (2017) and Mattioli et al. (2017) declared that age, breed, sex, diet or carcass portion show no significant effect on ash content of rabbit meat. However, Polak et al (2006) noted variations with the sex in SIKA rabbits, and Haque et al. (2016) found significant increase with the age in Soviet Chinchilla rabbits.

Glycogen content (%) of mammalian meat is in the range of 0.5-1.3 with an average of 0.8% (FAO, 1992). Lower result was obtained in the current study with no difference between mean values of fore and hind quarters (0.33% each). Rabbit meat is characterized by its lower energetic value compared with red meats (Dalle Zotte, 2004). Gross energy content of 120 Kcal/100g was reported by FAO (1992) for rabbit meat. The current obtained result is lower, it declared that energy content (Kcal/100g) of fore (112.42) quarter's rabbit meat is significantly ($P<0.05$) higher than that of hind (99.67) quarters (due to its higher fat content). Higher mean values of 899 and 658 (Kj/100g) were obtained by Dalle Zotte (2014) for fore and hind legs rabbit meat, respectively. In the same line, higher values of 494.79 Kj were recorded by Belichovska et al. (2017) and of 461.89 Kj by Pavelkova et al (2017) for fresh hind legs rabbit meat. Simonova et al. (2010) obtained a mean value of 415.11Kj for *Longissimus dorsi* muscle, and Mertin et al. (2012) of 468.01 Kj for muscle *Longissimus thoracis et lumborum*. Belichovska et al. (2017) recorded no significant effect of genotype on energy content of rabbit meat. Energy value of rabbit meat mainly related to its protein content rather than its fat content (low fat content), while that related to carbohydrates is negligible. Protein related energy is significantly ($P<0.05$) higher in case of hind quarter's rabbit meat, while fat related one is significantly ($P<0.05$) higher in fore quarter's meat (Table 1).

Lipid oxidation is a major non-microbial factor responsible for the quality deterioration of muscle foods leading to its discoloration and the development of off-odours and off-flavours Thiobarbituric acid-reactive substances are aldehydic secondary oxidation products of lipids, show correlation between its level and the flesh quality (Monahan, 2000). As cleared in Table 2, the TBA content mean value (mg malonaldehyde/kg flesh) of fresh rabbit meat was significantly ($P<0.05$) higher in fore (0.3) quarters than in hind quarters (0.19), which may be due to the higher fat content of the fore quarters meat. Dalle Zotte et al. (2014) and Mattioli et al. (2017) recorded higher mean values of 0.65 and 0.38 for fresh hind legs rabbit meat. Swami et al. (2014) estimated TBA mean value 0f 0.18 for rabbit meat, while El-Medany and El-Reffaei (2015) estimated a value of 0.75. Mattioli et al. (2017) detected a value of 0.26 for loin meat of New Zealand White rabbits, Dal Bosco et al. (2014) of 0.15 for *Longissimus dorsi* muscle and Dalle Zotte et al. (2014) of 0.43 for muscle *Longissimus thoracis et lumborum* of rabbirs. Kowalska (2015) registered mean values of 0.3 and 0.72 for Logissimus dorsi muscle of rabbit stored frozen at -20°C up to 14 and 90 days, respectively.

Meat from domestic livestock is a major source of saturated fatty acids and cholesterol in the human diet and its consumption could be related to cardiovascular diseases, hypertension, obesity and diabetes (Valsta et al., 2005).Rabbit meat is a lean meat with highly unsaturated lipids and low cholesterol content(Hernández and Gondret, 2006).

Cholesterol content mean value (mg/100g) of rabbit meat in this work was numerically, but insignificantly ($P>0.05$) higher in fore (59.13) than in hind (54.13) quarters rabbit meat. The same trend was noted for HDL (mg/100g), LDL (mg/100g), and LDL percentages; however triglycerides content (mg/100g) was significantly higher in meat of hind quarters (25.90) than in that of fore quarters (19.04). Tumova and Hrstka (2013) and Dalle Zotte et al. (2014) found higher cholesterol content of 65.3 and 92.2, whileNistor et al. (2013) nearly similar value of 56.4for hind legs rabbitmeat. Combes (2004) found cholesterol amount of 59 in rabbit meat, and Polak et al. (2006) of 67.6. Dalle Zotte et al. (2014) registered a mean value of 51.5 for muscle *Longissimus thoracis et lumborum* of rabbits. Fairly high values of total cholesterol were reported by Li et al. (2012), Attia et al. (2015) and El-Medany and El-Reffaei (2015) of123, 200.8 and 86 in rabbit blood serum. Moreover, Li et al. (2012) and El-Medany and El-Reffaei (2015) detected a fairly highHDL, LDL, and Triglycerides values in rabbit blood serum. Polak et al (2006) noted variation of cholesterol content of rabbit meat with the sex in SIKA rabbit, being higher in females.

Microbiological Quality

The safety of meat has been at the forefront of societal concerns in recent years. Numerous pathogens such as *Salmonella* and *E. coli* have recently contaminated the meat chains (Sofos, 2008). Safety and shelf life of meat is limited by microbial growth, where a high initial contamination of meat reduces product shelf life. The slaughtering process may cause extensive contamination of muscle tissue with a vast range of micro-organisms. Some of these micro-organisms come from the animal intestinal tract and others from the environment in contact with the animals before or during slaughter (Rodríguez-Calleja et al., 2004)

High total aerobes count can be used as indicator of bad hygiene during slaughtering and processing, being affect quality and safety of meat. As shown in tables 3 and 4, the mean values of total aerobes in fore and hind quarters from rabbit carcasses were $2.7 \pm 0.82 x10^6$ and $4.2 \pm 1.57 x10^6$ cfu/ml, respectively, with no significant difference (P>0.05). Nearly similar results were recorded by Rodriguez-Calleja et al. (2004) who detected that the mean aerobic mesophilic count of prepacked hind legs from supermarket was 5.87±1.03 log cfu/g, and in the prepacked whole carcasses from supermarket was 6.60±1.18 log cfu/g, while in carcasses from abattoirs, the mean aerobic mesophilic count ranged between 4.01-4.96 log cfu/g. Likewise, Cwikova and Pytel (2017) noticed that the total aerobes count in rabbit meat from butcher shops was 5.34 log cfu/g. Comin et al. (2008) evaluated the microbial quality of rabbit meat from 4 abattoirs, 433 carcasses, and 239 sectioned and jointed meats, and found that most carcasses had total aerobes count lower than 10^5 cfu/g, Similarly, Nakyinsige et al. (2014) found that the mean initial total bacterial count in meat samples from Halal slaughtered rabbit was less than 10^5 cfu/g. Swami et al. (2015) discovered that the mean value for standard plate count agar of fresh rabbit meat samples was ranged from 4.52 to 4.69 log cfu/g. Lower results noticed by Kone et al. (2016) who found that the mean total aerobic mesophilic count was 2.15± 0.63 log cfu/g in thighs of rabbit carcasses, and Isabel Berruga et al. (2005) who reported initial total viable count at 2.6 log cfu/cm^2.

Presence of Enterobacteriaceae indicates inadequate hygiene and presence of pathogenic microorganisms. In this study, the mean values of Enterobacteriaceae counts were recorded at $3.56 \pm 2.10 x10^5$and $9.53 \pm 4.97 x10^5$ cfu/ml in fore and hind quarters, respectively, withno significant difference (P>0.05) between them (Table 3). Lower results were recorded by Badr (2004) who detected Enterobacteriaceae count at 4.79 log cfu/g, and Rodriguez-Calleja et al. (2004) who discovered Enterobacteriaceae count ranged from 0.49 to 4.00 log cfu/g. Also, Cwikova and Pytel (2017) found that the mean value of Enterobacteriaceae count was 2.91 log cfu/g,Comin et al. (2008) who showed that the mean Enterobacteriaceae count was lower than 10^3 cfu/g in the examined rabbit meat samples, and Isabel Berruga et al. (2005) who demonstrated that the average Enterobacteriaceae count was 2.00log cfu/g.

The occurrence of *E. coli* in meat indicates fecal contamination and existence of other fecal pathogens. *E. coli* wasn't detected in the examined fore quarters, and found in only one hind quarter sample at $5x10^2$ cfu/ml (Tables 3 and 4).Swami et al. (2015) reported *E. coli* count that was ranged from 2.10 to 2.18 log cfu/g. Also, Nakyinsige et al (2014) showed mean initial *E. coli* count that was less than10^3cfu/g. Simonova et al. (2009) recorded *E. coli* mean count of 1.13±0.25to 2.32±0.46 log cfu/g for flesh of Hy-Plus rabbits breed slaughtered at varying periods of breeding. Rodriguez-Calleja et al (2004) and Comin et al. (2008) found lower *E. coli* counts.

As shown in table 3, mean values of *Staphylococcus* aureus count in the positive samples were $3.63 \pm 2.48\ x10^5$and $1.59 \pm 1.53\ x10^5$ cfu/ml in fore and hind quarters, respectively, with no significant difference in between. Lower results reported by Badr (2004) who detected counts at 3.98 log cfu/g, Rodriguez-Calleja et al. (2006) presented counts at 1.37±0.79 log cfu/g, in 52.9% of the examined samples, and Simonova et al. (2012) found *Staph aureus* count at 1.75 log cfu/g (ranged from 1.15 ±0.15 to 3.11 ± 0.00 log cfu/g). Simonova et al. (2009) recorded *Staph aureus* count in the range of 1.3–3.11log cfu/g for flesh of Hy-Plus rabbits breed slaughtered at varying periods of breeding. The presence of *Staph aureus* in meat is resulted from poor hygiene of handlers and utensils and it can produce heat stable enterotoxins without manifesting any change in sensory characteristics of meat that create food poisoning and gastroenteritis to consumers

Mean values of mold in fore and hind quarters were $1.29 \pm 1.25\ x10^5$ and $1.25 \pm 0.84\ x10^5$ cfu/ml, while those of yeast count were $3.2 \pm 0.98\ x10^6$and $4.6 \pm 1.95\ x10^6$ cfu/ml, respectively (Table 3). There was no significant difference (P>0.05) between the mean values of mold or yeast counts of fore and hind quarters. Lower results were reported by Cwikova and Pytel (2017) who found yeast and mold count at 2.97log cfu/g in rabbit meat from butcher shops. In the same line, Pereira and

Malfeito-Ferreira (2015) recorded yeasts and moulds at 3.92 log cfu/g, Chabela et al. (1999) estimated yeast and mold count at 3.76 log cfu/g, and Rodriguez-Calleja et al. (2004) found yeast ranged from 2.43 ±0.72 log cfu/g in abattoir to 5.45 ±1.00 log cfu/g in supermarkets rabbit samples. *Salmonella* species were detected at an incidence of 23.3%(7/30)and 20%(6/30) in fore and hind quarters, respectively (Table 5).Favorable incidence was estimated by Comin et al. (2008) who isolated *Salmonella* spp. from rabbit carcasses and rabbit meat samples in a range from 0.5 to 11.9% in the examined slaughterhouse samples. They attributed the pollution with *Salmonella* to cross contamination that resulted from slaughtering of other poultry carcasses. In contrary, Swami et al. (2015) couldn't isolate *Salmonella* from any of the examined fresh rabbit meat samples. Also, Rodríguez-Calleja et al. (2006) couldn't detect *Salmonella* in any of the examined hind leg or packaged rabbit samples.

CONCLUSION

In summary the results of the current work declared that fresh meat of rabbits in Assiut city, Egypt is of high protein, low fat, and low total and LDL cholesterol contents, besides it is of low caloric value. It showed low count and incidence of pathogenic bacteria of public health (*E. coli* and Salmonella). However, there were high counts of the total aerobes, Enterobacteriaceae, *Staph.aureus*, and yeast and mold indicating poor hygienic condition of slaughtering and dressing.
Meat of hind quarters seems leaner than that of fore quarters, being significantly higher in protein; significantly lower in fat and caloric value. Also, it is lower in cholesterol content despite insignificant.

From these current results it could be concluded that, from nutritional point of view, fresh rabbit meat is healthier over other meats and can be strongly recommended for consumption as functional food (high in protein and low in fat). Hind quarter rabbit meat recommended superior to that of fore quarters from the nutritional and public health points of views (higher in protein, lower in fat, Chol, LDL%, TBA, and as well in incidence of salmonellae).

REFERENCES:

AOAC (2012): Official Methods of Analysis of AOAC International. 19th Ed., Latimer G. W. (edit). Gaithersburg, Md Publisher.

Attia, Y. A.; Hamed, R. S.; Abd El-Hamid, A. E.; Al-Harthi, M. A.; Shahba, H. A. and Bovera, F. (2015): Performance, blood profile, carcass and meat traits and tissue morphology in growing rabbits fed mannan oligosaccharides and zinc-bacitracin continuously or intermittently. Ani Sci Papers and Rep., 33 (1,): 85-101.

Avila, A. R. A.; Marques, S. C.; Piccolli, R. H. and Schwan, R. F. (2013): Sensitivity to organic acids in vitro and in situ of *Salmonella* spp. and *Escherichia Coli* isolated from fresh pork sausages. J. Food Quality, 36: 155–163.

Badr, H. M. (2004): Use of irradiation to control food borne pathogens and extend the refrigerated market life of rabbit meat. Meat Sci., 67: 541-548.

Belichovska, D.; Belichovska, K.; Pejkovski, Z. and Uzunoska, Z. (2017): Effect of genotype on physico-chemical characteristics of rabbit meat. Meat Tech., 58 (1): 10–15.

Berruga, I. M.; Vergara, H. and Linares, B. M. (2005): Control of microbial growth and rancidity in rabbit carcasses by modified atmosphere packaging. J. Sci Food Agricul., 85: 1987–1991.

Bianchi, M.; Petracci, M. and Cavani, C. (2006): Effects of dietary inclusion of dehydrated lucerne and whole linseed on rabbit meat quality. World Rabbit Sci., 14: 247 – 258.

Bligh, E. G. and Dyer, W. J. (1959): A rapid method for total lipid extraction and purification. Can J Biochem Physiol, 37: 911-917.

Bora, A. (1995): Effect of dietary fiber levels on weight gain, feed conversion efficiency and blood biochemical profiles in rabbits. Ph.D. Thesis Assam Agric. Univ., Khanapara, Guwahati, pp. 781-022.

Buege, J. A. and Aust, S. D. (1978): Microsomal lipid peroxidation. Meth Enzy, 52: 302-310.

Chabela, M. L. P.; Serrano, G. M. R.; Calderon, P. L. and Guerrero, I. (1999): Microbial spoilage of meats offered for retail sale in Mexico City. Meat Sci., 51(4): 279-282.

Combes, S. (2004): Valeur nutritionnelle de la viande de lapin. Prod Anim., 17: 373–383.

Comin, D.;Mioni, R.;Gallocchio, L.;Bordin, P. andManiero, C. (2008):Microbiological qualityandsafetyofrabbit meatinVeneto region – Italy. 9th world *rabbit* congress – june 10-13–. Verona – Italy.

Cwikova, O. and Pytel, R. (2017): Evaluation of rabbit meat microbiota from the viewpoint of marketing method. Potravinarstvo Slovak J. Food Sci, 11 (1): 391-397.

Dal Bosco,A.; Gerencsér, Zs.; Szendrő, Zs.; . Mugnai,C.; Cullere,M.; Kovàcs,M.; Ruggeri,S.; Mattioli,S.; Castellini, C. and Dalle Zotte, A. (2014): Effect of dietary supplementation of Spirulina (*Arthrospira platensis*) and Thyme (*Thymus vulgaris*) on rabbit meat appearance, oxidative stability and fatty acid profile during retail display. Meat Sci., 96: 114–119.

Dalle Zotte, A. (2000): Main factors influencing the rabbit carcass and meat quality. In: Proceedings of the 7th World Rabbit Congress (Valencia, Spain), pp. 1–32.

Dalle Zotte, A. (2002): Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. Livestock Prod Sci, 75: 11-32.

Dalle Zotte, A. (2004): Dietary advantages: Rabbit must tame consumers. Viandes et Produits Carnés, 23: 161–167.

Dalle Zotte, A. (2014): Rabbit farming for meat purposes. Animal Frontiers, 4 (4):62-67.

Dalle Zotte, A.; Cullere, M.; Sartori; A.; Szendrő, Zs.; Kovàcs, M.; Giaccone, V. and Dal Bosco, A. (2014): Dietary Spirulina (*Arthrospira platensis*) and Thyme (*Thymus vulgaris*) supplementation to growing rabbits: Effects on raw and cooked meat quality, nutrient true retention and oxidative stability.Meat Sci., 98(2): 94-103.

Elamin,K. M.; Yousif, I. A. and Hassan, H. E. (2011): Carcass and meat biochemical traits of local Sudanese rabbits.Res. Opin. Anim. Vet. Sci., 1 (11): 739-742.

El-Medany, Sh. A. and El-Reffaei, W. H. M. (2015): Evaluation canola meal on Growing rabbits; nutritionally and on their nutritional meat quality. J. Food Nut Res, 3 (4): 220-234.

FAO (1992): Meat and Meat Products in Human Nutrition in Developing Countries.Bender A. (edit).Food and Nutrition Paper 53, Food and Agriculture Organization of the United Nations, Rome (Italy).

FAO (1997): The Rabbit - Husbandry, Health and Production. Lebas, F. Coudert, P. de Rochambeau H. and. Thébault R.G. (edits).FAO Animal Production and Health Series No. 21 (new revised version), Food and Agriculture Organization of the United Nations, Rome (Italy).

FAOSTAT (2012): The Statistics Division of the FAO. http://faostat.fao.org/.

Frunza, Gabriela, T.; Lazar, Roxana and Biosteanu, P. C. (2014): Research regarding nutritional quality of rabbit meat (Belgian giant breed). University of Agriculture Science and Veterinary Medicine Iasi, Scientific Papers – Animal Science Series, 62: 45-48.

Ghosh, N. and Mandal, L. (2008): Carcass and meat quality traits of rabbits (*Oryctolagus cuniculus*) under warm-humid condition of West Bengal, India. Livestock Res Rural Develop. Available on http://www.Irrd.org/Irrd20/9/ghos20146.html

Haque, A.; Rahman, M. and Bora, J. (2016): effect of breed, weaning age and feeding regime on chemical composition of rabbit meat. Int J Vet Sci Animal Husbandry, 1 (1): 12-13.

Hermida, M.; Gonzalez, M.; Miranda, M. and Rodríguez-Otero, J. L. (2006): Mineral analysis in rabbit meat from Galicia (NW Spain). Meat Sci, 73: 635–639.

Hernández, P. (2007): Carne de conejo, ideal para dietas bajas en ácido úrico. Revista científica de nutrición.Nº 8 Septiembre. Boletín de cunicultura, 154: 33-36.

Hernandez, P. (2008): Enhancement of nutritional quality and safety in rabbit meat. In: Proceedings of the 9th World Rabbit Congress - june 10-13, Verona – Italy.

Hernández, P. and Gondret, F. (2006): Rabbit meat quality. In: Maertens, L., Coudert, P. (edits.), Recent Advances in Rabbit Sciences, pp. 269–290, ILVO, Merelbeke, Belgium.

Hernández, P.; Cesari, V. and Pla, M. (2007): Effect of the dietary fat on fatty acid composition and oxidative stability of rabbit meat. In: Proceedings of the 53rd International Congress of Meat Science and Technology (August 2007, Beijing, China), pp. 367–370.

Jurgens, M. H. and Bregendahl, K. (2007): Animal Feeding and Nutrition. 10th Ed Kendall/Hunt Publishing Company, Iowa, USA.

Kone,, A. P.; Cinq-Mars, D.; Desjardins, Y.; Guay,, F.; Gosselin, A. and Saucier L. (2016): Effects of plant extracts and essential oils as feed supplements on quality and microbial traits of rabbit meat. World Rabbit Sci., 24: 107-119.

Kowalska, D. (2015): Physicochemical properties of meat from rabbits fed rapeseed-oil-enriched diets with different vitamin E levels depending on the packaging and storage method. Scientific Ann Polish Soci Animal Prod., 11 (1): 61-73.

Kowalska, D.; Gugołek, A. and Bielański, P. (2011): Effect of stress on rabbit meat quality.Ann. Anim. Sci., 11(3): 465–475.

Li, R. G.; Wang, X. P.; Wang, C. Y.; Ma, M. W. and Li, F. C. (2012): Growth performance, meat quality and fatty acid metabolism response of growing meat rabbits to dietary linoleic acid. Asian-Aust. J. Anim. Sci.,25 (8): 1169 – 1177.

Maikanov, B.; Auteleyeva, Laura, T. and Polatbekovna, S. (2017): Nutritional value of rabbit meat after contamination with 1,1-dimethylhydrazine. Inter J. Nutr. Food Eng., 11 (7): 580-583.

Marounek, M.; Skrivanova, V.; Dokoupilova, A.; Czauderna,M. and Berladyn, A. (2007): Meat quality and tissue fatty acid profiles in rabbits fed diets supplemented with conjugated linoleic acid.Veterinarni Medicina, 52 (12): 552–561.

Mattioli, S.; Cardinali, R.; Balzano, M.; Pacetti, D.; Castellini, C.; Dal Bosco, A.and Frega, N. G. (2017): Influence of dietary supplementation with prebiotic, oregano extract, and vitamin E on fatty acid profile and oxidative status of rabbit meat .J. Food Quality,5:9-17.

Merrill, A. L. and Watt, B. K. (1973): Energy Value of Foods: Basis and Derivation. Agriculture Handbook No. 74, ARS United States Department of Agriculture, Washington DC.

Mertin, D.; Slamečka, J.; Ondruška, Ľ.; Zaujec, K.; Jurčík, R. and Gašparík, J. (2012): Comparison of meat quality between European brown hare and domestic rabbit. Slovak J. Anim. Sci., 45 (3): 89-95.

Metzger, S.; Odermatt, M.; Szabo, A.; Radnai, I.; Biro-Nemeth, E.; Nagy, I.and Szendro, Z. (2011): Effect of age and body weight on carcass traits and meat composition of rabbits.Arch Tierz, 54 (4): 406-418.

Monahan F. (2000): Oxidation of lipids in muscle foods: Fundamental and applied concerns. In: Decker E., Faustman F., López-Bote C. (edits). Antioxidants in Muscle Foods. Wiley and Sons, Inc. Publication, New York, USA, 3-23.

Naeemi, E. D.; Ahmad,N.; Al-Sharrah, T. K. and Behbahani, M. (1995): Rapid and simple method for determination of cholesterol in processed food. J. AOAC Intl., 78:1522-1525.

Nakyinsige, K.; Fatimah, A. B.; Aghwan, Z. A.; Zulkifli, I.; Goh, Y. M. and Sazili, A. Q. (2014): Bleeding efficiency and meat oxidative stability and microbiological quality of New Zealand White rabbits subjected to halal slaughter without stunning and gas stun-killing. Asian Australas J. Animal Sci., 27(3): 406-413.

Nistor, E.; Bampidis, V. A.; Păcală, N.; Pentea, M.; Tozer, J. and Prundeanu, H. (2013): Nutrient content of rabbit meat as compared to chicken, beef and pork meat.J Anim Prod Adv.,3(4): 172-176.

Nistor, E.; Bampidis, V.; Pacala, N.; Pentea, M.; Tozer, J. and Prundeanu, H. (2013): Nutrient content of rabbit meat as compared to chicken, beef and pork meat. J Animal Pod Adv., 3 (4): 172-176.

Omojola, A.B. and Adesehinwa, A.O.K. (2006): Meat characteristics of scalded, singed and conventionally dressed rabbit carcasses. World J. Zool., 1 (1): 24-29.

Pasin, G.; Smith, G.M. and O'Mahony, M. (1998): Rapid determination of total cholesterol in egg yolk using commercial diagnostic cholesterol reagent. Food Chem., 61: 255-259.

Pavelková, A.; Tkáčová, J.; Červienková, K. and Bučko, O. (2017): The rabbit meat quality after different feeding.Potravinarstvo Slovak J. Food Sci.,11 (1): 634-640.

Peirettia, P. G. and Meineri, G. (2011): Effects of diets with increasing levels of *Spirulina platensis*on the carcass characteristics, meat quality and fatty acid composition of growing rabbits, Livestock Sci., 140 (1–3): 218–224.

Pereira, M. and Malfeito-Ferreira, M. (2015): A simple method to evaluate the shelf life of refrigerated rabbit meat. Food Control, 49: 70-74**.**

Pla, M.; Pascual, M. and Ariño, B. (2004): Protein, fat and moisture content of retail cuts of rabbit meat evaluated with the NIRS methodology. World Rabbit Sci, 12: 149–158.

Polak, T.; Ga{perlin, L.; Rajar, A. and Zlender, B. (2006): Influence of genotype lines, age at slaughter and sexes on the composition of rabbit meat. Food Technol. Biotechnol., 44 (1): 65–73.

Rodriguez-Calleja, J. M.; Santos, J. A.; Otero, A. S. and García-Lopez, M. L. (2004): Microbiological Quality of Rabbit Meat. J. Food Prot., 67(5):966-971.

Rodríguez-Calleja, J. M.; García-Lo´ Pez I.; García-Lo´ P, M-L.; Santos,J.´ S. A. and Otero,A.S. (2006): Rabbit meat as a source of bacterial food borne pathogens .J. Food Prot., 69(5):1106–1112.

Simonova, M. P.; Chrastinova,Ľ.; Mojto, J.; Laukova, A.; Szaboova, R. and Rafay, J. (2010): Quality of rabbit meat and phyto-additives. Czech J. Food Sci., 28: 161–167.

Simonova, M. P.; Laukova, A.; Chrastinova, Ľ.; Szaboova, R.;Mojto, J.; Strompfová1, V. and Rafay, J. (2009): Quality of rabbit meat after application of bacteriocinogenic and probiotic strain *Enterococcus faecium* CCM 4231 in rabbits. Inter J. of Probiotics and Prebiotics, 4 (1): 1-6.

Simonova, M. P.; Laukova, A.; Chrastinova, Ľ.; Szab◌́ova, R. and Strompfova, V. (2012): Microbial status and quality of rabbit meat after rabbits feed supplementation with phyto-additives. Potravinarstvo, 6 (4):41-44.

Sofos, J. N. (2008): Challenges to meat safety in the 21st century. Meat Sci., (78): 3-13.

Spectrum Diagnostics: www.spectrum-diagnostics.com.

SPSS (2001): Statistical Software Package for the Social Sciences, Version 13 for Windows. Inc., Chicago, IL.

Swami, J. N.; Raut, S. S. and Rindhe, S. N. (2015): Effect of freeze-thaw cycle on quality of rabbit meat. Haryana Veterinarian, 54 (2): 160-163.

Swami, J. N.; Rindhe, S. N.; Shashikumar, M.; Raut, S. S. and Dange, Anil (2014): Physico-chemical and microbial profile of fresh rabbit meat. J. Meat Sci., 10 (1): 1-4.

Thomas, A.; Lallo, C.H.O. and Badrie, N. (2006): Microbiological evaluation of broiler carcasses, washand rinse water from pluck shops (cottage poultry processors) in the county Nariva/Mayaro, Trinidad, Trinidad and Tobago, West Indies. Tropicultura, 24(3): 135-142.

Tůmová, Eva and Hrstka, Z. (2013): A comparison of the quality of nutria meat and rabbit meat, Maso Inter J. Food Sci Tech., 2:139-144.

Valsta L. M.; Tapanainen, H. and Männistö S. (2005): Meat fats in nutrition. Meat Sci., 70: 525-530.

Williams, P. G. (2007): Nutritional composition of red meat. Nutr Diet, 64 (Suppl. 4): S113–S119.