UBIQUINONE Q10 AND PROTEIN CONTENTS IN RABBIT MEAT IN RELATION TO PRIMAL CUT AND REARING SYSTEM

KRZYSZTOF SZKUCIK, RENATA PYZ-ŁUKASIK, MARTA WÓJCIK, AND MICHAŁ GONDEK

Department of Food Hygiene of Animal Origin,
1Department of Preclinical Veterinary Sciences, Faculty of Veterinary Medicine,
University of Life Sciences in Lublin, 20-033 Lublin, Poland
krzysztof.szkucik@up.lublin.pl

Received: December 18, 2012 Accepted: February 15, 2013

Abstract

The research material included 96 slaughter rabbit carcasses. Half of them came from the animals managed in small-scale backyard farming units where animals were fed a natural ingredient diet, while the other half was from rabbits kept under commercial production conditions and fed commercial rabbit pellets. The thigh and saddle muscle samples were collected from each carcass to establish a content of ubiquinone (CoQ10) and crude protein along with its collagen level. Determination of tissue coenzyme Q10 (UQ10) was carried out by high-performance liquid chromatography with some modification. Crude protein concentration was estimated using Kjeldahl procedure, while total collagen content by the method of Stegemann modified by Hurych-Chvapil, using hydrolysis according to Möhler and Volley. Ubiquinone level in slaughter rabbit tissue ranged between 76 and 127 μg/g tissue. The studies indicated that rabbit rearing system and muscle type are determinants of CoQ10 content. Meat of rabbits managed under the traditional backyard farming system exhibited higher CoQ10 concentration as compared to that determined in rabbits from the commercial rabbitry. Additionally, the CoQ10 level in the saddle was significantly higher than that in the thigh muscles, and the relationships was noted in both types of rabbit production systems. When the CoQ10 content was expressed per gram of fibrillar protein, there were not significant differences between saddle and thigh muscles. The correlation coefficient between ubiquinone and fibrillar protein averaged to 0.94. The studies also demonstrated a higher protein level in the saddle than in thigh muscles. However, no differences in protein concentration were reported in respect to the rabbit farming system. The protein composition in the saddle muscles, irrespective of a rabbit production system, revealed significantly lower collagen content compared to the proteins in thigh muscles. The obtained results and data from literature provide evidence that rabbit meat, especially from the traditional (organic) management system, is one of the best sources of animal protein and ubiquinone Q10.

Key words: rabbit meat, saddle, thigh, ubiquinone, protein, rearing system.

Ubiquinone (CoQ10) is a compound comprising a quinone ring linked to the isoprenoid side-chain made up of 10 isoprene units. The number of isoprene repeats in the tail is given as a subscript in the coenzyme name abbreviation – Q10 (4). The CoQ10 plays an essential role in human organism as it contributes to ATP synthesis, promotes thermogenic activity, stabilises cell membranes, prevents endothelial dysfunction, and serves as a potent antioxidant (1, 2, 5).

The tissue CoQ10 comes from endogenous synthesis. It derives from dietary sources, or is available as nutritional supplement (8). Under physiological conditions, ubiquinone is produced in sufficient amounts to promote optimal cell function in the human body. The need for CoQ10 is correlated with the body energy requirements. Its distribution in various organs is different but the highest ubiquinone levels in human body are reported in the most metabolically active organs, including heart, liver, and kidneys. Consequently, its concentration in the aforementioned organs ranges from 110.60 μg/g (heart), 70 μg/g (kidneys) to 60 μg/g (liver), while a markedly lower level is found in the lungs (8 μg/g) (5, 21). The total amount of CoQ10 in human body is 1.0 up to 1.5 g and it is most concentrated in muscle cells (21). Ubiquinone bioavailability from foods is estimated to be around 10% (21). Thermal processing of food items was shown to affect this coenzyme content, and particularly, significant differences were noted in its level in raw and cooked beef (15). The CoQ10 content in processed foods was lower by 15%-30% as compared to raw products (8). Ubiquinone oral bioavailability in nutritional supplements is very low due to its high molecular weight and poor water solubility (5, 27).

Plasma CoQ10 levels are found to decrease in patients with various medical conditions, even by 40%, as an adverse effect of interaction with medications (5). In these cases, the therapeutic procedure involves
coenzyme supplementation in the form of pharmaceutical preparations or a CoQ10-rich diet. The coenzyme is naturally present in most foods but in different amounts. As for muscle tissue, its concentration depends on a slaughter animal species (6, 10), primal cut (6), gender (17), muscle kind (14, 16, 18), and oscillates from 13.8 up to 45 µg/g in fish, 0.10-130 µg/g in shellfish/molluscs, 0.08 - 7.47 µg/g in vegetables, and finally, 0.51-9.48 µg/g in fruits (6, 9).

Rabbit meat is recognised a good source of easily available, high quality, and biologically useful protein (22, 24) but there is no information on the content of CoQ10 in rabbit tissues. The author’s research on rabbit meat quality has been focused on the presence of CoQ10 in the muscle tissue. Hence, the aim of the study was to determine the ubiquinone Q10 level and protein content in rabbit muscle tissue with regard to primal cut and rearing system.

**Material and Methods**

The research material comprised 96 carcasses of slaughter rabbits, 4.5–5.0 kg live body weight, classified into the 1st quality class according to the Polish Norms (12). The rabbits were allocated into two equal groups. The first group included the crossbreds from the small-scale (backyard) farming units and managed under natural feeding system, while the rabbits from the second group came from the commercial rabbit farm and fed commercial pelleted diets. In each of the examined groups, half of the samples were taken from males and half from females. Immediately after slaughter in the slaughterhouse approved for meat export, the rabbit carcasses were chilled to 4°C. After 24 h, the muscle samples from two different primal cuts were collected for examination, *i.e.* from the saddle and thigh, which are considered the most valuable primal cuts of a rabbit carcass. The content of ubiquinone Q10 (UQ10) and crude protein, as well as a collagen level in this protein, as a basic connective tissue protein, were determined in the muscles.

Determination of tissue UQ10 was carried out by high-performance liquid chromatography method (HPLC) with some modification (20, 28). Approximately 500 mg of freeze-clamped tissue was accurately weighed in the frozen state and homogenised with 2 ml of saline. Then, 3 ml of ethanol was added to remove protein by partition and denature enzymes. Finally, 100 µl of internal standard (10 µg/mL Q8) was added to each analysed sample. In order to ensure maximal extraction of ubiquinone, the extraction with dichloromethane was performed twice and the organic phase was evaporated to dryness under the nitrogen stream. The residue was dissolved in 100 µl of ethanol and injected to the column (RP C18, 250 x 4 mm, 5 µm, LiChrospher 100, Merck, Germany). The mobile phase ethanol: methanol (60:40 v/v) was pumped at a 1 mL/min flow rate. Ubiquinone was detected at 275 nm and computed using the Beckham HPLC Gold system. The tissue concentration of UQ10 was calculated according to the following formula: 

\[
\text{C}_{\text{p}} = \frac{\text{C}_s}{A_s} \times A_p,
\]

where 

- \(\text{C}_p\) - sample concentration of UQ10;
- \(\text{C}_s\) - standard concentration;
- \(A_s\) – standard peak area;\(A_p\) – sample of UQ10 peak area.

Crude protein concentration was measured using Kjeldahl method according to the Polish Norms (11) and subsequently, the nitrogen-to-protein conversion multiplier of 6.25 was applied. Total collagen content was assessed by the method of Stegemann modified by Hurycz-Chvapil, which is based on quantitative evaluation of hydroxyproline, using hydrolysis according to Möhler and Volley (26). The amount of collagen was obtained by multiplying the hydroxyproline content x 7.25. The total collagen content was expressed in percentages in relation to the crude protein.

The obtained results were analysed statistically calculating the mean value and standard deviation (±SD). Significance of differences between the means was determined using the t-Tukey test. Additionally, the correlation coefficient between ubiquinone and total protein content and between ubiquinone and fibrillar protein in saddle and thigh was calculated. Differences were considered as significant at P≤0.01 or P≤0.001.

**Results**

Protein and ubiquinone contents in rabbit muscles are summarised in Table 1. The examinations did not show a significant influence of the sex on the level of proteins and CoQ10, therefore results were presented altogether for females and males.

Determination of the crude protein level has displayed its higher concentration in the saddle than in thigh muscles. However, no difference was noticed in protein content with regard to the animal rearing system. Protein in rabbit saddle muscles obtained from both, traditionally farm-raised rabbits and those from commercial-scale production system, was characterised by a significantly lower collagen content as compared to the protein composition in thigh muscles.

The study revealed that the ubiquinone homologues (Q9 and Q10) occur in animal and human muscles, yet only coenzyme Q10 is clearly observed in rabbits.

The domination of this form of ubiquinone was found in the muscle tissue obtained from rabbits fed natural, as well as from those fed a commercial feed (Fig. 1). Ubiquinone concentration in slaughter rabbit muscle tissue ranged from 79 up to 127 µg/g of tissue.

The conducted studies indicated that the animal farming system and muscle type are determinants of CoQ10 content. Meat of rabbits from the traditional backyard raising system exhibited higher ubiquinone concentration as compared to that of commercial production origin. Similarly, the ubiquinone level in the rabbit saddle was significantly higher in comparison to thigh muscles and these relationships were noted in both management methods. Analysing CoQ10 content converted into 1 gram of fibrillar protein, no differences in its level were noted between the saddle and thigh muscles.
Table 1
Protein and ubiquinone levels in rabbit muscles (mean ± SD)

<table>
<thead>
<tr>
<th>Type of rabbit rearing (feeding principles) system</th>
<th>Conventional (natural diet)</th>
<th>Farm (commercial feed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>saddle</td>
<td>thigh</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>23.97a ± 0.79</td>
<td>22.54b ± 0.81</td>
</tr>
<tr>
<td>Collagen in protein (%)</td>
<td>1.59a ± 0.22</td>
<td>3.93 b ± 0.78</td>
</tr>
<tr>
<td>Q10 in tissue (μg/g)</td>
<td>127.18a ± 6.24</td>
<td>110.91b ± 5.72</td>
</tr>
<tr>
<td>Q10 per gram of crude protein (μg/g)</td>
<td>530.6 aA ± 43.76</td>
<td>492.1 aB ± 51.27</td>
</tr>
<tr>
<td>Q10 per gram of fibrillar protein (μg/g)</td>
<td>539.13 aA ± 31.52</td>
<td>512.29 aA ± 29.71</td>
</tr>
</tbody>
</table>

a, b, c – means denoted by different letters are significantly different at P≤0.01; A,B,C – significant difference at P≤0.001

Table 2
Correlation (r) between ubiquinone and protein level in the saddle and thigh muscles

<table>
<thead>
<tr>
<th>Type of rabbit rearing system</th>
<th>Ubiquinone</th>
<th>Crude protein</th>
<th>Fibrillar protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>saddle</td>
<td>thigh</td>
<td>saddle</td>
</tr>
<tr>
<td>Conventional</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>saddle</td>
<td>0.76*</td>
<td>0.69*</td>
<td>0.96**</td>
</tr>
<tr>
<td>thigh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>saddle</td>
<td>0.73*</td>
<td>0.67*</td>
<td>0.95**</td>
</tr>
<tr>
<td>thigh</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* P≤0.01; ** P≤0.001

The correlation coefficient between ubiquinone and fibrillar protein averaged to 0.94 and was significantly higher than the correlation between ubiquinone and total protein content in saddle and thigh muscles (Table 2).

Discussion

The comparison of the obtained results with literature data (7, 13) proves that rabbit meat constitutes a great source of ubiquinone. In particular, a significantly higher level of CoQ10 was established in the meat of crossbreds from small-scale farming units and fed traditionally.

The study demonstrated that rabbit meat is a rich source of protein and ubiquinone Q10. CoQ10 level in rabbit muscle tissue was found to be significantly affected by the management system and the type of primal cut.

A significantly higher CoQ10 content was determined in muscle tissue of rabbits from the traditional small-scale farming units called "organic farming". The highest concentration was established in rabbit saddle, where the protein level was also the highest. Additionally, a relationship between ubiquinone and fibrillar proteins was observed.

The obtained results provide strongly support the conclusion that rabbit meat, especially from the traditionally farmed animals, is one of the best sources of animal protein.

Furthermore, the meat obtained from the backyard-farmed rabbits had favourable fatty acid composition, especially a desirable ratio of n-6 to n-3 fatty acids. It was demonstrated that intramuscular fat in these rabbits satisfied the recommended dietary guidelines because of its good proportion between SFA, MUFA, and PUFA (25).
Fig. 1. A HPLC chromatogram of ubiquinone Q10, extracted from saddle of rabbits fed natural diet (A) and commercial feed (B). Ubiquinone Q8 as an internal standard was used.

The rabbit meat also turned out to be an alternative source of animal protein, with good sensory qualities, as well as recommended high nutritional value and dietetic properties. The fat and cholesterol levels in rabbit meat are lower than in red meat and poultry (3). The complex sensory evaluation of meat obtained from 15 species of animals showed that in terms of juiciness, rabbit meat is far superior to poultry (turkey) meat, venison and hare meat, whereas considering tenderness, it is better than beef (including young beef-veal), horse, goat, and turkey meat. At the same time, the rabbit meat was graded the lowest marble score out of all meats under evaluation (19).

The analysis of veterinary-sanitary examination results is another argument in favour of rabbit meat as a valuable and primarily safe functional food. The examinations were carried out in 2000-2010 and confirmed the good health status of the rabbit population raised for slaughter in Poland, as well as proper veterinary-sanitary inspection that ensures that high quality meat is supplied to the public (23).

References

6. Kubo H., Fuji K., Kawabe T., Matsumoto S., Kishida H., Hosoe K.: Food content of ubiquinolin-10 and ubiquinone-


11. Polish Norm PN-75/A-04018: Agri-food products – determination of nitrogen according to Kjeldahl and conversion to protein.


