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Review Article

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Rabbit Meat Consumption: A Mini Review on the Health Benefits, Potential Hazards and Mitigation

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Abstract

With increased consumer knowledge about the relationship between diet and a healthy lifestyle in recent decades, there has been an increase in awareness and demand for efficient protein sources. Rabbit meat is rich in easily digestible protein, polyunsaturated fatty acids (PUFAs), vitamins, and minerals (such as calcium, magnesium, and zinc), as well as being low in fat, sodium, and cholesterol, which makes it of good edible and nutritional value, so it needs to be handled properly. Rabbit meat, on the other hand, has been associated with the spread of microbial contamination (such as *Staphylococcus aureus*, *E. coli* and *Salmonella* species) that may originate from the animal itself, equipment, workers, or the surrounding environment. Each effort must be made to keep rabbit meat free of contaminants that could be harmful to humans. Few studies had been conducted, either internationally or in Egypt, to examine the physicochemical and microbiological characteristics of rabbit meat. We shall compile existing data on the quality of rabbit meat in this review. Furthermore, the potential hazards that influence the physicochemical and microbiological qualities and shelf life, as well as the proposals for decontamination trials to enhance the sensory attributes and shelf life of rabbit meat, will be presented.

KEYWORDS
Consumption, Health benefits, Potential Hazards, Quality assessment, Rabbit meat.

INTRODUCTION

The concept of meat quality is changing continuously. Nowadays, the consumer is very interested in meat quality, cooking ease and speed, and price. Rabbit manufacturing has recently attracted a lot of attention since rabbit meat has various advantages that entitle it to be one of the most favorite nutritious foods (El-Adawy *et al*., 2020). The awareness of the nutritive quality and healthiness of meat has led to the development of functional foods, which are a new approach to achieve a healthier status that reduces the risk of disease (Hathwar *et al*., 2012).

Rabbit is an ideal animal that is widely farmed worldwide for meat production, with short gestation intervals, prolific production, and high feed conversion rates (Rasinska *et al*., 2019). Furthermore, rabbit meat is very popular and widely consumed in Egypt and numerous Mediterranean countries (Zotte and Szendrő, 2011; Morshdy *et al*., 2021). However, the lack of understanding of the nutritional value and processing methods is another critical reason inhibiting the rabbit meat industry.

Rabbit meat, like any kind of meat, could be of public health importance. The widespread nature of foodborne diseases is due to food handlers' lack of understanding of basic food safety issues as well as the major sources of microbial contamination of food, such as food preparation, cooking and serving utensils, and personal hygiene (Li *et al*., 2018). Therefore, any fault during handling will cause microbial contamination. Raw meat is frequently contaminated with a wide range of bacteria, some of which may be zoonotic diseases. The most common pathogens found in rabbit meat were the following: Aerobic microorganisms, *Enterobacteriaceae*, Yeast and Mould, *E. coli* and *Salmonella* spp. (Mahmoud *et al*., 2022).

Several studies have been conducted to reduce microbial contamination using modern meat preservative technologies, particularly natural antimicrobial and antioxidative agents such as chitosan (CH) and rosemary essential oil (REO) (El Bayomi *et al*., 2023). Thus, the goal of this review is to summarize the available literature about the health benefits and quality of rabbit meat, as well as shed light on the possible health hazards connected with the presence of such foodborne pathogens. Furthermore, based on several decontamination studies of rabbit meat in Egypt and throughout the world, this review gives suggestions on how to improve rabbit meat quality and shelf life.

Health benefits and quality of rabbit meat

Rabbit meat is high in protein, vitamins, minerals such as calcium, potassium, and magnesium, as well as micronutrients such as iron, zinc, cobalt, and selenium. Additionally, rabbit meat

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contains valuable omega-3 fatty acids which make it an excellent food for consumption (Li S *et al*., 2018). The benefits of consuming rabbit meat for human health are clear because rabbit is a lean meat with low cholesterol level, in addition to high levels of unsaturated fatty acids (Abd-Allah and Abd-Elaziz, 2018). This makes it a valuable source of nutrition, particularly for individuals looking to maintain a healthy diet.

Rabbit meat is particularly recommended for young children, pregnant women, the elderly, and individuals suffering from hypertension. It is also associated with a lower risk of metabolic syndrome (Dalle, 2014). Rabbit meat contains high levels of both essential and non-essential amino acids. In the New Zealand White breed of rabbits, for example, the essential amino acids found in meat samples were lysine, histidine, phenylalanine, valine, methionine, threonine, isoleucine, and leucine. The meat samples from the Egyptian Balady breed have somewhat different amino acid compositions, with higher levels of phenylalanine than leucine, possibly due to their genetic makeup. The California breed of rabbits had a slightly different amino acid composition, with lysine, leucine, phenylalanine, histidine, valine, threonine, isoleucine, and methionine (Morshdy *et al*., 2022a).

Rabbit meat is usually offered as whole carcasses or cut-ups, with less emphasis on processed meat products. Factors such as genetics, breed, age, and weight, as well as management techniques, habitats, and pre- and post-slaughter circumstances can all impact carcass and meat quality. Consumer perception of the nutritional and functional properties of rabbit meat is important in promoting its consumption and the consumption of its meat derivatives. Rabbit meat has a tender taste and is often considered a good substitute for chicken meat (Zoltan *et al*., 2017). The thigh and loin cuts of rabbit carcass are particularly rich in protein and are the most acceptable cuts for determining the quality of meat (Rasinska *et al*., 2018).

In Spain, a study was conducted to utilize rabbits as raw materials in fresh sausages to increase their consumption and meet consumers' current requirements. Two final formulations were developed, including a low-fat with konjac gum and a control one. The sausages were kept in MAP under chilling storage and were subjected to microbiological and physicochemical analyses at days 1, 6, 8, and 13 after packaging. The results revealed a considerable decrease in fat content and energy value. Sensory evaluation revealed a drop in distinctive flavor and aroma and also a rise in rancid odor, in the low-fat treatment, while hardness and fragility decreased. The shelf life for all treatments was 7 days, and the multivariate method was deemed a powerful strategy since physicochemical, microbiological, and sensory factors were considered (Honrado *et al*., 2022).

Another study examined the effects of two packaging methods on the microbial stability (lactic acid bacteria, psychrotrophic, initial coliforms count), physicochemical changes (pH, total volatile nitrogen (TVN), thiobarbituric acid (TBA), drip loss, and color), and microbial stability (psychrotrophic, lactic acid bacteria, initial coliforms count) of ground rabbit meat under refrigerated storage. The study found that the stability and shelf life of ground meat significantly improved with low-cost vacuum packaging (around 10 days) compared to polystyrene tray samples that showed a shorter shelf life (around 5 days) (Redondo-Solano *et al*., 2022).

Italian researchers conducted a study to examine the impact of bovine colostrum on the chemical and bacteriological quality of New Zealand rabbit meat after 48 hours postmortem, three and eight days of chilled storage. The results exhibited that dietary colostrum supplement enhanced the oxidative fatty acid status of rabbits compared to the untreated group, and their fatty acid profile was higher in saturated fatty acids (SFA) and lower in unsaturated fatty acids (UFA) (Castrica *et al*., 2022).

A study was conducted in Romania to analyze meat samples from rabbit and hare nutritionally and technologically. The data obtained showed that the pH value in Triceps brachii muscles from both rabbit and hare was greater, however hare meat was favored as a as a diet due to its low-fat content, light energy, and improved lipid health index. The meat from both species was considered healthy for human consumers (Frunză *et al*., 2023).

Contamination and potential hazards of rabbit meat

In a healthy rabbit, meat is typically sterile. However, during the slaughtering and evisceration processes, the carcass may harbor many microbes. Upon arrival at the slaughterhouse, incoming rabbits may carry a significant number of microorganisms on their skin, feet, gastrointestinal tract, and fecal matter. Hides are also a primary source of contamination. Thus, carcasses can become contaminated at any point from slaughtering and transportation to consumption. The degree of carcass contamination depends on several factors such as the cleanliness of incoming rabbits, the slaughterhouse design (i.e., separation between clean and dirty areas), the slaughtering method, the sanitation and disinfection system, and hygienic measures (Zweifel *et al*., 2014; Morshdy *et al*., 2022b). Bacterial contamination can arise from inside the abattoir, cross-contamination can occur from one animal to another and from the environment and production line through animal fur, skin, and intestinal contents and equipment such as knives. Inadequate washing can distribute contamination throughout the carcasses. Manual slaughtering of rabbits, where bleeding and skinning are done on the floor, can act as a significant source of bacterial contamination (Bakhtiary *et al*., 2016).

Poor personal hygiene can be related to microbial contamination of foods. Food handlers may be the source of food contamination either as carriers of microbes or through poor hygienic practices. Poor personnel hygiene, improper handling and storage of foods, and inadequate knowledge about the significance of foodborne diseases are the primary risk factors of food contamination. Mishandling of rabbits during slaughter, dressing, and evisceration leads to high microbial contamination (Mahmoud *et al*., 2022).

The poor safety knowledge of meat and handling at slaughterhouses was identified as a key factor that affects the microbial status of the meat (Kimindu *et al*., 2022). Improper cooking, inadequate storage, cross-contamination, and the use of raw ingredients in food preparation are the most common factors contributing to outbreaks (De Jong *et al*., 2012). The spoilage microbes are often natural inhabitants of air, soil, water, and the intestinal tracts of animals. Thus, microbial contamination can occur at anytime from anywhere (Rawat, 2015).

Research was conducted to assess the bacteriological quality of smoked rabbit meat from ten different vendors on Logos-Benin Expressway, Nigeria. The Total viable bacterial count (TVBC), Total *Enterobacteriaceae* count (TEC), and Total *Staphylococcus aureus* count (TSAC) ranged from $1.48x10^5$ to $3.20x10^5$ CFU/g, $1.05x10^3$ to $1.36x10^3$ CFU/g, $1.10x10^3$ to $1.44x10^3$ CFU/g, and $1.14x10^2$ to $2.36x10^2$ CFU/g, respectively. The authors concluded that rabbit meat sold on Logos-Benin Expressway was of satisfactory bacteriological quality (Bello *et al*., 2018).

In a recent investigation, the microbiological quality of eighty rabbit meat samples from Sharkia province, Egypt was examined. The mean APC and *Enterobacteriaceae* values for shoulders were $1.1x10^6$ and $4.7x10^4$ CFU/g, $9.6x10^5$ and $5.7x10^4$ CFU/g for

ribs, $1.0x10^6$ and $5.1x10^4$ CFU/g for loins, and $1.2x10^6$ and $6.0x10^4$ CFU/g for thigh samples, respectively. The total mould and yeast count ranged from $2.6x10^4$ to $1.9x10^5$. *Salmonella*e were found in 30%, 35%, 30%, and 20%, whereas *E. coli* was detected in 90%, 80%, 75%, and 95% of the examined shoulder, ribs, loin, and thigh samples, respectively. The study suggests that fresh rabbit cuts may harbor a wide variety of microorganisms, highlighting the significance of stringent hygienic measures during the slaughtering and handling of the carcasses (Mahmoud *et al*., 2022).

A study conducted in Sharkia province, Egypt, examined the prevalence and morphological identification of *Eimeria* spp. in domestic rabbits (*Oryctolagus cuniculus*). The study found that 34.93% of rabbits were infected with *Eimeria* spp., with E. coecicola and *E. irresidua* being the most prevalent among the eight identified species. Additionally, PCR methods detected four *Eimeria* spp., and 72.55% of rabbits had mixed infections of different *Eimeria* spp. Histopathology revealed desquamation of the epithelial lining of the intestinal lumen and developmental stages of *Eimeria* in the enterocytes of intestinal villi. The study suggests the need to collect appropriate data to assess the possible infection and to implement future control measures against rabbit coccidiosis to reduce economic losses in the Egyptian rabbit sector (Ras, 2020).

Trials for controlling the potential hazards of rabbit meat

Despite the benefits, rabbit meat may contain food poisoning organisms that shorten the meat's shelf life and harm health. Therefore, each step of the slaughter process must be carefully studied in order to successfully regulate or reduce the initial microbial load effectively. To address this, numerous studies have shown that various herbs, spices, essential oils, and feed additives can improve the oxidative stability of rabbit meat and its products. Additionally, physical procedures such as vacuum packaging, irradiation, and the use of natural meat additives like onion and garlic can improve rabbit meat's microbiological purity and sensory attributes.

In a study, researchers tested hot water, 2% lactic acid, 2% acetic acid, or 2% levulinic acid washes to decontaminate pathogenic bacteria and inhibit their growth on meat surfaces. Lactic acid wash only outperformed water in decreasing *Salmonella* on chicken skin by less than 1 log CFU/cm^2. Also, organic acid washes were ineffective at inhibiting the development of *E. coli* O157:H7 and *L. monocytogenes* on chicken skin. Therefore, washing meat surfaces using organic acids (2%) is ineffective at eliminating harmful pathogens compared to washing with water (Smith, 2011).

A study was conducted to determine the impact of chitosan (1%), rosemary essential oil (0.2%), and their mixture on the quality and shelf-life extension of chilled rabbit meat. The pH, total volatile nitrogen (TVN) levels, thiobarbituric acid (TBA), bacteriological profile, odor, texture, and appearance were evaluated. Results showed that the use of 1% CH coating alone or in combination with 0.2% rosemary essential oil (REO) improved the shelf life of rabbit meat compared to untreated samples. The untreated samples had substantially higher pH, TVB-N, and TBA values, and the microbial analysis showed higher counts of *Enterobacteriaceae*, *Pseudomonas*, and Psychrotrophic bacteria. It was concluded that REO and CH coating may effectively lessen the degradation of rabbit meat during refrigerated storage (El Bayomi *et al*., 2023).

Another study aimed to investigate the antimicrobial and antioxidant properties of black seed oil (BSO) and lemongrass oil (LGO) at different concentrations on the physicochemical and bacteriological quality of chilled rabbit meat. The achieved results showed that samples treated with LGO and BSO had significantly lower values for both chemical and bacterial assessment than untreated samples. Therefore, LGO and BSO might be employed as substitute strategies to protect and lengthen the storage life of rabbit meat under refrigerated storage (Morshdy *et al*., 2021). In another study conducted in Egypt, the effectiveness of certain essential oils (EOs) on the sensory, chemical, bacterial quality of minced meat, as well as their ability to increase the shelf life of minced beef kept for 12 days at 4°C, was investigated. EOs of lettuce (*Lactuca sativa* L.), marjoram (*Origanum majorana* L.), and cumin (*Cuminum cyminum*) at a concentration of 2% were used. The cumin and marjoram oil-treated samples had significantly lower values for chemical and bacterial evaluations and improved sensory attributes followed by lettuce oil. As a result, the investigated EOs might be utilized as an alternative to chemical preservatives to minimize spoilage bacteria, prevent rancidity, and consequently prolong the freshness of minced beef (Mahmoud, 2019).

Modern preservative technologies, such as natural antimicrobials, irradiation, high hydrostatic pressure (HHP), and vacuum packaging, can reduce microbial contamination in meat (Składanowska-Baryza *et al*., 2022). According to Cwiková and Pytel, (2017), satisfactory packaging and storage conditions are necessary to ensure a longer shelf life and superior quality of rabbit meat, but it also depends on the initial microbial count of the meat. Additionally, (Al Jumayi *et al*., 2022) investigated the antioxidant activities, radical scavenging potential, and bioactive components of various plant aqueous extracts, as well as their mixture for improving the shelf life of cold-stored rabbit meat. They found that a combination of plant extracts (0.2%) improved the shelf life by 50%, had the lowest TBARS levels, and doubled storage period while preserving acceptable odor and flavor. These findings suggest that the plant extracts could be beneficial against rancidity and could be used as natural antioxidants to extend the shelf life of cold-stored rabbit meat.

CONCLUSION

Rabbit meat is a promising source of superior quality animal protein that provides high nutritional value for extra nutrients. However, it is also recognized as a potential carrier of spoilage and harmful microorganisms, which can cause health risks and reduce the meat's shelf life. These microorganisms can originate from abattoir, cross-contamination between animals, or the surrounding environment during the slaughtering process. Thus, it is imperative that rabbit slaughterhouses implement hygiene protocols those adhere to the principles of HACCP to ensure safe and hygienic slaughtering conditions, from the rabbit farm to consumption, to ensure the production of high-quality meat with low microbial contamination. Studies have shown that irradiation and the use of natural preservatives, such as chitosan, garlic, and essential oils, can improve the quality of rabbit meat.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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