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Radical Revelations: Electron Spin Resonance Sheds Light on Fried Chicken Integrity

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ABSTRACT: In recent times, there has been growing interest in free radicals due to their close association with human aging and various illnesses. Cooking processes, particularly those involving smoked meat, used oil, and fat are external factors that produce free radicals. Foods rich in proteins, lipids, and carbohydrates, as well as those containing reactive ingredients, serve as primary sources of these compounds. When free radicals accumulate in the body without proper removal, oxidative stress occurs. This buildup is linked to chronic and degenerative conditions such as cancer, autoimmune diseases, aging, cataracts, rheumatoid arthritis, cardiovascular diseases, and neurological disorders. The purpose of this study was to use electron spin resonance (ESR) to detect the presence of free radicals in various meat products as a potential human threat. Twenty-five randomly selected ready-to-eat fried chicken samples were collected from several supermarkets to assess the presence of free radicals using electron spin resonance (ESR). Our results showed that free radicals were present in the examined samples at various concentrations.

KEYWORDS: Chicken meat product – Diseases – Electron spin resonance (ESR) – Free radicals.

1. Introduction

Meat and meat products are vital components of the human diet, providing essential nutrients; however, they are susceptible to damage from microbes and oxidation processes, compromising their quality and safety. Free radicals have drawn a lot of attention because of the tight relationship between their reactions and human ageing and several diseases [1]. Chemical entities (atoms, molecules, or ions) with one or more unpaired electrons in their exterior orbitals are known as free radicals, and they are typically very reactive [2]. Free radicals and other non-radical reactive species are both comprised of reactive oxygen species (ROS) and reactive nitrogen species (RNS) collectively [3]. The primary dietary contents or their reactive constituents, such as proteins, lipids, and carbohydrates are where free radicals in food originate and the Food quality is impacted by chemical changes caused by the creation and decomposition of free radicals during preparation and storage [1]. Free radicals can come from two different sources: endogenous, which is generated by the body during normal metabolism, and exogenous, which is generated by external sources including radiation, cooking (smoked meat, used cooking oil), high temperatures, and environmental pollutants [4, 5]. The findings indicated that the roasted meat had a high radical concentration due to the high temperature, rapid heat transfer rate, and high content of polyunsaturated fatty acids (PUFAs) [1]. ROS and RNS improve the immune system and cellular response when present at low to moderate concentrations. However, an excess of free radicals cannot be gradually eliminated; they accumulate in the body, resulting in oxidative stress which is associated with various chronic pathological conditions such as cardiovascular, neurodegenerative, renal disorders[3, 6, 7]; inflammatory diseases, cataracts, and cancer [8]. Oxidative stress damages a wide range of molecular species, including lipids, proteins, and nucleic acids, which are associated with structural and functional changes [9] and result in serious diseases and irreparable harm to the body [8]. DNA damage is an undesirable alteration in the body that is linked to radicals. Recent research has validated the idea that minimizing radical damage

can slow down the aging process and increase lifespan [8]. Electron paramagnetic resonance spectroscopy (EPR), also known as electron spin resonance (ESR) spectroscopy, is a fundamental technique for developing methodologies to explore EPR-sensitive species, such as free radicals, ROS, RNS, and C-centered radicals and metal ions [10].Meat and meat products are vital components of the human diet, providing essential nutrients; however, they are susceptible to damage from microbes and oxidation processes, compromising their quality and safety. Free radicals have drawn a lot of attention because of the tight relationship between their reactions and human ageing and several diseases [1]. Chemical entities (atoms, molecules, or ions) with one or more unpaired electrons in their exterior orbitals are known as free radicals, and they are typically very reactive [2]. Free radicals and other non-radical reactive species are both comprised of reactive oxygen species (ROS) and reactive nitrogen species (RNS) collectively [3]. The primary dietary contents or their reactive constituents, such as proteins, lipids, and carbohydrates are where free radicals in food originate and the Food quality is impacted by chemical changes caused by the creation and decomposition of free radicals during preparation and storage [1]. Free radicals can come from two different sources: endogenous, which is generated by the body during normal metabolism, and exogenous, which is generated by external sources including radiation, cooking (smoked meat, used cooking oil), high temperatures, and environmental pollutants [4, 5]. The findings indicated that the roasted meat had a high radical concentration due to the high temperature, rapid heat transfer rate, and high content of polyunsaturated fatty acids (PUFAs) [1]. ROS and RNS improve the immune system and cellular response when present at low to moderate concentrations. However, an excess of free radicals cannot be gradually eliminated; they accumulate in the body, resulting in oxidative stress which is associated with various chronic pathological conditions such as cardiovascular, neurodegenerative, renal disorders,[3, 6, 7]; inflammatory diseases, cataracts, and cancer [8]. Oxidative stress damages a wide range of molecular species, including lipids, proteins, and nucleic acids, which are associated with structural and functional changes [9] and result in serious diseases and irreparable harm to the body [8]. DNA damage is an undesirable alteration in the body that is linked to radicals. Recent research has validated the idea that minimizing radical damage can slow down the aging process and increase lifespan [8]. Electron paramagnetic resonance spectroscopy (EPR), also known as electron spin resonance (ESR) spectroscopy, is a fundamental technique for developing methodologies to explore EPR-sensitive species, such as free radicals, ROS, RNS, and C-centered radicals and metal ions [10].

2. Materials and Methods

2.1. Sample Collection

Twenty-five ready-to-eat fried chicken samples were collected randomly from different supermarkets.

2.2. Sample Preparation

The highest temperature generally utilized for drying samples is between 105 and 110 °C, which is just above the boiling point of water. Drying all materials overnight or occasionally longer is a practical strategy, especially when working with several samples. Typically, this level of heating is more than adequate to dry materials for radiochemical examination [11]. Finally the sample grinded.

2.3. Sample Analysis

Samples were analyzed using electron spin resonance (ESR) spectroscopy, also known as electron paramagnetic resonance (EPR) spectroscopy, in the National Center for Radiation Research and Technology (NCRRT) at 3 Ahmed Al-Zamr, Eighth Region, Nasr City, Cairo, Egypt. The free radicals created (EPR signals) were recorded at room temperature by X-band EMX spectrometer (Bruker, Germany) using a standard rectangular cavity of ER 4102. The operating parameters applied during the EPR experiment are microwave power, y mW; modulation amplitude, y Gauss; modulation frequency, 100 kHz; number of x-scans, y; resolution in x, y sweep width, y Gauss; microwave frequency, y GHz; time constant, y ms; conversion time, y

ms and sweep time, y s. The detection limits of EPR technique depends on the type of sample, sample size, detector sensitivity, frequency of the incident microwave radiation, and the electronic circuits of the instrument. (note y is our own measurement parameters).

3. Results

Figures 1 and 2 showed the ESR spectra of various low intensity of the radical signal based on the concentration of free radicals within the samples, while Figures 3 and 4 showed the ESR spectra of various high intensity of the radical signal based on the concentration of free radicals within the samples. Table 1 stated that 25 analyzed samples and all are 100% positive. 10 of these samples have high concentrations (40%), while 15 have low concentrations (60%).

Table 1: Fried Chicken Sample Analysis Overview

Samples	No of analyzed samples	No of Positive samples	%	No of low conc.sample	%	No of high conc.samples	%
Fried chicken	25	25	100	15	60	12	40

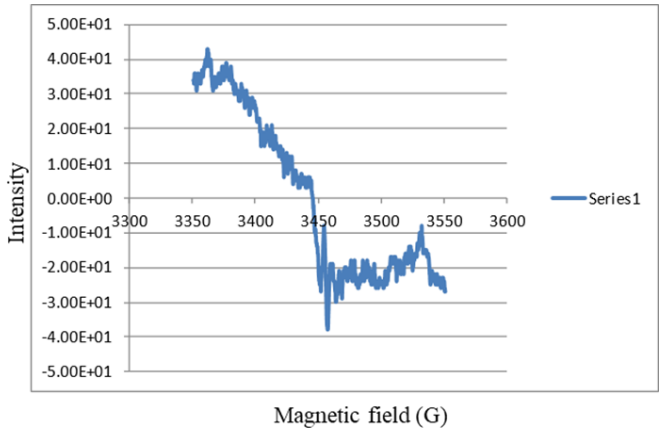

Figure 1: Electron spin resonance spectra of low intensity of the free radical signal

Discussion

Free radicals now play a dual role in biological systems after believing for several decades that they only have a harmful effect. First, they are hazardous byproducts of aerobic metabolism that result in oxidative damage and tissue malfunction; second, they are molecular signals that initiate advantageous stress responses [2]. It is clear from

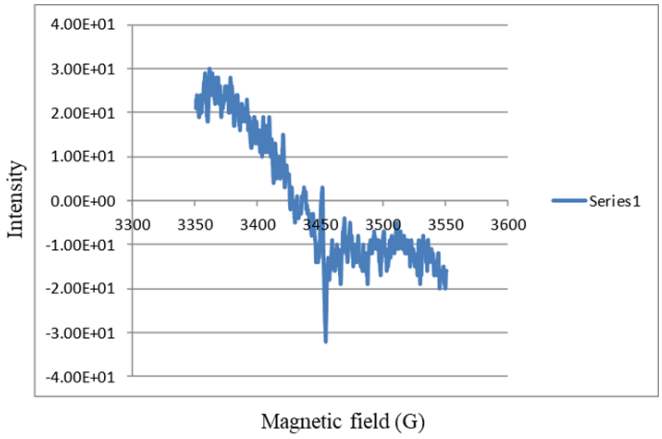

Figure 2: Electron spin resonance spectra of low intensity of the free radical signal

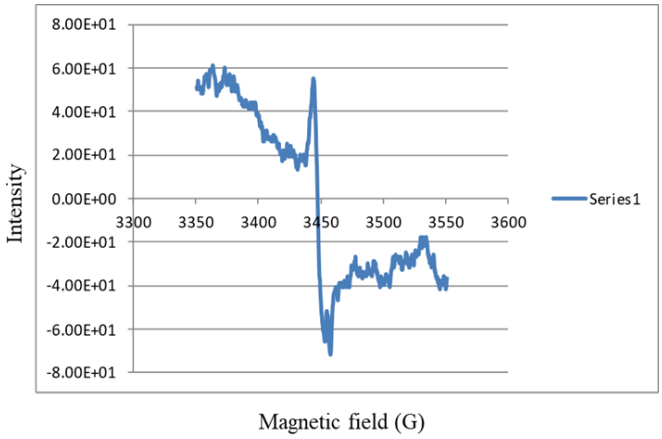

Figure 3: Electron spin resonance spectra of high intensity of the radical signal.

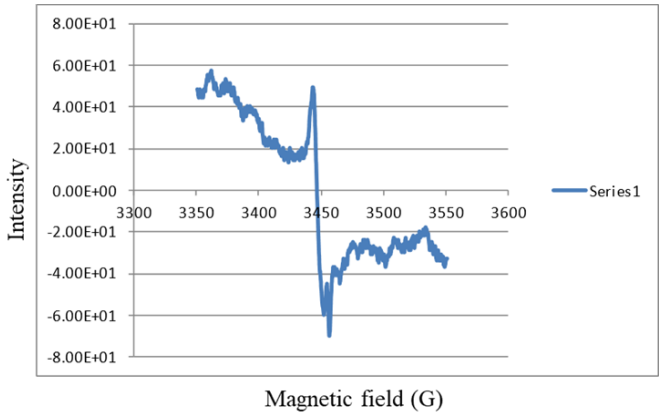

Figure 4: Electron spin resonance spectra of high intensity of the radical signal.

Table 1 that all analyzed samples were positive. 40% of these samples have high concentrations, while 60% have low concentrations. Nearly similar results were received by Leveque et al. [5]. Free radicals in food can be generated through various industrial processes like irradiation

by X- and γ-rays, accelerated electrons, heat treatment, or well-established food preservation techniques that are frequently used to extend the shelf life and microbiological quality of foods [5]. Electron paramagnetic resonance (EPR) spectroscopy, also known as electron spin resonance (ESR) spectroscopy, spin trapping, and reaction fingerprinting are the three methods most frequently employed to identify free radicals [9, 12]. ESR spectroscopy has been extensively employed in food research to identify radical formations [1]. As shown in this article the ESR spectra of various low intensity of the radical signal based on the concentration of free radicals within the samples (Figs. 1 and 2), while the ESR spectra of various high intensity of the radical signal based on the concentration of free radicals within the samples (Figs. 3 and 4). The results revealed significant variations in both the shape and intensity of the radical signal, depending on the concentration of free radicals present in the samples, indicating that the analytical sample conditions have an impact on the ESR measurement. Interestingly, our findings closely resemble those reported by Bao et al. [1], who utilized a similar analytical technique. Despite employing different food products and cooking methods, while they examined grilled, roasted, and barbecued beef, we focused on fried chicken in our study. While Bolumar et al.[13, 14] examined radical production in chicken meat products utilizing a non-thermal treatment combining low temperature and high pressure, our research concentrated primarily on heat treatment (high temperatures). Despite differences in treatment procedures, both investigations found free radicals in chicken meat products. This shows that radical production in chicken meat products can occur in a variety of processing settings, including non-thermal treatments such as low-temperature, high-pressure operations, and direct exposure to high temperatures.

Conclusion

This study highlights the presence of free radicals in ready-to-eat fried chicken, which can contribute to various chronic diseases. Using electron spin resonance, the research confirmed the existence of free radicals in these chicken products at different concentrations, providing valuable insights into their potential health risks.

Conflict of Interest

The authors reported no conflicts of interest.

Consent of publication

Not applicable

References

[1] Y. Bao, Y. Zhu, X. Ren, Y. Zhang, Z. Peng and G. Zhou, *Foods*, 2020, **9**, 572.

[2] S. Di Meo, P. Venditti *et al.*, *Oxidative medicine and cellular longevity*, 2020, **2020**, year.

[3] A. Phaniendra, D. Jestadi and L. Periyasamy, *Indian journal of clinical biochemistry*, 2015, **30**, 11–26.

[4] G. Martemucci, C. Costagliola, M. Mariano, L. D'andrea, P. Napolitano and A. D'Alessandro, *Oxygen*, 2022, **2**, 48–78.

[5] P. LEVEQUE, Q. Godechal and B. Gallez, *Israel Journal of Chemistry*, 2008, **48**, 19–26.

[6] N. Maddu, *Diseases related to types of free radicals*, Intech Open, London, UK, 2019, p. 1–18.

[7] L. Pham-Huy, H. He and C. Pham-Huy, *International journal of biomedical science: IJBS*, 2008, **4**, 89.

[8] Y. Elkhateeb and M. Alshammary, *American Journal of Laboratory Medicine*, 2017, **2**, 156–162.

[9] V. Lobo, A. Patil, A. Phatak and N. Chandra, *Pharmacognosy reviews*, 2010, **4**, 118.

[10] C. Drouza, S. Spanou and A. Keramidas, *EPR methods applied on food analysis*, Topics from EPR Research, 2018, p. 45–64.

[11] D. E. McCurdy, J. R. Garbarino and A. H. Mullin, *Interpreting and Reporting Radiological Water-quality Data*, US Department of the Interior, US Geological Survey, 2008.

[12] M. J. Morello, F. Shahidi and C.-T. Ho, 2002.

[13] M. Davies, *Methods*, 2016, **109**, 21–30.

[14] T. Bolumar, L. Skibsted and V. Orlien, *Food Chemistry*, 2012, **134**, 2114–212.