

ELECTRONIC SPECTRUM OF PORK AND BEEF MUSCLE TISSUE SURFACE SAMPLES, SUBJECTED TO ELECTRON-RADIATION PROCESSING

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Abstract

In definite processes, including pathological, regardless of the origin of solid object start from its surface. The processes develop in deep and change the structure and properties of the sample in volume, but in this case the surface itself is appropriately transformed. One of the most effective methods for studying solid surfaces is EDRS (electronic diffuse reflectance spectroscopy), along with IR (infra red) spectroscopy, Raman and ESR (electronic spin resonance) spectroscopy. The EDRS method in the wave length range 200–750 nm was used. In this work we studied the combined effect of ethanol and radiation with fast electrons (absorbed dose ranged from 12.5–50.0 kGy) on the electronic spectrum of surface of restructured muscle tissue of pork and beef.

Key words: optical diffuse reflection, electron-beam radiation, muscle tissue.

Introduction

The number of research methods of solid surface of biological objects which are complex heterogeneous systems is quite limited (IR-spectroscopy, Raman and EDRS). The limited number is caused by difficulty and non-uniqueness in interpreting of received data. EDRS method is used particularly to determine the quality of meat and fatty products by their colour in visible area of spectral range. The quantity of total protein and its degradation level in meat-food is estimated by absorption of two amino-acids – tryptophan and tyrosine in ultraviolet range (260 and 280 nm) of spectrum (Антипова и др., 2001; Василюнец, Колодязная, 2004; Демченко, 1981).

Integrated studies that have been conducted using plant (Неchiporenko и др., 2010; Плотный, 2007; Шамова, 2007) and animal (Неchiporenko и др., 2008a; Неchiporenko и др., 2008b; Неchiporenko и др., 2007) tissues for the last five years (in St. Petersburg State University of Low Temperature and Food Technologies) showed that EDRS method can be used more widely and efficiently.

A number of serial chemical treatments (extraction of water-soluble constituents of sarcoplasm, treatment with sodium chloride, alkali, ethanol, ether) showed in general that electronic spectrum of surface of biomaterials is presented by four clearly differentiating areas. It is well-known that in visible range of spectrum (535–640 nm) distinctly appears a doublet of bands – myoglobin and its oxidized forms – pigment proteins of meat.

Mucopolysaccharides give broad intensive and stable band in wavelength interval 410–425 nm, which is deleted from spectrum after treatment of samples by 0.6 M NaOH. In the near ultraviolet area (330–365 nm) lipid components is displayed in the form of 2–3 bands of medium intensity. The most complex and saturated one is the middle ultraviolet range (200–320 nm) of spectrum where absorb some of amino-acids (such as tyrosine, tryptophan, phenylalanine and cysteine) and also sugars, oligosaccharides and their different hybrids.

The goal of this study is to investigate the influence of ethanol and electron-beam radiation treatments on optical spectrum of pork and beef muscle tissues.

Materials and Methods

In this work minced pork sirloin (pH=5.82) and beef sirloin (pH=5.87) were tested. The muscle tissue was ground in meat mincing-machine with 2.5 mm holes on the disk. Pork muscle fiber was obtained from forcemeat by extraction of water-soluble constituents of sarcoplasm by bidistilled water during 12 hours. In parallel we studied the series of pork forcemeat samples which was taken from compact muscle tissue samples pretreated by 96%

ethanol for 2.0 minutes. Grind up to forcemeat muscle samples (2.0–2.5 g) were packed in polyethylene film (0.03 mm thickness), airproofed and exposed to radiation.

Sample radiation was carried out, using medium energy electron accelerator of resonant-transformer type RTE-1B (Saint-Petersburg Scientific Research Institute of Electrophysical Apparatus). Absorbed doses in series were: 12.5; 25.0; 37.5 and 50.0 kGy.

Electron absorption spectra of sample surface were received using spectrophotometer “Specord M-200” (AIZ Engineering GmbH, Germany) within wavelength range 200–750 nm on radiation day.

Results and Discussion

In Fig.1 it is shown electron absorption spectra of intact surface of forcemeat of pork muscle tissue sample (1) and pork muscle fiber sample (4). Their comparison shows that removal of sarcoplasm causes sharp decrease of the whole spectrum. However in this case clearly differentiate bands that belong to lipids (340 and 360 nm), proteins (220, 240, 260 and 280 nm) and one of the bands (290 nm) belong to monosaccharides. In spectrum of intact muscle tissue sample are more exhibited bands of carbohydrates –275, 285 и 300 nm (Элиас, Кохен, 1983).

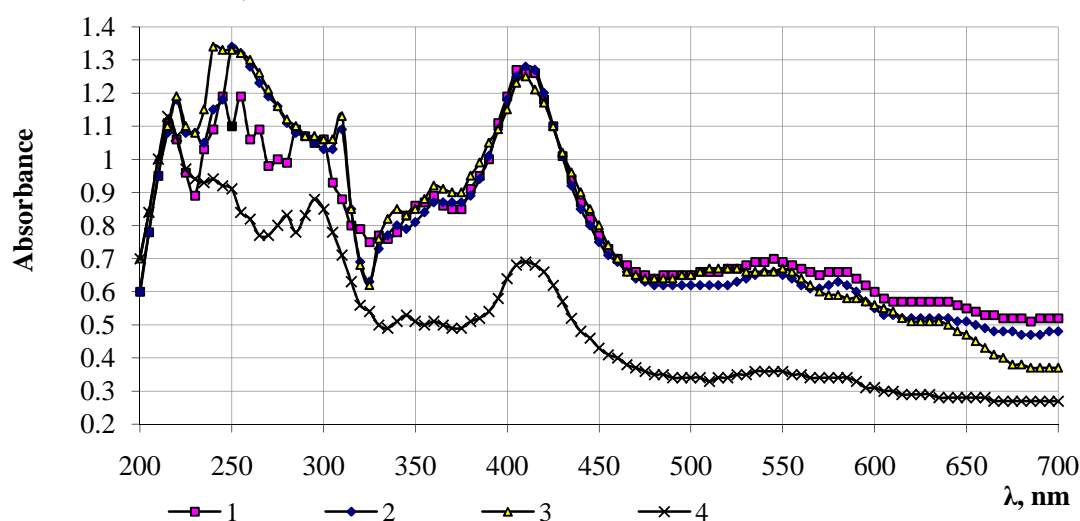


Figure 1. Electron absorption spectra of sample surface of pork forcemeat and muscle fibers

1 – intact; 2 and 3 – forcemeat from muscle tissue, pretreated by ethanol; 4 – muscle fiber

Treatment of sample (1) by ethanol also has an effect on all muscle tissue components, but it is more seen in UV-range where proteins and carbohydrates are absorbed (curve 2). At this wavelength range spectrum is located much higher than spectrum of intact sample and it is smoothed. It is of some interest the comparison of curves 2 and 3 received at 2 month interval, which illustrate absorption spectra of sample surface of forcemeat of two different species pretreated by ethanol before grinding of compact muscle tissue.

Smoothing character of both spectra and their closeness let us to assume the uniformity of destructive processes caused by ethanol activity on muscle tissue of the same anatomic part of different animals. Moreover destructive processes of ethanol affect mostly proteins and carbohydrates of sarcoplasm. The band with $\lambda=310$ nm we relate to oligosaccharides. In both spectra indicated differentiation of two strips belonging to lipid components.

The effect of electron-beam treatment on intact minced pork muscle tissue illustrates Fig.2. Bring to notice the inconsequence of electron spectra location in dependence with absorbed dose. Sample that absorbed the dose in 12.5 kGy has a spectrum very similar in UV-area to

the ones pretreated by ethanol and unexposed to radiation muscle tissue samples (Fig. 1, curve 2 and 3).

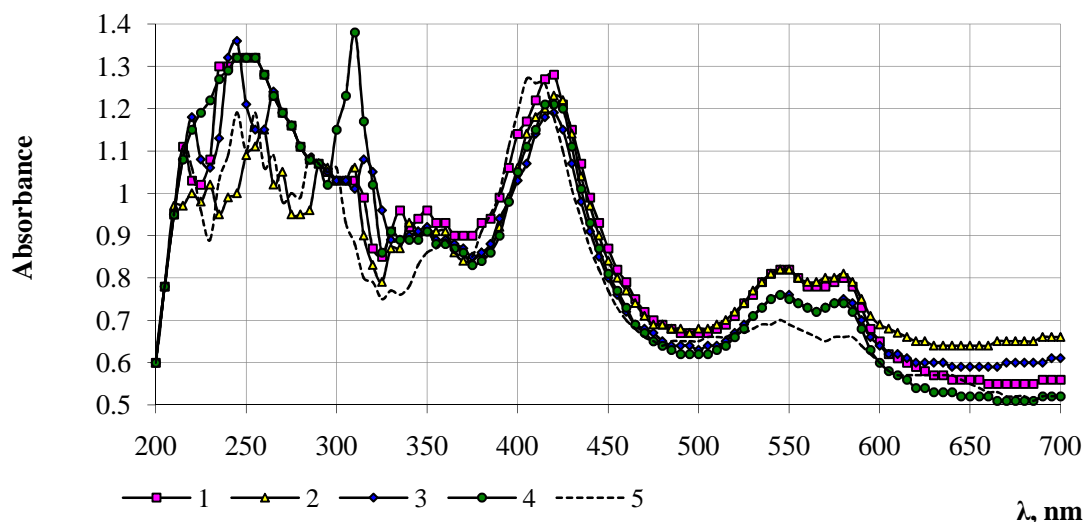


Figure 2. The effect of electron-beam treatment on optical spectrum of surface of intact pork muscle tissue samples

Absorbed dose is: 1 – 12.5; 2 – 25.0; 3 – 37.5; 4 – 50.0 kGy; 5 – is the control

This shows similar nature of action of ethanol and water radiolysis products on the most sensitive water-soluble components of sarcoplasm. Spectrum of sample absorbed 25.0 kGy declines and we turn to entirely other bands than in control. Absorbance lowering in wavelength range 200–280 nm, formation of maximums resulting from protein structures – 220, 240, 260 and 280 nm (qualitatively very similar to muscle tissue) and also bands that can be given by carbohydrates – 270, 290, 310 nm shows significant destruction of all sarcoplasm components.

Further increase of dosage lead to lift of electron spectra. Spectra concordance in interval 230–290 nm of samples 1 and 4, which absorbed 12.5 and 50.0 kGy respectively, suggests that from the dose of 50.0 kGy begins the destruction of muscle fiber. Evidently that 37.5 kGy dose is intermediate between the doses whereby starts disintegration of sarcoplasm components (25 kGy) and disintegration of muscle fiber (50.0 kGy).

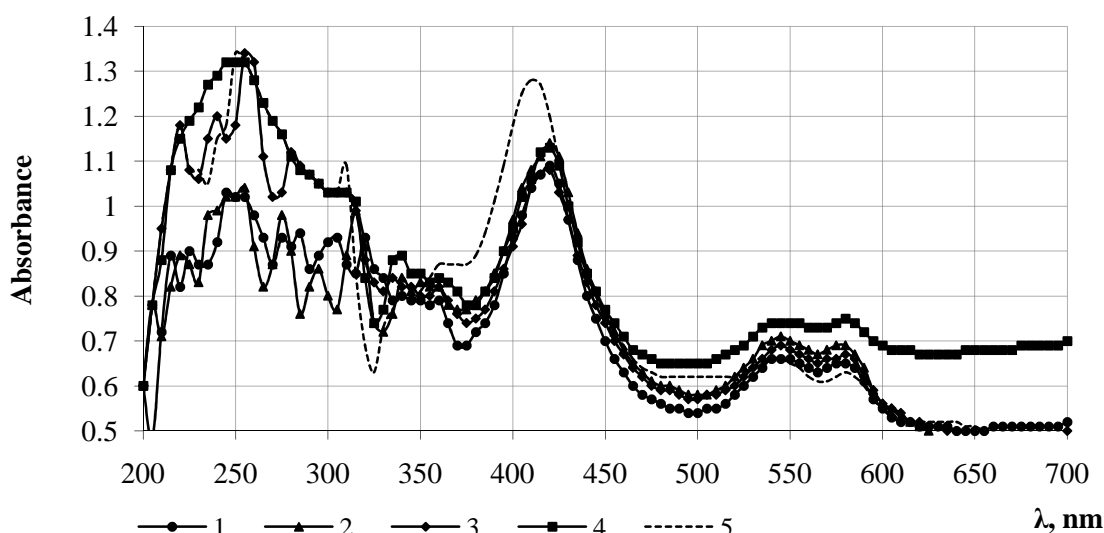


Figure 3. Influence of ethanol treatment on optic spectrum of radiated samples of pork muscle tissue

Absorbed dose: 1 – 12.5; 2 – 25.5; 3 – 37.5; 4 – 50 kGy; 5 – control

It is important to notice that obtained data is in a good agreement with pH-metry data received while post-radiation sample storage of given series (Orehova et al., 2011).

Electronic spectra show (Fig. 3) that pretreatment of samples by ethanol strengthens action of ionizing irradiation at low doses. It is seen from the position of curves 1 and 2. Absorbed dose 25.0 kGy in studied range present oneself as a threshold. The spectra of intact and radiation treated samples above threshold dose is not enough different from. However collating spectrums of samples 1 and 2 (Fig. 2 and 3) make possible to notice that ethanol not only enforce the action of ionizing radiation but gives certain direction to radiolysis.

In distinction from intact samples in spectra ethanol treated samples is absent bands specific for protein structures, but is present bands corresponding carbohydrates. It is possible to suppose that ethanol direct initial process of radiolysis on carbohydrate components.

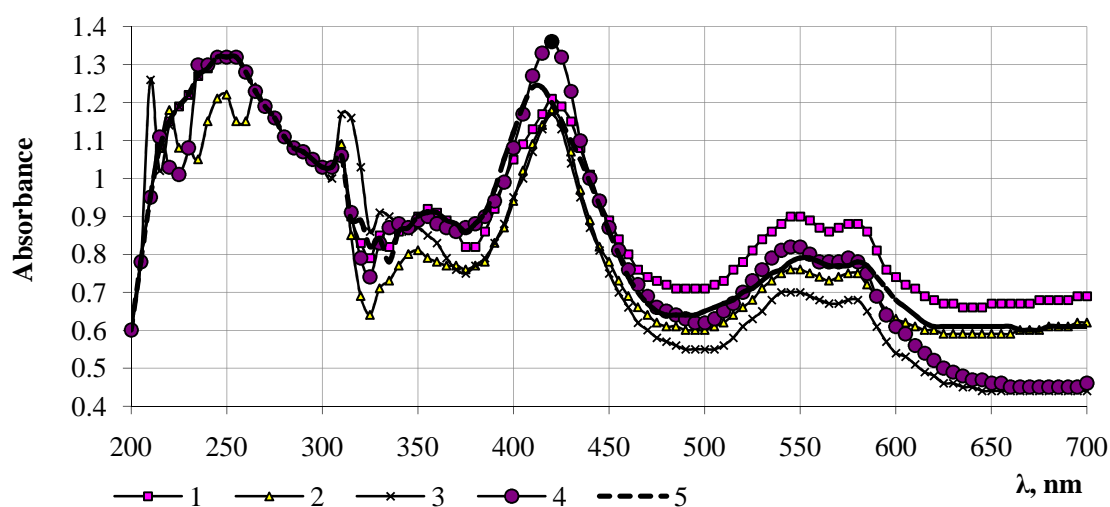


Figure 4. Electronic spectra of absorbance of sample transversal section surface of intact pork muscle tissue

Absorbed dose: 1 – 12.5; 2 – 25.5; 3 – 37.5; 4 – 50.0 kGy; 5 – control

By analysis of electronic spectra of sample section surface of intact pork muscle tissue (Fig. 4) we have turn to their identity to spectra showed on fig. 2. Just as in example of forcemeat muscle tissue the greatest destructive effect on sarcoplasm components gives 25.0 kGy doses.

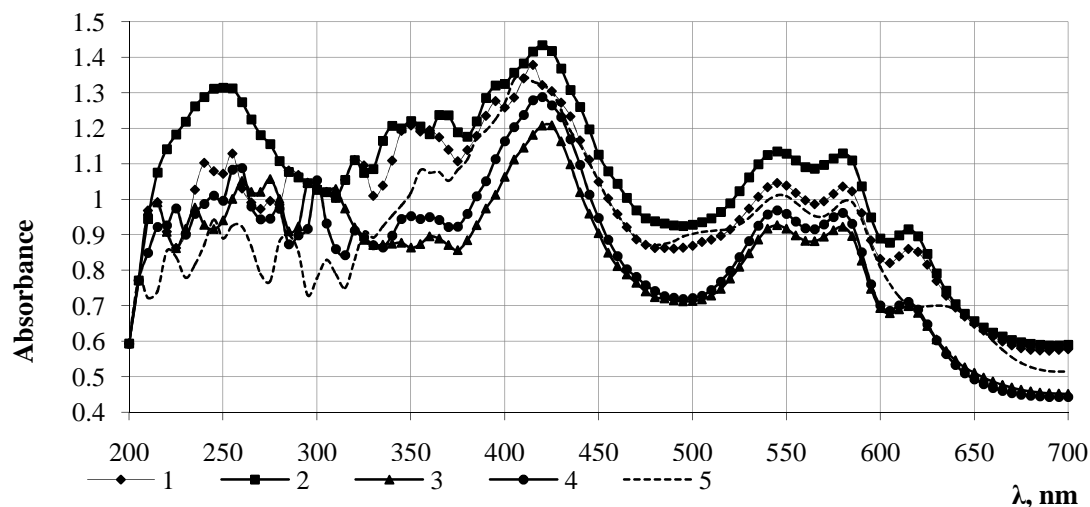


Figure 5. Electronic spectra of absorbance of sample transversal section surface of intact beef muscle tissue

Absorbed dose: 1 – 12.5; 2 – 25.0; 3 – 37.5; 4 – 50.0 kGy; 5 – control

Electronic spectra of absorbance show (Fig. 5) that samples transversal section surface of intact beef muscle tissue are more stability for electron-beam treatment than such samples pork muscle tissue, because in this case the process of radiolysis directed on carbohydrate and lipids components muscle tissue.

Conclusions

1. Surface pretreatment of the compact pork muscle sample by ethanol exhibits changes of surface optical properties of the sample after preparing forcemeat.
2. The protein structures are protected by ethanol, which redirect the process of radiolysis to carbohydrate components of muscle tissue.
3. The influence of ethanol on restructured samples is identical to the section samples of muscle tissue, but the beef muscle tissue is more resistant to the ionizing radiation than the pork.

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