DETECTION OF CHICKEN MEAT ADULTERATION IN MEAT MIXTURES WITH FOURIER TRANSFORM INFRARED (FT-IR) SPECTROSCOPY

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Abstract – Replacement of premium-quality meats with cheaper meats in order to lower the cost has been a common way of adulteration all over the world and meat authenticity focusing on determination of species has been becoming an emerging area of research. The current study was aimed to detect the meat types at different concentrations in the mixed raw meat samples by using FT-IR spectroscopy. Mixtures of chicken meat and beef were prepared by adding chicken meat at 0, 20, 40 and 100% (wt/wt) concentrations to beef as the main meat type. The IR spectrums were promising indicating that especially five bands (wavenumbers between 2917-2920 cm^{-1}, 2849-2850 cm^{-1}, 1740-1742 cm^{-1}, 1196-1197 cm^{-1}, 1176-1177 cm^{-1}) could be used in identifying species in the beef and chicken meat mixtures.

Key Words – Beef, Chicken meat, FT-IR spectroscopy

I. INTRODUCTION

Addition or replacement with different types of meat species or tissues in meat products is a common practice applied in most of the countries in the World for lowering the cost and improving the sensory and physical characteristics of the end product. However, substitution of premium-quality meats with low-cost meat species is considered fraudulent practices if it is not indicated on the label. Utilization of specific types of meats that are excluded from the diet due to religion concerns without accurate labeling has also been experienced.

At the present time, meat authenticity focusing on determination of species or origin has been drawn a great attention as an emerging area of research with scientific and technological developments in this regard [1]. Although histological tests, immunoassays or DNA analysis have been used for this purpose, there is a need to develop more reliable and faster techniques. In recent years, Fourier Transform Infrared Spectroscopy (FT-IR) has become a possible technique used for studies on species or origin detection in food products [2-4]; whereas, research conducted on this area is limited.

The present study was designed to overcome the voids in meat authenticity and thus, to contribute food safety. The aim of using FT-IR in this study was to determine differences in component structures specific to different meat species; to investigate if the changes in this structure could be used as specific biomarkers; and further to develop a method with FT-IR spectroscopy in order to evaluate meat products produced by using beef and chicken.

II. MATERIALS AND METHODS

Beef and chicken meats were utilized in species identification studies of raw meat mixtures using Fourier Transform Infrared Spectroscopy (FT-IR). For beef, *Longissimus dorsi* muscle and for chicken meat *Pectoralis major* muscle were used. The main meat type was beef, and chicken meat was added in 0%, 20%, 40% and 100% (wt/wt) proportions to make raw meat mixture. The mixtures were lyophilized (Millrock Freze Dry Ultra Tainer, Kingston, USA) and then shredded in a blender (Fakir^{TM}, Aromatic model, Germany). Spectroscopy measurements were performed on FT-IR spectroscopy (Bruker Tensor 37, USA). Spectra recorded the mid-infrared region, between 3800-850 cm^{-1} wavenumbers and interferograms were accumulated for 16 scans at 4 cm^{-1} resolution at 22ºC with a ZnSe attenuated total reflection (ATR) crystal (Pike Miracle ATR Cell). The spectrometer was controlled using OPUS software

(Version 5.5, Bruker Inc., USA). Spectras were collected in five replicates.

The experimental data were subjected to Analysis of Variance (One-Way ANOVA) and the significant differences between mean values were evaluated by Tukey HSD Multiple Comparison Test. Data analysis was performed using an SPSS package (SPSS 17.0 for Windows, SPSS Inc, Chicago, IL, USA).

III. RESULTS AND DISCUSSION

In this study, totally five characteristic bands were determined in order to distinguish beef and chicken mixtures. The locations of these bands and the obtained spectrums are shown in Figure 1 and also the wavenumbers and the intensities are given in Table 1.

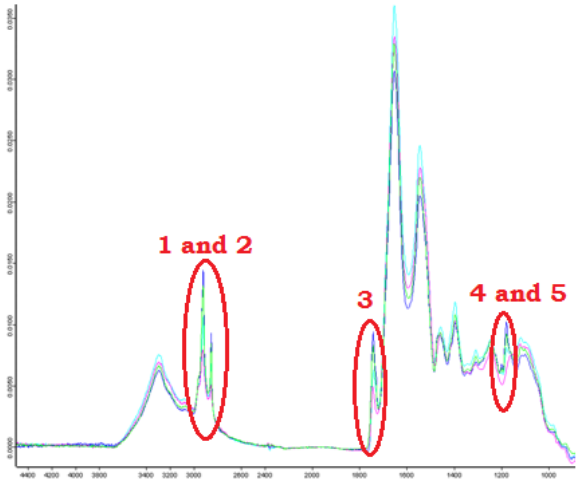

Figure 1 The general IR spectrum and number of the characteristic IR bands of beef-chicken meat mixtures.

The maximum differences between the spectrums of the samples were found 2917-2920 cm^{-1}, 2849-2850 cm^{-1}, 1740-1742 cm^{-1}, 1196-1197 cm^{-1}, and 1176-1177 cm^{-1} wavenumber ranges.

The fundamental vibrations in the 3000–2850 cm^{-1} are generally originated from C–H stretching bands from aliphatic hydrocarbon compounds. The C–H stretching bands of methyl groups (2920 and 2851 cm^{-1} are the asymmetric vibrations respectively) and methylene groups (2954 and 2860 cm^{-1} are the asymmetric vibrations respectively) are readily differentiated in this region. The most intense vibrations in the IR spectra of lipid systems in tissues are the CH_2 stretching vibrations [5].

2916-2919 cm^{-1} is characteristic for stretching vibrations of C-H, CH_2&CH_3 of phospholipids, cholestrol and creatine, 2922 cm^{-1} is for asymmetric stretching vibration of CH_2 of acyl chains (lipids) while 2850 is for C-H stretching vibrations of CH_2, lipids, fatty acids [6, 7].

The first and second characteristic bands in **Erreur ! Référence non valide pour un signet.** are due to fat content of the mixtures. It is apparent that the signals significantly decreased with the increase in chicken meat ratio. This result suggests that these signals could be used species identification in the meat mixtures. For instance, with increasing concentration of chicken meat, the intensity of the first band (2917 cm^{-1}) showed decreases which could be explained by the fact that cholesterol level of beef was higher than chicken meat [8]. Therefore, the cholesterol level of the mixture decreased when chicken meat was added to the beef-chicken meat mixture (**Erreur ! Référence non valide pour un signet.**).

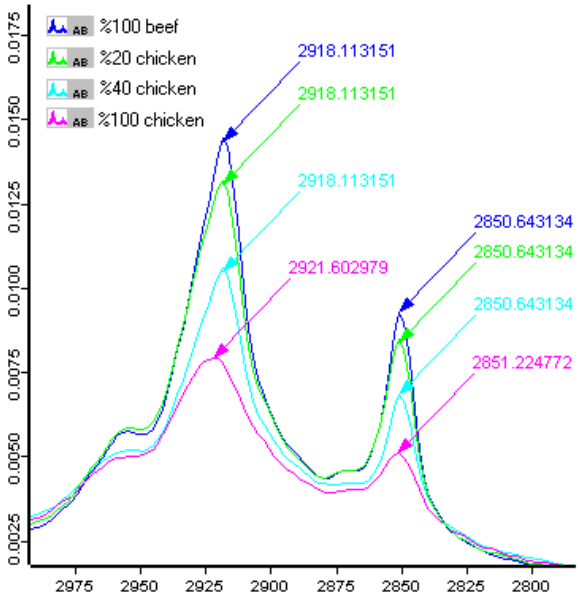

Figure 2 Zoomed view of first and second characteristic bands in IR spectrum obtained from chicken, beef and mixtures.

Table 1 The wave number and absolute intensities of characteristic bands of beef-chicken meat mixtures

	Band 1		Band 2		Band 3		Band 4		Band 5	
Species in the mixture	Wavenumber (cm^{-1})	Intensity	Wavenumber (cm^{-1})	Intensity	Wavenumber (cm^{-1})	Intensity	Wavenumber (cm^{-1})	Intensity	Wavenumber (cm^{-1})	Intensity
100% Beef	2917.0413	0.014	2849.8401	0.009	1741.3940	0.168	1197.1902	0.007	1176.8726	0.008
20% Chicken	2917.3238	0.013	2850.1701	0.009	1740.6651	0.008	1197.3347	0.006	1177.0331	0.009
40 % Chicken	2917.3853	0.011	2849.8399	0.007	1740.2697	0.006	1197.1209	0.006	1177.0756	0.008
100% Chicken	2920.0050	0.008	2850.3751	0.005	1742.8112	0.005	-	-	-	-

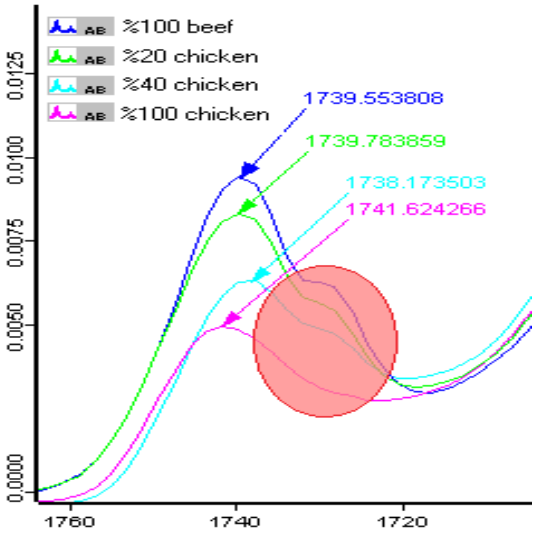

Figure 3 Zoomed view of third characteristic band in IR spectrum obtained from chicken, beef and mixtures.

With increasing chicken meat level, a decrease in the intensity of third characteristic band which has 1739 cm^{-1} wavenumber and also a shoulder band (shown in red circle) were detected (**Erreur ! Source du renvoi introuvable.**). These types of bands could probably be very decisive distinctions between bands. 1740 cm^{-1} is characteristic for C=O stretching of lipids [6, 9] while the region from 1300 to 1100 is dominated by phosphodiester stretching bands region (for absorbances due to collagen and glycogen) [6, 10].

1176 cm^{-1} wavenumber band of 100% beef sample was closer to 100% chicken's band by addition of chicken in mixture. 1161-1162 cm^{-1} wavenumber was indicated due to stretching modes of the C-OH groups of serine, threonine, and tyrosine residues of cellular proteins [6]. 1196 cm^{-1} wavenumber band was not found in chicken meat. Therefore, increasing the amount of chicken meat in mixtures can be interpreted in the spectrum as a reduction in the band intensity. It was observed that same situation in 1176 cm^{-1} wavenumber band and also a shift which was noticed in 1176 cm^{-1} wavenumber band due to chicken meat (Figure 4). The distinctive properties of these bands can be considered as the strong candidates for determination of the chicken- beef meat mixtures. Sample containing 100% beef gave a characteristic band which has 1176 cm^{-1} wavenumber. This band showed a distinct shift in comparison with samples that containing 100% chicken and other mixtures. This shifted band was monitored with 1162 cm^{-1} wavenumber (Figure 4).

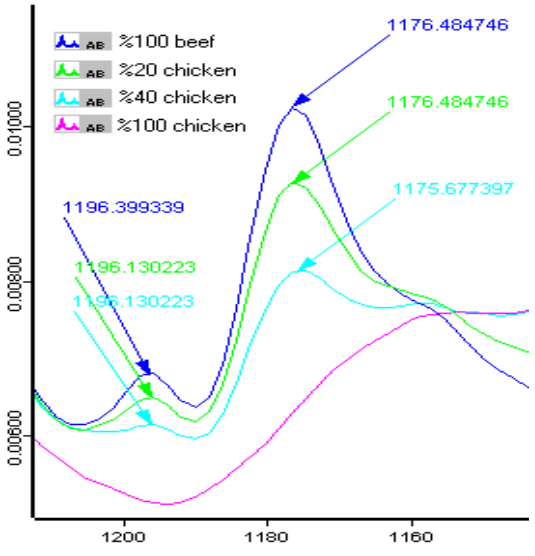

Figure 4 Zoomed view of 4th and 5th characteristic bands in IR spectrum obtained from chicken, beef and mixtures.

Area values were calculated of characteristic bands in the IR spectrums obtained from chicken, meat and mixtures. The zoomed views of the

characteristic bands were supported with these values which are distinctive (Table 2, Figure 5).

Table 2 Changes of the area values of the characteristic peaks in chicken-beef mixtures

	Band 1	Band 2	Band 3	Band 4	Band 5
%100 beef	$0.363^{a} \pm 0.053$	$0.098^{a} \pm 0.002$	$0.159^{a} \pm 0.006$	$0.017^{a} \pm 0.0005$	$0.096^{a} \pm 0.004$
%20 chicken	$0.356^{a} \pm 0.012$	$0.097^{a} \pm 0.003$	$0.144^{a} \pm 0.007$	$0.016^{a} \pm 0.0007$	$0.083^{a} \pm 0.003$
%40 chicken	$0.275^{b} \pm 0.011$	$0.064^{b} \pm 0.007$	$0.099^{b} \pm 0.007$	$0.014^{b} \pm 0.0008$	$0.039^{b} \pm 0.004$
%100 chicken	$0.210^{c} \pm 0.042$	$0.046^{c} \pm 0.001$	$0.068^{c} \pm 0.003$	$0.000^{c} \pm 0.000$	$0.000^{c} \pm 0.000$

[a-d] The means having different letters in the same column are significantly different ($p<0.05$).

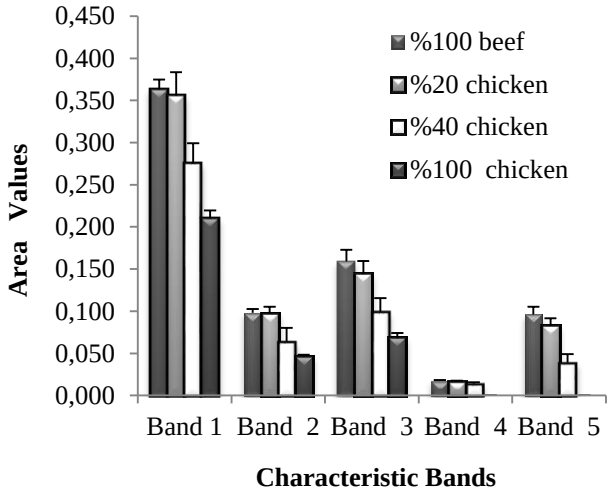

Figure 5 Changes in area values of the characteristic peaks in the chicken-beef mixture

According to the results of the current study, these five bands intensities could be used for identification of beef and chicken meat types.

IV. CONCLUSIONS

FT-IR could be fast and low-cost when compared to the alternatives. On the other hand, according to DNA/RNA-based methods is limited that detection of offal, bond, cartilage contaminations. FT-IR method, which can be defined as entry system of metabolomics, has a great potential to detect authentications in meat mixtures. Besides the data exhibited in this paper are guiding, the further experiments like using the other meat types are planning to perform.

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