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IDENTIFICATION OF MEAT TYPES BY ULTRASONIC METHODS

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Abstract

The ability of identification of meat types using ultrasonic measurement was evaluated in this work. Four types of muscles were analyzed (turkey breast and thigh, and pork loin and ham). Ultrasonic measurements were performed at storage (5 ± 1^{o}C) and room (20 ± 1^{o}C) temperatures using the through-transmission technique and differential method of determination of sound velocity and the attenuation coefficient. The mean values of sound velocity for the breast, thigh, loin and ham were respectively: 1550.7, 1536.6, 1558.7, 1559.7 m/s at the storage temperature, and 1582.7, 1578.5, 1596.9, 1592.7 m/s at the room temperature. The mean values of the attenuation coefficient in the same order were: 21.3, 23.2, 30.6, 28.1 m^{-1} and 22.2, 18.9, 22.0, 22.4 m^{-1}. Statistically significant differences in the sound velocity were observed between pork and turkey muscles, therefore, the meat of those species can be identified based on ultrasound measurements of sound velocity. The attenuation coefficient cannot be applied in the identification of meat types due to absence of significant differences in the mean values.

Symbols:
A – amplitude of registered ultrasound signal, mV,
c – sound velocity, m/s,
d – distance between transducers (sample thickness), m,
α – acoustic attenuation coefficient, m^{-1},
t – temperature, ^{o}C,
τ – time, μs.

Introduction

Cases in which food producers adulterate the composition of their products, intentionally or not, are well known. Some manufacturers cheat by adding or substituting ingredients in food products for cheaper ones to earn more profits (MOORE et al. 2012). Such illegal practices are also noted in the meat

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processing. In a recent publicized case, undeclared horse meat was added to meat products (PREMANANDH 2013). Whereas, the identification of the origins of meat is of great importance due to public health, legal and economic concerns as well as religious and ethical considerations (AMARAL et al. 2014).

Several modern techniques allow to identify meat type or some additives used in meat production. They include measurements of stable isotope ratios, histology and image analysis, spectroscopy, metabolomics and polymerase chain reaction assays, which have been described in detail by SENTANDREU and SENTANDREU (2014). Despite numerous advantages, the above methods share a common disadvantage: they require sophisticated equipment, which makes them comparatively expensive. However, the authentication of meat products should be used as a screening test that is fast, relatively cheap, nondestructive, and uses equipment that is compact and portable. Ultrasonic methods, which are used in the identification of other food products, such as honey (RATAJSKI et al. 2010), offer such capabilities.

A method for determining the composition of biological materials based on the velocity of sound waves penetrating that material is well known (GHAEDIAN et al. 1998, BENEDITO et al. 2001). A research hypothesis was formulated that the above method could be used to determine the proportions of raw meat (muscles of different origins of animals) in a meat product or to verify whether a product contains the raw materials declared by the manufacturer. But it could be possible only if significant differences in sound velocity are observed between ingredients. Therefore, the objective of this study was to evaluate the usefulness of ultrasonic measurements in differentiating various types of meat (e.g. poultry from pork) and muscles using sound velocity.

Materials and Methods

Four types of muscles were used in this study: pork loin (*m. longissimus dorsi*), pork ham (*m. biceps femoris*), turkey breast (*m. pectoralis major*) and turkey thigh (*m. extensor iliotibialis*). Every type of meat was represented by 30 samples, each obtained from a different animal. The muscles were analyzed 48 hours *post mortem*. They were regarded as food rather than living tissue, therefore, they were not de-aired.

Ultrasonic measurements were performed at storage temperature (5 ± 1°C) and room temperature (20 ± 1°C). The signals were acquired by the through-transmission (TT) technique perpendicular to muscle fibers. The experimental stand consisted of the OPBOX 2.0 acoustic pulser-receiver (PBP Optel, Poland) and transducers with nominal frequency of 2 MHz (PBP Optel, Poland). The experimental set up is shown in Figure 1.

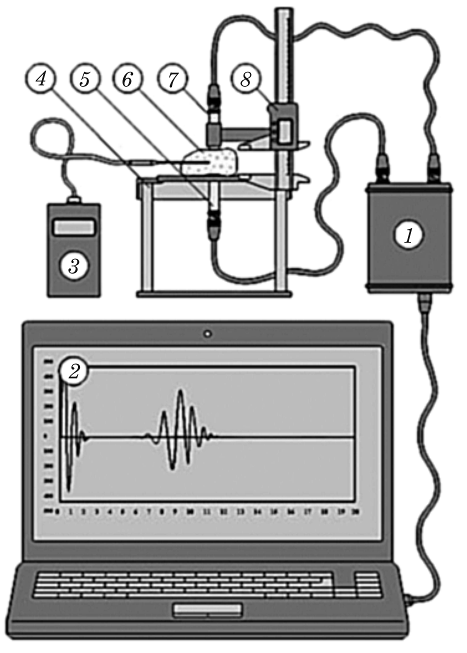

Fig. 1. Experimental stand: *1* – OPBOX 2.0, *2* – PC, *3* – electronic thermometer, *4* – platform, *5* – fixed acoustic transducer, *6* – sample, *7* – movable acoustic transducer, *8* – electronic caliper

Sound velocity was determined by the differential method (using two samples of the same material with different thickness) (NOWAK, MARKOWSKI 2013) based on Equation 1, where: d_1 and d_2 are thicknesses of thick and thin samples; τ_1 and τ_2 are time of flight (in this case, time when the received signal reaches maximum amplitude).

$$c = \frac{d_2 - d_1}{\tau_2 - \tau_1} \tag{1}$$

The attenuation coefficient was determined based on Equation 2.

$$\alpha = \frac{1}{d_2 - d_1} \ln \frac{A_1}{A_2} \tag{2}$$

The results were processed using one-way analysis of variance (ANOVA) and the Kruskal-Wallis nonparametric test at the significance level of $p = 0.05$. The Kruskal-Wallis test was chosen because the variances were heterogeneous. Data were processed in the STATISTICA 10.0 package (Stat Soft Inc., USA). The mean values of sound velocity, attenuation coefficient and the results of the statistical analysis are shown in Table 1. The correlations between the results are presented in Figure 2.

Table 1
Mean values of sound velocity and the attenuation coefficient in the analyzed muscles (standard deviation values are given in brackets)

Muscle	Sound velocity c [m/s]*		Attenuation coefficient α [1/m]*	
	$t = 5 \pm 1°C$	$t = 20 \pm 1°C$	$t = 5 \pm 1°C$	$t = 20 \pm 1°C$
Turkey breast (*m. pectoralis major*)	1550.7 (5.4)^{A}	1582.7 (6.3)^{A}	21.3 (10.4)^{A}	22.2 (10.1)^{A}
Turkey thigh (*m. extensor iliotibialis*)	1536.6 (8.6)^{B}	1578.5 (5.7)^{A}	23.2 (11.7)^{A,B}	18.9 (7.7)^{A}
Pork loin (*m. longissimus dorsi*)	1558.7 (8.5)^{C}	1596.9 (4.7)^{B}	30.6 (13.0)^{B}	22.0 (9.4)^{A}
Pork ham (*m. biceps femoris*)	1559.7 (5.5)^{C}	1592.7 (5.9)^{B}	28.1 (13.4)^{A,B}	22.4 (12.1)^{A}

* Values in the same column marked with different letters are statistically different (p=0.05).

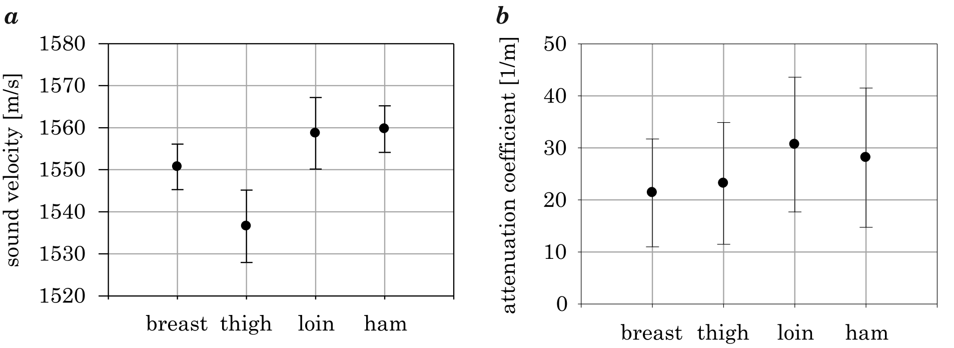

Fig. 2. Sound velocity and attenuation coefficients in the analyzed turkey and pork muscles at storage temperature (5 ± 1°C)

Results and Discussion

The mean values of the determined parameters and the results of the statistical analysis are presented in Table 1. Sound velocity in pork loin (*m. longissimus dorsi*) was similar to that reported in a different study (NOWAK, MARKOWSKI 2013) where it reached 1557.4 m/s at storage temperature and 1598.3 m/s at room temperature. At near room temperature (24 ± 0.5°C), sound velocity for the above muscle was determined at 1601.4 by SARVAZYAN et al. (2005). At room temperature, sound velocity in turkey breast was somewhat higher than that determined by GLOZMAN and AZHARI (2010) at 1576.3, but in the cited study, the muscles had been prepared to be as homogenous as possible, which probably resulted in lower sound velocity values. The above authors described the measurement technique, but failed to indicate the method of determining sound velocity (in particular time of flight). Whereas, the choice of method for determination of sound velocity based on the received acoustic signal can significantly underestimate the results (NOWAK, MARKOWSKI 2013).

Significant differences between mean values of sound velocity were noted in turkey muscles at storage temperature, and the observed values differed significantly from the relevant results in both pork muscles. The mean values of sound velocity did not differ significantly between pork muscles. At room temperature, no statistically significant differences in mean sound velocity values were found in the group of the analyzed turkey muscles or in the group of the evaluated pork muscles, but significant differences were observed between those groups. The above indicates that turkey muscles differ significantly from pork muscles in sound velocity regardless of temperature.

Taking into account the mean values of the attenuation coefficient at storage temperature, groups of turkey muscles and pork muscles did not differ significantly. No significant differences in the values of the attenuation coefficient were noted between turkey breast and turkey thigh, or between turkey thigh vs. pork loin and pork ham. There was a general absence of significant differences in the attenuation coefficient at room temperature.

Temperature seems to play a key role in the identification of meat types based on sound velocity. In this study 5°C increase in the temperature of a meat sample increased mean sound velocity by about 10 m/s, whereas the differences in mean sound velocity of turkey breast and both pork muscles were below 10 m/s. The above suggests that inaccurate temperature measurements can be largely responsible for errors in the future identification of meat from different animal species using sound velocity.

Conclusions

Statistically significant differences in the sound velocity were observed between pork muscles and turkey muscles, therefore, the meat from these two species can be identified based on the results of ultrasound measurements, in particular measurements of sound velocity. It should be noted that inaccurate temperature measurement and sound velocity determination can undermine the reliability of such identification of product ingredients.

The attenuation coefficient was not effective in differentiating meat types due to high standard deviation and the resulting absence of significant differences in the mean values of the attenuation coefficient describing the muscles of different species.

Further research is needed to evaluate the meat of other species (e.g. beef and chicken) and measure sound velocity in muscles that have been blended, mixed and thermally processed.

Acknowledgements

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