NOVEL APPROACH TO USG MEASUREMENTS ON THE *LONGISSIMUS* MUSCLE OF PIG CARCASSES

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Abstract – USG images of m. longissimus were taken between the 10 th and 11th thoracic vertebrae of 36 pig carcasses at two scanning sides: external (from the backfat side) and internal from the ribcage side). The brightness of the 3rd (114.7) and the 4th (105.9) region of images made at the internal scanning side was higher comparing to 3rd (98.4; P≤0.05) and 4th (77.1; P≤0.01) region of images made at the external scanning side. Though the brightness of images obtained at both sides was affected by the region of the image (P≤0.01). The images obtained at the external scanning side characterized with the biggest changes of brightness between regions (P≤0.01). The 2nd region had lower brightness than the 1st region by 36.8 points, the 3rd region had lower brightness than the 2nd region by 34.2 points, and the 4th region had lower brightness than the 3rd region by 21.3 points. The presented results indicate, that changing the USG scanning side on pig carcasses from external to internal enables to obtain high quality USG images of *m. longissimus* without changing the scanning point.

Key Words – Pork carcass, Scanning side, Ultrasound scanning.

I. INTRODUCTION

Research on the applications of ultrasound scanning indicate a significant correlation between the ultrasonic measurements and the real post-slaughter measurements made on animal carcasses. Thanks to the aforementioned the B-mode real-time ultrasound became popular as a non-invasive tool used to assess the body composition, meat yield and meat marbling of different livestock animals [1, 2, 3]. The quality of ultrasound images is defined by the presence of artifacts and the distribution of pixel brightness in the image, and strongly affected by echogenic properties of tissues and organs [4]. Image brightness is mostly affected by tissue interfaces, which interact with travelling ultrasound waves. The type and degree of these interactions depend on the difference in density and acoustic impedance of the neighboring tissues. The more even is the distribution of pixel brightness, the more valuable is the ultrasound image. Proper image brightness guarantees no loss of data and facilitates processing and analysis of digital images [5, 6]. Acquisition of good quality USG images is not always possible. In case of pork carcasses ultrasonic cross-sections of *m. longissimus* are strongly affected by the structure (number of layers) and thickness of backfat [5]. Thick and splitted backfat results in reverberation, an artifact caused by interaction of ultrasound with two strong parallel tissue interfaces, causing the sound beam to reflect back and forth between these interfaces. In consequence, multiple echoes are recorder, and displayed as numerous linear reflections [6]. The aim of the presented research was to solve the problem of the negative influence of backfat on the quality of ultrasonic cross-sections of *m. longissimus* of pig carcasses, not by changing the scanning point (between the 10th and 11th thoracic vertebrae) but by changing the side of ultrasound probe placement. The scientific hypothesis assumed that scanning the carcasses at the same point but from the inner side of the carcass should result in acquisition of USG images free of artifacts and other image distorts.

II. MATERIALS AND METHODS

Ultrasonic cross-sections of *musculus longissimus* between the 10th and 11th thoracic vertebrae were obtained on 36 pig carcasses,

directly after slaughter. The selected scanning point was at the same time the point of the lean meat percentage evaluation made with a hand-held opti-needle instrument used in the slaughterhouse for the classification of pig carcasses according to the SEUROP system. The examined group of carcasses of fattener pigs included 13.9% S class, 50% E class and 36.1% U class carcasses. Two scanning sides were analysed: the external (from the backfat side) and internal side (from the rib cage side) between the 10th and the 11th thoracic vertebrae of each carcass. The ultrasound examination was made with Hitachi EUB405B Ultrasound System equipped with a linear-array probe (75 mm, 5 MHz) positioned transversely to the spine. The ultrasound images were recorded in the real-time B-mode. A total of 72 ultrasonic muscle cross-sections was obtained and analysed. The images have been firstly analysed in terms of the presence of artifacts (re-verberations and acoustic shadows). All the images free of artifacts (N = 56) were analysed for brightness distribution in the 0-255 pixel value scale, by means of ImageJ ver. 1.50f3 (2015). The method of brightness evaluation was based on the division of each image into 4 rectangular regions (10x30 mm). On every image the 1st region was located beneath directly the epimysium surrounding the dorsal side of *m. longissimus*, and the three other regions were located beneath the 1st region. Statistical analysis included the Z test used to compare the percentage of images with and without artifacts, and the two-way ANOVA to analyse the influence of scanning side, and image region depth on the brightness of USG images (SAS ver. 9.1) [7].

III. RESULTS AND DISCUSSION

The results of this research show that the scanning side affects the percentage of images carrying artifacts. The internal scanning side allowed to obtained more free of artifacts images in comparison with the external scanning side (100% vs. 55.6%). A significant part (44.4%) of images made at the external scanning side was distorted by reverberations, making those images useless for image processing and analysis. Image brightness expressed in the 0-255 pixel value scale, and its distribution over the USG image is a good indicator of the image quality, and its utility for processing and analysis [5, 8]. The presented research indicates no influence of the scanning side on the brightness of the 1st and 2nd image regions ($P>0.05$) and a significant effect of the scanning side on the brightness of the 3rd and 4th image regions. The brightness of the 3rd (114.7) and 4th (105.9) region of images made at the internal scanning side was higher comparing to 3rd (98.4; $P\leq0.05$) and 4th (77.1; $P\leq0.01$) region of images made at the external scanning side. The study also indicates a significant effect of the depth of image region on image brightness ($P\leq0.01$). The biggest changes of brightness between regions were found for the external scanning side, negatively affecting the processing utility of these images. The 2nd region had lower brightness than the 1st region by 36.8 points, the 3rd region had lower brightness than the 2nd region by 34.2 points, and the 4th region had lower brightness than the 3rd region by 21.3 points. In the case of images of the internal side of pork carcasses the brightness changes with image depth were less sharp (27.2; 17.5 and 8.8 points, respectively). The lower quality of images obtained on the external side of carcasses results from the presence of different tissue interfaces through which the ultrasound waves have to travel before they reach the *longissimus* muscle. The interaction of sound waves with these reflectors includes the phenomena of reflection, scattering, and absorption of ultrasound energy [5, 6]. Therefore the final brightness of the display is uneven, or the abdominal part of the image is lacking, resulting in loss of data.

Table 1. Characteristics of image brightness (0-255 scale) in four regions of *m. longissimus* ultrasonic cross-sections, depending on the scanning side.

Region of image	Mean	Min.	Max.	S.E.
External side				
1st	169.4	115.7	197.3	16.6
2nd	132.6	86.1	168.2	16.4
3rd	98.4	54.7	134.9	13.9
4th	77.1	47.9	116.9	12.4
Internal side				
1st	159.4	86.3	212.5	22.5
2nd	132.2	68.9	181.8	21.7
3rd	114.7	60.5	167.0	10.5
4th	105.9	76.1	158.5	19.0

Table 2. The effect of the scanning side and region of the image on the brightness of ultrasound image.

Region of image	External side LSM ± S.E.	Internal side LSM ± S.E.	The effect of scanning side
1st	169.4±16.6 A	159.4±22.5 A	ns
2nd	132.6±16.4 B	132.2±21.7 B	ns
3rd	98.4±13.9 C	114.7±10.5 C	*
4th	77.1±12.4 D	105.9±19.0 D	**

Means in columns marked with different letters differ significantly at P≤0.01
ns – nonsignificant, * P≤0.05, ** P≤0.01

IV. CONCLUSION

Summing up, the presented results indicate, that changing the scanning side on pig carcasses from external to internal enables to obtain high quality USG images of *m. longissimus*. Selecting the internal scanning side allows to avoid the interaction of sound beam with backfat layers, and therefore helps to prevent image artifacts like reverberations, and loss of important data. Thanks to no ultrasound-backfat interaction the distribution of pixel brightness of images obtained on the internal side of the carcasses is uniform, increasing the processing utility of these images.

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