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Technical Note

Measurement of beef carcass ribeye area and backfat thickness using mobile phone application

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Abstract: Digital image analyses were used to measure livestock. In this study we determine the accuracy of beef carcass measurements obtained from digital images analysed using a mobile phone application. We photographed 100 cross-bred beef carcasses using a mobile phone camera and analysed the images using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application. Both methods were used to measure ribeye area and backfat thickness and the results were compared using a paired *t*-test. Ribeye area and backfat thickness measurements were not significantly different ($p > 0.05$) between the two methods. The correlation between beef carcass images of the ribeye area and backfat thickness analysed using the two methods were very high (concordance correlation coefficients of 0.9997 and 0.9926 respectively). The results of this study suggest that measurements of the beef carcass's ribeye area and backfat thickness can be easily and accurately obtained in the field using ImageMeter® on a mobile device.

Keywords: ribeye area, backfat thickness, beef carcass, digital image, mobile phone

INTRODUCTION

The beef yield grades of the US Department of Agriculture provide an indication of cutability or yield of boneless, closely trimmed retail cuts and are a relatively accurate predictor of carcass composition [1]. Carcass yield grade is determined based on the external fat (fat thickness), ribeye area, kidney, heart and pelvic fat and hot carcass weight [2]. Ribeye area is measured as the surface area (cm^2) of the *longissimus dorsi* muscle between the 12^{th} and 13^{th} ribs. Backfat thickness is measured at a point three-quarters of the length of the *longissimus dorsi* muscle from the split chine bone [3]. The ribeye area and backfat thickness are measured using specific tools. In Thailand the ribeye area is measured by placing a clear plastic sheet onto the carcass and drawing a cross-

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sectional area picture. The cross-sectional area is calculated from the area of a square sheet by estimating from the table for ribeye area and drawing the length of backfat thickness. However, this tool is a complex and cumbersome method.

Digital image analysis using software such as Adobe Photoshop® is used in many fields to measure the size of items in a digital photograph, for example cattle *longissimus dorsi* muscles and backfat [4], the composition of bull rib-cuts [5], plant leaf area [6], genetic parameters in pigs [7] and beef carcass ribeye area and backfat thickness [8]. However, for such analyses, the images must be transferred from the camera to the computer and then analysed using specific software, representing a major limitation of the method. Now mobile technology has advanced the digital image capture comparable to that of conventional cameras but with the benefit of greater convenience and ease of use. Mobile phones can be used to capture images of livestock in the field and smartphone applications have been developed to estimate body measurements from these images [9]. However, to our knowledge, the technology has not been developed for beef carcass measurement.

The aim of this experiment is to evaluate the efficacy of a mobile phone image analysis application for measuring beef carcass ribeye area and backfat thickness in the field.

MATERIALS AND METHODS

Carcass

This study was conducted at Kamphaeng Saen Beef Cooperative Ltd., Nakhon Pathom, Thailand. Beef carcasses were from cross-bred cattle with bloodline containing 25% Thai native cattle, 25% Brahman and 50% Charolais. We analysed 100 beef carcasses. Ribeye areas were photographed after cutting through the 12^{th} and 13^{th} ribs.

Photography

All carcasses were photographed at a distance of 20 cm from the ribeye using a mobile phone camera (Galaxy Tab A 8.0, Samsung®) and an image aspect ratio of 16:9 (width:height). Before each photograph was taken, a 14-cm protractor ruler was placed near the ribeye as a dimensional reference.

Image Analysis

The ribeye area and backfat thickness were measured from the images using Adobe Photoshop® CS6 computer software (Adobe Systems Inc., CA) for comparison with the mobile application results. Image analysis using ImageMeter® mobile application (Algorithmic Research, Germany) was performed as follows [9]. First, a pixel:cm ratio was calculated by measuring the number of pixels contained in the ruler. This pixel:cm ratio was used to transform all measurements on the image of the carcass into cm. The ribeye area (cm^2) was measured as the surface area of the *longissimus dorsi* muscle. The backfat thickness (cm) was measured at a point three-quarters of the length of the *longissimus dorsi* muscle from the split chine bone (Figure 1).

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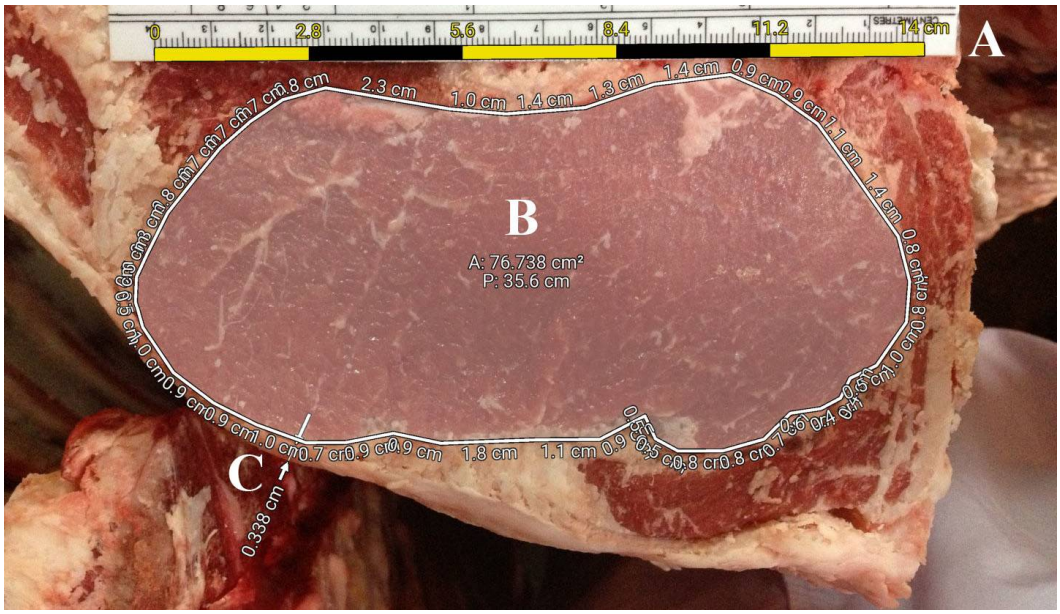

Figure 1. Representative screenshot showing ribeye area and backfat thickness measurements in ImageMeter® mobile application (A: protractor ruler dimensional reference, B: ribeye area measurement and C: backfat thickness measurement)

Statistical Analysis

All statistical analyses were performed using R version 3.6.1 [10]. Measurements are presented as mean ± standard deviation. The mean of ribeye area and of backfat thickness measurements obtained from the two methods were compared using a paired *t*-test. Lin's concordance correlation coefficients [11] were generated for each comparison of beef carcass images analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application. The concordance correlation coefficient takes the slope of the line of agreement as well as goodness of fit of the data into account when evaluating reproducibility of measures using the two techniques [11-13].

As an additional means of evaluating the differences between the two methods of measurement, Bland-Altman graphs of difference versus the mean of pairs of ribeye area and backfat thickness measured from each method were constructed and visually checked [12-14]. A p value ≤ 0.05 was considered significant.

Ethics Statements

This study was approved by Kasetsart University's Institutional Animal Care and Use Committee (Approval no. ACKU64-AGR-010).

RESULTS AND DISCUSSION

The ribeye area measurements obtained from 100 beef carcass images and analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application are not significantly different ($p > 0.05$) at 79.48 ± 10.32 cm^2 and 79.51 ± 10.33 cm^2 respectively (Figure 2). Similarly, the backfat thickness measurements obtained from 100 beef carcass images and analysed using Adobe Photoshop® CS6 and ImageMeter® mobile application are not significantly different ($p > 0.05$) at 0.67 ± 0.15 cm and 0.67 ± 0.16 cm respectively (Figure 3).

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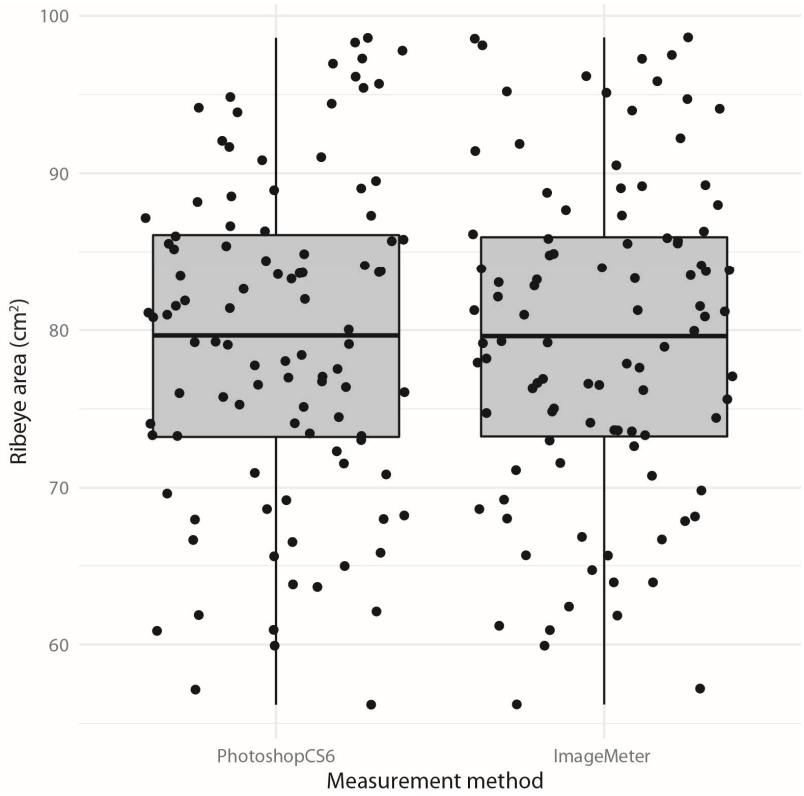

Figure 2. Boxplot of ribeye area measurements obtained from beef carcass images and analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application

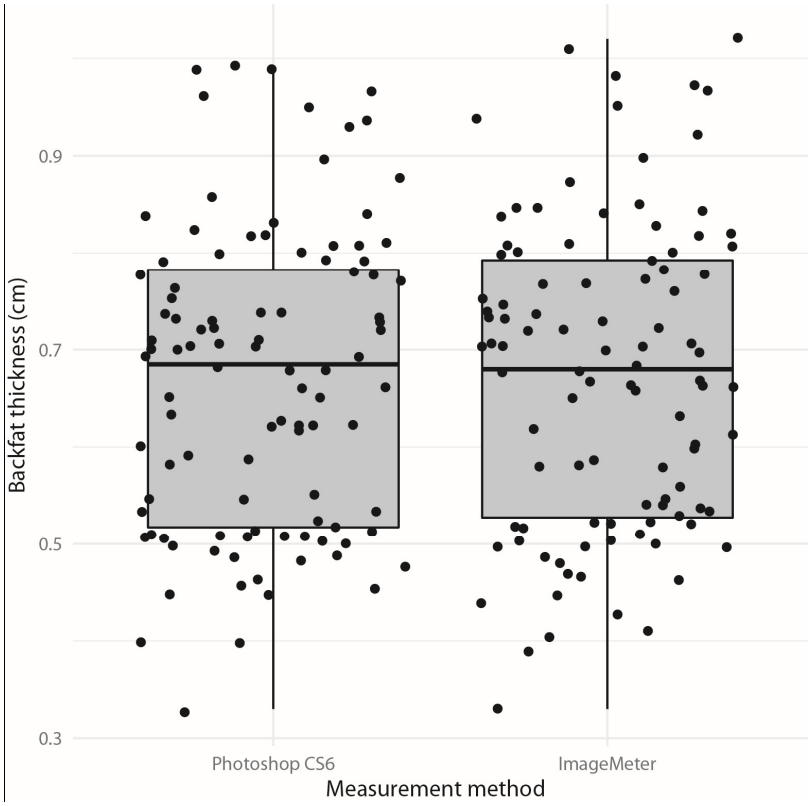

Figure 3. Boxplot of backfat thickness measurements obtained from beef carcass images and analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application

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The concordance correlation coefficients of beef carcass images analysed using Adobe Photoshop® CS6 computer software and those using ImageMeter® mobile application for the ribeye area and backfat thickness measurements are 0.9997 and 0.9926 respectively (Figures 4 and 5).

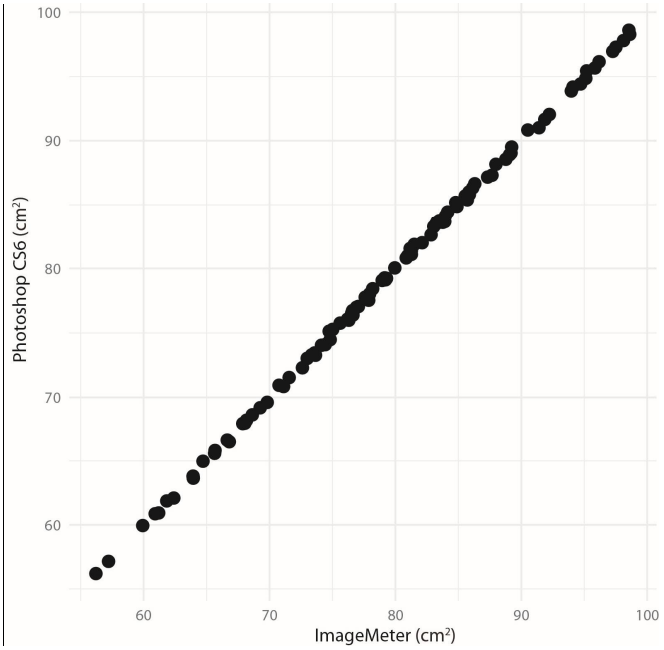

Figure 4. Scatter plot of correlation between beef carcass images analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application for ribeye area measurement (cm^2)

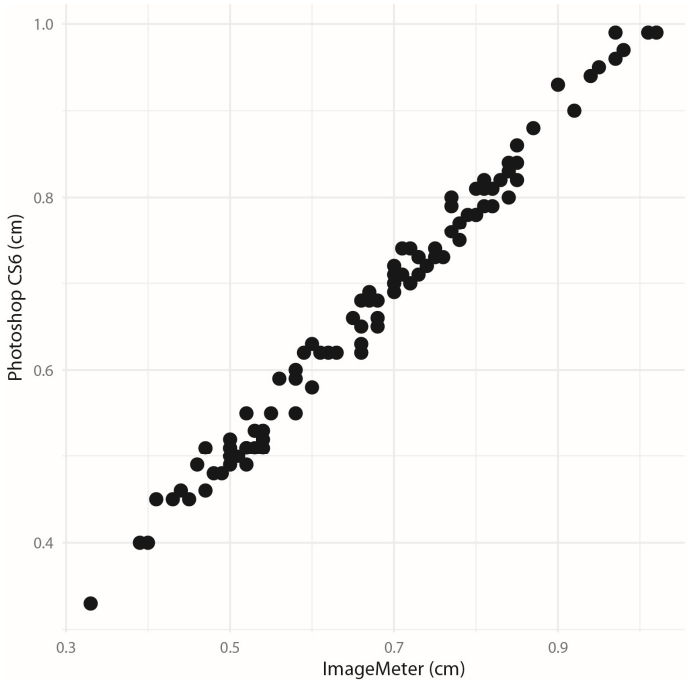

Figure 5. Scatter plot of correlation between beef carcass images analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application for backfat thickness measurement (cm)

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Digital photograph analyses are widely used to enhance productivity in beef processing [4, 5, 8, 15, 16]. There are several reports indicating that Adobe Photoshop® program is used in the computer for size and length measurement of items in a photograph [4, 6-9, 17]. Kapetch et al. [6] found that the paper area in a digital image measured by Adobe Photoshop® was closest to the real area (R^2 = 0.9999). Wongmanopanit [7] had similar success with digital images of pigs using the same procedures for body measurement. Santo et al. [17] demonstrated that Adobe Photoshop® CS6 was effective for breast measurement in women by using a computer and raw files with a specific software without the need for specific training.

Similarly, Nilchuen et al. [8] found that the measurement of rib eye area and backfat thickness of beef carcasses using images processed in Adobe Photoshop® did not differ significantly from measurements taken by the ruler method. However, the study on the use of mobile applications is limited. Nilchuen et al. [9] reported that the chest depth measurement of cow images analysed using Adobe Photoshop® computer program did not differ significantly from that using ImageMeter® mobile application.

In this study the ribeye area and backfat thickness measurements obtained from images of beef carcass did not differ using the computer program and mobile application methods. Moreover, the high concordance in correlation values between the beef carcass images analysed using the two methods suggests that there was very little departure in observation from the perfect 45° line through the origin on the linear regression plot [11-13]. The Bland-Altman graphs of differences and the mean differences of pairs of the ribeye area and backfat thickness measured by each method (Figures 6 and 7) again demonstrate that the agreement between the two methods of measurement is good [12-14].

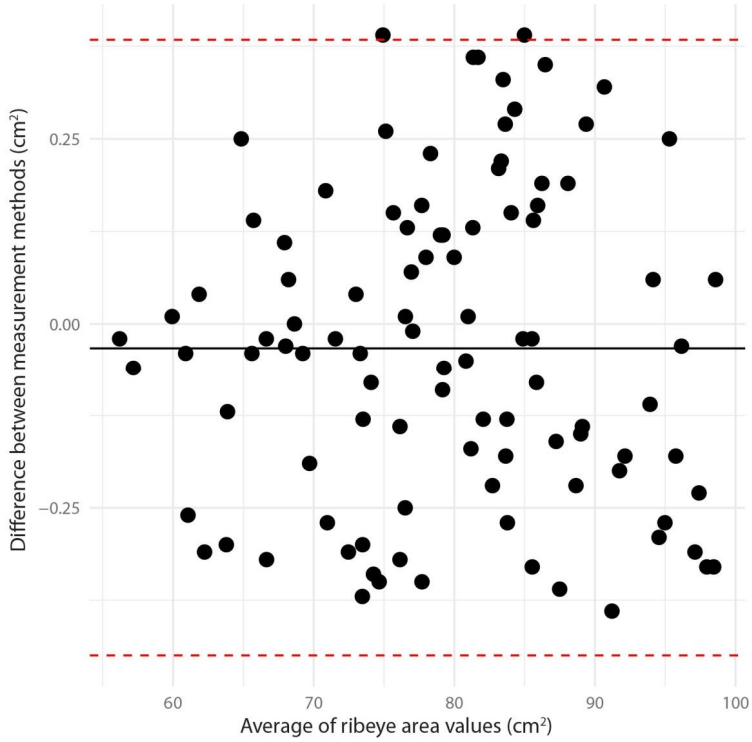

Figure 6. Bland-Altman graphs comparing differences in measurement of beef carcass images of ribeye area analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application. Mean difference is indicated by solid line and 95% confidence interval boundaries are indicated by upper and lower dashed lines.

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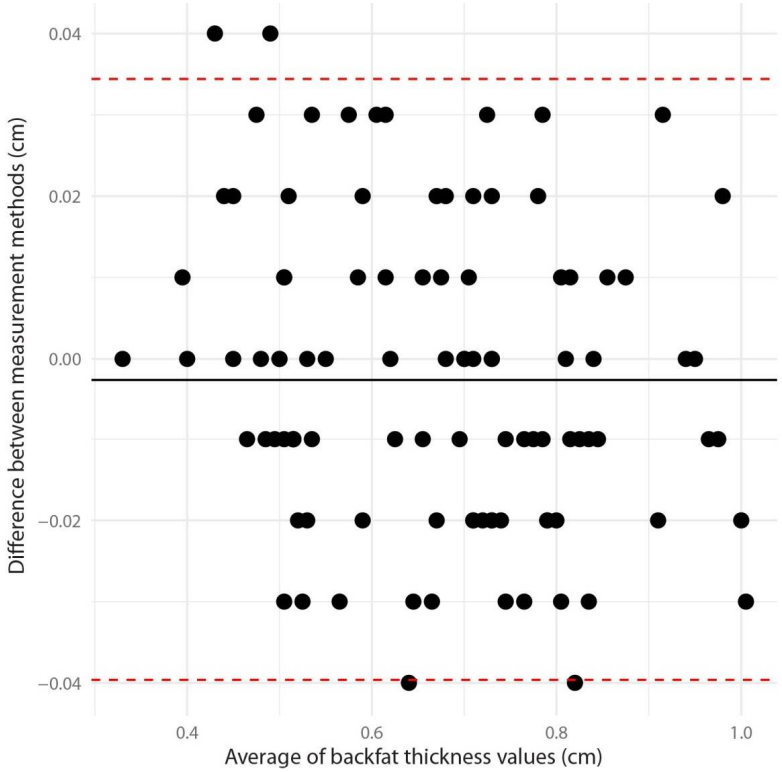

Figure 7. Bland-Altman graphs comparing differences in measurement of beef carcass images of backfat thickness analysed using Adobe Photoshop® CS6 computer software and ImageMeter® mobile application. Mean difference is indicated by solid line and 95% confidence interval boundaries are indicated by upper and lower dashed lines.

In both methods the same principle is employed to obtain measurements from images using a dimensional reference (ruler) for calculating the pixel:cm ratio, which can be used to obtain the length of any measurement in the image [18]. From observations in this study, the area and length measurement accuracy is found to depend on the setting of the camera to an angle of 90 degrees perpendicular to the object's surface and on the drawing of a reference line at a specified distance in the image.

CONCLUSIONS

The ImageMeter® mobile phone application can obtain accurate measurements of the ribeye area and backfat thickness of beef carcasses, providing an alternative to using computer software. Mobile applications are easy to use and convenient and do not require the extra steps of transferring images from the camera to the computer before analysis. This approach can be used with any smartphone that can download this mobile application and requires no specialised equipment.

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