71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

EVALUATION OF VARIABILITY IN CUT DIMENSIONS OF BEEF SHORT RIBS USING COMPUTED TOMOGRAPHY AND 3D IMAGING

Carlos Esquerre[1*], Jyoti P. Mishra[1], Stephen Hegarty[2], Alessandro Ferragina[3], Ruth M. Hamill[1]

[1] Food Quality and Sensory Science Department, Teagasc, Ashtown, Dublin 15, Ireland

[2] Centre for Advanced Photonics and Process Analysis, Munster Technological University, Bishopstown Campus, Cork, Ireland

[3] Department of Veterinary Science, University of Parma, Parma, 43126, Italy

*Corresponding author email: carlos.esquerre@teagasc.ie

I. INTRODUCTION

Variability in beef short ribs (SR) dimensions poses challenges for automated cutting and processing systems, requiring them to handle a range of sizes and shapes. Increasing automation of meat industry can deliver efficiencies, enhance labour availability and safety, and the sustainability of raw materials [1]. Short ribs, which are demanded by several international cuisines, have significant proportions of the four main meat tissues: lean, fat, connective tissue, and bones. SR dimensions are related to the size of the animal (weight), category and conformation. Computed tomography (CT) uses an X-ray generator that rotates around the specimen. Tissue-specific attenuation coefficients can be used to differentiate and quantify tissues, using tomographic reconstruction algorithms, and thus produce tomographic images. CT is recognised as being a gold standard in determining the lean meat content of carcasses and it is used to support calibration of other instruments [2, 3]. Three-dimensional scanning (3DS) provide precise dimensional information about its subject. While both methods are time consuming, they can provide valuable information about the variability in SR and models obtained can facilitate the development of technologies that can be deployed for online digitalisation in a meat-processing factory. The present study acquired and evaluated CT and 3DS data of steers, heifers, young bulls and cows to facilitate the development of automatic processing of bone-in SR products[4].

II. MATERIALS AND METHODS

The SR, corresponding to the 1st to 5th rib, of 42 animal sides were obtained from a commercial beef-processing factory of a range of categories (steers, heifers, cows and young), conformation class (E+, U-, U, R, O, P+), fat score (2, 3, 3+) and weights (118 to 261 kg). Samples were transported to Teagasc Meat Digitalisation Testbed and stored under refrigeration (~4 ºC) until analysis. On the day of the analysis, samples were stored at room temperature for at least 30 minutes before being scanned using an Aquilion Lightning (Canon Medical Systems Europe B.V., Netherlands). The CT scan parameters included helical acquisition, slice thickness 0.8 mm, 100 kVp. CT data was exported as 512 × 512 pixels DICOM files and converted to 3D meshes.
A wireless Artec Leo 3D scanner (Artec Europe, Luxembourg) was used to acquire single definition scans (0.5 mm). The samples were hung from one extremity with a hook to facilitate scanning. Scan data was exported to Artec Studio v17 (Artec Europe, Luxembourg) where was cleaned by removing artefacts and background, registered, converted to a 3D mesh with texture and exported to Wavefront obj format files. The meshes were centred and rotated using their eigenvectors. The depth, width and length of the SR were calculated by the average length of 91 lines parallel to the corresponding axis, the lines were in a grid of 9x9 in the other two dimensions. Bland and Altman diagram and t-test were used to evaluate systematic difference between both methods. Dimension measurements and data analysis was performed using Julia language[5].

III. RESULTS AND DISCUSSION

The surface meshes of both instruments provides topographic information about the SR dimensions and position of the rib bones (Fig 1a). The dimensions distribution per category were similar (Fig 1b). SR of young bulls were slightly longer than the other categories for 3D obtained meshes. The mean values of SR depth, width and length measured with the 3D scanner and CT were similar with 95% confidence (t-test) and Bland Altman diagram demonstrates the difference are random scatter and within d ± 2sd, where d is the mean of the observed difference. The difference between the width measured via 3D and CT was somewhat larger in relation to product depth and length (Fig. 1c). This may be due to the deformation on the product caused by hanging the SR by one extremity. Incomplete correlation is due to the variability in number of individual points assessed for estimation of depth by the different instruments.

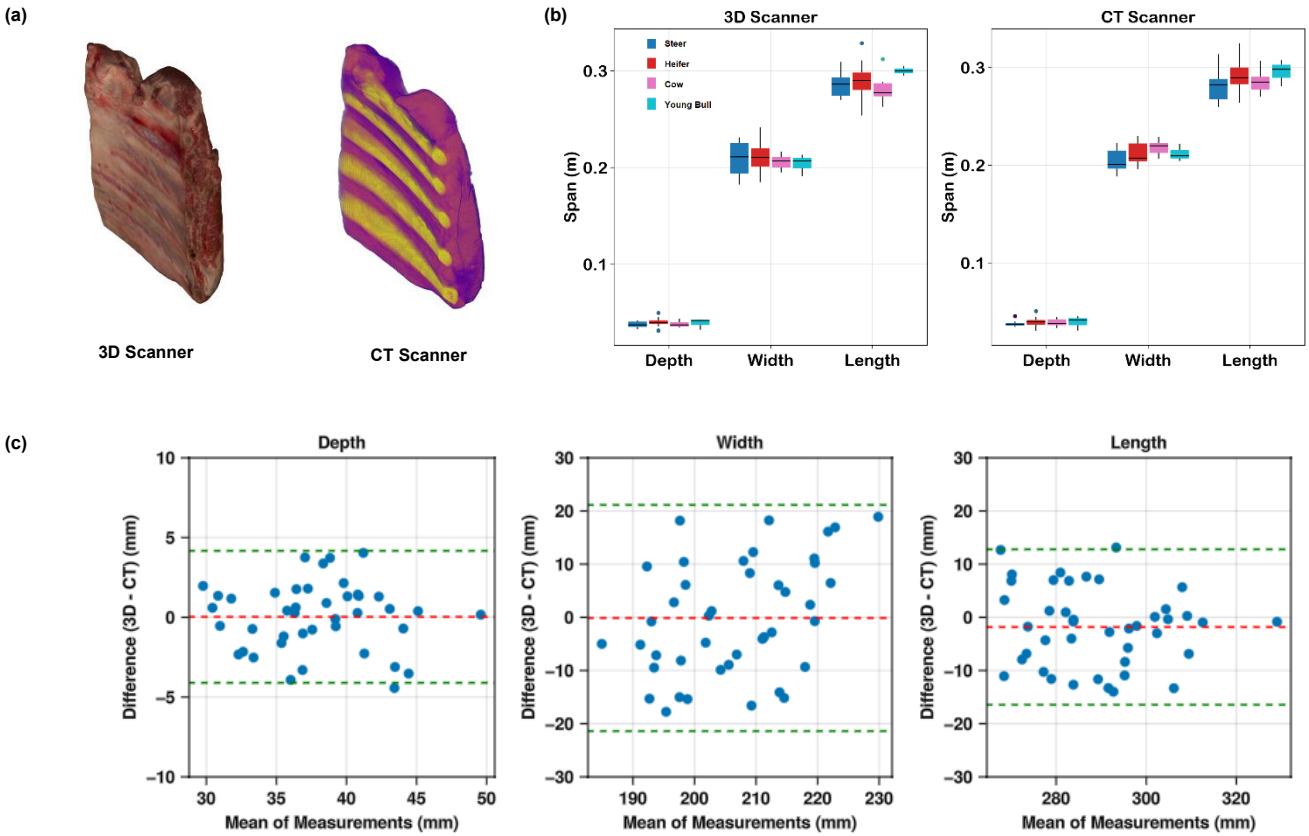


Figure 1. Surface meshes of a sample obtained with 3D and CT scanners, CT mesh false colour using HU (a), distribution of short rib dimensions per category (b), Bland and Altman diagram for the agreement between CT and 3D measured dimensions of short rib (c)

IV. CONCLUSION

There is a good agreement between the dimensions calculated with both instruments therefore the digital image acquired by any of these instruments could be used to create a digital representation of the SR. This could potentially be improved with greater number of comparator points between instruments. Data collected with these instruments can help to understand biological variability among short rib products and product deformation behaviour, providing underpinning information to support progress towards automation in meat processing.

ACKNOWLEDGEMENTS

This work was supported by Meat Technology Ireland (MTI) a co-funded Industry/Enterprise Project (TC 2016 002) and a Teagasc Walsh Scholarship Award (WS 2021039) to Jyoti P. Mishra. We acknowledge the facilitation of Georgios Anagnostou, Teagasc and staff at Liffey Meats, Ballyjamesduff, Co. Cavan.

REFERENCES

1. Hamill, R.M., et al., *Chapter 13 - Toward Meat Industry 4.0: opportunities and challenges for digitalized red meat processing*, in *Food Industry 4.0*, A. Hassoun, Editor. 2024, Academic Press. p. 259-281.
2. Liu, S., et al., *Fat deposition and partitioning for meat production in cattle and sheep.* Animal Nutrition, 2024. **17**: p. 376-386.
3. Delgado-Pando, G., et al., *Objective carcass measurement technologies: Latest developments and future trends.* Trends in Food Science & Technology, 2021. **111**: p. 771-782.
4. Watson, P.F. and A. Petrie, *Method agreement analysis: A review of correct methodology.* Theriogenology, 2010. **73**(9): p. 1167-1179.
5. Bezanson, J., et al., *Julia: A Fresh Approach to Numerical Computing.* SIAM Review, 2017. **59**(1): p. 65-98.