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Short Communications

COMPARISONS BETWEEN THE PORK WARNER-BRAZLER SHEAR FORCE VALUES OF THE ROASTING AND BOILING COOKING METHODS

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SUMMARY

This study focuses on investigating the difference in Warner Brazler Shear Force (WBSF) values of pork meatand its reliability between roasting and boiling cooking methods. Ten samples of *longissimus dorsi* (LD) whole cuts from commercial three-way crosswere trimmed to a length of 4 cm thickness each. Each sample was then separated into 2 groups: Group 1:Roasted with convection oven to internal temperatures of 70°C, and Group 2: Boiled in a water bath of 80°C for 30 min until internal temperature of 70°C. A total of 57 pairs of cylindrical cores (6-7 cylindrical cores) were obtained from each cooked LD for analysis. Difference between the two cooking methods for both the shear force values were compared using pairwise student T test statistical analysis and intraclass correlation coefficient (ICC) was used to establish and quantify reproducibility for reliability of the measurements. The WBSF values for roasted pork is significantly lower ($p<0.05$) than the WBSF values of boiled pork, with very high ICC between both samples [r=0.905, 95% CI (0.64, 0.98)]. Bland & Altman plots subjected to limits of agreements (LOA) also showed good agreements for all the measurements. Roasting gives a lower WBSF values when compare to boiling (0.51kg difference, 10.89% difference). Both roasted and boiled cooking methods can be used to determine the shear force values of pork.

Keywords: Pork; Roasting; Boiling; Warner Bratzler Shear Force, Cooking methods

INTRODUCTION

With consumer preferences changing towards the selections of good quality pork for consumption, the meat industry requires reliable meat quality information in order to guarantee high-quality meat products for consumers. Reliable meat quality information (such as, tenderness, flavour, juiciness, colour and etc), can be provided by different means of assessment, which may include mechanical methods (for example, the Warner-Bratzler shear force), optical methods (for example, colour assessments), electrical probing, ultrasonic measurements, electromagnetic waves, nuclear magnetic resonance-based metabolomics, near infrared spectroscopy and so on (Damez & Clerjon, 2008, Straadt *et al,* 2014).

For pork, tenderness of meat texture was found to be the most important quality attribute to consumers (Steenkamp and van Trijp, 1988). Being the most widely used and preferred systematic instrumental measures of meat tenderness, Warner-Bratzler shear force (WBSF) texture analysis is often used for objective instrumental approximate of meat tenderness. The texture assessment on cooked meat is made by running it through a texture analyser or a texturometer or tenderometers, which allows tissue resistance to both the fibre shearing and also the compression of the meat to be measured (Wheeler *et al.,* 1997a).

After its first introduction and establishment of the WBSF in the late 1920s, K. F. Warner and his associates, it continued to be further refined by other researchers on its specifics (such as the cooking methods before shearing, blade shape, blade thickness, shearing speed and etc) (Warner, 1952, Bratzler, 1949, Murray and Martin, 1980, Murray *et al,* 1983, Savell *et al.,* 1994, Wheeler *et al,* 1994, Wheeler *et al.* 2005). Research on WBSF are mostly done on beef steaks, but T.L. Wheeler and his associates have also recommended methods which they find to be accurate and repeatable for shear force measurement in pork *longissimus dorsi* (Wheeler *et al.* 2005).

One of the factors affecting the repeatability of shear force is the cooking method used, such as the hot water bath, belt grill cookery, open-hearth electric broiler cookery, and etc (Wheeler *et al.* 2005). Recent trends in consumer cookery methods shows that the consumers' preference of tenderness lean towards the roasted, grilled, and fried meat. In a survey done by Ngapo et al. (2012) for pork consumers, it was found that 70% of the consumers prefer to roast their pork, with only 10% preferring to boil their meat in Québec, Canada, while in France, it was 30% and 7% respectively (Ngapo*et al.*, 2004). Preference in Taiwan showed a different trend, with 14% of the consumers preferring to roast, while 53% prefer to boil (Chen *et al.,* 2010). On the other hand, the WBSF protocol commonly practiced in laboratories involves cooking the meat in plastic bag in a constantly heated hot water baths (boiling cookery method), as suggested by Honikel (1998). AMSA (1995) also describes the use of oven heating laboratory methods, to investigate towards the trends of consumers' preferences. In both cooking both methods, it is recommended that the steaks are removed when an internal temperature of 71°C is achieved, with similar laboratory procedures for WBSF value determination thereafter. However, there are no direct comparison and verification between the WBSF

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values of both methods and its reliability. Due to the difference, we have decided to look into the effects of different cooking method (the roasting and boiling method) on the WB shear force values of pork *longissimus dorsi.*

The present study aims tocompare the average values of the Warner-Bratzler shear force values between roasted and boiled pork meat. This study also attempts to make a comparison of the reliability of measurements obtained from the roasting and boiling cooking methods for WBSF values evaluation of pork meat quality.

MATERIALS AND METHODS

Animals

Ten commercial three-way cross *longissimus dorsi*(LD) wholesale cuts with desirable fresh meat characteristics, each 10 cm in length were obtained from commercial pork outlets of the same areawho obtained their pork from a government licenced slaughter house. The sampels were each immediately trimmed to a length of 4 cm thickness each and separated into 2 groups for further laboratory tests.

Laboratory evaluations

Each adjacent sample were separated into 2 groups; Group 1: Roasted with convection oven at a constant temperature of 80°C to internal temperatures of 71°C, and Group 2: Boil in a water bath of 80°C for 30 minutes until internal temperature of 71°C. Roasts were wrapped individually in aluminium foil and cooked in Kenmore electric range (model 103.9367613) at a constant temperature of 80°C and the internal temperature is monitored by a digital thermometer until it reaches 70°C. Warner Bratzler Shear Force (WBSF) of each sample was then determined by running 10-cylinder cores of 1.27cm in diameter and 2cm in length through a HD plus a texture analyser (Stable Micro System, Surrey, UK.), with a V blade was used (pre-test speed: 3.0 mm s^{-1}; test speed: 1.0 mm s^{-1}; post-test speed: 3.0 mm s^{-1}) with a down stroke distance of 30.0 mm (De Huidobro *et al,* 2005; Van *et al*, 1999). The resistance of the cores to shearing was recorded every 0.01 s and plotted by a computer in a force–deformation plot.Drip loss for each samplewas measured using the hanging bag method (Honikel, 1998) for 24 hours at 4°C.

Statistical Analysis

Difference between the two cooking methods for both the shear force values and drip loss values were compared using pairwise student T test statistical analysis and intraclass correlation coefficient (ICC) was used to establish and quantify reproducibility for reliability of the measurements. Bland and Altman plot were also used to show the agreement in the distribution of the measurements for both methods.

RESULTS AND DISCUSSION

According to the paired student-t test assessment, pork LM chops roasted in conventional oven had lower ($p< 0.05$) shear force values (Table 1) than chops subjected to the boiling method (4.13 kg vs 4.64 kg). Albeit the statistical difference between cookery methods in this study, the differences between the shear force values were small (0.51kg, 10.89% difference). Therefore, this does little to contradict the idea that cookery method has a dramatic impact on shear force values, similar to the study by Apple *et al. (*1999), where the difference is (0.20kg, . Notwithstanding the significance in the shear force values for pork LM chops for different cookery methods, they suggested that the variation in WBSF values may be attributed to different shearing methodology, such as Warner-Bratzler machine, Instron WBS device in compression mode, or Instron WBS device in tension mode (Apple *et al.* 1999), which in our study has been standardized throughout (using only the Warner-Bratzler method) and is ruled out.

Table 1. Shear Force values between roasted and boiled pork from 3 pork outlets in Malaysia

Cooking Method	Mean WBSF values	Standard Error	Reliability
Roasted (kg)	4.132^{a}	0.214	0.905*
Boiled (kg)	4.637^{b}	0.244	

** WBSF values represents the Warner-Bratzler Shear Force values*

However, the difference between within-subject scores is also of interest and taking the mean score of all subjects has the potential to provide misleading estimates. This is because a high scatter of individual difference can result in the difference between the means being non-significant. Therefore, intraclass correlation coefficient (ICC) was also calculated, where the estimated reliability between the two cooking methods is 0.905, with 95% CI (0.64, 0.98), describing the reproducibility of the WBSF values by using these methods for a wide range of values. This infers that the WBSF values for both cooking methods are consistent, reliable and reproducible for each sample, fulfilling the 'test-retest' reliability for WBSF values for pork.

This is further re-established by plotting the Bland and Altman method of analysis to assess the agreement between the two cooking methods on WBSF. The difference between the measurements were analysed, which was suggested to be more appropriate than a reliability coefficient or hypothesis (significance) testing (Rankin and Stokes, 1998). The differences between the two measures were plotted against the average of the two measurements, with the assumption that there is a constant level of error, where the mean increases, so does the difference. The closer is the mean of the difference to zero, and the smaller the value of the SD for the differences, the better the agreement between both cooking methods.The data obtained from the differences

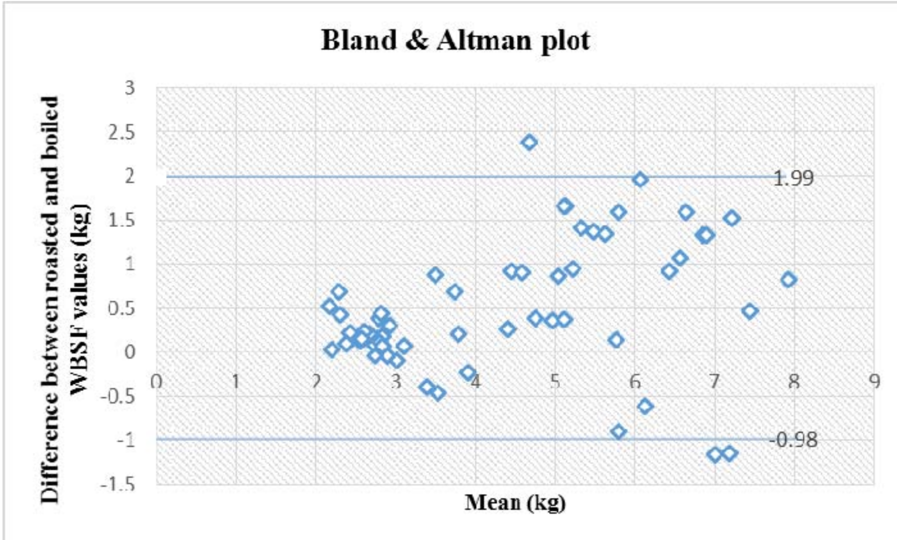

Figure 1. Bland and Altman plot for the difference in WBSF values between the replicates used for the roasted and boiled cooking methods

in WBSF between the two cooking methods were subjected to the 95% confidence intervals for these limits of agreement (LOA), calculated by this formula:

Limits of Agreement = (Mean of Difference) ± 2 (Standard Deviation of Difference)

Where, the means of difference is 0.5047 and the standard deviation of the difference is 0.7440. Therefore, the LOA obtained is between 1.993 and -0.9833 (Figure 1). This is superimposed to allthe difference in the readings of all the replicates (n=57) used for both cooking methods (roasted and boiled). It was found to show good agreement for most cases (majority of the difference lies within the LOA range; n = 54), but with 3 outliers (the values outside the LOA range). Hence, with these evidences for repeatability of measurements between the two cooking methods for WBSF, both the roasting and boiling cooking methods can be effectively used to estimate the WBSF values with good agreement with one another.

For both the roasting and boiling methods, there is considerable consistency in the data obtain, where both methods can be reliably used to estimate pork shear force in a laboratory setting. Results from this study suggests that the roasting of meat may give chops that are more tender than the boiling method, although with very little difference between the two (0.51kg). Our findings differ from the beef modification of the WBSF method, where it was reported that cooking conditions and core orientation significantly affected the shear force values (Wheeler *et al.,* 1994). They also suggested that steaks be cooked to 70°C and cored parallel to muscle fibres to detect the difference between animals. Albeit being adopted and done for both cookery methods in this study, and the WBSF values between the two cooking methods were found to have little significant differences in pork. This suggests that the variability in texture for the *longissimus dorsi* in pork is much smaller than for beef, which could be due to a higher degree of localised muscle shortening in the beef in comparison with the pork (Dransfield and MacFie, 1980).

There are numerous other cooking methods that have been used for research in the past, which includes broiling, cooking research samples inside a plastic bag in a water bath, ultrasound, microwave, deep-fat frying, roasting, impingement oven, and also various methods of grilling or broiling (AMSA, 1995, Chrystall, *et al.,* 1994, Wheeler *et al,* 1998). We found that conventional kitchen oven roasting and boiling of samples in a water bath were found to be widely used locally and are more easily accessible. This simulates the daily cooking method generally used for pork locally and remains relevant to the local consumers. Other methods may require more elaborate equipment, such as an ultrasonic cooker, belt grills or an open hearth electric broiler and etc are more likely to be more expensive, and less assessible to all households and hence, less relevant to the general local consumers.

CONCLUSION

Cooking methods of pork loin affects the WBSF values of LD where roasting gives a slightly lower shear force values when compared to boiling. Both roasted and boiled cooking techniques can be used interchangeably to determine the shear force values of pork in a laboratory setting. Both methods are significantly in agreements with one another, very reliable and are able to estimate the pork quality in a consistent manner.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

STATEMENT OF ANIMAL RIGHTS

Samples were taken in a humane manner, with minimum handling of live animals. Meat and liver samples and data were collected post-mortem.

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REFERENCES

American Meat Science Association (AMSA), (1995). Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. National Live Stock and Meat Board, Chicago.

Apple, J. K., Rakes, L. K., & Watson, H. B. (1999). Cooking and shearing methodology effects on Warner□Bratzler shear force values of pork. Journal of Muscle Foods, 10(3), 269-277.

Boccard, R., Buchter, L., Casteels, E., Cosentino, E., Dransfield, E., Hood, D. E., ... & Tinbergen, B. J. (1981). Procedures for measuring meat quality characteristics in beef production experiments. Report of a working group in the Commission of the European Communities'(CEC) beef production research programme. Livestock Production Science, 8(5), 385-397.

Bratzler, L.J. (1932). Measuring the tenderness of meat by means of a mechanical shear. M.S. Thesis. Kansas State University, Manhattan.

Bratzler, L. J. (1949). Determining the tenderness of meat by use of the Warner-Bratzler method. In Proc. Recip. Meat Conf (Vol. 2, pp. 117-121).

Chen, M. T., Guo, H. L., Tseng, T. F., Roan, S. W., & Ngapo, T. M. (2010). Consumer choice of pork chops in Taiwan. Meat science, 85(3), 555-559.

Chrystall, B. B., Culioli, J., Demeyer, D., Honkiel, K. O., Moller, A. J., Purslow, P. & Uytterhaegen, L. (1994). Recommendation of reference methods for assessment of meat tenderness.

Damez, J. L., & Clerjon, S. (2012). Recent advances in meat science quality assessment. In Y. H. Hui (Ed.), Handbook of meat and meat processing (pp. 161–175) (2nd ed.). New York: CRC Press.

De Huidobro, F. R., Miguel, E., Blázquez, B., & Onega, E. (2005). A comparison between two methods (Warner–Bratzler and texture profile analysis) for testing either raw meat or cooked meat. Meat science, 69(3), 527-536.

Dransfield, E., & MacFie, H. J. (1980). Precision in the measurement of meat texture. Journal of the Science of Food and Agriculture, 31(1), 62-66.

Holman, B. W., Fowler, S. M., & Hopkins, D. L. (2016). Are shear force methods adequately reported?. Meat science, 119, 1-6.

Honikel K. O. (1998). Reference methods for the assessment of physical characteristics of meat. Meat science, 49(4), 447-457. Murray, A. C., & Martin, A. H. (1980). Effect of muscle fiber angle on Warner-Bratzler shear values. Journal of Food Science, 45(5), 1428-1429.

Murray, A. C., Jeremiah, L. E., & Martin, A. H. (1983). Muscle fibre orientation and its effect on measurements of tenderness of bovine longissimus dorsi muscle. International Journal of Food Science & Technology, 18(5), 607-617.

Ngapo, T. M., Martin, J. F., & Dransfield, E. (2004). Consumer choices of pork chops: results from three panels in France. Food Quality and Preference, 15(4), 349-359.

Ngapo, T. M., Riendeau, L., Laberge, C., & Fortin, J. (2012). “Chilled” pork—Part II. Consumer perception of sensory quality. Meat science, 92(4), 338-345.

Rankin, G., & Stokes, M. (1998). Reliability of assessment tools in rehabilitation: an illustration of appropriate statistical analyses. Clinical rehabilitation, 12(3), 187-199.

NCA. (1994). National Beef Tenderness Conference. Natl. Cattlemen's Assoc., Englewood, CO

Savell, J., Miller, R., Wheeler, T., Koohmaraie, M., Shackelford, S., Morgan, B., ... & Dolezal, G. (1994). Standardized Warner-Bratzler shear force procedures for genetic evaluation. http://savell-j. tamu. edu/shearstand. html.

Straadt, I. K., Aaslyng, M. D., & Bertram, H. C. (2014). An NMR-based metabolomics study of pork from different crossbreeds and relation to sensory perception. Meat science, 96(2), 719-728.

Steenkamp, J. E. B. M. & van Trijp, J. C. M. (1988). Kwaliteitsbeoordeling van vers vlees door consumenten. Symposium vleeskwaliteit, 24 June 1988, Ede.

Van Oeckel, M. J., Warnants, N., & Boucqué, C. V. (1999). Pork tenderness estimation by taste panel, Warner–Bratzler shear force and on-line methods. Meat Science, 53(4), 259-267.

Warner, K. F. (1952). Adventures in testing meat for tenderness. In Proc. Recip. Meat Conf (Vol. 5, pp. 156-160).

Wheeler, T. L., Koohmaraie, M., Cundiff, L. V., & Dikeman, M. E. (1994). Effects of cooking and shearing methodology on variation in Warner-Bratzler shear force values in beef. Journal of animal science, 72(9), 2325-2330.

Wheeler, T. L., Shackelford, S. D., & Koohmaraie, M. (1996). Sampling, cooking, and coring effects on Warner-Bratzler shear force values in beef. Journal of Animal Science, 74(7), 1553-1562.

Wheeler, T. L., Shackelford, S. D., & Koohmaraie, M. (1997). Standardizing collection and interpretation of Warner-Bratzler shear force and sensory tenderness data. In Proc. recip. meat conf (Vol. 50, pp. 68-77).

Wheeler, T. L., Shackelford, S. D., Johnson, L. P., Miller, M. F., Miller, R. K., & Koohmaraie, M. (1997). A comparison of Warner-Bratzler shear force assessment within and among institutions. Journal of Animal Science, 75(9), 2423-2432.

Wheeler, T. L., Shackelford, S. D., & Koohmaraie, M. (1998). Cooking and palatability traits of beef longissimus steaks cooked with a belt grill or an open hearth electric broiler. Journal of Animal Science, 76(11), 2805-2810.

Wheeler, T.L., S. D. Shackelford, and M. Koohmaraie. (2005). Shear Force Procedures for Meat Tenderness Measurement. USDA ARS (updated 16th May 2005) [online]. Retrieved from https://www.ars.usda.gov/AR