ON-LINE MONITORING OF LEAN MEAT CONTENT OF CARTONED BEEF

I.J. EUSTACE, R.A. GIBBONS, W.J. BUTT* and R.F. THORNTON

CSIRO Division of Food Processing, Meat Research Laboratory, P.O. Box 12, Cannon Hill, Q. 4170, Australia

*Cambut Holdings Pty. Ltd., East Brisbane, Q. 4169, Australia

INTRODUCTION

Contracts for exports of Australian cartoned bulk-packed boneless meat for manufacturing purposes normally include specifications for minimum chemical lean meat content (CL). The monitoring of CL is currently done by removal, comminution and analysis of samples of meat from a small fraction of the cartons (approximately 1 in 20).

The procedure is far from ideal because it is labour-intensive and the results of the tests are generally not available before the cartons have been sealed and consigned to freezers. Uncertainties associated with estimation of CL lead some packers to deliberately pack leaner than the specification requires in order to reduce the risk of (excess fat) claims by importers. There is a need for a continuous on-line, non-invasive method for monitoring lean meat content.

In the mid 1970's scientists at the CSIRO Meat Research Laboratory evaluated an instrument which rapidly provided an estimate of the lean meat content of 27 kg cartons of beef (Husband *et al.*, 1977). They found it to have insufficient accuracy and to lack reliability. Subsequent to this evaluation, the manufacturing rights to this equipment were acquired by the DICKEY-john Corporation (Auburn, Illinois) and extensive design modifications were made. Recent publications show that, for piglets and human infants, there is excellent agreement between estimates of body composition obtained with the modified equipment and by traditional methods (Fiorotto *et al.*, 1987a, b). A second generation instrument has recently been developed for human use. In addition to extensive evaluations for estimations of the body composition of human adults it has been used to estimate the composition of live pigs (Keim *et al.*, 1988) and pig carcasses (Forrest *et al.*, 1988).

The present study investigated the ability of the modified equipment to reliably estimate the chemical lean content of cartons of boneless beef.

MATERIALS AND METHODS

Cartons (27.2 kg nett weight) of (cow) forequarter beef, which had been packed to a nominal 85% CL, were obtained from the normal output of a commercial boning room. They were placed in an insulated container and, within one hour, brought to the laboratory for instrumental and chemical analysis.

Instrument measurements were made with a Model Dj ME-M60 Boneless Meat Analyzer (DICKEY-john Corporation, Auburn, Illinois). This instrument generates a uniform electromagnetic field within a solenoid coil which is driven by a high frequency (5 MHz) oscillating current. When conductive materials such as meat are moved through the field there is a measurable dissipation of power.

The instrument was calibrated with the test coil provided, cartons of meat were passed three times through the coil as they were received from the packing room (large piece size), three times after size reduction of large individual pieces to a maximum of approx. 3 kg (intermediate piece size) and three times after further reduction to a maximum piece size of approx. 300 g (small piece size). The motorised conveyor through the instrument travelled at 0.24 m/s. The cartons, which had dimensions of 530 mm x 350 mm x 160 mm were placed in a rigid restraint during the repeated operations to avoid deformation and the flaps were glued closed before each series of measurements so that the dimensions varied as little as possible. Temperatures of the cartoned meat were measured.

The cartons of meat were transferred to a cold room at -2°C. Once the meat had cooled to -1°/0°C, it was ground twice through a plate with 10 mm diameter holes and thoroughly mixed. Three samples, each at 400 g, were accumulated by removing 8 to 10 plugs of ground material with a coring tube (diameter 35 mm). This was done with the meat from each carton. The samples were then analysed for water content (oven dried 16 hr, 103°C) and fat (exhaustive extraction with diethyl ether). Each sample was analysed in triplicate. Each CL was calculated as a percentage by subtracting the percentage fat content from 100. For each carton the electrical conductivity measurements were corrected for temperature (using the average temperature of the meat) according to a formula provided by the manufacturer of the equipment.

The relationships between the conductivity values and the chemical variables were assessed by regression analysis using a statistical package (Genstat 4.04). Differences between regression equations were tested using a procedure described by Williams (1959).

RESULTS

The 53 cartons of beef obtained for this laboratory evaluation were packed and labelled by the packer as 85 per cent CL product. The mean CL value for these cartons was 86.7% (range 76.3 to 94.1%).

Electrical conductivity measurements

The coefficients for the regression equations between the temperature-corrected measurements of electrical conductivity obtained using the ME-M60 equipment and water content are presented in Table 1.

Table 1. Prediction of water content (y) from electrical conductivity values (x). (n=53)

Size of meat pieces	Intercept	Slope	SEE[a]	r[b]
Large	42.9	0.027	1.27	0.92
Intermediate	40.2	0.031	1.04	0.95
Small	42.1	0.029	1.00	0.95

[a]SEE - Standard error of estimate

[b]r - Correlation coefficient

The coefficients for the regression equations between the temperature-corrected electrical conductivity values and chemical lean content are given in Table 2. The predictions from conductivity measurements on the meat reduced in size (intermediate, small) were significantly better (P) than that from the measurements on large pieces.

Table 2. Prediction of CL (y) from electrical conductivity values (x). (n=53)

Size of meat pieces	Intercept	Slope	SEE[a]	r[b]
Large	42.9	0.027	1.27	0.92
Intermediate	40.2	0.031	1.04	0.95
Small	42.1	0.029	1.00	0.95

DISCUSSION

The results of this study confirm the validity of the electrical conductivity method for predicting the water content of beef packed for manufacturing purposes. The high correlation between the conductivity values and water content supports published data relating electrical conductivity values and total body water estimates for live humans and pigs (Van Loan and Mayclin, 1987; Keim *et al.*, 1988). The relatively high electrical conductivity of hydrated lean meat and extracellular water is related to their content of free ions. The fact that the relationship is not impaired by extensive slicing of the meat to small individual pieces suggests the relationship is not dependent upon body tissues remaining intact.

The relationship between the water content of meat and its chemical lean content is highly correlated (Thornton *et al.*, 1981; Eustace and Jones, 1984). It therefore follows that lean meat content should be predicted from electrical conductivity values with good precision. Our study has confirmed that th is so. The data in Table 2 indicate that predic of CL is improved by reducing the size of individ pieces of meat in the cartons. This may be becau of the better contact between adjacent lean m surfaces where the pieces of meat are small. W have also established that if the meat in cartons packaged into several plastic bags (eith polyethylene or vacuum packaging films), t instrument response is greatly reduced (data n shown).

The test coil provided with the equipment was us to periodically check the electrical stability of th instrument. On some occasions regu recalibration was required. This instability m have been largely caused by the irregular use of th equipment during the evaluation period.

Electrical conductivity measurements were made triplicate on each of the 162 occasions cartons beef were tested. The coefficient of variation these measurements was 0.46%. Based on th performance, single instrument measurements commercial boning rooms would give relia predictions of CL content.

The values given in Tables 1, 2 for the standa errors of the estimates are for estimates on sing cartons of product. If the equipment is used estimate the mean CL of larger numbers of carto these errors are greatly reduced. For instance a consignment lot of 625 cartons (approximately t number of cartons in a standard shipping contain the standard error of the instrumental estimate less than 0.1%.

A study to evaluate the performance of the ME-M instrument in an industrial environment h commenced.

CONCLUSIONS

Our data show that electrical conductiv measurements obtained using the Dj ME-M instrument can accurately estimate the CL bulk-packed cartons of beef. It is hoped that furt evaluation will confirm its suitability as a rap reliable technique that will enable the lean m content of every carton of meat packed manufacturing purposes by Australian packers be determined.

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