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CUTS COMPOSITION DETERMINED FROM COMPUTED TOMOGRAPHY IMAGES OF PIG CARCASSES

Albert Brun*, Maria Font-i-Furnols

[1] IRTA- Food Quality and Technology, 17121 Monells, Catalonia, Spain

*Corresponding author email: albert.brun@irta.cat

I. INTRODUCTION

For the pig slaughterhouses and cutting plants it is important to know the composition of carcasses and their cuts at the same slaughter line so they can select the best carcasses for each purpose. Slaughterhouses have devices to determine the lean meat percentage because in the UE its determination is compulsory. These devices can be fully automatic, semi-automatic or manual and are based on different technologies such as reflectance, ultrasounds or vision [1]. These devices can also determine the cuts composition but need prior calibration. Calibration can be performed either by dissection of the cuts, which is very time consuming and devalues them, or by using a computed tomography (CT) scanner [2].
The aim of this work is to determine the weight, lean and fat content of the four main cuts from CT images of pig carcasses.

II. MATERIALS AND METHODS

Sixty-four carcasses of pigs from different genetics and sexes (entire male, female and surgically castrated male), with an average weight of 86.99 ± 9.90 kg were selected. Carcasses came from pigs from different producers to ensure a wide variety. Left half carcasses were fully scanned with the device Philips Brillance 16, taking helical 3 mm-thick images every 3 mm (pitch 0.938), at 120kV, 200mA, field of view (FOV) 500 mm, 512x512 matrix and collimation 16x1.5. Cold carcasses were scanned without head, foot and hand but with cheek. After scanning, carcasses were cut according to Walstra and Mekus reference cutting [3] and four main pieces (ham, loin, shoulder and belly) were dissected to obtain the weight of the lean and fat tissues.
The CT images were analyzed with Matlab software (version R2008b; The MathWorksTM Inc., Natick, USA) to obtain the volume associated to each Hounsfield unit (HU). Different ranges of HU volumes were used as predictors: HU-200 to HU-150, HU-149 to HU-1, HU-20 to HU20, HU0 to HU140, HU141 to HU2000, HU141 to HU 499, HU500 to HU999, HU1000 to HU 1499, and HU1500 to HU2000.
Statistical analysis was carried out in SAS software (SAS Institute Inc., Cary, NC, USA). Lineal regressions (REG procedure) were developed considering the dissected tissue as a dependent variable and the ranges of HU volumes as independent variables. Stepwise selection was used to select the HU volume ranges included in each prediction equation. Goodness of fit of the prediction equation was evaluated by mean of the root mean square error of prediction determined by cross-validation leave-one-out (RMSEP), the coefficient of determination (R^2) and the Coefficient of Variation (CV), i.e. the relative RMSEP calculated as CV=100*RMSEP/mean.

III. RESULTS AND DISCUSSION

Average weight of fat and lean were 2152.88±499.54 g and 7631.89±1089.18 g for ham, 2199.34±670.83 g and 4394.45±690.20 g for loin, 1624.08±316.96 g and 4158.70±565.90 g for shoulder, and 1463.24±376.91 g and 2373.11±401.14 g for belly. The prediction equations for each parameter and its goodness of fit are presented in Table 1. For each cut, the lowest relative error (CV) always corresponded to the lean content compared to the fat content, except for belly, which was very similar for both tissues. Similarly, when lean and fat weight from the whole carcasses were predicted, the prediction of lean was less in error than those of fat [4]. Comparatively, errors obtained for the estimation of lean and fat in the cuts, are higher than those found in carcasses in previous works [4,5]. This is probably due to the fact that cuts were scanned separately from the carcasses, and the prediction is from the scanned whole carcass. The estimation of cuts composition from the images of the whole carcass, instead of those from the individual cuts, would help to reduce the time to know the composition and to reduce carcass devaluation.

Table 1 –Prediction equations to determine the weight of cuts and their tissues from computed tomography images of the whole carcass.

Weight (g)	n	Prediction equation	RMSEP	CV(%)	R^2
Ham fat	64	-215.13161 + 158.49522*HU-149 to HU-1 + 151.99503*HU-20 to HU20 + 8.17441*HU0 to HU140	132.58	6.16	0.934
Ham lean	63	718.09254 + 339.13162*HU0 to 140 - 650.37136*HU141 to HU2000 + 25016*HU1500 to HU2000	259.75	3.40	0.947
Loin fat	63	849.83779 + 207.01776*HU-149 to HU-1 - 5319.88366*HU-200 to HU-150 + 364.70060*HU-20 to HU20 - 544.26067* HU141 to HU499 - 23326*HU1500 to HU2000	227.88	10.36	0.887
Loin lean	63	481.9327 + 211.19111*HU0 to HU140 + 38.27086*HU-149 to HU-1 - 301.53520*HU-20 to HU20 - 403.12847*HU141 to HU499	234.44	5.33	0.893
Shoulder fat	63	457.25813 + 97.30561*HU-149 to HU-1 + 204.56313*HU-20 to HU20 + 2246.47599*HU1000 to HU1499 - 4687.03005*HU-200 to HU-150 + 11.74873*HU0 to HU140	106.42	6.55	0.899
Shoulder lean	64	-9.94048 + 153.95034*HU0 to HU140 + 35754*HU1500 to HU2000 + 153.77324*HU141 to HU2000	140.93	3.39	0.942
Belly fat	61	178.45375 - 421.94036*HU141to HU200 + 132.46367*HU-149 to HU-1	111.10	7.59	0.911
Belly lean	62	123.45938 + 110.41924*HU0 to HU140 - 273.25432*HU141 to HU499	168.86	7.12	0.821

RMSEP: root mean squared error of prediction; CV: 100*RMSEP/mean; R^2: coefficient of determination.

IV. CONCLUSION

In the conditions of the present trial, it is possible to predict the composition of cuts from CT carcass images. The prediction of lean content is more precise than the fat content.

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