FAT ESTIMATION OF RIPENED LOIN AND SHOULDER OF PORK USING DIGITAL IMAGE ANALYSIS

E. Novelli[1], S. Balzan[1], F. Blaas[2], L. Fasolato[1], F. Montemurro, E. Sturaro[3]

[1]Department of Biomedicina Comparata e Alimentazione, University of Padova, 35020 Legnaro, Italy; [2]Provincia Autonoma di Bolzano Alto Adige, 39100 Bolzano, Italy; [3]Department of Agronomia Animali Alimenti Risorse Naturali e Ambiente, University of Padova, 35020 Legnaro, Italy

Abstract – In this study it was treated the applicability of a rapid analytical method, the Video Image Analysis, to determine the fat percentage of smoked dry-cured meat products. Two different pig carcass primal cuts, loin n= 125 and shoulder n=88, ripened according to the same manufacture method were tested. The end product, cut into slices, was submitted to digital image collection then to analytical procedure for the determination of proximate composition. The image analysis allowed to perform linear measurements on lean and fat fractions and to calculate their respective areas. The data acquired with image analysis were significantly related to the data of chemical composition, both for loin and shoulder. In particular, the ratio fat area/total area % for loin showed a correlation coefficient equal to 0.80* versus the fat percentage. It was derived an equation able to predict the fat percentage just knowing the ratio fat area/total area % detected with the image analysis**.

Key Words – Fast analytical methods, meat products, proximate composition.

I. INTRODUCTION

The image analysis (Video Image Analysis, VIA) has been implemented in the slaughterhouse for carcass grading and the estimation of meat yield [1-3]. In the present study we would to test the effectiveness of VIA in predicting the fat concentration of two meat products (loin and shoulder) obtained from pig carcass and processed according to an old manufacture tradition spread in the geographical area of Northern Italy called Alto Adige. The end product, named Bauernspeck, is a primal cut salted, smoked and ripened. With the aim of improving the quality of raw meat to submit to process, a Consortium of local operator with the technical supervision of local Public authority, started a trial program, with the aid also of Video Image Analysis beside analytical determination, aimed to evaluate the proximate composition of end products. The study's object was to verify the effectiveness of VIA as a rapid, reliable and economical tools to determine the chemical composition of a large number of end products in order to understand ex ante which is the best carcass quality for this kind of meat product.

II. MATERIALS AND METHODS

Ripened loin, (n= 125) made of m. *L. dorsi* plus subcutaneous fat plus skin, and shoulder primal cut (n=88) were obtained from pigs equally distributed against sex (barrow and gilt), sire breeds and live weight of slaughter (from 120 to 150 kg). After cooling, the carcasses were dissected and primal boneless cuts sent to six different processor plants.

The ripening process included a salting step (by means of dry salt mixed with spices) that ranged from a minimum of 2 and a maximum of 4 weeks, cold smoking that took a variable range time, between 3 days and 6 weeks, and a maturing phase that ranged from a minimum of 2 and a maximum of 6 months. At the end of process a sample of 500 g was taken, vacuum packaged and stored at 4 °C up to the analysis. A sub-sample slice of about 100 g was freed of skin, frozen by liquid nitrogen and homogenized with a knife mill (Retsch, GmbH, Hann, Germany) by three successive cycles of grinding (2500 rpm x 5 sec, 3500 rpm x 8 sec, 5500 rpm x 5 sec). Moisture, crude protein (Kjeldahl x 6.25), crude fat and ash were estimated according to AOAC [4].

The image collection was accomplished with a digital camera positioned at a fixed distance from the sample placed over a green background. Exposure time and diaphragm opening were kept constant. The image, in JPEG, was acquired at the maximum allowable definition (1600 x 1200 pixels). The sample was illuminated by a blue-light lamp (45 W) with an angle of 45° respect to the sample. The reference for linear measurement was a metal bar (25.16 mm long) painted with a black anti-reflection varnish. The image analysis was performed with the Image Pro Plus 4.1 software Media Cybernetics [5]. The software worked by identifying areas on the basis of color contrast (differences between different frequency bands) and taking dimensional measurements of the areas previously identified against the reference bar. The measurement of areas and linear distances into the digital image were done by an operator using a semi-automated method. Therefore, have been detected, i) total area of the sample section in mm^2, ii) the area covered by lean in mm^2, iii) the area covered by fat and intermuscular fat deposits in mm^2, iv) the thickness of fat in mm (in the middle of section), v) the thickness of lean in mm (in the middle of section), vi) total thickness in mm (in the middle of section), vii) the percentage ratio fat/section. An algorithm was developed for the measurement of the average thickness of fat which also provided the minimum and maximum values of the same estimation.

The arithmetic mean, standard deviation and coefficient of variation of the data collected by VIA and chemical analyses were calculated. Correlation coefficient between VIA and chemical data were also calculated using SAS software package [6].

III. RESULTS AND DISCUSSION

In Table 1 the values of measures of length and areas of lean and fat obtained by image analysis of loin at the end of ripening process are shown. In Figure 1 there is the explication of the highlights of the linear measurements of the fat and lean fractions of the loin at the end of ripening process. It is worth to note that the fat area is slightly higher than that of lean (3992 vs 3656 mm^2) although the height of the last outweighs that of the subcutaneous fat (32.12 vs 17.56). Therefore, the relationship between fat and lean areas is greater than 50% and this is an indication relevant if it is seen from the point of view of the subjective evaluation of the consumer, that is always more sensitive on the caloric content of meat products. The corresponding chemical analysis would seem instead to indicate that the lipid content of the product is little lower than the lean (if intended as crude protein plus moisture). In the perspective of the consumer's judgment, the indication which emerges from the image analysis is probably the most valuable predictor of the propensity toward the choice of the product.

In Table 2 the values of the correlation coefficients between chemical data and VIA estimations have been shown. Most of the correlations are highly significant. The ratio fat area/total area fitted with fat percentage for a value of 80% (Figure 2). In the case of ripened shoulder, in Table 3 the values of chemical data and VIA estimations have been reported. Unlike the loin, the fat area of shoulder is lower than that of lean (2993 vs 3707 mm^2).The fat area, calculated by image analysis, was significantly correlated with the percentage of fat (r=0.79***). To loin application, has been derived the equation $y_{ijk} = \alpha + S_i + \beta x_{ijk} + \varepsilon_{ijk}$ which allow to estimate the fat concentration (in percentage) of the sample (y_{ijk}) starting from the quotient fat area/total area % (x_{ijk}) obtained by VIA considering the effect of sex (S_i).

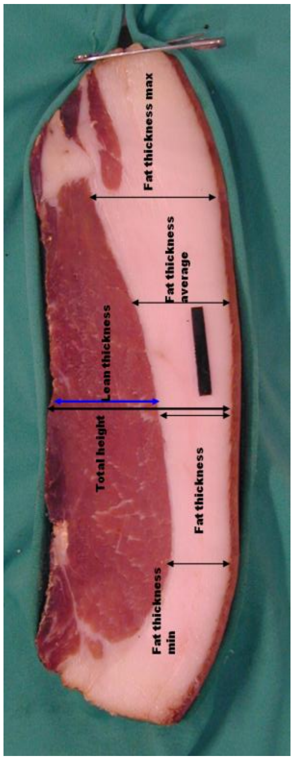

Figure 1. Ripened pork loin. The points of linear measurements for fat and lean areas are highlighted. The metal bar (25.16 mm long) has been placed over the subcutaneous fat.

Table 1. Ripened pork loin, VIA estimation data and proximate composition. S.d. standard deviation; C.v. coefficient of variability.

Video Image data	Mean	S.d.	C.v.
Fat (mm)	17.56	5.88	33.51
Lean (mm)	32.12	8.47	26.37
Total height (mm)	51.22	10.41	20.33
Fat thickness average (mm)	19.11	5.79	30.32
Fat thickness min (mm)	13.97	5.66	40.55
Fat thickness max (mm)	27.16	7.48	27.55
Fat area (mm^2)	3992.9	1325.54	33.2
Lean area (mm^2)	3656.26	1146.18	31.35
Total area (mm^2)	7649.16	1914.58	25.03
Fat/total section (%)	51.92	10.01	19.28
Proximate composition			
Moisture (%)	25.15	5.86	23.32
Crude protein (%)	25.40	5.42	21.18
Crude fat (%)	44.67	11.34	25.22
Ash (%)	4.2	0.96	21.8

Table 2. Ripened pork loin, correlation coefficient of VIA estimation data vs proximate composition. *** (P<0.001), ** (P<0.05), n.s. not significant.

Proximate composition / VIA	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)
Fat	-0.58***	-0.57***	0.69***	-0.52***
Lean	0.46***	n.s.	-0.22*	n.s.
Total height	n.s	-0.52***	0.33**	-0.34**
Fat thick average	-0.64***	-0.68***	0.78***	-0.57***
Fat thick min	-0.59***	-0.55***	0.68***	-0.45***
Fat thick max	-0.56***	-0.59***	0.69***	-0.55***
Fat area	-0.45***	-0.64***	0.65***	-0.48***
Lean area	0.55***	n.s.	-0.31**	n.s.
Total area	n.s.	-0.45***	0.27**	-0.28***
Fat/total section	-0.80***	-0.57***	0.80***	-0.51***

Table 3. Ripened shoulder, VIA estimation data and proximate composition.

Video Image data	Mean	Min	Max
Fat thickness average (mm)	13.30	3.48	31.12
Fat area (mm^2)	2993.01	615.46	6210.00
Lean area (mm^2)	3707.11	1374.21	6813.31
Fat area (%)	43.47	13.26	73.06
Lean area (%)	56.53	26.94	86.74
Proximate composition			
Moisture (%)	29.38	11.64	42.45
Crude protein (%)	27.50	16.20	41.43
Crude fat (%)	37.20	12.82	67.89
Ash (%)	4.83	2.10	7.60

Table 4. Ripened pork shoulder, correlation coefficient of VIA estimation data vs proximate composition. *** (P<0.001), ** (P<0.05), n.s. not significant.

Proximate composition VIA	Moist. (%)	Crude protein (%)	Crude fat (%)	Ash (%)
Fat thick average	-0.66***	-0.59***	0.69***	-0.33**
Fat area (mm^2)	0.47***	-0.57***	0.58***	-0.52***
Lean area (mm^2)	0.46***	0.32**	-0.42***	n.s.
Fat area (%)	-0.71***	-0.72***	0.79***	-0.50***
Lean area (%)	0.71***	0.72***	-0.79***	0.50***

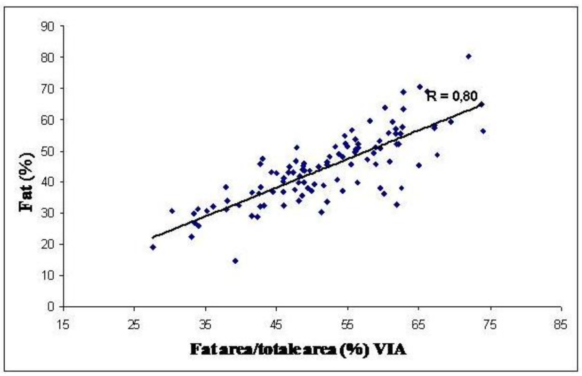

Figure 2. Correlation between fat (%) determined by chemical analysis and Fat area/total area (%) estimated according to digital image analysis.

IV. CONCLUSIONS

The analysis of the digital image acquired on a section of smoked and dry-cured pork loin and shoulder ripened according to the methodology of Bauernspeck was applicable as an alternative rapid method for the chemical analysis generally used for the determination of fat percentage of the end product. This result is of great added value where, for the purposes of genetic selection or the choice of the best live weight of slaughter, it is necessary to proceed with a very large number of analytical measurements.

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