Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/
POSTER

Non-destructive analysis of loin by Magnetic Resonance Imaging and fractals

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SUMMARY

Quality traits of meat products have been traditionally analyzed by tedious methods, which are also time and solvent consuming, and destructive processes. As an alternative, MRI and computer vision algorithms for MRI analysis have been proposed. Currently, there is a growing interest in the use of fractal techniques instead of texture classic algorithms for image analysis. In this work, three different algorithms (GLCM, CFA and FTA) are compared. FTA and GLCM achieved very good to excellent correlations. The result of this study could validate the use of FTA for MRI analysis in order to predict traits of loins.

Additional keywords

Physico-chemical parameters.
Computer vision algorithms.
Computational features.

Análisis no destructivo del lomo mediante imagen de resonancia magnética y fractales

RESUMEN

Las características de calidad de los productos cárnicos han sido tradicionalmente analizadas por métodos tediosos que además de consumir tiempo y reactivos químicos, son procesos destructivos. Como alternativa, la imagen de resonancia magnética (MRI) y los algoritmos de visión por computador han sido propuestos para analizar MRI. Actualmente, hay un creciente interés en el uso de las técnicas fractales en lugar de los algoritmos clásicos de texturas para analizar imágenes. En este estudio, tres algoritmos diferentes (GLCM, CFA y FTA) son comparados, FTA y GLCM lograron correlaciones entre muy buenas y excelentes. Los resultados de este estudio podrían validar el uso de FTA para analizar MRI con el fin de predecir características del lomo.

Palabras clave adicionales

Parámetros físico-químicos.
Algoritmos de visión por computador.
Características computacionales.

Information

Cronología del artículo.
Recibido/Received: 12.01.2017
Aceptado/Accepted: 08.07.2017
On-line: 15.01.2018
Correspondencia a los autores/Contact e-mail:
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INTRODUCTION

Nowadays, the methods for determining quality attributes of meat and meat products are tedious, time and solvent consuming and usually, require the destruction of the meat pieces. Magnetic resonance imaging (MRI) and computer vision have been proposed as an alternative to the traditional methods in order to analyze meat products (Antequera et al. 2007, Fantazzini et al. 2009, Manzoco et al. 2013).

Usually, computational texture algorithms have been used for analyzing MRI of Iberian meat products. However, currently there is a growing interest in the use of fractal techniques instead of classical texture methods for image analysis (Celigueta-Torres et al. 2012). The most of these works are centered in characterizing the structure of the food, and only some authors have used fractal technique to predict physico-chemical parameters on food. Polder et al. measured the chlorophyll of tomato (Polder et al. 2004) and Tsuta et al. predicted the sugar content of melons (Tsuta et al. 2002).

This work aims to compare the appropriateness of three different algorithms (classical texture (GLCM), classical fractal (CFA) and fractal texture (FTA)) to analyze MRI of loins in order to predict moisture, lipid and salt content.

MATERIAL AND METHODS

This study was carried out with ten Iberian loins. Five of them were fresh and the other five were dry-cured loins. **Figure 1** shows the experimental design of this study.

MRIs from loins were generated at the Animal Source Foodstuffs Innovation Services (SiPA) at the faculty of Veterinary Science of University of Extremadura

(Cáceres, Spain). A low field MRI scanner (ESAOTE VET-MR E-SCAN XQ 0.18 T) was used, with a hand/wrist coil, with nine different configurations on echo time (TE) and repetition time (TR). Sequences of Spin Echo (SE) weighted on T1 were applied, 29 slices per loin were obtained, for a total number of 2D images of 2610 images (29 images x 10 loins x 9 configurations).

Physico-chemical analysis of loins were carried out by means of traditional methods in order to obtain values for moisture, salt and lipid content. (AOAC 2000, Pérez-Palacios et al. 2008).

When the MRI of loins were obtained, three computer vision algorithms were applied to extract numerical data from them. The first method, GLCM, gray level co-occurrence matrix, is a classical computational texture algorithm proposed by Haralick (Haralick et al. 1973): ten features were extracted from this algorithm. The second method, CFA, is the classical fractal algorithm proposed by Minkowski-Bouligand (Mandelbrot 1982), from the application of this algorithm: eight features were obtained. The third method, fractal texture algorithm (FTA) is a novelty texture algorithm based on fractal features that are obtained from a two dimensional variation of Minkowski-Bouligand algorithm and the application of second order statistics: ten features were obtained from this algorithm.

A database was constructed with data from MRI and physico-chemical analysis. Prediction techniques of data mining were applied on this database, specifically, multiple linear regression (MLR). For that, the free software tool WEKA (downloaded from www.cs.waikato.ac.nz/ml/weka) was used.

RESULTS AND DISCUSSION

Table I shows correlation coefficients (R) of the prediction equations, for lipid, moisture and salt content, obtained when applying the different computer vision algorithms. GLCM and FTA achieved the highest R values, being higher than 0.75 that means very good to excellent correlation according to the rules of Colton (Colton 1974). GLCM reached the highest R values for moisture and salt content, and FTA achieved the highest value for lipid content.

Table I. R values of the prediction equations, for lipid, moisture and salt content, obtained when applying the different computer vision algorithms (Valores de R de las ecuaciones de predicción, para el contenido en sal, humedad y grasa, obtenidos cuando se aplican diferentes algoritmos de visión por computador).

	GLCM	CFA	FTA
Lipid content (%)	0.791	0.201	0.835
Moisture (%)	0.948	0.289	0.832
Salt content (%)	0.949	0.507	0.795

Table II shows the prediction equations of physico-chemical parameters of loins as a function of computer vision features obtained from FTA and GLCM algorithms. As can be observed, prediction equations from FTA only have one dependent variable and that from GLCM is composed by 7-10 features. Thus, prediction equations from FTA are simpler and require less computational cost.

These results could be indicated that GLCM (texture algorithm) achieved highest predictions with the parameters related to water content and FTA (fractal algorithm) reached highest predictions with the remaining parameters.

Since the use of GLCM has been already proved for determining quality parameters of meat products by using MRI (Antequera et al. 2007, Caballero et al. 2016, 2017, Fantazzini et al. 2009, Manzoco et al. 2013, Pérez-Palacios et al. 2014). Results of this study seems to indicate that FTA could be applied as computer vision algorithm, instead of GLCM algorithm, for analysing MRI in order to predict quality traits of loins.

CONCLUSIONS

The use of FTA as Computer vision algorithm could be an alternative to the classical texture algorithms to analyze MRI in order to determine physico-chemical traits of loins in a non-destructive way with a high rate of accuracy.

ACKOWLEGMENTS

Daniel Caballero thanks the COST association, Farm Animal Imaging action (FAIM) (COST-FA1102) and the European Social fund for the grant for a short stay (COST-STSM-FA-1102-26642). The authors wish to acknowledge the funding received from the FEDER-MICCIN Infrastructure Research Project (UNEX-10-1E-402) and Junta de Extremadura economic support for research group (GRU15113 and GRU15025). We also to thank Animal Source Foodstuffs Innovation Service (SiPA, Cáceres, Spain).

Table II. Prediction equations of physico-chemical parameters of loins as a function of computer vision features from GLCM and FTA algorithms (Ecuaciones de predicción de parámetros físico-químicos del lomo en función de las características de los algoritmos de visión por computador FTA y GLCM).

	GLCM	FTA
Lipid content (%)	= 11.641 * ENE – 10.390 * ENT + 7.151 * HC – 16.961 * IDM – 22.840 * INE + 8.873 * CS + 12.602 * CP – 22.772 * CON + 27.98 * DIS + 17.497	= 25.028 * JC + 3.770
Moisture (%)	= -11.038 * ENE + 6.316 * ENT – 7.109 * COR +24.830 * HC + 24.390 * IDM + 55.696 * INE – 20.659 * CS – 15.407 * CP + 10.157 * CON – 70.601 * DIS + 45.927	= -84.705 * JC + 94.168
Salt content (%)	= 1.838 * COR – 2.226 * HC – 1.037 * IDM – 6.009 * INE + 1.574 * CS + 1.344 * CP + 7.336 * DIS + 0.821	= 6.682 * JC – 2.237

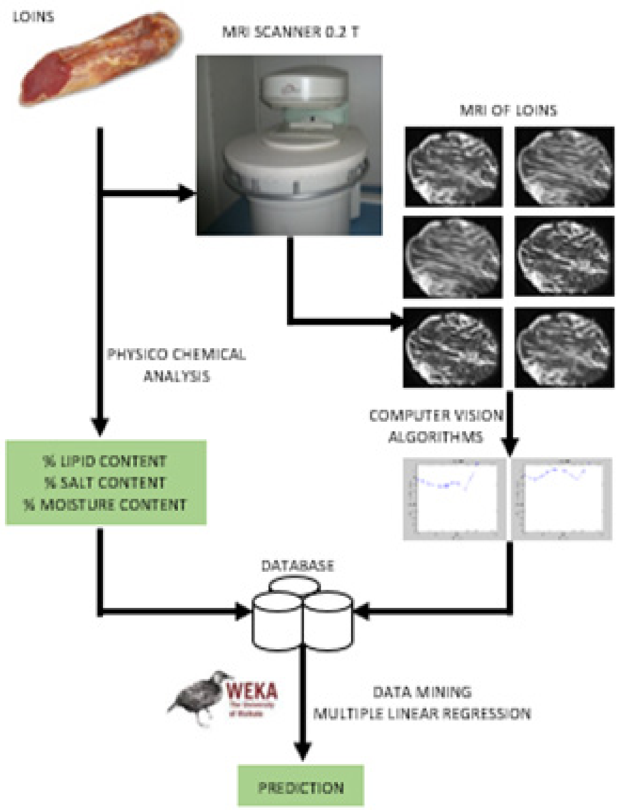

Figure 1. Experimental design (Diseño experimental).

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