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The sustainability of the "dehesas"

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SUMMARY – An analysis of the productive systems used in "dehesa" grazing lands confirms that the highest quality products come from Iberian pigs that have been fed on acorns. Furthermore, this productive system also offers the best prospects for sustainability. However, there are currently two factors that could condition this situation in the relatively short term: on the one hand, the deterioration of oak trees as the result of oak decline ("*seca"*) and an absence of natural regeneration caused by intensive systems; and on the other hand, market competition with Iberian pork produced using intensive farming methods. Faced with these challenges there are several possible courses of action, mainly focusing on oak reforestation and the establishment of classification and traceability methods that ensure clear differentiation of products on the market. This paper deals with our efforts to create georeferenced records for oak trees using GIS tools, which include compositional and nutritional information about the acorns produced. Our research into quality differentiation systems for Iberian pig carcasses and pork products using NIRS technology is also discussed. This paper considers the viability of the various courses of action and the feasibility of simultaneously considering environmental and cultural alternatives.

Keywords: Oak trees, acorns, composition, GIS, Iberian pork, quality, NIRS.

RESUME – *"La durabilité des dehesas". L'analyse des systèmes productifs qui se pratiquent dans les forêts de chênes verts et de chênes-liège ("dehesa") donne comme résultat que la production du porc ibérique nourri aux glands est celle qui présente la plus grande singularité et, à la fois, celle qui a de meilleures perspectives de durabilité. Cependant, il existe actuellement deux facteurs qui peuvent conditionner cette situation à pas très long terme: d'une part, la détérioration qui se produit sans cesse dans les forêts de chênes verts en conséquence du phénomène de desséchage (seca) et du manque de rejets, dérivé de l'intensification réalisée dans les systèmes productifs. D'autre part, la concurrence dans le marché subie par le porc ibérique des forêts de chênes verts, face à celui qui provient de systèmes d'élevage intensif. Devant ces défis, plusieurs mesures sont considérées, centrées sur la reforestation contrôlée des chênaies et sur l'établissement de méthodes de typification et de traçabilité qui assurent nettement la différenciation des produits sur le marché. Cette communication présente les travaux de recherche que l'on réalise visant à dresser l'inventaire de chênes verts et de chênes-liège géographiquement référencé, et avec l'information bromatologique et nutritionnelle de leurs glands, associé à un SIG, ainsi que ceux qui se rapportent à l'établissement de systèmes de différenciation de la qualité en carcasse et des produits dérivés du porc ibérique, centrés sur l'utilisation de la technologie NIRS.*

La viabilité des différentes mesures et la pertinence de prendre en considération simultanément des alternatives complémentaires de type environnemental et culturel sont ici soumises à réflexion.

Mots-clés : *Chênaie, glands, composition, SIG, porc ibérique, qualité, NIRS.*

Introduction

"Dehesa" ecosystems are currently suffering deterioration and decline, which represents a significant loss of our heritage. Navarro and Fernández (2000) analysed the phenomenon of *oak decline* ("seca") and classified the various different factors responsible into the following groups: predisposition factors (pruning, ploughing, grazing), which would weaken the trees, lead to a lack of regeneration or age the trees; detonating factors, which are mainly related to water shortages and high temperatures; catalyst factors, which are dependent on the tree's genetics and soil conditions; and executing agents, including various different diseases (*Phytophthora, Hypoxilon, Diplodia*, etc.) and pests (*Cerambyx, Coroebus,* etc.).

There are two potentially complementary ways of tackling this loss of forest land. By reducing livestock grazing and the ploughing of lands, the holm oaks would naturally regenerate. However, this is a very slow method and it could prove somewhat ineffective, bearing in mind that productive systems will always tend to intensify. The other option would involve regeneration by sowing or planting new trees that, if they were sufficiently protected and supported, would lead to faster regeneration (fast being a relative term, considering the characteristics of this species).

Leaving aside the inherent problems of how natural forest land could be turned into a kind of plantation, we should also consider the material needed to put it into practice and the selection criteria to be used. In addition to resistance to certain diseases, the criteria to be considered should include production levels and the nutritional composition of the acorns produced.

Another issue to bear in mind is changing market demand for pork from acorn-fed pigs. The quality of these products is widely known and accepted; however, traditional productive systems have been modified and the use of compound feed has given rise to new products that aim to imitate the characteristics of pork from Iberian pigs fed on fallen acorns and fodder ("*montanera"*). This has led to changes being introduced in product controls, but the productive systems have responded by making further adjustments so that their products continue to mimic "*montanera"* pork. All of this has given rise to a loss of differential value and consumers are willing to pay for products that are not clearly differentiated.

The following sections explain the work our group has been doing to analyse and value information about compositional and nutritional variations in acorns, as well as our research into quality controls in the Iberian pork industry. Finally, we consider the effect that current circumstances might have on grazing land productive ecosystems.

Compositional inventory of acorns in the Pedroches Valley (Córdoba)

Through our various different studies (Fernández *et al*., 2004, 2005; Moreno *et al.*, 2005), we have examined the influence of several factors, such as the ripeness of the acorns, the soil and climate of the area as well as the combined effect of factors linked to the year of production on compositional and nutritional variations of the acorns produced in the Pedroches Valley (Cordoba). We have also examined the possible influence of the area of production on the differential quality obtained in Iberian pigs fed in each of these areas. Beyond the specific data, which can be analysed in these publications, of greater interest are the conclusions we have been able to draw.

There is a great deal of variation in the compositional characteristics of acorns from the same area (Table 1). Furthermore, the differences observed between different areas cannot be the sole justification for the differences in the quality of the pork, which must be affected more by handling conditions.

Table 1. Mean values of the compositional parameters of acorn pulp in the Pedroches Valley (Cordoba) (Fernández *et al*., 2005)

Parameters	Mean	Minimum	Maximum
DM (%)	56.00	44.61	60.94
CP (% DM)	5.87	3.62	10.50
EE (% DM)	8.79	4.03	13.10
Starch (% DM)	61.88	54.78	69.77
Sugar (% DM)	4.71	2.04	9.96
Gross energy (kcal/kg DM)	4705	4080	5052
Palmitic acid (%)	15.65	12.00	19.30
Stearic acid (%)	2.77	1.80	4.90
Oleic acid (%)	63.55	53.30	70.60
Linoleic acid (%)	15.83	10.80	21.80

Owing to the heterogeneity between the oak trees in any one geographical area and the lack of identification of morphological factors that could be linked to this diversity and which could be used to differentiate the quality of the acorns without the need for previous analysis (correlations between size of the acorns and their fat, protein, starch and oleic acid content, as the most significant components, do not explain more than 10% of variability), it is crucial to establish techniques that could perform these analyses quickly and economically, if we aim to explore the greatest possible number of oak

trees. In this respect, of particular interest is our research into calibration equations for said parameters using NIRS (Near Infrared Spectroscopy) techniques. Table 2 shows the provisional results of this research.

Table 2. NIRS calibration statistics obtained for the various different analytical parameters (Fernández *et al*., 2005)

Parameters†	Mean	Range	SD	No.	SECV	R^2	RPD	RER
Protein	5,79	3,62-7,96	0,869	150	0,223	0,934	3,89	19,46
Fat	8,90	13,10-4,12	1,560	154	0,308	0,961	5,06	29,15
Oleic acid	63,77	54,40-70,60	2,435	164	1,204	0,762	2,02	13,45
Linoleic acid	15,72	10,80-20,70	1,902	164	0,728	0,856	2,61	13,59

† SD: standard deviation; No.: number of samples; SECV: standard error of cross validation; R^2: coefficient of multiple determination; RPD: ratio of the SD of the reference data to the SECV; RER: ratio of the range between the reference data to the SECV.

Finally, in order to keep records of the geographical location of the trees analysed, we linked the information obtained to a GIS survey carried out for the area. This georeferenced database is shown in Fig. 1 and could be linked in with additional information about resistance to disease, which is currently being studied by a forestry engineering group that we are working with.

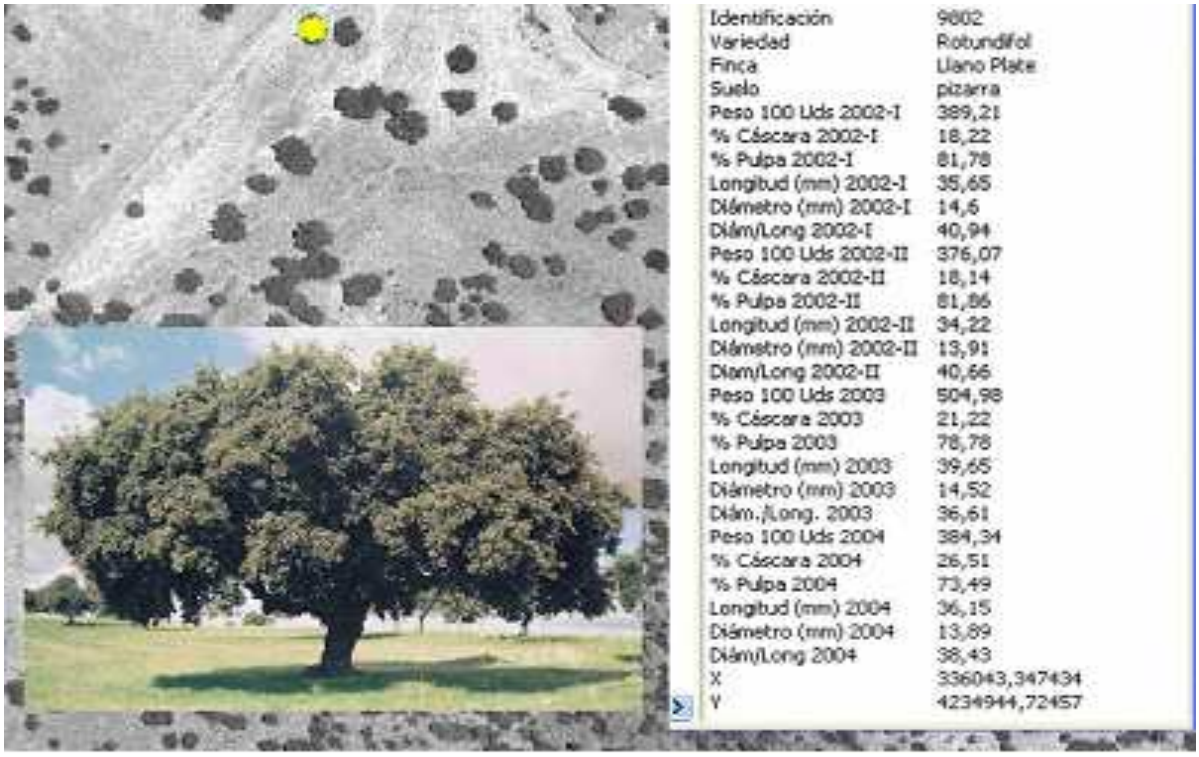

Fig. 1. Associated information of one oak tree analysed.

Quality control systems for Iberian pork

Several different methodologies have been proposed to assess pigs' feeding regimes. The simplest of these proposals involves carrying out periodic field controls during the animals' fattening stage. However, these controls present a high degree of subjectivity and hence tend to be unreliable.

The first analysis methods used were based on the determination of slip temperature (*fusion*) or iodine levels in the pig's subcutaneous fat. Both methodologies assess the level of unsaturated fatty acids in the subcutaneous fat. Despite the contribution of these analysis techniques, they were eventually abandoned because it was too easy to modify both the slip temperature and iodine levels, by adding polyunsaturated fats to the animals' diet.

In the 1990s, various different analytical techniques were used to assess the feeding regime of Iberian pigs (García Olmo, 2002), including:

(i) Determination of the fatty acid content in the animals' subcutaneous, hepatic and intramuscular fat or the non saponifiable fraction (chiefly in phospholipids) using gas chromatography.

(ii) Determination of the triglyceride content using high resolution liquid chromatography.

(iii) Determination of aldehydes in the fat using gas chromatography.

(iv) Determination of the isotope ratio $^{13}C/^{12}C$ or $^{15}N/^{14}N$ using radioactive isotopes.

(v) Detection of volatile compounds in fat and cured products using mass spectrometry or electronic nose technology.

(vi) Determination of the content of antioxidant compounds (chiefly α-tocopherol) in muscle tissue using liquid chromatography.

All the studies carried our using these methods produced excellent results, with a high success rate classifying batches of animals into "*bellota*" (fattening only with acorn and grass), "*recebo*" (fattening with acorn, grass and same feed compound) "*cebo*" (fattening only with feed compound) quality categories.

Of all the analysis methodologies, the most commonly used by the industry to assess feeding regimes is the determination of fatty acids in subcutaneous fat. This analysis technique was introduced by MAPA (Spanish Ministry of Agriculture and Food) in around the mid-1990s and the Official Sales Contract (OSC) determined that this criterion should be used along with field controls in order to asses the feeding regimes of Iberian pigs to be slaughtered. The OSC indicated maximum and/or minimum levels for the most common fatty acids present in pig fat (palmitic, stearic, oleic and linoleic acid), which must be detected in order for the product to be classified in a specific commercial category.

The application of these levels made a great contribution in this area when the Official Sales Contract was first implemented. However, nowadays, this classification criterion is the object of continual criticism, both by industrialists and livestock farmers.

As a replacement for the classification method based on composition levels, the use of quality indexes has been proposed, based on the complete fatty acid profile of the pig's subcutaneous fat, using multivariate statistical analysis tools. The efficiency of these quality indexes has been demonstrated and validated by ten years of research carried out with the industry. Differences between the results obtained by the quality indexes and observations in field controls are minimal.

However, there are several limitations when it comes to implementing fatty acid determination using gas chromatography in the industry itself. The analyses take a long time and the cost per sample is high. Furthermore, specialised staff is required to use the analytical instruments, which makes it impossible to carry out a complete analysis of all the animals in a batch. Hence, a single representative sample is obtained from a batch of pigs and analysed by public or private laboratories.

This difficulty could be avoided using Near Infrared Spectroscopy (NIRS). García Olmo (2002) described this methodology using the different forms of sample presentation: either as melted fat or as subcutaneous adipose tissue. In both cases, the analytical capacity of this technique outperforms gas chromatography, as demonstrated by the values shown in Table 3, which includes data obtained by 15 laboratories using gas chromatography and by our own facilities using NIRS.

Table 3. Comparison of fatty acid values in Iberian pork fat obtained via gas chromatography (CG) or by NIRS

Method	C16:0	C18:0	C18:1	C18:2
CG range (15 laboratories)	21.0-22.6	9.5-10.8	50.8-52.3	9.3-10.4
CG mean	21.5	9.9	51.8	9.7
NIRS (1 laboratory)	21.8	9.9	51.6	9.6

Furthermore, spectral information and discriminant analysis techniques have been proven to be highly efficient in the differentiation of feeding regimes in the final fattening stage in fresh loin Iberian pork samples.

Final considerations

Is it worth trying to improve productivity in oak forests? It is worth supporting a clearly differentiated product in the market, produced by traditional grazing methods? Is it possible to share this commitment if current indiscriminate "*Recebo*" categories are maintained, narrowing the gap between traditionally produced pork products and those produced by farmers who do not have grazing land but who have invested in dietary studies so that their products can compete with traditional Iberian "*montanera*" pork? In order to do this, objective product controls would have to be implemented that were very different from the current systems of field observations and analytic control of certain fatty acids which, although possible to achieve using NIRS, would require a significant research effort.

In any case, the need to regenerate grazing land should not only be considered in terms of producing a quality product, or even just as a way of improving the agricultural productive system, but rather it should be considered in terms of all of its attributes: productive, environmental and cultural. In our opinion, it is worth trying to maintain a balanced ecosystem, even though it remains unclear how future sustainability could be supported economically. Further work needs to be done in this area, since the future is not predetermined, but rather constructed from the present.

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