Relationships between meat quality measurements in rabbits fed with three diets of different fat type and content

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Abstract

Two hundred and eighty-four, genetically similar (a three-way cross), young rabbits were fed ad libitum, from weaning, either a commercial diet (group C, ether extract 2.6%) or a diet containing vegetable fat (group V, ether extract, 9.9%) or animal fat (group A, ether extract 11.7%). A principal component (PC) analysis was performed with the variables: ultimate pH at 24 h post mortem measured in the longissimus dorsi (LD) and in the biceps femoris (BF) muscles, colour measured on the surface of the loin, fatty acid composition of perirenal fat, meat fat content of the hind leg, water holding capacity and cooking losses of the meat, and sensory variables determined by a trained panel test. The four first PC explained 62% of the total variation (27, 13, 11 and 11%, respectively). The first PC grouped the fatty acids, the second PC grouped the sensorial variables, and the third and fourth PCs grouped the pHs and the water holding capacity. The projection of the data in the first two PCs showed three separate groups of points. Animals fed with diet V were on the left side of the graph, where the variable C18:2 lies, whereas animals fed with diets A and C lay on the right side of the graph, where the saturated acids were grouped. These were slightly separated by the higher content of oleic acid in the animals fed with diet A. The second PC, where the sensorial variables were grouped, did not separate the animals fed with diets A, V and C. The diets used in this experiment had only a slight influence on the organoleptic characteristics of rabbit meat.

Keywords: Rabbit meat quality; Principal components; Fat composition

1. Introduction

Rabbit meat consumption is important in the Mediterranean area, especially in France, Italy and Spain (Lebas & Colin, 1992). Rabbit meat is considered a leaner and healthier meat than beef, lamb or pork, due to its lower fat and cholesterol content (Enser, Hallet, Hewitt, Fursey & Wood, 1996; Lee & Ahn, 1997; Lukenfahr, Nwosu & Rao, 1989). In monogastric animals, like rabbits, the quantity and proportion of fatty acids in the meat and fat tissues changes with the diet (Cobos, Cambero, Ordoñez & de la Hoz, 1993; Fraga, De Blas, Perez, Rodriguez, Perez & Galvez, 1983; Ouhayoun, Kopp, Bonnet, Demarne & Delmas, 1987; Raimondi, de Maria, Auxilia & Masoero, 1975), and the ratios of unsaturated to saturated fatty acids in rabbit fats can be changed to improve the nutritional quality of the meat.

Besides, the addition of animal or vegetable fats to rabbit diets is attractive from an economic point of view, since they are an inexpensive source of energy.

Little work has been done on the effect of high levels of fat in the diet on rabbit meat quality. Studies on rabbit meat quality have mostly concentrated on analytical measurements, such as pH, colour or meat fat content (Blasco & Piles, 1990; Ouhayoun & Delmas, 1988; Pla & Cervera, 1997; Pla, Guerrero, Guardia, Oliver & Blasco, 1998; Pla, Hernández & Blasco, 1995; Pla, Hernández & Blasco, 1996), and sensory studies have been rarely used (Holmes, Wei, Harris, Cheeke & Patton, 1984; Oliver, Guerrero, Diaz, Gispert, Pla & Blasco, 1997; Xiccato, Parigi-Bini, Dalle Zotta & Carazzola, 1994). Recently, Oliver et al. studied the effect of three diets of different fat contents on the meat quality of rabbits, using both analytical measurements and sensory analysis.

Karlsson (1992) proposed the use of principal component analysis for evaluating meat quality when...
several correlated measurements are used. This technique is used to find a smaller set of measurements explaining most of the observed variability in the measurements taken, but also helps in examining the relationships between traits and the differences between the groups of animals compared.

The objective of this work was to examine the relationships between several measurements of meat quality, including chemical and physical measurements, and the results of sensory evaluation.

2. Material and methods

2.1. Animals and diets

Two hundred and eighty-four young rabbits from the same genetic type (a three-way cross) were divided into three groups at weaning and fed ad libitum with three different diets. Two experimental and one control diet were used. The control diet (C) was a commercial diet (ether extract 2.6%). The experimental diets contained either vegetable fat (group V, ether extract, 9.9%) or animal fat (a commercial mixture, 65% lard, 25% tallow and 10% poultry fat, group A, ether extract 11.7%). The detailed composition of the diet is given by Oliver et al. (1997). At 65 days of age, 60 animals from each group, weighing between 1.75 and 2.25 kg, were slaughtered on the same day at an abattoir located at the farm, thereby avoiding stress caused by transportation. The animals were not fasted before slaughter. Two hours after slaughter, the carcasses were refrigerated for 22 h at 3°C. The cold carcass weights of the C, V and A groups were 1122, 1142 and 1146 g, respectively. A complete description of the carcass quality can be found in Pla and Cervera (1997).

2.2. Meat quality measurements

The ultimate pH at 24 h post mortem (p.m.) was determined with a Crison microPH 2001 (Crison Instruments, Barcelona, Spain) using a combined electrode penetrating 3 mm into the M. longissimus dorsi (LD) at the level of the fifth lumbar vertebra and into the biceps femoris (BF) muscle. The colour was assessed on the surface of the LD, at the level of the fourth lumbar vertebra, at 24 h p.m., using a Minolta CR300 chromameter (Minolta Camera Co., Osaka, Japan). Lightness (LDL) was measured and Chroma LDC = \((a^2 + b^2)^{1/2}\) and Hue LDH = \(\tan^{-1} (B/A)\) were calculated. The perirenal fat was collected from the carcass, weighed and frozen at \(-20^\circ\)C until analysed. The fatty acid composition of the perirenal fat was determined (Oliver et al., 1997). Water holding capacity (WHC) of the LD was measured according to Hamm, (1986) and was expressed as the ratio \((\times 100)\) of muscle area to total area. Cooking loss (CL) was determined by cooking the preweighed LD in an electric oven at 200°C for 30 min and weighing it 30 min later. A hind leg was dissected and the fat percentage was determined by Soxhlet.

2.3. Sensory evaluation

A quantitative descriptive analysis (Stone, Sidel, Oliver, Woolsey, & Singleton, 1974) was carried out by eight trained tasters of rabbit meat in 16 sessions. Firstly four sessions of generation, selection and description of attributes were undertaken. The parameters retained were as follows: aniseed flavour, grass flavour, liver flavour, sweet taste, toughness, juiciness, chewiness and fibrousness. The sensory analysis was carried out on samples of the LD following a complete block design. Samples were cooked in an electric oven for 22 min at 180°C and then cut into four pieces and distributed in such a way to the panellists to eliminate any location effect within the loin. To prevent the product from cooling, samples were served on preheated plates.

2.4. Statistical analyses

A principal component analyses was performed using the Princomp procedure of the SAS (1990) package.

3. Results

The means of the variables analysed are in Table 1. A more detailed description can be found in the work of Pla and Cervera (1997) and Oliver et al. (1997). Table 2 shows the coefficients of correlation between the variables used in the analysis. The results of the principal component (PC) analysis are shown in Figs. 1–3. The four first PC explain a 62% of the total variation (27, 13, 11% and 11%, respectively). Each PC represents an independent cause of variation, thus traits near each other are positively correlated, traits separated by 90° are independent and traits separated 180° are negatively correlated. All PC are linear combinations of traits, but a trait far from the origin that lies on a PC is predominant in defining this PC.

Fig. 1 shows a plot of the traits on the two first principal components. Two groups of variables were clearly distinguished lying on the first PC far from the origin. The first group included the saturated fatty acids C14:0, C16:0, C18:0, and C16:1. These variables are correlated and negatively correlated with the other group, the polyunsaturated acids C18:2 and C18:3, lying near the first PC on the opposite side. The second PC essentially grouped the sensorial variables, as an independent cause of variation, the variables placed farthest from the...
Table 2
Correlation coefficients between the variables used in the PC analysis.a–f

|          | pHLD | pHBF | LDL  | LDC  | LDH  | Fat  | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | CL   | WHC  | Anis. | Grass | Liver | Sweet | Tough | Juici. | Chewi | Fibrou |
|----------|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|------|------|-------|-------|-------|-------|--------|--------|-------|
| pHLD     | 1    |      |      |      |      |      |       |       |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| pHBF     | -0.06| 1    |      |      |      |      |       |       |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| LDL      | -0.18| -0.07| 1    |      |      |      |       |       |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| LDC      | -0.04| -0.12| -0.07| 1    |      |      |       |       |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| LDH      | -0.16| -0.16| -0.17| -0.07| 1    |      |       |       |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| CL       | -0.12| -0.12| -0.21| -0.06| -0.12| 1    |       |       |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| WHC      | -0.12| -0.12| -0.11| -0.11| -0.09| -0.05| 1     |       |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| Anis.    | 0.01  | 0.01  | 0.07  | 0.07  | 0.07  | 0.07  | 0.07  | 1     |       |       |       |       |       |      |      |       |       |       |       |        |        |       |
| Grass    | 0.14  | 0.14  | 0.27  | 0.27  | 0.27  | 0.27  | 0.27  | 0.27  | 1     |       |       |       |       |      |      |       |       |       |       |        |        |       |
| Liver    | 0.18  | 0.18  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 1     |       |       |       |      |      |       |       |       |       |        |        |       |
| Sweet    | 0.22  | 0.22  | 0.46  | 0.46  | 0.46  | 0.46  | 0.46  | 0.46  | 0.46  | 0.46  | 1     |       |       |      |      |       |       |       |       |        |        |       |
| Tough    | 0.18  | 0.18  | 0.28  | 0.28  | 0.28  | 0.28  | 0.28  | 0.28  | 0.28  | 0.28  | 0.28  | 1     |       |      |      |       |       |       |       |        |        |       |
| Juici.   | 0.51  | 0.51  | 0.73  | 0.73  | 0.73  | 0.73  | 0.73  | 0.73  | 0.73  | 0.73  | 0.73  | 0.73  | 1     |      |      |       |       |       |       |        |        |       |
| Chewi    | 0.69  | 0.69  | 0.90  | 0.90  | 0.90  | 0.90  | 0.90  | 0.90  | 0.90  | 0.90  | 0.90  | 0.90  | 0.90  | 1     |      |      |       |       |       |       |        |        |       |
| Fibrou   | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |      |      |       |       |       |       |        |        |       |

a pHLD, ultimate pH of the LD; pHBF, ultimate pH of the BF.
b LDL, LDC, LDH: L*, C*, H* of the LD surface respectively; fat, meat fat content of the hind leg.
c C14:0, C16:0, C16:1, C18:0, C18:1, C18:2, C18:3: miristic, palmitic, palmitoleic, stearic, oleic, linoleic and linolenic acids, respectively.
d CL, cooking loss; WHC, water-holding capacity.
e Anis., Grass, Liver, Sweet: aniseed flavour, grass flavour, liver flavour, sweet taste, respectively.
f Tough., Juici., Chewi., Fibrou.: toughness, juiciness, chewiness and fibrousness, respectively.
origin were chewiness and fibrousness, followed by toughness and grass flavour, and then aniseed flavour and sweet taste. On the opposite side of the CP2 was juiciness, near to intramuscular fat content. Colour, pH, water holding capacity and cooking loss were not well represented by the first two PCs, lying near the origin. The pH values of both muscles were close to each other, showing a high positive correlation. Water holding capacity and fat content were negatively correlated with cooking losses.

Fig. 2 represents the variables in the plan defined by PCs three and four. Here again, chewiness and toughness were negatively correlated with juiciness. Both PCs were influential on the pH and water holding capacity, but cooking losses had no noticeable influence on the PCs. All fatty acids lay near the origin.

Fig. 3 shows the projection of the data in the first two PCs. The figure shows three separate groups of points. Animals fed with diet V were on the left side of the graph, where the variable C18:2 lay, whereas animals fed with diets A and C lay on the right side of the graph, where the saturated acids were grouped. These two groups, although near each other, were separated, group C was further from the origin than group A.

4. Discussion

Principal component analysis has been used before to describe meat quality in rabbit (Hernández, Pla & Blasco, 1997, 1998), but never with sensory data and fatty acid components included among the traits analysed. It seems that both set of traits play an important role is describing the variation observed in rabbit meat.
quality. None of the physical measurements appeared to be related to the sensorial variables, implying that both were needed to describe rabbit meat quality.

There was a negative correlation between C18:2 and C18:1. High contents of C18:2, as a consequence of a diet containing high levels of this acid, lead to lower values of C18:1 (Morgan, Noble, Cocchi, & McCartney, 1992). This could be explained by the fact that C18:2 is the most potent inhibitor of the enzyme Δ9-desaturase, responsible for oleic acid synthesis (Jeffcoat & James, 1984). Juiciness was positively correlated with intramuscular fat and negatively with chewiness and toughness. Meat fat content has been related to quality as fat content has been shown to affect flavour, juiciness and tenderness of both beef and pork (Miller, 1994).

There was a positive correlation between intramuscular fat content and water holding capacity and both were negatively correlated with cooking losses. A negative correlation between fat content and water holding capacity and both were negatively correlated with cooking losses. A negative correlation between fat content and cooking losses has been reported in rabbit meat by Hernández et al. (1998). A decrease in water holding capacity is usually related to a decrease in tenderness (Gault, 1985; Hofmann, 1987), but in our case, no significant correlation was seen between water holding capacity and tenderness. The high positive correlation of ultimate pH of the LD and BF, agreed with the results found by Blasco and Piles (1990) and Hernández et al. (1998).

When data were represented on the plan defined by the first two PCs, two groups were clearly defined, composed of the V animals and those of the A and C rabbits. These two last groups, A and C, although near each other, were separated, by higher content of C18:1 in group A. It is clear that the effect of diet composition on fatty acid profile, is the cause of the groupings A, V and C. However this was not reflected in the sensory analysis; the first two PCs did not group the animals on the A V or C diets. It seems that these experimental diets, despite their clear effects on fatty acid composition, only slightly modified the organoleptic characteristics of the rabbit meat.

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