Ultrasonic monitoring of Iberian fat crystallization during cold storage

2012 IOP Conf. Ser.: Mater. Sci. Eng. 42 012035

(http://iopscience.iop.org/1757-899X/42/1/012035)

IOP Conf. Series: Materials Science and Engineering **42** (2012) 012035 doi:10.1088/1757-899X/42/1/012035

Ultrasonic monitoring of Iberian fat crystallization during cold storage

E Corona, J V García-Pérez, J V Santacatalina, R Peña and J Benedito[1]
Grupo de Análisis y Simulación de Procesos Agroalimentarios (ASPA).
Departamento Tecnología de Alimentos, Universitat Politècnica de València,
Valencia, 46022, Spain. Tel: +34 96 387 91 47.

E-mail: jjbenedi@tal.upv.es

Abstract. The aim of this work was to evaluate the use of ultrasonic measurements to characterize the crystallization process and to assess the textural changes of Iberian fat and Iberian ham during cold storage. The ultrasonic velocity was measured in two types of Iberian fats (Montanera and Cebo) during cold storage (0, 2, 5, 7 and 10 ºC) and in vacuum packaged Iberian ham stored at 6ºC for 120 days. The fatty acid profile, thermal behaviour and textural properties of fat were determined. The ultrasonic velocity and textural measurements showed a two step increase during cold storage, which was related with the separate crystallization of two fractions of triglycerides. It was observed that the harder the fat, the higher the ultrasonic velocity. Likewise, Cebo fat resulted harder than Montanera due to a higher content of saturated triglycerides. The ultrasonic velocity in Iberian ham showed an average increase of 55 m/s after 120 days of cold storage due to fat crystallization. Thus, non-destructive ultrasonic technique could be a reliable method to follow the crystallization of fats and to monitor the changes in the textural properties of Iberian ham during cold storage.

1. Introduction

The overall quality of Iberian ham is highly dependent on the fat content, state and its fatty acid composition, which is greatly affected by the rearing system of pigs [1]. The most important traditional rearing systems are “Montanera” (diet based on acorns and grass) and “Cebo” (diet based on concentrate feeds). Cold storage is used during distribution and retail sale of Iberian ham and can exert a notable effect on textural properties [2]. Therefore, there is a great interest in seeking non-destructive techniques that allow monitoring the crystallization of fat and the effect of storage on the overall quality of Iberian ham. The aim of this work was the use of ultrasonic measurements to characterize the crystallization of Iberian fat and the textural changes of Iberian ham during cold storage.

2. Materials and methods

2.1. Raw material and sampling procedure

Two Iberian subcutaneous fats were used: Montanera and Cebo. Moreover, a total of 10 packages of vacuum packaged Iberian ham (10-20mm thickness) were analyzed. Different points were marked on

[1] To whom any correspondence should be addressed

the surface of each package and the ultrasonic measurements and fat content [3] were determined for each one. All samples were stored at 6±1 ºC during 120 days.

2.2. Fatty acid composition
The fatty acid composition of Iberian fats was determined by gas chromatography (5890A, Hewlett Packard, USA) of the fatty acid methyl esters (FAME) following the method described by Niñoles et al [1].

2.3. Differential Scanning Calorimetry (DSC)
Iberian fat samples were monitored using differential scanning calorimetry (DSC) (DSC5200CU, Seiko Instruments, Inc., USA). The sample (20 mg) was subjected to cooling from 70 to -50 ° C using a wide range of cooling rates (0.2, 0.5, 1, 5 and 10 ºC/min).

2.4. Instrumental textural analysis
The textural analysis was carried out (TA-XT2i, Stable Micro Systems, Survey England) using a conical probe in fat previously melted (70 °C for 30 min) and then placed in Petri dishes (60 mL). Three storage temperatures were tested: 0, 2 and 5 ºC. Measurements were performed during 5 days.

2.5. Ultrasonic measurements

2.5.1. Iberian fats. The experimental set-up consisted of an aluminium cylindrical ultrasonic cell (diameter 17.8 mm, length 25 mm) with two piezoelectric transducers (1MHz, 0.5'' diameter, A303S, Panametrics, Walthman, MA, USA) inserted in each side of the cell, a ultrasonic pulser-receiver (5058PR, Panametrics, Walthman, MA, USA) and PC with a data acquisition card (PCI 5112, National Instruments, USA). The ultrasonic velocity, measured during the storage period, was obtained considering the time of flight and the distance between transducers (25 mm). The fat was melted (70 ºC for 30 min) and placed into the ultrasonic cell set to the experimental temperature (0, 2, 5, 7 and 10 ºC).

2.5.2. Iberian ham. The experimental set-up consisted of a couple of narrow-band ultrasonic transducers (1MHz, 0.5" diameter, A303S-SU, Panametrics, Walthman, MA, USA), a pulser-receiver (5058PR, Panametrics, Walthman, MA, USA) and a digital storage oscilloscope (TDS5034, Tektronix, Bearverton, Oregon, USA). A digital height gage was linked to the computer by a RS232 interface to measure the sample thickness. The ultrasonic velocity in the sample was computed from the time of flight obtained from the signal and the thickness provided by the height gage. The ultrasonic velocity was determined for all samples at 6 ºC in a temperature-controlled chamber (±0.1 ºC) (AEC330R, Infrico, Spain). Measurements were carried out at the beginning (1 day) and end of the storage (120 days).

3. Results and discussion
3.1. Fatty acid profile
The content of saturated fatty acids was significantly different ($p<0.05$) between both fats, being the content higher for Cebo (45.1 %) than for Montanera (41.8 %). For unsaturated fatty acids content (Monounsaturated and Polyunsaturated fatty acids), Montanera showed a significantly ($p<0.05$) higher content than Cebo (58.2 % versus 54.9 %) as a consequence of the rearing system. Montanera animals are mainly fed by acorns, which are a rich source of oleic acid, one of the most important unsaturated fatty acids [1].

3.2. Thermal behavior characterization of Iberian pork fat

Similar DSC curves were found for both fats for all the cooling rates (figure 1(a) and (b)), showing two main peaks (A and B). The peak A was related with the crystallization of the most saturated triglycerides (TGs), while the peak B with the crystallization of the most unsaturated TG fraction [2].

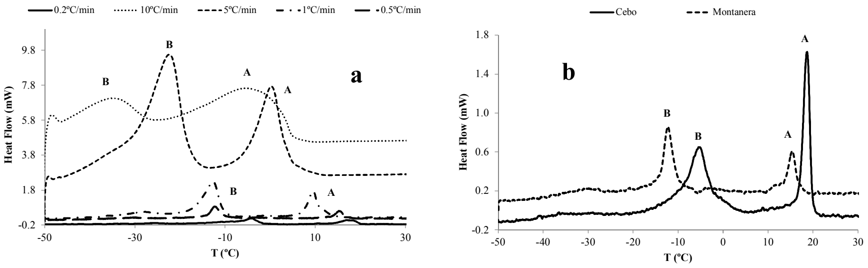

Figure 1. (a) DSC thermograms of Montanera crystallized at different cooling rates (10, 5, 1, 0.5 and 0.2 ºC/min). (b) DSC curves of crystallization profiles of Cebo and Montanera at 1 ºC/min.

As can be observed, both peaks (A and B; figure 1(a)) were broadened and displaced to lower temperatures when the cooling rate increased. On the other hand, Montanera showed significantly ($p<0.05$) lower peak (A and B; figure 1(b)) temperatures than Cebo. It was related to the higher content of unsatured TGs in Montanera.

3.3. Characterization of the textural measurements during cold storage

Figure 2 (a) and (b) highlights that for both fats, the penetration force increased during storage for all experimental temperatures.

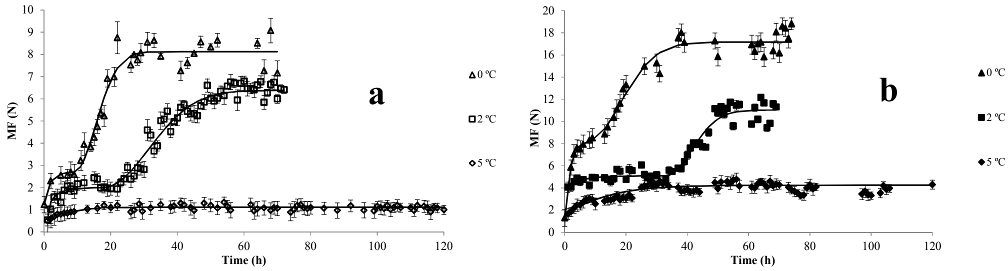

Figure 2. Changes of the maximum penetration force (MF) at different temperatures of Montanera (a) and Cebo (b) fats during cold storage. Average values ± Standard deviation are plotted.

For experiments at 0 and 2 ºC, the curves showed two steep increases during the storage. The first increase was related with the crystallization of the most saturated TGs fraction found by DSC (peak A) and the second steep increase with the most unsaturated TGs fraction (peak B in DSC). At 5 ºC, the most unsaturated TGs fraction did not crystallized during the storage. Figure 2 (a) and (b) shows that the lower the storage temperature, the higher the penetration force as a consequence of the formation of small fat crystals and a denser and harder structure [2]. For the same temperature, Cebo (figure 2(b)) was harder than Montanera (figure 2(a)) fat, which is explained by the fact that saturated fatty acids can easily align themselves to form a compact mass. The unsaturated fatty acids have kinks in their aliphatic chains, causing a zig-zag bending, which results in a less dense structure [4]. Therefore, the higher the saturated TGs content, the harder the texture during crystallization.

3.4. Monitoring of ultrasonic velocity during cold storage

The shape of the ultrasonic velocity curves during storage was similar to the textural ones (figure 3(a) and (b)). Thus, the crystallization of the two fractions of TGs was observed (0, 2, 5 and 7 10 ºC) and related with the increase of the fat solid/liquid ratio, which results in a harder sample where ultrasound waves travel faster. For measurements at 10 ºC, only the first increase of the ultrasonic velocity was observed. Moreover, the higher the storage temperature, the softer the crystalline structure and consequently the lower the velocity.

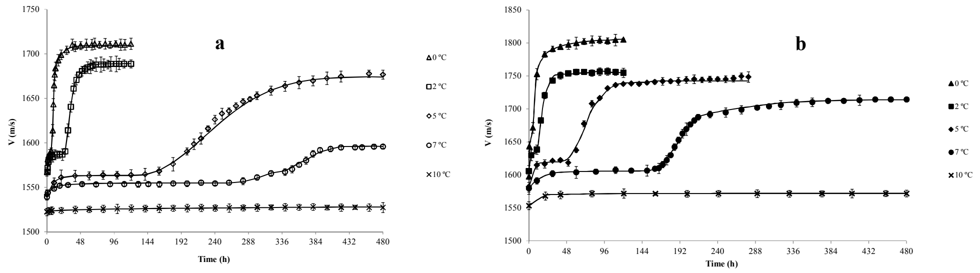

Figure 3. Changes of the ultrasonic velocity during cold storage at different temperatures of Montanera (a) and Cebo (b) fats. Average values ± Standard deviation are plotted.

Finally, when comparing between both fats, the highest values of ultrasonic velocity for the same storage temperature were always found in Cebo (figure 3(b)). As explained in section 3.3, the higher content of saturated TGs in Cebo results into a harder crystalline structure, where ultrasound propagates faster than in Montanera.

On the other hand, for Iberian ham (figure 4), the ultrasonic measurements were well related with the fat content (R^2=0.80) ($p<0.05$) in samples at 6 ºC, before and after cold storage. The ultrasonic velocity in Iberian ham showed an average increase of 55 m/s after 120 days of cold storage due to fat crystallization and therefore to an increase of hardness.

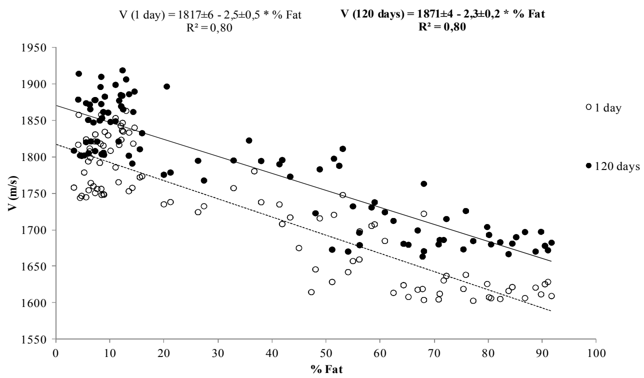

Figure 4. Influence of cold storage (6 ° C) on the ultrasonic velocity in samples of dry-cured Iberian ham.

4. Conclusions

Ultrasonic techniques could be used to identify overall quality in Iberian fats and ham and to monitor the textural changes during cold storage. This application is highly relevant considering ultrasound as a non destructive technology, being easily automated on-line.

Acknowledgements

The authors acknowledge the financial support from the ''Ministerio de Economia y Competitividad'' in Spain (Project RTA 2010-00029-C04-02).

References

[1] Niñoles L, Clemente G, Ventanas S and Benedito J 2007 *Meat Sci.* **76** 102-11
[2] Santacatalina J V, Garcia-Perez J V, Corona E and Benedito J 2010 *Food Res. Intl.* **44** 146-55
[3] AOAC International 1997 *Official Methods of Analysis of AOAC International* 16th ed (Washington, DC: Association of Official Analytical Chemist)
[4] Himawan C, Starov V M and Stapley A G F 2006 *Advn. in colloid and Interface Sci.* **122** 3-33