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Anisotropy and *postmortem* changes in the dielectric properties of *Semitendinosus* muscle

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Abstract – **A polarimetric microwave device is described in this paper. In meat processing, ageing poses storage problems and information is needed to optimize this ageing period. Our microwave device is based on the decay of the anisotropy of dielectric properties of meat. We present our first measurements on meat which are encouraging.**

Keywords: meat, anisotropic dielectric properties, sensor, polarimetric device.

1 INTRODUCTION

A polarimetric microwave device was developed to analyze the anisotropic dielectric properties of meat. Accurate measurements of this anisotropy are interesting to better understand muscle material, as well as for practical applications. In this paper, we present a method to follow *postmortem* structural degradation of muscles.

Meat is a very high anisotropic dielectric material because of its geometric organization and the nature of its components (muscle, myofibres, myofibrils, sarcomeres and protein filaments) which are long and more or less parallel (especially in *m. Semitendinosus*) forming "bundles" of conjunctive tissue and myofibers which have very different dielectric properties [1].

During *rigor* and maturation, structural damages appear [2], [3], [4] that should produce a decrease in the dielectric anisotropy. A sensor able to follow this decrease could be a tool for the optimization of the duration of meat ageing.

This paper presents two types of accurate measurement of dielectric anisotropy.

2 PRINCIPLE OF MEASUREMENT

2.1. Polarimetric method

The principle of the polarimetric method consists [5] of the measurement of variations of interaction between an electromagnetic wave and an anisotropic material when the angle *theta* (θ) between the electric field $\vec{E}$ and the axis of the material varies, as shown in figure 1. A rectangular waveguide linearly polarises microwave as needed in this method.

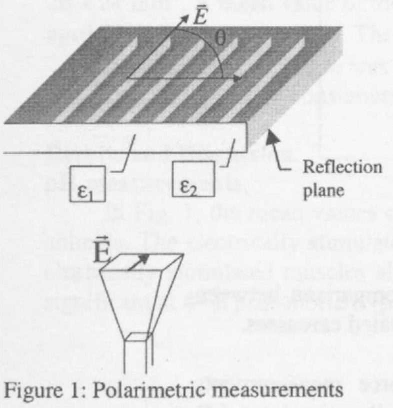

Figure 1: Polarimetric measurements

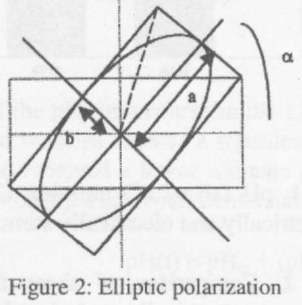

Figure 2: Elliptic polarization

When a linearly polarized wave is reflected on an anisotropic material, the reflected wave is no more linear, but elliptic (figure 2). Ellipticity (a/b) and rotation (α) depend on the anisotropic material. In an anisotropic material, dielectric permittivity (ε) is different according to the direction (*theta*) in which the electric field $\vec{E}$ "sees" the material. The intensity of a linearly polarised wave after passing through an anisotropic material is given by:

(1) $I = r_{E//} \cos^2 \theta + r_{H//} \sin^2 \theta$.

For each angular position *theta* between $\vec{E}$ and sample fibres two kinds of measurements could be done (figure 3) : simple measurement of reflected wave amplitude in the direction of $\vec{E}$ or 3 amplitude measurements in order to obtain information on ellipticity and rotation of the reflected wave.

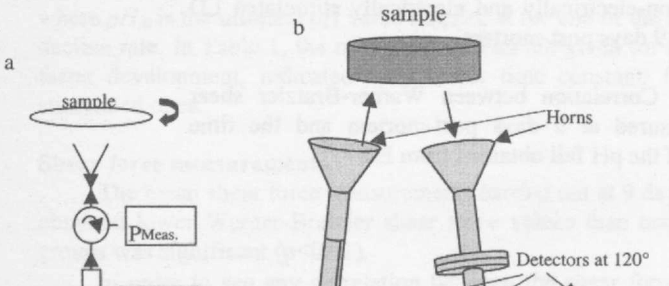

Figure 3: Reflection polarimetric measurement. a: amplitude only, b: polarization state measurement

2.2. Materials

This study involves three sample of *m. Semitendinosus*. Measurements were made on muscles from 3 to 6 days *postmortem*. In all cases, a cut was done on the middle of the muscle in a plane parallel to fibre orientation. This face was used as the reflection plane and the active area was delimited by a flat plate of microwave absorber with a circular window of diameter 90 or 100 mm. Samples were placed on a 100 µm thick plastic film which can be seen as a transparent material for the microwave.

It was necessary to limit temperature variations of the samples. Acquisitions were made with samples at 4°C, and were sufficiently fast to avoid measurement drift due to temperature changes.

3 RESULTS AND DISCUSSION

For each *m. Semitendinosus* sample, measurements were made for angular position from 0 to 360° between meat fibres and electric field. Figures 4 to 6 present the reflected wave power versus *theta* angle. This curves have been obtained thanks to the 10 GHz device presented in figure 3.a.. In both studies reflected power was at a maximum when muscle fibres were parallel to $\vec{E}$. Figure 4 was obtained with a muscle at 6 days *postmortem*, and the active area had a 90 mm diameter. Figures 5 and 6 were obtained with another *m. Semitendinosus*, at 3 and 4 days *postmortem*, respectively, with an active area of 100 mm diameter.

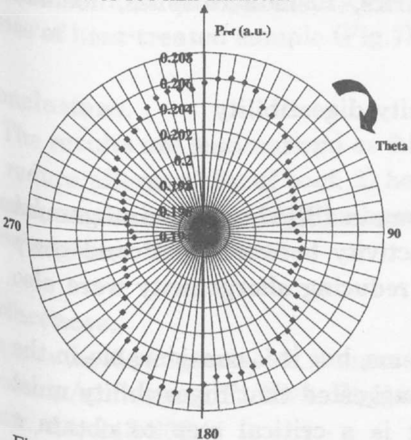

Figure 4: Reflected wave amplitude of ST nb 1

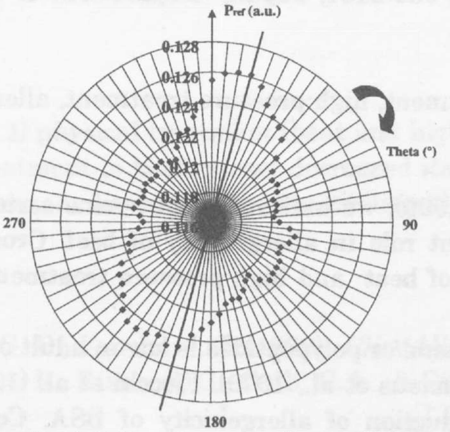

Fig. 5: Reflected wave amplitude of ST nb 2

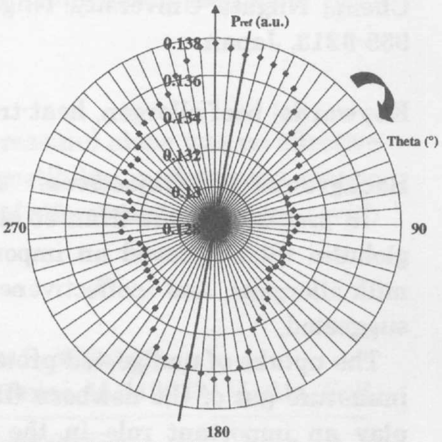

Figure 6: Reflected wave amplitude of ST nb 2, second configuration

These three first results show some important information :

- Our method gives the fibres direction. In figures 5 and 6, there is a shift between the visual direction and the measured direction. This can be explained by the penetration depth of the microwave (a few millimeters in biological tissues at 10 GHz).
- Anisotropy is very weak (about 3 %).
- The ratio signal/noise is not enough to measure weak variations of dielectric anisotropy during ageing. This ratio must be improved by changing device.

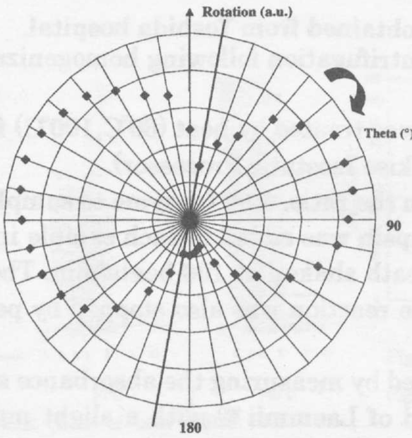

Figure 7: Rotation wave amplitude for STnb 3

Figure 7 shows the rotation of reflected wave versus the angular position *theta*. These results have been obtained with the 30 GHz device presented in figure 3.b.. The studied muscle was *m. Semitendinosus* at 3 days *postmortem*, and the active area was a 100 mm diameter disk. Rotation was at a minimum when fibres were parallel to $\vec{E}$.

This result is in good agreement with figures 4 to 6 : rotation of the polarization direction induce a decrease of amplitude wave in the incident direction. This kind of measurement seemed to be more accurate than a simple amplitude measurement.

4 CONCLUSION

A microwave polarimetric method is described. This non-invasive method is used to obtain information about the decay of the dielectric anisotropy of meat with an aim to optimize ageing duration.

These first measurements were done on *m. Semitendinosus* at 3 to 6 days *postmortem*. Amplitude and rotation wave measurements versus angular position, *theta*, between muscle fibers and electric field are both encouraging.

5 REFERENCES

[1] Epstein B.R Foster K.R "Anisotropy in the dielectric properties of skeletal muscle". *Medical and Biological Engineering and Computing*. 1983;21:51-55.

[2] Marsh B.B., Carse W.A. "Meat tenderness and the sliding-filament hypothesis". *Journal of Food Technology*. 1974;9:129-139.

[3] Koohmaraie M. "Muscle proteinases and meat aging". *Meat Science*. 1994;36:93-104

[4] Taylor R.G., Geesink G.H., Thompson V.F., Koohmaraie M., Goll D.E. "Is Z-disk degradation responsible for *postmortem* tenderization ?" *Journal of Animal Science*. 1994;73:1351-1367.

[5] Fleury P. and Mathieu J.P., *Lumière*, Eyrolles, Paris: 1970, p 182.