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Begining of fish defrosting by using non-destructive ultrasonic technique

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During the experiments carried out on the monitoring and the study of fish defrosting by an ultrasonic technique, we have difficulties in detecting the beginning of the thawing which is an important criterion of fish quality control. To address this problem, we use the Singular Value Decomposition method (SVD) which is a mathematical tool that permits to separate the high and low energies of an histogram. The image representing low energy signals indicates the start of the thawing by showing an echo that was hidden in the original image for cod fish. However for salmon fish, this method doesn't provide good results. Therefore, this method is suitable for fish whose fat content medium or low.

Keywords: Ultrasonic technique, fish, defrosting, SVD method, quality control

1 Introduction

The state of freshness of the raw material is essential for the quality of the final fish product (Olafsdottir et al., 1997). At present there is no instrumental method for freshness determination that has gained commercial recognition. Requirements to an instrumental method are speed, objectivity, feasibility, nondestructivity, ease of use and moderately prices. The use of low intensity ultrasonics (LIU) in food applications has been extended to, among others, meat, fish, dairy products, vegetables, fruits and fats and oils (Mc Clements, 1997; Mulet et al., 1999; J.N. Coupland, 2004; L. Ninoles et al., 2008). LIU have been used not only for well known process control applications but also for product quality control. The retrodiffused signal by fish presents an overlapping echos. The aim of this work is to detect the beginning of the thawing, known to be an important criterion of fish quality control, by using the Singular Value Decomposition method (SVD) which is a mathematical tool that permits to separate the high and low energies of an histogram.

2 Materials and Methods

2.1 Materials

Cod fillets are purchased from a fish shop and are transported to the laboratory. These fillets of 2 cm thickness are cut in cubes and are placed directly to freezer at temperature -18°C for a minimum of 24 hours. Then the fish sample is brought from the freezer and placed immediately into the vat, and we start the thawing monitoring is started.

2.2 Methods

a) Experimental set-up

The experimental set-up is constituted by a panametrics broadband contact transducer of 500 KHz or 5 MHz central frequency placed under the vat containing the fish cube to study.

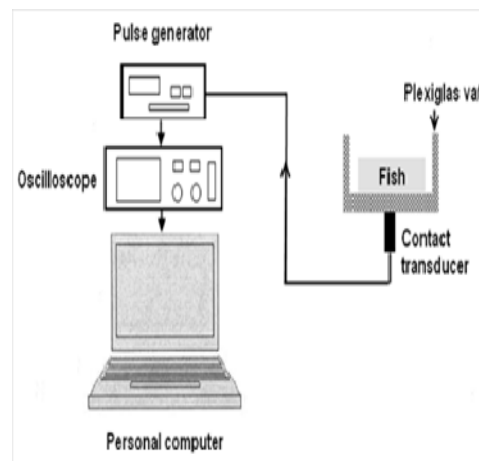


Figure 1: Experimental set-up

The transducer that is directly in contact with the sample (Fig. 1), is used successively as emitter and receiver. The pulse generator sends to the transducer a short electrical pulse, which is transformed into an acoustic wave. After propagation in fish the incident acoustic beam is reflected and picked by transducer. The reflected acoustic signal (Fig. 2), composed of a series of echoes, is converted into an analogic electrical signal, and is amplified and collected by a 300 MHz Lecroy digital oscilloscope. The data are sent through an IEEE 488.2 interface to a personal computer. The duration of the experience is 150 minutes. Every minute 10 signals are acquired and averaged to get one signal.

b) Example of a retrodiffused signal by cod fillet

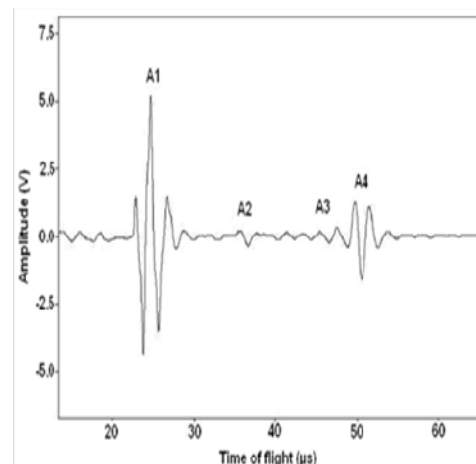


Figure 2: Type of the retrodiffused signal by fish during its defrosting

Figure 3 describes the different paths taken by the ultrasonic wave. Each path provides an echo, which is labeled ($n = 0, 1, 2, 3 \dots$). Fig. 2 considers only observed echoes A_1 to A_4 .

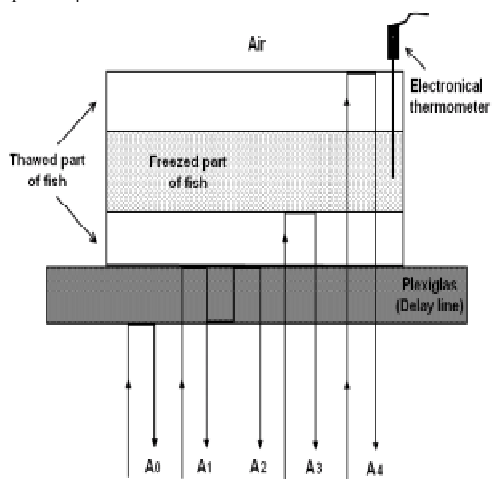


Figure 3: Type Propagation paths in fish during defrosting (A_0 to A_4 are observed echoes)

- A_0 is the specular echo reflected on the bottom face of the fish cube.
- A_1 is the retrodiffused signal by the interface plexiglas/thawed part of fish.
- A_2 is the retrodiffused signal by the interface thawed part of fish / frozen part of fish.
- A_3 is the second back-and-forth in the plexiglas.
- A_4 is the retrodiffused signal by the interface thawed part of fish/air.

3 Results and Discussion

The application of the SVD method on experimental ultrasonic signals obtained from the monitoring of the fish thawing in real time by the ultrasonic technique in reflection, allows us to respond to stresses such as: noise, overlapping echos.

3.1 Characterization of the cod first defrosting

The superposition of 150 retrodiffused signals during the experience creates an image which allows to control the defrosting process. The retrodiffused signals are recorded in a matrix form containing the superposition of all the retrodiffused signals for 150 minutes. Each signal is composed of 5000 points, so the dimension of the result matrix X of the experience is 5000×150 . The image shows, the movement of the echoes and the evolution of their amplitudes. Every echo have maxima and minima. We must remember that the A_2 echo corresponding to the interface thawed part of fish / frozen part of fish, has a very low energy compared with the other echoes, and is overlapped at the beginning of the thawing with the A_1 echo which has a high energy.

$$[USV] = svd(X) \quad \text{Eq. (1)}$$

The figure 4 shows the image of the result matrix of the cod first defrosting using the transducer of 500 KHz central frequency .

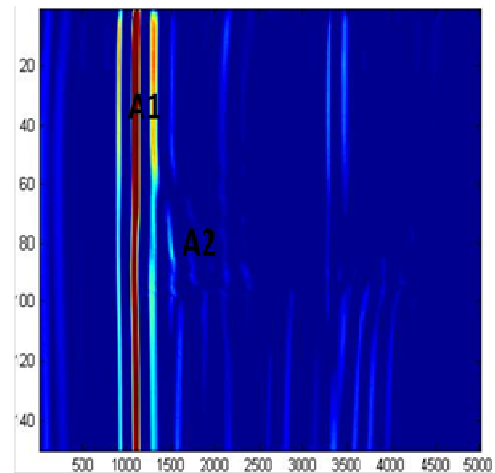


Figure 4: Type Superposition of the retrodiffused signals during cod first defrosting; transducer 500 kHz

The SVD method is based on the calculation of singular values of the resulting matrix.

- ✓ Calculation of the singular values:

The figure 5 shows the diagram of the singular values σ_i .

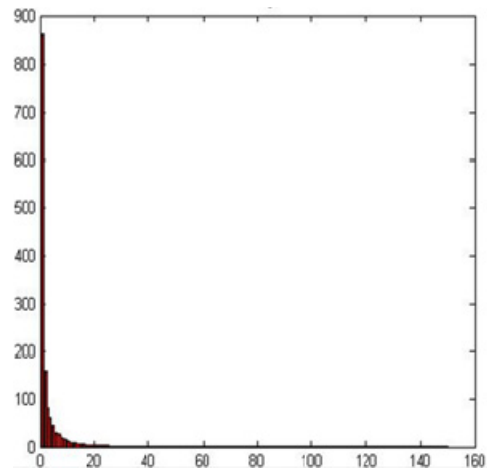


Figure 5: The singular values diagram of the Cod first defrosting

As we see in Figure 5, the difference between the singular values corresponding to the higher energy contributions and the singular values corresponding to the low energy contributions is very large. This will facilitate the contributions separation. The signal subspace high-energy is represented by the Q initial specific sections and the matrix X_D (D for dominant); $(K-Q)$ sections represent the low energy contributions and X_{LE} is its corresponding matrix; and $(150-K)$ sections and N represent the noise subspace and its matrix. X is equal to:

$$X = X_D + X_{LE} + N \quad \text{Eq. (2)}$$

✓ **Extraction of the dominant energy contributions**

E_{1-4} :

The calculation of the dominant contribution is defined by the equation 3:

$$E_{1-4} = \sum_{i=1}^4 \sigma_i * U_i * V_i^T \quad \text{Eq. (3)}$$

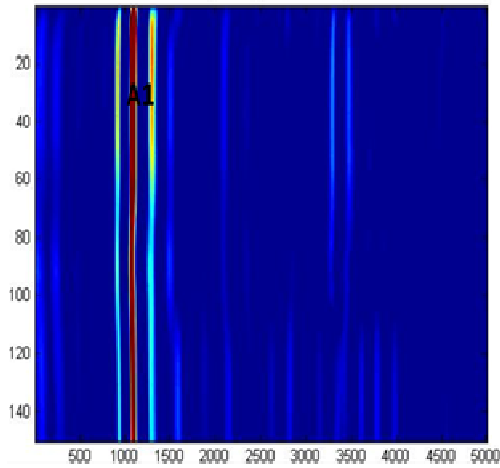


Figure 6 : Image of the dominant energy contributions E_{1-4}

We verify clearly the separation of the A_1 echo.

✓ **Extraction of the low-energy contributions E_{5-20} :**

As well, we calculate the low-energy contributions by the equation 4:

$$E_{5-20} = \sum_{i=5}^{20} \sigma_i * U_i * V_i^T \quad \text{Eq. (4)}$$

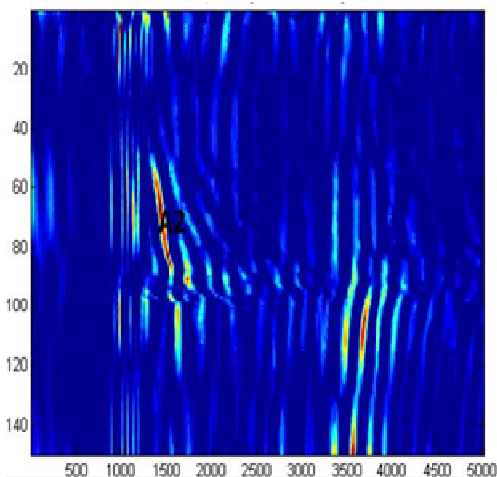


Figure 7 : Image of the low-energy contributions E_{5-20}

We note that the detection of the fish defrosting beginning is improved, it is equal to 33 min. While without treatment, it was equal to 78 min.

✓ **Noise extraction:**

The calculation of the noise subspace is defined by the equation 5:

$$E_{21-150} = \sum_{i=21}^{150} \sigma_i * U_i * V_i^T \quad \text{Eq. (5)}$$

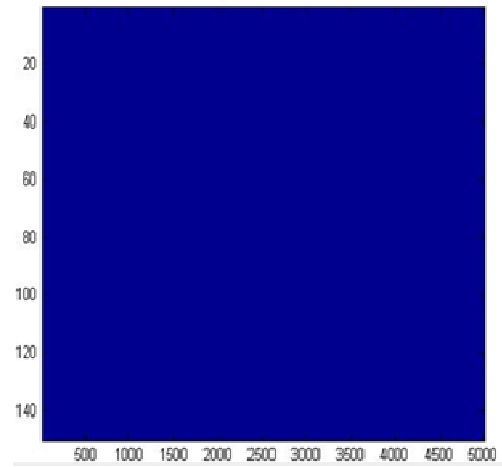


Figure 8 : The noise subspace

The noise contribution is very low.

3.2 Characterization of the salmon first defrosting

We did the same as for cod fish, but the extraction of the low-energy contributions gave no result as shown in figure 9:

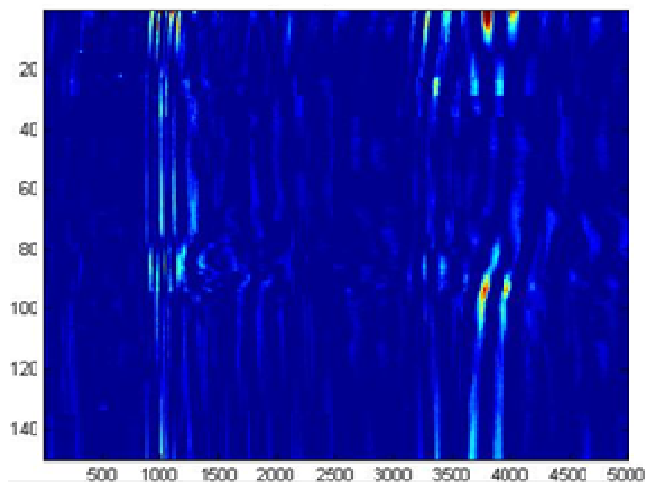


Figure 9 : Image of the low-energy contributions E_{5-20}

4 Conclusion

The SVD method has allowed us to show the beginning of fish thawing for cod fish which has an average fat content. The results were good with a contact transducer of 500 KHz central frequency. However for salmon which is a fish that has a high content of fat, and with transducers for central frequencies above 500 kHz the observed results are not very good.

References

- [1] Olafsdottir, G., Martinsdottir, E., Oehlenschläger, J., Dalgaard, P., Jensen, B., Undeland, I., Mackie, I. M., Henahan, G., Nielsen, J., & Nilsen, H. (1997). Methods to evaluate fish freshness in research and industry. *Trends in Food Science and Technology*, 8(8), 258–265.
- [2] DiMucci, D., Mastrangelo, F., Milano, A., D'Aleo, A. "From acoustic to the wall of sound", *J. Acoust. Soc. Am.* 105(11), 1957-1967 (2004)
- [2] McClements, D.J. 1997. Ultrasonic Characterization of food and drinks: Principles, methods and applications. *Critical Reviews in Food Science and Nutrition*, 37, 1-46.
- [3] Mulet, A., Benedito, J., Bon, J. and Sanjuan, N. 1999. Low intensity ultrasonics in food technology. *Food Sci and Technology International*, 5, 285-297.
- [4] J.N. Coupland, Low-intensity ultrasound, *Food Res. Int.* 37 (2004) 537-543.
- [5] L. Ninoles, N. Sanjuan, S. Ventanas, J. Benedito, Ultrasonic and sensory characterization of dry-cured ham fat from Iberian pigs with different genetics and feeding backgrounds, *Meat Sci.* 80 (2008) 896-902.