Scientific Bulletin. Series F. Biotechnologies, Vol. XVII, 2013
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

SOME IMPORTANT QUALITY PARAMETERS OF PORK MEAT-BIODEGRADABLE PACK SYSTEM MONITORING AT REFRIGERATION STORAGE

Vlad Ioan POPA[1], Elena TANASE[1], Mihaela GEICU-CRISTEA[1], Cristian-Andi NICOLAE[2], Raluca Augusta GABOR[2]

[1]University of Agronomic Sciences and Veterinary Medicine Bucharest, Faculty of Biotechnologies, Department of Industrial Biotechnologies, 59 Marasti Blv, District 1, zip code 011464 Bucharest, Romania, phone: +4021.318.22.66, fax: +4021.318.22.88, e-mail address: popa.ivlad@yahoo.com; elena.eli.tanase@gmail.com; mihaela_geicu@yahoo.com
[2] The National Institute for Research&Development in Chemistry and Petrochemistry Bucharest, Polymer Department, 202 Splaiul Independentei, District 6, zip code 060021, Bucharest, Romania, phone: +4021. 315.32.99, fax: +4021.312.3493, e-mail address: office@icechim.ro

Corresponding author: popa.ivlad@yahoo.com

Abstract

The quality of fresh meat is an extremely important characteristic influencing the consumer's purchase decision. The behavior of biodegradable tray in contact with meat is important also for food chain logistic management. The stability of this system meat-biodegradable tray is depending by a variety of factors and can be monitored through physic-chemical and microbiological assessment of meat on the one hand and tray material behavior on the other hand. The effect of chilling temperature on both meat and tray material have been experimented in this work. For this purpose, Longissimus dorsi from pork carcass was packed in biobased trays and stored at 4°C ±1 for 7 days. During the chilled storage physic-chemical analysis as pH, color, dry matter content, a_w, titratable acidity, presence of hydrogen sulfide, ammonia in the free state and microbiological analysis as total plate count, number of yeasts and moulds, coliform bacteria, the enterobacteriaceae, Salmonella sp., also thermo gravimetric analysis (TGA-DTG), differential scanning calorimetry (DSC), dynamic mechanical analysis (DMA) and Fourier transform infrared spectrometry (FTIR) of biobased trays were performed. Thermal analyzes showed no changes in the properties of polymeric materials used in the manufacture of food trays. FTIR and TGA analysis revealed the occurrence of some deposits consisting especially in moisture and organic material on the inside of the food trays.

Keywords: *meat quality, biodegradable trays, meat shelf life, refrigeration storage.*

INTRODUCTION

Consumers find pork meat a very important food product because of its high nutritional value. *Longissimus dorsi* it is specifically important, from a scientific point of view, because of its uniformity, which helps getting very accurate results from different analyzes. Another important issue regarding pork meat is the preservation by freezing or chilling and the effects of low temperatures on meat. For a conclusive set of results, the meat was stored in biodegradable trays, as if it was on the commercial shelf. The behavior of biodegradable tray in contact with meat is important also for the food chain logistic management. The stability of this system meat-biodegradable tray is depending on a variety of factors and can be monitored through physical - chemical and microbiological assessment of meat on the one hand and tray material behavior on the other hand. In this paper, some important parameters have been assessed in order to establish both meat quality and biodegradable material in contact with meat behavior in certain storage conditions.

MATERIALS AND METHODS

In this study, the system *Longissimus dorsi* pork muscle – biodegradable tray was analyzed in different conditions of low temperature preservation.

The meat was analyzed fresh as control, after 3 and 7 days of refrigeration (chilling) storage at 4°C, and after the freezing storage at - 18°C for 8 months, during which the meat was analyzed at the 1st, 2nd, 3rd, and the 8th month.

Physical – chemical analysis

In order to establish the degree of freshness of meat samples during the storage period, a certain number of physical-chemical analysis were performed.

- *Preparation and characteristics of watery extract.* For the preparation of the watery extract, 10 g of meat were put in an Erlenmeyer, along with 100 ml of distilled water for 15 minutes. They were given 2-3 shakes then filtered. Filtration time is shorter if the pork meat is fresh. If the product is fresh, filtering is done in a continuous jet and takes about 5 minutes. The filtration efficiency (the ratio between the amount of filtered and distilled water initially added) is 90 - 95%. For a fresh product, the watery extract has the following characteristics: it is clear, has clear pink color and specific odor.

- *Determination of the free ammonia with the Nessler reactive.* The free ammonia inside the watery extract forms with the Nessler reactive a yellow precipitate that shows the degree of alteration.

-*Determination of dry matter.* Determination of the dry matter with the Precisa XM 60 thermal balance represents a fast and reliable determination of moisture content using thermo gravimetric principle. Thermogravimetry represents weighing the sample before and after heating to determine the moisture content by difference.

Sample preparation: the sample is prepared at the time of measurement. This prevents moisture exchange with the environment. Weigh 5 g of the sample, which are distributed in a thin and uniform layer over the entire surface of the dish.

- *Determination of a_w. A_w* index is a measurement of the energy status of water in a system. In this study, a_w was determined with a NOVASINA system, which is very easy to use and provides both the a_w index value and the temperature of the sample.

Sample preparation: using a spatula, pork meat samples were placed in boxes fitted with thermostatic apparatus for determining a_w, so the box is covered completely with the sample, and filled only halfway to avoid contact between the sample and the filter covering the reading sensor.

- *pH determination.* The samples′ pH was determined after each storage time with an INOLAB 720 WTW series pH-meter with an automated temperature compensator equipped with an insertion electrode. The electrode was inserted into the sample vertically, so that the glass electrode′s membrane is entirely in contact with the sample and was maintained until stabilization of pH on the screen. When the reading is over, the pH value is displayed. Three readings were taken at different positions in each sample.

- *Determination of titratable acidity.* Acidity of different products can be determined by titration of their watery, or other solvent solutions, with sodium or potassium hydroxide.

Microbiological analysis

The total plate count was determined using the SR ISO 4833-94 standard. The analysis method includes the following steps: 10 g of each sample were placed in Erlenmayer with 90 ml of distilled water. From the sample thus obtained 1 ml was placed in 9 ml of distilled water, producing the 1st decimal dilution. More decimal dilutions were produced, different for each sample. 1 ml of each dilution was inoculated, in duplicate, on RIDA COUNT type petrifilms. Petrifilms were incubated aerobically for 72 hours at a temperature of 30 ° C and then grown colonies were counted on each plate. The aerobic count of each sample was determined by applying the formula:

$$N = \frac{\sum C}{(n_1 + 0{,}1n_2)d}$$

where:

N = the microorganisms load in 1 ml of sample;

$$\sum C$$

=total number of colonies on the held plates;

$(n_1 + 0{,}1n_2)$ = total number of held plates, with the same dilution;

d = the first applied dilution;

The same method was used for the determination of coliform bacteria, *Enterobacteriaceae*, *E. coli* and *Salmonella sp.*

Color determination

The color of the food is a very important attribute in the food industry because food

products are frequently purchased by their color. Many of the consumers believe that if a food product looks good and has an appealing color, this means it′s safe to consume. Color measurements are made to determine the food quality.

After each storage period sample color evaluation was performed after opening the package using a MINISCAN^{TM} XE PLUS colorimeter connected to a computer provided with the Universal Software V.4.01. The following settings were used for color index calculations: D65 illuminant, a 10º observer angle, LAV vision range and the CIELAB′76 color system. The *L**, *a** and *b** color indexes were obtained from the average values of ten readings on the surface of *longissimus dorsi* samples placed in the glass recipient provided by the colorimeter. The samples were then placed in the colorimeter′s reflectance port and color measurements were taken from ten different positions (Viana et al., 2005).

Packaging Trays Behavioral analysis methods

During this experiment thermal analysis were performed on the biodegradable trays which have been used for the packaging of the pork meat samples. The trays material was made as "sandwich" from 2 different components as follow: first layer – 10% PLA, second layer – 80% [(PLA-Ecoflex)- wood fiber - (50:50):15 wt%] and the third layer – 10% PLA. The brand name Ecoflex produced by BASF company is consisting of biodegradable aliphatic-aromatic copolyesters.

The TA Q2000 apparatus was used for differential scanning calorimetry (DSC). Differential scanning calorimetry (DSC) it′s a technique in which the heat needed to raise the temperature of the reference zone is measured in terms of time. Both the initial sample and the reference are kept at the same temperature through the whole experiment. The reference zone must have a heat capacity well-defined in scanner′s temperature range. DSC is used to confirm the formation of a complex in the solid state (Mourtzinos I. et al., 2007).

The thermo-gravimetric analysis (TGA) is a method that determines mass changes in a controlled atmosphere, under the effect of temperature. This analysis uses the TA Q5000 IR machine and is based on 3 accurate measurements: mass, temperature and temperature changes. The thermo-gravimetric analysis is a process that uses heat and stoichiometric ratios to determine the solution′s mass percentage. The mass loss is proportional to the increase of temperature, which in some cases goes above 1000 °C.

The dynamical mechanical analysis (DMA) uses the DMA Q800 machine and is used to study and characterize the mechanical properties of different materials, especially polymers. This is the best way to determine the visco-elasticity in the polymer matrix.

Fourier transform infrared spectroscopy (FTIR) is a technique which is used to obtain an infrared spectrum of absorption, emission, photoconductivity or Raman scattering of a solid, liquid or gas. An FTIR spectrometer simultaneously collects spectral data in a wide spectral range. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time (Krishna G.M. et al, 2013).

RESULTS AND DISCUSSIONS

Physical – chemical analysis

The results are shown in Table 1 and 2.

Over the refrigeration period the pH decreased from 5.97 initially to 5.77 after 7 days. During the freezing period the pH increased to 5.92 after 1 month, 6.03 after 2 months, 6.19 after 3 months. After the whole 8 months period, the pH decreased to 5.73.

The determination of the free acidity of pork meat samples during the refrigeration and the freezing periods showed a slight decrease.

Table 1. Values of physical-chemical analysis

Period of cold storage	pH	H_2S	Acidity (g oleic acid/100g)	NH_3 (Nessler react)
Chilled samples				
Control	5.97	Negative	0,18612	Negative
4 days	5.78	Negative	0.25116	Negative
7 days	5.77	Negative	0.16926	Positive
Frozen samples				
1 month	5.92	Negative	0.37224	Negative
2 months	6.03	Negative	0.24816	Negative
3 months	6.19	Negative	0.1974	Negative
8 months	5.73	Negative	0.24024	Negative

The fresh sample recorded a value of 0.18 g of oleic acid/100 g of product, while after 7 days of refrigeration the value decreased to 0.16 g of oleic acid/100 g of product.

During the freezing period the overall acidity was higher than the fresh sample, ranging from 0.37 g of oleic acid/100 g of product after 1 month, to 0.24 g of oleic acid/100 g of product after 8 months.

The results indicated that the meat samples kept their freshness during the experiment, except on the 7th day of refrigeration, in which case the meat showed signs of alteration (through the Nessler reactive index which was positive).

The determination of aw index of pork meat samples has shown that during the refrigeration the a_w index slightly increased, while during the freezing period the aw index decreased. Thus the fresh sample recorded a value of 0.973, while after 7 days of refrigeration the sample had a value of 0.976. During the freezing period the a_w value decreased from 0.970 after one month to 0.950 after 8 months (see Table2).

The determination of dry matter in pork meat samples showed that during the refrigeration the dry matter percentage increased, while during the freezing period it decreased. Thus the fresh sample had a value of 71.21% dry matter, while after 7 days of refrigeration it increased to 82%. During the freezing period the meat samples recorded a value of 77.54% after 1 month, decreasing to 71.41% after 8 months (Table 2).

Table 2. Values of physical-chemical analysis

Period of cold storage	Watery extract	Super natant	a_w	Dry matter
Chilled samples				
Control	Clear, normal, pink	Clear, yellow	0.973	71.21%
4 days	Clear, normal, pink	Clear, yellow	0.973	83%
7 days	Turbid, dark pink	Turbid, yellow	0.976	82%
Frozen samples				
1 month	Clear, normal, pink	Clear, yellow	0.970	77.54%
2 months	Clear, normal, pink	Clear, yellow	0.966	72.26%
3 months	Clear, normal, pink	Clear, yellow	0.960	76.07%
8 months	Clear, normal, pink	Clear, yellow	0.950	71.41%

Microbiological analysis

The results of the microbiological analysis for the total plate count are shown in Figure 1.

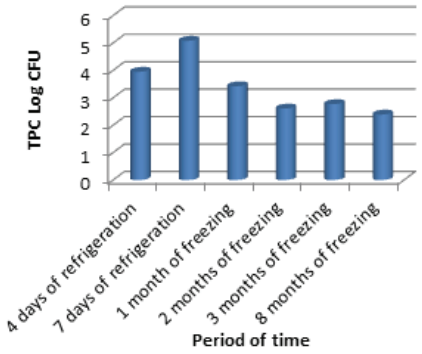

Figure 1. TPC evolution

It can be observed a slight decrease of CFU in all the samples except the fresh one in which case there were no CFUs at all.

The results of the microbiological analysis to determine the yeast CFUs are shown in Figure 2. It can be observed a slight increase of CFU during the refrigeration period, while during the freezing period the CFU value decreased.

Yeast was also present in all of the samples except the fresh one.

Molds were present in all of the samples but under the countable values in the first dillution.

Coliforms were only present in the meat samples that were analyzed after 4 and 7 days of refrigeration, and after 1 and 3 months of freezing.

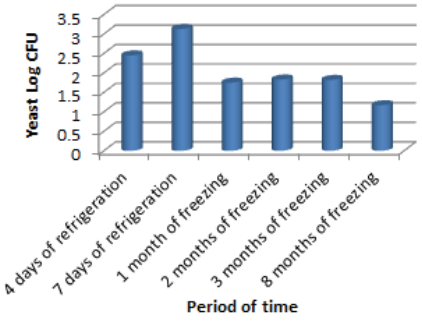

Figure 2. Yeast count evolution

The enterobacteriaceae analysis showed CFUs only after 7 days of refrigeration and after 1 month of freezing.
E. coli and *Salmonella* were not present in any pork meat sample during the monitoring period.

Color measurements

The values determined with the Hunter Lab colorimeter for L*, a* and b* are showedin Table 3 and they are graphically represented in Figure 3.Color measurements showed very little difference between fresh meat and stored meat. Some differences were noticed among samples related to yellow and red intensity, most probably due to heterogeneity of the sirloin fat content.

Table 3. The values of L*, a* and b

Period of cold storage	L*	a*	b*
Control	36,57	10,77	12,03
4 days	37,28	11,42	11,88
7 days	34,51	10,21	11,5
1 month	39,15	12,1	15,54
2 months	36,06	10,09	12,42
3 months	28,8	10,46	9,06
8 months	37,47	9,26	10,88

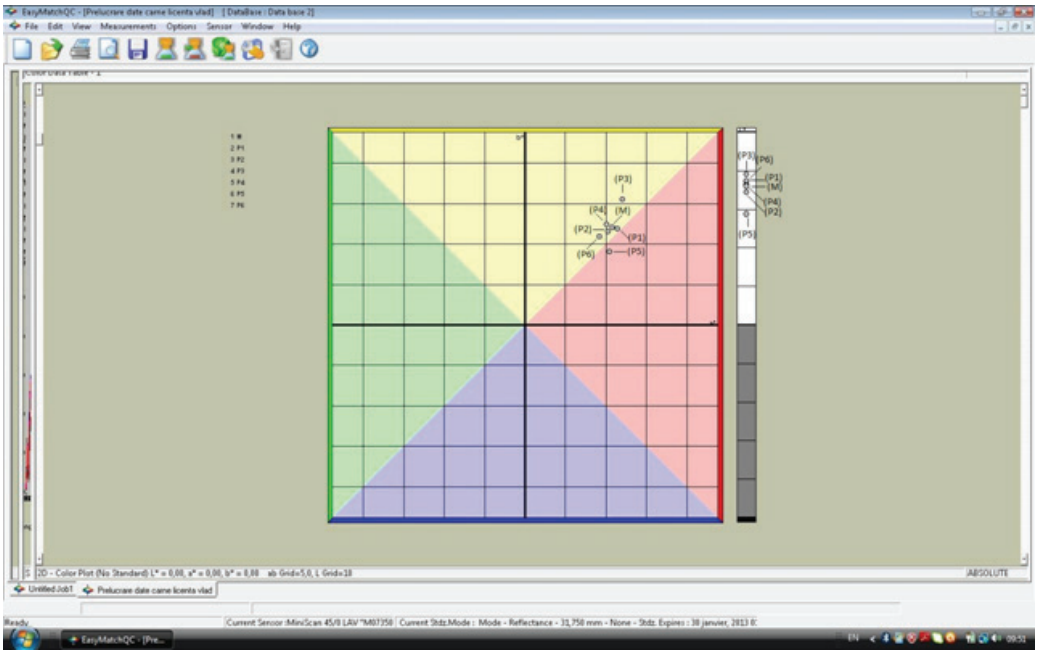

Figure 3. Graphic representation of L*, a*, b* values, according to Universal Software V4.01 MiniScanTM XE Plus program, for longissimus dorsi meat samples during the assessment period. M – fresh meat sample (control); P1 – 4 days of refrigeration sample; P2 – 7 days of refrigeration sample; P3 – 1 month of freezing sample; P4 – 2 months of freezing sample; P5 – 3 months of freezing sample; P6 – 8 months of freezing sample

However, in the graph presented in Figure 3, it can be observed that the values for a* and b* are grouped around the control for the chilled meat samples and slightly different positioned from control for the frozen meat samples.

Biodegradabile food tray analysis

The results for thermo – gravimetric analysis (TGA) of the biodegradable food trays are graphically represented in Figure 4 for the refrigerated samples, respectively in Figure 5 for the frozen samples.

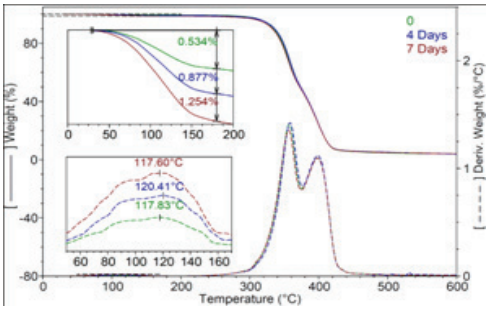

Figure 4. Standard TGA results of FT-Sandwich: 0 (reference), 4 D and 7D, refrigerated for 4 and 7 days.

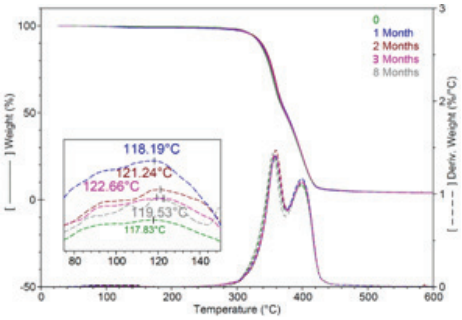

Figure 5. Standard TGA results of FT-Sandwich: 0 - reference, 1, 2, 3, 8 months.

In Figure 6 are represented the values obtained by analyzing the refrigerated biodegradable food trays with Differential Scanning Calorimetry (DSC). Also, the values obtained for the food trays that were kept at - 18ºC are graphically represented in Figure 7.

The differences between samples in terms of specific heat (ΔCp), enthalpy of cold crystallization (ΔHc) and total melting enthalpy (ΔHm) measured by DSC are probably due to absorption of water during your time spent in contact with meat.

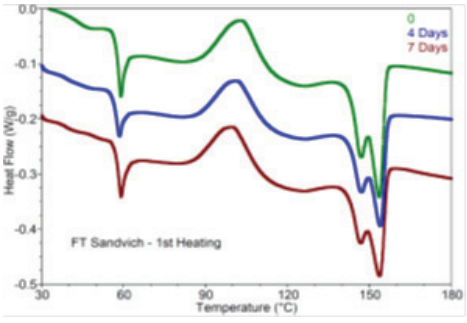

Figure 6. DSC curves of FT-Sandwich: 0 (reference), 4 D and 7D, refrigerated for 4 and 7 days

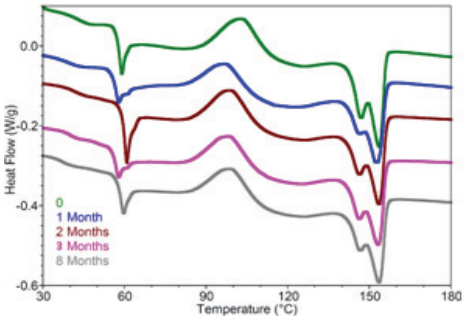

Figure 7. DSC curves of FT-Sandwich – 0 - reference, 1, 2, 3, 8 months

In the figures below (Figure 8 for the refrigerating period and Figure 9 for the freezing period) are graphically represented the values obtained after analyzing the biodegradable food trays from dynamic mechanical point of view.

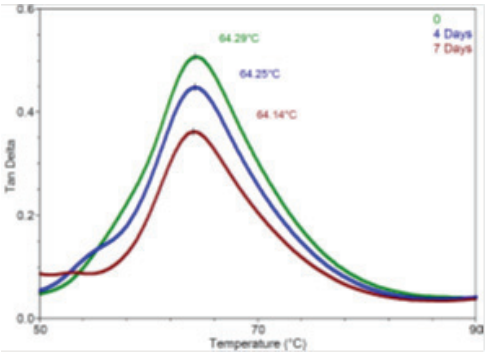

Figure 8. Graphic representation of Dynamic Mechanical Analyses (DMA) (Loss Factor – tan δ)

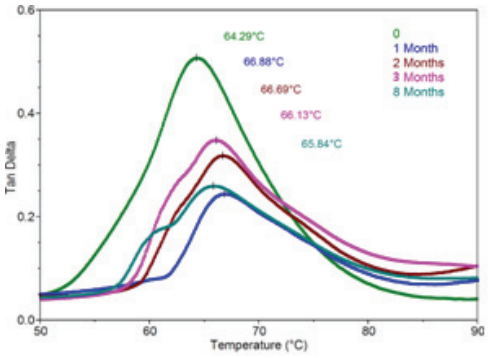

Figure 9. Figure DMA curves (Tan Delta) of FT-Sandwich: 0 - reference, 1, 2, 3, 8 months

The results for FT-IR analysis performed on the biodegradable trays are presented in the figures below. In Figure 10 are presented the results of

the analysis performed during the refrigeration storage time, respectively in Figure 11 are presented the results of the analysis performed on the food trays during the freezing storage time. FTIR analysis carried out on trays with frozen meat showed the occurrence of a layer that contains water and organic materials probably due to microbial cultures formed on the surface (peaks 3288cm-1, 1653 and 1544 cm−1), fact confirmed by thermal analysis which showed an increase in weight loss of around 120ºC.

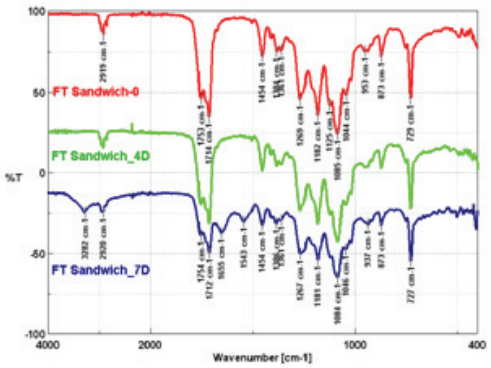

Figure 10. FT-IR Patterns of FT-Sandwich (0 - reference, 4D and 7D - with refrigerated meat for 4 and 7 days)

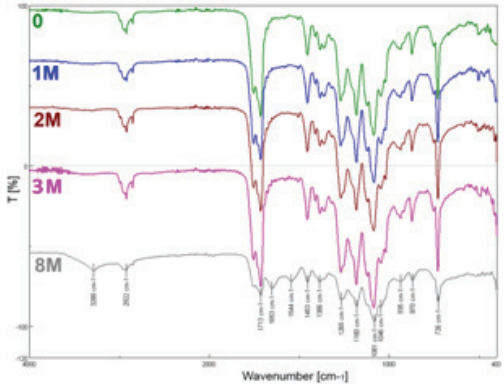

Figure 11. FT-IR Patterns of FT-Sandwich: 0 - reference, 1, 2, 3, 8 months

CONCLUSIONS

Temperature is one of the major factors affecting physical chemical and microbiological quality of meat.

Storage at chilling temperature (4^{o}C) of the meat packed in trays for minimum 4 days according to present study, showed no significant quality degradation.

Storage at freezing temperature (-18^{o}C) for 8 months showed no significant quality changes from physical chemical point of view and an improvement for the microbiological parameters.

Thermal analysis (TGA, DSC and DMA) carried out on "Sandwich" Food Tray Prototype have shown that meat storage conditions did not lead to significant changes in terms of thermal degradation, glass transition, cold crystallization temperature or melting temperature. Any small differences between the analyzed samples are most probably due only to material heterogeneity.

ACKNOWLEDGMENTS

This work was part of the EU FP7 project “Forest resource sustainability through bio-based-composite development” (FORBIOPLAST), GA 212239, 2008 - 2012.

REFERENCES

Krishna G.M., Muthukumaran M., Krishnamoorthy B., Nishat A., 2013. A critical review on fundamental and pharmaceutical analysis of FT-IR spectroscopy. International Journal of Pharmacy, 3(2), 396-402.

Mourtzinos I., Salta F., Yannakopoulou K., Chiou A., Karathanos V.T., 2007. Encapsulation of olive leaf extract in β-Cyclodextrin. Journal of Agricultural and food Chemistry, 15.

Viana E.S., Gomide L.A.M., Vanetti M.C.D., 2005. Effect of modified atmospheres on microbiological, color and sensory properties of refrigerated pork. Meat Science, 71, 696-705.

*** - Final report of FP7 - KBBE Project FORBIOPLAST (Forest resource sustainability through bio-based-composite development) 212239/2008.