LIQUID SMOKE AND ITS EFFECT ON THE OXIDATIVE STABILITY OF THE LIPIDS OF PORK ADIPOSE TISSUE

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Background

Food smoking by means of liquid smoke or smoke flavourings, rather than the traditional process using smoke, is widely used in some countries. This is due to the various advantages associated with the process and also for economic, ecological and food safety reasons. The smoke causes several changes (1) in colour and texture of foods, as well as in odour and flavour. However, if the smoking process is not correctly controlled, smoke can contaminate foods with polycyclic aromatic hydrocarbons. These latter components can be either eliminated or reduced to very low concentrations in liquid smoke and smoke flavourings (2); for this reason the use of smoke preparations provides very safely smoked foods. A very interesting potential property of smoke is its antioxidant ability because it could increase the oxidative stability of smoked food.

The usual methodology to study the oxidative stability of lipids includes a method for provoking the oxidation of the sample under specific conditions, and the use of one or more methods to determine parameters which are able to give information about the oxidation degree of the sample; the most common methods being Peroxide Value and Thiobarbituric Acid Value. However both methods have been criticised, mainly because they are time-consuming and need many chemical reactives. Fourier transform infrared spectroscopy (FTIR) has been successfully applied to the study of the oxidative stability of different edible oils (3,4). Changes observed in the infrared data have been shown to be simultaneous with changes observed in classic parameters such as Peroxide Value and Anisidine Value in different edible oils under oxidative conditions (5).

Objectives

This paper has a double objective, on the one hand to study if two commercial liquid smokes of very different composition show antioxidant activity on the lipids of pork adipose tissue, and on the other to test the usefulness of FTIR spectroscopy as a tool for monitoring the oxidation of these samples.

Methods

Approximately 6 kg of adipose tissue of the same animal were acquired in a local butcher's shop. It was cut in right-angled strips which were salted by covering them completely with culinary salt for 24 hours. After the salt was removed, the strips were smoked by immersion in the liquid smoke flavourings named LSA and LSB for 3 minutes (samples LSA3 and LSB3 respectively). Unsmoked pork adipose tissue strips submitted to the same sample preparation process were used as control. Samples were stored in individual bags under vacuum at –80ºC until analysis. After the samples were defrosted they were cut into small pieces and 10 g of each sample were weighed in polystyrene Petri dishes and placed without their lids in a *Selecta* convection oven at 70ºC with circulating air. All the experimental procedures were carried out in duplicate.

FTIR spectra of control and smoked pork adipose tissue were collected every day of the experiment, by depositing a small amount of the melted fat of each sample between two disks of KBr, on a *Bruker Vector 33* Spectrometer interfaced to a personal computer operating under Windows NT. All spectra were recorded from 4000 to 500 cm^{-1} with a resolution of 4 cm^{-1} co-adding 32 interferograms. A frequency value for each band was obtained automatically by the software. The height and area of each band were measured in absorbance automatically, taking two baselines: 3750-2472 and 1900-530 cm^{-1}.

Results and discussion

The FTIR spectrum of pork adipose tissue is similar to that of other animal or vegetable fats and oils because all of them mainly consist of triglycerides. However, they show some differences either in the exact frequency and absorbance of the bands or in the presence or absence of some bands because of differences in length and unsaturation grade of the acyl groups of the triglycerides. In general, changes observed in the spectrum of pork adipose tissue during oxidation at 70ºC are similar to those observed in the spectra of different edible oils submitted to similar conditions (3-5).

Table 1 shows the days at which significant changes are produced in the oxidation process of pork adipose tissue under oxidative conditions. In non-oxidised samples a low intensity band appears at approximately 3471 cm^{-1}, associated with the overtone of the carbonyl group of the triglyceride ester. A broadening of this band from 3600 to 3100 cm^{-1} is produced from the first day of the experiment in the control sample and from the third day in the smoked samples LSA3 and LSB3. It becomes a high intensity band at approximately 3464 cm^{-1} on the second day in the control sample and on the day 5^{th}-7^{th} in the smoked samples LSA3 and LSB3. This band is observed during the rest of the oxidation process at higher wavenumbers. The appearance of this band is a consequence of absorptions both between 3460 and 3400 cm^{-1}, due to the generation of hydroperoxides, and at approximately 3530 cm^{-1} due to the generation of alcohols in the samples. The beginning of the broadening from 3600 to 3100 cm^{-1} in the FTIR spectrum is an indicator of the beginning of the oxidation process. The band at approximately 3006 cm^{-1} is due to the *cis* double bond stretching vibration. A slight decrease in frequency value and in absorbance is observed when the oxidation process begins. The extinction of the band, which represents the disappearance of *cis* double bonds, takes place at day 9 in the control sample, at day 14 in the smoked sample LSA3 and does not take place in the smoked sample LSB3. The disappearance of this band from the FTIR spectrum indicates a very oxidised sample. In all samples, near 987 cm^{-1}, there appears a low intensity band at approximately the same time as the beginning of the broadening between 3600 and 3100 cm^{-1} (see Table 1) and disappears after 3 days in the control sample and after 3 and 6 days in the smoked samples LSB3 and LSA3 respectively. This band is associated with the bending vibration of conjugated CH *trans,trans*- and/or *cis,trans*- olefinic groups. The changes observed indicate that compounds with conjugated double bonds are intermediate compounds in the oxidation process. At advanced stages of oxidation a band at approximately 1630 cm^{-1} appears, which has been assigned to α,β-unsaturated aldehydes and ketones. In the control sample this band appears at day 3 whereas in the smoked samples its appearance is delayed for 4-5 days (see Table 1). The appearance of this band could be an indicator of the presence of unsaturated aldehydic or ketonic groups in appreciable proportions.

Conclusions

FTIR spectroscopy is a useful technique for monitoring the oxidation process of smoked pork adipose tissue. The timing of the appearance or disappearance of certain infrared bands could be considered as an indicator of the oxidative stability of the sample. The changes observed in the FTIR spectrum of a sample reflect its oxidation degree.

Liquid smokes LSA and LSB have shown antioxidant activity on the lipids of pork adipose tissues. Smoking with LSA and LSB has increased the oxidative stability of the samples in comparison to the control sample.

Pertinent Literature

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Table1. Days at which significant changes are observed in the FTIR spectra of the samples under oxidative conditions.

Sample	Broadening 3600-3100 cm^{-1} (day)	Disappearance band 3006 cm^{-1} (day)	Appearance band 987 cm^{-1} (day)	Disappearance band 987 cm^{-1} (day)	Appearance band 1630 cm^{-1} (day)
control	1	9	1	4	3
LSA3	3	14	4	9	8
LSB3	3	15*	3	6	7

*It remains as a shoulder.