PHYSICO-CHEMICAL METHODS FOR DETERMINATION OF LARD IN FOOD PRODUCTS FOR HALAL AUTHENTICATION STUDY

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ABSTRACT

Food authenticity is a great concern not only for consumers but also for food producers. Lard and pork are prohibited to be consumed by followers of Islamic religion. Lard and pork intakes are associated with several health problems. Because of the restriction reasons to consume lard and pork and its biological implications, indeed, analytical methods offering fast and reliable methods are required. This article will describe some physico-chemical methods i.e. Fourier transform infrared (FTIR) spectroscopy, chromatography, electronic nose, and differential scanning calorimetry (DSC) used to analyze the presence of lard and pork in food products.

Keywords: *lard, physical-chemical methods, food, halal*

INTRODUCTION

At present, food authenticity is a subject of great concern to food authorities, because the inappropriate labeling of foodstuffs can represent a commercial fraud. The implication of incorrect labeling can be much more important, especially concerning with the presence of potentially allergenic foods. The need to support food authentication has provided the development of analytical techniques for the analysis of food ingredients (Mafra *et al*., 2007).

The determination of food authenticity and the detection of adulteration are as major issues, not only for food producers but also for consumers (Lai *et al*., 1995; Al-Jowder *et al*., 1997). Detection of food adulterant is important for the protection of wealth and health of consumers, as well as for religious reason (**Poulli** *et al***., 2007).** In some countries, food manufacturers choose to use lard as substitute for oil because it is less expensive and readily available (Aida *et al*., 2005).

Food products containing pork and lard are prohibited to be consumed for the followers of Islamic and Orthodox Jewish religion. Furthermore, diets rich in lard and pork are associated with certain health risks such as hypercholesterolemia and coronary health disease (Syahariza *et al*., 2005). Lard is also associated with the risks of breast, pancreas, and colon cancers. Lard appears to act both at initiation and during promotion of carcinogenesis. A survey conducted by Food and Agricultural Organization (FAO) showed that there was a significant correlation between dairy and lard intake and the incidents of cancer in different organs such as breast, prostate, rectum, colon, and lungs (Rashood *et al*., 1996).

Need For Halal Authentication Study

Authentication is a paramount importance in the food industry for compliance with regulatory and health specifications. Product authenticity and authentication are become emerging topics within the food sector, at all levels of production processes, from raw materials to finished products (Baeten and Aparicio, 2004; Hurley *et al*., 2006). It is a major concern not only for consumers, but also for producers and distributors. Indeed, regulatory authorities, food processors, retailers and consumer groups are all interested in ensuring that foods are correctly labeled; therefore determination of food authenticity is one of the most crucial issues in food quality control and food safety (**Arvanitoyannis** *et al***., 1999;** Fernandez *et al*., 2003; Yang *et al*., 2005; Karoui and De Baerdemaeker, 2007; Pascoal *et al*., 2008).

Halal means "allowed', 'lawful" or 'permitted' (Chaudry and Regenstein, 1994). When used in relation to food and drinks, halal means permission to be consumed by Muslim. It is obligatory for Muslims to eat halal foods and consume halal products. To the Muslim, food must not only

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be of good quality but also must be truly halal or authentic. This Islamic law related to food are strictly observed by Muslims of all ethnic and geographical origin (Chaudry, 1992). Most religions forbid certain foods (e.g., pork and not ritually slaughtered meat in Judaism and Islam, pork and beef in Hinduism and Buddhism), with the notable exception of Christianity, which has no food taboos (Bonne and Verbeke, 2008).

As much food available in the market, the authenticity of halal food has been raised concern among Muslim consumers throughout the world. The religious group requires some protection to ensure that information related to food labels is accurate. Labels should be quite informative, descriptive, clear, and meaningful (Eliasi, 2002). In many countries, halal certification has become necessary for products to be imported (Regenstein *et al*., 2003).

Analytical Methods for Lard and Pork Detections

There is a clear trend concerning authentication issues towards labeling products with information about their composition and quality, which brings about the need to develop and standardize analytical methods, either to confirm the information given by the label or to explore a hidden fraud (Martinez *et al*., 2003). The new and sophisticated techniques have been developed for the authentication study of food products especially in lard and pork as adulterants for halal purposes.

The detection of lard and pork adulterations has technical problems, because an adulterant (lard and pork) consists of approximately the same chemical composition with food products in which they include. To overcome these problems, there are some approaches to detect an adulterant. The first approach is by determining the ratio between some chemical constituents and assuming that these ratios are constant in particular food products. This approach seems to make sense since that any addition of adulterant in any food products will modify or change these ratio values or will highlight an anomaly in its chemical compositions. Usually, this approach is associated with a number set of analyses and use of chemometrics. The second approach is by searching a specific marker in food products, either chemical constituents or morphological components, which proves the presence of adulterants in food products. The third approach, a global approach for detection of adulteration in food products, is by using analytical methods derived from physico-chemical analysis by taking into account the whole samples to show the adulteration effects on the physico-chemical properties (Cordella *et al*., 2002). The analytical methods used for the detection of adulteration of oils and fats (like lard) are based on the differences in the nature and the composition of the minor and major components of the adulterant and those of the unadulterated oils or fats. These methods usually depend on their physical-chemical constants or based on chemical and biological measurements (Kowalski, 1989).

Several physico-chemical methods have been developed for the analysis of lard and pork in food products such as chromatography, Fourier transform infrared (FTIR) spectroscopy, electronic nose, and differential scanning calorimetry (DSC). Ideally, the analytical method used for pork detection should be rapid, easy to use, and low cost. Table 1 lists some physical-chemical methods used for lard and pork analyses in food and food products.

Table 1. Analytical methods Used for analysis of lard and pork in food and its products

Methods	Food Samples	Issue	Detection Limit of Adulterant	References
IR	Cake formulation	Lard adulteration in shortening	4 % (w/w) level	(Syahariza *et al*., 2005)
	Chocolate and its products	Lard adding	3 % (w/w) level	(Che Man *et al*., 2005)
	Biscuit	Lard adulteration	4 % (w/w) level	(Syahariza, 2006)
	Edible oil	Lard chracterization	NR	(Guillen and Cabo, 1997)
	Meat	Lard mixed with other meat	NR	(Che Man *et al*., 2001)
	Meat	Pork identification	NR	(Al-Jowder *et al*., 1997)
	Meat	Lard mixture	1 % (w/w) level	(Jaswir *et al*., 2003)
HPLC	Meat products	Detection of pork and lard	1% in beef 3% in mutton	(Saeed *et al*., 1989)
	Meat products	Detection of lard	5%	(Rashood *et al*., 1995)
	Meat	Detection of meat adulteration	10% meat	(Wissiack *et al*., 2003)
	Edible oil	Contamination of lard	NR	(Marikkar *et al*., 2005)
GC	Ghee	Detection of lard in cow and buffalo ghee	10% (buffalo), 5% (cow)	(Farag *et al*., 1982)
	Edible oil	Adulteration of lard in some vegetable oils	2% (w/w) lard	(Marikkar *et al*., 2005)

Table 1 (continued)

	Food Samples	Issue	Detection Limit of Adulterant	References
DSC	Chee, butter	Adulteration of goat body fat	10% (w/w) level	(Lambelet, 1983)
		Adulteration of cow and buffalo ghee by pig	5% (w/w) level	(Lambelet *et al*., 1980)
		Detection of lard and lard contaminated with tallow	1% tallow in lard	(Kowalski, 1989)
	Edible Oil	Detection of lard and randomized lard in RBD palm oil	1% (w/w) lard/randomized lard	(Marikkar *et al*., 2001)
		Adulteration of RBD palm oil with lipase catalyzed interesterified lard (ERLD)	1% (w/w) ERLD	(Marikkar *et al*., 2002)
		Detection of lard in selected food product deep fried ini lard	10% (w/w)	(Marikkar *et al*., 2003)
		Monitoring lard, tallow and chicken fat adulteration in Canola oil	2 % (tallow) 8% (lard)	(Marikkar *et al*., 2002)
EN	Edible oil	Detection of lard	1% lard	(Che Man *et al*., 2005)

IR = Infrared spectroscopy; HPLC = high performance liquid chromatography; GC = gas chromatography, DSC = differential scanning calorometry; EN = electronic nose; NR = not reported

Infrared (IR) spectroscopy. IR spectroscopy is a fast and non-destructive technique, sensitive, and free of chemical preparation. It is used in a variety of analyses such as in food products for many years, either in near-infrared or mid-infrared regions (Che Man and Setyowati, 1999; Geesink *et al*., 2003; Christy *et al*., 2004; Roggo *et al*., 2007; Xing *et al*., 2007; Wang and Paliwal, 2007; Woodcock *et al*., 2008). IR spectroscopy has been identified as an ideal analytical method for authenticity studies (Reid *et al*., 2006). Analysis of a food sample using-the mid infrared spectrum (4000–400 cm^{-1}) give a valuable information about the presence of molecular bonds; therefore, it can give details of the types of molecules present in the food (Pavia *et al*., 2001). Fourier transform infrared (FTIR) spectroscopy can be used for qualitative and quantitative purposes (Downey, 1998). The main advantages of FTIR instrument are that they have increased sensitivity, permit much higher energy throughput and dramatically improve the speed of spectral acquisition (Goodacre and Anklam, 2001). Combined with computer and its advance chemometrics software, FTIR can easily manipulate the spectral information. With FTIR, a particular bond absorbs electromagnetic (EM) radiation at a specific wavelength so that one can construct an infrared "fingerprint" of the original food sample (Xing *et al*., 2007).

FTIR, combined with attenuated total refectance (ATR) and partial least square (PLS) regression, has been used to identify the presence of lard in selected food systems, namely cake formulation (Syahariza *et al*., 2005), chocolate formulation (Che Man *et al*., 2005), and biscuit formulation (Syahariza, 2006). The spectral bands associated with lard, cocoa butter, cake, biscuits, and their blends were recorded. A semi-quantitative approach is proposed to measure the percent of lard in blends on the basis of spectral data at the frequency region 4000–650 cm^{-1} (for chocolate), 1117 – 1097 cm^{-1} (for cake), and at frequency 3500 – 2900 cm^{-1} (for biscuit). A semi-quantitative approach is proposed to measure the percent of lard in blends on the basis of spectral data using the equation $y = 0.9225x + 0.5539$ with coefficient of determination (R^2) of 0.9872 and standard error of measurement (SEM) of 1.305 (for chocolate); $y = 0.9937x + 0.1980$ with R^2 0.9937 and SEM 2.257 (for cake); and $y = 0.9962x + 0.1396$ with R^2 0.9974 and SEM 2.819 (for biscuit); where x is actual value and y is FTIR predicted values for lard content in those food models. Further more, Che Man and Mirghani (2001) have used FTIR to detect the lard presence in the other animal fats such as lamb, chicken and cow (Che Man *et al*., 2001).

Monitoring of lard in mixtures of mutton and cow body fats has been carried out by Jaswir *et al* (2003) using FTIR. PLS was applied for quantitative determination on percent of lard in its blend with mutton body fat using FT-IR spectral data at frequency 3010 – 2000; 1220 – 1095; 968 – 965 cm^{-1}. The equation used is $y = 1.151 x – 0.1882$; $R^2 = 0.9868$; SEM

= 2.01. For the blend of cow body fat, frequencies at region 1419 – 1414 and 968 – 965 were used for qualitative and quantitative determinations. The equation is y = 0.7239 x + 1.1369; R^2 = 0.9749; SEM = 1.86 (Jaswir *et al*., 2003).

Guillen and Cabo (1997) have developed FTIR to detect and to characterize edible oil and lard (Guillen, and Cabo, 1997). Identification related to pork in meat species has been conducted by Al-Jowder *et al* (1997) using FTIR, ATR sample presentation, and chemometrics of principal component analysis (PCA) and PLS regression. Using FTIR spectra, it is possible to distinguish minched chicken, pork, and turkey meat. Furthermore, PCA can be used to distinguish between fresh and thawed samples of each species (Al-Jowder *et al*., 1997).

FTIR offers fast and non destructive techniques for qualitative characterization and quantitative measurements; however, it has limitation i.e FTIR can only be used for certain formulations, because FTIR is fingerprint technique. If the composition of sample formulation to be analyzed is different, the FTIR spectra will be different. Another limitations of FTIR for lard detection in food products is that the calibration model developed are only used to samples with similar functional group characteristics to those of standards used to derive the calibration model.

Chromatography. Various chromatographic techniques offer a unique possibility for the rapid and reliable separation and quantitative determination of macro- and micro-components of highly similar chemical structures in complicated matrices of foods and food products. Because of their advantageous separation characteristics, numerous chromatographic techniques have been tested, accepted and employed in the analysis of food and food products. Because of the high separation capacity of chromatographic techniques, they can be used for analysis of food adulterant and authenticity of foods (Cserháti *et al*., 2005).

Liquid and gas chromatography are capable of separating and enabling identification of almost any type of molecule present in a food sample. The principal disadvantage of the two techniques relates to its use in conjunction with chemometrics (Reid *et al*., 2006).

High performance liquid chromatography. High-performance liquid chromatography (HPLC) is widely used in food analysis. It is used as a quality control tool because it can separate various chemical constituents of mixtures. It is also often used for characterizing food products or for detecting an adulterant (Cordella *et al*., 2002). Its application for the detection of adulteration in foods has attracted much attention since the technique itself has many advantages i.e. the fact that sample components that are not readily volatilized could be separated easily by HPLC. Therefore, it is applicable to highly polar, high molecular mass, strongly ionic and thermally unstable components in food systems. The other advantage of HPLC is that derivatization of analyte is not required frequently as in gas-chromatographic analysis (Marikkar *et al*., 2005).

Pork and lard as adulterants in processed beef and mutton mixture has been analyzed by HPLC using reversed phase and UV detection. The amounts of triglyceride (TG) containing saturated fatty acid at C-2 position were larger than those of other meat fats. The presence of pork in the samples cause the ratio of TG containing saturated fatty acid vs. TG containing unsaturated fatty acid at the same (C-2) position increased, compared with ratios of beef or mutton (Saeed *et al*., 1989). Furthermore, by profiling of TG, it was possible to detect lard in fried chicken and tempeh (fermented soybean cake) products (Marikkar *et al*., 2003). Rashood *et al*. (1995) has carried out TG-profiling of pork, beef, mutton, chicken and turkey fats using A LiChrospher-100 RP-18 (5 μm) column. TG-separation and checking genuinity and adulteration was achieved isocratically in 15 min by using CH_3CN/CH_2Cl_2 (58 :42, v/v) at ambient temperature (Rashood *et al*., 1995).

TG profiling of genuine and randomized lard has been investigated by Rashood *et al* (1996) using refractive index detector. The same peaks of both genuine and randomized lard are obtained, but the percentage area of major peaks changed due to randomization. 2-palmitooleostearin (SPO) was found in high proportion in lard. However, the ratios of SPO to 2-palmitooleolinolein of both genuine and randomized lard are close (0.6 ± 0.05) and significantly can be distinguished from that of beef (4.24), mutton (6.17), chicken (0.21), and turkey (0.14) fats (Rashood *et al*., 1996).

Marikkar, *et al*. (2005) has identified lard contamination in vegetable oils, namely palm oil, palm kernel oil, and canola oil using HPLC. Analyses were performed to monitor the TG compositional changes in the oil samples before and after adulteration. The results showed that qualitative determination of lard contamination in palm kernel oil can be seen visually by a comparison of TG profiles of palm kernel oil adulterated with different animal fats with those of the animal fats. Furthermore, HPLC data treated with multivariate analyses, distinguishable grouping of lard-contaminated samples was achieved for all three oils (Marikkar *et al*., 2005).

HPLC is also used to differentiate pork from other animal meats to detect meat adulteration through the determination of hemoglobin by cation exchange chromatography and diode array detection. Different peak patterns for extracted hemoglobins of pork, cow, or lamb meats are obtained to be further used as qualitative assessment in meat adulteration (Wissiack *et al*., 2003).

Another methods based on differences in the levels of saturated fatty acids in the 2-position have been also proposed for detecting pork fat in beef and sheep products. Ozonolysis

of the fat, followed by separation of the ozonides and the unaffected saturated TG on a reversed phase column detects and distinguishes unsymmetrical TG, in which the unsaturated fatty acid is at the 1 or 3 positions (saturated-saturated-unsaturated or SSU), and symmetrical TG (saturated-unsaturated-saturated or SUS). For manufactured mixtures, levels down to 3 % pork fat can be detected (Jee, 2002).

Gas chromatography (GC). Gas chromatography (GC) is used widely in applications involving food analysis (Lehotay, 2002). GC is a unique and versatile technique. In its early development, it was applied to the analysis of gases and vapors from very volatile components. If the sample to be analyzed is nonvolatile, the techniques of derivatization or pyrolysis GC can be utilized (Grob and Barry, 2004). One of the main characteristics of GC, in fact, is the minimization of band broadening which means that narrow solute bands pass very rapidly through the detection system. The consequential formation of high and narrow peaks leads to a higher signal-to-noise ratio and to an improved detectability of analytes in comparison to traditional methods (Mondello *et al*., 2004). There are two types of GC, depending on stationary phase used, namely gas-liquid chromatography (GLC) and gas-solid chromatography (GSC) (Fowlis, 1995; Settle, 1997).

GLC was used for the detection of lard added to buffalo and cow ghee using OV-17 1 % column and flame ionization detector. The ratios of total hydrocarbons to total sterols in the unsaponifiable matter for margarine and lard were most different for the various lipids. Adulteration of cow and buffalo ghee with various levels of lard or margarine caused significant changes in the unsaponifiable compounds (Farag *et al*., 1982).

Analysis of lard adulteration in some food products depend on the identification and determination of certain characteristic constituents. Therefore, analysis of fatty acid methyl ester (FAME) by GLC is an important method for authentication purposes (Gordon,1968).

The compositional and positional distribution of fatty acids, TG profiling has been done by GC (Farag *et al*., 1983). Individual and total saturated and unsaturated fatty acid composition in total fats of both genuine and randomized lard were identical. Analysis of TG compositional showed that both genuine and randomized lard had six dominant TG (C46, C48, C50, C52, C54, and C56) with quite different concentrations. TG with C52 represents the major constituent of genuine and randomized lards (Rashood *et al*., 1996).

It has been suggested that lipolysis of the fat with pancreatic lipase followed by GC resulting in formation of 2-monoglyceride can detect the presence of lard in beef product. It is necessary to determine the enrichment factor (percentage of total fatty acid in 2-monoglyceride per percentage in whole triglyceride) for palmitic acid, enrichment value of unsaturation ratio, and ratio of C16/C18 fatty acids in the monoglycerides. These values are: > 0.8 for pork; < 1.4 if lard present; and > 4.0 for lard (Jee, 2002).

GLC, combined with pancreatic lipolysis (which hydrolyzes the fatty acids preferentially esterified at the 1,3- positions of TG) and chemometrics of multivariate data analysis (canonical descriminant), has been used for identification of lard contamination in some vegetable oils (palm oil, palm kernel oil, and canola oil) by monitoring the changes of fatty acid composition in those vegetable oils adulterated with lard, especially in *sn-2* position (Luddy; Marikkar *et al*., 2005). The results showed that oil samples which are contaminated with as little as 2 % of lard could be easily distinguished and no misclassification of other animal fats occurred within the spatial region of the LD-adulterated series.

Differential Scanning Calorimetry (DSC). Differential scanning calorimetry (DSC) is non chemical method and the most versatile of thermal analysis. The principle of DSC is to keep sample and reference placed in separate micro ovens, at equal temperature. The electrical power needed for the compensation is equivalent to the calorimetric effect (Tan and Che Man, 2002). DSC analysis offers a direct method to study the thermal properties of various materials (Tan and Che Man, 1999). DSC has a possibility to be developed as quality control procedure in food adulteration (Coni *et al*., 1994).

Lambelet (1983) has developed DSC to detect pig in cow and buffalo gees. The pig adulteration was detected by the presence of the additional peak at high temperature on the DSC crystallization curves. The relative area of this peak or its location on the DSC curve measures the degree of adulteration (Lambelet, 1983).

DSC has been used to detect the adulterant presence of lard and randomized lard in refined-bleached-deodorized (RBD) palm oil. Lard which is extracted from adipose tissue was chemically inter-esterified using sodium methoxide, as a catalyst. The thermal profiles of DSC from both genuine lard and randomized lard were compared with those of animal fats like chicken fat, mutton tallow, and beef tallow. The results showed that DSC cooling profiles of adulterated RBD palm oil samples revealed an adulteration peak corresponding to genuine lard and randomized lard in the low temperature region. This peak was used as an indicator of the lard presence in palm oil. The detection limit obtained for lard/randomized lard was 1 % (Marikkar *et al*., 2001). Furthermore, Marikkar *et al* (2002) also determine the presence of enzymatically-randomized lard (ERLD) as an adulterant in RBD palm oil using DSC. Thermal characteristics of ERLD were compared with those of genuine lard (GLD). A typical cooling

thermogram of unadulterated RBD palm oil showed two major exothermic transition peaks at 17.75 and 1.25 °C, and two minor shoulder peaks at -6.82 and -43.86 °C, respectively. The shoulder peak appearing at -43.86°C is sensitive to adulteration with both genuine and chemically-randomized lard. This peak undergoes an enlargement with increasing concentration of ERLD (ranging from 1 to 20%) (Marikkar *et al*., 2001; *et al*., 2002).

Lard detection, as frying medium in deep-fat frying for four fat containing products namely, peanuts, tempeh (fermented soybean cake), chicken and beef, has been investigated using DSC. Based on DSC heating thermograms, lard contamination of tempeh and chicken, resulted in a strong endothermic peak emerging in the range of 22–23°C. This adulteration peak could only be visualized in the subtracted thermogram. This study also suggests the use of cooling thermograms for determining lard in fried beef because a clear distinct adulteration peak tended to emerge in the lower temperature regions (Marikkar *et al*., 2003).

The thermal characterization of genuine lard and randomized lard has been investigated by Rashood *et al* (1996). Thermal transitions of genuine lard occurred in three steps with peak maxima at -0.35, 30.25, and 44.28°C., whereas the thermal transitions of randomized lard occurred in five steps with peak maxima at -51.26, -1.44, 4.3, 19.04, and 27.8°C. DSC thermogram and thermodynamics of phase transitions of both samples were quite different and do not reveal common characteristics that could be used for immediate detection of lard substances in fat admixtures (Rashood *et al*., 1996).

The use of cooling and heating thermograms from DSC for monitoring the presence of genuine lard, beef tallow, chicken fat as adulterants in canola oil has also been investigated. For the purpose of detection of lard in canola oil, cooling thermogram was found to be unsuitable whereas heating thermogram enabled the detection from 8% (Marikkar *et al*., 2002).

Electronic Nose. Electronic nose' systems involve various types of electronic chemical gas sensors with partial specificity. Using suitable statistical methods, it is enable to recognize the complex odors. Application of electronic noses in the evaluation of volatile compounds in food, cosmetic and other items of everyday life is observed and has increased in research (Schaller *et al*., 1998). An electronic nose is a vapor analyzer in which its working principle is claimed to mimic the human nose. The sensory array represents the sensors in the human nose. The circuitry represents the conversion of the chemical reaction on the human sensors to electrical signals into the brain. Finally, the software analysis represents the brain itself. The electronic nose is therefore analogous to the human olfactory system (Gan *et al*., 2005[a]).

Using an electronic nose, it allows the odor quality of vegetable oils to be followed continuously from the raw material stage right through to the final product. It would be useful to incorporate electronic noses in the food industry to determine whether the deodorization process has been successfully completed. With the characteristic aroma fingerprint of each vegetable oil, it is possible to detect any adulteration like lard to be viewed and recognized as part of a previously learned image set (Gan *et al*., 2005[b]).

Che Man *et al* (2005) has developed surface acoustic wave (SAW) sensing electronic nose (zNose™) for detection of lard as an adulterant in RBD (refined, bleached, deodorized) palm olein. RBD palm olein was spiked with lard at levels ranging from 1% to 20% (w/w) to be further analyzed. The zNose™ produced Vapor Print, a two-dimensional olfactory image which could be used qualitatively for immediate detection of lard substances in sample admixtures. Lard adulteration could be determined by a few distinct peaks of chromatogram in the zNose™. The best relationship between percentage of lard in adulterated RBD palm olein and SAW detector response was observed in adulterant peak E (R^2 = 0.906) (Che Man *et al*., 2005). Electronic Nose was also used to classiffy Iberian lard or pig fat with different fatty acid composition (Carrapiso *et al*., 2001).

CONCLUSION

There have been great efforts to develop new applications for existing analytical methods for lard and pork analyses in Halal food studies. Because of its capacity in the separation technique, chromatography techniques have been used for lard and pork analyses especially through TG compositions. FT-IR spectroscopy in conjunction with chemometric analysis has been shown to be a sensitive and rapid technique in the analysis of lard in food samples, with the advantage of being easy to use. DSC analysis offers a direct method to study thermal properties of lard in various food samples. The technique possesses the advantages of being relatively quick and simple to carry out, with relatively little sample preparation necessary. Electronic nose technology has the advantage of being relatively cheap, quick and easy to operate for lard analysis. With the characteristic aroma fingerprint, Electronic nose make possibility to detect lard to be viewed and recognized as part of a previously learned image set.

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