Food Chemistry **30** (1988) 167–180

Detection and Evaluation of Lard in Certain Locally Processed and Imported Meat Products

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(Received 6 March 1987; revised version received 22 December 1987; accepted 19 January 1988)

ABSTRACT

Studies on detection of lard in certain locally processed and imported meat products were carried out. The data showed that the palmitic acid enrichment factor could be used in detecting lard in meat products, as it markedly increases as lard percentage is increased. The data for unsaponifiable components revealed that beef luncheon meat contained a high percentage of lard, reaching 7% or more. Moreover, corned beef was shown to contain not less than 3% lard. Meanwhile, frankfurter-type sausages contained a rather high level of lard, reaching 13% or more. Based on IR data, imported meat products contained an ascending order of lard contamination; namely, 3%, 6% and 13% or more in corned beef, beef luncheon meat and frankfurter-type sausages, respectively.

INTRODUCTION

Usually imported canned meat, sausages, biscuits, oils and fats are adulterated with pork and/or lard (Abdel-Fattah, 1970; 1974; El-Dashlouty, 1978; Abou-Arab, 1980; Bayoumy, 1982).

The consumption of pork and its by-products is prohibited in Egypt and other Islamic countries due to religious concepts.

Food Chemistry 0308-8146/88/$03·50

El-Dashlouty (1978) found that an increase of palmitic acid enrichment factor to 0·8 as well as a decrease of unsaturation ratio to 1·3 or less indicated the presence of 5% pork or more. Likewise, an increase of total C_{16}/total C_{18} fatty acids at β-monoglyceride and the same increase of % saturated fatty acids/unsaturated fatty acids ratio at β-monoglyceride to 1·0 or more indicated the presence of 20% and 10% pork or more, respectively.

The present work was undertaken to assess lard adulteration in some popular foodstuffs, commonly consumed in Egypt.

MATERIALS AND METHODS

Materials

Fat tissues

Meat samples were procured from an Oslo, Norway, slaughter house immediately after slaughtering. Pork fat was removed from pork outer back fat of male Yorkshire pigs, while beef fat was trimmed free of lean meat from male animals.

Imported products

Three types of imported canned meat were used namely, pure beef luncheon meat, Plumrose Company, Copenhagen, Denmark, Corned beef (Mispo), packed under Brazilian government specifications; while frankfurter-type sausages in brine, Van der Lann, Holland, were purchased from the local Egyptian market.

Methods

Technological methods

Smoked sausages. Liquid smoked beef sausages were manufactured according to the method described by Donald (1983) and served as the control.

Experimental liquid smoked sausages and corned beef were prepared using different levels of lard and beef tallow combinations as outlined in Table 1.

TABLE 1

Percentages of Different Types of Fat Utilized in Producing Liquid Smoked Beef Sausages and Corned Meat Formulations

Treatments	*1*	*2*	*3*	*4*	*5*
% Lard	0·0	3·0	6·0	9·0	100·0
% Beef tallow	100·0	97·0	94·0	91·0	0·0

Canned meat. 'Stewed canned beef' was processed according to the method described by Ranken (1984), and was used as a control.

Analytical methods

Fat extraction. Fat was extracted from fatty tissues using the method described by Folch *et al.* (1957) as modified by Ways & Hanhan (1964) using the chloroform:methanol ratio, 2:1.

Preparation of triglycerides. The triglycerides were separated from total fat by the method of Dister & Bauer (1965).

Preparation of β-monoglycerides. Pancreatic lipase (E. Merck AG., Darmstadt, West Germany) was used in the preparation of β-monoglycerides as described by Rossell *et al.* (1978).

Preparation of methyl esters of fatty acids. The methyl esters of fatty acids were prepared from triglycerides and β-monoglycerides using 5 ml 3% H_2SO_4 in absolute methanol and 2 ml benzene by the method of Rossell *et al.* (1983).

Gas–Liquid chromatography of methyl esters of fatty acids. The methyl esters of fatty acids were separated using a Pye Unicam (GCD) gas–liquid chromatography apparatus with a S 8 autosampler. The separation was performed with a glass column, 2 m long and 2 mm outside diameter, packed with 10% SP-2330 on 100–120 mesh Chromosorb WAW. The chromatographic analysis was carried out under the following conditions: column temperature programme, 135°C and increased to 230°C by 16°C/min., and final hold for 8 min; injector temperature, 240°C; detector temperature, 260°C (FID) detector, carrier gas: nitrogen, 20 ml/min.

Factors calculation. The palmitic acid enrichment factor, the unsaturation ratio and other ratios based on the fatty acids composition of triglycerides and β-monoglycerides were calculated by the method recommended by Abdel-Fattah (1974), El-Dashlouty (1978), and Bayoumy (1982).

The following equations were used, respectively:

$$\text{Palmitic acid enrichment factor} = \frac{\%\text{ of palmitic acid in } \beta\text{-MGs}}{\%\text{ of palmitic acid in TGs}} \quad (1)$$

$$\text{Unsaturation ratio} = \frac{\%\text{ of unsaturated fatty acids in } \beta\text{-MGs}}{\%\text{ of unsaturated fatty acids in TGs}} \quad (2)$$

$$\frac{\%\text{ of total } C_{16} \text{ fatty acids in } \beta\text{-MGs}}{\%\text{ of total } C_{18} \text{ fatty acids in } \beta\text{-MGs}} \quad (3a)$$

$$\frac{\%\text{ of saturated fatty acids in } \beta\text{-MGs}}{\%\text{ of unsaturated fatty acids in } \beta\text{-MGs}} \quad (3b)$$

Gas–liquid chromatography of unsaponifiable components. The unsaponifiable substances in the lipid samples were analyzed with a GCV Pye Unicam gas chromatograph equipped with dual flame ionization detectors, as described by Farag *et al.* (1982). A coiled glass column (2·8 m × 4 mm) was used, packed with acid-alkali and silanized Diatomite C (100–120 mesh) and coated with 1% OV-17. For separating the unsaponifiable materials injector, column and detector temperatures of 280, 270 and 300°C, respectively, were used. The gas flow rates were 30, 33 and 330 ml/min for nitrogen, hydrogen and air, respectively.

Infrared spectrophotometric analysis. Infrared absorption spectra for the extracted fats were determined on a Perkin Elmer-580 B infrared spectrophotometer connected with Perkin Elmer infrared data station 3500 as described by Arnold & Hartung (1971).

RESULTS AND DISCUSSION

Processed products

Unsaponifiable components of fat extracted from processed products

The mean values of the unsaponifiable components of canned meat products and liquid smoked sausages are shown in Tables 2 and 3. The data in the tables indicate that the hydrocarbons of the unsaponifiable fraction were separated into four identifiable compounds, namely: *n*-octacosane (C_{28}); *n*-nonacosane (C_{29}); *n*-triacontane (C_{30}) and hentriacontane (C_{31}). In addition, three identifiable sterols, i.e., cholesterol, β-sitosterol and stigmasterol, were present in both types of products, except that stigmasterol was non-existent in treatments Nos 1 and 2 (0·0% lard and 3% lard), respectively.

In both canned meat products and liquid smoked sausages, where only lard was added, it was found that the *n*-octacosane (C_{28}) level was fourfold higher than in treatment No. 1 (0·0% lard), 6·78% and 6·69%; and 1·81% and 1·80%, respectively.

The *n*-nonacosane (C_{29}) and hentriacontane (C_{31}) levels of treatment No. 5 were almost fivefold that of treatment No. 1, while the *n*-triacontane (C_{30})

TABLE 2

Mean Values of the Unsaponifiable Components of Fat extracted from Canned Meat Products (% of the total)[a]

Treatments[b]	*Unsaponifiable components*									
	C_{28}	C_{29}	C_{30}	C_{31}	*Total hydrocarbons (TH)*	*Chole-sterol*	*β-Sito-sterol*	*Stigma-sterol*	*Total sterols (TS)*	*TH:TS*
1	1·81	6·78	0·56	2·36	11·5	75·8	11·4	0·00	87·3	0·132:1
2	1·87	7·18	0·81	2·82	12·7	74·0	11·1	0·00	85·1	0·149:1
3	1·92	8·60	1·62	4·83	17·0	72·2	10·2	0·21	82·6	0·205:1
4	2·07	10·1	2·38	5·41	19·9	70·5	7·81	0·56	78·9	0·253:1
5	6·78	32·4	12·6	13·3	65·1	28·7	1·38	3·24	33·3	1·95:1

[a] Each figure given in this table is a mean of three determinations.

[b] Treatments are outlined in Table 1.

TABLE 3
Mean Values of the Unsaponifiable Components of Fat extracted from Liquid Smoked Sausages (% of the total)[a]

Treatments[b]	*Unsaponifiable components*									
	C_{28}	C_{29}	C_{30}	C_{31}	*Total hydrocarbons (TH)*	*Cholesterol*	*β-Sitosterol*	*Stigmasterol*	*Total sterols (TS)*	*TH:TS*
1	1·80	6·83	0·52	2·44	11·6	76·2	11·4	0·00	87·6	0·132:1
2	1·88	7·20	0·83	2·90	12·8	74·7	11·1	0·00	85·8	0·149:1
3	1·91	8·57	1·56	4·76	16·8	72·2	10·1	0·22	82·6	0·203:1
4	2·00	10·1	2·42	5·52	20·1	70·9	7·66	0·06	79·3	0·253:1
5	6·69	32·5	12·70	13·3	65·2	29·0	1·36	3·66	34·1	1·92:1

[a] Each figure given in this table is a mean of three determinations.
[b] Treatments are outlined in Table 1.

level of the former treatment was almost 24-fold greater than that of the latter. Tables 2 and 3 indicate that, in general, treatment No. 5 in both products had comparatively high levels of hydrocarbons and this phenomenon can be used as a reasonable criterion for lard detection in processed meat products. On the other hand, treatment No. 1 (0·0% lard) in both products had the highest cholesterol and β-sitosterol content.

The total hydrocarbons to total sterols (TH/TS) ratio for treatment No. 5 (100% lard) was high in comparison to that of treatment No. 1 (0·0% lard), 1·954:1 and 1·915:1 and 0·132:1 and 0·132:1, respectively.

It may be expected that the *n*-octacosane (C_{28}); *n*-nonacosane (C_{29}); *n*-triacontane (C_{30}) and hentriacontane (C_{31}) levels would be higher in treatments Nos 2, 3 and 4 (containing 3%, 6% and 9% lard) than in treatment No. 1 (100% beef tallow). There was a marked decrease in the cholesterol and β-sitosterol levels as the percentage lard increased in both products, followed by a noticeable increase in the TH/TS ratio. These data agree with the findings of Farag *et al.* (1982).

Fatty acid composition of triglycerides and β-monoglycerides in processed products

The data revealed that if only beef tallow was added to canned meat and liquid smoked sausages, the palmitic acid content was higher in the triglycerides that in the β-monoglycerides (24·0 and 28·2; 20·8 and 20·6%) in canned meat and liquid smoked sausages, respectively. On the other hand, if only lard was added to these products, the palmitic acid content was higher in the β-monoglycerides than in the triglycerides (55·9 and 55·8%, 24·3 and 24·2%) in the canned meat and liquid smoked sausages, respectively. This is due to the fact that β-monoglycerides of lard are specifically occupied with saturated fatty acids, mainly palmitic acid. These results are in good agreement with those reported by Mattson *et al.* (1964), Abdel-Fattah (1970, 1974), El-Dashlouty (1978) and Bayoumy (1982).

It would be expected that the palmitic acid content would be higher in β-monoglycerides in other treatments containing various levels of lard. Also, increasing the percentage lard in all treatments resulted in marked reduction in the $C_{18:1}$ content of the β-monoglycerides, which was accompanied by a noticeable increase in $C_{18:2}$ in the triglycerides. In general, the higher the palmitic acid content in any treatment studied, the lower the amount of $C_{18:1}$, and vice versa.

Palmitic acid enrichment factor

Table 4 shows the palmitic acid enrichment factor of different canned meat products and liquid smoked sausages. The data reveal that the palmitic acid enrichment factor was 0·868 and 0·887 in treatment No. 1 (0·0% lard) for canned meat products and liquid smoked sausages, respectively.

TABLE 4
The Palmitic Acid Enrichment Factor for Canned Meat (CM) and Liquid Smoked Sausages (LSS)

Treatments	*Palmitic in TGS*		*Palmitic in β-MGS*		*Factor*	
	LSS	*CM*	*LSS*	*CM*	*LSS*	*CM*
1	23·3	24·0	20·6	20·8	0·887	0·868
2	23·6	24·0	21·9	22·1	0·928	0·920
3	24·0	23·9	25·5	25·4	1·06	1·07
4	24·1	24·0	27·9	28·0	1·16	1·17
5	24·2	24·3	55·8	55·9	2·31	2·30

It can be seen that the palmitic acid enrichment factor increased to 0·920, 1·065, 1·150 and 2·301 in canned meat products, while it was 0·928, 1·062, 1·161 and 2·306 in liquid smoked sausages in treatments Nos 2, 3, 4 and 5 (3, 6, 9 and 100% lard), respectively. Therefore, the palmitic acid enrichment factor could be helpful in detecting lard in canned meats and sausages as it markedly increases as the lard percentage is increased.

These results are in good accord with those previously reported by Abdel-Fattah (1974), El-Dashlouty (1978), Abou-Arab (1980) and Bayoumy (1982).

The unsaturation ratio

The data on the unsaturation ratio of canned meat products and liquid smoked sausages, respectively, revealed that treatment No. 1 (0·0% lard), in both products had an unsaturation ratio of 1·024. For treatment No. 5 (100% lard) the ratio was only 0·415 and 0·413 in canned meat products and liquid smoked sausages, respectively. This may be due to the high content of unsaturated fatty acids in the β-position and the low content of triglycerides of beef tallow, which is opposite to that in lard.

It is evident from the data that the unsaturation ratios for treatments Nos 2, 3 and 4 were 0·865 and 0·853; 0·759 and 0·762; and 0·721 and 0·713 for canned meat products and liquid smoked sausages, respectively. This means that the unsaturation ratios decreased with the amount of the added lard. Such data are in agreement with those previously reported by Amer *et al.* (1974), Abdel-Fattah (1974), El-Dashlouty (1978), Abou-Arab (1980) and Bayoumy (1982).

Total C_{16}/total C_{18} fatty acids and saturated/unsaturated ratios in β-monoglycerides

Data on the ratio of total C_{16}/total C_{18} fatty acids and saturated/unsaturated fatty acids in the β-monoglycerides of canned meat products

and liquid smoked sausage, respectively, revealed that treatment No. 1 (0·0% lard) had a low value of total C_{16}/total C_{18} fatty acids (0·510% and 0·515) in canned meat and liquid smoked sausage, respectively. It was 2·15 and 2·23 for treatment No. 5 (100% lard) in both products. This may be due to the fact that the β-monoglycerides of lard contain high levels of C_{16} fatty acids and low levels of C_{18} fatty acids.

In the case of treatments Nos 2, 3 and 4 (3%, 6%, and 9% lard) the values were 0·620 and 0·625; 0·785 and 0·786; and 0·830 and 0·832 in the canned meat products and liquid smoked sausages, respectively. The data agree with those previously reported by Abdel-Fattah (1974); El-Dashlouty (1978) and Bayoumy (1982).

In regard to the saturated/unsaturated fatty acid ratio, treatment No. 1 (0·0% lard) had a low ratio of 0·595 and 0·595 for canned meat and liquid smoked sausages, respectively. It was markedly higher for treatment No. 5 (100% lard) as it was 2·81 and 2·85 in these two products, respectively. This is due to the fact that the β-monoglycerides of lard are specifically occupied with saturated fatty acids. In the case of treatments Nos 2, 3 and 4 (3%, 6% and 9% lard) the values were 0·723 and 0·731; 0·914 and 0·929 and 1·02 and 1·06 for canned meat and liquid smoked sausages, respectively.

Such data quite agree with that published by El-Dashlouty (1978) and Bayoumy (1982) for detection of lard contamination in canned beef, sausages and canned mutton products.

Infrared analysis

The results of absorption ratios in the infrared for canned meat and smoked sausages are tabulated in Table 5. These data reveal that in both canned

TABLE 5
The Results of Absorption Ratio of Infrared in Canned Meat (CM) Products and Liquid Smoked Sausages (LSS)

Fat mixture (w/w)		*Absorption ratio* (R_3)	
Lard (%)	*Beef tallow* (%)	*CM*	*LSS*
0·0	100	0·107	0·106
3·0	97	0·108	0·108
6·0	94	0·110	0·110
9·0	91	0·112	0·112
100	0·0	0·170	0·169

meat and smoked sausages increasing the lard percentage causes a gradual increase in the absorption ratio (R_3). Lard percentage could be detected in all products by using the regression equation as follows:

$$\hat{Y} = A + BX$$

where $\hat{Y}$ = lard percentage
A and B = constants
X = absorption ratio (R_3)

On the basis of such findings the IR method is recommended for lard detection in meat products.

Imported products

Unsaponifiable components of fat extracted from imported products
The mean values of the unsaponifiable components of imported canned meat products indicate that the hydrocarbons of the unsaponifiable fraction were separated into four identifiable compounds, namely; *n*-octacosane (C_{28}), *n*-nonacosane (C_{29}), *n*-triacontane (C_{30}) and hentriacontane (C_{31}). Three sterols were also identified, i.e., cholesterol, β-sitosterol and stigmasterol, and were present in all products.

In the first product (beef luncheon meat), it was noticed that there is a slight increase in the *n*-octacosane (C_{28}) and *n*-nonacosane (C_{29}) levels in comparison with the corresponding components in beef tallow. While the *n*-triacontane (C_{30}) and hentriacontane (C_{31}) levels were threefold and twofold higher than that of the latter, respectively. As mentioned earlier, the data indicate that, in general, beef luncheon meat products have high levels of hydrocarbons in comparison to that of beef tallow (17·3 and 11·7, respectively).

On the other hand, beef luncheon meat had a lower cholesterol and β-sitosterol content than beef tallow. Besides, beef luncheon meat contains a relatively high amount of stigmasterol. The discrepancies in stigmasterol content in beef luncheon meat may reflect the original vegetable oils used in its formulation. The total hydrocarbons to total sterols (TH/TS) ratio was comparatively high in beef luncheon meat in comparison to beef tallow (0·212:1 and 0·130:1), respectively. In conclusion, it is apparent that imported beef luncheon meat contained a high percentage of lard, reaching 7% or more.

Corned beef proved to contain not less than 3% lard, frankfurter-type sausages apparently contained 1·5-fold more *n*-octacosane (C_{28}) then beef tallow (2·56 and 1·85% respectively). Likewise, the *n*-nonacosane (C_{29}) and hentriacontane (C_{31}) levels of frankfurter-type sausages were almost 2- and

3-fold higher than that of beef tallow (12·3 and 6·87%; and 7·37 and 2·46%), respectively. The *n*-triacontane (C_{30}) level of the former was almost 8-fold more than that of the latter. The data indicate that, in general, frankfurter-type sausages had a comparatively high level of hydrocarbons. There was a marked decrease in the cholesterol and β-sitosterol levels and a noticeable increase in the TH/TS ratio in comparison to beef tallow.

In conclusion, it is clear from the data that frankfurter-type sausages contain a rather high level of lard, reaching 13% or more.

Fatty acid composition of triglycerides and β-monoglycerides in certain imported products

The data reveal that in beef luncheon meat, the palmitic acid content is slightly higher in β-monoglycerides than in triglycerides (26·7 and 26·2% respectively). While, it was markedly higher in β-monoglycerides than in triglycerides (33·8 and 24·1% respectively) in frankfurter-type sausages. On the other hand, in corned beef the palmitic acid content was lower in β-monoglycerides than in triglycerides (21·5 and 22·6%, respectively). The $C_{18:1}$ content of β-monoglycerides was rather high in the corned beef followed by beef luncheon meat and frankfurter-type sausages (31·4; 30·8; and 20·6% respectively). However, the $C_{18:2}$ content of the triglycerides showed an opposite trend.

Palmitic acid enrichment factor. Data on the palmitic acid enrichment factor of fat extracted from certain imported canned meat products revealed that it was 1·02, 0·954 and 1·40 in beef luncheon meat, corned beef and frankfurter-type sausages, respectively. It is evident from the data that the palmitic enrichment factor was higher in the frankfurters than in the other two products, which would indicate the presence of lard at 13% or more as previously shown. This is due to the fact that β-monoglycerides of lard are specifically occupied with saturated fatty acids, mainly palmitic acid. It is also obvious that the palmitic factor was 1·02 in beef luncheon meat, while it was 0·954 in corned beef. These values would indicate the presence of lard at 6% or more and 3% or more in these two products, respectively.

On the basis of the data obtained the palmitic acid enrichment factor may be useful in detecting lard in canned meat products, which is in close agreement with the Abdel-Fattah (1974), El-Dashlouty (1978) and Bayoumy (1982) findings.

The unsaturation ratio. The unsaturation ratio of fat extracted from certain imported canned meat products revealed that frankfurter-type sausages recorded the lowest ratio (0·677), followed by beef luncheon meat and corned beef (0·791 and 0·848, respectively). This may be attributed to the

low content of unsaturated fatty acids in β-monoglycerides in the former compared with that of the latter products.

Due to the fact that unsaturation ratio decreased as lard percentage was increased, it could be concluded that frankfurter-type sausages contained a rather high percentage of lard, reaching about 13% or more, while beef luncheon meat, and corned beef contained about 6% and 3% lard, respectively.

Total C_{16}/total C_{18} fatty acids and saturated/unsaturated fatty acids ratios in β-monoglycerides. The data of total C_{16}/total C_{18} fatty acids and saturated/unsaturated fatty acids ratios in β-monoglycerides for certain imported canned meat products revealed that the C_{16}/C_{18} ratio was higher in frankfurter-type sausages (1·13) than in beef luncheon meat and corned beef (0·789 and 0·658, respectively). This may be due to the high content of C_{16} fatty acids in β-monoglycerides and the low content of C_{18} fatty acids in frankfurter-type sausages. The other two meat products exhibited an

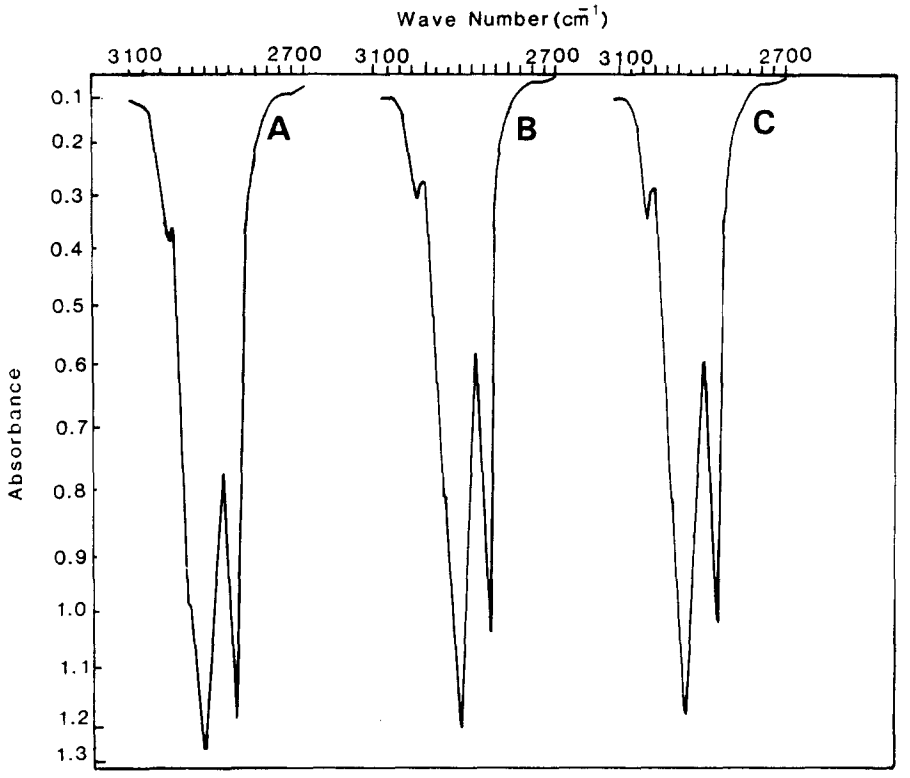

Fig. 1. Infrared absorption patterns of: A, imported corned beef; B, imported luncheon meat; C, imported sausages.

opposite trend. Regarding the saturated/unsaturated fatty acid ratio, the data showed that frankfurter-type sausages recorded the highest ratio (1·51), followed by beef luncheon meat and corned beef (0·928 and 0·762, respectively). This may be due to the high content of saturated fatty acids and low content of unsaturated fatty acids in β-monoglycerides in the frankfurter-type sausages, and vice versa, in the other two products.

In general, it can be concluded that such ratios may allow us to detect about 13% or more, 6% or more, and about 3% lard in frankfurter-type sausages, beef luncheon meat, and corned beef, respectively.

Infrared analysis

Figure 1 shows the infrared (IR) absorption spectra, from 3110 cm^{-1} to 2700 cm^{-1}, for certain imported canned meat products. Absorption values were plotted at 3010 cm^{-1} and at 2855 cm^{-1} for all products.

The data reveal that the absorption ratios (R_3) were 0·108; 0·111 and 0·115 for corned beef, beef luncheon meat and frankfurter-type sausages, respectively. It is evident from these data that lard contamination could be detected at 3, 6 and 13% in the three meat products, respectively.

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