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DETECTION OF SMALL AMOUNTS OF LARD IN OTHER ANIMAL FATS

By

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كشف إضافة كميات صغيرة من دهن الخنزير إلى دهون الحيوانات الأخرى

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يصف هذا البحث طريقة لتقدير دهن الخنزير المضافة إلى دهون الحيوانات الأخرى بغرض الغش باستخدام بيانات توزيع الأحماض الدهنية بين ذرات الكربون الثلاثة لجزئيات الجلسريد . تعتمد الطريقة عل تقدير تركيب الأحماض الدهنية الكلية للدهن كروماتوجرافيا ثم تقدير تركيب الأحماض الدهنية المتصلة بذرة الكربون الثانية بواسطة طريقة مبسطة باستخدام انزيم الليبيس والتحليل الكروماتوجرافي ثم معالجة البيانات رياضياً للحصول على مؤشرات نقاوه لكل دهن . طبقت هذه الطريقة على عدد من العينات من مصادر مختلفة للدهن البقري (١٥ عينة) والخنزير (٦ عينات) والضأن (٦ عينات) والماعز (٦ عينات) وكذلك خلطات من دهن الخنزير والبقر بنسب مختلفة . ثم حساب مؤشرات النقاوة لكل دهن أو خليط على حده ثم معالجة البيانات وحساب المتوسطات ومجال القيم لكل نوع من الدهون .

كانت مؤشرات النقاوة لكل دهن تقع في مجالات معينة من القيم تعتمد عل التغيرات الطبيعية في تركيب كل دهن وكانت أقل كمية يمكن تقديرها من لحم الخنزير في الدهن البقري يتناسب طردياً مع اتساع مجال القيم لهذه المؤشرات للخنزير والدهن البقري وعكسياً مع الفرق بين قيمتها المتوسطة لهذين الدهنين . وقد وجد أن الفرق بين القيمة المتوسطة لمؤشر النقاوة المحسوب بقسمة النسبة بين حمض البالمتيك/حمض الأوليك المتصلين بذرة الكربون الثانية عل النسبة بين نفس الحامضين المتصلين بذرتي الكربون الأولى والثالثة لدهن الخنزير (٣٨,٠٥) والبقر (٠,٢٣) كان كبيراً بما فيه الكفاية لتقدير حوالي ٤٪ من دهن الخنزير في الدهن البقري .

Key Words: Detection, lard, animal fats

ABSTRACT

The composition of fatty acids at the β-position (β-FA) and α, α`-positions of the triacylglycerol was used to establish new criteria for the detection of small amounts of lard in other fats. Determination of β-FA was achieved by a new simple method using a combination of lipase hydrolysis technique and GLC. The method was applied to the analysis if 15 tallow, 6 lard,. 6 mutton and 6 goat fat samples extracted from the fatty tissues of the meat taken from different animal breeds and also laboratory prepared blends of lard and tallow at different proportions. The data obtained were used to calculate a number of factors by means of some formulae. The value of each factor for a fat varied within a specific range depending on the natural variation in fatty acid distribution within the triacylglycerols of that fat. The minimum detectable amount of lard in tallow by any factor was proportional to the width of the range of that factor for lard and tallow and inversely proportional to the difference between its average value for the 2 fats. The factor calculated by dividing the palmitic / oleic ratio at the β-position by this ratio at the α, α`-positions showed significant specificity for lard and tallow. The difference between its average value for lard (38.05) and tallow (0.23) was wide enough to detect less than 4% of lard in tallow.

INTRODUCTION

Identification of fats in general is achieved using a variety of features, the most important of which is the fatty acid composition. The fatty acid composition of animal fats, unlike oils, varies widely within the same fat depending on many factors including the nutritional status and feeding habits of animals (Mattson *et al.*, 1964), animal breeds and the anatomical locality within the animal from which the fat was taken (Hal *et al.*, 1987 and Chacko & Perkins, 1964). Previous investigations revealed that in spite of the natural variations in fatty acid composition within the same fat yet the distribution of some fatty acids in the triacylglycerol molecules remains almost unchanged (Mattson *et al.*, 1964). The distribution of fatty acids within the triacylglycerols is obtained by lipase hydrolysis, TLC and GLC (IUPAC, 1979, Chacko and Perkins, 1964 and Jayme *et al.*, 1988). Based on these data of distribution palmitic acid enrichment factor, unsaturation ratio and two other ratios were recommended by Bayoumy (1982) for the detection of lard in other animal fats. Youssef *et al.*, (1988) calculated the same factor and ratios for only one sample of each of lard and beef tallow and also for prepared blends of the same two samples at different proportions. They used the values of these factors as criteria for estimating as low as 3% of lard in a number of canned luncheon meat and sausage samples imported from different countries. Saeed *et al.* (1986) reported that lard contained 11, 14 eicosadienoic acid (C 20:2) which was not found in the other commonly consumed fats. The presence of this fatty acid was used as a marker for lard. However, C20: 2 was later detected in beef and mutton by Firestone (1988). Sawaya *et al.* (1990) found that for each triglyceride molecule with certain carbon equivalent (CE) the ratio between the 2 isomers of the S2U fraction (SSU/SUS), where S and U denote the saturated and unsaturated fatty acids attached to the triglyceride molecule, in lard was, contrary to other fats, significantly high. They used this factor for detection of 2% lard in commercial meat samples.

No consideration was given in these studies to the natural variations in fatty acid distribution when the minimum detectable amount of lard was evaluated. Such variations may lead to false detection results. Therefore, the aim of the present work was to study the effect of natural variations of fatty acid distribution on the detection limit of lard and to determine new factors for the detection of small amounts of lard in tallow.

MATERIALS AND METHODS

MATERIALS :

Pure lard from pig skins, containing about 0.5% free fatty acids, was obtained from Sigma Chemical Co., U.S.A., another pure sample was obtained from Upland bacon factory, East Africa and four more samples of lard were extracted from the fatty tissues of pork imported from France. Different samples of beef, sheep and goat fats were extracted from the fatty tissues of the meat of freshly slaughtered animals. Other tallow samples were extracted from frozen beef cuts imported from U.S.A.; frozen minced meat imported from Denmark; frozen beef cut imported from Holland. Blends of tallow and lard containing 3, 5, 15, 50 , 70 85 and 90% of lard were prepared in the laboratory.

Sodium cholate from ox or sheep bile and crude lipase (triacylglycerol lipase: triacylglycerol acylhydrolase, from porcine pancreas, type II, contains amylase and protease activity, were obtained from Sigma chemical Co., U.S.A. All solvents used were of chromatographic grade and used without distillation.

Chromatographic standard fatty acid methyl esters (FAME) were purchased from Merk Darmstadt, F. R. G.

Apparatus:

Chromatographic analysis was performed on a 50 m wide bore (0.53 mm id) fused silica "WCOT" column coated with CP WAX 52 CB operated at a programmed temperature retaining 150°C for 43 min. then raised to 220°C at 5°C/min. The column was installed in a Packard 439 gas liquid chromatograph fitted with flame ionization detector and connected to a data processor (Chrompac CR-3A" with memory capacity of 180 K. bytes.

Methods:

Extraction of fats: Fat was extracted from meat overnight using diethyl ether and dried by filtration through anhydrous sodium sulphate. The recovered dry fat was used without purification.

Preparation of methyl esters of fatty acids:

A. At the β-position of triacylglycerol (β-fatty acids):

Lipolysis of fat was conducted following the method of IUPAC (1979) but using 40 mg of lipase and adapted amounts of substrate to achieve quantitative release of α, α`-fatty acids. The ethereal phase produced, containing the β-monoglyceride and the free fatty acids was transferred into 50 ml conical flask, 10 ml of 0.01% methanolic sodium hydroxide was added and refluxed for 20 min at 75°C. The methyl ester of β-fatty acids formed was extracted with diethyl ether the soap solution washed out with water.

B. At the α, α`-positions: The free fatty acids released from the α, α`-positions (α, α`-fatty acids) were recovered from their soap solution and converted into methyl esters using sulphuric acid as a catalyst.

C . Preparation of the methyl esters of the total fatty acids: The alkali catalyzed transesterification method of IUPAC (1979) was employed for preparation of FAME triacylglycerol.

Data Processing:

Estimation of α, α`-fatty acids:

The composition of α, α`-fatty acids was estimated from the relationship:

$$\alpha.\,FA = 3/2\ t.FA. - {}^{1}/_{2}\ \beta.FA \quad \ldots\ldots (1)$$

Where α.FA. is the estimated concentration of the fatty acid at the α, α`-positions of the triacylglycerol of the fat; t.FA. the concentration of the same fatty acid in the total triacylglycerol and β.FA.its concentration at the β-position of the triacylglycerol of the same fat. The differences between the value of α.FA as estimated by formula (1) and as determined by GLC analysis were less than 2%. Therefore, the estimated α.FA was considered in all calculations.

Calculation of factors:

The factors 1, 2 and 3 were ratios between the percentages of each of myristic, palmitic and oleic acids at the β-and α, α`-positions of the triacylglycerols respectively.

$$\text{i.e.} \quad FCT(i) = \frac{\%\text{ of the } \beta\text{-fatty acid (i)}}{\%\text{ of the } \alpha, \grave{\alpha}\text{-fatty acid (i)}}$$

Where i is an integer from 1 to 3 representing the three fatty acids respectively.

$$FCT(4) = \frac{(\%\text{ of } \beta\text{-palmitic acid} / \%\text{ of } \beta\text{-stearic acid})}{(\%\text{ of } \alpha, \grave{\alpha}\text{-palmitic acid} / \%\text{ of } \alpha, \grave{\alpha}\text{-stearic acid})}$$

$$FCT(5) = \frac{(\%\text{ of } \beta\text{-palmitic acid} / \%\text{ of } \beta\text{-oleic acid})}{(\%\text{ of } \alpha, \grave{\alpha}\text{-palmitic acid} / \%\text{ of } \alpha, \grave{\alpha}\text{-oleic acid})}$$

$$FCT(6) = \frac{(\text{Total }\%\text{ of } \beta\text{-C16} / \text{Total }\%\text{ of } \beta\text{-C18})}{(\text{Total }\%\text{ of } \alpha, \grave{\alpha}\text{-C16} / \text{Total }\%\text{ of } \alpha, \grave{\alpha}\text{-C18})}$$

$$FCT(7) = \frac{(\text{Total } \beta\text{-saturated} / \text{Total } \beta\text{-unsaturated})}{(\text{Total } \alpha, \grave{\alpha}\text{-saturated} / \text{Total } \alpha, \grave{\alpha}\text{-unsaturated})}$$

$$FCT(8) = \frac{\text{Total } \beta\text{-C14 fatty acids}}{\text{Total } \alpha, \grave{\alpha}\text{-C14 fatty acids}}$$

$$FCT(9) = \frac{\text{Total } \beta\text{-saturated fatty acids}}{\text{Total } \alpha, \grave{\alpha}\text{-saturated fatty acids}}$$

$$FCT(10) = \frac{\text{Total } \beta\text{-C16 fatty acids}}{\text{Total } \alpha, \grave{\alpha}\text{-C16 fatty acids}}$$

$$FCT(11) = \frac{\text{Total } \beta\text{-C18 fatty acids}}{\text{Total } \alpha, \grave{\alpha}\text{-C18 fatty acids}}$$

Where total C14, total C16 and total C18 are the total percentage of fatty acids with 14, 16 and 18 carbon atoms respectively. Total saturated and total unsaturated are the total concentration of the saturated and unsaturated fatty acids respectively.

Computer program:

A computer program was written in "BASIC" to calculated the different factors from the data of fatty acid distribution and select the most significant ones. The output data of the program were stored in a "LOTUS123" spread sheet and printed as Tables (Tables from 1 to 8).

RESULTS AND DISCUSSION

The composition of fatty acids of the total triacylglycerols and at the β, α, α`-positions of the tested fats is shown in Tables (1, 2 and 3, respectively). In line with previous reports (Mattson *et al.*, 1964) the data of Tables 2 and 3 indicate that there was a general tendency for myristic and palmitoleic acids to be concentrated at the β-position of the triacylglycerols while stearic acid was found esterified more heavily at the α, α`-positions. In lard, the concentration of palmitic acid was specifically higher at the β-position (57.19% - 68.69%) than at the α, α`-positions (4.46% - 6-68%) while oleic, linoleic and linolenic acids were lower at the β-position (14.56 - 22.23, 3.73 - 5.78 and 0.01 - 0.28% respectively) than at the α, α`-positions (48.96 - 70.26, 10.73 - 12.77, and 0.44 - 0.51% respectively). In the other tested fats, contrary to lard, palmitic acid esterified predominately at the α, α`-positions (29.24 - 32.79 in tallow; 20.54 - 30.85 % in lamb fat and 29.8 - 34.98 % in goat fat while the concentration of oleic, linoleic and linolenic acids were less at the α, α`-positions than at the β-position. It is also obvious from Table 1 that palmitic acid level in the total triacylglycerols ranged from 2386. to 28.01% in tallow, from 17.02 to 23.28% in lamb fat and from 24.17 to 27.28% in goat fat. At the β-position of the triacylglycerol the percentage of palmitic acid varied from 8.4 to 18.47% in tallow, from, from 8.12 to 9.98% in lamb fat and from 11.86 to 12.9 in goat fat. In general the data of Tables 1, 2 and 3 show that the fatty acid levels at the different positions of the triacylglycerol have wide ranges within the same fat.

In previous work (Youssef *et al.* 1988) small amounts of lard was detected in tallow using ratios based on the fatty acid distribution in the triacylglycerols. The ratios used were between the percentage of unsaturated fatty acids at β-position and in the total triacylglycerol (unsaturation ratio), the division product of the percentage of saturated by the unsaturated fatty acids at the β-position (R2) and the ratio between the percentage of fatty acids with 16 carbon atoms and 18 carbon atoms at the β-position (R3). The same study also used palmitic acid enrichment factor (PAEF) relating the percentage of palmitic acid at β-position to its percentage in the total triacylglycerol. Using the data obtained in the present work the above ratios and factor were evaluated for pure fats taken from different animal breeds (Table 5) and for laboratory prepared blends of lard and tallow (Table 6). Fig. (1) gives the graphical representation of the data of Table (6). The x and y-axis represent the percentage of lard in the blend and the corresponding value of the factor respectively. Table (5) shows that the values of the factors number 1, 3 and 4 were bigger for tallow than lard while the values of factor number 2 were smaller for tallow than lard. The lower limit of the range of each of the three factors for tallow was extrapolated to intersect with the x-axis at points LM1, LM3 and LM4 indicate the minimum detectable level of lard in tallow by factors 1, 3 and 4 respectively. For factor number 2 the point LM2 was obtained by extrapolating the upper limit of its range for tallow. It is obvious from the data presented in Table (5) and (6) that PAEF for fat blends containing up to 10% of lard (0.32 - 0.62) laid within the range of this factor for pure tallow (from 0.35 to 0.66). It is also clear from Fig. (1) point LM1 that the minimum detectable limit of lard by this factor is 12%. The unsaturation ratio for tallow covered the range 1.32 - 1.56 (Table 5) while in lard the values were from 0.43 to 0.50. The values of the same ratio in Table (6) and Fig. (1)

Table 1
Fatty acid composition in the total triacylglycerols of different fats

Animal fat			Fatty acid composition percent													
			C14:0	C14:1	C15:0	C15:1	C16:0	C16:1	Ukn1	Ukn2	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	Others
Tallow	Range	From	2.44	0.3	0.28	0.6	23.86	2.32	0.45	0.78	0.69	0.42	11.96	31.86	1.85	0.32	0.01
		To	4.05	1.52	1.05	0.49	28.01	5.25	0.77	1.76	2.27	1.82	22.99	48.03	4.37	1.94	0.46
	Average		3.73	0.88	0.59	0.19	25.05	3.93	0.59	0.97	1.35	0.85	15.98	42.35	2.58	0.75	0.1
Lard	Range	From	1.67	0.1	0.09	0.01	22.04	1.44	0.01	0.07	0.26	0.21	6.03	37.49	8.22	0.3	0.01
		To	1.77	0.11	1.17	0.02	27.42	3.99	0.04	0.1	0.47	0.45	22.36	54.25	10.44	0.43	0.1
	Average		1.69	0.11	0.11	0.02	25.87	3.12	0.03	0.08	0.41	0.31	12.3	47.93	9.81	0.4	0.03
Sheep fat	Range	From	1.69	0.11	0.5	0.16	17.02	0.75	0.35	0.8	2.2	0.53	9.83	33.39	2.09	0.01	0.01
		To	3.95	1.43	1.73	0.38	23.28	3.48	0.65	1.43	3.1	3.34	37.88	48.28	2.85	0.01	0.24
	Average		2.62	0.56	0.99	0.28	20.49	2.23	0.48	1.17	2.64	1.71	22.02	42.09	2.58	0.01	0.13
Goat fat	Range	From	3.89	0.59	0.76	0.29	24.17	1.69	0.51	0.93	1.73	0.79	14.68	38.49	1.79	0.14	0.26
		To	5.15	0.34	0.91	0.3	27.28	3.32	0.63	0.99	1.93	1.58	22.37	41.87	2.19	0.15	0.33
	Average		4.21	0.4	0.82	0.3	26.01	2.94	0.55	0.95	1.77	1.23	16.89	40.91	2.01	0.15	0.3

The fatty acids Uknl and Ukn2 are unknown branshed chain saturated acids with 16 carbon atoms.

Table 2

Fatty acid composition at the β-position of the triacylglycerols of different fats

Animal fat			Fatty acid composition percent													
			C14:0	C14:1	C15:0	C15:1	C16:0	C16:1	Ukn1	Ukn2	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	Others
Tallow	Range	From	3.44	0.68	0.12	0.08	8.4	4.06	0.03	0.27	0.24	0.73	4.62	48.18	2.21	0.01	0.01
		To	9.56	3.37	0.79	0.59	18.47	7.93	0.38	1	1.59	2.55	9.72	63.18	7.2	0.65	0.01
	Average		5.62	1.83	0.32	0.21	11.99	5.73	0.19	0.62	0.81	1.34	7.08	59.16	4.3	2.84	0.01
Lard	Range	From	3.97	0.01	0.1	0.01	57.19	1.96	0.05	0.05	0.42	0.28	2.96	14.23	3.93	0.01	0.01
		To	4.19	0.04	0.26	0.01	68.69	6.23	0.09	0.07	0.54	0.71	5.44	22.23	5.78	0.28	0.01
	Average		4.18	0.02	0.21	0.01	61.54	4.65	0.06	0.06	0.52	0.47	3.89	19.4	4.26	0.21	0.01
Sheep fat	Range	From	2.25	0.2	0.28	0.2	8.12	1.21	0.11	0.61	1.09	0.47	3.79	53.64	4.12	0.01	0.2
		To	5.28	2.44	0.8	0.52	9.89	4.24	0.24	1.38	1.27	5.02	15.15	68.48	5.5	1.5	5.47
	Average		3.56	1.16	0.53	0.37	9.11	2.7	0.17	1.03	1.19	2.53	9.07	61.08	4.92	0.58	2
Goat fat	Range	From	4.84	0.38	0.45	0.32	11.86	2.62	0.14	0.59	0.71	1.24	5.92	59.28	3.33	0.3	0.39
		To	5.87	0.94	0.46	0.33	12.9	4.77	0.2	0.64	0.87	2.63	10.19	62.75	4.32	0.32	0.43
	Average		4.99	0.56	0.46	0.33	12.67	3.52	0.16	0.61	0.81	1.85	7.57	61.14	3.72	0.31	0.42

The value of 0.01 was given to the undetected fatty acids
Ukn1 and Ukn2 represent saturated branshed chain fatty acids with 16 carbon atoms.

Table 3

Fatty acid composition at the α α`-position of the triacylglycerols of different fats

Animal fat			Fatty acid composition percent													
			C14:0	C14:1	C15:0	C15:1	C16:0	C16:1	Ukn1	Ukn2	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	Others
Tallow	Range	From	1.95	0.01	0.36	0.01	29.24	1.34	0.5	0.72	0.91	0.01	15.46	23.7	0.79	0.15	0.01
		To	4.82	0.92	1.19	0.43	32.79	4.42	1.13	2.5	2.58	1.69	29.63	39.22	2.59	2.91	0.4
	Average		2.79	0.4	0.73	0.18	31.58	3.02	0.78	1.14	1.61	0.61	20.44	33.95	1.72	0.92	0.14
Lard	Range	From	0.53	0.14	0.01	0.01	4.46	1.18	0.01	0.08	0.18	0.18	7.57	48.96	10.37	0.44	0.01
		To	0.56	0.16	0.21	0.03	6.78	2.87	0.04	0.14	0.43	0.32	30.82	70.26	12.77	0.51	0.01
	Average		0.63	0.15	0.13	0.02	6.13	2.23	0.03	0.11	0.36	0.3	20.2	57.47	11.39	0.47	0.01
Sheep fat	Range	From	1.41	0.01	0.6	0.14	20.54	0.53	0.46	0.9	2.75	0.55	12.86	23.27	1.08	0.01	0.01
		To	3.29	0.92	2.2	0.31	30.85	3.1	0.85	1.45	4.02	2.51	49.24	38.17	1.61	0.01	0.2
	Average		2.15	0.26	1.22	0.23	26.18	2	0.63	1.254	3.36	1.3	28.49	32.59	1.41	0.01	0.01
Goat fat	Range	From	3.41	0.41	0.9	0.27	29.8	1.22	0.66	1.08	2.23	0.56	19.06	28.09	1.02	0.06	0.19
		To	4.79	0.32	1.13	0.28	34.98	2.6	0.87	1.19	2.46	1.06	28.46	31.43	1.12	0.07	0.28
	Average		4.34	0.35	1.97	1.07	31.56	1.96	0.83	1.18	2.39	0.98	25.01	30.07	1.08	0.07	0.25

The value of 0.01 was given to the undetected fatty acids
The fatty acids Ukn1 and Ukn2 are unknown branshed chain saturated acids with 16 carbon atoms.

Table 4
Fatty acid distribution in the triacylglycerols of of mixtures of tallow and lard at different proportions.

		Fatty acid composition percent								
		C14:0	C14:1	C15:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3
100%	t	2.88	0.37	0.7	28.28	3.7	5.01	53.97	4.24	0.84
Tallow	α	2.5	0.2	0.86	37.97	3.04	4.1	47.45	3.22	0.66
	β	3.65	0.72	0.39	8.92	5.01	6.83	67.01	6.27	1.2
3%	t	2.42	0.55	1.23	21.29	3.57	13.77	50.58	4.78	1.81
Lard	α	2.06	0.49	1.54	27.33	3.33	17.31	41.15	4.29	2.49
	β	3.13	0.67	0.61	9.23	4.04	6.69	69.43	5.76	0.44
5%	t	2.29	0.37	0.81	19.04	3.17	16.66	52.46	4.65	0.57
Lard	α	1.82	0.22	0.75	22.61	2.46	21.78	45.66	4.08	0.63
	β	3.22	0.68	0.93	11.89	4.57	6.42	66.06	5.78	0.45
10%	t	2.34	0.33	0.79	21.26	3.62	13.52	52.71	4.75	0.69
Lard	α	2.12	0.23	0.98	25.31	3.38	16.97	46.24	4.14	0.63
	β	2.79	0.53	0.41	13.15	4.09	6.62	65.64	5.96	0.82
15%	t	2.06	0.34	0.77	20.29	3.32	13.54	54.14	4.8	0.75
Lard	α	1.3	0.07	0.64	22.73	2.41	17.55	49.44	4.94	0.91
	β	3.58	0.87	1.03	15.39	5.14	5.53	63.53	4.5	0.43
55%	t	2.71	0.81	0.66	22.69	5.3	7.87	51.4	7.69	0.87
Lard	α	1.86	0.51	0.74	15.79	4.2	9.92	57.25	8.7	1.02
	β	4.41	1.42	0.49	36.48	7.5	3.78	39.71	5.65	0.57
70%	t	2.24	0.55	0.45	22.13	5.16	6.62	53.06	9.23	0.56
Lard	α	1.18	0.25	0.46	11.92	3.78	8.34	62.54	10.94	0.59
	β	4.37	1.14	0.43	42.57	7.92	3.18	34.12	5.79	0.49
85%	t	2.06	0.46	0.59	21.53	4.98	6.4	53.52	9.91	0.55
Lard	α	1.15	0.42	0.75	8.48	3.8	8.02	64.82	11.92	0.63
	β	3.87	0.53	0.25	47.63	7.34	3.15	30.93	5.9	0.4
90%	t	1.81	0.23	0.16	21.77	4.67	5.84	55.26	9.71	0.56
Lard	α	0.73	0.11	0.08	7.59	3.15	7.27	68.7	11.73	0.64
	β	3.96	0.48	0.32	50.12	7.69	3	28.37	5.68	0.39
100%	t	1.69	0.1	0.18	22.23	4.02	6.08	54.72	10.53	0.44
Lard	α	0.52	0.14	0.21	4.39	2.88	7.63	70.83	12.87	0.52
	β	4.02	0.01	0.1	57.92	6.31	2.99	22.51	5.85	0.28

t, α and β indicate the fatty acid composition at the total triacylglycerol, the 1 and 3-positions and the 2-position respectively.

point LM2 revealed that for up to 22% lard in tallow the value of the unsaturation ratio was within the range for pure tallow. Similarly the ratios (R2) and (R3) were not sensitive enough for less than 47% and 24% respectively of lard in tallow (points LM3) and LM4 of Fig. 1). It is evident therefore that the ranges of the unsaturation ratio, (R3), (R3) and (PAEF) for tallow were wide enough to accommodate about 12%, 22%, 47% and 24% respectively of lard in tallow without being detected or give false detection of these levels of lard.

Table 5
Detection factors for tallow and lard determined using the data of Table 1 and formulae taken from the literature.

Factor	Tallow			Lard		
	Range			Range		
	From	To	Average	From	To	Average
PAEF	0.35	0.65	0.47	2.51	2.61	2.59
Unsat. ratio	1.28	1.53	1.4	0.39	0.41	0.4
R2	0.25	0.66	0.36	1.86	3.84	3.12
R.3	0.17	0.36	0.25	2.03	2.95	2.57

* Youssef *et al.* (1988

In an attempt to improve the detection sensitivity of lard from the fatty acid distribution in fats, different formulae involving the levels of fatty acids at the β-position and α, α`-positions were proposed and evaluated for the analysed fats. The formulae showing different specific values for the different fats were chosen as fat detection criteria (factors from F1 to F11 in Table 7 and 8). The division product of palmitic / oleic acids ratio at β-position by this ratio at α, α`-positions (F5) in tallow covered narrow range of small values from 0.15 to 0.31 compared with its big values in lard (from 34.3 to 41.8). It is obvious also from the data of Table (8) that for blend containing less than 4% of lard the value of F5 (0.33) was more than the upper limit of its range for tallow (point no. m5 in Fig. 2). The factor F5 was therefore, sensitive to detect 4% of lard in tallow. The other factor in Table (8) showed variable degree of specificity for the different fats and different detection limits. The values of F7 for tallow covered the range from 0.2 to 0.35 while it was ranging from 6.15 to 12.73 for lard. Fig. (4) indicates that (F7) had minimum detection limit of 8% of lard in tallow. The value of F6 for tallow was ranging from 0.27 to 0.55 while in lard it covered the range from 10.22 to 13.55 and according to Table (8) it was possible to detect about 11% of lard in tallow by this factor. Figs. (2) and (5) also show that F2, F10 and F11 enabled minimum detection limits of 10%, 9% and 4% of lard respectively. On the other hand the factor F1 was highly specific for lard. Its values for the analyzed lard samples were almost the same (from 7.6 to 7.7) while for tallow it was ranging from 1.35 to 2.55. Similar specificity for lard was shown by F3, F8 and F10 (Tables 7 and 8), where they ranged from 0.30 to 0.32, from 5.56 to 5.88 and from 8.84 to 8.95 respectively and they were able to detect about 1% to tallow in lard. The values of the same factors covered wider ranges fro tallow (1.48 - 2.07, 1.52-3.81 and 0.39 - 0.65 respectively) and according to the data of Table 7 and 8 F3 and F8 were able to detect about 6% and 12% respectively of lard in tallow.

Quantification of lard in blends containing lard and tallow was achieved using Figs. (2, 3, 4 & 5). The values of the factors were calculated using the fatty acid compositional data at β-position and α,α`-positions, obtained by analysis. The percentage of lard in the blend is then given by the mean value of the percentages of lard at the x-axis corresponding to the calculated values of the factors. At present a computer programme is being written for quantitative determination of the fat constituents of blends from the data of fatty acid distribution at the triacylglycerols.

Table 6
Detection factors calculated using the data of Table (4) and formulae taken from the literature*

formula	Percentage of lard in tallow. 0	3	5	10	15	55	70	85	90	100
1	0.35	0.43	0.62	0.62	0.76	1.61	1.92	2.21	2.3	2.61
2	1.39	1.37	1.26	1.24	1.17	0.77	0.64	0.58	0.51	0.41
3	0.25	0.24	0.28	0.29	0.34	0.82	1.02	1.22	1.35	1.86
4	0.17	0.16	0.21	0.22	0.28	0.88	1.16	1.36	1.54	1.7

* The formulae (1, 2, 3 and 4) were taken from the work of Youssef *et al.* (1988)
Formula 1 = percentage of palmitic acid at the 2-position/its percentage in the total triacylglycerol.
Formula 2 = Percentage of unsaturated fatty acid at β-position/total triglycerides
Formula 3 = Total sum of saturated / unsaturated fatty acids at the β-position
Formula 4 = Total sum of fatty acids with 16 carbon atoms/total sum of fatty acids with 18 carbon atoms at the β-position

Table 7
Detection factors calculated using the formulae proposed in the data processing method for a number of fats.

Factor	Tallow			Lard			Sheep fat			Goat fat		
	Range			Range			Range			Range		
	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
F1	1.35	2.55	2.01	7.6	7.74	7.71	1.58	1.95	1.71	1.2	1.4	1.3
F2	0.27	0.56	0.38	10.22	13.29	12.01	0.26	0.51	0.37	0.34	0.43	0.42
F3	1.48	2.07	1.74	0.3	0.32	0.31	1.67	2.52	1.98	1.97	2.06	2.04
F4	0.74	1.72	1.11	33.81	57.86	38.84	0.98	1.58	1.14	1.09	1.21	1.14
F5	0.15	0.31	0.22	34.31	41.78	39.53	0.16	0.2	0.18	0.17	0.21	0.19
F6	0.27	0.56	0.38	10.22	13.24	12.72	0.26	0.51	ERR	0.34	0.43	0.41
F7	0.2	0.35	0.25	6.15	12.69	10.22	0.15	0.21	0.19	0.2	0.21	0.21
F8	1.52	2.63	2.21	5.88	6.09	6.01	1.64	2.88	2.11	1.2	1.49	1.41
F9	0.36	0.56	0.44	2.07	5.09	4.12	0.36	0.42	0.39	0.39	0.45	0.41
F10	0.39	0.65	0.51	8.88	8.95	8.92	0.36	0.56	0.44	0.44	0.49	0.46
F11	1.12	1.33	1.23	0.26	0.34	0.32	1.09	1.39	1.25	1.26	1.38	1.35

Table 8
Detection factors for blends of lard and tallow at different proportions.

Factor	Percentage of lard in the blend.									
	0	3	5	10	15	55	70	85	90	100
F1	1.78	1.52	1.77	1.32	2.75	2.38	3.71	3.37	5.42	7.7
F2	0.27	0.34	0.53	0.52	0.68	2.31	3.57	5.62	6.6	13.2
F3	1.72	1.69	1.45	1.42	1.29	0.69	0.55	0.48	0.41	0.32
F4	0.74	0.87	1.79	1.33	2.15	6.07	9.38	14.28	16.01	33.61
F5	0.15	0.2	0.36	0.37	0.53	3.33	6.55	11.77	15.99	41.53
F6	0.27	0.34	0.53	0.52	0.68	2.31	3.57	5.61	6.6	13.15
F7	0.2	0.26	0.33	0.36	0.47	2.08	3.65	5.4	7.25	12.73
F8	2	1.49	1.91	1.41	3.23	2.46	3.85	2.8	5.29	6.06
F9	0.36	0.41	0.48	0.51	0.6	1.59	2.31	2.98	3.66	5.1
F10	0.39	0.43	0.66	0.6	0.82	2.2	3.22	4.47	5.38	8.84
F11	1.33	1.26	1.09	1.16	1.02	0.65	0.53	0.47	0.42	0.33

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