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DETERMINATION OF FAT CONTENT IN MEAT BY PULSED NUCLEAR MAGNETIC RESONANCE (P-NMR) TECHNIQUE

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This paper reports on the results obtained with the pulsed nuclear magnetic resonance (P-NMR) technique applied for determining fat content in fresh meat. The interfering moisture content of meat was removed by microwave drying and the dried residue was quantitatively transferred into the P-NMR tubes. The total analysis time was about 50 min. Experiments were performed with rendered pure pork, beef and goose fats, sunflower oil and with lean pork – fat and lean beef – tallow mixtures (batters). The regression (prediction) equations (intensity of P-NMR signal vs. fat content determined with the Soxhlet reference method) of the sunflower oil and fat samples did not differ appreciably. Consequently, contrary to the results obtained with the CW-NMR technique, the variability of the fatty acid composition of the examined fats and oil had no substantial effect on the regression (prediction) equations in this case. On the other hand, there was a considerable difference between the regression lines of the lean pork-fat and lean beef-tallow mixtures. Therefore, due to the interfering effect of the non-fat dry matter and the type of meat on the intensity of P-NMR signal, this technique can only have a restricted practical application in the in-line process control of fat content of meats.

Keywords: P-NMR, fat determination, meat analysis, NMR

Rapid methods are often needed for the in-line process control of the fat content of meat in meat processing plants. A previous report (NAGY et al., 2000) demonstrated that, among others, the high sensitivity of continuous wave nuclear magnetic resonance (CW-NMR) signal to the fatty acid composition interferes with the quantitative determination of fat content in meat, inducing occasionally a noticeable bias in the prediction.

NILSSON and KOLAR (1970), as well as CASEY and MILES (1974) obtained an acceptable accuracy by determining the fat content in meat with the NMR technique.

According to RENOU and co-workers (1985) the results of P-NMR spectrometry correlated well with the chemical analysis data, the mean standard deviation of the difference was 0.8%. Using a "home built" P-NMR spectrometer, they established that the ratios of the respective NMR peaks correlated closely with the results obtained by standard chemical analysis. However, different fats produced different $-CH_2-$signal intensities with a mean error of ca. 1% (RENOU et al., 1987). Recently, DIVAKAR (1998) published a critical appraisal on NMR spectroscopy in food applications.

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The objective of the present work was to assess the accuracy (INTERNATIONAL STANDARD, 1994) of the P-NMR technique for determining fat content in meat.

1. Materials and methods

The measurements were performed with post rigor lean pork and lean beef l. dorsi samples (pH=5.8–5.9, and fat contents not exceeding 1.1%).

Freshly rendered pork, beef and goose fat samples (without addition of antioxidants) were obtained from the pilot plant of the Hungarian Meat Research Institute. Fresh sunflower oil, without addition of antioxidant, was obtained from a commercial source.

Furthermore, different meat-fat mixtures (batters) were prepared with rendered pork and beef fats, with fat contents ranging from 1.1% to 47.5% for pork and from 1.1% to 31.2% for beef (see Table 1).

The P-NMR measurements were made with the NMS 100 minispec NMR Analyser of the Stollwerck Confectionery Industry LLC (Budapest), using tubes of 1 cm diameter.

The test materials were preincubated for 45 min at 50 °C. After careful homogenization in Moulinex apparatus, 5.00 g of the sample units were dried in microwave oven for about 23 min (NAGY et al., 1991). The dried residue was then transferred quantitatively into the NMR-tubes.

Prior to NMR analysis, the fats and oil were dehydrated with anhydrous Na_2SO_4.

Results (signals) obtained with the P-NMR technique were compared with the fat content obtained by Soxhlet extraction (HUNGARIAN STANDARD, 1985).

2. Results

Calculations (intensity of P-NMR signal against Soxhlet reference method) were carried out by the classic regression analysis (HALD, 1962). Results are presented in Tables 1 and 2.

Table 1. Relationship between intensity of P-NMR signal (y) and amount of fat (x)

Serial numbers	Sample	Interval (g fat)	n	a	b
1	Rendered pork fat	0.052–1.989	13	0	46.22
2	Rendered beef tallow	0.049–2.004	15	0	47.02
3	Rendered goose fat	0.051–2.008	15	0	48.65
4	Sunflower oil	0.052–2.001	15	0	45.12
5	Pork with various fat contents	[a]0.056–2.376	13	5.22	36.71
6	Beef with various fat contents	[a]0.056–1.560	10	0	52.21

$\hat{y} = a+b\,x$; a: intercept; b: slope; n: sample size.

[a] Amount of fat (in g) in 5 g test material

Table 2. Paired comparison of slopes presented in Table 1, with the *t*-test

	1	2	3	4	5*
2	NS				
3	NS	NS			
4	NS	NS	S		
5	S	S	S	S	
6	S	S	S	S	S

S: significant difference;
NS: no significant difference.
For serial numbers from 1 to 6, see Table 1
* The intercept is significantly different from 0

The evaluation of data (KÖRMENDY et al., 1989; KÖRMENDY & ZUKÁL, 2002) showed that the relations presented in Table 1, except sample with serial number 5, can be described with the $\hat{y} = b.x$ equation, i.e. proportional relations exist between intensity of P-NMR signal (y) and fat content (x) measured with the Soxhlet method. In Table 2, the slopes of the various regression lines were compared by Student's *t*-test (HALD, 1962). As seen in Tables 1 and 2 and in Figs 1 to 3:

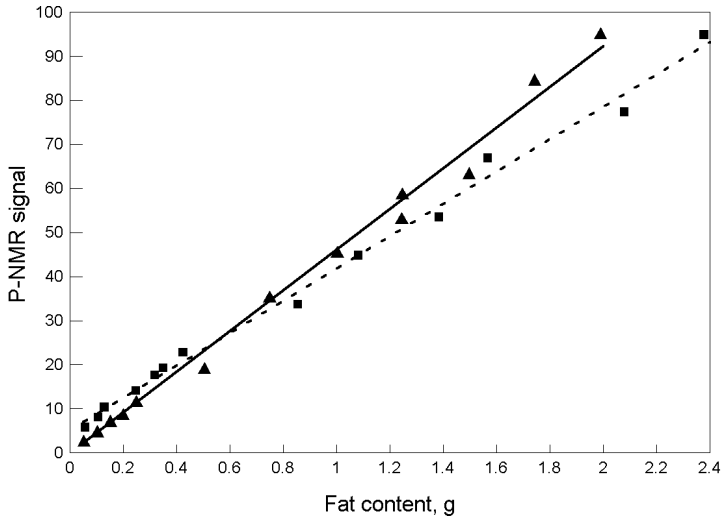

Fig. 1. Intensity of P-NMR signal plotted against the amount of fat (g) for rendered pork fat (▲) and for pork (■) with various fat contents

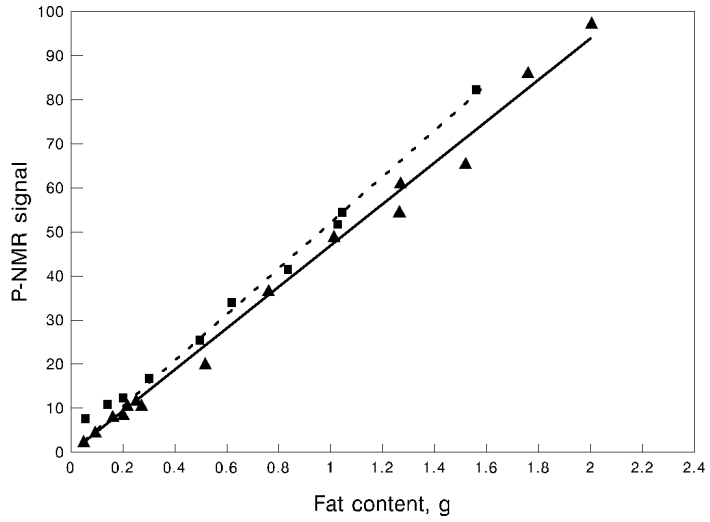

Fig. 2. Intensity of P-NMR signal plotted against the amount of fat (g) for rendered beef fat (▲) and for beef (■) with various fat contents

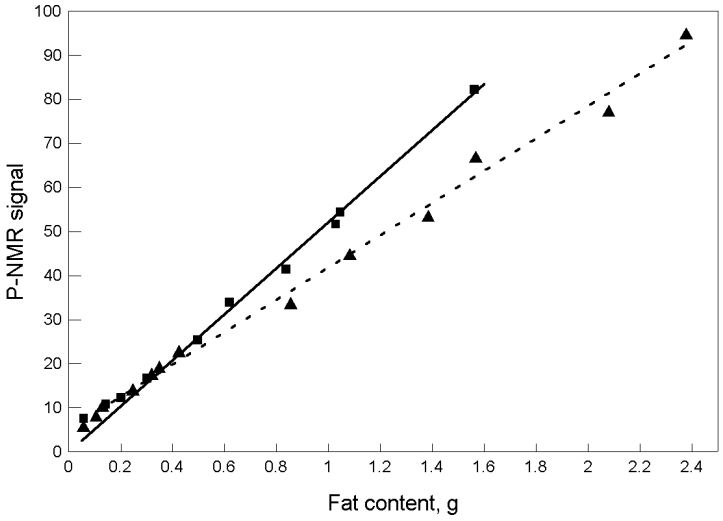

Fig. 3. Intensity of P-NMR signal plotted against the amount of fat (g) for pork (▲) and beef (■) with various fat contents

– Although the slopes (b) of pure goose fat and pure sunflower oil were significantly different (Table 2), there were no considerable differences between the pure fat and oil samples (see samples with serial numbers from 1 to 4 in Table 1).

It should be noted that, contrary to these results, the essential differences in the fatty acid composition of the fat and oil samples (SZEREDY & PERÉDI, 1956; BELITZ & GROSCH, 1985) induced a considerable difference in the CW-NMR signal (NAGY et al., 2000).

– The highly significant differences in the slopes (b = intensity of P-NMR signal/amount of fat) of pork and beef mixtures with various fat contents, compared to the pure fat samples (Figs 1 and 2), suggest that the non-fat dry matter content of the test materials, as might be expected, has a considerable effect on the intensity of P-NMR signal.

– Comparison of data in Table 1, also presented in Fig. 3, also shows that the interfering effect of the non-fat dry matter varies noticeably according to the type of meat (pork or beef).

3. Conclusions

Comparing the regression equations between intensity of P-NMR signal and amount of pure fats and sunflower oil, it appears that, contrary to the results obtained with the CW-NMR technique (NAGY et al., 2000), the fatty acid composition has no substantial effect on them.

On the other hand, the regression equations (intensity of P-NMR signal vs. amount of fat), obtained with pork-fat and beef-tallow mixes, deviated considerably. Consequently, because of the interference caused by the non-fat dry matter content of the test materials and the type of meat, the P-NMR technique can only have a restricted practical application for the in-line process control of fat content in meat processing plants.

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