THE DETERMINATION OF FAT CONTENT IN MEAT AND MEAT PRODUCTS BY NUCLEAR MAGNETIC RESONANCE

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INTRODUCTION

To obtain a true measure of the fat content of different substances one usually uses complicated extraction methods, e.g. the method by Schmid-Bondzinsky-Ratzlaff. But methods like this one are tedious and only a limited number of analyses can be carried out with given resources of space and staff.

By simplifying the extraction methods in different ways it is possible to increase the number of samples to be analysed but the accuracy with such rapid methods is often inadequate. When dealing with meat and meat products it is also doubtful if one of these methods could be used for the whole range of products.

Instead of chemical methods physical ones may also be used for fat determination. The refractive index of fat and the volume weight has been used for this purpose but as the measured qualities vary somewhat with the material or product to be analysed the scope of these methods is limited. However, one method, where these limitations are not so pronounced, is to measure the nuclear magnetic resonance (NMR) of the product and from the values obtained calculate the fat content.

NMR has been used for a long time in the fat industry to determine the fat content in oil seeds or to determine the proportion between solid and liquid fat in seeds. But it is only recently that it has also been used for products containing more than a few percentages of water (1,2,3). This report deals with the use of NMR for the determination of fat content in meat and meat products, an application which does not seem to have been described previously.

METHOD

The sample was minced twice in a meat mincer and blended thoroughly after each mincing.

5-8 g was weighed on a polyester film (Mylar A 5099) placed on a crucible of stainless steel.

The sample was then dried at 135°C for 4 h or at 104°C for 15 h.

The dried residue together with the film was then transferred to a 6.5 ml probe and placed in an aluminium block at 70°C for 1 h.

The probe was then placed in the measuring unit of the NMR-apparatus and the signal was measured.

The fat content was calculated from a calibration curve obtained by measuring the signal for different amounts of lard.

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The NMR-apparatus used was a Newport Quantity Analyzer with a Supplementary Modulation Unit Type A10, Digital Voltmeter CDV200A and Temperature Control Unit Type AA.

The measurements were carried out in the following conditions:

R.F. level: 80 u A
A.F. gain: 250
Integration time: 33 s
Automatic loss control: High
Supplementary modulation: On
Sample temperature: 70°C

RESULTS AND DISCUSSION

One condition which has to be fulfilled if the NMR-method is to be used for meat and meat products is that fat from different animal sources must give the same NMR signal on weight basis.

This assumption was fulfilled as shown in Table 1.

Substans	Amount g	NMR-signal	MV	MV/g with lard taken as 100%	
Lard	2.300	1.000, 1.004, 0.995, 1.001	0.999	99.85	100.0
Lard	2.284	0.993, 0.992, 1.000, 0.998	0.995	100.184	
Ballow	2.225	0.964, 0.968, 0.971	0.967	99.90	100.0
Ballow	2.355	1.024, 1.028, 1.026	1.026	100.09	
Cocoanut	2.390	1.031, 1.027, 1.022	1.026	98.68	98.8
fat	2.403	1.038, 1.037, 1.030	1.035	99.0	
Soybean	2.495	1.016, 1.017, 1.018	1.017	92.41	92.6
fat	2.475	1.002, 0.998, 0.994	0.998	92.69	

Table 1. The NMR-signal for different fats.

The animal fats gave identical signals per g fat. Vegetable fats gave a somewhat lower value, especially if they contained a high amount of polyunsaturated fatty acids such as soybean oil. The results show clearly that NMR can be used for fat determination in meat and meat products. It may also be used for products containing a mixture of animal and vegetable fats as in prepared food, with reasonable accuracy.

The degree of oxidation did not influence the NMR signal as the same value was obtained for lard with peroxide numbers between 1 and 65.

Another point that had to be settled was the effect of moisture on the NMR signal. Wiggall et al. (1) have shown that only a small amount of water will be tolerated by the Newport instrument. By using a more elaborate technique it might, however, be possible to determine the fat content in the presence of a rather high content of water as shown by Shanbag et al. (2) and by Conway (3). But usually we also determine the water content of our samples and the simplest way for us was to use the residues from the water determination by the NMR method.

The usefulness of the NMR method was tested by analysing a number of meat and meat products as well as prepared food and comparing the results with an official standard method (Schmidt-Bondzinsky-Ratzlaff). Some of the values obtained are shown in Tables 2-4.

Fat content %		
NMR (y)	SBR (x)	Diff. % (y-x)
4.8	5.1	-0.3
0.9	0.7	0.2
2.0	1.4	0.6
29.5	29.1	0.4
4.1	4.0	0.1
4.5	4.3	0.2
3.3	2.9	0.4
4.1	3.7	0.4

Table 2. The fat content of different cuts of beef measured by the NMR and the SBR methods.

Fat content %			
Product	NMR (y)	SBR (x)	Diff. % (y-x)
Ham	9.9	9.8	0.1
	9.1	9.1	0.0
	8.1	8.0	0.1
	14.5	14.2	0.3
	6.5	6.2	0.3
	5.6	5.2	0.4
	13.1	13.2	-0.2
Pork	12.6	12.2	0.4
	19.1	18.6	0.5
	37.3	37.3	0.0
	15.0	14.6	0.4
Veal roll	15.3	15.1	0.2
	3.7	3.3	0.4
	15.2	14.9	0.3
Pickled beef	2.6	2.3	0.3
	2.4	2.4	0.0
	1.7	1.6	0.1
	1.6	1.7	-0.1

Table 3. The fat content of cured meat products measured by the NMR and the SBR methods.

Fat content %				Fat content %			
Product	NMR (y)	SBR (x)	Diff. (y-x)	Product	NMR (y)	SBR (x)	Diff. (y-x)
Medwurst	32.3	32.3	0.0	Blodpudding	15.4	14.9	0.5
"	33.0	33.0	0.0	"	16.4	16.0	0.3
Falukorv	22.6	22.6	0.0	Leverpastej	24.7	24.6	0.1
"	23.6	23.7	-0.1	"	32.5	32.5	0.0
"	24.9	24.3	0.6	"	32.0	31.4	0.6
"	25.7	25.6	0.1	Kalvsylta	6.7	6.4	0.3
"	26.0	25.7	0.3	Isterband	13.5	13.3	0.2
"	26.1	25.6	0.5	"	23.1	23.2	-0.1
				"	18.1	17.9	0.2

Table 4. The fat content of different Swedish sausages measured by the NMR and the SBR methods.

As shown in the Tables the agreement between the methods is good. The agreement is not dependent on the fat content neither is it influenced by the rather high salt content of some of the cured products.

The correlation between the methods is shown in Table 5 which gives both the regression equations and the correlation coefficients.

Product group	n	Regression equation	Linear correlation coef.
Beef meat	24	$y = 0.393 + 1.002\,x$	0.998
Cured meat	78	$y = 0.415 + 0.991\,x$	0.999
Fermented products	11	$y = 0.504 + 0.981\,x$	0.997
Cold-smoked products	11	$y = 0.898 + 0.976\,x$	0.997
Prepared food	9	$y = 0.132 + 1.010\,x$	1.000

Table 5. The correlation between the fat content determined by the NMR-method (y) and the SBR-method (x).

Even if the correlation is very good there was a slight difference as the NMR method in the mean gave an 0.3 % higher fat content than the standard method. The difference was the same in the whole range of fat percentage and may be due to a weak NMR signal from non-extractable substances. The same difference was found by Wiggal et al. (1) for chocolate products.

The accuracy of the method was sufficient for routine analyses as the difference of the mean value did not exceed 0.25%. If necessary it could, of course, be improved by using a probe of 40 ml instead of 6.5 ml.

The NMR method seems to be an ideal routine method as it is both accurate and rapid enough and also simple to use. It is possible for one person to perform more than 100 analyses a day instead of a few when using the standard method.

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References

1. Wiggall, P.H., Inge, A.D. and Walker, E. The rapid determination of fat in chocolate and related products using low resolution nuclear magnetic resonance. J. Food Techn. 5, 353, 1970.

2. Shanbag, S., Steinberg, M.P. and Nelson, A.I. Determination of oil in aqueous emulsions by wide-line NMR. J. Am. Oil Chem. Soc. 48, 11, 1971.

3. Conway, T.F. A wide line NMR R-F saturation method to measure fat in moist samples of defatted corn germ. J. Am. Oil Chem. Soc. 48, 54 (1971).

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