Effect of measuring temperature on NMR relaxation pattern in meat Model System

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Background

In meat industry and meat market, fast and non-destructive method for the component analysis and the quality estimation of meat has been requested, which can be corresponded by NMR. However application of NMR in food system still has some restriction due to insufficiently explained correlation between NMR data and laboratory results.

Objectives

This study was carried out to accumulate basic data for component analysis of fresh meat with low field NMR. Since relaxation times of NMR are tightly related with temperature, and the effect of temperature on correlation between component analysis and NMR relaxation pattern was evaluated.

Method

The NMS 120(Bruker, Germany) instrument with 10VTS(various temperature system) probe was used. Water and fat were added to trimmed lean meat(beef and pork), based on desired fat and moisture contents. The meat was homogenized (Model AM-11, Nihonseiki Kaisha. LTD) after mixing and then kept 0,5,10,15,20 °C in tubes (1.00×15cm) with a temperature controller. Moisture, fat and protein were analyzed by AOAC methods. 90 degree pulse sequence(SFC; solid fat content), 180° -τ -90 ° pulse sequence(T$_1$ IR: Inversion recovery), 90° -τ -90 ° pulse sequence (T$_1$ SR: Saturation recovery), 90° -τ -180 ° -τ -180 °……. pulse sequence(T$_2$ CPMG) and spin echo(90° -τ -180 ° -τ) pulse(T$_2$ SE) were used, respectively.

Results and discussion

In beef, the lower temperature of meat, the higher correlation between SFC results and meat compositions was shown. Especially, the correlations of moisture or fat with SFC results were highly shown at 0°C. The R^2 values were 0.91, 0.81 respectively. T$_2$ CPMG at high temperature and T$_2$ SE at low temperature, the correlation between NMR relaxation pattern and meat composition was high. The correlations between beef composition(moisture and fat) and T$_1$(both T$_1$ IR and T$_1$ SR) relaxation patterns were high in low temperature range. T$_1$ relaxation times showed higher correlation with meat compositions than T$_2$ relaxation times. In pork, the correlation of moisture and fat with 90° pulse results of NMR was relatively high at 0 and 5 °C. The correlation between moisture and fat with T$_2$ relaxation times showed higher values at low temperature. However, increase of temperature led the higher correlation between T$_2$ results(T$_2$ SE and T$_2$ CPMG) and meat composition, which R^2 values ranged in 0.97-1.00 at 15-20 °C.

Conclusions

These results our study suggested that establishing the proper temperature set of sample should be profoundly considered for individual NMR pulse sequences to analyze meat. Overall, measuring NMR at low temperature could improve the correlation of NMR results with meat composition.

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Fig. 1. Relationship of NMR result(SFC) and fat contents of pork at various temperatures

Chart showing NMR result (SFC) on y-axis (12 to 28) versus fat content on x-axis (0 to 20), with data series:
- $0°C ; R^2 = 0.983$
- $5°C ; R^2 = 0.982$
- $10°C ; R^2 = 0.876$
- $15°C ; R^2 = 0.413$
- $20°C ; R^2 = 0.001$
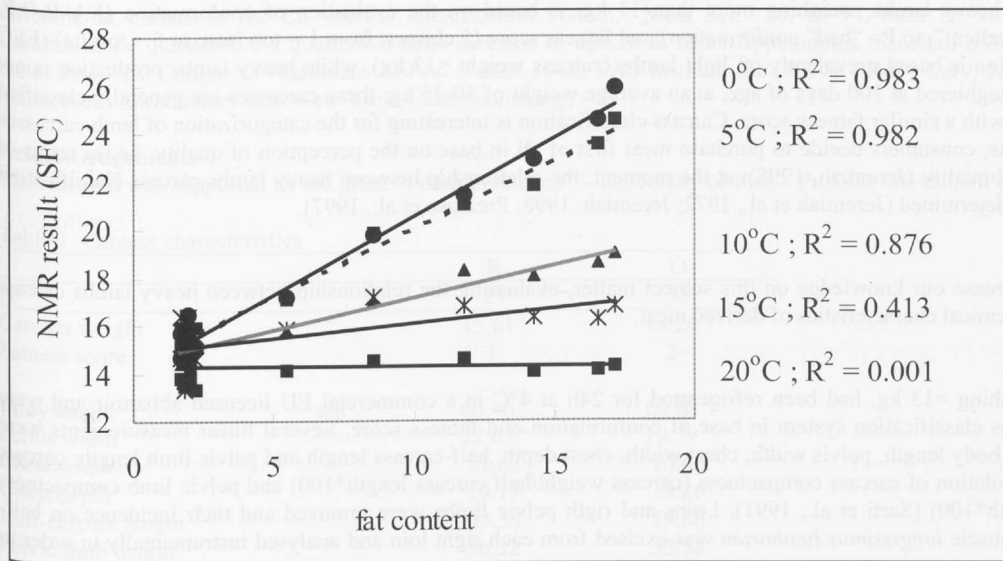
Table 1. Corelation values(R2) of NMR results and meat composition at various temperatures

		0°C			5°C			10°C			15°C			20°C		
		Moisture	fat	Protein	Moisture	fat	Protein	Moisture	fat	Protein	Moisture	fat	Protein	Moisture	fat	Protein
Pork	SFC	0.16	0.00	0.12	0.29	0.47	0.29	0.00	0.01	0.00	0.62	0.61	0.60	0.67	0.79	0.69
	moi	0.44	0.79	0.45	0.69	0.16	0.70	0.38	0.01	0.34	0.13	0.01	0.11	0.01	0.16	0.02
	T2 cp	0.95	0.51	0.95	0.95	0.63	0.99	0.89	0.51	0.92	0.95	0.52	0.96	0.28	0.11	0.27
	T2 se	0.82	0.35	0.77	0.94	0.68	0.92	0.93	0.67	0.93	0.87	0.39	0.87	0.32	0.15	0.24
Beef	SFC	0.96	0.98	0.77	0.60	0.64	0.47	0.14	0.12	0.04	0.08	0.07	0.00	0.04	0.02	0.06
	moi	0.07	0.03	0.01	0.27	0.21	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	T2 cp	0.48	0.54	0.36	0.21	0.14	0.04	0.19	0.15	0.04	0.07	0.08	0.12	0.26	0.25	0.14
	T2 se	0.84	0.90	0.72	0.09	0.08	0.03	0.05	0.03	0.00	0.06	0.03	0.00	0.26	0.33	0.26
	T1 ir	0.35	0.43	0.38	0.77	0.76	0.42	0.61	0.60	0.30	0.66	0.67	0.41	0.61	0.62	0.36
	T1 sr	0.58	0.67	0.85	0.18	0.15	0.05	0.54	0.52	0.39	0.09	0.11	0.20	0.54	0.52	0.44