EFFECT OF COOKING AND MICROWAVE HEATING ON THE FATTY ACID COMPOSITION OF BEEF INTRAMUSCULAR LIPID

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Introduction

Numerous studies confirmed that cooking had little effect on fatty acid composition of beef lipid extracts. But Duckett and Wagner (1998) found cooking increased the contents of stearic acid and total SFA, with the reduction of total PUFA. By the way, the use of the microwave oven for cooking has increased considerably during the past few decades (Sumnu, 2001). Microwave ovens change regular electricity into high-frequency microwaves that water and fat can absorb, causing food particle vibration, and thus the heating of the foodstuff. Microwave can generate high temperature and in seed oils may affect the oxidation of the lipids and quantitatively change the fatty acid composition (Yoshida, Hirooka and Kajimoto, 1990). García-Ariasa et al. (2003) found SFA increased, but n-3PUFA reduced in sardine, while, Hearn et al. (1987) have not observed important changes in the lipid composition of fish using microwave. Maranesi et al. (2005) reported fatty acid composition changed in lamb with microwave treated, however limited research is available to document changes in fatty acids composition of beef with microwave heating. The objective of this study was to assess the changes in fatty acids composition during cooking and microwave heating, and evaluate the implications to human health.

Materials and Methods

Beef samples (n = 10) were obtained as described by Chen et al. (2007), The samples were thawed at room temperature (about 15□) for 24 hours, one steak sampled directly as the uncooked control. The samples left were prepared into 20 × 20 × 20mm cubes each and then heated by cooking or microwave. Samples were individually placed inside polyethylene bags and cooked in a water bath at 70□, 80□ and 90□ to final internal temperatures of 60□, 70□ or 80□ respectively. Internal temperature was determined using thermocouples piercing probes attached to a thermometer. In microwave heating treatment, beef samples were placed in separate glass dishes in a microwave oven and treated with microwave (output power 600W, frequency 2,450 MHz) for 5s, then shut down the microwave oven for 10s to permit the internal heat equilibration, and measured the internal temperature of beef samples with digital thermocouples piercing probes outside the microwave oven, and then went on with the repetition of microwave (5s) - shut down (10s) - measured internal temperature until the internal temperature reach 60℃, 70℃ or 80℃.

Muscle samples were dissected free of intermuscular fat and the epimysium, weighed (about 2g). Lipids were extracted from the muscle by Dry Column method. The saponifiction, methylation, and fatty acids analyses of lipids were the same as described by Chen et al. (2007).

Mean differences of fatty acids from different lipid fractions were analyzed as a 2×3 factorial experimental design, by GLM-ANOVA model, with the factors heating treatment (cook and microwave) and terminal temperature (60℃, 70℃ and 80℃), and using the unheated meat data as a covariate. The statistical analysis was performed using SAS 8.2 (SAS Inst. Inc., Cary, NC).

Results and Discussion

In intramuscular fat (Table 1), percentages of 16:0, 16:0 + 18:0 and total SFA were increased ($P < 0.05$) significantly after cooking and microwave heating treatment. It was noted that SFA increased ($P < 0.05$) 9.09% with cooking at the internal temperature of 80℃, while SFA only increased about 5% ($P > 0.05$) when internal temperature reached 60℃ or 70℃. It is suggested that beef overcooked (internal temperature ≥ 80℃) was not good for human health as SFA increased significantly. The proportion of MUFA did not differ significantly ($P > 0.05$) after cooking. However, the percentage of 18:1*cis*-9 increased ($P < 0.05$), which caused the proportion of MUFA increased ($P < 0.05$) with microwave heating. Percentage of 18:2*cis*-9,12 was slightly reduced ($P > 0.05$), however, 18:3*cis*-9,12,15 and 20:4*cis*-5,8,11,14 decreased with beef cooked or microwave heated. These changes caused the reduction of total PUFA and n-3PUFA compositions ($P < 0.05$) after the internal temperature of meat samples reached to 70℃. These findings agreed with Duckett and Wagner (1998) that cooking reduced PUFA composition in total intramuscular lipid. Fatty acid of 18:2*cis*-9,*trans*-11 percentage decreased ($P < 0.05$) when cooked to the internal temperature of 80℃. Percentage of 18:2*cis*-9,*trans*-11 decreased ($P < 0.01$) significantly

with beef microwave heating.

Table 1. Changes in fatty acid composition (%), ratios and indices in intramuscular fat (n = 10) †

Fatty acid	Raw	Cooking			Microwave heating			SEM	Effect Sig.		
		60□	70□	80□	60□	70□	80□		H	T	H×T
16:0	14.0^{c}	16.0^{b}	16.5^{ab}	16.9^{ab}	16.4^{ab}	16.4^{ab}	17.4^{a}	0.37	NS	NS	NS
16:1*cis*-9	1.6^{ab}	1.5^{b}	1.8^{ab}	1.7^{ab}	1.7^{ab}	1.5^{b}	2.0^{a}	0.08	NS	*	NS
18:0	13.0^{b}	14.6^{a}	14.0^{ab}	15.0^{a}	14.1^{ab}	14.3^{ab}	14.0^{ab}	0.29	NS	NS	NS
18:1*cis*-9	20.7^{b}	20.0^{b}	22.6^{ab}	22.7^{ab}	23.9^{ab}	24.2^{a}	26.7^{a}	0.91	*	NS	NS
18:2*cis*-9, *trans*-11	0.18^{a}	0.16^{a}	0.19^{a}	0.12^{b}	0.04^{c}	0.03^{c}	0.04^{c}	0.02	***	*	*
18:2*cis*-9,12	15.7	15.4	13.8	14.0	14.8	14.7	13.5	0.80	NS	NS	NS
18:3*cis*-6,9,12	0.53^{a}	0.26^{b}	0.24^{b}	0.10^{c}	0.06^{c}	0.06^{c}	0.06^{c}	0.02	**	*	*
18:3*cis*-9,12,15	1.5^{a}	1.3^{ab}	1.2^{ab}	0.8^{c}	1.1^{b}	1.0^{bc}	0.8^{c}	0.11	NS	*	NS
SFA	34.6^{b}	36.5^{ab}	36.2^{ab}	37.7^{a}	37.0^{a}	37.9^{a}	37.5^{a}	1.14	NS	NS	NS
MUFA	29.9^{bc}	28.8^{c}	31.3^{bc}	30.7^{bc}	32.3^{b}	32.1^{bc}	35.0^{a}	1.08	*	NS	NS
PUFA	25.9^{a}	24.8^{ab}	22.4^{b}	22.2^{b}	23.6^{ab}	23.2^{ab}	21.5^{b}	0.90	NS	NS	NS
P/S	0.75^{a}	0.69^{ab}	0.63^{b}	0.59^{b}	0.58^{b}	0.62^{b}	0.65^{b}	0.03	NS	NS	NS
M/S	0.87^{ab}	0.79^{b}	0.86^{ab}	0.81^{b}	0.93^{a}	0.85^{ab}	0.88^{ab}	0.02	NS	NS	NS
n-6/n-3	6.7^{c}	8.4^{b}	7.9^{b}	11.2^{a}	9.5^{b}	9.1^{b}	10.5^{a}	0.81	NS	*	NS

†; H, heating treatment; T, terminal temperature; * $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$; NS, not significant.

^{abc} Comparisons within a row without a common superscript are significantly different ($P < 0.05$).

Cooking or microwave heating lean beef without external fat resulted in changes in the fatty acid composition. P/S ratio in beef decreased ($P < 0.05$) during heating to the internal temperature of 70□ (0.62 vs. 0.75). Both SFA and MUFA increased with beef cooking or microwave heating comparing with unheated meat samples, which caused ratios of M/S did not change ($P > 0.05$). In present study, n-6/n-3PUFA value was 6.72 in unheated samples and increased to 11.15 and 10.46 when the internal temperature reached to 80□during cooking or microwave heating ($P < 0.01$).

Conclusions

Fatty acids profiles changed with heating methods (cook or microwave) and the terminal temperatures. Microwave heating decreased 18:2*cis*-9,*trans*-11 content greatly compared with cooking. The n-6/n-3PUFA value increased significantly when beef internal temperature increased from 60□ to 80□.

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