A17

THE EFFECT OF SEX TYPE AND AGE ON FATTY ACID COMPOSITION OF INTRAMUSCULAR LIPID OF LOIN MUSCLE OF JAVAN RUSA (*Cervus timoriensis*) DEER AND ITS RELATION TO PALATABILITY.

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Rusa deer is the most widely farmed tropical species but little is known about its meat quality (Sookhareea *et al.*, 1993). Fatty acids (FA) are an essential and integral component of meat and influence its palatibility, keeping properties and nutritional value. Saturated FA (lauric, myristic and palmitic) are cholesterol raising while stearic and unsaturated FA (USFA) are not hypercholesteremic (Grundy, 1990). Ruminant fat is usually highly saturated because of biohydrogenation of the dietary components in the rumen. Yet, it has been observed that intramuscular lipid of wild ruminants, compared to domestic livestock, contain higher proportions of USFA because of their inherent and extreme leaness (Sinclair *et al.*, 1982; Miller *et al.*, 1986). High degree of unsaturation can cause development of off flavors. Sex type and age influence fat accretion and FA profile (Melton *et al.*,1982). In cervidae sex and seasons interact in lipid accretion and metabolism.

The objectives of this study were to quantify the FA composition of rusa deer and investigate the effects of castration and age at slaughter on FA profile of the intramuscular fat of the M.*longissimus dorsi* (LD). The relationships of FA with eating qualities were also examined.

Materials and Methods

In 3 separate experiments 19 entires (**E**) and 16 castrates (**C**) were reared on tropical pasture and slaughtered at the age of 13, 19 and 25 months. Slaughter was carried out under commercial conditions and carcasses electrically stimulated. After overnight chilling at 1 - 2°C, one side of the carcass was dissected and samples of the LD muscle were removed and stored at -20°C for chemical and sensory assays. FA of the trimmed tissue of LD muscle were analysed by standard GLC procedures. Lipid content was measured by extraction with petroleum spirit. Trained tasters at the CSIRO Meat Research Laboratory, Cannon Hill evaluated the samples according to the procedures of Harris and Shorthose (1988). The cooked samples were tasted at room temperature and scored for Tenderness (T), Juiciness (J), Flavor (F) and overall Acceptability (A) on a 9-point scale. Statistical analysis was performed by the SAS GLM procedures (SAS, 1989).

Results and Discussion

Eighteen FA were identified and grouped in 3 classes as follows: saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) (Table 1). Intramuscular lipid of rusa males contain a wide range of FA including long chain FA (C20:4 and C22:5). The most abundant SFA were C16:0, C18:0 and C14:0; in MUFA class, C18:1c(9), C16:1 and C18:1c(11) and in the PUFA class C18:2c and C20:4. SFA, averaged 35.7%, MUFA 31.6% and PUFA 28.4% of the total FA. The average ratios of USFA:SFA, PUFA:SFA & PUFA:MUFA were high being 1.61, 0.69 and 1.32 respectively. The distribution of major FA and the presence of C20:4 & C22:5 were comparable to other species of deer including the Sambar (Sinclair *et al*, 1982), Red deer (Manley and Forss, 1979; West and Chrystall, 1994), mule deer (Miller *et al.*, 1986) and others; the variation in the quantity of certain FA was probably due to differences in species, diet and age. Our data show that rusa deer had a comparable proportion of SFA, lower proportion of MUFA and higher proportion of PUFA than domestic livestock. The high proportion of PUFA in the lean of wild ruminants was suggested (Sinclair, 1982; Miller et al., 1986) to be due to the very low content of triglyceride (low PUFA and high in SFA) and high content of phospholipid (high in PUFA and low in SFA) in the tissue. The PUFA:SFA ratio, a measure of nutritional value, which is around 0.3 for domestic livestock, is 0.69 in this study. The inverse relationship between fatness and PUFA:SFA ratio (Sinclair and O'Dea, 1987) was observed with rusa , PUFA:SFA and PUFA:MUFA (r = - 0.36 * and - 0.72 *) respectively.

Table 1.Least square means of selected fatty acids of LD muscle of C & E deer slaughtered at 13, 19 & 25 months of age#.

Age	*Sex*	*14:0*	*16:0*	*18:0*	*14:1*	*16:1c*	*18:1c9*	*18:1c11*	*18:2c*	*18:3c*	*20:4*	*22:5*	*SFA*	*MUFA*	*PUFA*
13	C	9.9^{a}	16.1^{b}	10.7	1.2c	6.4^{d}	12.3	5.0^{c}	13.0^{b}	4.0	$8.7b^{c}$	0	38.3^{a}	25.6^{c}	25.7^{bd}
13	E	6.8^{b}	10.9^{c}	11.4	0.9c	2.9^{e}	9.3^{a}	4.1^{d}	17.7^{a}	4.5	13.2^{a}	0	30.9^{b}	18.3^{d}	35.4^{c}
19	C	2.4^{d}	16.8^{b}	11.1	1.7^{c}	10.2^{bc}	14.2	9.9^{a}	16.2^{a}	4.3	7.0^{c}	2.7^{a}	32.6^{b}	37.7^{a}	30.3^{cd}
19	E	2.1^{d}	16.0^{b}	12.1	1.6^{c}	8.9^{cd}	13.8	8.1^{b}	17.2^{a}	4.2	9.7^{b}	3.2^{a}	32.6^{b}	33.3^{b}	34.2^{c}
25	C	4.0^{cd}	23.4^{a}	12.0	2.5^{ab}	10.9^{ab}	13.4	6.5^{c}	12.2^{bc}	3.6^{a}	6.4^{c}	1.8^{b}	40.7^{a}	$35a^{b}$	24^{b}
25	E	4.5^{bc}	22.4^{a}	10.8	3.4^{a}	13.1^{a}	14.6	7.4^{bc}	10.3^{c}	3.0^{a}	6.2^{c}	1.7^{b}	39.2^{a}	39.7^{a}	21.1^{b}
SED		1.91	1.69	1.54	0.79	2.05	2.2	1.0	1.88	0.71	2.4	0.73	3.63	4.37	4.34
Age		* *	* *	ns	* *	* *	* *	* *	* *	*	* *	* *	* *	* *	* *
Sex		ns	* *	ns	ns	ns	ns	*	ns	ns	* *	*	*	ns	*
Age x	*Sex*	* *	* *	ns	ns	* *	ns	* *	* *	ns	ns	* *	*	*	* *

within column means with same superscript are not significantly different (* P < 0.05, ** P < 0. 01)

Effect of age (Table1)

Age affected FA composition significantly. In the SFA class C14:0 decreased with advancing age while C16:0 increased (P < 0.05). In the MUFA class C14:1, C16:1c, C18:1c(9), C18:1c(11) increased with age (P < 0.05). PUFA tended to decrease with age. Oldest deer had lower C18:2c and C18:3c than the younger groups, and C20:4 and C22:5 decreased with increasing age. The overall trend was for total SFA and MUFA to increase with age while PUFA decreased (P < 0.05). The ratio of USFA:SFA was high and peaked in the 19 months old group and was lowest in the oldest deer. Both PUFA:SFA and PUFA:MUFA ratios decreased with age (P < 0.05). This age effect was observed in bovine (Link *et al.*, 1970), with increasing age C18:0 decreased and C18:1 and C18:3 increased in subcutaneous fat while in muscle PUFA declined.

Effect of castration (Table1)

Castration had lesser effects than age and significant differences were observed only in 13 and 19 months old deer. Entires of 13 months had lower C16:0 than C (P < 0.05); and in both age groups C18:1c(11) was higher in E than C (P< 0.05) but the reverse was true for 25 months old deer. Total SFA was 19 % higher in C than E of 13 months male (P < 0.05). In contrast, total PUFA was higher in E than C by 28% and 12% in 13 and 19 months old deer respectively (P < 0.05). The ratios of PUFA:SFA and PUFA:MUFA were 63% and 23% higher in E than C of 13 and 19 months deer respectively (P < 0.05).

Usually the degree of FA saturation is influenced by sex through a change in fatness. In the bovine, Eichhorn *et al.*, (1985) found that bulls contained more C18:2, C18:3 and C20:4 than steers and in rams total USFA was higher than in wethers (Kemp *et al.*, 1981); rams had less MUFA than ewes, Solomon *et al.* (1991). In this study sex differences were observed for both PUFA and SFA. Entires had more PUFA than C and concomitantly less SFA. One would expect only minor sex effects in FA of intramuscular lipid as fat deposition in cervidae is mostly as

abdominal and subcutaneous fat and will therefore influence those fat depots and not the FA of lean tissue. In this study C had consistantly more separable fat but intramuscular lipid remained below 1% in both sex types.

Age and sex interaction (Table 1)

Age and sex interaction was observed for several FA. Total SFA and C14:0 decreased from 13 to 19 months but increased in 25 months deer, C16:1c and C18:1C(11) were lower in E than C of 13 and 19 months old male but higher in 25 months deer ($P < 0.05$). Linoleic acid which was higher in E than C of 13 and 19 months was lower in E of 25 months ($P < 0.05$). Total MUFA was higher in E than C of 25 months but was lower in E of the other groups; the reverse was true for PUFA, being lower in E of 25 months and higher in C of the other groups.

Carcass fatness and fatty acid composition

The intramuscular lipid of LD muscle indicate extremly lean (<1% fat) venison, absence of marbling, no differences between sex type but a small significant increase with age ($P < 0.05$). Carcass separable fat increased with age (liveweight as covariate) ($P > 0.05$) but was significantly higher in C than E across all age groups ($P < 0.05$). The association of of carcass fatness with FA was variable. In the SFA class C14:0 was positively correlated ($r = 0.62$, $P < 0.05$) and C18:0 & C22:0 were negatively correlated. In the MUFA group C14:1 and C16:1c had positive correlations ($r = 0.71$ & 0.59 $P < 0.05$) respectively. In contrast, the PUFA (except C18:3) were negatively correlated with fatness. Total MUFA and PUFA showed significant positive and negative correlations ($r = 0.62$ and $- 0.69$) respectively.

Table 2. Carcass weight , muscle fat % (EE) of LD muscle, carcass fat (kg & %) C & E deer slaughtered at 13, 19 & 25 months.

Age (months)	*13*	*13*	*19*	*19*	*25*	*25*	*sed*	*age*	*sex*
Sex Type	C	E	C	E	C	E			
Carcass wt (kg)	37.3^{c}	37.7^{c}	53.9^{ab}	53.8^{ab}	56.9^{b}	51.1^{a}	3.64	* *	ns
Muscle fat % (EE)	0.56^{c}	0.47^{c}	0.70^{b}	0.78^{b}	0.93^{a}	0.89^{a}	0.20	* *	ns
Carcass Fat (kg)	3.80^{ad}	3.02^{bc}	5.66^{a}	3.46^{bd}	5.47^{a}	4.65^{ac}	1.09	ns	* *
Carcass Fatness %	7.17^{ade}	5.19^{ce}	11.78^{a}	7.39^{bcd}	11.44^{a}	9.62^{ac}	2.14	ns	* *

within rows means with same superscripts are not significantly different (* * $P < 0.01$)

Fatty acids and taste panel scores.

Correlations of FA with taste panel scores were variable, being relatively higher with (A) score than other palatibility parameters (Table 3); associations were positive with C14:0, C18:3c and negative with C14:1, C16:1 and C22:5. Flavor and (J) had low correlation with FA except that C18:2 and C18:3 showed association with (J). Total SFA and MUFA showed relatively high correlation with (F) and (A) scores respectively. Relationship of FA with meat palatibility parameters have shown that generally SFA and MUFA are positively associated and PUFA negatively associated with eating qualities. With rusa venison, relatively higher correlations were obtained only with overall (A). The positive correlation of C14:0 with (A) score was expected but that of C18: 3 and C20:4 were unexpected . However, Cameron and Enser, (1991) found similar correlations in pigs. The negative correlations of (A) score with C14:1 and C16:0 was also unusual. The poor correlation of flavor with FA suggest that long chain non volatile FA do not contribute much to the flavor of rusa venison. Kim Ha and Lindsay, (1990) attributed characteristic venison flavor to the branched chain volatile FA (2-ethyl hexanoate) which has a phenolic, waxy and woody aroma. Flavor may also come from water soluble compounds in the protein fraction. The positive correlations of MUFA and PUFA (except C18:2) were not expected because in beef C18:3 is associated with less desirable flavors (Melton *et al.*, 1982; Miller *et al.*, 1987). The negative correlation of C18:0 with flavor is also uncommon but was observed with pork (Cameron and Enser, 1991).

Table 3. Correlation coefficients (x100) of FA with (T), (J), (F) and (A) scores for LD of C & E deer killed at 13, 19 & 25 months.

	SFA			MUFA				PUFA				TOTAL FA		
Parameter	**14:0**	**16:0**	**18:0**	**14:1**	**16:1c**	**18:1c-9**	**18:1c-11**	**18:2c**	**18:3c**	**20:4**	**22:5**	**SFA**	**MUFA**	**PUFA**
Tenderness	21	6	-16	-1	0	-13	17	-29	-3	-4	-4	14	2	-19
Juiciness	25	-26	18	-30	-32	-10	-16	43*	48*	-7	-31	5	-23	18
Flavor	13	26	-11	2	10	11	8	-24	16	-16	13	40	10	-17
Acceptability	52* *	-39	-10	-41**	-47*	-28	-19	14	48*	17	-44*	2	-42*	13

(* $P < 0.05$, * * $P < 0.01$)

Conclusion

Javan rusa male has comparable FA composition to that of other species of deer and is different to domestic livestock in having high level of PUFA. While increasing age decreased PUFA and increased SFA, castration had minor effects on FA profile. MUFA unlike PUFA had negative effects on overall acceptability of rusa venison. The contribution of FA to venison flavor was minimal. The inherent leaness and high level of PUFA in rusa venison would appear to satisfy dietary and health guidelines.

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