Asian-Aust. J. Anim. Sci.
Vol. 22, No. 5 : 740 - 746
May 2009

www.ajas.info

Characteristics and Cutability of Farmed Rusa Deer (*Cervus timorensis*) Carcasses for Marketing of Venison

I. Dahlan*

Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

ABSTRACT : Rusa deer are the only viable commercial tropical deer species for farming in the tropics because of their hardiness, adaptability and prolific characteristics. Twelve entire rusa stags were slaughtered according to halal procedure and used for carcass evaluation and cutability studies. Three carcass categories; large (46 to 55 kg), medium (36 to 45 kg) and small (25 to 35 kg) were developed for rusa stags. This study indicated that entire Moluccan rusa deer stags with mean live weight ranges from 50 to 80 kg and age groups of 15 to 29 months showed dressing percentage of 58 to 62%. Carcass conformation of rusa stags showed significantly ($p<0.05$) higher forequarters portion than hindquarters for medium (mean weight, 40.8 kg) and large (mean weight, 50.0 kg) carcass categories. The large carcass category was significantly ($p<0.05$) bigger in hindquarters portion (47.3% vs. 45.4%) than the medium carcass category. This study showed that medium and large carcass categories are more suitable for boneless cuts since the muscles were larger than small carcasses and easy for deboning. Stag carcasses showed higher proportion of the musculature in the high-priced areas of the carcass such as in round cuts. Bone-in cuts are more suitable for small carcasses since the muscles were smaller and difficult to debone (mean weight, 30.5 kg). About 90% of total deer carcasses in the small carcass category were developed into retail bone-in cuts (excluding 9.9% of breast, shank and trimming). The carcass characteristics and cutability information derived from this study can be used as a basis for a venison marketing strategy for deer farming and production in the tropics. (**Key Words :** Rusa Deer, Carcass Characteristics, Cutability, Retail Cuts, Venison)

INTRODUCTION

Deer farming to produce venison or deer meat in tropical countries is important for production of high value gourmet product notable for its leanness and also to replace game venison from illegal hunting of endangered tropical wild deer species. Elsewhere, venison is also known as king's meat. The tenderness, fine and unique taste of venison makes it a special dish or feast for the rich only. The product is extremely high in protein and iron while being very low in fat, energy and cholesterol (Drew et al., 1991; Dahlan, 2000; Shin et al., 2000). Venison from farmed deer is very popular in Australia (Woodford and Dunning, 1992; Dryden, 2000), New Zealand (Drew, 1985) and Europe (Reinken et al., 1990), and especially in Malaysia, lately (Dahlan, 2000). The aim of the deer farmer is to produce venison which is of a superior quality to the flesh of wild deer. This is only possible when the meat comes from animals of a particular age and stage of production, is lean and tasty and is produced according to the stringent rules governing the slaughtering of farm animals (Drew, 1985; Reinken et al., 1990). As the deer farmer is striving to sell a product of as high a quality as possible, at a competitive price, he should be fully aware of the stipulations in force as regards meat production. The "Halal meat market" is a new potential market for venison throughout the world. The Halal procedures and quality standard in meat marketing including venison is the most important opportunity for the deer producer, especially from Muslim countries. "Halal" slaughtering procedures need to be followed and the rules are based on The Quran with 10 generally accepted principles pertaining to halal (permitted) and haram (prohibited) in Islam for providing guidance to Muslims in their customary practices (Regenstein and Chaudry, 2002). It is believed that the halal venison market is huge and has wide marketing outlets and distribution throughout the world.

The quality standard and grading system of venison is still not available in most developing countries. There are no well established carcass classification systems for deer carcasses anywhere in the world (Kirton, 1989a). However

* Corresponding Author: I. Dahlan. Tel: +603-8946-6893, Fax: +603-8943-2954, E-mail: dahlan@agri.upm.my
Received June 23, 2006; Accepted December 6, 2006

it is anticipated that a deer carcass system would have a carcass weight as a key component in any classification system. Carcass weight is clearly the simple most important measurement included in any payment system where carcasses are traded, or where they are purchased from a producer on a carcass weight and grade/class basis. Carcass weight is a principle component in the prediction of the weight of saleable meat from any carcass. Animal age is also anticipated to be included in a deer carcass classification system. A deer carcass system would have an age classification for young, yearling and over 2-year aged animals. Carcasses of young deer are likely to be more palatable than those from old stags that have been retained for several years for velvet production (Kirton, 1989a). The Australian Rural Industries Research and Development Corporation (RIRDC) developed "The Deer Quality Assurance Program" in May 1998 (Deer newsletter, 2006). RIRDC also has developed Australian body condition scoring charts for deer. The charts have been developed to aid Australian deer farmers and processors to objectively assess the body condition of deer. According to RIRDC (Deer newsletter, 2006), the venison market (hot carcass weight) in Australia is at about AUD 5.10 per kg of carcass. The price of venison in the Malaysian market ranges from RM 25 (AUD 9.00) to RM 38 (AUD 13.70) per kg of carcass. Most of the venison in Malaysia came from rusa deer (*Cervus timorensis*) and locally farmed animals (Dahlan et al., 1995). Fallow deer (*Dama dama*), red deer (*Cervus elaphus*) and other temperate deer species comprise mostly imported venison.

The most widely farmed of the tropical species is rusa deer (Dryden, 2000). The two most important subspecies from a farming perspective are Javan rusa (*C. timorensis russa*) and Moluccan rusa (*C. timorensis moluccensis*). Javan rusa are widely farmed in Australia (Woodford and Dunning, 1992). The Moluccan rusa deer is a subspecies of rusa deer, brown deer with a very coarse, open coat. The underparts are a lighter colour, with a white chin. This subspecies is smaller in body size than Javan rusa deer. Mature live weight ranges from 80 to 100 kg for the male. The Moluccan rusa has the same general appearance as the Javan strain. The two subspecies will readily interbreed. They are non-seasonal breeders and prolific tropical deer (English, 1988; Dryden, 2000a).

Deer farming was initiated in Malaysia in the early1990s by using imported deer species such as rusa, sika, fallow, chital and red deer. New approaches in deer raring were introduced in park and recreational areas such as bio-parks and integration with forestry (agroforestry) and oil palm plantations (Dahlan and Jiwan, 2003; Dahlan, 2005). In Malaysia, game venison is mostly derived from wild sambar deer (*Cervus unicolor*), which is unpredictable and inferior in quality. The quality of venison from farmed deer is better than wild deer (Drew, 1985; Reinken et al., 1990; Dahlan, 2000). Farmed deer are usually slaughtered at the right time or age and with less pre-slaughter stress that can lead to dark, firm and dry (DFD) or dark cutting meat in wild deer (Drew, 1985; Reinken et al., 1990). Dahlan (2000) showed that venison produced from local farms was better in quality in relation to the fat, cholesterol and polyunsaturated fatty acid (PUFA) omega-3 type (linolenic acid) content than other types of meat from other livestock reared under modern farming. There is a lack of information on carcass evaluation of venison or deer meat from tropical countries, especially information on tropical deer species. Sookhareea et al. (2001) provided some information on carcass and body composition of Javan rusa deer up to 25 months of age. They showed that rusa males at 19 to 25 months produced marketable carcasses of at least 40 kg weight. In New Zealand carcass evaluation on deer has been done by using on-line carcass evaluation methods (Kirton, 1989b). The aim of evaluation is to identify characteristics that assist in placing a monetary value on a carcass or its products. Such information may be carried through in the different steps of the marketing chain. Important factors that may be assessed, and in some cases are measured in different systems, include muscle mass, level of fatness, aesthetic qualities and taste appeal.

Due to lack of information on carcass composition and quality of venison in most tropical countries, carcass characterization and grading systems need to be developed. The best marketing strategy for the "king's meat" is through the development of standard retail and prime cuts for the carcasses according to carcass weight-age categories. Thus, the objective of this study was to develop standard procedures for the retail and prime cuts of deer carcasses for the purpose of defining venison marketing options for tropical deer farming and production based on carcass weight categories and cutability.

MATERIALS AND METHODS

Animals and management

The study was conducted at the Meat Laboratory, Department of Animal Science, Universiti Putra Malaysia. Twelve male farmed Moluccan rusa deer (*Cervus timorensis moluccensis*), aged 15 to 29 months and live weight range 50 to 80 kg, were selected from the Arab-Malaysian Agriculture Farm in Segamat, Johor (about 220 km from the slaughter house, Department of Animal Science, UPM) and were used in the carcass evaluation and cutability studies.

The deer were imported from New Caledonia in the late 1980s and farmed on improved sown pastures of Guinea grass (*Panicum maximum*), Seteria grass (*Seteria splendida*) and Paspalum grass (*Paspalum dilatatum*). Concentrate

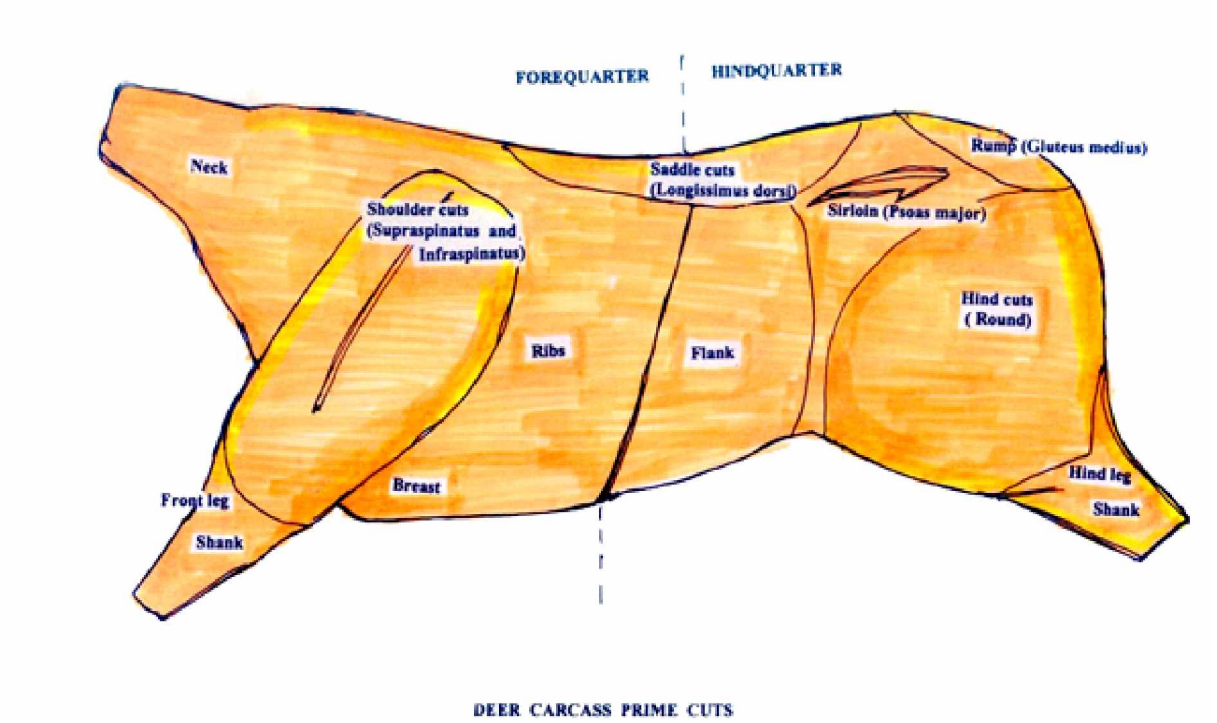

Figure 1. Anatomical points of deer carcass cuts

feed comprising commercial cattle pellet (50%) and palm kernel cake (50%) mixture was provided at the rate of 250 g/d/animal in the paddock as a feed supplement during the dry season. Stags were separated from the breeding herds when they were more than 6 months of age. A rotational grazing system was practiced on the farm for the rusa stags. Culling and selling of stags was based on age (>14 months or emergence of the first antler) and live weight criteria of more than 30 kg.

Slaughtering procedure

The deer were slaughtered according to Muslim halal slaughtering procedures. The animals were slaughtered by severing the throat, carotid artery and jugular vein with a sharp knife in the neck. After complete bleeding, the head was severed at the atlanto-occipital joint. The thoracic limbs were removed at the carpo-metacarpal joint and the pelvic limbs at the tarso-metatarsal joint. The unskinned tail was removed at the first intercoccygeal joint. The skin was completely removed. The contents of thoracic and abdominal cavities were removed. The killing-out percentage or dressing percentage was calculated based on (hot carcass weight)/(live weight)×100.

Carcass storage and cutting procedures

The dressed carcasses were chilled and stored at 4°C for 24 to 36 h. The carcasses were stored in the freezer at -20°C for a week before the carcass retail and prime cuts were made using an electrical band saw. The retail and prime cuts were performed according to adjusted carcass weight groups, shape and anatomical points (Figure 1). Three weight groups of carcasses were selected for the retail and prime cuts development. The groups were: small (25 to 35 kg), medium (36 to 45 kg) and large (46 to 55 kg) categories. The small carcass category was cut according to procedures for lamb standard primal cuts (NAMP, 1981). A lamb skeletal chart (based on location, structure and names of bones) was used as points of cutting. The bone-in cuts were performed by using an electrical band saw. Medium and large carcasses were cut according to beef standard primal cuts (NAMP, 1981). Expensive muscles were deboned and separated from bones and fat and weighed. Deboning procedure was done according to the location, structure and name of bones in a beef skeletal chart (Tucker et al., 1952).

Measurement of carcass cutability and data analysis

Weighing of cuts was carried out based on carcass categories. Retail cuts were performed on the small carcass category and prime cuts on the medium and large carcass categories. Four carcasses were selected for each group based on weight and conformation. No fat trimming was done on any carcasses in this study, due to thin fat cover on all evaluated carcasses. All cuts were weighed and proportion of cuts were calculated according to percentage of quarter carcasses, i.e. forequarters and hindquarters. Carcass deboning was performed by identifying and separating the major muscles, muscle groups, bones, connective tissues (tendon and cartilages), and

Table 1. Carcass characteristics of farmed rusa deer

Carcass category	Medium	Large
Number	4	4
Age (month)	18-24	>24
Live weight (kg) (mean)	67.9	80.7
Carcass weight (kg) (mean)	40.8	50.0
Carcass weight range (kg)	36-45	46-55
Dressing percentage	60[a]	62[b]
Forequarter (%)	54.6[a,c]	52.7[b,c]
Hindquarter (%)	45.4[a,d]	47.3[b,d]

[a, b] Means within same row with different superscripts are significantly different ($p<0.05$).
[c, d] Means in the same group within a column, with different superscripts are significantly different ($p<0.05$).

subcutaneous fat from each cuts. Percentage of the components was calculated based on the cuts and frozen carcass weight. The effect of carcass category on the proportion of muscles, carcass bone, fat, meat and lean: bone ratio was subjected to analysis of variance using a general linear model (SAS, 1989). Significant differences between means were assessed using the t-test for pair comparison between large and medium carcass categories.

RESULTS AND DISCUSSION

Live weight of entire stag

Table 1 shows carcass characteristics of farmed Moluccan rusa stags. Mean live weight of larger stags slaughtered was less than 100 kg. These stags were more than 24 months old and they are considered as mature animals. Similar live weight was stated by English (1988) and Dryden (2000a) for matured Moluccan rusa stags in Australia. Mean live weight of the medium group stags showed similar live weight to Moluccan stags at yearling to maturity stages. The mean live weight of the small group stags was 52.6 kg. The mean live weight of entire stags in large, medium and small categories in this study showed similar weight criteria to entire Moluccan rusa stags recorded by English (1988). Mean live weight of entire Javan rusa stags is higher than Moluccan stags used in this study. At similar age (>18 months), entire Javan rusa stags showed mean live weight of more than 70 kg. At 18 to 24 months of age they showed weight ranges from 70 to 94 kg and at more than 24 months of age they showed mean live weight of more than 96 kg (Sookharees et al., 2001). Dryden (2000b) stated that Moluccan rusa deer was smaller than Javan rusa and was introduced to the Torres strait in 1912 and brought to Queensland in 1980. Most Queensland rusa are Javan or Javan×Moluccan hybrids. New Caledonian rusa are slightly smaller-mature males weigh approximately 102 kg (Le Bel, 1999).

The live weight criteria of the stags used in this study has confirmed the live weight characteristics of the Moluccan rusa deer subspecies as stated by English (1988); Dryden (2000b) and Sookhareea et al. (2001).

Table 2. Proportion of expensive muscles, total meat, total fat, total bone and lean:bone ratio of large and medium deer carcasses

Carcass category	Medium (%)	Large (%)
Forequarter proportion		
Muscles[+]		
Longissimus dorsi (rib)*	6.0	4.6
Thick muscles	24.0	31.0
Shank, leg and trimming	43.4	35.3
Total forequarter meat	73.4	70.9
Total forequarter bone	24.9[a]	28.4[b]
Total forequarter fat (plus connective tissues)	1.3[a]	0.7[b]
Forequarter lean:bone	2.9	2.5
Hindquarter proportion		
Muscles[+]		
Longissimus dorsi (lumbar)*	7.3	7.7
Psoas major	3.9	2.6
Flank	6.6	5.4
Round	39.4	36.7
Gluteus medius	5.0	4.8
Shank, leg and trimming	19.2	17.9
Total hindquarter meat	81.4	75.1
Total hindquarter bone	18.0[a]	21.4[b]
Total hindquarter fat (plus connective tissues)	0.6[a]	3.5[b]
Hindquarter lean:bone	4.5[a]	3.5[b]
Whole carcass		
Total carcass fat	1.1[a]	2.1[b]
Total carcass bone	21.4	24.9
Total carcass lean	77.5[a]	73.0[b]
Total carcass lean:bone	3.6	2.9

* Saddles (rib+lumbar of *m. l. dorsi*).
[a, b] Means within same row with different superscripts are significantly different ($p<0.05$).
[+] Prime cuts muscles: Forequarters = *m. longissimus dorsi* and thick muscles group. Hindquarters = *m. l. dorsi, psoas major*, round muscles and *m. gluteus medius*.

Carcass characteristics

The results showed that mean carcass weight of the small, medium and large rusa stag category was 30.5, 40.8 and 50.0 kg, respectively. The mean dressing percentage for small, medium and large categories was 58, 60 and 62%, respectively. The results showed that dressing percentage increased as size and age increased. Sookhareea (2001) showed that dressing percentage of 19 month-old rusa deer was about 64% and at 25 months was 56.5%. The dressing percentage of rusa deer was reported at between 51 and 64% by many workers (Woodford and Dunning, 1992; Le Bel, 1999; Sookhareea, 2001). As an animal increases in age, especially after reaching maturity, body fat will accumulate at a higher rate. The results also showed that percentage total fat of large carcasses was significantly ($p<0.05$) higher than for medium carcasses. The proportion of fat rose with the carcass weight, while the proportion of

Table 3. Carcass characteristics and cutability of rusa deer (small carcass category)

Carcass category	Small	
Number	4	
Age (month)	<18	
Live weight (kg) (mean)	52.6	
Carcass weight (kg)	30.5	
Carcass weight range (kg)	25-35	
Dressing percentage (%)	58	
Cuts (bone-in)	%	Bone-in retail products*
Shoulder	30.9	shoulder chops
Ribs	7.5	rib chops
Loin	5.9	loin chops
Sirloin	2.8	tenderloin chops
Round	43.0	hindsaddle/legs
Breast	4.4[1]	breast, flank on
Shank	4.1[1]	foreshank
Others	1.4[1]	trimmed meat
Total	100.0	

* Nomenclature according to lamb portion cuts of NAMP (1981).
[1] Excluded for bone-in cuts (about 9.9% of total carcass).

lean to bone fell. Gregson and Purchas (1985) reported similar results with male fallow deer aged thirteen, seventeen and twenty-five months. Dryden (1997) concluded that rusa carcasses yield more lean meat than cattle, and typically there was little fat in carcasses of entire rusa stags.

Carcass conformation of rusa stags showed significantly ($p<0.05$) higher forequarters proportion than hindquarters for medium and large carcass categories. The medium carcass category was significantly ($p<0.05$) bigger in forequarters portion than the large category. The large category was significantly ($p<0.05$) bigger in the hindquarters portion than the medium category. The hindquarters portion of the carcass was comprised of many expensive muscles/cuts. Thus, a bigger hindquarters portion is considered a better carcass conformation. This study showed that the large carcass category had a bigger hindquarters portion and showed better carcass conformation than medium carcasses. Similar carcass conformation (bigger forequarters carcass portion) was recorded for zebu cattle (Dahlan, 1985) and swamp buffalo (Dahlan et al., 1988) grazed on tropical pastures. This study showed that the entire male of rusa deer, zebu cattle and swamp buffalo had a bigger forequarters portion because the shape or conformation represents a dominant male character of most indigenous ruminants.

Cutability of rusa stags carcasses

Table 2 shows the proportion of expensive muscles, total meat, total fat, total bone and lean:bone ratio of large and medium deer carcasses. Boneless cuts were applied for medium and large carcasses categories. Bone-in cuts were performed on the small carcasses category (Table 3). The results showed that the forequarters muscle mass, comprising thick muscles of shoulder, chuck and blade, were well developed. The percentage of muscle composition was significantly ($p<0.05$) higher in the medium than the large carcass category. Total percentage of hindquarters and forequarters bone of the medium carcass category was significantly ($p<0.05$) lower than for the large carcass category. Total percentages of carcass fat and hindquarters fat of large carcasses were significantly ($p<0.05$) higher than for the medium carcass category. In boneless cuts, thick muscles need to be identified, separated and classified according to their location and palatability values. Saddles cut, which consisted of *m. longissimus dorsi* of the rib and lumbar region of carcasses showed a total of 13.3% and 12.3% proportion of the whole carcass of medium and large categories, respectively. The thick muscles component of medium and large carcasses was 24% and 31%, respectively. The proportion of less expensive muscles from shanks and leg trimming was 62.6% and 53.4% of medium and large carcasses, respectively. Fillet boneless cut (*m. psoas major*) was 3.9% and 2.6% of medium and large carcasses, respectively.

Boneless rump cuts (*m. gluteus medius*) were 5.0% and 4.8% of medium and large carcasses, respectively. Boneless round cuts (*m. semitendinosus*, *m. biceps femoris*, *m. gastrocnemius*, *m. gracilis* and *m. semimembranosus*) were 39.4% and 36.7% of medium and large carcasses, respectively.

Reinken et al. (1990) found that in fallow stags the proportion of fillet was 2.5% (ranging from 1.7 to 3.1%). The proportion of valuable joints (best neck, saddle, fillet and rump) was 57.2% on average. This study showed that medium and large categories are more suitable for boneless cuts. Higher or premium price of venison can be obtained from boneless prime cuts such as saddles, fillet, shoulder blade (*m. infraspinatus* and *m. supraspinatus*) and round cuts. The cutability of rusa carcasses in this study can be considered as excellent and efficient due to less fat trimming and wastage which occurred during cutting. The muscle distribution of the stag carcass is also advantageous when compared with sheep and cattle with a higher proportion of the musculature in the higher priced areas of the carcass. Drew and Fennessy (1986) showed that the high-priced muscle groups of the hind-leg are relatively 16 to 18% heavier in the mature stag compared with the mature bull and ram. The muscles of the saddle area also form a substantially greater proportion of total muscle in the stag than in the bull. Such muscle development is simply the deer's response to its evolutionary environment-it attempts to escape its predators (Drew and Fennessy, 1986).

Proportion of fat, lean and the lean:bone ratio in rusa deer was much better than that of zebu cattle (Dahlan,

1985) and swamp buffalo (Dahlan et al., 1988) grazed on a similar type of tropical pastures. Gregson and Purchas (1985) stated that the proportion of fat and the muscle:bone ratio in fallow deer was much better than that in the sheep, cattle or pig. This study showed that total carcass fat of rusa stags is very low. The low carcass fat characteristics of rusa stags most probably related to rutting behavior of these animals. Male red deer can mobilize virtually all their body fat over the period of the rut, and do not replenish this loss till the following spring when feed intake increases (Drew, 1985). In young growing males the changes are not so dramatic, so are not a problem in the slaughter population of one and two-year-old animals. However, in older stags, it is advisable to slaughter them post-rut to avoid any over fatness problems (Drew, 1985). Capitalizing on the characteristics, especially low carcass fat composition, we can state that the major selling point for rusa venison is its leanness.

Table 3 shows carcass characteristics and cutability of small category rusa deer carcasses. Results showed that the small carcass category belongs to younger animals (<18 months). Bone-in cut was performed on this type of carcass, because of the similarity with the lamb carcass especially in terms of size and shape (NAMP, 1981). The carcasses were cut into 7 type of bone-in cuts. Five bone-in retail products -loin chops, sirloin/ tenderloin chops, hindsaddle, rib chops and shoulder chops were developed. The sequence of these retail products represents the descending order of palatability value of the cuts. In the small carcass category about 90 % of total carcass was converted into retail bone-in cuts (excluding breast, shank and trimming which comprised 9.9% of total carcass). Round cuts or hind saddle were the major proportion of rusa carcasses. Since the small carcasses have no fat cover and no fat trimming was performed on them, the cutability of small carcasses was considered as excellent bone-in venison cuts. Medium and large carcass categories are more suitable for boneless cuts. Higher or premium price of venison can be obtained from boneless meat coming from prime muscles such as *m. longissimus dorsi, m. psoas major, m. gluteus medius, m. bicep femoris* and others. Small carcasses are more suitable for bone-in cuts. Since young animals are devoid of carcass fat, the flavour of the venison should be contributed by bone's fatty tissue components. Thus, the bone-in cuts of small carcasses will contribute to the improvement of venison palatability value.

CONCLUSIONS

Rusa deer is the only viable commercial tropical deer species for farming in the tropics. The hardiness, adaptability and prolific characteristics of rusa deer have been shown by many workers from Australia, Malaysia, New Caledonia and other tropical countries. This study indicates that entire Moluccan rusa deer stags with mean live weight of 50 to 80 kg and age groups of 15 to 29 months can produce excellent venison for the "lean" red meat market and also can be used to replace game or wild deer venison from illegal hunting or poaching of endangered tropical deer species. The information on percentage of retail and prime cuts can be used in planning of a venison marketing strategy. Prime cuts which can be sold at higher or premium price for a specific market can help in lowering the price of other retail cuts. It is suggested that the price structure of venison can be adjusted according to the current information on venison retail and prime cuts in this study. It is also essential that the leanness and quality of venison be emphasized in local marketing programs. For example, deer that forage on green grasses and ferns contain more omega-3 fatty acids in their meat. Venison produced from local farms were better in quality in relation to the fat, cholesterol and polyunsaturated fatty acids (PUFA) content than other type of meat animals reared in modern farming.

The carcass characteristics and cutability information derived from this study can be used as a basis for a venison marketing strategy for deer farming and production in the tropics. The carcass weight is clearly the single most important measurement included in any classification system, being a key component in any payment system where carcasses are traded or where they are purchased from producer on a carcass weight and grade/class basis. Carcass weight is also a key component in the prediction of the weight of saleable meat from any carcass. Live weight and age is always related to carcass weight and conformation. Thus, the relationship between carcass weight and age groups of rusa deer in this study will provide meaningful information for the development of a venison grading system and slaughtering strategy for farmed rusa deer.

REFERENCES

Dahlan, I. 1985. Growth performance, body conformation, carcass characteristics and palatability of Kedah-Kelantan cattle and it's crosses. M. Sc. Thesis. Universiti Pertanian Malaysia, Serdang, Selangor.

Dahlan, I. 2000. Integrated production systems for deer farming in Malaysia. Agro-search. 7(1):23-28.

Dahlan, I. 2005. Deer-Acacia Integrated Production System: Estimation of Ecological Carrying Capacity. In Proceedings Integrating Livestock-Crop Systems to Meet the Challenges of Globalisation. AHAT/BSAS Intl. Conf. Khon Kaen, Thailand. 1:131-132.

Dahlan, I., M. H. I. Sukri and O. Abu Hassan. 1988. Body components and carcass characteristics of swamp buffaloes fed with oil palm by-products or grass diet. MARDI Res. J. 16(2):125-132.

Dahlan, I., N. M. Majid and M.Y. Sabri. 1995. Farming of chital, fallow and timorensis deer on right-of-way land of gas pipeline. Malay. J. Anim. Sci. 1(1):19-23.

Dahlan, I. and M. Jiwan. 2003. Breeding and reproductive performance of tropical deer and mousedeer in bio-park. Malay. J. Anim. Sci. 8(1):114-116.

Deer newsletter. 1999. Deer products research and development newsletter. www.rirdc.gov.au/pub/deer/august99.htm

Drew, K. R. 1985. Meat production from farmed deer (Ed. P. F. Fennessy and K. R. Drew) "Biology of Deer Production". The Royal Society of New Zealand. Bulletin 22:285-290.

Drew, K. R., J. M. Stevenson and P. F. Fennessy. 1991. Venison- a marketable product. In Proceeding of a Deer course for Veterinarians. Deer Branch of New Zealand Veterinary Association. 8:31-35.

Drew, K. R. and P. F. Fennessy. 1986. Venison research-carcass features, processing and packaging. In Proceeding of a Deer Course for Veterinarians. Deer Branch of New Zealand Veterinary Association. 3:17-34.

Dryden, G. McL. 1997. Venison in the human diet- is venison a low-fat meat ?. Proc. Nutr. Soc. Aust. 21:44-51.

Dryden, G. McL. 2000a. An overview of sub-tropical and tropical deer production systems. Asian-Aust. J. Anim. Sci. 13(Suppl. C):62.

Dryden, G. McL. 2000b. Biology and production attributes of the farmed rusa deer. Asian-Aust. J. Anim. Sci. 13(Suppl. C):69-72.

English, A. W. 1988. Diseases of deer. Vade Mecum series for domestic animals. No.11. Publ. Univ. Sydney. Australia.

Gregson, J. E. and R. W. Purchas. 1985. The carcass composition of male fallow deer. Royal Soc. New Zealand. 22:295-298.

Kirton, A. H. 1989a. Principles of classification and grading. In: Meat Production and Processing (Ed. R. W. Purchas, B. W. Butler-Hogg, A. S. Davies). New Zealand Soc. Anim. Prod. Occasional Publication. 11:143-157.

Kirton, A. H. 1989b. Current methods of on-line carcass evaluation. J. Anim. Sci. 67:2155-2163.

Le Bel, S.1999. Morphologie et anatomie. In : Elevage et Gestion du Cerf. Rusa en Nouvelle Caledonie (Ed. S. Le Bel). 18-19 Aout.

Le Bel, S., M. Salas, P. Chardonet and M. Bianchi. 1997. Rusa deer (*Cervus timorensis russa*) farming in New Caledonia: Impact of different feed levels on herd breeding rate and performance of newborn fawns. Aust. Vet. J. 75:199-203.

NAMP (National Association of Meat Purveyors). 1981. The meat buyers guide. McLean, Verginia 22102, LITHO USA. Fourth Printing. pp. 77-94.

Reinken, G., W. Hartfiel and E. Korner. 1990. Deer farming: a practical guide to German techniques. Farming Press Books. United Kingdom.

Regenstein, J. M. and M. Chaudry. 2002. Kosher and halal issues pertaining to edible films and coatings. In: Protein-based films and coatings. (Ed. Aristippos Gennadios). CRC Press. NewYork. pp. 601-620.

SAS Institute Inc. 1989. SAS/STAT User's Guide: Version 6. 4th edn. SAS Inst. Inc. Cary, N. Carolina.

Shin, H. T., R. J. Hudson, X. H. Gao and J. M. Suttie. 2000. Nutritional requirements and management strategies for farmed deer- review. Asian-Aust. J. Anim. Sci. 13(4):561-573.

Sookhareea, R., K. B. Woodford and G. McL. Dryden. 2001. The effect of castration on growth and body composition of Javan rusa stags. Asian-Aust. J. Anim. Sci. 14(5):608-614.

Tucker, H. Q., M. M. Voegeli, G. H. Wellington. 1952. A cross sectional muscle nomenclature of the beef carcass. Michigan State Collage Press.

Woodford, K. B. and A. Dunning. 1992. Production cycles and characteristics of rusa deer in Australia. In the Biology of Deer (Ed. R. D. Brown). Springer-Verlag. New York. pp. 197-202.