UNIVERSITI PUTRA MALAYSIA

PHYSICAL CHARACTERISTICS, CARCASS COMPOSITION AND NUTRIENT CONTENT OF MALAYAN PORCUPINE MEAT

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PHYSICAL CHARACTERISTICS, CARCASS COMPOSITION AND NUTRIENT CONTENT OF MALAYAN PORCUPINE MEAT

By

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Dedicated to my parent,

Yusof bin Shafie and Romlah Bt Saad,

my family, porcupine's group members

and all my friends

ABSTRACT

Porcupine is one of the wild species that have been eaten in several countries because porcupine meat has been accepted as a good source of food. In Sarawak, porcupine is hunted for food as it is the source of protein and believed has traditional medicinal values although it is a protected wildlife. However, there is a limited data available for physical characteristics of porcupine, and there is no data available on nutrient content and carcass composition at all. The basic information on this species of porcupine is required for the future. Thus the aim of this study was to determine basic information on physical characteristics, carcass composition, and nutrient content of Malayan porcupine (*Hystrix brachyura*) meat in two different environment and to update information about Malayan porcupine in Malaysia generally and Sarawak specifically. In this study, only two samples of same species were used because of the difficulties to get many sample. The samples individually came from different environments which are wild porcupine (sample A) from plantation and from captivity (sample B). The samples were studied for physical observation and measurements, carcass composition, proximate analysis and minerals (Zinc, Magnesium, Potassium, Calcium, Iron, and Manganese) analysis. The body weight, body length, total number and length of spine at body for sample A were 8.40 kg, 67 cm, 6532 and 1.8-22 cm respectively while for sample B were 4.6 kg, 56 cm, 4773 and 2.0-21 cm respectively. Dry matter, protein and fat value for this porcupine's meat were 22.0 ± 0.01, 1.57 ± 0.45, 18.4 ± 0.05 and 5.21 ± 0.03 for sampel A respectively while for sample B is 21.3 ± 0.16, 0.94 ± 0.05, 16.9 ± 0.13 and 1.43 ± 0.05. From the study that have been done, it appeared that porcupine meat can be used as one of the food source because it has high protein

and low fat. However, further study should be carried on in the future with more samples to get more complete data.

ABSTRAK

Landak adalah salah satu daripada spesis hidupan liar yang dimakan oleh sesetengah negara kerana daging landak telah diterima sebagai sumber makanan yang baik. Di Sarawak, landak diburu untuk dagingnya kerana merupakan sumber protein dan dipercayai mempunyai nilai perubatan tradisional walaupun ianya adalah haiwan liar yang terlindung. Walaubagaimanapun, data berkenaan ciri-ciri fizikal landak adalah terhad, manakala tiada langsung data berkaitan dengan kandungan nutrien dalam daging dan komposisi karkas. Maklumat asas berkenaan spesis ini diperlukan untuk kegunaan masa hadapan. Oleh itu, sasaran kajian ini adalah untuk mengenalpasti maklumat-maklumat asas berkaitan dengan ciri-ciri fizikal, komposisi karkas dan kandungan nutrien dalam daging Landak Raya (*Hystrix brachyura*) di dalam dua persekitaran yang berbeza dan untuk memperbaharui maklumat berkaitan Landak Raya di Malaysia amnya dan di Sarawak khasnya. Di dalam kajian ini, hanya dua sampel dari spesis yang sama telah digunakan kerana kesukaran untuk mendapatkan banyak sampel. Sampel ini adalah dari persekitaran yang berbeza iaitu landak liar (sampel A) dari ladang dan landak dalam kurungan (sampel B). Sampel yang diperolehi telah dikaji berkenaan pemerhatian fizikal dan pengukuran, komposisi karkas, analisis proximat dan analisis mineral (Zink, Magnesium, Kalium, Kalsium, Besi dan Mangan). Berat badan, panjang kepala hingga badan, jumlah dan panjang bulu dibadan bagi sampel A adalah 8.40 kg, 67 cm, 6532 dan 1.8-22 cm manakala bagi sampel B adalah 4.6 kg, 56 cm, 4773 dan 2.0-21 cm. Bahan kering, protein dan lemak pada daging landak ini adalah 22.0 ± 0.01, 1.57 ± 0.45, 18.4 ± 0.05 dan 5.21 ± 0.03 untuk sampel A dan 21.3 ± 0.16, 0.94 ± 0.05, 16.9 ± 0.13 dan 1.43 ± 0.05 untuk sampel B. Daripada kajian yang telah dijalankan, nampaknya daging landak boleh digunakan sebagai salah satu sumber

makanan kerana mempunyai kandungan protein yang tinggi dan kandungan lemak yang rendah. Walaubagaimanapun, kajian yang seterusnya perlu dijalankan pada masa hadapan dengan sampel yang lebih banyak untuk mendapatkan data yang lebih sempurna.

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APPROVAL SHEET

I certify that this research project report entitled "Physical characteristics, carcass composition and nutrient content of Malayan porcupine meat" has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus.

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LIST OF ABBREVIATIONS

AOAC	Association of Official Analytical Chemist
Ca	Calcium
CP	Crude Protein
DM	Dry Matter
Fe	Iron
FPL	Food Product Laboritory
G	Gram
IUCN	International Union for the Conservation of Nature and Natural Resources
K	Potassium
kg	Kilogram
Mg	Magnesium
Mn	Manganese
S.D	Standard Deviation
S.D.W	Sample dry weight
T.P.U	Taman Pertanian Universiti
UPMKB	Universiti Putra Malaysia Kampus Bintulu
Zn	Zinc

CHAPTER 1

INTRODUCTION

Meat is a product that can provide valuable nutrients in the diet, including large amounts of high quality protein, important minerals such as iron and zinc, and significant amounts of vitamins. There are many sources of meat for human consumption which are from the livestock and also wild animals. Beef, pork, lamb, veal, chicken, turkey and others have traditionally been the primary meats consumed in the diet. Most of the meat is from the livestock raised in the farm, while porcupine is one of the wild species that have been eaten in several countries. The porcupine meat has been accepted as a good source of food in certain neighboring country. The popularity of porcupines has increased but there is reduction in their population due to indiscriminate hunting and deforestation which destroys the porcupine's habitat.

In Malaysia there are four species of porcupines which are *Hystrix brachyura, Thecurus crassispinis, Trichys fasciculata* and *Atherurus macrourus* but only the first three of these species are found in Borneo and Sarawak. The most frequently encountered species of porcupine is *Hystrix brachyura* (Wood, 1968; Chua, 1969) and has been hunted especially in Sarawak as indicated by figures from the Department of Wildlife Conservation. In Sarawak, porcupines are protected animals (Appendix A) under the Wildlife Protection Ordinance (1998) and the activities of killing, hunting and catching these animals are not allowed. However, this animal is still hunted for food as it is the source of protein and believed to have traditional medicinal values. Lao Wildlife Report (1992) stated that porcupine's quill, stomach and other parts of the body are used in traditional medicine. It is said that it can cure many types of diseases, such as asthma. It is also used as an aphrodisiac and can help women in process of childbirth (Subakti Sidek, 2003).

The study on porcupine in Malaysia is lacking but some study on this species (*Hystrix brachyura*) in captivity has been done at Malacca Zoo by Zainal (1998). He proposed that this species has potential to be commercialized as a source of food because of its large size and is consumed by many races in Malaysia. Besides that this meat is said to be tasty and the consumers are determined to make porcupine meat as alternative source of meat (Norsuhana et al., 2004). Although this species of porcupine will be a good potential as alternative meat source and have potential to be farmed but, legislation forbids killing, catching and hunting unless there is any change in the Act which allow the above conditions.

The basic knowledge on this species of porcupine is still required for the future and for the other country that allow this animal as their food source. Since there is limited information on the growth, habitation, and even basic data on sizes and characteristics, it is deemed necessary to do research to get as much information as possible on the various aspects including physical characteristics, carcass composition and nutrient content of porcupine meat.

Thus the objectives of this study are:

1) To determine basic information on physical characteristics, carcass composition, and nutrient content of Malayan porcupine (*Hystrix brachyura*) meat in two different environments.
2) To update information about Malayan porcupine in Malaysia generally and Sarawak specifically.

CHAPTER 2

LITERATURE REVIEW

2.1 Porcupine

Porcupine belongs to the family Hystricidae (Old world porcupine) and Erethizontidae (New world porcupine). They are the largest of South-East Asian rodents (Hughes, 1987). Unlike the New world porcupines, the Old world species are unable to climb and are confined to the ground. The Asian porcupines are ground-living animals and dig burrows in which they rest by day and have their young (Tweedie, 1978). There are four species of porcupines that can be found in Malaysia, which are localized to certain area in their distribution namely Malayan porcupine, Long–tailed porcupine, Thick-spined porcupine and Brush-tailed porcupine (Payne and Francis, 1998). In South-East Asia, particularly Sarawak, three species namely *Thecurus crassispinis* (Thick-spined porcupine), *Hystrix brachyura* (Malayan porcupine) and *Trichys fasciculata* (Long-tailed porcupine) can be found (Harrison, 1964). Porcupines are like gigantic rats which are protected by coat of hard sharp spines called quills, which grow among the fur. The quills normally lie flat on the back, but can be erected so that they point out in all directions (even forward over the head in some species). The animal cannot roll up and it cannot shoot out its quills, but it can, and will charge backwards and ram its sharp quills into the face of an attacker. Porcupines are the best examples of rodents as gnawing animals. Their huge incisor teeth and powerful jaw muscles are always in need of something to gnaw at, and they seem to gnaw at anything (Harrison, 1964).

2.1.1 Taxonomy (Old World Porcupines).

Kingdom : Animalia

Phylum : Chordata

Class : Mamalia

Order : Rodentia

Suborder : Hystricognathi

Family : Hystricidae

Species : *Atherurus macrourus,* Asiatic Brush-tailed Porcupine

Hystrix cristata, African Porcupine

Hystrix africaeaustralis, Cape Porcupine

Hystrix hodgsoni, Himalayan Porcupine

Hystrix indicus, Indian Porcupine

***Hystrix brachyura* , Malayan Porcupine**

Thecurus crassispinis, Bornean Porcupine

Thecurus pumilis, Philippine Porcupine

Thecurus sumatrae, Sumatran Porcupine

Trichys fasciculata, Long-tailed Porcupine

(Source: Atkins, 2007)

2.1.2 *Hystrix brachyura* (Malayan porcupine).

Common name	: Common/ Malayan porcupine
Malay name	: Landak raya
Head and body length	: 590-630 mm
Tail length	: 95-130 mm
Hind foot length	: 80-95 mm
Skull	: 100-200 mm
Weight	: 8 kg

(Source: Payne and Francis, 1998)

Hystrix brachyura is the largest porcupine, and the commonest one in the whole Malaysian region (Harrison, 1974). This species is considered vulnerable by International Union for the Conservation of Nature and Natural Resources (IUCN) because predation and human encroachment are the main threats. They are hunted for meat (considered a delicacy in some societies) and to acquire quills as ornaments also for get the bezoars stone in their stomach as medicinal properties (Grzimeks et al., 1975).

2.1.3 Physical characteristics

The body is stocky built and the tail is very short for this species. According to Payne and Francis (1998), the head and body length is about 590-630 mm while the tail length is about 95-130 mm. Eyes and external ears are generally small, with a poor sense of sight but a sharp sense of hearing. Nostrils are usually S-shaped, with a sharp sense of smell. The upper lip is cleft, and the tip of the nose is stubbed and covered with velvety hairs. Large, chisel shaped lower and upper incisor teeth do not have longitudinal grooves and grow throughout life; molars are rooted and have irregular enamel folds that are rapidly worn down (Grzimeks et al., 1975).

The skull is long and sometimes inflated with air chambers over the rostrum and top of head. The infraorbital foramen (lower orbital cavity in upper jawbone) is unusually enlarged, resulting in portions of masseter (chewing) muscle being penetrated through it, thus enabling muscles to adhere to the frontal side surface of the upper jawbone (called hystricomorphous). The lower jaw is hystricognathous. Features (generally called postorbital processes) possibly evolved to enlarge chewing volume and to allow animals to smell underground bulbs. Both forelimbs and hind limbs are short and heavily built; as a result, this species are excellent diggers and construct their own burrows. On the two forelimbs, each foot has four well-developed clawed digits and one thumb, which is regressed and externally visible only by nail and thumb pad; each of two hind feet has five functional digits. Claws are short and soles of feet are smooth, naked, and fitted with pads. When walking or running, the entire sole of the foot touches the ground and they are able to swim (Grzimeks et al., 1975).

The most characteristic physical features are the quills, spines, and bristles. The spines are long, black and white and round in cross section (Hughes, 1987). Longest spines tend to be found on rump and shortest on cheeks and for this species, spines develop into hollow quills that reach 7.9 inches (20 cm) in length (Harrison, 1964; Grzimeks et al., 1975). The spines of the back are so long and they hide their tail, which is short and covered with specially modified spines which rattle when the tail is shaken. The tail is usually carried almost upright, so the animal appears to have no tail (Harrison, 1964). Normally, quills lie flat and point to the rear. When the animal is threatened or showing aggression, quills can be raised instantly. Hind feet are usually then stamped and quills shaken with a rattling sound which serves as a warning to potential predators. Both males and females have hollow quills on the tail, which are shaken to make a noise (Payne and Francis, 1998). If threat continues, the porcupine may charge backwards or sideways into predator with attempt to strike intruder with quills. Quills are loosely attached but cannot be projected. There is no evidence that the quills can be discharged, like arrows but they come out easily (Harrison, 1964). They penetrate flesh and stick readily. No poison is carried; however, bacteria on quills can infect, and sometimes kill the victim if the puncture wound is deep enough. The area with detached quills will grow back new quills (Grzimeks et al., 1975).

2.1.4 Distribution

This species is confined to Southern, Thailand, Malaysia, Sumatra and Borneo which includes Sabah and Sarawak (Tweedie, 1978). It is known from many localities throughout the lowlands and hills, up to 900 m on Mount Kinabalu (Payne and Francis, 1998).

2.1.5 Habitat

This species are usually terrestrial and normally do not climb trees; need only shelter from the weather and for periodic nesting. They always can be found in agricultural area and in forests. They often use abandoned deep burrows of other animals such as caves, rock crevices, decaying logs, hollow trees, and holes dug by other animals; or deep burrows that they have excavated themselves. Burrows can be complex systems, where many may live in adjoining burrows and may be used for many years. A single burrow may hold up to 10 individuals (Grzimeks et al., 1975).

2.1.6 Behavior

They are nocturnal herbivores, which mean that they eat plants and are active during the night to find their food and they are ground living (terrestrial). These animals walk heavily on the sole of the foot with the heel touching the ground, and run with a shuffling gait or gallop clumsily when pursued. They rattle their spines when moving and may also stamp their feet when alarmed. From observations in captivity, this species ranges from shy and nervous to docile and they are moderately gregarious than the other species (Grzimeks et al., 1975).

2.1.7 Feeding ecology and diet

Their diet varies with location and the season of the year. Porcupines are mixed vegetarians, feeding on fallen fruit, bark, shoots, and tree saps, but also chewing a bone if it is available (Hughes, 1987). The diet consists of mostly vegetation with many kinds of plant material and crops such as sweet potatoes, bananas, peanuts, pineapple, maize, sugarcane, potatoes, cucumbers, long beans, melons, bambangan, and jering (Grzimeks et al., 1975; Marina et al., 2005). The most preferred by the captive *Hystrix brachyura* is long bean followed by bread, sweet potatoes and swamp cabbage (Norsuhana et al., 2005). For wild species they like to eat tubers, stem, roots, succulent stems, fallen fruit and crops (Walker, 1995). That is why they are considered as pests in plantation and agricultural area. Loss of newly-planted palms through attacks by porcupines has been reported as serious on a number of occasions from both Sumatra and Malaysia (Wood, 1968; Chua, 1969; Young, 1971).

Porcupines chew through the frond bases to reach the tender stem tissues and the extent of damage is greater than with rats in young palms (Chua, 1969); and the most frequently encountered species of porcupine is *Hystrix brachyura* (Wood, 1968; Chua, 1969).

2.2 Carcass Composition

Animal carcass has three main constituents which are muscle, fat and bone. All three increase in total amount as growth occurs. However, as one tissue comprises a higher percentage of the carcass, the others comprise proportionately less. As an animal grows older and larger, the proportion of bone and muscle tissue decreases whereas the percentage of fat of the carcass increases. Typical body composition of an adult mammal such as cow and goat is about 60% water, 16% protein, 20% fat, and 4% mineral matter (Pond et al., 1974).

2.3 Meat

Meat is high in protein quality and quantity making it a complete protein. High-quality fresh meat has bright color, slight marbling of firm structure, and fine texture. The nutritional value of meat comes from its proteins, vitamins, minerals, and fats. Although nutritionists no longer advise meat at every meal, meat is a good source of calories, proteins, fats and minerals. Carcass meat consists of lean, fat and bone, together with connective tissue. The fat can be subcutaneous (lying under the skin of the animal), intramuscular (lying between individual muscles) or intra muscular (occurring within the body of the muscle). Subcutaneous fat is relatively easy to trim to produce leaner-looking meat, intramuscular fat is more difficult to remove simply, intramuscular fat also referred to as marbling fat because when abundant it gives a marbled appearance to the lean (Warris, 2000). The composition of meat depends upon the species from which the meat was obtained. The average values for the proximate composition and energy of the edible portion of the fresh meat are protein 17%, fat 20%, moisture 62%, and ash 1% (Schweigert and Price, 1971).

2.3.1 Bush meat

Bush meat is the term commonly used for meat of terrestrial wild animals, killed for subsistence or commercial purposes throughout the humid tropics of the Americas, Asia and Africa. However, originally the term was only used to describe the hunting of wild animals in West and Central Africa. The term bush meat crisis tends to be used to describe unsustainable hunting of wildlife in West and Central Africa or the humid tropics (rainforest), depending on interpretation. Among the majority of the people, bush meat is recognized as a valued resource and consumed. In many areas bush meat also represents the only viable source of meat protein, with domestic meat being prohibitively expensive and largely unavailable. Bush meat affects a wide range of communities, from traditional hunter or gatherers, rural farming and herding communities, as well as urban centres in the region. For example, bush meat was found to be much cheaper than domestic meat in six of the seven countries surveyed, with bush meat being 75% cheaper than domestic meat in Zimbabwe. The study also found that it is the poorer households that are more greatly reliant on bush meat (Ntiamoa-Baidu, 1997). According to this, total wildlife consumption is significant. For example in Sarawak approximately 23, 500 tones of wild meat are eaten per year (Bennet, 2002) and porcupines are included.

2.3.2 Nutrient content of wild animal meat

Nutrient can be defined as any chemical element or compound in the diet that supports normal reproduction, growth, lactation, or maintenance of life processes. The six classes of nutrients are water, proteins and acid amino, carbohydrates, lipids, vitamins and inorganic elements. Energy, which is required in diets of all humans and animals can be provided by fat, carbohydrate and carbon skeleton of amino acids after removal of nitrogen. The nutrients support cellular needs for water, fuel, structural constituents (skin, muscle, bones, nerves and fat) and metabolic regulation. Certain nutrients are required in the diet because they cannot be synthesized by the body in sufficient amounts to satisfy metabolic needs and are termed as "essential" or "indispensable" nutrients (Pond et al., 1974). A number of studies on the nutrient content of wild animal meat indicate that bush meat is comparable but not better than domestic meat (Sales, 1995). The general trend is that the meat of most wild animal species tend to be low in fat, while equal or better than beef, mutton, chicken or pork in protein content and much higher in vitamin content. Apart from the large game species, nutritional studies on wild animals have been carried out for "non-conventional" species such as rodents. The nutritional studies of rodents used as food in the Zambezian woodland, (Appendix B) gave average protein content of 24% (fresh weight) and fat content of 2.8% for twelve species (Malaisse and Parent, 1982).

2.4 Proximate Analysis

Proximate analysis is the most common analysis done for nutritional testing. It is a combination a number of analytical procedures developed in Germany well over a century ago, and are intended for the routine description of feedstuffs (Pond et al., 1974). Proximate testing includes fat, protein, moisture, ash, carbohydrates and calories (by calculation). Each of the proximate tests has testing variations that are applied to specific food types. Not all food will get the same type of testing. The ash component can be used for minerals analyses and the fat component can be used for determination of cholesterol, and for fatty acid analysis. Food Product Laboratory (FPL) uses Association of Official Analytical Chemist (AOAC) testing methods for nutritional analyses (FPL, 2006).

2.4.1 Moisture Content and dry matter

Moisture content means water that contained in the food. From moisture content we can determine dry matter in the food which is important in the analysis to get dry weight basis.

2.4.2 Ash

Ash relates to the inorganic (not carbon based) elements of the diet that are left behind after burning at 500^0C, which removes all carbon. It mainly consists of the minerals, both major such as calcium, potassium and magnesium, and minor including iron, manganese and copper. In proximate analysis, data on ash are required to obtain other values such as the other minerals (Pond et al.,1974).

2.4.3 Protein

Protein is made up of amino acids. The nine essential amino acids, or the amino acids that the body cannot make and must get from food, are found in meat. Few plant sources are complete proteins. The proteins are the third class of macro components of living systems and therefore, of foodstuffs that we must consider. Proteins have a very wide range of functions. Proteins principally contain carbon, hydrogen, oxygen, nitrogen and sometimes sulphur. They are made up of chains of amino acids which there are 20 common ones. Animals cannot synthesize the amino group (NH2) which characterizes amino acids so must have protein in their diet. The human body uses protein to build new cells, maintain tissue, and synthesize new proteins that make it possible for the body to perform basic functions. Proteins from animal origin are example of complete proteins (Warris, 2000).

Protein in meat often has a high biological quality compared to many plant foods. Some processed forms of meat tend to have a lower protein quality than the fresh counterparts but still generally higher than plant foods. Meat protein contains all the essential amino acids in the correct proportions required by the body for optimum growth. Maintaining our lean weight is crucial for keeping the metabolic rate sufficiently high enough to burn enough calories to lose weight. The quality of the protein in meat basically means that most of its protein can be used for protein synthesis and limits the amount burned as fuel. Health professionals recommend that protein makes up 10 to 15 per cent of diet. They suggest men eat 55.5g of protein a day and women eat 45g per day.

2.4.4 Fat

Fat is a concentrated source of energy for the body, providing 9 Calories per gram. It is generally recommended that no more than 30 percent of the total calories consumed come from fat. Fat should account for 30% or less of the calories consumed daily. Fats are a concentrated form of energy which help maintain body temperature, and protect body tissues and organs. Fat also plays an essential role in carrying the four fat-soluble vitamins; A, D, E, and K. Excess calories from protein and carbohydrates are converted to and stored as fat. Fat calories in food are readily stored, while it takes energy to transform protein and carbohydrates to body fat. The only proven way to reduce body fat is to burn more calories than one consumes.

2.5 Minerals

All foods contain varying amounts of minerals. The mineral material may be present as inorganic or organic form. The minerals that act as nutrients in the body are absolutely essential to a host of vital processes, from bone and tooth formation to the functioning of neuro-logical and digestive systems and the heart (Crosby, 1977; Countinho, 1981). In recent years, scientists have been paying a great attention to minerals and are looking for links between them and major chronic diseases. As Margen (1992) pointed out, there are more than 60 minerals in the body, but only a few are considered to be essential, among them, iron, calcium, zinc, magnesium, phosphorus, sodium, potassium, manganese, selenium, copper,and others. Sodium, potassium and phosphorus are present in relatively high amounts. Muscle tissue contains much more potassium than sodium. Meat also contains considerably more magnesium than calcium. During cooking, sodium may be lost, but the other minerals are well retained. Processing does not usually reduce the mineral content of meat.

2.5.1 Potassium

Potassium is essential for maintaining proper fluid balance, nerve impulse function, and muscle cardiac (heart muscle) function. Potassium is found in bananas, raisins, apricots, oranges, avocadoes, dates, cantaloupe, watermelon, prunes, broccoli, spinach, carrots, potato, sweet potato, winter squash, mushrooms, peas, lentils, dried beans, peanuts, milk, yogurt, and lean meats (Nutristrategy, 2005).

2.5.2 Calcium

Calcium is needed for healthy bones and teeth, normal blood clotting, and nervous system functioning. Calcium is found in dairy products, broccoli, cabbage, kale, tofu, sardines and salmon (Nutristrategy, 2005).

2.5.3 Magnesium

Magnesium is needed for healthy bones and teeth, proper nervous system functioning, and energy metabolism. Magnesium is found in dairy products, meat, fish, poultry, green vegetables, and legumes (Nutristrategy, 2005).

2.5.4 Iron

Iron is the most important transition metal in the animal body, where it occurs naturally in elaborate co-ordination compounds based on the porphyrin nucleus notably the haem pigments. Iron is generally abundant in foodstuffs, of plant as well as animal origin (Coultate, 1989).

2.5.5 Manganese

Manganese is needed for enzyme structure. Manganese is found in whole grain products, fruits and vegetables (Nutristrategy, 2005).

2.5.6 Zinc

Zinc is a component of insulin and many enzymes. Zinc is needed for cell reproduction, tissue growth and repair, appetite, taste, night vision and the immune system that are dependent on an adequate supply of zinc. Meat, shellfish, whole grains and legumes are good sources of zinc (Nutristrategy, 2005).

CHAPTER 3

MATERIALS AND METHODS

3.1 Animals

In this study, two samples of Malayan Porcupine (*Hystrix brachyura*) had been used, which were made available from Lana Oil Palm Plantation and from captivity in Biopark, UPM Bintulu Campus. The samples were sexually matured animals with body weight range between 4 to 9 kg. The sample from the Plantation (wild porcupine) was represented with sample A while from the Biopark (in captivity) was represented with sample B (Appendix C).

3.2 Origin of samples

3.2.1 Lana Oil Palm Plantation

Lana Oil Palm Plantation is a planted oil palm area situated far from Bintulu town. Before this the area was a disturbed forest area and has been deforested for oil palm plantation. Majority of the area was covered by oil palm and the trees are around 3 month to 3 years old (Rohim, Lana Oil Palm Plantation, 2007: Personal Communication). Palm head area is the area which is always being attacked by porcupines for their tender stem tissues.

3.2.2 Biopark, UPM Bintulu Campus

Biopark, UPM is the integrated area of *Acacia mangium* with animals such as deer and porcupines. Porcupines are reared in captivity and fed with kangkung and sweet potatoes every day (Iskandar, Taman Pertanian Universiti (TPU), 2007: Personal Communication).

3.3 Physical characteristics

The porcupines were sexually identified and the physical characteristics such as weight, head and body length, numbers of spine on body and range of spines length were taken.

3.3.1 Body weight

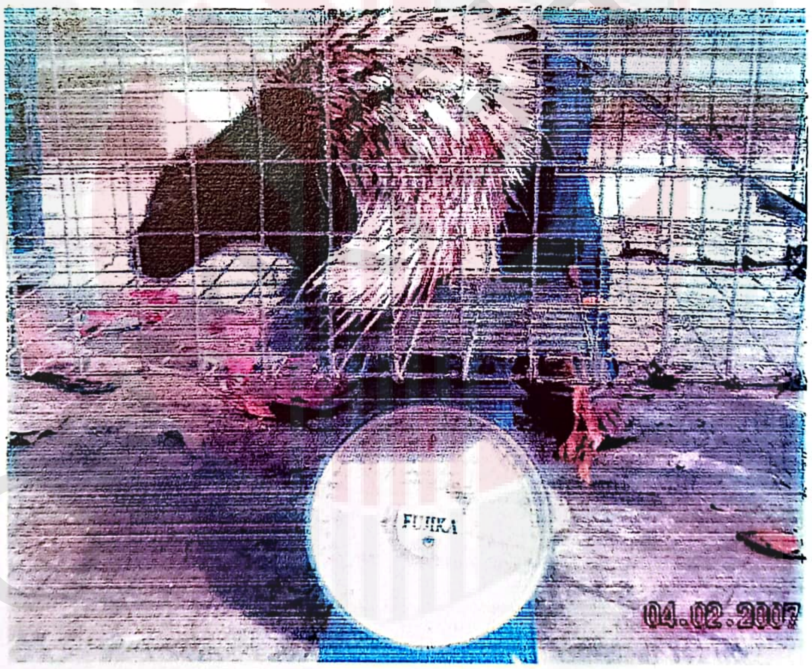

Figure 1: Weighing the sample

3.3.2 Head and body length

Figure 2: Measuring Head and Body length

3.3.3 Numbers of spines and length of spines

Numbers of spine was calculated only on the body. All the spines were calculated for each sample and the mean value was taken. For length of spines, randomly 100 spines of different lengths were taken from each sample. The spines were measured as in figure:

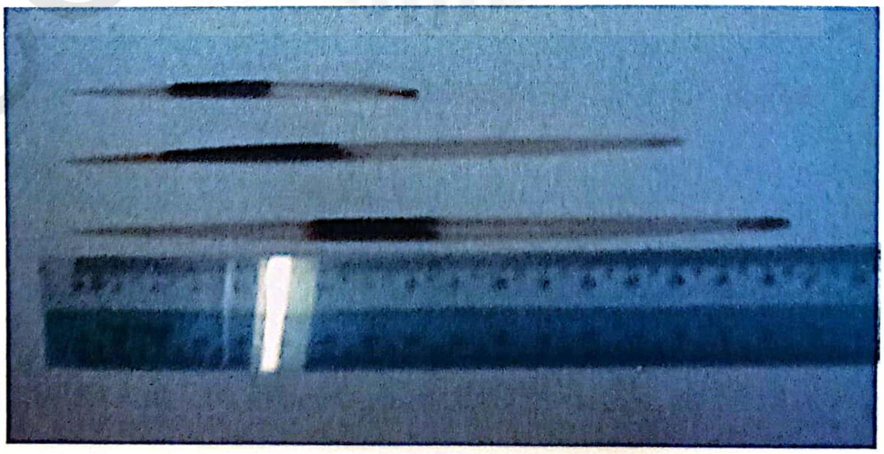

Figure 3: Measuring of spine's length.

3.4 Sample preparation

The porcupines were slaughtered at the Animal Depository Laboratory, UPM Bintulu according to the Muslim (Halal) way by severing the throat and major blood vessels in the neck (Kadim et al., 2003) and undergo carcass composition analysis (Appendix D).

3.5 Carcass composition analysis

After slaughter, the carcass was weighed, split and eviscerated (Correa et al., 2006). Every part of internal offal (non-carcass component) such as heart, liver, trachea and lung, kidney, and visceral organ (cecum, rectum, and stomach) was weighed. Hot carcass weight was recorded and used to calculate the dressing yield percentage. The external offal parts which are head, leg, tail, and skin with spine were weighed. The carcass was chilled for 48 hours at 4 ± 1^0C. The dissection was done to separate the bone and meat. The weight of bone and meat was taken.

3.6 Meat samples

The meat was dissected from the bone and 120 g from four parts of the carcass which were front feet, hind feet, breast and loin were taken. All of this part was grinded with meat grinder and was dried in oven below 60^0C for 3 days. Then the dried sample was grinded to powder form (Appendix E). Then the samples were undergo proximate and minerals analysis.

3.7 Proximate analysis

Proximate composition analysis was according to AOAC (1990) method. Proximate analysis included dry matter, ash, protein, and fat.

3.7.1 Determination of dry matter

Dry matter was determined by following the method of AOAC (1990). Porcelain crucibles were soaked and cleaned with detergent and rinsed with distilled water, dried in the oven at 105°C. The dried crucibles were cooled in desiccators and weighed (W_1). About 10 g of sample was placed in the previously weighed empty crucible and the weight of sample and crucible was recorded (W_2). The crucibles were covered with the lids and kept in the oven set at 105°C until there was no further loss in weight (Appendix F1). After 24 hours of drying, the crucibles were removed from the oven, cooled in the desiccators, and weighed (W_3). The crucibles were handled with a metal tong. Each sample determination was replicated three times and the mean value was taken. The moisture and dry matter (DM) were calculated by using the following formula.

$$\text{Dry matter \%} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

W_1= Dry weight of crucible

W_2= Weight of fresh sample + crucible

W_3= Weight of crucible + dry sample

%Moisture = 100- DM%

3.7.2 Determination of ash

Porcelain crucibles were cleaned, dried and cooled in desiccator. The empty crucibles were weighed and about 1 g of samples was taken to determine the ash content. The crucibles, with the samples were covered and placed in the muffle furnace (Appendix F2). The temperature was increased gradually to 550°C and the samples were ignited for 5-6 hrs or until white, light gray residue was obtained. The crucibles were then transferred from the furnace to the desiccators, allowed to cool and weighed. Each sample determination was replicated three times and the mean value was taken. The ash content was calculated according to the formula:

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{S.D.W}} \times 100$$

Where,

S. D. W = Sample Dry weight

3.7.3 Determination of crude protein

The procedure used to determine crude protein was known as the Kjeldahl method (AOAC,1990). The average protein contains about 16% N. There were three process involved to determine the crude protein which were digestion, distillation and titration (Appendix F3).

Preparing samples before digestion

About 1 g of sample and 12 ml of concentrated H_2SO_4 98% were placed in the digestion tubes. Two selenium tablets were added for each tube to facilitate digestion. The tubes were placed in the tube rack. The tube rack placed onto the digester in the fume cupboard. The digester was set at 420°C and the heating will be run about 3-4 hours until the samples were digested completely. Then the sample was undergo distillation process using 2400 Kjeltec system.

Procedure for using 2400 Kjeltec system

Before the apparatus was switched on, a digestion tube should be in place and the safety door closed. When power was turned on, a self test programme was initiated. Analysis of the sample was started. Twenty-five ml of boric acid 4% was dispensed into the titration vessel from the tank by the pump and simultaneously dilution water was dispensed into the digestion tube from the water tank by the pump. Fifty ml of NaOH 40% was dispensed into the tube from the tank by the pump. After a short delay, the steam valve opened and delivered steam to the tube and at the same time, the cooling water valve opened; delivered water to the condenser. The liberated gas was condensed in the condenser and delivered to the titration vessel containing receiver solution. The distillation continued until the end point was reached.

Titration

After the distillation, the solution was titrated using 0.1 M Hydrochloric acid until the solution color change from green color to brick red. The volume of acid that used to titrate was taken. The calculation of crude protein was calculated according to formula:

$$\%N = \frac{(\text{Titrated volume} - \text{Blank volume}) \times 14 \times \text{No. of mol}}{\text{Weight of sample}} \times 100$$

$$\%\text{Protein} = \%N \times 6.25$$

3.7.4 Determination of fat

Approximately 1 g of sample was weighed into an extraction thimble which allowed rapid passage of petroleum benzene or petroleum ether. The thimbles were placed into the extraction unit along with previously weighed extraction cups. About 50 ml of petroleum ether will be put into the extraction cup and used for extraction. The samples were determined by Soxtex System-Tecator. After that, the cups were released and dried in the oven for 2 to 3 hours at 105°C and weight was taken with the extract (Appendix F4). The calculation of fat content was according to the formula:

$$\text{Fat Content Percentage} = \frac{B_1 - B_2}{B_3} \times 100$$

B_1 = Extraction cup with extract sample weight

B_2 = Extraction cup weight

B_3 = Sample weight

3.8 Determination of minerals

The samples were digested according to the method reported by Hair-Bejo and Alimon (1995) where inorganic constituents were determined by destroying the organic matter by wet ash method (Appendix G). Approximately 0.2g of fresh sample was placed in the digestion tubes and 4ml 69% HNO_3 was added to sample. All tubes were covered with glass marbles and left overnight at room temperature. Then, all samples were heated in a heating block initially at 70 to 80°C approximately 1 hour and then at higher temperature was increased until slightly below 140°C until samples were completely digested and the colour changed from dark brown to colourless. One ml of digested sample was diluted with 4 ml distilled deionized water to make the volume to 5 ml and then analyzed using Atomic

Absorption Spectrophotometer (AOAC, 1990) to determine the minerals which were Zn, Mg, K, Ca, Fe, and Mn.

3.9 Data analysis

In this experiment, there were two samples of Malayan porcupines which were wild porcupine (sample A) and captive porcupine (sample B). Each sample was replicated 3 times (for proximate and minerals analyses) and the mean values with standard deviation for each sample was taken.

CHAPTER 4

RESULTS

4.1 Physical characteristics

The Malayan porcupines (*Hystrix brachyura*) were individually observed due to their weight, length of their body, number of spines on body only and the length of the spines (Appendix H1). The value was taken for each sample as presented in Table 1.

Table1: Physical characteristics of two samples of Malayan porcupines

Characteristics	Sample A	Sample B
Body weight (kg)	8.40	4.60
Head and body length (cm)	67	56
Total spine (body only)	6532	4773
Length of spine (cm)	1.8-22.0	2.0-21.0

Sample A: Wild Malayan porcupine
Sample B: In captivity Malayan porcupine

4.2 Carcass composition

Carcass composition was measured according to the percentage of carcass components (Appendix H2) as showed at Table 2:

Table 2: Percentage of carcass component of two samples

Components	Sample A (%)	Sample B (%)
External offal	31.4	27.8
Internal offal	27.6	19.2
Dressing percentage	31.5	39.9
Bone	10.4	8.7
Meat	21.1	31.2

Sample A: Wild Malayan porcupine
Sample B: In captivity Malayan porcupine

4.3 Proximate analysis

The table below shows the proximate analyses (Appendix H3) which was done on meat samples obtained from these two types of porcupines.

Table 3: Proximate analyses (means ± standard deviations) of Malayan porcupine meat (dry weight basis)

Sample	Dry matter (g)	Ash (g)	Protein (g)	Fat (g)
Sampel A	22.0 ± 0.01	1.57 ± 0.45	18.4 ± 0.05	5.21 ± 0.03
Sampel B	21.3 ± 0.16	0.94 ± 0.05	16.9 ± 0.13	1.43 ± 0.05

Sample A: Wild Malayan porcupine
Sample B: In captivity Malayan porcupine

4.4 Minerals

The meat samples of the two samples of porcupines were analyzing and the competitions of the various minerals (Zn, Mg, K, Ca, Fe, and Mn) are presented (Appendix H4) in Table 4.

Table 4: Minerals analysis (means ± standard deviations) for two samples of Malayan porcupines meat

Minerals (mg)	Sampel A	Sampel B
Zn	13.02 ± 1.05	9.87 ± 1.27
Mg	13.02 ± 0.70	9.04 ±1.04
K	376.3 ± 0.04	376.5 ± 0.00
Ca	8.20 ± 0.63	14.49 ± 7.54
Fe	5.69 ± 0.60	4.41 ± 0.76
Mn	0.93 ± 0.06	0.14 ± 0.10

Sample A: Wild Malayan porcupine
Sample B: In captivity Malayan porcupine

CHAPTER 5

DISCUSSION

5.1 Physical characteristics

The results showed that the body weight of Sample A was 8.4 kg while the body weight for sample B was 4.6 kg. It was appeared that sample A (Wild Malayan porcupine) was comparable with reported values which the weight is up to 8 kg (Payne and Francis, 1998). This may due to feeding factor of the porcupines according to the area it belongs. The feeding factors were different among animal species (Pulliam, 1975; Calvert, 1985) and depend to their habitat (Calvert, 1985). The head and body length for sample A was 67 cm and for sample B is 56 cm. The value were comparable with 59-63 cm which recorded by Payne and Francis (1998). There was no recorded data on the number of spine at the body of this species but from this study, it was showed that the estimated number of spines at the body for sample A is 6532 and for sample B is 4773. The spine's length range for sample A was 1.8-22 cm while for sample B was 2.0-21.0 cm. The length of the spine could reach about 20 cm long (Harrison, 1964; Grzimeks et al., 1975).

5.2 Carcass composition

The porcupine's external offal percentage (head, leg and skin with spine) was 31.4% for sample A (wild porcupine) and 27.8% for sample B (captive porcupine) while the internal offal percentage was 27.6 and 19.2 for sample A and B respectively. The data showed that the external offal percentage for sample A was higher. This is due to the number of spines on the body which make more than on sample B. Dressing out percentage based on full and empty live body weights were 31.5% for sample A and 39.9% for sample B. The bone percentage was 10.4% for sample A and 8.7% for sample B. The meat the percentage was 21.1% for sample A and 31.2% for sample B. From the data, sample B had high meat percentage because the percentage for the internal, external organ and bone was less while sample A had high percentage of bone which made the meat percentage less (Pond et al., 1974). From the recent research of rodents, the dressing out percentage of rabbit was 56.4% (Piles et al., 2000) and goats were in range of 39.5-41.8 and 53.3-56.6% (Kadim et al., 2003).

5.3 Proximate analysis

Dry matter, ash, protein and fat of the porcupine meat for sample A were 22.0 ± 0.01, 1.57 ± 0.45, 18.4 ± 0.05 and 5.21 ± 0.03 respectively while for sample B were 21.3 ± 0.16, 0.94 ± 0.05, 16.9 ± 0.13 and 1.43 ± 0.05. It was appeared that sample A had high protein and fat content. This may be due to differences in feeding of this captive and wild animals. According to Norsuhana et al. (2005), the captive Malayan Porcupine had selected their food items based on nutrient content especially protein in their diet. The wild Malayan Porcupine (sample A) depends their food to the tender stem tissue of palm tree in the plantation while sample B depends their food which were given daily. According to Iskandar, TPU (2007: Personal Communication) the food that given for captive porcupine was kangkong and tapioca. Kangkong was the most preferred food for captive porcupine (Marina et al., 2005) while according to Norsuhana et al. (2005) long been was the most preffered by captive Malayan porcupine as it had 18.4% proteins. Although the food is high protein, the nutrient content in meat also depends on how much the food that animals take and the digestibility of the food (Smith and Follmer, 1971). The wild sample can eat as much as they want in the plantation as there are a lot of food especially in palm plantation area. Because of that, there is loss of newly-planted palms through attacks by porcupines has been reported (Chua, 1969; Wood, 1968; Young, 1971). The captive porcupine just depends to the food that given which is limited. So, this made sense why wild porcupine had more protein content and fat content in their meat as these factors were related with their feeding.

5.4 Minerals

It was founded that zinc content in sample A was 13.02 ± 1.05 while in sample B was 9.87 ± 1.2. Zinc distribution was fairly uniform in soft tissues and higher concentration was found in muscle with 160.44 ppm in goats (Wan Zahari and Abdul Wahid, 1985). The value of magnesium in meat was comparable with zinc which were 13.02 ± 0.70 and 9.04 ± 1.04 while the value of potassium in porcupines meat was higher than the other minerals with 376.3 ± 0.04 and 376.5 ± 0.00. This value was appeared to be similar for both samples. The potassium in porcupine's meat was higher than the other minerals because it plays important part in animal's physiology (Coultate, 1984) and to reproduce spines. Since K was found in every cell, the organs or tissues,with the largest number of cells would contain the largest amount of K (Thompson, 1978). The calcium content was 8.20 ± 0.63 in sample A and 14.49±7.54 in sample B while the iron content was 5.69 ± 0.60 and 4.41 ± 0.76. The most less minerals in meat were manganese which only 0.93 ± 0.06 for sampel A and 0.14 ± 0.10 for sample B. This is because the total body supply of Mn is less than that of most other required minerals (Pond et al., 1974).

During this study there were many problems that occurred especially in getting samples. Only two porcupines were available for this study which was from Lana Oil Palm Plantation and from UPM Bintulu Campus. Porcupine is a wildlife animal which is very hard to find unless in a jungle or agricultural area. It is also having a sharp sense of hearing and smell (Grzimeks et al., 1975) to make it very difficult to catch. Porcupine is a protected animal and we must have a permit to catch, kill or hunt them (Wildlife Protection Ordinance, 1990). The only way was to get the sample from the Plantation because they have a legal permit since these animals have become a pest at their plantation. However, the Plantation also could not provide many samples because of several factors such as raining season during which the porcupines do not come out. Actually, there have been many attacks by the porcupine reported at their Plantation (Rohim, Lana Oil Palm Plantation, 2006: Personal Communication).

The other reasons were that the plantation workers hunt and eat the animals and do not want to give away their source of food. Another important factor was the distance and poor communication between UPMKB and the Plantation as a source of supply of research material. So, because of the above factors, we were unable to obtain more than one sample of wild porcupine. The only alternative source was porcupine in captivity at Biopark, UPMKB. Hence, we were able to utilize two samples for this study and still can get the basic data as much as we can about this wild and captive Malayan Porcupine. It is suggested that the further study be conducted using a larger number of the porcupine.

CHAPTER 6

CONCLUSION

In conclusion, the basic data on physical characteristics, carcass composition, and nutrient content of meat for wild and captive Malayan porcupine (*Hystrix brachyura*) had been obtained. The environment and habitat of the porcupine would influence physical characteristics of the animals and nutrient content of the meat. From the study that had been done, it appeared that porcupine meat can be used as one of the food source because it had high protein and low in fat. However, further study should be carried out in the future with more samples to give more complete data.

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APPENDICES

Appendix A: List of protected animals (Mammals) in Sarawak according to Wildlife Protection Ordinance, 1998.

English Name	Scientific Name	Local Name
All treeshrews	All species of Tupaiidae	
All bats	All species of Chiroptera excluding those already listed in Part I	
All primates	All species of Primates excluding those already listed in Part I	
Flying lemur/colugo	*Cynocephalus variegatus*	Kubung
Pangolin	*Manis javanica*	Tenggiling
All flying squirrels	All species of Petuaristinae	Tupai terbang
Porcupines	**All species of Hystricidae**	**Landak**
Sun bear	*Helarctos malayanus*	Beruang
Bear cat	*Arctitis binturong*	Binturung
All civets and mongooses	All species of Viverridae	Musang
All otters	All species of Lutra and Aonyx	Memerang
All cats	All species of Felidae excluding those already listed in Part I	Kuching hutan

(Source: Sarawak Forestry Department, 2004)

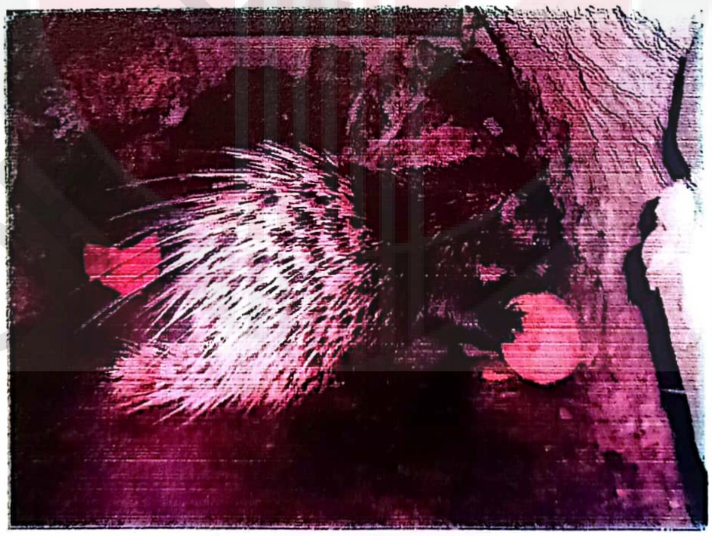
Appendix B: Proximate composition (g/100 g) of meat of some wild animal species.

Species	Moisture	Protein	Fat	Ash
Paraxerus cepapi	74.3	21.0	3.2	1.5
Aethomys kaiseri	73.1	19.1	3.0	2.0
Cricetomys gambianus	49.1	42.6	4.7	2.6
Dasysmys sp.	71.7	21.0	4.0	2.0
Lophuromys flavopunctatus	66.7	27.5	2.9	2.6
Praomys sp.	70.0	19.8	7.0	2.0
Saccostomus campestris	68.4	19.0	10.2	2.2
Thamnomys sp.	70.7	16.3	3.4	2.0
Pelomys fallax	75.1	19.9	2.8	1.8
Hystrix africae-australis	48.0	45.8	41	1.7
Thryonomys swinderianus	52.0	28.0	16.8	2.9
Cryptomys hottentotus	69.2	16.6	9.9	1.8

(Sources: Ajayi & Tewe, 1979; Malaisse & Parent, 1981)

Appendix C: Animals

Sample A: Wild Malayan porcupine

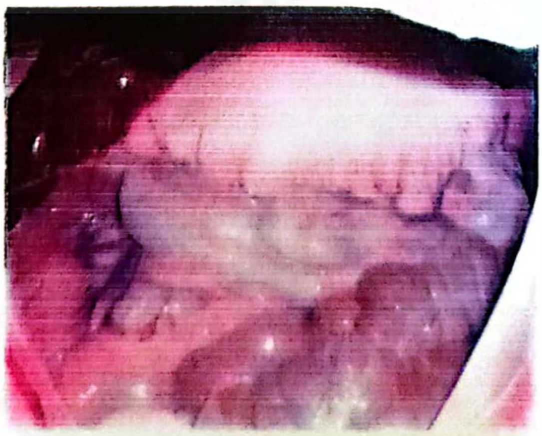


Sample B: In captivity Malayan porcupine

Appendix D: Carcass composition analysis

Dissecting the porcupine

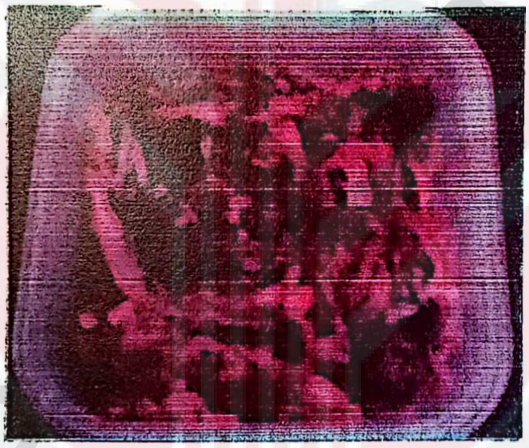
Dressing out carcass



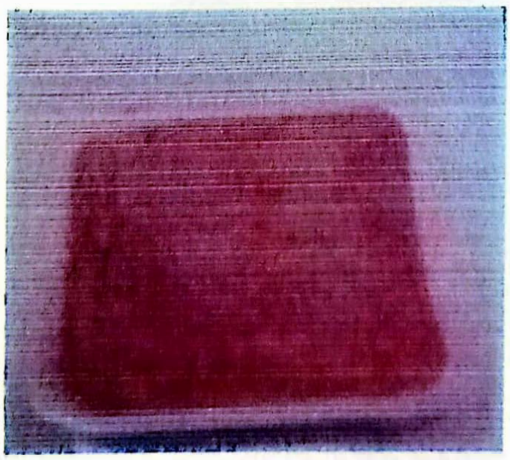
Internal offal

Appendix E: Meat samples preparation

Process of separating meat from bone



Fresh meat samples



Dry meat sample

Appendix F1: Determination of dry matter and moisture content

The samples kept in oven at 105°C for 24 hours

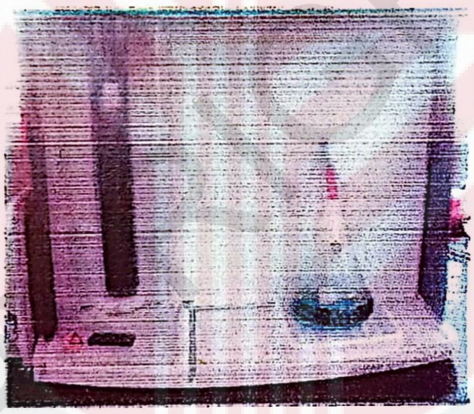
Appendix F2: Determination of ash

Placed the samples in muffle furnace

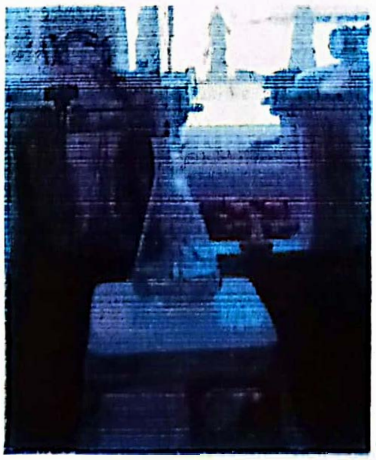
Muffle furnace

Appendix F3: Determination of crude protein

Digestion process



Distillation process



Titration process

a) Calculation for preparing 4% Boric acid (Receiver solution)

4% Boric Acid from (pellet) (volume 5000 ml)

= 4% x Volume needed
= 4% 5000
= 200 g in 5000ml

b) Calculation for preparing 40% NaOH (volume 5000 ml)

= 40 % x 5000
= 2000 g in 5000 ml

c) Calculation for preparing solution for titration (0.1 M HCL)

Density = 1.18
J.M.R = 36.46

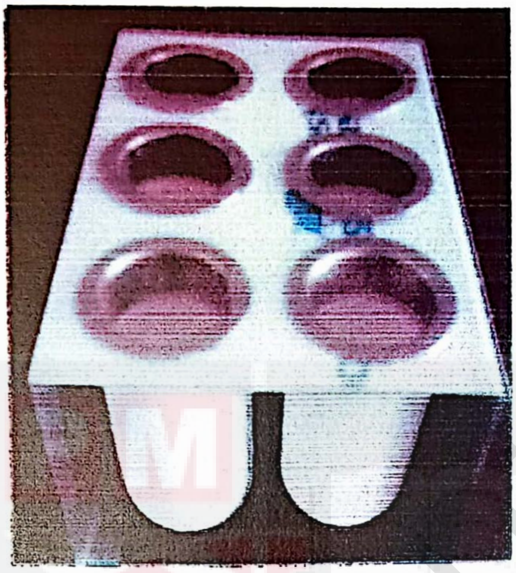
$M_1V_1 = M_2V_2$

M_I = Density/ JMR x % x 1000
= 1.18/36.46 x 38% x 1000
= 12.29

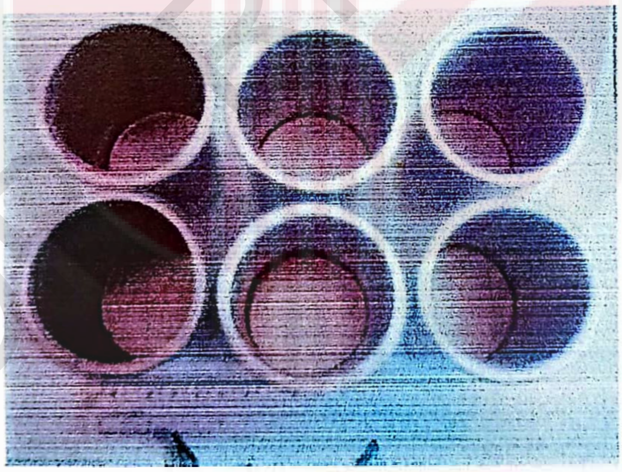
$V_1 = \frac{0.1 \times 1000}{12.29}$

V_1 = 8.15 ml in 1000 ml

Appendix F4: Determination of fat

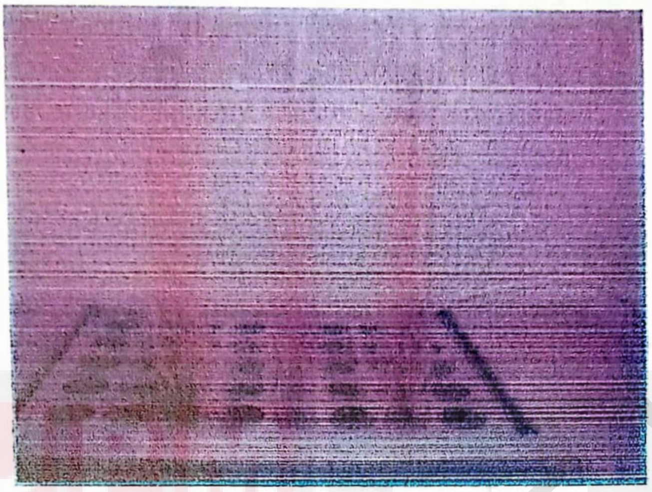


Extraction thimble

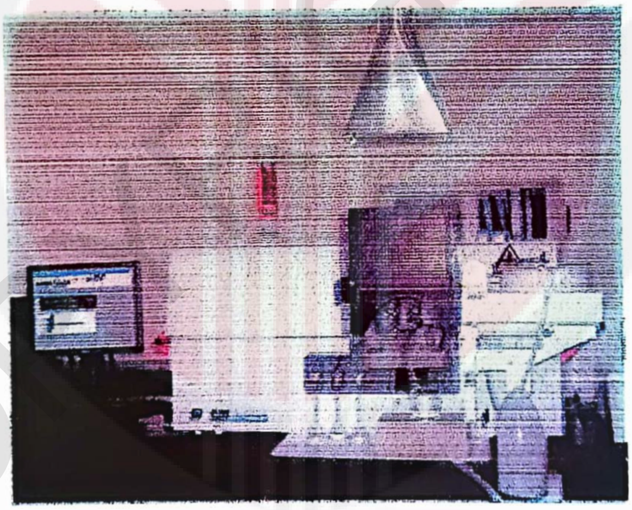


Extraction cup with samples (after analysis)

Appendix G: Minerals analysis



Digestion of meat samples



Atomic Absorption Spectrophotometer

Appendix H: Result Tables

1) Length of spines

No.	Captive	Wild
1	13.2	22.0
2	17.4	21.0
3	16.5	20.1
4	15.9	19.4
5	13.4	18.8
6	15.4	17.8
7	15.0	18.0
8	13.5	17.7
9	13.4	18.0
10	12.5	17.7
11	13.1	16.7
12	13.0	17.5
13	9.8	16.5
14	10.1	18.0
15	13.0	18.6
16	16.6	17.2
17	11.5	17.1
18	14.6	16.8
19	12.5	16.8
20	13.3	17.6
21	11.6	16.0
22	10.1	15.8
23	11.5	16.3
24	9.6	16.0
25	18.5	15.0
26	17.2	15.5
27	15.0	14.7
28	8.5	16.1
29	14.8	14.3
30	11.5	14.5
31	18.0	14.3
32	11.0	13.0
33	14.0	13.2
34	11.0	12.2
35	16.0	12.6
36	19.0	13.7
37	18.0	12.0
38	12.4	12.5
39	12.7	11.5
40	17.8	10.8
41	16.4	10.0
42	20.0	8.9

No.	Captive	Wild
51	14.0	8.6
52	17.2	8.4
53	17.0	7.5
54	17.2	8.6
55	17.0	7.5
56	11.0	8.6
57	16.5	7.5
58	17.0	4.5
59	4.5	5.5
60	8.5	6.5
61	14.5	4.0
62	17.2	4.2
63	17.0	3.2
64	17.0	3.0
65	12.0	16.0
66	13.0	2.2
67	15.2	1.8
68	14.8	14.3
69	7.5	10.3
70	13.5	11.3
71	6.7	12.3
72	7.6	13.2
73	11.2	18.2
74	10.5	14.4
75	6.6	14.5
76	9.0	8.7
77	12.1	8.8
78	9.0	10.4
79	5.5	12.1
80	13.5	10.5
81	11.1	7.6
82	11.0	5.4
83	8.5	5.6
84	7.5	4.7
85	7.0	11.3
86	6.0	10.6
87	5.0	10.7
88	4.8	13.7
89	6.0	9.3
90	8.5	8.5
91	5.5	4.5
92	6.0	11.0

43	17.2	9.5
44	19.0	9.4
45	18.0	8.9
46	15.5	8.8
47	16.7	8.6
48	13.3	8.4
49	21.0	8.1
50	13.5	7.5

93	3.5	11.0
94	3.5	9.5
95	6.0	10.9
96	5.5	4.4
97	2.0	5.5
98	4.5	5.6
99	2.0	3.0
100	13.8	12.1

2) Percentage of carcass component of two samples of Malayan porcupines

Criteria	Malayan Porcupines			
	Sample A (g)	%	Sample B (g)	%
Live weight	8,400.0		4,600.0	
Weight after slaughter	7,600.0		4,000.0	
Blood % blood	800.0	 9.5	600.0	 13.0
Part of (Head, leg and tail) Head Leg Tail Skin+ spine weight	 610.0 150.0 200.0 1,680.0		 320.0 60.0 100.0 800.0	
external offal % external offal Organ part Heart Liver Lung and trachea Kidney Spleen Visceral organ (stomach, intestine, cecum, rectum) Reproductive organ Weight of all organ (internal offal) (% internal offal)	2,640.0 80.0 120.0 80.0 40.0 16.1 1,780.0 200.0 2,316.1	 31.4 27.6	1,280.0 20.0 40.0 20.0 10.0 15.3 700.0 80.0 885.3	 27.8 19.2
Weight of carcass without organ dressing out percentage (% carcass)	2,643.9	 31.5	1,834.7	 39.9
Weight of bone % bone	875.0	 10.4	400	 8.7
Weight of meat % meat	1,768.9	 21.1	1,434.7	 31.2
		100		100

3) Proximate analyses of Malayan porcupine meat

Sample	Dry matter	Ash	Protein	Fat
1	22.033	1.115	18.408	5.22
	22.011	2.48	18.296	5.25
	22.009	1.14	18.487	5.16
	22.0 ± 0.01	1.57 ± 0.45	18.4 ± 0.05	5.21± 0.03
2	21.322	1.0362	16.752	1.53
	21.055	0.84	16.986	1.34
	21.597	0.957	17.216	1.43
	21.3 ± 0.16	0.94 ± 0.05	16.9 ± 0.13	1.43 ± 0.05

4) Minerals analyses of Malayan porcupine meat

Sample	Zn	Mg	K	Ca	Fe	Mn
A	10.92	14.45	376.3	7.92	6.88	0.09
	14.05	12.45	376.35	7.29	5.24	0.11
	14.09	12.17	376.45	9.4	4.95	0.09
	13.02± 1.05	13.02±0.7	376.3± 0.04	8.20±0.63	5.69±0.60	0.933±0.06
B	7.77	7.26	376.5	4.66	3.12	0.35
	12.18	8.97	376.5	9.51	4.34	0.04
	9.67	10.89	376.5	29.33	5.77	0.04
	9.87± 1.27	9.04±1.04	376.5±0.00	14.49±7.54	4.41±0.76	0.14±0.10

PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled "Physical characteristics, carcass composition and nutrient content of Malayan Porcupine meat" by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, University Putra Malaysia Bintulu Campus and published in the form approved by the Faculty.

Ma Sharipah Bt Yusof

Date: 03 May 2007