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# Carcass Analysis and Meat Composition of the Donkey

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**Abstract:** The objective was to determine the meat yield, proximate and mineral composition in donkey carcasses, aged between 5-8 years. Proximate analysis of the minced carcass was done and reported as moisture, dry matter, crude protein, total ash and organic matter. Moisture content was 68.35-74.72% and the dry matter content was 23.68-30.68%. Total ash content was also higher in donkeys (5.10-8.19%) as compared to 1.5-1.09% in beef, however, the organic matter content was slightly lower in donkeys (91.81-94.90%), compared to 98.5 and 98.91% reported in beef. The crude protein content 55.05-62.27 on dry matter basis. Mineral analysis revealed that donkey meat is rich in Fe, P, K and Zn. (For Ca, P, Mg, Cu and Mn), there was no significant difference between the cuts (P< 0.05). However, a significant difference was observed in K, N, Zn and Fe (P< 0.05). The investigation suggested tenderness, juiciness, flavour and odour as being the main criteria, by which consumers judge the quality of donkey meat. The male and female respondents differed significantly in their responses on donkey meat's tenderness and firmness. (P< 0.05).

**Key words:** Meat composition, dressing-out percentage, meat quality, proximate composition

## Introduction

Donkeys *Equus asinus* are domestic animals falling under the equine family, which includes horses, zebras and the mules (Wilson, 1990). The donkey is one of the mans oldest domesticated animals and despite many contributions to the development of various civilizations, this is an animal that has been neglected as an object of scientific inquiry. Donkeys therefore contribute to economic development as they are used in every-day life. They are even used more frequently than cattle and horses and have taken the work that was in the past done by cattle, horses and machinery such as tractors (Starkey, 1994). They are an important means of transport in rural Botswana. They are used mainly for carrying loads, such as firewood, water drums and also commonly used for riding, mainly by children and women. Most traditional households use their donkeys for transport, fetching water and for gathering firewood. (Aganga *et al.,* 1994). Despite the increase in mechanization throughout the world, donkeys are still well deserving of the beasts of burden. They have an important role to play in transport of people and goods in arid and semi-arid areas where roads are poor or non-existent. This is shown by the wide spread use of donkeys in urban and rural areas in Africa, as well as parts of the Central America and Asia. (Aganga *et al.*, 1994).

Most farmers in Botswana are able to keep donkeys because they do not require technical husbandry practices. They are tolerant to some tropical diseases and parasites. Donkeys are therefore easy to manage and not too demanding in terms of feeding. They can almost survive on poor quality feeds and thrive under adverse climatic conditions. They can tolerate a considerable heat and dehydration. (Aganga *et al.*, 2000). Therefore the challenge facing farmers is to make the best use of the resources that are available, while the challenge to livestock researchers and extension officers is to provide information that will help farmers achieve this (Pearson *et al.*, 1997). The people of Botswana are interested in donkey husbandry and so keen to boost their incomes through the use of donkeys. Therefore it would be a good idea for the country to try to improve the poor animals social standing or social position.

The domestic donkey in the tropics is a small hardy animal, which rarely exceeds and usually considerably less than 110cm at the withers and its weight is usually well less than 150 kg. The dominant color is the mousy grey, although the whole range from black to white are generally rare. In a study that was carried out in Gaborone agricultural area, Botswana, it was shown that the mean body weight of a mature donkey is about 140 kg (Aganga and Maphorisa, 1994). In a survey that was carried out in Northern Kenya, the median donkey herd sizes in Samburu and Turkana societies were 4-10 respectively. In both societies the main reason for keeping donkeys was to provide pack transport for water and domestic items. Median weights of loads reported by Samburu and Turkana women were 40 kg and 45 kg respectively. Fifty two percent of the Samburu women indicated that a glass of donkey milk was given to their children as a medicine against whooping cough. For the Turkana women, donkeys were multi purpose, as they not only provide transport, but also milk, blood and meat. Donkeys were used in the dowry payments of both tribes and their exchange value was one cow or 12 sheep/ goats to 1 donkey. (Twerda, 1997). Donkeys are more common in Africa than horses with an exception of Ethiopia and Morocco. Egypt, Nigeria, Mali, Niger and Sudan provide examples of the numerical dominance of donkeys over horses. (Payne and Wilson, 1990). In Botswana, more donkey populations are found in Central region, Maun region and Borolong region, with 55.8, 52.3 and 45.6 respectively. (Botswana Agri. Statistics, 1999)

A liberal meat supply has always been associated with a happy and virile people and has always been the main food available to settlers of new undeveloped territories. (Romans and Zeigler, 1977) The composition of meat cannot be described simply in terms of the different components and their percentages, since meat include the entire carcass, along with the muscles, fatty tissues, bones, tendons, edible organs and glands This obviously gives a wide range of components and thus of composition and nutritive value. Consequently, when speaking about meat, it is necessary to specify the tissue or cuts and whether or not it includes the bone and tendon, as well as the amount of external fat covering and the quantity of marbling. The percentage of separate lean varies widely and it is inversely related to the fat content. It is also interesting to note that the percentage of bone and tendon declines directly with the amount of muscle. Variation in composition results in differences in nutritive value. This is further complicated by the fact that variation in composition also occurs from species to species. Grossly speaking, meat is composed of water, fat, protein, total minerals (ash) and a small proportion of carbohydrate. (Pearson and Gillett, 1999). The composition is measured in terms of the major chemical components such as proteins, fats, carbohydrates, minerals and moisture. The purpose of this study is to determine donkey meat's nutritional value. The study was designed to address the following objectives:

1. To carry out Carcass Analysis, determine lean meat yield and the dressing percentage of Donkeys.
2. To determine Proximate Composition of donkey meat, namely crude protein, moisture content, dry matter content, total ash and organic matter.
3. To determine Mineral composition of donkey meat, namely Phosphorus, Calcium, Magnesium, Iron, Zinc, Manganese and Copper.

## Materials and Methods

The experiment was conducted in Botswana College of Agriculture, Content farm, Sebele, Gaborone. Five donkeys were used in this study (4 female and 1 male) and the carcasses of these animals provided data for this study. The animals were inspected by a veterinarian for obvious diseases and they were all certified as disease free. The age of the animals were estimated using age indicators from the donkeys six bottom incisor teeth as specified by Wesselow (1973). The animals were kept in a fenced enclosure, with some tree species for shade. *Ad libitum* roughage feed was offered daily and a free choice of clean drinking water. About 12 hours prior to slaughter the feeds and water were withdrawn.

**Slaughter protocol/procedure:** A humane slaughter method was used, which consisted of two parts: Stunning and exsanguinations (bleeding). Therefore the slaughtering process involved rendering the animal insensible by stunning and then killing completely by bleeding.

**Stunning method used:** A penetrative percussive stunning method was used, which involved the use of a captive bolt piston (stunning gun). The piston was triggered to fire a steel rod through the animal's skull into the brain, thus rendering it insensible to pain.

**Bleeding:** Bleeding was carried out by an incision on the Jugular furrow at the occipito-atlantal junction close to the head, severing both the carotid arteries, jugular veins, trachea, oesophagus and the spinal cord. The animal therefore died from cerebral anoxia resulting from bleeding before sensibility returned Immediately after slaughter, the head was removed at the Atlanta-occipital joint and the fore and hind feet at the carpal and tarsal joints respectively. The head was removed and the carcass was hung by the hind legs using a pulley and then skinned. Immediately after skinning evisceration was carried out and the carcass components were weighed.

The carcass was then split along the mid line and the right half carcass was randomly selected and cut into hip, sirloin, loin, flank, rib, plate, chuck, brisket and shank as per the beef information centre, specifications (Ashrook, 1955). The percent composition of the cuts was calculated as a proportion of the chilled half carcass weight, the carcass was chilled and then dissected into lean, fat and bone The lean was then ground using an electric mini-meat mincer. The samples were ground through a 4.7 mm hole plate to obtain a homogeneous mince.

**Panel of tasters:** All portions of the meat cuts were given to a panel of randomly selected tasters. The total number of tasters was 25, being composed of 14 men and 11 women. The panelists were given the guidelines on meat attributes and were asked to assess each sample for the following attributes:

| | |
|---|---|
| Colour | Cherry red to dark red |
| Liking of aroma (odour) | Natural to pronounced off flavour |
| Strength of aroma (odour) | Strong to weak (odourless) |
| Liking of flavour | Very good to tasteless (very |

| | |
|---|---|
| | poor) |
| Strength of flavour | Strong to weak |
| Juiciness | Very moist to very dry |
| Tenderness | Very tender to very tough |
| Firmness | Very firm to very soft |
| Overall | Excellent to very poor |

For all the attributes, the scores ranged from 5-1 as shown in the taste panel score sheets. Certain attributes such as appearance were excluded, as they are regarded as kitchen controlled and not part of the product tested. (Levie, 1979). Frequencies and the mean scores are presented in the results.

**Dressing percentage:** It is used to compare the dead weight, with the live weight and expressed as a % of the live weight of the animal. It is a comparison of the carcass yield in relation to the live weight. (Ledger, 1994).

$$\text{Dressing \%} = \frac{\text{Cold carcass weight X 100}}{\text{Live weight}}$$

$$\text{Dressing \%} = \frac{\text{Hot carcass weight X 100}}{\text{Live weight}}$$

(Warriss, 2000)

Table 1: Approximate killing-out percentages for different species

| Species | Killing out percentage |
|---|---|
| Sheep | 50 |
| Cattle | 53 |
| Pigs | 75 |
| Broiler chickens | 72 |

Adapted from Warris, 2000

Table 2: Composition of lean Meat

| Component | Percentage Net Weight |
|---|---|
| Water | 75.0 |
| Protein | 19.0 |
| Lipids | 2.5 |
| Carbohydrate | 1.2 |
| Non- protein N | 1.65 |
| Minerals | 0.65 |
| Vitamins | minute quantities |

Adopted from (Gracey *et al.*, 1972 page: 59)

**Chemical Analysis:** The dried ground samples were subjected to chemical analysis using the procedures of (AOAC, 1996) on meat and meat products. Proximate and Mineral analysis were done.

**Statistical Analysis:** The experiment employed a Completely Randomized Block Design in which each donkey was treated as a replicate and the cuts as dependent variables. Data analysis was done using, Analysis of Variance (ANOVA) according to the Statistical Analysis System (Snedecor and Cochran, 1989) and the general linear model procedure was used for the taste panel results because of the unequal numbers of males and females. Differences among sample means were tested for significance with Duncan's multiple-range test (Duncan, 1955), at a significance level ($P< 0.05$). The panelists score sheets were analyzed using frequencies, means and the standard error of means. Individual means between the male and female tasters were separated using a t-test. (Significance level $P< 0.05$, $P< 0.01$).

## Results and Discussion

### Carcass Yield Or Dressing Out Percentage

Table 3: Proximate killing out percentages for Beef animals, compared to Donkeys, calculated on hot carcass weight

| Age (years) | Beef (Steers)+ | Donkeys |
|---|---|---|
| 5 | 57.5 | 59.5 |
| 6 | 57 | 57.5 |
| 6.5 | 56 | 57 |
| 7 | 54 | 54.5 |

(+ Gerrard, 1977)

As shown in Table 3, donkeys have a slightly higher carcass yield compared to cattle. This is further explained by (Gerrard, 1977) that the dressing out percentage depends upon the stage of maturity, degree of finish, breed and the intestinal contents (offals). Donkeys as non-ruminants have a slightly lower offal contents. Since they lack a rumen, therefore, most of the digestion takes place in the caecum and the small intestines. Basing on the data, as animals get older, their carcass yield declines. Warriss (2000) supported by saying that when animals get older and heavier, the proportion of fat in their carcass increases and the proportion of muscles and bone decreases. This is due to the fact that fat, particularly subcutaneous fat is the least tissue to mature, thus older animals tend to be fatter and the percentages of muscle and bone decreasing progressively.

### Proximate Composition

**CUTS:** Hip (1) Sirloin (2) Loin (3) Flank (4) Rib (5) Plate (6) Chuck (7) Brisket (8) Shank (9)

There were several distinctions between proximate composition in beef and donkeys.

**Moisture:** The moisture content was lower for donkeys (68.35-74.72%) Table 6 and slightly higher for beef as shown by Libby (1975) and Srinivasan *et al.* (1998), which reported mean values of 75 and 77.12% respectively (Table 4 and Table 5).

Table 4: Proximate composition of muscle tissues from steers fed on grass and grain from grass

| Composition (%) | SM Muscle | | Cardiac Muscle | |
|---|---|---|---|---|
| | G | GG | G | GG |
| Moisture | 77.12 ± 0.91[b] | 75.23 ± 1.00[c] | 79.24 ± 0.62[a] | 78.99 ± 0.75[a] |
| Protein | 20.07 ± 0.16[c] | 22.23 ± 0.51[b] | 18.02 ± 0.07[d,e] | 17.82 ± 0.13[e] |
| Fat | 1.28 ± 0.10[c] | 1.97 ± 0.38[c] | 3.62 ± 0.37[b] | 4.66 ± 0.74[a] |
| Total ash | 1.09 ± 0.07[b] | 1.11 ± 0.04[b] | 1.04 ± 0.02[c] | 1.04±0.01[c] |

G = Steers fed on grass, GG = Steers fed on grain on grass. [a b c d], Means± (SD) within a row with the same superscript are not significantly different (P< 0.05). (Adapted from Srinivasan *et al.*, 1998: page 546)

Table 5: Proximate composition of lean beef muscle tissue

| | | | |
|---|---|---|---|
| Moisture | 75 | Dry Matter | 25 |
| Protein | 18 | | |
| Fat | 3 | | |
| Total ash | 1.5 | Organic Matter | 98.5 |

(Adapted from Libby, 1975)

Table 6: Proximate composition of Donkey carcasses, aged between 5-8 years

| | Composition (%) | | | | |
|---|---|---|---|---|---|
| Cuts | Moisture | Dry matter | Ash | OM | CP (N x 6.25) |
| 1. | 74.72 ± 0.85[a] | 23.68 ± 1.05[b] | 8.11 ± 1.59[a] | 91.90 ±1.59[a] | 62.27 ± 0.75 |
| 2. | 72.51 ± 0.91[a,b] | 27.49 ± 0.91[a,b] | 8.19 ± 1.58[a] | 91.81 ± 1.58[a] | 58.47 ± 1.05[b] |
| 3. | 71.24 ± 1.81[a,b] | 27.99 ± 1.81[a,b] | 5.62 ± 0.69[a] | 94.38 ± 0.69[a] | 56.51 ± 1.02[c,b] |
| 6. | 68.35 ± 2.75[b] | 30.68 ± 2.34[a] | 5.60 ± 0.94[a] | 94.40 ± 0.94[a] | 56.81 ± 1.03[c,b] |
| 7. | 71.69 ± 1.79[a,b] | 28.31 ± 1.79[a,b] | 8.02 ± 1.79[a] | 91.98 ± 1.79[a] | 55.60 ± 0.89[c,b] |
| 8. | 71.05 ± 1.26[a,b] | 28.95 ± 1.26[a] | 5.28 ± 0.71[a] | 94.72 ± 0.71[a] | 55.05 ± 1.08[c] |
| 9. | 73.35 ± 1.01[a] | 26.65 ± 1.01[a,b] | 5.10 ± 0.55[a] | 94.90 ± 0.55[a] | 56.83 ± 0.71[c,b] |

a, b Means (± SEM) within a column with the same superscript are not significantly (P>0.05) different. Class: cuts Levels: 9, DF: 8, OM = Organic Matter, CP = Crude Protein

Gracey (1972), supported Libby (1975), by reporting moisture content of 75% in lean beef (Table 2). The lower moisture levels in donkeys is due to the fact that water loss by donkeys is 2-4 times that of cattle and camels, under comparable conditions. Donkeys like other Equips, dissipate heat mainly by sweating and the sweat glands are found all over the body. Sweating rates of 145g water/m$^2$ body area per hour occur at high ambient temperatures and respiration rates can rise from normal 14-30 to as high as 130 breaths per min. (Payne and Wilson, 1999).

Water is a major constituent (70-78%) of lean muscle tissue and within a muscle is inversely related to the fat content. The fatter the animal, the less the moisture. Libby (1975). However, the specific details cannot be mentioned regarding donkeys, as the crude fat content was not determined due to time constraints.

The hip had a higher mean (74.72%), followed by the shank (73.35%) and the plate had the least mean of (68.35%). Other cuts did not have any significant difference (Table 6). These results are correct because the hip is composed of more lean than fat and the plate is composed of more fat than lean.

As can be seen from the data, water is the most variable of these proximate components, but is closely and inversely related to the fat content and to a lesser extent to the ash and the carbohydrate content. In general terms, if the fat content is held relatively constant, the percentage of water declines, until the animal's body reaches chemical maturity, regardless of the species. However, as the animals mature, they also usually increase in fatness, which causes an even greater decline in the percentage of water (Pearson and Gillett, 1999).

**Dry matter:** The dry matter content for donkeys was slightly higher (23.68-30.68), compared to beef. Libby (1975) reported a dry matter content of 25% in beef, while Srinivasan *et al.*, 1998) reported a slightly lower value of 22.9%.

All the cuts were not significantly different (P > 0.05) except the hip, which showed a lower mean value of (22.68%) and the plate with a higher mean of (30.68%) (Table 6).

This indicates that the dry matter is calculated as a residue after determining the moisture content.

Table 7: Mineral composition of SM and Cardiac muscles from steers fed grass (G) and grain on grass (GG)

| Mineral (Mg /100g) | SM muscle | | Cardiac muscle | |
|---|---|---|---|---|
| | G | GG | G | GG |
| Sodium | $46 \pm 5^{b}$ | $50 \pm 4^{b}$ | $146 \pm 44^{a}$ | $135 \pm 24^{a}$ |
| Potassium | $147 \pm 32^{c}$ | $191 \pm 32^{b}$ | $160 \pm 24^{b,c}$ | $120 \pm 43^{d}$ |
| Calcium | $10 \pm 2^{a,b}$ | $11 \pm 2^{a}$ | $5 \pm 1^{c,d}$ | $7 \pm 1^{b,c}$ |
| Iron | $3.7 \pm 0.4^{b}$ | $2.7 \pm 0.6^{c}$ | $5.4 \pm 0.1^{a}$ | $4.9 \pm 0.7^{a}$ |
| Copper | $0.17 \pm 0.10^{a,b}$ | $0.10 \pm 0.04^{b}$ | $0.21 \pm 0.02^{a,b}$ | $0.27 \pm 0.03^{a}$ |

[a,b,c,d]Means(± SD) within a row with the same superscript are not significantly(P>0.05) different. SM: Semi-membranous muscle. (Adapted from Srinivasan *et al.*, 1998: page 546).

Table 8: Minerals present in lean beef

| Element | % in lean meat | Element | % in lean meat |
|---|---|---|---|
| Potassium | 0.184 - 0.415 | Phosphorus | 0.131 - 0.343 |
| Magnesium | 0.019 - 0.033 | Calcium | 0.008 - 0.020 |
| Iron | 0.001 - 0.005 | Zinc | 0.002 - 0.006 |

(Adopted from Libby, 1975: page 243)

Table 9: Some selected values showing the minerals of various cuts of meat, expressed as amount per 100g edible portions

| Product description | Ca | P | Fe | Na | K |
|---|---|---|---|---|---|
| Beef carcass: | | | | | |
| Good grade | 10 | 152 | 2.5 | 65 | 355 |
| Standard grade | 10 | 166 | 2.7 | 65 | 355 |
| Commercial grade | 9 | 145 | 2.4 | 65 | 355 |
| Utility grade | 11 | 172 | 2.8 | 65 | 355 |

(Adopted from Pearson and Gillett, 1999 page: 32-33)

Therefore, where moisture content is high, then the dry matter is low, as these are inversely related. (Koniecko, 1979).

**Total ash:** The total ash content in donkey cuts was too high (5.10-8.19%), compared to that of beef. Libby, 1975, reported (1.5%), Table 4, while Srinivasan *et al.*, 1998, were slightly lower, reporting a mean value of 1.09% (Table 4).

Ash, (almost synonymous with inorganic minerals) content of muscle tissue, is approximately (1%). Ash content accurately reflects the mineral content, but does not differentiate between minerals. Because of the relatively low content of minerals in fatty tissues, the fat level also indirectly influences the mineral or ash content of meat and meat products (Pearson and Gillett, 1999).

**Organic matter:** The organic matter was lower in donkeys (91.81-94.90%) and higher in beef, as the two are also inversely related. The composition of organic matter was within the range of values reported in the literature. Srinivasan *et al.*, 1998) reported a value of (98.91%) Table 6, while Libby (1975) also reported a value of (98.91%) (Table 6). Organic matter in meat represents complex compounds of Carbon(C), Hydrogen (O) and Oxygen (O). (Warriss, 2000).

There was no significant difference in the means of the donkey cuts (P>0.05), as shown by the Duncan's grouping (Table 6).

**Crude protein:** The protein content is high (55.05-62.75% on dry matter basis) for donkey meat, than the crude protein in beef. Warriss (2000) reported a protein content of 20% in beef, Srinivasan *et al.* (1998), also reported a mean value of 20.07%, Table 4, while Libby, 1975), reported a value of 18% crude protein in lean beef muscle tissue (Table 5). Gracey *et al.*, 1972, reported 19.0% in lean meat. The mean value of crude protein in donkeys was 3 times higher than the value of crude protein in beef as reported by various authors.

From the standpoint of nutrition, the Nitrogenous components of meat are the most important. Proteins are polypeptides or combinations of amino acids, linked together into chains by the reaction of amino and carboxyl groups of adjoining amino acids, by means of peptide linkages. (Pearson and Gillett, 1999).

However, the hip was significantly different (P<0.05), from other cuts, showing a higher mean of (62.27%) crude protein. The sirloin, flank and the brisket were also significantly different (P < 0.05), showing the mean of 58.47, 58.54 and 55.05% respectively. Other cuts were not significantly different (P> 0.05). From this data (Table

Table 10: Mineral Composition of donkey cuts aged between 5-8 years

| Cuts | Composition (%), macro minerals | | | | |
|---|---|---|---|---|---|
| | Ca | P | Mg | K | N |
| 1 | $0.095 \pm 0.014^{a}$ | $0.182 \pm 0.007^{a}$ | $0.081 \pm 0.006^{a}$ | $0.414 \pm 0.010^{a}$ | $9.997 \pm 0.128^{a}$ |
| 2 | $0.112 \pm 0.020^{a}$ | $0.195 \pm 0.002^{a}$ | $0.074 \pm 0.011^{a}$ | $0.358 \pm 0.030^{b,c}$ | $9.362 \pm 0.166^{b}$ |
| 3 | $0.124 \pm 0.035^{a}$ | $0.184 \pm 0.004^{a}$ | $0.061 \pm 0.010^{a}$ | $0.362 \pm 0.018^{b,c}$ | $9.012 \pm 0.214^{bc}$ |
| 4 | $0.159 \pm 0.047^{a}$ | $0.167 \pm 0.006^{a}$ | $0.061 \pm 0.009^{a}$ | $0.357 \pm 0.016^{b,c}$ | $9.368 \pm 0.076^{b}$ |
| 5 | $0.120 \pm 0.015^{a}$ | $0.182 \pm 0.007^{a}$ | $0.064 \pm 0.009^{a}$ | $0.399 \pm 0.009^{a,b}$ | $9.043 \pm 0.163^{b,c}$ |
| 6 | $0.146 \pm 0.032^{a}$ | $0.174 \pm 0.006^{a}$ | $0.057 \pm 0.007^{a}$ | $0.382 \pm 0.007^{a,b,c}$ | $9.091 \pm 0.166^{b}$ |
| 7 | $0.121 \pm 0.029^{a}$ | $0.167 \pm 0.010^{a}$ | $0.066 \pm 0.009^{a}$ | $0.287 \pm 0.016^{d}$ | $8.901 \pm 0.143^{b,c}$ |
| 8 | $0.128 \pm 0.022^{a}$ | $0.173 \pm 0.013^{a}$ | $0.069 \pm 0.009^{a}$ | $0.342 \pm 0.014^{c}$ | $8.810 \pm 0.172^{c}$ |
| 9 | $0.160 \pm 0.046^{a}$ | $0.183 \pm 0.014^{a}$ | $0.057 \pm 0.008^{a}$ | $0.341 \pm 0.012^{c}$ | $9.128 \pm 0.119^{b,c}$ |

[a,b,c,d] Means(± SEM) within a column with the same superscript are significantly (P>0.005) different. Levels: 9, DF: 8

Table 11: Mineral composition of donkey carcasses aged between 5-8 years

| Cuts | Composition (ppm) Trace minerals | | | |
|---|---|---|---|---|
| | Zn | Fe | Cu | Mn |
| 1 | $3.024 \pm 0.345^{a,b}$ | $35.246 \pm 3.138^{a,b}$ | $0.052 \pm 0.003^{a}$ | $0.292 \pm 0.043^{a}$ |
| 2 | $3.847 \pm 0.181^{a}$ | $29.096 \pm 1.469^{b}$ | $0.062 \pm 0.004^{a}$ | $0.215 \pm 0.018^{a}$ |
| 3 | $3.418 \pm 0.188^{a,b}$ | $31.440 \pm 0.633^{a,b}$ | $0.060 \pm 0.005^{a}$ | $0.252 \pm 0.024^{a}$ |
| 4 | $3.460 \pm 0.286^{a,b}$ | $35.838 \pm 3.738^{a}$ | $0.060 \pm 0.005^{a}$ | $0.266 \pm 0.028^{a}$ |
| 5 | $3.161 \pm 0.376^{a,b}$ | $32.418 \pm 1.648^{a,b}$ | $0.062 \pm 0.006^{a}$ | $0.219 \pm 0.024^{a}$ |
| 6 | $3.472 \pm 0.435^{a,b}$ | $33.363 \pm 2.404^{a,b}$ | $0.062 \pm 0.007^{a}$ | $0.220 \pm 0.035^{a}$ |
| 7 | $2.623 \pm 0.347^{b}$ | $32.245 \pm 0.619^{a,b}$ | $0.064 \pm 0.006^{a}$ | $0.217 \pm 0.023^{a}$ |
| 8 | $3.794 \pm 0.180^{a}$ | $34.604 \pm 0.737^{a,b}$ | $0.064 \pm 0.004^{a}$ | $0.222 \pm 0.020^{a}$ |

a,b,c,d Means(± SEM) within a column with the same superscript are not significantly (P > 0.05) different.

6), it was established that the hip, flank and the sirloin were relatively higher in crude protein compared to other cuts.

**Phosphorus and Calcium:** Mineral analysis revealed that donkey meat is good in Nitrogen, Phosphorus, Potassium, Zinc and Iron. However, Libby, 1975 reported higher percentage of Potassium and Phosphorus in lean beef (Table 8) and Srinivasan *et al.* (1998) reported higher mean values of Sodium, Potassium and Iron, presented in mg/100g of muscle. Meat is also reported to be a good source of dietary Phosphorus and Iron, but low in Calcium (Pearson and Gillett, 1999).

Pearson and Gillett stated that calcium is the most abundant mineral element in the animal body and described it as an important constituent of the skeleton and teeth, in which about 99% of the total body calcium is found. Calcium is essential for the activity of a number of enzyme systems, including those necessary for the transmission of nerve impulses. This clearly explains why the calcium content was low in the flesh of beef (Table 7 and 8) as well as in the donkey cuts (Table 10). Pearson and Gillett (1999) reported that meat is a good source of Phosphorus compared to Calcium (Table 9). The data on donkey cuts agree with Pearson and Gillett (1999), by showing a P mean ranging from 0.167-0.195%, which was higher than that of Ca (0.095-0.160%) (Table 10). Libby, 1975, further supported Pearson and Gillett (1999), reporting a P % of 0.131, as compared to 0.008% of Ca in lean beef (Table 8). However, there was no significant difference between the donkey cuts (P > 0.05) in both P and Ca (Table 10).

**Nitrogen:** The Nitrogen content was higher (8.810-9.99%), indicating higher levels of crude protein. The hip was higher in N (9.997%) and the brisket was lower (8.810%). The sirloin and the flank were not significantly different, 9.362 and 9.368% N respectively. Other cuts differed significantly (P < 0.05).

**Magnesium:** The magnesium levels were also higher in donkeys (0.057-0.081) (Table 10) as compared to (0.018-0.033%), reported by Libby, 1975 (Table 8).

Magnesium is closely associated with Calcium and Phosphorus and about 70% of the total Mg is found in the skeleton. Magnesium is an enzyme activator, for example in systems with thiamine pyrophosphate as a cofactor and oxidative phosphorylation is reduced in Mg deficiency. It is an essential activator of phosphate transferase, activates pyruvate carboxylase, pyruvate oxidase and the reactions of the tricarboxylic acid cycle. Thus, it can be seen that Mg is a key element in cellular biochemistry and function. (McDonald *et al.*, 1995).The Mg concentration was not significantly different in donkey

**Taste Panel Results**

Table 12: The frequency procedure for the taste panel assessment (1-5 scale) for meat from donkeys

| Question | Frequency | % of panel Scoring | M | F | Cum. frequency | Cum. %. |
|---|---|---|---|---|---|---|
| Q. 1 Colour | | | | | | |
| 1- dark red | 6 | 24.00 | 8 | 16 | 6 | 24.00 |
| 2- slightly dark red | 9 | 36.00 | 20 | 16 | 15 | 60.00 |
| 3- red | 8 | 32.00 | 20 | 12 | 23 | 93.00 |
| 4- light red | 2 | 8.00 | 8 | 0 | 25 | 100.00 |
| Q.2. Odour (Aroma) | | | | | | |
| 2- slightly off flavour | 7 | 28.00 | 8 | 20 | 7 | 28.00 |
| 3- moderate | 8 | 32.00 | 12 | 20 | 15 | 60.00 |
| 4- good | 7 | 28.00 | 28 | 0 | 22 | 88.00 |
| 5- natural | 3 | 12.00 | 10 | 2 | 25 | 100.00 |
| Q.3. Odour intensity | | | | | | |
| 2- slight odour | 5 | 20.00 | 12 | 8 | 5 | 20.00 |
| 3- moderate | 16 | 64.00 | 36 | 28 | 21 | 84.00 |
| 4- fairly strong | 4 | 16.00 | 8 | 8 | 25 | 100.00 |
| Q.4. Flavour | | | | | | |
| 2- fair | 3 | 12.00 | 4 | 8 | 3 | 12.00 |
| 3- moderate | 5 | 20.00 | 16 | 4 | 8 | 32.00 |
| 4- good | 11 | 44.00 | 20 | 24 | 19 | 76.00 |
| 5- very good | 6 | 24.00 | 12 | 12 | 25 | 100.00 |
| Q.5. Juiciness | | | | | | |
| 2- dry | 1 | 4.00 | 0 | 4 | 1 | 4.00 |
| 3- moderate | 20 | 80.00 | 44 | 36 | 21 | 84.00 |
| 4- juicy | 3 | 12.00 | 6 | 6 | 24 | 96.00 |
| 5-very juicy | 1 | 4.00 | 0 | 4 | 25 | 100.00 |
| Q. 6. Tenderness | | | | | | |
| 2- tough | 1 | 4.00 | 4 | 0 | 1 | 4.00 |
| 3- moderate | 6 | 24.00 | 4 | 20 | 7 | 28.00 |
| 4- tender | 17 | 68.00 | 28 | 40 | 24 | 96.00 |
| 5- very tender | 1 | 4.00 | 0 | 4 | 25 | 100.00 |
| Q. 7. Firmness | | | | | | |
| 2- soft | 10 | 40.00 | 32 | 8 | 10 | 40.00 |
| 3- slightly firm | 12 | 48.00 | 20 | 28 | 22 | 88.00 |
| 4- firm | 3 | 12.00 | 4 | 8 | 25 | 100.00 |

Table 13: Predicted means (S.E) for taste panel assessment (1-5 scale) of colour, aroma (odour), odour intensity, flavour, juiciness, tenderness and firmness of donkeys aged between 5-8 years

| Variable | Mean | Standard Error (S.E) | Variable | Mean | Standard Error (S.E) |
|---|---|---|---|---|---|
| Q. 1 - Colour | 2.2 | 0.2 | Q. 5 - Juiciness | 3.2 | 0.1 |
| Q. 2 - Odour | 3.2 | 0.2 | Q. 6 - Tenderness | 3.7 | 0.1 |
| Q. 3 - Odour intensity | 3.0 | 0.1 | Q. 7 - Firmness | 2.7 | 0.1 |
| Q. 4 - Flavour | 3.8 | 0.2 | | | |

cuts (P> 0.05) (Table 10).

**Potassium:** The K levels in donkeys ranged from (0.287-0.414%), which agreed with Libby (1975) who reported 0.184-0.415% in lean beef (Table 8). The concentration of K was the highest among minerals that were quantified in semi-membranous muscle of steers. This agreed with the published data for Pearson and Gillett, 1999. Table 9 however this was not the case in Cardiac muscle, where both K and Sodium were present in large quantities. (Srinivasan *et al.*, 1998). Table 7. Potassium is important in osmotic regulation of the body fluids and in acid base-balance in the animal It plays an important part and nerve and muscle excitability and in carbohydrate metabolism. (McDonald, *et al.*, 1995). The hip had slightly higher K levels (0.414%) and the chuck was lower (0.287%). The brisket and the shank were not significantly different and all other cuts showed a significant difference. (P > 0.05) Table 10.

**Iron:** The iron concentration in donkeys was the highest

(30.958-35.838 ppm), when compared to other trace minerals, Zinc, Copper and Manganese. Srinivasan *et al.* (1998) reported the Iron content of 3.7 mg/100g in SM muscles and a 5.4 mg/100g in cardiac muscle, which were lower than Sodium, Potassium and Calcium (Table 7).

Libby (1975), reported 0.001-0.005% of Iron in lean beef which was also lower than Potassium, Phosphorus and Magnesium. The flank was higher in Iron (35.835 ppm) and the sirloin was lower (29.096 ppm). Other cuts were significantly different (P>0.05) Table 11. Meat is a major source of iron. Iron in meat has a high bioavailability, the main reservoir being as a component of the haem protein my globin. Iron deficiency is the most common nutritional deficiency in the world. (Warriss, 2000). More than 90% of the Iron in the body is combined with proteins, most important being haemoglobin, which contains about 3.4g/kg of the element. It has a major role in a host of biochemical reactions, particularly in connection with enzymes of the electron transport chain (Cytochromes). Electrons are transported by the oxidation and reduction activity of bound iron. (McDonald *et al.*, 1995)

**Zinc:** Zinc was the second in abundance after Iron in the donkey cuts (3.024-3.794 ppm). The sirloin and the brisket were not significantly different and the chuck had the lowest mean (2.623 ppm). Other cuts were significantly different (P > 0.05).

Zinc has been found in every tissue in the animal's body. The element tends to accumulate in the bones rather than the liver, which is the main storage organ of many of the other trace elements. High concentration has been found in the skin, hair and wool of animals. It is an activator of several enzyme systems. It is involved in cell replication and differentiation, particularly in nucleic acid metabolism. It is also involved in production, storage and secretion of hormones, in immune system and electrolyte balance. (McDonald *et al.*, 1995). Copper and Manganese concentrations were not significantly different between the donkey cuts. (P< 0.05) Table 11.

It was necessary to establish which characteristics of quality in donkey meat were most important to consumers and to examine both their relative influences on satisfaction and what were the mass requirements in respect of each characteristic.

Table 12 summarizes the average response of the panelists and shows in a general way, the extent to which the panelists detected differences in colour, odour (aroma), odour intensity, flavour, juiciness, tenderness and firmness. It is worth commenting that there were differences among the respondents. A total of 36% of the respondents believed the donkey meat to be slightly dark red in colour (20% male and 16% female). The characteristic of colour and appearance are determined by two main factors, the concentration and the state of the haem pigments, myoglobin (Mb) and the haemoglobin (Hb). The myoglobin (Mb), oxymyoglobin ($MbO_2$) and the met myoglobin (met Mb) and their three haemoglobin equivalents, are the common forms of the pigments that occur in meat. The formation of oxymyoglobin from myoglobin involves the attachment of an oxygen molecule ($O_2$), to the myoglobin molecule. Myoglobin is purple in colour, Oxymyoglobin is bright red and Met myoglobin is grey-brown in colour. To the consumers the bright red colour of the Oxymyoglobin is desirable as the colour of fresh meat, whereas the purple and the grey-brown of the other two forms of the pigment are less desirable. (Warriss, 2000).

Since the meat is believed to have a slightly-dark red colour, according to (Warriss, 2000) the meat has a desirable colour. This colour however explains the depth of Ox haemoglobin layer. The depth of the Oxyhaemgplobin layer depends on the extent of penetration of $O_2$ from the atmosphere. However, describing the colour of meat subjectively is rather difficult, because the perception of colour depends entirely on the individual.

The consumer panels were also asked to score the intensity of the flavour they believed the donkey meat possessed, according to the five-point schedule. There was an indication that consumers were on average; able to distinguish the flavour of donkey meat. 44% of the respondents believed that the donkey meat has a good flavour (20% male and 24% female). An equal number of respondents (12% male and 12% female) believed that the meat had no off-flavours (Very good). However, there are two components of flavour: taste and aroma (Smell). Aroma or smell is produced by volatile substances that are detected by olfactory receptors in the passages at the back of the nose. The information from the tongue and the nose is integrated and interpreted by the brain. Raw meat has little flavour. Only on heating during cooking do the characteristic flavours associated with meat develop. These flavours have two aspects: on-species-specific component common to all meat and the species-specific component, that determines the differences between beef, lamb, pork and chicken. Species-specific flavour comes from heating the fats present in meat, especially the phospholipids and to a lesser degree the triglycerides.

**Juiciness:** A greater percentage of respondents (80%), believed that donkey meat is moderately juicy. (44% male and 36% female) The water holding capacity of the meat (WHC) influences juiciness of the meat. Meat with low WHC loses a lot of fluid in cooking and may taste dry and lack succulence. When measuring meat texture, some estimation of potential juiciness is made and this made from chemical analysis of the amount of fat in the meat. Since donkey meat is moderately juicy, this implies that there is less fat content.

Table 14: A t-test procedure to check for any significant difference between males and females in determining the meat quality attributes of donkey meat

| Variable | Method | Variances | DF | t - value | Pr > I t I | Significance |
|---|---|---|---|---|---|---|
| Q .1 | Satterthwaite | Unequal | 22.6 | -1.66 | 0.1098 | ns |
| Q .2 | Satterthwaite | Unequal | 16.5 | -0.24 | 0.8149 | ns |
| Q. 3 | Sattrethwaite | Unequal | 21.3 | 0.28 | 0.7795 | ns |
| Q. 4 | Satterthwaite | Unequal | 22.6 | 0.94 | 0.3587 | ns |
| Q. 5 | Satterhtwaite | Unequal | 15.6 | -0.51 | 0.6143 | ns |
| Q. 6 | Satterthwaite | Unequal | 19.3 | 3.39 | 0.0030 | * * |
| Q. 7 | Satterthwaite | Unequal | 19.3 | -2.53 | 0.0203 | * |

* P< 0.05(Significant at P< 0.05). ** P< 0.01(Significant at P< 0.01)

**Tenderness:** 68% of the respondents believed that the meat is tender (28% male and 40% female). Meat with a high WHC tends to be tendered. However, tenderness can be influenced by the cooking method. High cooking temperatures can reduce tenderness, as well as long cooking times. Cooking by boiling can tenderize meat containing large amounts of connective tissue by converting it to gelatin (Warriss, 2000). The perception of tenderness is also based on the ease of penetration of the meat by the teeth, ease of fragmentation of the meat and the size of the residue remaining after chewing (the chewy bit). Other factors affecting tenderness are: pre-rigor meat temperatures, rate of PH fall, ultimate PH of the meat, preservation and cooking methods, sex, age and the species of the animal (Warriss, 2000).

**Firmness:** 48% of the respondents believed that the donkey meat is slightly firm (20% male and 28% female). The cooking method and the ease of penetration of the meat by teeth also influences firmness. The age of the animal, the species and the purpose of the animal will also influence the firmness of meat. Therefore the meat for donkeys is expected to be slightly firm because they are used for drought purposes but not as meat animals.

This investigation suggested tenderness, juiciness and flavour and odour as being the main criteria by which consumers judge the quality of donkey meat. This is indicated by the means in Table 13, showing a mean of 3.8, 3.7 and 3.2 for flavour, tenderness odour and juiciness respectively. According to Brayshaw *et al.* (1967), preliminary investigation suggested tenderness, leanness and flavour as being the main criteria by which consumers judge the quality of beef.

The t-test procedure clearly shows that there was no significant difference between the male and the female respondents regarding colour, odour, odour intensity, flavour and juiciness (P> 0.05). However, a significant difference was observed in tenderness and firmness. (P< 0.05 and P< 0.01) Table 14.

**Conclusion:** The investigation revealed that donkey meat is good quality meat. The data indicates that the meat is very high in crude protein, compared to beef and high in important minerals such as Fe, Zn, K and P. It is important to consider the significance of donkeys in Botswana and how best to utilize the donkey products. Therefore, donkeys should not be undermined, because with some attention given to them, they can become an appropriate technology. The people of Botswana can also generate income from the sale of donkeys as well as their products.

**Recommendations:** The donkey (*Equus asinus*) should be used as a cheap meat animal because it has high quality meat .There should be markets for donkeys in Botswana. This will reduce the current problem of high donkey populations, which causes serious problem of overgrazing and soil erosion.

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