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Chapter 6

QUALITY AND NUTRITIONAL CHARACTERISTICS OF DONKEY MEAT

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ABSTRACT

Meat has exerted a crucial role in human evolution and is an important component of a healthy and well balanced diet due to its nutritional richness. The aim of the present chapter is to shed light on the nutritional composition of donkey meat and the implications for human health. Donkeys are not perceived as multi-use animals. Cattle, buffaloes and camels are usually kept for their milk and their meat as well as for work. In many areas donkeys are not sold for their meat. One of many exceptions is Lesotho where donkeys are culled for meat when they are considered too old to work, and for this reason donkeys are relatively expensive in this Country. In the rest of the world, the lower cost of donkeys makes them more affordable to small farmers. On the other hand, donkey meat can be considered a good alternative in red meat consumption, being a dietary meat. Donkey meat is in fact characterized by low fat, low cholesterol content, a favourable fatty acid profile and is rich in iron. Today consumers are health conscious and demand high quality food products; they require leaner meat, with less fat (the minimal fat level required to maintain juiciness and flavour) and a consistent quality. Ultimately, the success of any food product is determined by the consumer's acceptance. Meat quality and acceptability is determined by

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its physico-chemical characteristics, although consumer preferences for meat are difficult to define. In this context, this chapter will describe the quality of donkey carcass and donkey meat quality parameters, showing its chemical and sensorial characteristics (when possible in different muscles) and evaluating the effects of the age of slaughtering.

Keywords: donkey meat, donkey carcass, meat quality, meat nutritional value

INTRODUCTION

Donkeys are said to have originated in north-east Africa and then spread to other parts of the world. The world donkey population is about 44 million; half is found in Asia, just over one quarter in Africa and the rest mainly in Latin America. There are pictures of donkeys in the tombs of the Egyptian pharaohs and 82 biblical references to donkeys. The ancient Romans used donkeys for pack transport and agriculture.

Donkey (*Equus asinus, Perissodactyla*) is a domestic animal belonging to the equine family, which includes horses, zebras and mules, and its progenitor was the small gray donkey of northern Africa (*Equus africanus*) domesticated around 4000 BC on the shores of the Mediterranean Sea. Donkey has been domesticated for thousands of years (Aganga et al., 2003), and has contributed to the development of various civilizations. Despite the increase in mechanization throughout the world, donkeys have still an important role to play in transport of people and goods in arid and semi-arid areas where roads are poor or non-existent. 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, and they can also tolerate a considerable heat and dehydration (Aganga et al., 1994).

Figure 1. Amiata breed (Italy).

Donkeys are not perceived as multi-use animals. Cattle, buffaloes and camels are usually kept for their milk and their meat as well as for work. In many areas donkeys are not sold for their meat. One of many exceptions is Lesotho where donkeys are culled for meat when they are considered too old to work, and for this reason donkeys are relatively expensive in this Country (Fernando & Starkey, 2000). In the rest of the world, the lower cost of donkeys makes them more affordable to small farmers. On the other hand, horse meat is considered a good alternative in red meat consumption, being considered as a dietary meat, and this has led to an increase of their consumption in recent years (Lorenzo et al., 2014). Horse meat is in fact characterized by low fat, low cholesterol content, a favourable fatty acid profile and is rich in iron (Franco et al. 2011). Today consumers are health conscious and demand high quality food products; they require leaner meat, with less fat (the minimal fat level required to maintain juiciness and flavour) and a consistent quality. Ultimately, the success of any food product is determined by the consumer's acceptance.

Meat quality and acceptability is determined by its physico-chemical characteristics, although consumer preferences for meat are difficult to define. Horse meat has a good reputation for consumers (Belaunzaran et al., 2015); in this context, the aim of this chapter is to assess the quality of donkey meat, showing its chemical and sensorial characteristics (when possible in different muscles) and evaluating the effects of the age of slaughtering.

DONKEY CARCASS

The composition of meat cannot be described simply in terms of the different components and their percentages, since meat production involves also the evaluation of 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. As firstly demonstrated by Aganga et al. (2003), donkeys have a carcass yield in the range between 54.5 to 59.5%, according to the different age, with the lowest value obtained for the oldest animals, slaughtered at the age of 7 years, while the highest value had been obtained with animals slaughtered at the age of 5 years. The dressing out percentage depends in fact 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. 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.

A study (Polidori et al., 2008) performed using 15 entire donkey males of the Martina Franca breed, slaughtered at 15 months of age and a mean fasted final body weight of 181±37 kg, determined warm (98.7 kg) and cold (96.7 kg) carcass weights, shown in Table 1, together with warm (54.5%) and cold (53.3%) dressing percentage. Obviously, comparisons with the dressing percentages of horses can be made, but most of the

horses used for meat production belong to specialized breeds or to genetic types very different from donkeys: in these studies carcass weight and dressing percentage were usually higher compared than those obtained in donkeys.

Table 1. Donkey carcass characteristics (means±S.E.)

	(n = 15)
Warm carcass weight (Kg)	98.7±1.22
Cold carcass weight (kg)	96.7±1.13
Warm dressing %	54.5±0.83
Cold dressing %	53.3±0.92

Source: Adapted from Polidori et al. (2008).

MEAT QUALITY

Donkeys can constitute an important source of meat in arid and semi-arid areas, but in the past the potential of donkey breeding for meat production has received little attention. In most of the countries where the donkeys are still used as work animals or for milk production, they are slaughtered at an advanced age, at the end of their useful working life. This age factor probably accounts for the general opinion that donkey meat is unacceptably tough, and in fact is mostly destined to be transformed into salami or other salted meat-based products (Marino et al., 2015). However, not all male donkeys reared on farms can be used for breeding, but meat from young males is an easy way to obtain a cheap meat, and to increase the income of local farmers. Compared to other livestock, donkey has an exceptional ability to survive under adverse climatic conditions such as high temperatures, low rainfall and scarcity of feed. Therefore, it offers an ideal animal for meat production in arid and semi-arid regions of the world. Donkey is a good source of meat in areas where the climate adversely affects other animal's production efficiency. The aim of the following sections is to describe the different quality parameters of donkey

meat, such as meat tenderness, chemical composition, mineral content and fatty acid profile.

Figure 2. Catalan breed (Spain).

Meat Tenderness

Tenderness is probably the most important factor considered by the consumer in assessing the eating quality of meat; without adequate tenderness, consumers are unlikely to appreciate the more subtle characteristics of flavour and juiciness. Two structural components determine the tenderness of meat. The collagen of connective tissue has firstly been recognized as an important influence on quality, and till the 1970's was considered as the sole cause of tenderness variation. The contractile apparatus, by contrast, was established as a potential contributor to toughness only in the early 1960's. This does not mean that connective tissue has been relegated to play merely a minor role as a toughening

agent: in some circumstances toughness is due almost entirely to collagen, whereas in others it is caused almost exclusively by the contractile machinery (Marsh, 1977). There is a list of the factors known to influence meat tenderness, they may be roughly divided into three groups:

- Factors which are determined before the birth of the animal (species, breed, sex, etc.).
- Factors modified by management during life (age, animal feeding, etc.)
- Factors affected by treatment after slaughter (ageing, cooking method, etc.)

After an animal has been slaughtered, meat tenderness can be affected only by the factors belonging to the third group, and depends mainly on the variations in myofibrillar proteins, connective tissue proteins, water content and state, as well as the interactions between the components during cooking (Fabiansson & Reuterswärd, 1985).

In a study performed in order to evaluate donkey meat tenderness (Polidori et al., 2011), 40 entire donkey males of the Martina Franca breed were used. They were reared in an extensive pasture system in the same farm in the south of Italy and receiving the same diet. Twenty animals (Group 1) were slaughtered at 12 months of age and a mean fasted final body weight of 148±27 kg. The other 20 animals (Group 2) were slaughtered at 18 months of age and a mean fasted final body weight of 202±45 kg. After 24 h storage in the cold room (2°C), *Longissimus thoracis* muscle (LT) samples (weighting approximately 400 g) were collected from the left side of each carcass, between the 12^{th} and the 13^{th} rib. Samples were stored for two and for seven days post slaughter before evaluating the shear force values. Two days after slaughtering no significant differences were determined (Table 2) between meat samples collected from donkeys slaughtered at 12 months of age (6.25±0.53 kg/cm^2) and from donkeys belonging to Group 2 (6.53±0.41 kg/cm^2). At seven days post slaughter, the shear force values determined for LT muscles obtained from donkeys belonging to Group 1 (5.15±0.31 kg/cm^2)

were significantly lower (P<0.01) compared to the values registered in the same group at two days. The shear force obtained seven days post slaughter in Group 2 showed higher values (5.88±0.23 kg/cm^2) compared with Group 1 but significantly lower (P<0.05) with the results obtained in the same animals at two days.

Table 2. Tenderness evaluation (kg/cm^2) of donkey *Longissimus thoracis* after two and seven days *post mortem* (means±S.E.)

Two days post mortem	Mean	S.E.
Group 1 (n = 20)	6.25^a	0.53
Group 2 (n = 20)	6.53^a	0.41
Seven days post mortem		
Group 1 (n = 20)	5.15^c	0.31
Group 2 (n = 20)	5.88^b	0.23

Group 1: animals slaughtered at 12 months of age (n = 20)
Group 2: animals slaughtered at 18 months of age (n = 20)
Different letters in the column indicate significant difference (b: P<0.05; c: P<0.01)
Source: adapted from Polidori et al. (2011).

The results of this study demonstrated that, after an adequate ageing period, donkey meat tenderness can be considered very similar to the same quality parameter determined on horse meat, according also to the results obtained in Sanfratellano and Halflinger foals by Lanza et al. (2009), and confirming the hypothesis that an ageing period of seven days is considered necessary to improve meat tenderness for most of the red meats (Thompson, 2002).

Intra-muscular collagen content and maturation are considered as primary factors contributing to meat tenderness (Maiorano et al., 2001). Literature reports differences in collagen properties among various muscles of the same animals due to different muscle metabolism, structure, physiological function, localisation and growth rate (Lawrie, 1985). A study conducted by Polidori & Vincenzetti (2013) determined collagen concentration in muscles Semimembranosus (SM) and Semitendinosus (ST) taken from 10 entire donkey foals slaughtered at 10 months of age

and with a mean final body weight of 126 kg. Collagen content was significantly ($P<0.01$) higher in ST muscle (44.2 μg/mg) compared to SM muscle (32.1 μg/mg). Studies conducted on male and female horse foals showed higher values in total collagen amount compared to donkey foals (Sarriés & Beriain, 2005). The results obtained by Tateo et al. (2008) confirmed the significantly higher statistical difference between total collagen content determined in ST muscle compared to SM muscle taken from Italian Heavy Draft Horses.

Electrical stimulation has been extensively used since the 1950s to hasten *rigor mortis* and to modify steps of the glycolytic pathway (Hwang et al., 2003). It is generally accepted that the accelerated post mortem glycolysis induced by electrical stimulation can prevent the development of toughness caused by cold shortening (Fabiansson & Laser Reuterswärd, 1985; Polidori et al., 1996; Devine et al., 2014). In order to determine whether a low voltage (28 V peak) early post mortem electrical stimulation, designed to accelerate glycolysis and proteolysis, could significantly improve the tenderness of donkey meat obtained from 16 entire male donkeys crossbred foals (Martina Franca x Ragusana), slaughtered at 8 months of age and at a mean final body weight of 106±22 kg, a study (Polidori et al., 2016) demonstrated that use of low voltage electrical stimulation in donkey carcasses can improve some meat quality traits, reducing shear force values in electrically stimulated donkey meat.

Meat Chemical Composition

Donkey meat has been historically obtained from animals that were slaughtered at the end of their working lives; for this reason the meat usually had not good sensorial and nutritional characteristics, as perceived by a lot of consumers. Meat production from male foals can be an interesting source of proteins and a cheap alternative to other red meats. A study had been performed to evaluate the effects of different slaughter age on chemical composition of donkey meat obtained from Martina Franca breed entire males (Polidori et al., 2011). Twenty animals (Group 1) were slaughtered at 12 months of age and a mean fasted final body weight of

148±27 kg. The other 20 animals (Group 2) were slaughtered at 18 months of age and a mean fasted final body weight of 202±45 kg. After 24 h storage in the cold room (2°C), Longissimus thoracis muscle (LT) samples were collected in order to evaluate chemical composition and glycogen content. Donkeys slaughtered at 12 months of age showed a significant ($P<0.05$) lower fat content, specifically 2.41 g/100 g compared with 3.71 g/100 g obtained in older animals (Table 3). Cholesterol content was similar in both the groups of animals, 67.4 mg/100 g in Group 1 and 68.7 mg/100 g in Group 2, confirming that cholesterol level in meat is not strictly related to fat content (Lawrie 1985). Protein content increased significantly ($P<0.05$) in donkeys slaughtered at 18 months of age, showing a value of 22.3 g/100 g compared with 21.4 g/100 g obtained in Group 1. Ash and glycogen content did not show significant differences between the two groups. Moisture content was significantly lower ($P<0.05$) in samples of LT collected from animals belonging to Group 2 (72.5 g/100g) compared to Group 1 (74.8 g/100 g), due to the increase of protein and fat content in older animals. Glycogen and cholesterol content were very close to the values obtained in many studies conducted on horse meat (Badiani et al., 1997; Lorenzo et al., 2014).

An evaluation of mineral levels in donkey meat samples was carried out using 15 entire donkey males of the Martina Franca breed, slaughtered at 15 months of age and a mean fasted final body weight of 181±37 kg (Polidori et al., 2008). Potassium (343 mg/100 g) and phosphorus (212 mg/100 g) were the two main represented minerals, followed by sodium (52 mg/100 g) and magnesium (24 mg/100 g). Iron content (3.80 mg/100 g) was higher than zinc content (3.67 mg/100 g): the levels of these micro elements, essential in the human diet, were similar with those determined in beef meat (Lawrie, 1985). The donkey meat had a calcium content of 8.6 mg/100 g. The mineral content of donkey meat varied widely between animals (Table 4).

Table 3. Chemical characteristics (mean ± S.E.) of the *Longissimus thoracis* muscle taken in 12 old months (Group 1) and in 18 old months (Group 2) entire donkey males

	Group	Mean±S.E.
Moisture (%)	1	74.8^{a}±3.31
	2	72.5^{b}±2.21
Fat (%)	1	2.41^{a}±0.71
	2	3.71^{b}±0.43
Protein (%)	1	21.4^{a}±2.95
	2	22.3^{b}±3.01
Ash (%)	1	1.04^{a}±0.77
	2	1.10^{b}±0.89
Glycogen (%)	1	0.36^{a}±0.03
	2	0.42^{a}±0.07
Cholesterol (mg/100 g)	1	67.4^{a}±0.81
	2	68.7^{a}±0.93

Different letters in the column indicate significant difference (b: $P<0.05$).
Source: adapted from Polidori et al. (2011).

Table 4. Mean values (±S.E.) of minerals (mg/100 g) of *Longissimus Thoracis* muscle of donkeys carcasses

Mineral	Mean±S.E.
Calcium	8.65±2.13
Magnesium	24.8±6.71
Potassium	343.7±65.9
Phosphorus	212.9±56.7
Sodium	52.5±13.3
Zinc	3.67±0.78
Iron	3.80±1.01

Source: adapted from Polidori et al. (2008).

Fatty Acid Composition

There is growing consensus that the dietary habits adopted by Western societies over the past century have contributed to an increased risk of coronary heart disease, hypertension, diabetes and cancer (Coates & Ayerza, 2004). Clinical data strongly support a relationship between the incidence of coronary heart disease and consumption of cholesterol and saturated fatty acids. Consumption of fish would provide a more balanced fatty acid diet, but for many people increasing their intake of fish is not readily accepted because of taste preferences. A study performed (Polidori et al., 2009) using 12 entire donkey males of the Martina Franca breed, slaughtered at 14 months of age with a mean fasted final body weight of 169±13 kg, demonstrated that fatty acid composition of the intramuscular fat determined on muscle *Longissimus Thoracis et Lumborum* and on muscle *Biceps Femoris* did not show significant differences between the two muscles examined, with the exception of myristic acid (C14:0), that was significantly greater in the *Biceps Femoris* (Table 5). An interesting content of polyunsaturated fatty acids (PUFA) was found in both muscles, The two most abundant fatty acids in both muscles were oleic acid ($18:1_{cis9}$) and palmitic acid (C16:0); saturated fatty acid (SFA) content was very similar in both muscles (Table 5).

According to the results shown in Table 5, donkey meat is characterised by a high content of unsaturated fatty acids, particularly PUFA, some of which can play important healthy roles, as described before in this chapter.

Meat Colour

In a study performed in order to determine rheological characteristics (Polidori et al., 2009), meat samples were taken four days *post mortem* from muscles *Longissimus thoracis et lumborum* (LTL) and *Biceps femoris* (BF) from 12 Martina Franca donkey males, slaughtered at 14 months of age and a mean final body weight of 169 kg. Colorimetric parameters were

measured to determine L* (lightness), a* (redness), b* (yellowness) and chroma. Results showed a significantly ($P<0.05$) higher lightness (L*) and redness (a*) in the LTL compared to the BF, respectively 35.86 versus 31.34 and 10.43 versus 9.23 (Table 6), indicating a darker colour of the LTL compared with the hind leg muscle BF. Colour is considered the most important sensory attribute affecting consumer purchasing decisions of red meat, because red colour is associated with freshness. The L* values obtained indicated that donkey meat colour can be considered very similar to other red meats, such as beef (Boakye & Mittal, 1996), horse meat (Tateo et al., 2008) and lamb (Luciano et al., 2009). Redness (a*) and yellowness (b*) indexes can be important in evaluating meat quality when it is possible to determine changes over time, because their changes describe meat colour deterioration from red to brown, reflecting myoglobin concentration and its redox state in muscle (Mancini & Hunt, 2005). In this study a* and b* values were determined only four days after slaughter; in the future it will be important to follow changes during storage. Chroma (Table 6) was significantly ($P<0.05$) different between the LTL and BF, with values of respectively 10.46 and 9.26. Chroma describes the intensity of a fundamental colour with respect to the amount of white light in the background (Boakye & Mittal, 1996); the differences between the two muscles demonstrated for all indexes evaluated a darker colour in the LTL compared with the BF.

An experiment performed with the aim of determining the effect of two different slaughter age (8 vs 12 months) on 16 entire donkey male foals of the Martina Franca breed (Polidori et al., 2015) determined that the colorimetric characteristics of donkey meat showed not significant differences in lightness (L*) and redness (a*) in the LTL muscle collected from foals slaughtered at 8 and 12 months of age, respectively 33.57 versus 32.34 for L* and 12.24 versus 11.49 for a* (Table 7). Similarly, the age of the animals did not affect the colorimetric characteristics, according to previous results obtained in horse meat (Sarriés & Beriain, 2006), confirming therefore that feeding systems play an important role in differentiating between meat samples on the basis of colour. Meat colour is also influenced by the myoglobin content, and the myoglobin content

within a species varies with age (Lawrie, 1985). A possible explanation of the results obtained in that study could be that haemoglobin contents in LTL muscle did not differ between foals slaughtered at 8 and 12 months of age.

Table 5. Fatty acid composition (% total fatty acids) determined in donkey *Longissimus Thoracis* and *Biceps Femoris* muscles (means±S.E.)

Fatty acid	LT (n = 12)	BF (n = 12)
C14:0	3.88±0.53[a]	4.51±0.74[b]
C16:0	29.77±2.98	29.44±2.01
C16:1	3.16±0.64	3.78±0.58
C18:0	7.43±0.87	6.83±1.01
C18:1	29.65±3.23	29.54±2.88
C18:2	18.75±2.86	19.43±3.01
C18:3	4.32±0.89	3.89±0.76
C20:1	0.95±0.11	0.93±0.09
C20:4	2.09±0.37	1.65±0.29
SFA	***41.08±2.02***	***40.78±1.91***
MUFA	33.76±1.68	34.25±1.55
PUFA	25.16±1.21	24.97±1.01

SFA: saturated fatty acids
MUFA: monounsaturated fatty acids
PUFA: polyunsaturated fatty acids
Different letters in the same row indicate a significant difference (b: $P<0.05$)
Source: adapted from Polidori et al. (2009).

Table 6. Colour parameters for the LTL and BF donkey muscles (means±S.E.)

Parameter	LTL	BF
L*	35.86±1.49[a]	31.34±1.63[b]
a*	10.43±0.38[a]	9.23±0.43[b]
b*	- 0.78±0.11	- 0.67±0.21
Chroma	10.46±0.66[a]	9.26±0.58[b]

Different letters in the same row indicate a significant difference (b: $P<0.05$)
Source: adapted from Polidori et al. (2009).

Table 7. Colour parameters (means±S.E.) of the LTL muscle of donkeys slaughtered at different ages

	Slaughter age (months)	
	8	12
	(n = 8)	(n = 8)
L*	33.57±2.94	32.34±2.36
a*	12.24±0.48	11.49±0.83
b*	8.76±0.22	7.87±0.13

Source: Adapted from Polidori et al. (2015).

Amino Acid Composition

Amino acid composition has been determined in donkey meat (Polidori et al., 2009). The content of the different amino acids is shown in Table 8; both the LTL and BF had higher essential amino acid percentages, respectively 52.88% in LTL and 51.26% in BF, compared with the total amino acid contents. Arginine was included between the essential amino acids, as done by Hoffman et al. (2005), because arginine is considered a conditionally essential amino acid. The essential amino acids at the highest concentration in donkey meat were lysine (1.77 g/100 g in LTL, 1.63 g/100 g in BF) and leucine (1.51 g/100 g in LTL, 1.60 g/100 g in BF), as shown in Table 8. No statistically significant differences in amino acid contents were found between the muscles. Values were very similar than those given by Badiani et al. (1997) in a review on horse meat quality characteristics, while Lorenzo & Pateiro (2013) found histidine as the most abundant amino acid in meat obtained by 12 foals of Galician Mountain breed slaughtered at 15 months of age.

Evaluating the results shown in table 8, we can affirm that the nutritional qualities of donkey meat are also confirmed by the high content of essential amino acids, a factor that is very important in determining food quality. The ratio between essential/non-essential amino acids was larger than 50% also in another study (Polidori et al., 2015) performed on donkey

foals slaughtered at 8 months of age (52.8%) and at 12 months of age (51.3%) confirming the high biological values of donkey meat proteins.

A study conducted by Paleari et al. (2003) compared the amino acids content determined in deer, boar, horse, beef and goat meat; beef meat had a significant lower content (47.4%), while both deer and goat meat showed in that study higher proportions of essential amino acids, respectively 58.8% and 54.8%. The results obtained for donkey meat can be considered close to horse (54.5%) and boar meat (50.0%).

Table 8. Amino acid composition (g/100 g muscle) of LTL and BF muscles (means±S.E.) of donkey

	LTL	*BF*
Essential		
Arginine	1.44±0.18	1.38±0.21
Histidine	0.86±0.08	0.93±0.09
Isoleucine	1.05±0.11	0.99±0.14
Leucine	1.51±0.65	1.60±0.51
Lysine	1.77±0.34	1.63±0.48
Methionine	0.74±0.13	0.65±0.18
Phenylalanine	0.83±0.17	0.76±0.13
Threonine	0.88±0.14	0.91±0.13
Tryptophan	0.24±0.08	0.19±0.12
Valine	1.01±0.34	1.09±0.45
Non essential		
Alanine	1.22±0.23	1.09±0.11
Aspartic acid	1.79±0.45	1.92±0.59
Cystine	0.22±0.05	0.18±0.05
Glutamine	3.09±1.25	3.26±1.58
Glycine	0.97±0.36	0.84±0.65
Proline	0.95±0.58	1.00±0.42
Serine	0.75±0.23	0.64±0.20
Tyrosine	0.59±0.17	0.70±0.29
Total	19.91	19.76
Essential AA (%)	10.33 (52.88%)	10.13 (51.26%)

Source: adapted from Polidori et al. (2009).

DONKEY MEAT PRODUCTS

Due to the continuous evolution of the economic and social countries, food demands have been transformed and modified. Cured, fermented and dried meat products from different species (Paleari et al., 2003) have recently appeared on the market and are being sold alongside traditional beef and pork products. The production of typical processed meat products could be a tool to increase the value of donkey meat. Traditional salting, fermenting and drying technologies have been used since ancient times to produce dry cured meat products available throughout the year and consumed in many countries (Marino et al., 2015).

Salami is a very popular fermented meat product, its quality depends on the variations in raw meat, formulation and manufacturing processes. Among cured meat products, bresaola is a product originated in different areas of north Italy since the 15th century as a way of preserving both beef and horse meat (known as "slinzega"). Products similar to bresaola are consumed in Brazil (known as "charqui," "manta de carne de sl"), in Spain (known as "cecinas" or "cecina de leon," Canton of Grisons, Switzerland (known as "Viandes de Grison" or "Bindenfleisch"), in France, Doubs region (known as "Bresi") and in Peru (known as "charqui" and produced with both lama and alpaca meat).

A study performed with the aim to evaluate the nutritional properties of bresaola and salami from donkey meat compared with respective conventional products (Marino et al., 2015) demonstrated that donkey bresaola and salami showed higher content of protein and lower content of fat compared with beef bresaola and pork salami. Significant differences in unsaturation level of fatty acids were found in this study, particularly, donkey meat products showed lower saturated fatty acids and higher polyunsaturated fatty acid content. Furthermore, donkey meat products, especially bresaola, showed the highest content of essential amino acids. Both donkey meat products resulted to be more tender than conventional products, in addition donkey bresaola showed also higher consumer acceptability. Basically, this study demonstrated the possibility of

processing donkey meat into products comparable to traditional ones with a high nutritional value.

Figure 3. Donkey butchery in China.

CONCLUSION

Donkey, as a domestic animal, could be bred not only for leisure activities or for working as a draught animal, but also for donkey meat production, being this kind of meat a quite popular food in China (see Figure 3) or in south America. Donkey meat production under sustainable extensive systems should be encouraged in order to maintain endangered local donkey breeds, to obtain a healthy product and finally to conserve natural resources (mountain areas), as grazing could provide greater diversity of habitats benefiting fauna and flora that bring environmental and social advantages to rural areas. Moreover, donkey meat production could be managed as short productions chains improving the local autochthonous breeds reared according to low input production systems by applying feeding strategies to improve quality standards either in fresh

meat or meat products. Production of donkey meat shows a very important potential to be considered in the economical development of many countries; there is a big challenge for the farmers to use donkeys as meat animals, not only for the aspects related to the breeding development for these animals, but especially in the rational productive aspect. This approach can be very useful economically for many donkey farmers all over the world.

The nutritional characteristics of donkey meat show interesting aspects in comparison to the usual red meat; when related to the human health parameters, this kind of meat can be favourably accepted by the consumers. In fact, donkey meat presents low levels of lipids and cholesterol, and shows a beneficial relationship between the different fatty acids.

The studies performed till now determined that donkey meat is good quality meat; data obtained indicates that the meat is very high in crude protein, characterized by low fat content and high in important minerals such as Potassium, Phosphorus, Iron and Zinc.

Donkey, especially males, can be used as cheap meat animals, and donkey meat can easily have a market also in the western countries, considering the high quality level shown by this kind of red meat.

REFERENCES

Aganda, A.A., Tsopito, C.M., & Seabo, D. (1994). Donkey power in rural transportation. Botswana case study. *Appropriate Technological Journal*, 21, 32-33.

Aganda, A.A., Aganda, A.O., Thema, T., & Obocheleng, K.O. (2003). Carcass analysis and meat chemical composition of the donkey. *Pakistan Journal of Nutrition*, 2, 138-147.

Badiani, A., Nanni, N., Gatta, P.P., Tolomelli, B., & Manfredini, M. (1997). Nutrient profile of horsemeat. *Journal of Food Composition and Analysis*, 10, 254-269.

Belaunzaran, X., Bessa, R.J.B., Lavín, P., Mantecón, A.R., Kramer, J.K.G., & Aldai, N. (2015). Horse-meat for human consumption – Current research and future opportunities. *Meat Science*, 108, 74-81.

Boakye, K., & Mittal, G.S. (1996). Changes in colour of beef m. *longissimus dorsi* muscle during ageing. *Meat Science*, 42, 347-354.

Coates, W., & Ayerza, R. (2004). Fatty acid composition of llama muscle and internal fat in two Argentinian herds. *Small Ruminant Research*, 52, 231-238.

Devine, C.E., Hopkins, D.L., Hwang, I.H., Ferguson, D.M., & Richards, I. (2014). Electrical stimulation. In C. Devine & M. Dikeman (Eds), Encyclopedia of Meat Sciences, 2nd edit., Vol. 1 (pp. 486-496). Oxford, UK: Elsevier Ltd.

Fabiansson, S., & Reuterswärd, A.L. (1985). Ultrastructural and biochemical changes in electrically stimulated dark cutting beef. *Meat Science*, 12, 177-188.

Fernando, P., & Starkey, P. (2000). Donkeys and development: socio-economic aspects of donkey use in Africa. In P. Starkey & D. Fielding (Eds) Donkeys, People and Development (pp. 31-44). Wageningen, The Netherlands: ATNESA press.

Franco, D., Rodríguez, E., Purriños, L., Crecente, S., Bermúdez, R., & Lorenzo, J.M. (2011). Meat quality of "Galician Mountain" foals breed. Effect of sex, slaughter age and livestock production system. *Meat Science*, 88, 292-298.

Hoffman, L.C., Kritzinger, B., & Ferreira, A.V. (2005). The effects of region and gender on the fatty acid, amino acid, mineral, myoglobin and collagen contents of impala (*Aepyceros melampus*) meat. *Meat Science*, 69, 551-558.

Hwang, I.H., Devine, C.E., & Hopkins, D.L. (2003). The biochemical and physical effects of electrical stimulation on beef and sheep meat tenderness. *Meat Science*, 65, 677-691.

Lanza, M., Landi, C., Scerra, M., Galofaro, V., & Pennisi, P. (2009). Meat quality and intramuscular fatty acid composition of Sanfratellano and Halflinger foals. *Meat Science*, 81, 142-147.

Lawrie, R.A. (1985). *Meat Science*. 4th ed., Oxford: Pergamon Press.

Lorenzo, J.M., & Pateiro, M. (2013). Influence of type of muscles on nutritional value of foal meat. *Meat Science*, 93, 630-638.

Lorenzo, J.M., Sarriés, M.V., Tateo, A., Polidori, P., Franco, D., & Lanza, M. (2014). Carcass characteristics, meat quality and nutritional value of horsemeat: a review. *Meat Science*, 96, 1478-1488.

Luciano, G., Monahan, F.J., Vasta, V., Biondi, L., Lanza, M., & Priolo, A. (2009). Dietary tannins improve lamb meat colour stability. *Meat Science*, 81, 120-125.

Maiorano, G., Filetti, F., Salvatori, G., Gambacorta, M., Bellitti, A., & Oriani, G. (2001). Growth, slaughter and intra-muscular collagen characteristics in Garganica kids. *Small Ruminant Research*, 39, 289-294.

Mancini, R.A., & Hunt, M.C. (2005). Current research in meat color. *Meat Science*, 71, 100-121.

Marino, R., Albenzio, M., della Malva, A., Muscio, A., & Sevi, A. (2015). Nutritional properties and consumer evaluation of donkey bresaola and salami: comparison with conventional products. *Meat Science*, 101, 19-24.

Marsh, B.B. (1977). The basis of tenderness in muscle foods. *Journal of Food Science*, 42, 295-297.

Paleari, M.A., Moretti, V.M., Beretta, G., Mentasti, T., & Bersani, C. (2003). Cured products from different animal species. *Meat Science*, 63, 485-489.

Polidori, P., Kauffman, R.G., & Valfrè, F. (1996). The effects of electrical stimulation on meat quality. *Italian Journal of Food Science*, 3, 183-199.

Polidori, P., Vincenzetti, S., Cavallucci, C., & Beghelli, D. (2008). Quality of donkey meat and carcass characteristics. *Meat Science*, 80, 1222-1224.

Polidori, P., Cavallucci, C., Beghelli, D., & Vincenzetti, S. (2009). Physical and chemical characteristics of donkey meat from Martina Franca breed. *Meat Science*, 82, 469-471.

Polidori, P., Beghelli, D., Cavallucci, C., & Vincenzetti, S. (2011). Effects of age on chemical composition and tenderness of muscle Longissimus

thoracis of Martina Franca donkey breed. *Food and Nutrition Sciences*, 2, 225-227.

Polidori, P., & Vincenzetti, S. (2013). Meat quality in donkey foals. *Italian Journal of Food Science*, 25, 390-393.

Polidori, P., Pucciarelli, S. Ariani, A., Polzonetti, V., & Vincenzetti, S. (2015). A comparison of the carcass and meat quality of Martina Franca donkey foals aged 8 or 12 months. *Meat Science*, 106, 6-10.

Polidori, P., Ariani, A., Micozzi, D., & Vincenzetti, S. (2016). The effects of low voltage electrical stimulation on donkey meat. *Meat Science*, 119, 160-164.

Sarriés, M.V., & Beriain, M.J. (2005). Carcass characteristics and meat quality of male and female foals. *Meat Science*, 70, 141-152.

Sarriés, M.V., & Beriain, M.J. (2006). Colour and texture characteristics in meat of male and female foals. *Meat Science*, 74, 738-745.

Tateo, A., De Palo, P., Ceci, E., & Centoducati, P. (2008). Physicochemical properties of meat of Italian Heavy Draft horses slaughtered at the age of eleven months. *Journal of Animal Science*, 86, 1205-1214.

Thompson, J., (2002). Managing meat tenderness. *Meat Science*, 62, 295-308.