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Influence of Common Eland (*Taurotragus oryx*) Meat Composition on its further Technological Processing

DISSERTATION THESIS

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Declaration

I hereby declare that I have done this thesis entitled "Influence of Common Eland (*Taurotragus oryx*) Meat Composition on its further Technological Processing" independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 5th October 2018

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I would like to dedicate this thesis to my son Tomáš.

Abstract

Eland (*Taurotragus oryx*) is a large African ruminant with suitable abilities for domestication and farming potential to produce lean meat. Therefore, evaluation of their response to enriched diet, carcass characteristics, effect of age and muscle on meat physical and chemical properties and technological parameters to be processed into meat products was studied. Carcass parametres, chemical and technological meat traits were studied as influenced by the effect of muscle and diet. Experiment investigating the effect of diet enriched in energy and fatty acids was performed in the first part. Ten young bulls were divided into two balanced groups, one with only standard bulk diet (n=5) and second supplemented with enriched diet (n=5). Animals with enriched diet, had higher content of the free pectoral suet (p=0.012), total suet (p=0.025), separable fat (p=0.002) and higher carcass yield (p=0.009). Meat of the animals with enriched diet had higher content of the fat (p=0.0291) and also showed significant interaction of the diet and muscle part (p=0.0007). Chemical and technological meat traits showed significant influence of the meat part (p<0.0001). Texture and colour characteristics evaluated on 25 animals showed signigicant effect of muscle (p<0.0001), redness (a*) showed also the effect of age (p=0.0063) and interaction those effecs (p<0.0001). Meat from older animals were more red. The most tough was *m. sternomandibularis* (404.67±12.80 N) and the most tender was *m. longissimus thoracis et lumborum* (48.08 ± 12.48 N). In the second part of the experiment, 12 liver pâté batches (4 varieties from fresh, 45 days frozen and 90 days frozen meat) were made and their organoleptic properties were evaluated by the panelits (n=35). Pâté batch made of the fresh eland meat and chicken liver received the best scores in the evaluated properties. Using of eland liver, or beef liver respectivelly, and also freezing of the material resulted into the worse scores.

Enriched diet provided more energy for eland growth, but elands with enriched diet shoved just more reserve fat and not transformed extra energy gain into muscle growt. Eland meat can be considered as lean and nutritionally valuable meat suitable for culinary and meat processing.

Key words: eland, enriched diet, carcass traits, meat traits, pâté, organoleptic properties

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List of the Abbreviations Used in the Thesis

CIE	Commission Internationale de l'Éclairage
CULS	Czech University of Life Sciences Prague
DFD	dark, firm, dry (muscle myopathy
EU	European Union
FA	fatty acids
FTA	Faculty of Tropical AgriSciences
GDP	Gross domestic product
HPM	high priced meat
LDPE	low-density polyethylene
LPM	low priced meat
LSMEAN	least square mean
m.	*musculus* (latin expression for the word muscle)
MUFA	monounsaturated fatty acids
PSE	pale, soft, exudative
PUFA	polyunsaturated fatty acids
SAR	South African Republic
SE	standard error
SFA	saturated fatty acids
WHC	water-holding capacity

1 INTRODUCTION AND LITERATURE REVIEW

Game animals were traditionally exploited by a man long time before the invention of the agriculture. It's obvious, that game animals served not only as a source of food to the mankind. Several reasons have been presented by for making use of wild animals. Firstly, wild animals can exploit difficult habitats, such are regions too arid for conventional livestock, mountainous areas, tundra or taiga vegetation. Secondly, wild herbivores have specific adaptations; they have numerous anatomical, physiological and behavioral adaptations to the ecosystems, where they are found. Thirdly it is their digestive efficiency – wild ungulates are capable to feed on roughages; they differ in their appetite and choice of diet in comparison with domestic animals or they can be selective and thus to be complementary to roughage eaters. Lastly, carcass quality of wild ungulates and the dressing percentage can be quite as good as that of domestic species (Kay 1970; Lawrie and Ledward 2006).

Average Czech citizen consumed 0.9 kg of game meat in 2014. It is almost double amount then in 2005. Game meat have slowly found its place in the czech retail shops and its popularity within consumer is still increasing (Sekaninová 2016). In addition to that, new specialized plant for game meat processing has been opened in 2012 in Kralupy nad Vltavou. It belongs to the Bidvest company and the daily processing capacity is about 150 carcasses and up to 5,000 kg of game meat, which originated in the Czech forests (Bidvest 2014).

Meat and leather of the eland (*Taurotragus oryx*, Pallas 1766) was traditionally valued by hunters (Van Zyl 1962). Eland was due to its qualities recommended by the FAO as a species suitable for domestication (Scherf 2000) and since 2002 elands have been breed under the management of the Faculty of Tropical AgriSciences of the Czech University of Life Sciences Prague. Elands are used for the research and educational purposes and meat production. Research was conducted e.g. on thermoregulation (Kotrba et al. 2007), organoleptic properties of meat (Bureš et al. 2010) and meat quality (Bartoň et al. 2014).

All elands used in the experiment were born in captivity. They have been descendants of those ones, which were imported to the Czech Republic by Dr. Josef Vágner from East Africa between 1969 and 1972 (Vágner 1974).

Author's research would like to extend knowledge in the field of eland's meat quality and technological processing.

1.1 Breeding of Game Animals

1.1.1 Game Farming

It is estimated, that the herding of livestock (e.g. goat, sheep, cattle) may have started somewhere in the lowlands of Tigris and Euphrates rivers in the Middle East about eight thousand years ago. During the time the process of hybridization and selection have led to many different varieties of livestock. It is obvious, that the man has never lost his "passion" for descendants of those first farmed animals (Lambrecht 1983). There is also evidence, that the ancient Egyptians tamed animals such as hyena, gazelle or ibex (Kay 1970). Effective deer farming in the parks, chases and forests as a part of the other agricultural and woodland activities was also documented in the medieval England. Domestic animals were often grazed together with the deer in the parks. But game meat was those times high status meat and land-owners had considerable benefits from it (Birrell 1991). In the end of the 19th century and during first decades of 20th century game farming first attempts with domestication of new species including eland were made (e.g. the South Africa, the USA and Russia). Game farming grew in popularity during the 20th century also in many countries around the world (Lambrecht 1983).

Red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) are the most common deer species farmed in Europe (Kotrba et al. 2010). Wapiti (*Cervus canadensis*), fallow deer, sika deer (*Cervus nippon*) and axis deer (*Axis axis*) dominate farms in the US and Canada (Anderson et al. 2007). Deer farming has developed into important export industry in New Zealand, where red deer is the most common species farmed. During the season 2015/16 12,911 tonnes were exported of venison reaching value $164 million (Deer Industry New Zealand 2017). Most of the rusa deer animals are (*Cervus timorensis*) produced in the world originate from the French speaking tropical islands Mauricius, Reunion and New Caledonia. Around the world game production systems varies from wild and extensive to sophisticated intensive systems. Consumers also become increasingly interested in the ethical and environmental issues concerning the game farming (Hoffman & Wiklund 2006).

Great example of the importance of game ranching can be presented on the SAR example. Almost six million of animals live on 8,979 wildlife ranches covering area of 170,419 km^2. The most abundant species are impala (*Aepyceros melampus*) (comprising 24.1% of all animal counts), kudu (*Tragelaphus strepsiceros*) (11.8%) and springbok (*Antidorcas* *marsupialis*) (11.6%). For example, live sales of animals generated R4.3 billion[1], hunting R2.6 billion and meat production R610 million in 2014. This sector provided 65,170 permanent jobs in 2014 and median salary of employees was R3,441. It was produced approximately 21 million kilograms of meat (Taylor et al. 2015). So-called scientific game ranching and its history in South Africa was described in the study of Carruthers (2008).

1.1.2 Origin and Description of the Eland

Eland (*T. oryx*) is one of the largest African antelope. Males are bigger than females. This species occupies about one third of the continent. It can be found mainly in southern and eastern parts (Pappas 2002). It lives at various altitudes up to 4,600 m (Estes 1993). At this area, nomadic eland moves seasonally, what depends on the food and water availability (Kingdon 1982). Elands can be found in open plains, savannahs or lightly wooded areas. They are avoiding thick forests (Hosking & Withers 1996). They are social species; inhabiting open habitats, they form large groups, although the size of groups often declines, when they occupy more visually dense habitats where the group cohesion is more difficult to maintain (Shackleton & Harestad 2003).

Eland as ruminant has morphological adaptions, what enables them to feed on low quality fibre roughage for the period about two weeks. This adaptation places them between so called intermediate, mixed feeders. Elands practice obvious degree of forage selectivity. Their way of foraging is opportunistic, they avoid feed with high content of fibre as long as possible (Hofmann 1989).

Eland belongs taxonomically to: class Mammalia, order Artiodactyla, suborder Ruminantia, family Bovidae, subfamily Bovinae, tribe Tragelaphini, genus Taurotragus (Shackleton & Harestad 2003).

The average mass of eland body ranges from 450 to 942 kg for bulls and from 317 to 470 kg for cows (Pappas 2002). Elands have long spiral shaped horns with smooth surfaces (Shackleton & Harestad 2003). There is a crest of hair running from a nape to a small hump withers; male elands have a strong tuft of hair on the forehead (Hosking & Withers 1996). Dewlap is typical for both sexes. Dewlaps of males become very large and distinctive with increasing age. It often hangs down almost to wrists (Kingdon 1997). The color of eland's pelage varies from dark brown to reddish brown depending on

[1] R (rand) is the currency of the Republic of South Africa

season; bulls tend to turn in blue-gray with increasing age (Hillman 1974). Elands have on their sides from 2 to 15 transverse white stripes; anterior stripes are more distinct then the posterior ones (Halternorth & Diller 1980). Color of their pelage and distinctness of stripes can vary throughout the area of distribution and among subspecies too (Skinner & Smithers 1990). All elands have a black spot on the posterior upper region of the forelegs and a dark dorsal stripe running down the dorsum (Posselt 1963).

1.1.3 Breeding of Eland in Captivity

A scientists Miller (1952) characterized the eland as “Fortunately, it is an easy natured and peaceful animal, and is in fact very tamable. … and the eland is considered to be the most fit of all veld animals for full domestic breeding. Its flesh is comparable to beef, and it accumulates considerable fat – a rare feature in game animals.”

African ungulates have great potential for game meat production. This fact has been long known. It was widely discussed and summarized by Von La Chevallerie (1970). Several studies about the eland dedicated to its abilities and possibilities of its breeding in captivity were published by authors Van Zyl (1962), Posselt (1963) or Skinner (1967). Eland production and management was also extendedly reviewed and discussed by Lightfoot (1977).

Eland is considered as a mixed feeder. It can “switch” from “browsing” to “grazing” in dependence of season or nomadic overgrazing (Hofmann 1989). It makes this species suitable for a joint farming with grazers such as cattle or sheep. They can together utilize former grasslands invaded by woody vegetation (Topps 1975; Lambrecht 1983; Hofmann 1989). Eland can subsist without water, except that obtained from its daily browsing of leaves. The independence of regular water supplies makes the eland capable to browse on larger areas than cattle. It makes eland more suitable to use in arid or semiarid regions (Posselt 1963; Lambrecht 1983). Eland are also referred by Posselt (1963) to be resistant or tolerant to trypanosomiasis transmitted by the bite of the tsetse fly (*Glossina* spp.).

Thermoregulatory response of the eland in comparison with similarly sized Holstein-Frisian dairy cattle was studied by Kotrba et al. (2007). It was concluded, that eland has the potential to adapt to winter housing conditions in temperate climatic zones with inside temperatures above 0 °C.

One of the first attempts to domesticate the eland is dated to the beginning of the 20th century in the Kruger National Park. According to Lambrecht (1983) elands had been farmed continuously in Askanija Nova at Southern Ukraine from 1892[2]. Therefore, eland has been recommended as candidate for domestication by the FAO (Scherf 2000). The possibility of eland breeding for the economical purposes in the Czech Republic had been positively evaluated (Kotrba & Ščevlíková 2002).

Authors Hoffman & Wiklund (2006) stated, that in the SAR was only one farmer recorded, who had number of tame elands, which were finished off at a feedlot before being slaughtered. Production was about 100 animals per year, but this enterprise had been closed recently (Hoffman, pers. communic.). Authors Ndibalema & Songorwa (2007) referred that the eland dominates between several illegally hunted species. Because eland's meat was referred as tasty within local population, this species is thus more vulnerable.

1.2 Meat, Venison and its Properties

1.2.1 Meat, Venison and its Consumption

Meat can be defined in a following way: "Meat is defined as the flesh of animals used as food." But next to the musculature, some organs and other tissues are also consumed. Meat from various animal species is consumed around the world. Local habits, social conditions or simply availability of certain kinds of meat plays important role in a meat consumption (Lawrie & Ledward 2006).

Great body of studies about the role of meat in human diet have been made. Meat represents source of high quality protein and variety of essential nutrient. Meat is considered as a part of healthy, mixed and balanced diet. Health risks, such as obesity, cardiovascular diseases or some types of cancer are more likely connected with the higher, respectively excessive, consumption of saturated fatty acids, processed meats or ready-to-eat foods than with unprocessed meat (Biesalski 2005; Binnie et al. 2014; De Smet & Vossen 2016). Consumption of meat may differ in developed and developing countries both in quantitative and qualitative aspects (McNeil & Van Elswyk 2012).

Authors Lawrie & Ledward (2006) estimated evolutionary changes in feeding habits when our ape-like ancestors gradually changed into present day human beings, they also started to hunt by the plan. Wild ruminants and their tissues were main lipid source of the pre-agricultural humans. Lipids of the wild North American and African ruminants were

[2] Southern Ukraine has been recently claimed as Russian territory and the current status of Askanija Nova is uknown.

found similar to pasture-fed cattle but different to grain-fed cattle and due to their different composition may serve as a model for dietary lipid recommendation in treating and preventing chronic diseases (Cordain et al. 2002).

Western Cape in the South Africa is often visited by overseas tourist. Most of them indicated that game meat is the most ordered in restaurant. Tourists were aware of health benefits of game meat Tourists also understood game meat as a part of the South Africa experience. The most consumed game species was the warthog. Tourists originated from Europe were also concerned about safety and healthiness of game meat. Interest of visitors in red game meat consumption should resulted in its bigger promotion of game meat on a larger scale in the South Africa (Hoffman et al. 2003). Another research was investigating the importance of availability of information to the consumers (Hoffman et al. 2005); South African consumers were often incorrectly informed about game meat and its positive attributes. Game meat was perceived as rather exotic, seasonal product, than a “regular” type of meat from farm animals such as pigs, cattle or poultry. It was revealed, that game meat and its attributes were not promoted enough by its producers and marketers. Poor availability and higher price of game meat were perceived negatively. South African consumers also indicated the importance of the fat content because they tend towards the consumption of lean meat.

Despite the fact, that game meat offers possible health benefits for the meat consumers, food choice is a complex process. It is influenced e.g. by the sensory appeal, habits, social interactions, availability, marketing related factors or awareness about game meat (Radder & le Roux 2005). The knowledge about game meat has been increasing in last decades. It is also apparent, that modern farming practices (e. g. improved nutrition, lairage, stunning, electrical stimulation) and principles (effect of sex, area etc.) have influence on the meat quality and composition. In the study is concluded, that game meat fits most of selection criteria, which consumers nowadays expect from valuable product. (Hoffman & Wiklund 2006).

1.2.2 Meat and Carcass Composition

Animal’s body consists approximately from 55 to 60% of water and 3 to 4% of minerals; these make the inorganic component. There are 35 to 40% of organic substances, what are mainly proteins, fats and carbohydrates. Further, muscle tissue itself is consisted of about 75% water and 20% protein. Remaining part (i.e. 5%) is consisted of fat, small amount of carbohydrates (especially glycogen), free amino acids, dipeptides and nucleotides (Warris 2000).

Dressing percentage of cattle is next to the chemical composition of the body an important indicator in meat production showing us the product yield from an animal body; according to Albertí et al. (2008) it can vary from 50.1% in the Jersey cattle to 63.7% in the Limousine cattle in dependence on cattle breed. Composition of body and carcass were also studied on wild ruminants; for example, dressing percentage of common duiker was 61.1 ± 1.8% (Ferreira & Hoffman 2001) and dressing percentage of night-cropped impala was 58.0% in female and 57.5% in male. It did not differ significantly (Hoffman 2000). Research conducted on springbok, blesbok, and impala by authors Van Zyl & Ferreira (2004) showed also high dressing percentage ranging from approximately 63 to 66%. It was thus concluded, that wild ruminants could have better potential for red lean meat production in comparison with domestic ruminants.

Proteins are the main constituents of the muscle fibers. They are creating the muscle mass and enable muscle functionality. Muscle proteins can be divided into several groups according to their solubility. Firstly, proteins of the contractile apparatus (extractable with concentrated salt solutions) are distinguished, secondly myoglobin and enzymes (proteins soluble in water or dilute salt solutions). Into last group insoluble proteins (connective tissue, membrane proteins) belong. Meat become from muscles during so-called post mortal changes (Lawrie & Ledward 2006; Belitz et al. 2009). Meat contains so-called essential amino acids, which are irreplaceable in human diet due to their role in metabolic pathways. The proportion of amino acids in all kinds of meat is generally considered as almost ideal for the human diet. Meat protein has very high digestibility (Purchas 2005; Castro Cardoso Pereira & Reis Baltazar Vicente 2013; Binnie et al. 2014). Venison has generally low levels of fat, so the protein levels tend to be correspondingly higher than in meats with higher fat content. The concentration of protein in lean meat does not vary widely. Some existing variations can often be explained in accordance with differences in levels of intramuscular fat. Slightly lower percentages of protein are thus associated with higher content of fat (Hoffman & Cawthorn 2013).

Fats[3] have several physiologic functions in the organisms. They are essential part of cell membranes, acts as vehicle for energy storage and form bases. They are important energy

[3] More correctly lipids

source for the living organisms and they can thus survive longer period without feeding. So-called marbling of meat is caused by the intramuscular fat. It is also important for the meat taste and tenderness or processing properties (Warris 2000; Lawrie & Ledward 2006; Willie 2013). Fat and especially fatty acids content in meat has been studied intensively especially due to the relation to human health. Very often attention in studies was focused on mono and polyunsaturated fatty acids, which are considered beneficial to human health (Castro Cardoso Pereira & Reis Baltazar Vicente 2013; Willie 2013). Fat content and fatty acids composition in the meat of wild ruminants have been also intensively studied. Meat of wild ruminants was presented in several studies as low-fat meat with fatty acid profile favorable to human health. Cholesterol content was low in venison too (Purchas 2005; Hoffman & Wiklund 2006; Hoffman & Cawthorn 2013). Human eating habits and lifestyle have changed much more quickly than man could genetically adapt. Modern diet compared to diet of hunter-gatherers can be characterized by higher energy intake, higher fat intake or lower intake of quality protein and fibre. Intake of saturated fatty acids is higher, amount of mono- and polyunsaturated fatty acids is lower; ratio of n-6/n-3 acids has increased several times (Simopulous 1999; Simopulous 1999a; Cordain et al. 2002). Meat of wild ruminants contains more favorable fatty acid profile than the meat of domestic ruminants. Composition of game meat thus corresponds more to the diet of our hunter-gathering ancestors and consumption of the game meat was recommended in several studies as a part of diet for healthy lifestyle and as a prevention and treatment of chronic disease (Cordain et al. 2002; Hoffman & Wiklund 2006).

Very important indicator of meat quality is pH value. It is caused by the degradation of glycogen into lactic acid. Muscle is thus acidified. The pH value is measured commonly 45 minutes[4] and 24 hours[5] *post mortem* in the meat production to detect right development of conversion of muscle into meat, respectively the pH value development is also an indicator of muscle myopathies, such PSE or DFD are. Those myopathies are caused by improper conditions and handling before slaughter of animals (Warris 2000; Huff-Lonergan & Lonergan 2005). Both myopathies have negative impact on the meat quality. They are causing organoleptic alterations and represent hygiene risk (Casoli et al. 2005). In the study of Hoffman et al. (2007a) pH_{24} value showed regional effect, but it was possible that difference was caused by another level of stress during slaughter of

[4] pH_{45} = pH value of meat measured 45 minutes after death
[5] pH_{24} = pH value of meat measured 24 hours after death

springbok. The pH values of game harvested in South Africa for export using professional and sophisticated methods were higher due to lower levels lactic acid and stress (Merwe et al. 2013). Electrical stimulation is a method which can be applied to a carcass to prevent muscle myopathies. Electrical stimulation increased pH value decline in the meat of red deer and lower shear force values on samples taken were also measured up to three weeks *post mortem* (Wiklund et al. 2001).

Moisture of meat can be generally defined as the total water content of meat. Lean meat contains according to Honikel (2009) approximately 75% of water, but moister content can change in dependence on the other meat components. For example, authors Neethling et al. (2014) found strong negative correlation between protein and moisture content when investigating several muscles of blesbok. Authors Van Zyl and Ferreira (2004) observed on springbok, blesbok and impala that females have significantly lower moisture percentages then males, but they also have higher fat percentage.

1.2.3 Technological Properties of Meat

Colour of meat is one the key factor influencing consumers' decision to buy a meat or not (Troy & Kerry 2010). Red meat appearance is determined by the overall concentration and chemical state of the haem pigments - myoglobin and haemoglobin. Color of fresh meat is influenced by pre-slaughter (e.g. diet, animal management) and post-slaugther (e.g. packaging, aging, antioxidants) factors. Those factors are thus important for the marketability of meat (Warris 2000; Mancini 2013; Suman et al. 2014). Higher myoglobin levels were generally found in muscles of more active animals (e.g. game) in comparison to intensively reared animals (Purchas 2005), and in older animals also compared to younger ones. Muscles with residual blood contains higher concentration of haem pigments (Warris 2000). Myoglobin content and thus color differ within game species (Onyango et al. 1998). Further, according to Bekhit et al. (2007) redness (a*) values were affected by *rigor* temperature and *post mortem* time in venison. Authors Scanga et al. (1998) presented that game meat in South Africa was normally perceived to have a dark and unattractive red colour which looked similar as DFD in beef; this myopathy is normally associated with the *ante mortem* stress occurring mainly in male animals (Lawrie & Ledward 2006).

Meat has an important ability to retain all or part of its own water during processing or when some external force is applied. This ability is called water-holding capacity (WHC) and depends on the way of handling and the state of the system. Because the state of meat and the treatments vary greatly, the meaning of WHC can vary to a large extent. Most of the water is immobilized by the myofibrilar and cytoskeletal proteins. WHC is primarily depended on the pH value and protein structural changes in meat during the post-mortem period. WHC is influenced by concentration of salts present in meat (Huff-Lonergan & Lonergan 2005; Honikel 2009; Apple & Yancey 2013). WHC has also great practical importance during further meat processing and its unacceptable low values represent significant losses for the meat industry. Several methods in various modifications have been developed to measure WHC, such as Filter Paper Press Method (FPPM), drip losses or heating losses (Warris 2000; Huff-Lonergan & Lonergan 2005; Apple & Yancey 2013). Water-holding capacity can differ significantly within the meat of game species. For example, cooking losses of 21.9% were found in zebra loin and 36.4% were found in oryx leg (Onyango et. al. 1998). Animals which were stressed due to slaughter had higher cooking losses (Hoffman et al. 2007a). With the increase in *rigor* temperature WHC of venison decreased (Bekhit et al. 2007).

1.2.4 Meat Texture

Production, processing or culinary method used to prepare meat for consumption by consumer are factors influencing tenderness of meat (Thomson 2002). Texture of meat is influenced by several factors, namely sarcomere length, amount of connective tissue and its degree of cross-linking, and extent of proteolytic changes that occur during aging post mortem. pH value influences activity of proteolytic enzymes, which are present in meat, and thus tenderness can be influenced (Warris 2000; Lawrie and Ledward 2006; Kerth 2013). Relationship between meat structure, changes in texture of meat and cooking losses during heating were investigated by authors Palka & Daun (1999). Collagen is a main constituent of intramuscular connective tissue and in mammals can content from 20 to 25% of the total protein (Belitz et al. 2009). Amount of collagen in muscles varies from 1.5% to 10% of dry weight. Collagen as itself has complicated molecular structure; it is composed from polypeptide chains which are cross-linked. Type and amount of those cross-linkages are important for the mechanical strength of collagen fibres and it changes with the age of animals. Several types of collagen can be distinguished, but in the muscles type I and III are predominating. Structure of meat is also influenced with pH value next to the heating during processing. Meat can be thus traditionally marinated to enhance meat tenderness; proteinases can be used also as part of the marinades due to their impact on meat structure (Lepetit 2008). Collagen changes structure during heating. It shrinks, and it is converted from solid state into liquid gelatin. This has importance for the texture of final product (Feiner 2006; Belitz et al. 2009). Number of those cross-linkages increase with the increasing age of animal. Solubility of collagen is thus lower. This explains higher toughness of meat from older animals. (Hill 1966; Lawrie & Ledward; Kerth 2013). Solubility of collagen and its dependency on temperature in beef was studied by Palka (1999); it was presented, that percentage of soluble collagen in bovine *m. semitendinosus* slightly changed up, when internal temperature of meat was 60 °C, at 70 °C was almost doubled, but in the range from 80 to 121 °C dramatically decreased. It was also reported, that meat tenderness is highly correlated with collagen solubility especially in pork, but in beef or lamb correlations are often lower (Lepetit 2008). Relationship between tenderness and pH value in was investigated in Czech pied cattle in the study of authors Jelenikova et al. (2008). It was found that tenderness and pH value are influenced by the housing of cattle before slaughter. It was found also, that meat of bulls was less tender than meat of cows. Tenderness of cow meat was found independent on housing. Meat of bulls which were housed individually was found more tender than the meat from bulls housed in groups probably due to higher depletion of glycogen before slaughter and thus insufficient decline of pH value. Tenderness of meat cuts is different within muscles; it is connected on the collagen content and with the anatomical position (Kerth 2013). For example, Destefanis et al. (2003) studied properties (including tenderness) of several muscles and the effect of castration in Piemonties cattle. Electrostimulation of the carcasses is often used in game meat industry. Effects of electrical stimulation on red deer carcasses were studied in by Wiklund et al. (2001). It was found, that electrical stimulation improves meat tenderness, but the effect is not permanent. After 3 weeks of aging effects started to disappear, thus the procedure was not concluded as necessary for a long term aged chilled product. Bekhit et al. (2007) had presented, that tenderness of red deer meat could be improved by the manipulation of rigor temperature. Acceptable level of tenderness early *post mortem* could be also obtained with less damaging effect on color stability. In the study on beef cattle by Archile-Contreras et al. (2010) was found, that feeding regime had an important effect on animal growth. It also influenced particularly collagen characteristics; tenderness of studied muscles was affected in different extend.

1.2.5 Meat Quality and Factors Influencing it

Meat quality is widely described and discussed in literature by many authors. Two perspectives can be used to define it – scientific status and consumer preferences. Scientific factors affecting the quality of a food include composition, spoilage, colorants, additives, flavorants, functional ingredients, contaminations and general safety. On the other hand, consumer preferences are linked directly to human senses, such as sight, touch, smell, taste and mouth-feel (Warris 2000; Lawrie & Ledward 2006; Hui 2007).

Meat quality and composition can be influenced by many factors, which can be sorted out as intrinsic and extrinsic ones. Intrinsic factors are connected to the function of the muscle (e.g. breed, sex, anatomical position of the muscle, age, plane of nutrition). Extrinsic factors influence muscle behavior immediately post mortem, during store and processing (e.g. food, fatigue, fear, pre-slaughter manipulation) (Lawrie & Ledward 2006). Importance and impacts of these factors have been widely described in literature, e.g. by authors Warris (2000) or Lawrie & Ledward (2006). As well as previously mentioned factors, information about relation between animal diet and meat quality and mechanisms involved was presented in the several studies published e.g. by Wood et al. (2003), Raes et al. (2004), Wood et al. (2008) or Woods & Fearon 2009; special attention was paid on the importance of fat and fatty acids composition. Authors Daley et al. (2010) for example presented, that meat of grass-fed cattle seemed more favorable to human health (e.g. lower in overall fat, favorable FA profile) but it could also have grassy flavor and unique cooking qualities.

Aging is a process important for the meat quality; meat becomes soft and tender and aroma is formed. Aging of beef requires according to Belitz et al. (2009) about 14 days at 3 °C. In the studies of Huidobro et al. (2003) and Monsón et al. (2005) was found, that aging of meat significantly improved organoleptic properties of beef and thus acceptability to consumer. In the study of Monsón et al. (2005) the effect of cattle breed was observed; meat of Limousine cattle was more acceptable between 7 and 14 days of aging, while meat of Blonde d'Aquitaine cattle was evaluated with highest scores between 14 and 35 days of aging.

Wild animals evolutionary differ in diet according to their natural habitats. They are thus adjusted to feed on local vegetation utilizing available resources (Hofmann 1989). Impact of intrinsic factors and meat quality attributes in game animals has been studied intensively just for last decades (Hoffman & Wiklund 2006; Hoffman & Cawthorn 2013). For example, enhanced diet had a positive impact on body growth, carcass traits and composition in red deer (Webster et al. 2001; Phillip et al. 2007), and in reindeer (Sampels et al. 2005) also. Age related effects were found minor or without influence during large survey on the springbok (Hoffman et al. 2007a; Hoffman et al. 2007b; Hoffman et al. 2007c; Hoffman et al. 2007d). Samples et al. (2005) presented several significant differences, which were age-related, on slaughter weight, trim fat and total fat of reindeer. Cropping methods were studied by Hoffman & Laubscher (2009); it was found, that meat of day-cropped greater kudu had in comparison with night-cropped animals' higher drip loss and lower ultimate pH value[6]. Furthermore, it was presented, that day-cropped animals tend to have more ante mortem stress. They had lower shear force value and paler color, which were positive meat quality attributes associated with less stress. In the study by Kritzinger et al. (2003) was found, that night time cropping had positive influence on certain meat quality properties of impala probably due to lower stress during harvest.

1.3 Common Eland and its Meat

In the studies of Van Zyl (1962) and Posselt (1963) some brief information on meat, meat yield or carcass and body traits of eland were brought. Some more detailed information about eland meat were presented by Von La Chevallerie (1972) and about carcass composition by Von La Chevallerie et al. (1971). Growth of elands in captivity was studied by Jeffery & Hanks (1981).

Content of fatty acids was studied in domestic and wild ruminant's meat (eland including). It was found, that meat of free living ruminants contains less total fat and more unsaturated and poly unsaturated fatty acids (Crawford et al. 1970). Fatty acid composition in several tissues of wild eland and wild buffalo were compared in thy study of Crawford & Woodford (1971); it was found, that eland had greater content of polyunsaturated fatty acids in its tissues than buffalo probably due to its feeding habits. Comparison of domestic Fleckvieh cattle and eland bulls were made in the study of Bartoň et al. (2014). Proportion of total PUFA was higher in eland, but total PUFA contents were similar between species, because cattle had higher content of total fat. Proportions of SFA and MUFA were higher in cattle.

[6] Ultimate pH = the pH that is reached when muscles reach *rigor mortis*

Edible offal can represent varied range of nutritiously attractive foods in developing countries. Offal may be associated with transmission of zoonotic diseases. In the study of Magwedere et al. (2013) was found, that pH values of edible offal of several game species were above 6. This indicated that alternative measures would be required to inactivate certain endogenous pathogens in edible wild game offal sourced from endemic areas. pH value of eland livers was 6.25 ± 0.20 and pH value of eland lungs was 6.68 ± 0.18 four hours after slaughter.

Bartoň et al. (2014) compared meat of Fleckvieh cattle and eland bulls, which were raised under similar conditions. Meat of eland compared to beef was found darker and less yellowish. It has higher value of $pH_{24,}$ lower contents of intramuscular fat and total collagen. Eland meat received worse scores during sensory evaluation. It could be most likely explained also by age of slaughtered animals because cattle bulls were slaughtered at age of 18 months and elands at the age of 36 months.

Van Zyl (1962) reported, that eland meat was traditionally considered as the best game meat in South Africa. Bureš et al. (2010) made the survey to evaluate organoleptic properties of eland meat in comparison with beef. Influence of final core temperature during culinary preparation and aging were evaluated. High culinary value of eland meat was confirmed in this study and lately from some restaurants in Prague. The best scores received eland meat aged for 21 days and prepared to final inner temperature of 80 °C; lower inner temperature during preparation was better suited for meat aged for seven days. Meat aged for 7 days and prepared to final temperature of 90 °C had better flavor characteristics, but it received worse scores for juiciness, chewingness and for overall characteristics too.

Lack of marbling was reported by Lightfoot (1977) and observed also by Bureš et al. (2010). Eland meat was found low-fat with beneficial FA composition from a human nutrition perspective (Bartoň et al. 2014).

1.4 Game Meat Products

1.4.1 Slaughter and Maturing of Meat

Important changes start in the organism after the slaughter. They lead towards the conversion of muscle tissue into meat. Animal is stunned and exsanguinated and its metabolism stops. Certain content of glycogen in muscle is necessary for proper development of *post mortem* changes. In other case, muscle myopathies such as PSE or

DFD can be developed. The pH value of muscle is used to monitor the development of *post mortem* changes (Warris 2000; Huff-Lonergan & Lonergan 2005; Branden 2013). Great focus is aimed on pH_{24} value of beef, what is connected to good development of changes *post mortem*, which results in tender meat. Previously mentioned can cause problems in meat quality in case of slaughter in extensive farm conditions (e.g. Watanabe et al. 1996; Silva et al. 1999; Huidobro et al. 2003). Antemortem handling, such as good conditions during transport, pre-slaughter manipulation and slaughtering of animals are necessary to achieve desired meat quality (Aguilar-Guggembuhl 2012).

Domestic livestock can be relatively easily processed in the high capacity meat production facilities. On the other hand, wild behavior and extensive nature of game animals bring more requirements to meet good hygienic and manufacturing standards in game meat production (Van Schalkwyk et al. 2011).

Cropping methods of game animals were studied. Day-cropped greater kudu's meat in comparison with night-cropped animals' meat had higher drip loss and lower ultimate pH value. Although day cropped animals tend to have more *ante mortem* stress, they had lower shear force value and paler color, which are positive meat quality attributes associated with less stress (Hoffman & Laubscher 2009). It was found, that cropping during night time had positive influence on certain meat quality properties of impala, namely slower decline of pH value and lower shear force value and lower drip loss (Kritzinger et al. 2003). Several studies and manuals have been also published about field slaughter of game animals to ensure, that game meat would meet hygienic requirements and would have superior quality in the South Africa (e.g. Van Schalkwyk & Hoffman 2010; Van Schalkwyk et al. 2011; Van der Merwe et al. 2014) or in the Europe (Food Safety Authority of Ireland 2014).

Rigor mortis is a result of *post mortem* changes. It occurs in beef muscle within 10 to 24 hours and it is resolved from 2 to 3 days *post mortem*, thus meat becomes again soft and tender in process called aging. Further aging of meat improve tenderness and aroma is also formed during this time, but it depends on the temperature. Aging time requires approximately 14 days for beef stored at 3 °C (Belitz et al. 2009). Aging of meat significantly improves beef organoleptic properties and thus acceptability to consumer (e.g. Warris 2000; Huidobro et al. 2003; Monsón et al. 2005). Also effect of breed in cattle was observed. For example, authors Huidobro et al. (2003) compared meat of young bulls and heifers ending in result, that after six days of aging meat of both sexes did not differ in most of parameters (e.g. pH value, moisture, cooking loss) and organoleptic properties of cooked meat were also quite similar. Authors Monsón et al. (2005) compared beef of different cattle. It was found, that different breeds need different aging time to obtain optimum acceptance by consumer, namely beef of Limousine cattle was more acceptable between 7 and 14 days of aging, while beef of Blonde d'Aquitaine cattle had highest scores between 14 and 35 days of aging.

1.4.2 Meat Processing

Raw meat is perishable material sensitive to decomposition by microbes. Several processes (e.g. salting, smoking, heating) are used to increase shelf life of meat. Chemical, technological and sensory traits are changed during the preserving of meat (Kyzlink 1990; Heinz & Hautzinger 2007). Meat processing plays important role, because it can fully utilize meat resources including almost all edible parts of livestock or game. Muscle meat, animal fat, edible offal, skin or blood are used together with non-meat additives to enhance product flavor, appearance, volume or shelf-life stability. Non-muscle parts, such as offals, blood, skin parts or bone craps can be used as nutrient rich ingredient in processing of some different types of products to maximize utilization of the animal. Many processing technologies and their combinations respectively also can be used to obtain products of desired qualities and shelf-life (Heinz & Hautzinger 2007; Belitz et al. 2009; Maddock 2012).

A great variety of meat products have been developed during history, often driven by the necessity to preserve food as a source of nutrient and/or with a consumer's demand for some new culinary and eating experience (Warris 2000; Maddock 2012). On the other hand, meat, meat products respectively can be associated with e.g. obesity, higher risk of cardiovascular diseases or some types of cancer due to content of fat, saturated fatty acids, cholesterol, higher amount sodium chloride etc. (Arihara & Ohata 2012). There has been for some time growing interest in developing and producing of nutritionally valuable and healthier meat products (Jiménez-Colmenero et al. 2001) and many strategies have been developed and used in creating such products (Arihara 2006). During time low-fat products or fat-free, or with some functional ingredient (e.g. oats, soy bean), or with probiotic bacterial cultures etc. have been developed and introduced to market (Arihara & Ohata 2012).

In the Southern Africa biltong is referred as a traditional product. Biltong is dried strip of meat made of beef or game meat. Most muscle meat from the carcass may be used, but the largest are the most suitable, namely fillet is considered as the most suitable. Principal preparation is following. Meat cuts 150 to 250 mm long and 30 – 50 mm thick are dry cured in mixture of salt pepper for several hours, then dipped into hot mixture of water and vinegar to prevent growth of mould and finally sun or solar dried for approximately one day. Biltong is sold in sticks or slices. The usual shelf-life is several months without refrigeration and packaging (Van Rooyen et al. 1996, Hainz & Hautzinger 2007). Drying kinetics in laboratory conditions and with use of the solar drier was studied by Kučerová (2015). This study indicates, that drying behavior of eland jerky is similar to drying behavior of traditional beef jerky.

Game meat is also used for production of meat products, especially for special or traditional ones. For example, Todorov et al. (2007) studied microbial starter cultures for production of salami from different meats, including meat of blesbok and springbok. Matured salamis were made from meat of different game species and tested for its attributes (Van Schalkwyk et al. 2011). No significant differences chemical in the chemical composition were found. When evaluating organoleptic properties, trained panelists liked the salami produced from gemsbok, kudu and zebra, but disliked salami from springbok. Game flavour did not featured as strongly as expected. It was concluded, that products made from gemsbok, kudu and zebra can be confidently offered to consumers.

1.4.3 Pâté Production

Edible meat by-products are also significant sources of essential nutrients and their utilization can have also some economic benefits (Hainz & Hautzinger 2007; Dalmás et al. 2011). Great variety of meat paste products are now available to consumers. The basic ingredients of pâté can vary, but generally they are made from liver of beef, pork, poultry, duck, or from seafood, wild game, and even from vegetables. Meat ingredients of great variety of species, herbs, spices, milk, or starches are also used for pâté fabrication. (Legarreta 2012).

Although this type of product is generally called pâté, the correct name is “paste” or “liver paste”. Pork liver pâté are the most commonly available products at the market, followed by duck liver pâté. These types of products have its origins in the French cuisine. They are often produced as traditional local specialties. They can be divided to several types: “pâté” (cooked in casings), “terrine” (hot-molded in recipients), “mousse” (including eggs to form a foamy texture), “rillete” (made with meat and liver) (Totosaus-Sánches 2010; Legarreta 2012).

Quality characteristics of ostrich liver pâté was studied by Fernández-Lopéz et al. (2004). Products made in the experiment showed high acceptability based on their chemical composition and sensory scores. Samples exposed to light during storage had higher 2-thiobarbituric acid values and higher decrease in a* values, due to prooxidant effect of light. So that these changes mainly in fat and meat pigments led to lower quality. It was concluded, that effect of antioxidants should be evaluated in further studies (Fernández-Lopéz et al. 2004). Fat level content and its influence on the properties of foal liver pâté during chill storage were studied by Lorenzo et al. (2014). Higher fat levels resulted in significant changes in lipid oxidation. Values of lightness and redness were gradually decreasing over time, while yellowness values were the highest at the end of storage. During storage amount of non-heme iron increased, and microbial counts were also influenced by storage time and among fat levels. Further studies evaluating the effect of antioxidants to control colour, lipid and protein stability were recommended. Authors Pateiro et al. (2014) and Lorenzo et al. (2014) studied influence of natural antioxidants on pâté storage quality. They found, that some natural antioxidants (e.g. green tea, grape extract) had preservative and protective effect on pâté during storage proving fact, that some natural extracts can be promising additive in pâté pate production. Authors Hawashin et al. (2016) showed in their study, that destoned olive cake powder has antioxidant and antimicrobial impact and can be used as the shelf-life improver of beef patties.

Authors Terrasa et al. (2016) used successfully chicken liver as a by-product of chicken industry and sunflower oil to improve nutritional characteristics of liver pâté products; 28% of sunflower oil was suitable for chicken liver pâté.

“Variety meat” of goat (Dalmás et al. 2011), lamb (Amaral et al. 2015) or sheep (Dutra et al. 2013) can be also used successfully in development of the new value-added product with desired nutritional and technological quality.

1.5 Sensory Analysis of Meat and Meat Products

Sensory analysis is a multidisciplinary discipline. Its role in food evaluation is irreplaceable. Results obtained are sometimes hardly comparable to those results obtained from chemical and physical analysis (Pokorný et al. 1998; Deliza & Gloria 2009).

Organoleptic properties of meat, such as tenderness, juiciness or flavor are those properties, which are evaluated with human senses. They have great importance for the perception of quality and consumer behavior (Hui 2007; Deliza & Gloria 2009; Nute 2009). Sensory evaluation methods were used in the study meat of South African beef cattle by Schönfeldt & Strydom (2011); it was shown, that aroma, flavor and juiciness of beef were closely and significantly related the age of animal. Decrease of the initial juiciness and flavour intensity were observed with the increasing age beef cattle. In the study of Rincker et al. (2006) meat of reindeer and caribou was evaluated as meat with desirable sensory characteristics. Those meats were found more tender, had more intense off-flavour and less intense meat flavor in comparison to beef. Authors Wiklund et al. (2003) found several differences in flavor of meat from reindeer in the study, where two groups of differently fed animals were compared. Effect of region had some influence on sensory characteristics of the meat of springbok, but effects of age and gender were found negligible (Hoffman et al. 2007d). Authors Huidobro et al. (2003) studied organoleptic properties of the meat of heifers and young bulls' and how the meat changed during the first 6 days of ageing. It was concluded that with such young animals it seemed enough to let the meat age for 6 days. Values obtained for the quality parameters (hardness, springiness, juiciness) seemed to be compatible to tender meat.

Organoleptic aspects such as visual appearance, in-mouth texture, flavor and odor are important qualitative characteristics of the product. Next to the marketing and several psychological factors they influence consumer behavior and willingness to pay for the product or not to pay (Font-i-Furnols & Guerrero 2014). Sensory evaluation can be used in companies for several purposes, such as product development, quality control or product sensory specification. To evaluate sensory properties several methods have been developed to meet such purposes. Educated specialists or amateur consumers may be used in sensory studies in controlled or 'street' conditions (Pokorný et al. 1999; Deliza & Gloria 2009).

2 AIMS AND HYPOTHESES

2.1 Carcass and Meat Traits of Eland

The first aim was to evaluate meat (different muscles) on chemical, physical and technological parameters. Another was to evaluate the effect of diet enhanced by essential fatty acids and increase of total accessible energy on eland growth, carcass composition and meat chemical composition and physical properties. Effect of animal age on dressing percentage, carcass composition and meat physical and chemical attributes was of interest from farming and production perspective.

H1: Different muscles will have different physical, chemical and technological parameters.

H2: Animals with enriched diet will have better performance, dressing percentage and will differ in carcass traits compared to the animals with standard diet.

H3: Meat of the animals with enriched diet will differ in basic characteristics (dry matter content, crude fat content, crude protein content, pH value) from the meat of animals with standard diet.

H4: Meat of the animals with enriched diet will differ in instrumental characteristics (texture, meat color) from the meat of animals with standard diet.

H5: Meat of the animals with enriched diet will differ in WHC, collagen content and total haem pigments content from the meat of animals with standard diet.

H6: Older animals will differ in instrumental characteristics of meat (texture, colour). Meat will be darker, more reddish and tougher muscles.

2.2 Eland Meat Processing

Due to lack of knowledge on technological processing of eland‘s meat the **second aim** was to develop new product containing meat of eland and to analyze its organoleptic properties. In this case pâté type product has been chosen. Meat parts with higher content of connective tissues and edible offal (livers) will be used in the experiment. They are less suitable for the culinary processing but they are suitable for processing of liver pâté product and also they have lower marketing value. Refrigeration storage of raw materials for pâté processing (meat, livers) will be tested. Eland meat or livers may not be available for the processing at sufficient amount at the moment due to its limited production.

H7: Use of the eland meat and/or livers will improve organoleptic properties of the pâté by the composition of product.

H8: Refrigeration storage of raw materials will not influence organoleptic properties of pâté type product.

3 MATERIALS AND METHODS

3.1 Breeding of Elands in Captivity

3.1.1 Description of the CULS Farm at Lány

Elands have been held at the farm at Lány (50°7'41.704"N, 13°57'31.370"E). This farm belongs to the Faculty of Tropical AgriSciences of the Czech University of Life Sciences Prague. This farm has been built in 2005 and animals arrived in 2006 from private farm, where FTA had kept elands from 2002.

The farm consists of the barn, where elands are housed during winter and two separated paddocks (see Appendix XXIX) of total area of 2.3 ha. There is a central corridor with feeding alley in the barn, which divides barn into two separated parts (see Appendix XXX). If necessary, each part can be further divided by barriers into three pens. From each pen elands can enter one of the paddocks. Elands are reared on deep litter bedding. Every day keeper is present to feed and control the animals (see Appendix XXVIII). If necessary, the elands are provided by veterinary care. The farm is also equipped with a place and regime for a slaughter of animals by free bullet (see Appendix XXXI).

3.1.2 Experimental Animals and Breeding Facilities

The slaughter and experimental data collection described in this chapter were carried out under standard regime and eland farm management procedures comparable to cattle breeding and was approved by the Institutional Animal Care and Use Committee (Czech University of Life Sciences Prague). Facilities (paddocks and barn) are designed to breed animals in two separated groups. Each breeding group consists of about 15 to 25 animals. Approximately 5 to ten calves are delivered every year in each breeding group according to the breeding plan and number of adult females. New-born calf were ear-tagged, weighed and measured. Therefore, information on birthdate, morphometry, weight, sex, parentage is recorded on every animal. Elands were fed with the basic feed mixture and meadow hay, water and mineral lick blocks SOLSEN Minerlleckstein mit Kupfer (European Salt Company, Hannover, Germany) were available ad libitum to all animals (see also Appendix II).

For feeding experiment comparing two different diets on eland male fattening performance, the individuals were selected pseudorandomly, i.e. according to weight/age to have comparable pairs between groups with the same/similar starting weight/age.

After selection of animals in each group, males in first group (no. 43, 47, 59, 62 and 64 called as experimental) received feeding pellets in addition to basic feed mixture due to the other parallel experiment[7] for prior to the slaughter (Váňa 2010).

All data collected and used for this research were conducted from 2010 to 2014 totally on 25 animals (Appendix I).

3.2 Eland Slaughter and Carcass Evaluation

3.2.1 Slaughter of the Animal

Animals determined for slaughter were weighted and separated from the herd with pen barriers in the barn approximately 1 hour before the slaughter. Animals were slaughtered without fasting. Life weight of the animals was collected using tensometric scales True-test series indicator EC2000 (True-Test Limited, Auckland, New Zealand) placed in passage connection between pens. Elands were shot into the neck by a free bullet from riffle operated by professional marksman, immediately exsanguinated and eviscerated at the farm (seeAppendix XXXI). Carcasses together with the removed and identified visceras were then transported in a refrigerator van to experimental slaughter house (50°1'32.139"N, 14°37'10.228"E) located in Prague - Uhříněves which belongs to the Institute of Animal Science for further slaughter processing and veterinary inspection. The transport was about 75 km long and took about one 60 to 90 minutes. Carcasses were uniformly processed in the abbatoir by skilled operators according to EU specifications (see Appendix XXXII). Carcass halves were stored and chilled in the slaughter house till the second day to reach 4 °C.

The slaughter runs in accordance with EU (Reg. EC 852/2004, Reg. EC 853/2004, EC Reg. 854/2004 and EC Reg. 178/2002 as subsequently amended) and Czech (Reg. no. 166/1999 as subsequently amended) legislation.

3.2.2 Carcass Characteristics

Furthermore, slaughter weight, weight of visceras and suet were recorded using meat-industry scales NETTO HWS (Netto Electronics, Inc., Prague). Carcass yield was calculated (Barton et al. 2008). Carcass pH_{24} value was collected in the abattoir approximately 24 hours *post mortem* after slaughter by inserting pH probe into

[7] Experiment was performed from September 2009 to July 2010 (Váňa 2010).

m. longissimus dorsi between 8th and 9th rib using pH meter Testo 205 (Testo, Lenzkirch, Germany).

Chilled halves were analyzed 24 hours after slaughter for further characteristics using meat-industry scales NETTO HWS (Netto Electronics, Inc., Prague). Right sides were cut into standardized joints (see Appendix XXXIII). Weight of meat, bones, tendons and separable fat were recorded. Total meat yield was calculated as the lean meat from all the parts together with the lean trimmings. High price meat cuts were determined as total weight from the rump (without shank), shoulder (without foreshank), loin and fillet. Low priced meat cuts were determined were determined as total weight of the remaining lean meat cuts and lean trimmings also (Bartoň et al. 2008).

During the carcass dissection second day after slaughter meat samples for the laboratory analysis were taken (approximately 300 g per sample). Samples were thoroughly packed in LDPE bags and then transported to the laboratory.

3.3 Properties of Eland Meat

3.3.1 Description of Used Chemical and Technological Analyses of Meat

Meat samples were cleared from membranes and visible fat and then properly homogenized prior to the analysis. Reference method of drying of meat with sea sand was used to determine **dry matter content** according to ČSN ISO 1442 (1997). Measurement of each sample was repeated three times at different part. **Crude fat content** was analyzed using extraction in the Soxhlet extractor. Crude fat content was analysed gravimetrically after extraction with petrol-ether with boiling range from 40 to 65 °C (Lachner s.r.o, Neratovice) from a sample dried with sea-sand (ČSN ISO 1444 1997). Measurement of each sample was repeated three times at different part. To analyze **crude protein content** Kjehldal method was used according to ČSN ISO 937 using Kjehltec Foss 2200 (FOSS Analytical, Denmark). Measurement of each sample was repeated two times at different part. **pH value** was measured using the pH meter Testo 205 (Lenzkirch, Germany). Electrode used was two-point calibrated using commercial buffer solution of pH 4.0 and 7.0 (ČSN ISO 2917:1999). Measurement of each sample was repeated three times at different part.

Water-holding capacity was measured on using two methods (Prokůpková & Bubnová 2009). Firstly, **cooking looses** were measured on homogenized sample. Sample was put into a glass test tube and weighted. Then tube was covered by an aluminium foil and put into water bath (80 °C) for 30 minutes. Losses of water were determined gravimetrically. Measurement of each sample was repeated two times at different part. Secondly, water-holding capacity was determined by **Grau and Hamm's press method** (Grau & Hamm 1953) modified by Hofmann et al. (1982), chromatographic paper Whatman 2 with adapted relative humidity of 60 % was used. Meat and total fluid areas were then measured with a digital planimeter Planix 7 (Tamaya Technics Inc, Japan). Measurement of each sample was repeated twelve times at different part.

Total haem pigments content was analyzed using the modified method according to Hornsey (1956). Pigments were extracted from the sample using a solution of acetone and HCl; 10 ml of acidified acetone (1.125 ml of the concentrated hydrochloric acid per 100 ml of acetone) and distilled water, so that the final concentration of acetone would be 80%, are added to 2.5 g of minced sample, then mixed and kept 60 minutes at light. After filtration the amount pigments were determined spectrophotometrically (UV-2900PC, Tsingtao Unicom-Optics Instruments Co., Ltd., China) and expressed as total haem pigments content (AMSA 1991; Prokůpková & Pipek 1992). Measurement of each sample was repeated two times at different part.

Content of total collagen was analyzed by the determination of 4-hydroxyproline using AOAC Official method 990.26 (AOAC 2007). Measurement of each sample was repeated two times at different part. Further, method according to Hill (1966) was used to determine the **content of soluble collagen**. Soluble fraction of the intramuscular collagen was solubilized using Ringer's solution at 77 °C. After separation of the supernatant, samples were hydrolyzed and 4-hydroxyproline was determined with different reacting time of oxidizing agent, namely 4 minutes. Measurement of each sample was repeated two times at different part.

Texture and color of meat was measured on the meat samples prior to a homogenization. Both measurements were made at the University of Chemistry and Technology Prague.

Texture of the meat samples was measured instrumentally as a shear force using Instron Model 5544, software Series IX (Instron Co., USA) equipped with the device according to Warner-Bratzler. Muscle samples were cleared from all covering membranes and cuts with geometry 15 x 20 x 60 (mm) were prepared. Shear blade was moving at the velocity of 80 $mm.min^{-1}$. Each sample was measured two times at different part.

Meat colour was measured instrumentally as a reflectance using spectrophotometer device Minolta CM206d and software Spectra Magic CM S100w (Minolta Co. Ltd., Japan). Muscle samples were cleared from all covering membranes and cut crosswise. Reflectance was measured immediately on freshly cut sample (AMSA 1991). Minolta device was set on following settings: radiance source D65 (6504 K), 8 mm aperture, mode of measurement SCI (specular component included). Information about lightness (L*), redness (a*) and yellowness (b*) were obtained. Sample was thick at least 10 mm. Each sample was measured three times at different part.

Fatty acids composition was obtained at the Institute of Animal Science on homogenized *m. longissimus lumborum* as a service. Lipids were extracted according to Folch et al. (1957) and then alkaline trans-methylated (ISO 5509 2000). Gas chromatography was performed on HP 6890 gas chromatograph (Agilent Technologies Inc., Santa Clara, CA, USA) using a 60 DB-23 capillary column.

3.3.2 Chemical and Technological Characteristics of Eland meat

Firstly, meat traits of four different muscle cuts and basic carcass traits were measured on ten eland bulls (animals no. 37, 43, 45, 47, 49, 54, 59, 60, 62, 64; see also Appendix I). Meat samples (see Table 1) were taken second day after slaughter (see also 3.2.2), then stored at temperature ranging from 4 °C to 7 °C. Texture and instrumental colour were measured at the University of Chemistry and Technology Prague on 7th day after slaughter; pH value, WHC, and total haem pigments content were measured on the 8th day after slaughter at the Faculty of Agrobiology, Food and Natural Resources (CULS Prague). Rest of samples were thoroughly packed to aluminium foil and stored at minus 24 °C for subsequent analysis of dry matter content, crude fat content, crude protein content and for content of total and soluble collagen (see 3.3.1 for description of used analysis).

Table 1 – Overview of meat samples collected for the analysis

Anatomical name of muscle	Abbreviation	Meat part
m. triceps brachii	TB	Shoulder
m. semimembranosus	SEM	Topside
m. pectoralis profundus	PP	Brisket
m. longissimus thoracis et lumborum	LTL	Loin

In addition, possible influence of diet enriched with the feeding pellets on the growth, carcass traits (see 3.2.2) and meat composition of eland was evaluated on these elands which were also used in parallelly ongoing experiment, which was focused on eland blood parameters (Váňa 2010). Previously described ten young bulls of the comparable age and initial weight were divided into two groups. Both groups were separated from each other, and from the other elands too. Animals in 'control group' (males no. 37, 45, 49, 54, 60) were fed with the basic feed mixture, while the animals in 'experimental group' (males no. 43, 47, 59, 62, 64) received feeding pellets next the basic same mixture (Váňa 2010). See Appendix II for description of feeding. When feeding was finished, animals from both groups were gradually slaughtered (see 3.2.1).

Secondly, texture of meat measured as Warner-Bratzler shear force and instrumentally measured colour of meat were measured on 12 different muscles (Torrescano et al. 2003) as described in Table 2 from 25 eland males (see Appendix I). Additionally, muscle parts TB, PP, SEM and LTL were also analysed for the crude protein content, total collagen and soluble collagen. Differences between muscle parts were investigated. Animals were also divided according to age into three age categories ('less than two years' - eight animals, 'two to three years' – twelve animals, 'older than three years' – five animals) to investigate possible effect of age on the meat properties (Budková 2012).

Table 2 – Description of samples for the instrumental analysis

Anatomical name of muscle	Abbreviation	Meat part
m. biceps femoris	BF	Silverside
m. quadriceps femoris	QF	Thick flank
m. flexor digitorum	FD	Shank
m. gluteus medius	GM	Rump steak
m. infraspinatus	IS	Buttler steak
m. longissimus thoracis et lumborum	LTL	Loin
m. psoas major	PM	Tenderloin
m. pectoralis profundus	PP	Brisket
m. semimembranosus	SEM	Topside
m. semitendinosus	SM	Eye round steakr
m. sternomandibularis	STER	Chuck
m. triceps brachii	TB	Shoulder

This categorization is coming from eland biology, because males up to two years are hormonally prepubertal, between two and three years of age are in puberty and over three years are functionally sexually mature with specific traits (size and proportion of neck, depth of chest and typical loner hair at forehead).

Elands were kept (see 3.1) and processed (see 3.2) as described in previous chapters.

3.4 Processing of Eland Meat into Meat Product

This experiment was designed to study possible utilization of eland meat or livers for a technological processing. Several tens of elands have been slaughtered already durint last ten years. It has been practically shown, that more valuable cuts (e.g. loin, tenderloin, rump) can be sold relatively easily to the customers in comparison to less valuable meat cuts, which are represented by those with higher collagen content (e.g. brisket, neck). Liver pâté type of product was chosen to be made in the semi-operational conditions, because it enables processing of less valuable parts and livers too. Liver pâté products are common product on the market in the Czech Republic. Effect of the refrigeration storage of raw meat was also investigated because of the expectation, that continuous supply and amount of eland meat could not be possible due to the limited range of production.

Products were fabricated at the company Alimpex – maso, s.r.o. (Alimpex food, a.s., Prague, Czech Republic; 49°59'07.2"N 14°34'37.3"E) by using various combinations of different kinds of meat and livers (eland, cattle, chicken). Analysis of the final products and sensory evaluation by trained panelist were made in cooperation with the Faculty of Agrobiology, Food and Natural Resources, CULS Prague (Maxová 2012).

3.4.1 Raw Materials Used in the Experiment

Breeding of elands and conditions of their slaughter are described in the chapters 3.1 and 3.2. Meat parts from neck, brisket, flank and livers were taken from the eland slaughtered on 24.11.2011[8]; age or sex of the animal were not taken into consideration. Meat was vacuum packed second day after slaughter and taken to the pâté processing facility being kept at 4 °C for the whole time. Beef meat (similar meat cuts as from eland) and liver, and chicken liver were purchased at a retail shop. Meat was then kept for five days prior to processing at 4 °C. Both eland and beef were then divided into three proportionally similar parts. First part was processed, second stored frozen for 45 days before processing

[8] Meat for pâté came from animal no. 7 (female, 3245 days old, slaghter weight 337 kg).

and third stored frozen for 90 days before processing. Liver parts were also stored frozen together with meat. Frozen meat was thawed for two days at 4 °C before processing into the pâté.

Fresh meat samples were taken for the analysis of the basic composition (see 3.3.1 for the analysis description). Average eland meat sample contained 74.7% of moisture, 2.1% of fat, 22.2% of protein and average beef sample contained 73.2% of moisture, 4.5% of fat and 21.1% of protein.

3.4.2 Processing of the Pâté

Pâté formula was derived from the common formula used by the company Alimpex and batches totally of five kilograms of emulsion each were made. Products varied in the kinds of meat and livers used as well as in the period of refrigeration storage; materials used are described in the Table 3.

Table 3 - Overview of pâté varieties made in the semi-operational conditions

Refrigeration storage	Liver	Meat
0 days	Chicken	Beef
	Chicken	Eland
	Eland	Eland
	Beef	Elan
45 days	Chicken	Beef
	Chicken	Eland
	Eland	Eland
	Beef	Eland
90 days	Chicken	Beef
	Chicken	Eland
	Eland	Eland
	Beef	Eland
Raw materials for 5 kg batch of pâté	1.25 kg of livers (eland, beef or chicken), 1.25 kg of shortened pork lard, 1.015 kg of meat, 1.25 kg of broth, 0.14 kg of commercial additive mixture (Natura food additives Inc., Prague[9]), 0.235 kg of aroma, 0.0375 kg of nitrite curing mixture, 0.0375 kg of (common) salt	

[9] Commercial additive mixture was composed of starch, milk proteins, sugar, stabilizing agents (triphosphates - E 451, polyphosphates - E 452)[9] and antioxidant (sodium ascorbate - E 301)

Pâtés were made in a following way: Homogenized meat was pre-cooked in transparent casings with a diameter of 70 mm. Those casings were filled manually to the weight of about one kilogram. Then they were cooked in the steam chambre for four hours using 78 °C hot steam. Technological limit of pasteurization was 30 min. Escaped juice was also utilized later during processing.

Liver were homogenized with nitrite curing mixture till 20 °C when small bubbles showed on the surface. Then pork fat was added (50 – 70 °C), then chopped for 30 – 60 s. Gradually one third of broth was added (60 – 80 °C), chopped for 30 – 60 s, then additive mixture and, cooked meat, aromatic compound was added and finally rest of the broth. Temperature of final batter was optimally 35 – 42 °C. For the meat homogenization was used bowl cutter Mainca (22 l bowl/ max. batch 15 kg; Granollers, Spain) with three knifes on the head of its shaft (see Appendix XXXIV). Final batter was filled manually to the consumer packages (100 g), sealed with aluminium foil and heat processed[10].

3.4.3 Sensory Evaluation of Pâté Organoleptic Properties

Panellists (n=35) were briefly questioned about their relation to the pâté type products before the main sensory evaluation. Appendix III is summarizing presented questionnaire.

Sensory analysis of organoleptic properties of pâtés was carried out at the sensory analytical laboratory of the Czech University of Life Sciences Prague under the conditions of ISO 8589 (2007). The 35 experienced panellists (students and employees) of the Department of Quality of Agricultural Products were involved is the experiment. The panellists were selected, trained and monitored according to ISO 8586 (2012). Panellists participating in the experiment had special sessions for training in the evaluation of meat products and for the understanding of all attributes. Sensory quality was assessed using sensory profiling method according to ISO 13299 (2016). The evaluated sensory traits and the orientation of linear unstructured graphical 100 mm scales are given in Table 4. Samples were coded using three-digit, randomly generated numbers and served according to the ISO 6658 (2017). Drinking tap water and white bread were given as neutralizers to the panellists between the samples.

Final products are shown on the picture in Appendix XXXV.

[10] In accordance with the Regulation of Ministry of Agriculture no. 69/2016

Table 4 - Sensory evaluation of organoleptic traits (descriptors) – overview of parametres

Organoleptic traits	Rating 0 mm	Rating 100 mm
Overall appearance	Very bad	Excellent
Pleasantness of colour	Rejectable	Very pleasant
Color hue	Pink	Brown
Intensity of colour	Imperceptible	Very strong
Uniformity of colouring	Uneven	Uniform
Pleasantness of smell	Rejectable	Very pleasant
Intensity of smell	Imperceptible	Very strong
Pleasantness of taste	Rejectable	Very pleasant
Overall intensity of taste	Imperceptible	Very strong
Intensity of salty taste	Imperceptible	Very strong
Intensity of other taste	Imperceptible	Very strong
Intensity of off-flavour	Imperceptible	Very strong
Pleasantness of consistency	Disguisting	Very pleasant
Overall texture	Very tough	Very tender
Friability	Very friable	Compact

3.5 Statistical Data Analysis

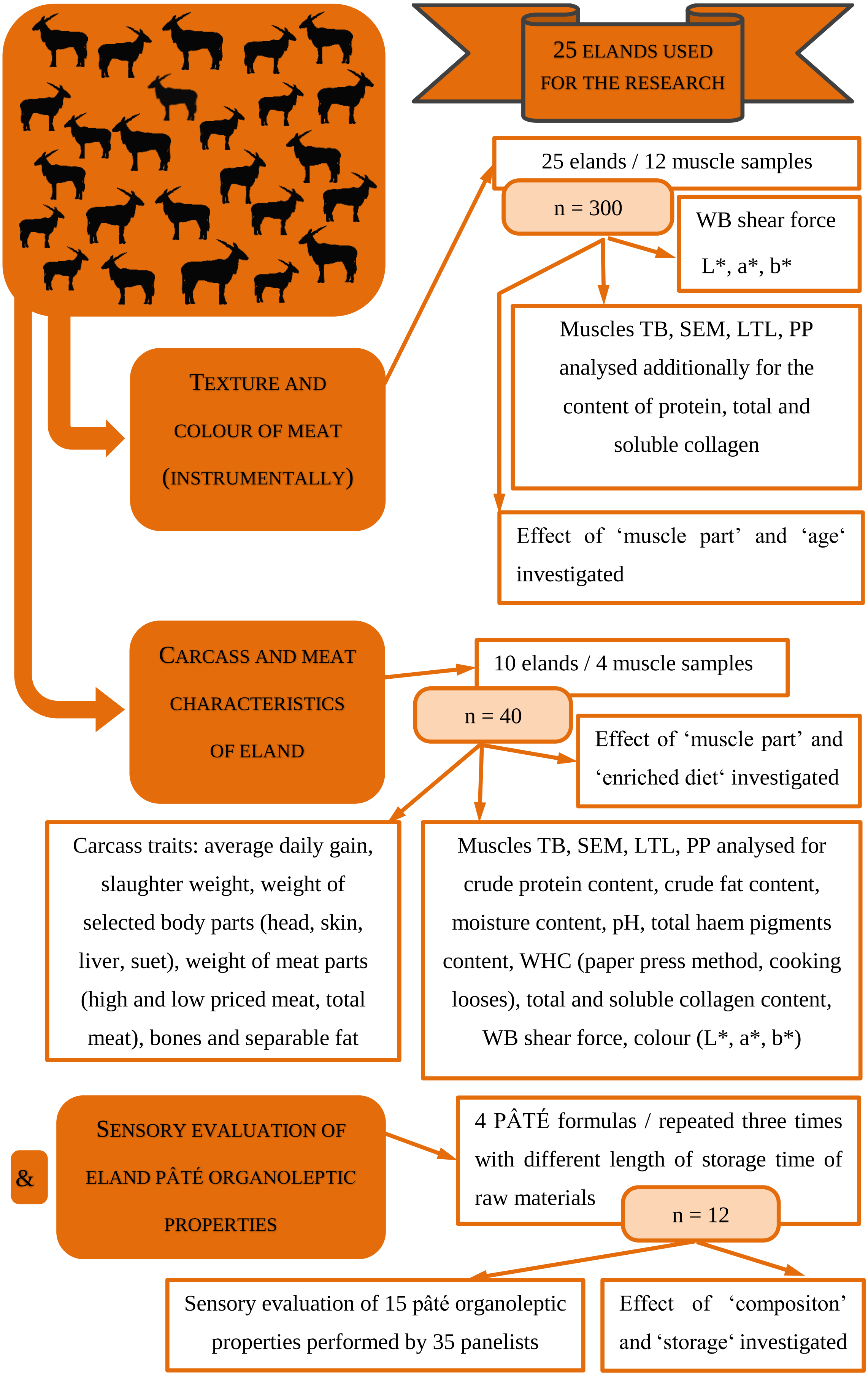
All analyses were performed using statistical software SAS System V 9.4 (SAS Inst. Inc., Cary, NC, USA). Data normality was assessed by plotting histograms and normal probability plots. Four different tests were performed (Shapiro–Wilk, Kolmogorov–Smirnov, Cramer–von Mises and Anderson–Darling).

Detected analytical values were analyzed by Generalized Linear Mixed Models – proc Mixed, treated for repeated measures, where fattening parameters, dressing percentage, carcass composition, physical, chemical and technological parameters were the dependent variables and the independent fixed effects were muscles (4 and 12 muscles according to experiment), the diet (basic and enriched). Animals were also divided according to age into three age categories (‘less than 2 years’ - 8 animals, ‘2 – 3 years’ - 12 animals, ‘older than 3 years’ – 5 animals) to investigate possible effect of age on the meat properties.

All sensory traits were included also as dependent variables and were analysed separately using the Generalized Linear Mixed Model (GLMM). The explanatory variables included in analysis were categorical of ’Composition’ of pâté batch with four levels (CHL-Beef, CHL-Eland, EL-Eland, BL-Eland) and length of ‘Storage’- including fresh (0 days), 45 and 90 days as described in Table 3. Interaction between ‘Composition*Storage’ was included in analysis also. To account for repeated evaluation by same panellist over the experimental period, analyses were performed with PROC MIXED, using the individual panellist as a random factor. We started with a complete model containing all effects and calculated Akaike's Information Criterion, which was adjusted for small sample biases (AICc). In the next step, we reduced the model through exlusion of non-significant explanatory effect found in previous analyses. The PROC MIXED was then initiated to compare AICc with the full model. These interactions were repeated until only significant effects remained; as we reached maximum likelihood estimates, the AICc fell to its lowest level. In the best fitting model, the within-group means were adjusted to account for the remaining effects using the least-squares means statement (LSMEANs) as opposed to arithmetic means. LSMEANs were calculated for each effect. Differences between the effects were tested using the F-test. For multiple comparisons, the Tukey-Kramer adjustment was used.

Figure 1 is summarizing overview of used samples and performed analyses during the research.

Figure 1 – Overview of used samples and performed analysis during the research



4 RESULTS

4.1 Carcass and Meat Characteristics

4.1.1 Carcass Characteristics

Slaughter weight ranged from 360.0 ± 21.66 kg in control group to 416.66 ± 21.66 kg in experimental group, but it did not differ significantly. Free pectoral suet (p=0.012) and total suet had (p=0.025) significantly higher proportion of slaghter weight in the group with enriched diet together with the the carcass yield (p=0.009). Animals with enriched diet had about one percent of the slaughter weight higher amount of total suet (2.48% compared to 1.47%), higher content of free pectoral suet (0.59% to 0.36%) compared to the animals with standard diet. Content of the kidney suet was not statistically significant, but it showed slight tendency to differ (p=0.069). Separable fat expressed as a percentage of weight from right processed carcass half differed in animals with enriched diet (3.14%) compared to animals with standard diet (1.70%) significantly (p=0.0002). Animals with enriched diet had also higher carcass yield (59.99%) compared to animals with standard diet (57.32%).

In both groups high priced meat made over 42% of carcass but it did not differ significantly. Bones and tendons were in both groups about 19% of carcass, but it also did not differ significantly. Total meat yield was 76.64% of processed carcass in animals with enriched diet and 78.02% in animals with standard diet, but statistical difference was not found. Proportion of meat and bones were in both groups slightly over 4.

Average value of pH_{24} (n=25) was 5.61 ± 0.06.

Results summarizing carcass characteristics are presented in Table 5 and Table 6.

Table 5 - Overview of eland carcass traits and statistical significance of differences between the groups with enriched and standard diet (I)

	Carcass traits	Enriched diet		Standard diet		F-value	Df	p value
		LSMEAN	SE	LSMEAN	SE			
Age (months)		32.80	3.22	34.60	3.22	0.16	8	0.703
Slaughter weight [kg]		414.60	21.66	360.00	21.66	3.18	8	0.113
Expressed as percentage from the slaughter weight	Skin [%]	8.23	0.04	7.99	0.04	12.39	1	0.176
	Head [%]	4.63	0.30	4.37	0.30	0.39	8	0.551
	Liver [%]	1.33	0.09	1.22	0.09	0.68	8	0.4349
	Suet kidney [%]	0.54	0.07	0.34	0.07	4.42	8	0.069
	Suet stomach [%]	0.25	0.06	0.16	0.06	1.30	8	0.287
	Suet scrotum [%]	0.11	0.02	0.06	0.02	2.25	8	0.172
	Suet pericardium [%]	1.00	0.20	0.55	0.20	2.49	8	0.153
	Suet free pectoral [%]	**0.59**	**0.05**	**0.36**	**0.05**	**10.51**	**8**	**0.012**
	Suet total [%]	**2.48**	**0.26**	**1.47**	**0.26**	**7.60**	**8**	**0.025**
	Carcass yield [%]	**59.99**	**0.55**	**57.32**	**0.55**	**12.01**	**8**	**0.009**

Table 6 - Overview of eland carcass traits and statistical significance of differences between the groups with enriched and standard diet (II)

Carcass traits		Enriched diet		Standard diet		F-value	Df	p value
		LSMEAN	SE	LSMEAN	SE			
Expressed as percentage from the processed right carcass half	Shoulder [%]	8.64	0.43	8.22	0.43	0.48	8	0.508
	Round of beef [%]	25.56	0.45	26.61	0.45	2.70	8	0.139
	Brisket [%]	12.17	0.47	11.11	0.47	2.52	8	0.1507
	Loin [%]	5.53	0.22	5.66	0.22	0.18	8	0.686
	Tenderloin [%]	2.29	0.07	2.40	0.07	1.34	8	0.281
	HPM[11] [%]	42.02	0.65	42.88	0.65	0.87	8	0.379
	LPM[12] [%]	34.27	0.65	34.70	0.65	0.22	8	0.648
	Total meat [%]	76.64	0.46	78.02	0.46	4.44	8	0.068
	Bones, tendons [%]	18.85	0.53	19.39	0.53	0.53	8	0.489
	Separable fat [%]	**3.14**	**0.22**	**1.70**	**0.22**	**20.75**	**8**	**0.002**
HPM/LPM		1.23	0.04	1.24	0.04	0.05	8	0.824
Meat/Bones		4.07	0.14	4.05	0.14	0.02	8	0.887

[11] High priced meat (rump, shoulder, loin and fillet plus lean trimmings)
[12] Low priced meat (other meat parts plus lean trimmings)

4.1.2 Meat Characteristics

Meat samples from the group of 10 eland males were evaluated for chemical and technological parametres. The effect of 'muscle part' was shown in all measured characteristics except for the moisture content and the content of soluble collagen. In both cases no significant differences were found at all (for more see Table 7).

Effect of the 'diet' was shown in the crude protein content (p=0.0251), but no interaction between effects was found. Effect of the 'enriched diet' (p=0.0291) together with the interaction of evaluated effects 'enriched diet*muscle part' (p=0.0007) were significant in crude fat content.

Table 7 - Statistical significance of the effects of 'diet' and 'muscle part' influencing basic and advanced meat characteristics

Analysis	Effect	Degrees of freedom num	Degrees of freedom den	F test value	p value
pH value	Enriched diet	1	6.00	0.01	0.9066
	Muscle part	**3**	**82.00**	**12.96**	**<0.0001**
	Interaction	3	82.00	6.44	0.0006
Moisture content	Enriched diet	1	8.00	0.31	0.5908
	Muscle part	3	104.00	1.72	0.1675
	Interaction	3	104.00	0.70	0.5536
Crude protein content	**Enriched diet**	**1**	**8.11**	**7.52**	**0.0251**
	Muscle part	**3**	**62.50**	**37.75**	**<0.0001**
	Interaction	3	62.50	0.59	0.6206
Total colagen content	Enriched diet	1	62	1.73	0.1932
	Muscle part	**3**	**62**	**33.71**	**<0.0001**
	Interaction	3	62	4.68	0.0052
Content of soluble collagen	Enriched diet	-	-	-	-
	Muscle part	3	104	0.67	0.5701
	Interaction	-	-	-	-
Total haem pigments content	Enriched diet	1	8.08	1.49	0.2559
	Muscle part	**3**	**66.20**	**33.88**	**<0.0001**
	Interaction	3	66.20	1.84	0.1477
Crude fat analysis	**Enriched diet**	**1**	**8.00**	**7.04**	**0.0291**
	Muscle part	**3**	**104.00**	**69.42**	**<0.0001**
	Interaction	**3**	**104.00**	**6.16**	**0.0007**
Water holding capacity	Enriched diet	1	8.00	0.19	0.6739
	Muscle part	**3**	**463.00**	**7.61**	**<0.0001**
	Interaction	3	463.00	1.99	0.1145
Cooking losses	Enriched diet	1	8.02	0.31	0.5948
	Muscle part	**3**	**63.00**	**32.21**	**<0.0001**
	Interaction	3	63.00	0.31	0.8182

Lightness (L*)	Enriched diet	1	8.02	1.96	0.1986
	Muscle part	**3**	**107.00**	**10.69**	**<0.0001**
	Interaction	3	107.00	1.78	0.1549
Redness (a*)	Enriched diet	1	8.00	0.33	0.5833
	Muscle part	**3**	**107.00**	**53.74**	**<0.0001**
	Interaction	3	107.00	1.81	0.1497
Yellowness (b*)	Enrichd diet	1	7.99	0.20	0.6683
	Muscle part	**3**	**107.00**	**19.50**	**<0.0001**
	Interaction	3	107.00	0.90	0.4435
Texture (WB shear force)	Enrichd diet	1	6.28	1.80	0.2267
	Muscle part	**3**	**101.00**	**42.48**	**<0.0001**
	Interaction	3	101.00	1.29	0.2814

Results of the **pH value** are presented in Table 8. Highest pH value was found in brisket, while the lowest in LTL. Generally, muscle LTL differs from SEM (p=0.0305), TB (p=0.0408) and PP (p<0.0001). Significant differences were also between TB and PP (p=0.004) and between PP and SEM (p=0.0057). Avarege pH value ranched from 5.77 in LTL to 5.95 in PP.

In the control group significant differences between LTL and TB (p=0.0288), LTL and PP (p<0.0001), TB and PP (p=0.002), and PP and SEM (p=0.00041) were found (see also Appendix V). pH24 value (n=25)

Results of the **moisture content** after drying of meat samples with sea sand content are presented in Table 8 and Appendix VI. Moisture content ranged from 74.83 ± 0.50 g.100 g^{-1} in LTL to 76.17 ± 0.50 g.100 g^{-1}, but no significant statistical differences were found.

Results of the **crude protein content** are presented in following Table 8 and Appendix VII. Crude protein content was higher in the experimental group (21.65 ± 0.15 g.100 g^{-1}) in comparison with the control group (21.07 ± 0.15 g.100 g^{-1}) and the difference was significant (p=0.0251). Generally, muscle LTL differed from TB (p<0.0001) and PP (p<0.0001), but it did not differ from SEM (p=0.0516); SEM differed from TB (p<0.0001) and PP (p<0.0001). Muscle LTL had the highest average content of crude protein (22.19 ± 0.15 g.100 g^{-1}) and muscle PP the lowest one (20.61 ± 0.15 g.100 g^{-1}).

In the control group significant differences were between SEM and PP (p=0.0043), and PP and LTL (p<0.0001); in the experimental group were found between TB and SEM (p<0.0001), PP and LTL (p<0.0001), and PP and SEM (p<0.0001).

Results of the **total collagen content** are presented in Table 8 and Appendix VIII. Muscle PP differed from LTL (p<0.0001) and SEM (p<0.0001) and muscle TB differed from LTL (p < 0.0001) and SEM (p<0.0001) too. Highest average content of total collagen was found in muscles PP and TB. These values were approximately two times higher then in muscles LTL and SEM.

In the control group PP differed significantly from TB (p=0.0029), from LTL (p<0.0001) and from SEM (p<0.0001). Further TB differed from LTL (p=0.0084).

In the experimental group PP differed significantly from LTL (p=0.004) and from SEM (p=0.0007); TB then differed from LTL (p<0.0001) and from SEM (p<0.0001).

Spearman correlation coefficient for the total collagen content and Warner-Bratzler shear force was 0.502 (p<0.001). No differences between tested groups or muscle parts were found in the **soluble collagen content** (see Table 8).

Results of the **crude fat content** are presented in Table 8. Generally, muscle PP differs from the LTL (p<0.0001), SEM (p<0.0001), and TB (p<0.0001). SEM differs from TB (p<0.0001) and LTL (p<0.0001). Highest fat content was found in PP (1.10 ± 0.09 g.100 g^{-1}), followed by LTL, TB, while SEM had the lowest fat content (0.24 ± 0.09 g.100 g^{-1}).

In the control group significant differences were found between PP and TB (p=0.0178), PP and LTL (p=0.0631), PP and SEM (p<0.0001), TB and SEM (p=0.0072) and between LTL and SEM (p=0.0016) too. In the experimental group significant differences were found between PP and TB (p<0.0001), PP and LTL (p=0.003), PP and SEM (p<0.0001), TB and SEM (p<0.0001) and finally between LTL and SEM (p<0.0001).

In absolute numbers, crude fat content in meat of animals with enriched diet is approximately twice as big as in the animals with standard diet (see also Appendix IV).

In the combined interaction of diet and muscle PP (p=0.0081) differed significantly. Muscle LTL (p=0.0791) did not differ, but slight tendency was shown.

Table 9 is showing results for **fatty acid profile** of MLD. As is evident from the results, no significant differences were found between the experimental groups.

Results of the analysis of **total haem pigments content** are presented in the Table 8 and Appendix IX. Muscle PP differed from TB (p=0.0087) and LTL (p<0.0001). Muscle TB differed from LTL (p<0.0001) and from SEM (p<0.0001). Muscle LTL had the highest content of total haem pigments (540 ± 32 mg.100 g^{-1}), while the content of pigments in the other musles was significantly lower. The lowest content was found in muscle LTL, namely 342 ± 32 mg.100 g^{-1}.

In the control group significant differences were found between TB and PP (p<0.0001), TB and LTL (p<0.0001), and TB and SEM (p<0.0001). In the experimental group significant differences between PP and LTL (p=0.0263), TB and LTL (p<0.0001) and at last between TB and SEM (p=0.0006) were found. It was also found, that experimental TB differ from control group significantly (p=0.0072).

Two methods were used to measure water-holding capacity of eland meat, namely paper press method and cooking losses. Results of the **WHC measured as paper press method** are presented in Table 8 and Appendix X. Generally, muscle PP significantly differed from TB (p=0.0478). Muscle TB differed from LTL (p<0.0001) and SEM (p=0.0276). Water holding capacity ranged from 50.35 ± 4.9% in TB to 63.91 ± 4.9% in LTL. Significant effect of muscle part was found in eland meat, that is in the experimental group between PP and TB (p=0.0208), and TB and LTL (p<0.0001).

Results for **cooking losses** are presented in following Table 8 and Appendix XI. Muscle SEM differed significantly from TB (p<0.0001) and PP (p<0.0001). The highest cooking looses were found similarly in TB and PP (slightly over 26%), while the lowest were found in LTL (18.34 ± 1.35%).

In the control group significant differences were found between LTL and TB (p<0.0001), LTL and PP (p<0.0001), TB and SEM (p=0.0097), and PP and SEM (p=0.0063).

In the experimental group significant differences were found between LTL and TB (p<0.0001), LTL and PP (p<0.0001), TB and SEM (p=0.006), and PP and SEM (p=0.0010).

Meat colour was also measured instrumentally obtaining L*, a* and b* parameters. Results of **L* (lightness)** are presented in following Table 8 and Appendix XII. Generally, muscle PP differed from TB (p<0.0001) and from SEM (p=0.0183). Muscle TB differed from LTL (p=0.0105), difference between TB and SEM (p=0.0523) was not any more significant. The lightest muscle were PP and LTL, while SEM and mainly TB were significantly darker.

In the control group were found significant differences between PP and TB and (p=0.0075), PP and SEM (p=0.0327) and further in the experimental group differences were between PP and TB (p=0.0011), TB and LTL (p=0.0182) and in the end between TB and SEM (p=0.0325).

Results of **a* (redness)** are presented in following Table 8 and Appendix XIII. Muscle LTL differed significantly from SEM (p<0.0001), TB (p<0.0001) and PP (p<0.0001). Muscle SEM differ significantly from TB (p<0.0001) and PP (p<0.0001). Muscle TB and PP had comparable highest value of redness, while SEM and LTL were significantly less red.

In the control group following significant differences were found, namely between PP and LTL (p<0.0001), PP and SEM (p=0.0033), TB and LTL (p<0.0001), and between TB and SEM (p=0.0015). Further in the experimental group differences between PP and LTL (p<0.0001), PP and SEM (p=0.0112), TB and LTL (p<0.0001), TB and SEM (p=0.0194), and finally between LTL and SEM (p<0.0001) were found.

Results of **b* (yellowness)** are presented in following Table 8 and Appendix XIV. Muscle LTL differed from SEM (p=0.0066), TB (p=0.0001) and PP (p<0.0001). Muscle PP differed from TB (p=0.0074) and SEM (p=0.0003) also. Muscle LTL had the lowest b* value, significantly higher, were b * values of TB and SEM, but comparable within each other. The highest b* value had muscle PP.

In the control group significant differences between PP and TB (p=0.0378), PP and LTL (p<0.0001), and PP and SEM (p=0.0423) were found. Further in the experimental group were found some significant differences, namely between PP and LTL (p<0.0001), and TB and SEM (p=0.0011).

Results of texture measured as **Warner-Bratzler shear force** are presented in the following Table 8 and Appendix XIV. Muscle PP differed from LTL (p<0.0001), TB (p<0.0001) and SEM (p<0.0001). Muscle TB differed from LTL (p=0.0056) and SEM (p=0.0241). Muscles LTL and SEM had similar value of shear force, muscle TB and especially PP had significantly higher value of shear force (105.77 ± 15.38 N, 237.24 ± 15.46 N respectively) making those muscles less tender.

In the control group differences were found between PP and TB (p=0.0034), PP and LTL (p<0.0001), PP and SEM (p<0.0001), whereas in the experimental group were between PP and TB (p<0.0001), PP and LTL (p<0.0001) also between PP and SEM (p<0.0001).

Table 8 – Meat characteristics of LTL, TB, PP, SEM measured on 10 elands

Meat characteristics	LTL		TB		PP		SEM	
	LSMEAN	SE	LSMEAN	SE	LSMEAN	SE	LSMEAN	SE
pH value	5.77	0.08	5.85	0.08	5.95	0.08	5.85	0.08
Moisture content [g.100 g^{-1}]	74.83	0.50	75.39	0.50	76.17	0.50	75.93	0.50
Crude protein content [g.100 g^{-1}]	22.19	0.15	20.88	0.15	20.61	0.15	21.76	0.15
Content of total collagen [g.100 g^{-1}]	0.20	0.27	0.38	0.27	0.45	0.28	0.24	0.27
Content of soluble collagen [mg.100 g^{-1}]	7.30	1.70	9.20	1.80	9.60	1.80	6.50	2.00
Total haem pigments content [mg.100 g^{-1}]	3420	32	540	32	418	33	377	32
Crude fat analysis [g.100 g^{-1}]	0.78	0.09	0.67	0.09	1.10	0.09	0.24	0.09
Water holding capacity [%]	63.91	4.90	50.35	4.90	57.76	4.90	58.32	4.90
Cooking looses [%]	18.34	1.35	26.40	1.34	26.39	1.34	20.44	1.34
Lightness (L*)	42.03	0.60	40.37	0.59	43.32	0.60	41.73	0.60
Redness (a*)	8.76	0.54	12.22	0.53	12.24	0.54	10.51	0.54
Yellowness (b*)	7.91	0.41	9.08	0.40	9.96	0.41	8.81	0.41
WB shear force [N]	37.72	16.08	105.77	15.38	237.27	15.46	50.61	14.72

Table 9 - Fatty acid content of the *m. longissimus dorsi* comparing animals from experimental group with enriched diet (n=5) and animals from the control group fed with basic feed mixture (n=5) [$mg.kg^{-1}$]

Fatty acid Profile	Experimental group		Control group		F-value	Df		p value
	LSMEAN	SE	LSMEAN	SE		num	den	
MUFA	521.38	72.02	365.75	72.02	2.33	1	8	0.165
SFA	649.06	84.42	510.54	84.42	1.35	1	8	0.2794
PUFA	234.21	16.69	209.35	16.69	1.11	1	8	0.323
PUFA N-6	199.84	13.39	177.79	13.39	1.36	1	8	0.2776
PUFA N-3	34.37	3.90	31.56	3.90	0.26	1	8	0.6239
Fatty acids (total)	1442.11	172.26	1111.7	172.26	1.84	1	8	0.2121
PUFA/SFA	0.37	0.03	0.44	0.03	3.03	1	8	0.1197
MUFA/SFA	0.81	0.04	0.70	0.04	3.97	1	8	0.1229
PUFA N-6/N-3	5.91	0.44	5.86	0.44	0.01	1	8	0.9331

4.2 Texture and Colour of Eland Meat

Texture (Warner – Bratzler shear force and colour of meat (L*, a*, b*) were measured on the 12 muscle samples from 25 elands (see also Table 11). The effect of 'muscle part' and 'age' were investigated. In addition, crude protein content, content of total and soluble collagen (see also Table 12) were measured on the selected muscle samples, namely on LTL, TB, PP, SEM. Overview of the significance of evaluated effects is presented in Table 10.

Table 10 – Statistical significance of the effects of 'muscle part' and 'age' influencing eland meat characteristics

Analysis	Effect	Degrees of freedom num	Degrees of freedom den	F test value	p value
Texture (WB shear force)	**Muscle part**	**11**	**697**	**77.14**	**<0.0001**
	Age * Muscle part	24	544	0.33	0.9991
L* (lightness)	**Muscle part**	**11**	**999**	**37.61**	**<0.0001**
	Age * Muscle part	**24**	**683**	**1.93**	**0.0051**
a* (redness)	**Muscle part**	**11**	**1002**	**71.02**	**<0.0001**
	Age	**2**	**22**	**6.45**	**0.0063**
	Interaction	**22**	**1002**	**3.22**	**<0.0001**
b* (yellowness)	Muscle part	11	999	29.53	**<0.0001**
	Age * Muscle part	24	684	3.14	**<0.0001**
Crude protein content	Age	2	164	0.08	0.9226
	Muscle part	**3**	**164**	**42.23**	**<0.0001**
	Interaction	6	164	1.53	0.1725
Total collagen content	Age	2	164	1.52	0.2211
	Muscle part	**3**	**164**	**61.87**	**<0.0001**
	Interaction	**6**	**164**	**2.48**	**0.0252**
Content of soluble collagen	**Age**	**2**	**98**	**4.35**	**0.0154**
	Muscle part	3	98	0.44	0.7252
	Interaction	6	98	0.98	0.4411

As is presented in the Table 10, the effect of ‘muscle part’ influenced significantly Warner-Bratzler shear force, lightness, redness, yellowness, crude protein content, total collagen content with the exception of the content of soluble collagen, where the effect of ‘age’ was evident. Although total collagen content and texture showed interaction ‘age*muscle part’, no differences between same muscle parts from different age categories were found.

Texture of meat measured as **Warner-Bratzler shear force** ranged from approximatelly 50 N (LTL) do 400 N (STER). Effect of ‘muscle part’ was evidently showing difference between more (e.g. LTL, PM) and less (e.g. STER) valuable meat parts (see also Table 11 and Appendix XIX).

The highest **content of total collagen** (Appendix XVII) was found in muscle PP. It is about more than double amount compared to LTL and SEM, which have the lowest content of collagen (about 0.2 $g.100\ g^{-1}$). Muscle LTL had the highest **crude protein content** (Appendix XVI) reaching almost 22%, followed by SEM and TB. Muscle PP had the lowest crude protein content, namely 20.5%. Generally, LTL differs significantly from PP ($p<0.0001$), from TB ($p<0.0001$) and from SEM ($p=0.0007$). SEM differs significantly from PP ($p<0.0001$) and from TB ($p<0.0001$) too. **Content of soluble collagen** (Appendix XVIII) did not differ within muscle parts, but it increased with incresing age significantly ($p=0.0154$).

Colour of meat measured as L*, a* and b* parametres showed clearly significant effect of muscle part ($p<0.0001$) at all parametres. Redness showed significantly interaction with ’muscle part’ * ’age’ ($p=0.0063$). Meat from older animals had higher value of redness (see also Table 11).

Table 11 – Texture (Warner – Bratzler shear force) and colour (L*, a*, b* parametres) of 12 different muscles measured on 25 elands

Muscle sample	WB shear force [N]		L* (lightness)		a* (redness)		b* (yellowness)	
	LSMEAN	SE	LSMEAN	SE	LSMEAN	SE	LSMEAN	SE
m. biceps femoris	85.79	12.44	44.57	0.70	6.89	0.49	8.99	0.35
m. quadriceps femoris	115.16	12.13	37.58	0.70	11.28	0.48	7.42	0.35
m. flexor digitorum	257.65	13.00	40.96	0.69	8.79	0.49	7.37	0.35
m. gluteus medius	69.66	12.28	44.13	0.72	7.35	0.50	8.62	0.36
m. infraspinatus	120.66	12.98	37.80	0.70	10.86	0.49	7.22	0.35
m. longissimus thoracis et lumborum	48.08	12.48	41.13	0.68	7.52	0.48	7.35	0.34
m. psoas major	58.45	12.76	40.30	0.70	12.62	0.49	10.21	0.35
m. pectoralis profundus	216.16	12.18	42.83	0.70	10.10	0.49	9.00	0.35
m. semimembranosus	74.41	11.63	41.67	0.69	8.72	0.49	8.46	0.35
m. semitendinosus	88.48	12.95	41.40	0.70	10.11	0.49	9.10	0.35
m. sternomandibularis	404.67	12.80	42.41	0.68	10.11	0.49	7.66	0.34
m. triceps brachii	120.00	12.05	39.67	0.70	10.39	0.49	8.14	0.35

Table 12 - Meat characteristics of selected muscles measured on 25 elands

Meat characteristics	LTL		TB		PP		SEM	
	LSMEAN	SE	LSMEAN	SE	LSMEAN	SE	LSMEAN	SE
Crude protein content [g.100 g^{-1}]	22.19	0.15	20.88	0.15	20.61	0.15	21.76	0.15
Content of total collagen [g.100 g^{-1}]	0.20	0.27	0.38	0.27	0.45	0.28	0.24	0.27
Content of soluble collagen [mg.100 g^{-1}]	7.30	1.70	9.20	1.80	9.60	1.80	6.50	2.00

4.3 Eland Meat Processing

4.3.1 Consumers' Relations to Pâtés

The panelists (n=35) were questioned about their relation to the pâté as was described in the chapter 3.4.3 prior to the sensory evaluation of the products. Table 13 is presenting results of the presented questionnaire. See also Appendix XX, Appendix XXI, Appendix XXII for the graphical presentation of those results.

Pâtés are liked by most of the consumers. Only negligible share (6%) of panelists disliked pâté. Pâté is consumed often (17%) or sometimes (60%). Most of panelists (77%) would buy special pâté with unusual composition.

Table 13 - Results of the questionnaire investigating the relation of panelists (n=35) to pâté presented as a count of answers and as a share of answers on the whole

Question / Answer	Number of answers	[%]
What is your relation to pâté?		
I like them very much.	7	20.0
I like them.	26	74.3
I don't like them.	2	5.7
How often do you consume pâté?		
Often (once a week or more times)	6	17.1
Sometimes (once to three times in a month)	21	60.0
Rarely (several times during a year)	7	20.0
Not at all	1	2.9
Would you buy some pâté for the price higher than usual, if you know, that the pâté is unusual or untypical in its composition?		
Yes	11	31.4
No	3	8.6
Rather yes	16	45.7
Rather no	5	14.3
Don't know	0	0

4.3.2 Sensory Evaluation of Pâté Organoleptic Properties

Four different combinations of pâté were made from meat or livers, which were fresh, frozen 45 and 90 days. Totally twelve batches of pâté were made (see Table 3 for more details). Chemical composition of those pâté batches is presented in Appendix XXIII. Results of the sensory traits evaluation are presented in Appendix XXIV (fresh raw materials), Appendix XXV (raw materials frozen for 45 days) and Appendix XXVI (raw materials frozen for 90 days). Statistical significance of all tested effects, namely 'composition', 'storage', and their interaction are presented in Table 14. For more details see also figure in Appendix XXVII.

Pâté which were made from fresh material primarily showed differences in textural characteristics, namely in friability and overall texture. Two pâté batches made with chicken liver had higher score in pleasantness of taste and the intensity of colour was also higher than in remaining batches with beef or eland liver ($p<0.05$). The other characteristics, such as intensity of off-flavour, overall appearance, pleasantness of colour, colour hue and pleasantness of consistency did not show differences ($p>0.05$; see Appendix XXVII for more details).

Freezing of raw material (meat and liver) before processing into pâté resulted in worse scoring of the final product. Batches with chicken liver scored better in sensory traits, namely overall appearance, pleasantness of taste, colour and intensity of colour, colour hue, textural friability, overall texture and pleasantness of consistency ($p<0.05$). Pâté made with chicken liver from frozen material also had also lower intensity of off-flavour.

Table 14 - Significance (p) of the tested effects for all the sensory traits of evaluated pâté batches

Sensory trait	Effect	Num DF	Den DF	F Value	p<0.05
Overall appearance	Composition	3	400	27.13	<0.0001
	Storage	2	400	11.00	<0.0001
	Interaction	6	400	4.94	<0.0001
Pleasantness of colour	Composition	3	400	34.37	<0.0001
	Storage	2	400	6.10	0.0025
	Interaction	6	400	4.97	<0.0001
Color hue	Composition	3	400	30.94	<0.0001
	Storage	2	400	3.49	0.0314
	Interaction	6	400	28.34	<0.0001
Intensity of colour	Composition	3	400	34.49	<0.0001
	Storage	2	400	9.37	0.0001
	Interaction	6	400	4.75	0.0001
Uniformity of colouring	Composition	3	400	6.41	0.0003
	Storage	2	400	1.37	0.2541
	Interaction	6	400	1.75	0.1089
Pleasantness of smell	Composition	3	400	7.57	<0.0001
	Storage	2	400	3.93	0.0204
	Interaction	6	400	2.44	0.0250
Intensity of smell	Composition	3	400	5.90	0.0006
	Storage	2	400	1.62	0.1986
	Interaction	6	400	0.33	0.9213
Pleasantness of taste	Composition	3	400	30.31	<0.0001
	Storage	2	400	5.30	0.0053
	Interaction	6	400	1.99	0.0656
Overall intensity of taste	Composition	3	400	2.22	0.0857
	Storage	2	400	0.58	0.5631
	Interaction	6	400	2.41	0.0267
Intensity of salty taste	Composition	3	400	2.72	0.0440
	Storage	2	400	0.22	0.8062
	Interaction	6	400	1.45	0.1939
Intensity of other taste	Composition	3	400	12.79	<0.0001
	Storage	2	400	0.77	0.4659
	Interaction	6	400	0.54	0.7808
Intensity of off-flavour	Composition	3	400	20.29	<0.0001
	Storage	2	400	1.20	0.3027
	Interaction	6	400	0.82	0.5533
Pleasantness of consistency	Composition	3	400	22.42	<0.0001
	Storage	2	400	0.33	0.7180
	Interaction	6	400	6.69	<0.0001
Overall texture	Composition	3	400	46.79	<0.0001
	Storage	2	400	11.58	<0.0001
	Interaction	6	400	2.13	0.0488
Friability	Composition	3	400	31.45	<0.0001
	Storage	2	400	1.13	0.3248
	Interaction	6	400	7.05	<0.0001

Figure 2 – Sensory profile of pâtés made of fresh raw materials

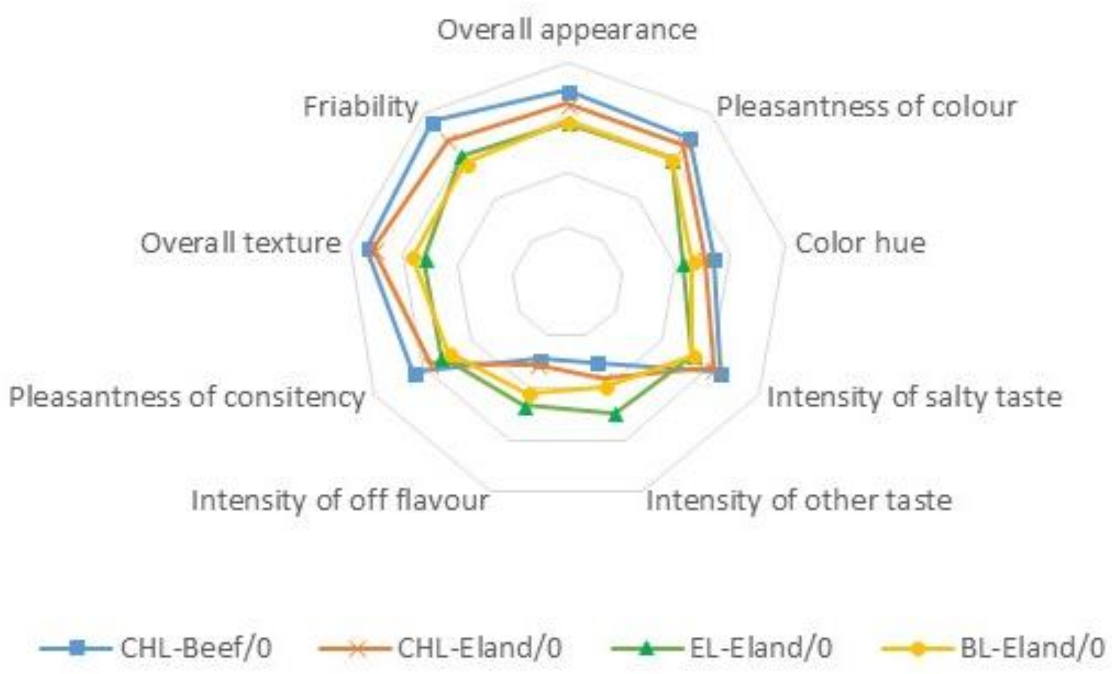


Figure 3 - Sensory profile of pâtés made of raw materials frozen for 45 days

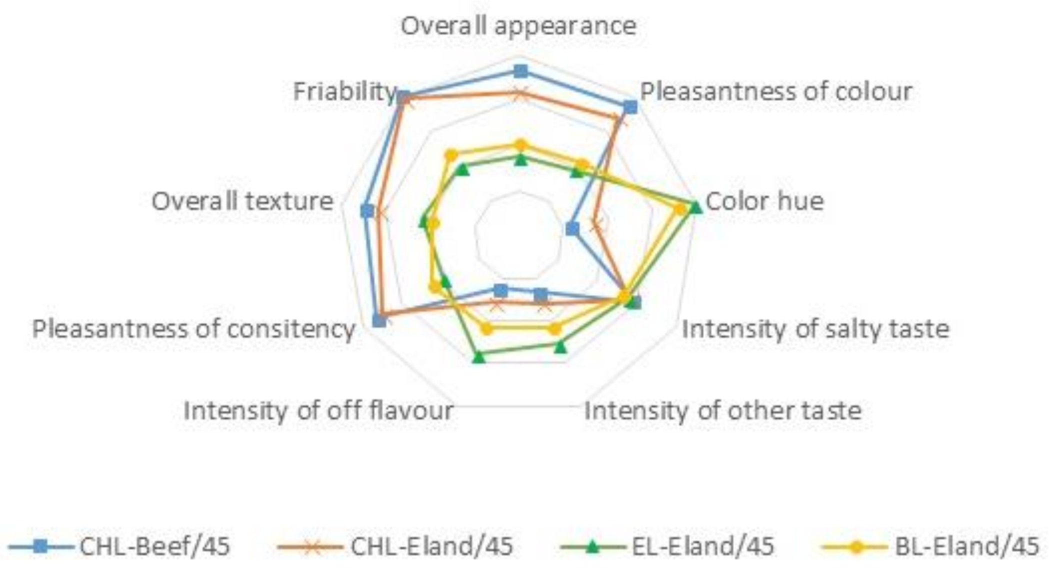
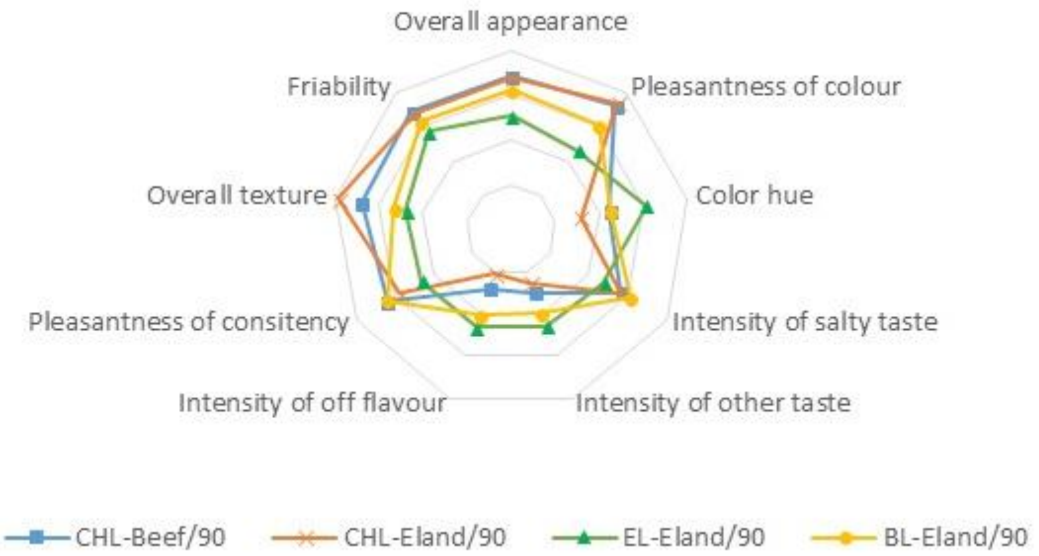


Figure 4 - Sensory profile of pâtés made of raw materials frozen for 90 days



5 DISCUSSION

5.1 Carcass and Meat Characteristics

In the first experimental part nutritional experiment was performed. Carcass and meat traits of the elands in the group with enriched diet (‘experimental group’) were compared to the carcass and meat traits of the elands in the group with standard diet (‘control group’).

5.1.1 Carcass Traits

Elands with enriched diet had according to Váňa (2010) significantly higher average daily weight gain compared to the control group (0.49 ± 0.03 $kg.day^{-1}$ vs. 0.26 ± 0.04 $kg.day^{-1}$, $p<0.0001$), but slaughter weights of both groups did not differ significantly (see Table 5 for more details). Despite the fact, that animals with enriched diet had higher average slaughter weight (414.6 ± 36 kg vs. 360.0 ± 58.3 kg in control group). It can be explained by the wide range of age animals (see Appendix I) when they were slaughtered.

Compared to the study of Carles et al. (1981), farmed eland showed comparable growing performance, as elands captured or raised in captivity from birth (0.209, respectively 0.223 $kg.day^{-1}$); which was better than growing performance of oryx but worse than of cattle. Skinner (1967) reported, that daily weight gain during a three-month long fattening period at Russian elands (20 to 45 months old) ranged from 0.709 kg to 0.840 kg. This result is evidently higher compared the elands with enriched diet in this study. Presented results of the growing performance in this study correspond also to the results of Barton et al. (2014). In their study elands were slaughtered at a live weight of 414.2 kg (s.d. 47.5 kg) at the age of 1112 days (s.d. 138 days). In the study of Alberti et al. (2008) several European cattle breeds were compared. Average daily gain ranged from 1.01 $kg.day^{-1}$ in Highland cattle to 1.97 $kg.day^{-1}$ in Aberdeen Angus cattle.

In this study, elands with enriched diet had significantly higher amount of free pectoral suet, total suet and separable fat (see Table 5 for more details). Experimental group of animals compared to the control group of animals had also higher carcass yield (59.99% vs. 57.32%, $p=0.009$), but probably it was to significantly higher ($p=0.002$) amount of previously mentioned separable fat (3.14% vs. 1.70%). Despite the fact, that enriched diet improved the grow of elands and elands with enriched diet had almost two times higher average daily weight gain, elands grow evidently more slowly when compared to the cattle. Skinner (1966) reported dressing percentage of the eland ranging from 58 to 60%, what corresponds to this study. According to Alberti et al. (2008) dressing percentage depends on cattle breed and animal types; can range from about 50% (Jersey cattle) to almost 64% (Piemontese cattle). Dressing percentage of eland can be compared to the dressing percantage of Simmental (58.8 ± 2.29%), Marchigiana (58.8 ± 2.29%) or South Devon (58.7 ± 2.29%) cattle.

Authors Volpelli, Valusso and Piasentier (2002) studied diet supplementation in male fallow deer. It was found, that better diet resulted in heavier carcass, higher dressing proportions, bigger amounts of first quality cuts. Muscle development and fat deposition were improved. This study thus corresponds to the results of this experiment. Phillip et al. (2007) presented, that the increased ratio of grain/forage in the feed intake improved energy balance and thus the growth of the red deer; On the other hand, increased grain intake had negative impact on the carcass fatness and on the fatty acid profile also.

Furthermore, total meat yield in the experimental group of animals (76.64%) was slightly lower than in control group (78.02%), but the difference was close over the threshold of significance (p=0.068); see also Table 5 and Table 6. These results support the idea, that additional energy provided by the enriched diet improves growth, but this energy is saved preferably to the adipose tissue (energy reserves) than to the meat yield.

5.1.2 Meat Characteristics

Enriched diet of the experimental group of elands had significant effect on the crude fat content, where the effect of ‘diet’ (p=0.0291), ‘muscle part’ (p<0.0001) and their interaction (p=0.0007) were evident. Crude protein showed the effect of ‘diet’ (p=0.0251) and ‘muscle part’ (p<0.0001). All other examined traits showed the significant effect of ‘muscle part’ (p<0.0001) except for the dry matter content and content of soluble collagen, where no differences were found (for more details see Table 7).

Crude protein content was influenced by the effect of muscle. Although the diet effect was statistically significant, muscle cuts from the control and experimental animals did not differ significantly when compared to each other. Results indicates, that the enriched diet generally provided more energy for the muscle grow and development and corresponds to eland carcass traits.

Our results also revealed, that significant differences were between the meat cuts of higher and lower quality (for more details see chapter 4.1.2). It means that LTL and SEM had about of one gram of crude protein more than TB and PP in 100 g portion. LTL and SEM were also lower in the collagen and crude fat content. For example, eland LTL has average content of 21.91 ± 0.21 g.100 g^{-1} of crude protein in control group and 22.47 ± 0.21 g.100 g^{-1} in enriched group. Barton et al. (2014) found 21.85 g.100 g^{-1} of protein in the muscle of eland, which is fully comparable. Meanwhile Hoffman et al. (2015) found higher protein content (24.1 ± 0.42 g.100 g^{-1}) in elands slaughtered in Namibia; in this case, slightly higher content of the protein can be probably explained by higher age of harvested animals. Meat quality of roe deer (*Capreolus capreolus* L.) coming from two different regions of the Czech Republic was studied in the study of Dominik et al. (2013). It was presented, that *m. gluteus medius* of roe deers from Southern Moravia contained 23.84 ± 1.86 g.100 g^{-1}, while those hunted in the Liberec region had only 19.50 ± 1.41 g.100 g^{-1}. Authors of this study presumed, that this difference was due to the different diet, which came from the different face of the landscape. Similarly, effect of production region influenced significantly the contents of amino acids and minerals in the meat of springbok (Hoffman et al. 2007b) and it was explained by the different nutrition in production regions, from which the animals originated. These studies principally support the idea of enriched diet, which provides more energy for growth of animal.

Low fat content in the African game species was reported several years ago, e.g. in the study of von La Chevallier (1972); eland was reported to contain 2.4% of fat and 75.8% moisture. According to this study, seasonal variations in the fat content were observed within the species.

Low fat content in the meat of eland corresponds to the fact, that eland is not domesticated species as cattle for example. Profile of fatty acids in LTL showed no differences between the groups of elands. It can be explained by the fact, that eland is a ruminant and eaten feed is metabolized by rumen microflora (Hofmann 1989).

Seasonal variations were found in several muscles of blesbok in the study of Neethling et al. (2014). Although the differences were of low magnitude, changing level of nutrition during the year had influence on the chemical composition of the meat of farmed blesbok. It is evident, that appropriate level of nutrition certainly improves condition of animal. It can be concluded, that eland can create energy reserves in response to the period with higher intake of more nutritious feed preferably stored as carcass fat.

No significant differences were found in the moisture content, despite the fact, that control group results were seemed lower then results of experimental group. Moisture content in the meat of eland corresponds to the other literature (Hoffman & Cawthorn 2013). Meat with a lower moisture content have usually higher content of fat (Lawrie & Ledward 2006).

Basic composition of eland meat is generally low in fat and rich in protein. From this point of view eland meat can be considered as nutritionally valuable. Basic composition of eland meat is comparable to the meat of other African ungulates and it is in an agreement with other studies (Hoffman & Cawthorn 2013). But in fact, it shall be taken into consideration, that different animal species were compared. Although there is a wide range in bovine meat composition due to the existence of many different breeds, it seems that beef have lower content of crude protein content but higher content of fat compared to eland meat (Lawrie & Ledward 2006), which can be thus considered as highly nutritious and similarly as other game species can be recommend for consumers, who are interested in healthy lifestyle (Hoffman & Wiklund 2006). In contrary, meat from the national Korean cattle breed Hanwoo is preferred and valued more than imported beef from Angus or Holstein steers in Korea, and LTL of the Hanwoo cattle was reported to contain 14.03 ± 0.42% of fat in *m. longissimus dorsi* and 7.62 ± 0.42% of fat in *m. semimembranosus*; in fact meat of this breed is valued for its high marbling and marbling is an important factor in selection of breeding animals (Young-Hwa et al. 2010).

pH value of meat can be influenced by many factors (Lawrie & Ledward 2006). Several differences in the pH value were found within the meat parts in the control group, but generally pH value was slightly over 5.8. Authors Torrescano et al. (2003) presented in their study, that different bovine muscles may differ in pH value. Possible explanation is that different muscles are differently physically loaded prior to the slaughter. Huidobro et al. (2003) reported, that pH value measured in the bulls' *m. longissimus thoracis et lumborum* aged for six days was 5.53 ± 0.021 and this value did not significantly differ from the value of pH_{24}. It seems, that pH value can be naturally slightly higher in game animals than in domestic cattle. Higher pH value was also found in *m. longissimus thoracis and lumborum* (5.67 ± 0.019) and *m. biceps femoris* (5.66 ± 0.004) of the male springbok 30 hours after slaughter (North et al. 2016). Average pH value (5.82 ± 0.129) of male impala taken 36 hours *post mortem* (Hoffman 2000) also indicates, that slightly higher pH value of eland meat corresponds to the other literature as well as the average value of pH_{24} presented in this study. Christensen et al. (2011) presented, that pH_{24}

differed significantly within cattle breed, when 15 european cattle breeds were compared in their study.

No effect of diet was found in pH value of meat. It corresponds to the study of Volpelli et al. (2003), where pH value was also unaffected by diet in the meat of fallow deer fed by enriched diet.

pH value of meat, as well as the development of the pH value during changes *post mortem* in meat, is essential for meat quality and further processing of meat. Meat become more tender, specific aroma and flavour of meat are developed during the aging period. Game meat becomes more suitable for culinary processing. Importance of aging of eland's meat was showed in the study of Bureš et al. (2010) where optimal time of aging for grilled eland meat and beef was investigated. Similar experiment such was presented in the studies of authors North et al. (2015) and North et al. (2016) shall be designed to study changes *post mortem* and aging of eland's meat in more detail. Optimal aging period for culinary and technological processing can be settled with the regards on the costs of cold storage.

Total haem pigments content was influenced significantly by the effect of muscle. From the results is evident, that TB had the highest amount of total haem pigments content, namely 530 mg.100 g^{-1} in the standard diet group and 540 mg.100 g^{-1} in the enriched diet group. On the other hand, the lowest content had LTL, 310 mg.100 g^{-1} in the standard diet group and 380 mg.100 g^{-1} in the enriched diet group. It can be expected, that TB is more active muscle than LTL. In the study of Hoffman et al. (2005) was found, that impala *m. longissimus dorsi et lumborum* contained from about 725 to 750 mg.100g^{-1} and no effects of region or sex were found. *Longissmus dorsi* muscles of adult kudu contained higher amount of myoglobin 638 ± 62 mg.100 g^{-1} (Hoffman et al. 2009). Eland muscles evaluated in this study thus contained significantly lower amount of total haem pigments, of which myoglobin makes major part in the muscle. In addition, authors Young-Hwa et al. (2010) reported, that *m. longissimus dorsi* and *m. semimembranosus* of Hanwoo cattle contain 732 ± 26 mg.100 g^{-1}, 785 ± 23 mg.100 g^{-1} respectively, of myoglobin (animals in this study had the same carcass grading, but age and sex were not specified in the study). Moreover, iron bound in haem pigments in meat represent important contribution of the dietetic income of iron (Pretorius et al. 2016).

Meat texture measured as Warner-Bratzler shear force is connected to the amount of the connective tissue in the muscle and to the function of the muscle part (Torrescano et al.

2003, Lepetit 2008, Christensen et al. 2011). Evidently, LTL and SEM are much less tender compared to PP. TB showed higher values of shear force compared to LTL and SEM, but it did not differ significantly. Difference between more (LTL, SEM) and less (TB, PP) valuable meat cuts is evident; shear force thus indicates quality and technological use of meat parts. Authors Bartoň et al. (2014) found that Warner-Bratzler shear force in eland was decreasing in time of storage, namely 76.5 N after three days of aging and 63.17 N after 14 days of aging. Shear force values presented in this study were lower, but it can be explained by different age of slaughtered animals. Low values of the eland LTL (36.65 ± 19.28 N in the standard diet group and 38.79 ± 25.74 N in the enriched diet group) indicates, that eland LTL is tender muscle and suitable for culinary processing. Authors Volpelli et al. (2003), that the different diets did not affect shear force in fallow deer steers and this result correspond the presented study. Warner-Bratzler shear force measured on 12 muscles on 25 elands were showing clear differences between muscles. Raw bovine muscles can be strongly correlated with collagen content (Torrescano et al. 2003; Christensen et al. 2011). According to Hopkins et al. (2013) collagen content can not provide meaningfull explanation of the variations in shear force. It can be probably better explained based on knowledge of biophysical and biochemical characteristics of the muscle. Those characteristics of eland muscles have not been studied yet and further research in this area can be suggested. Despite the fact, that relation between shear force, collagen content and texture of cooked meat is not fully explained, shear force values can be used as clue for meat possible utilization. Meat cuts with lower shear force are more suitable for culinary processing and they have traditionally higher markeding value (e.g. PM, LTL. SEM, PM). Muscles with shear force values (e.g. PP, FD or STER) are traditionally considered as less valuable and they are more often used for the meat processing.

Total collagen content showed the effect of different muscle ($p < 0.0001$) and it tend to show the interaction 'muscle part' * 'diet', but the combined effect was not significant ($p = 0.0052$). It can be expected, that this tendency was connected to the enriched diet and better grow of the animals in experimental group. It was showed also, that PP and TB had higher content of total collagen then SEM and LTL. Different contents of the total collagen between the more and less valuable cuts corresponds to the other literature (Torrescano et al. 2003). Meat samples from the LTL had about 2.0 $g.kg^{-1}$ of total collagen content. It is little bit less that was presented by authors Bartoň et al. (2014) for the eland *m. longissimus lumborum* (2.85 g.kg^{-1}). It seems that eland muscle contained less total collagen than beef, when compared to the results of authors Christensen et al. (2011). They found approximately from 2.7 to 4.1 g.kg^{-1} of total collagen in the meat of 15 different cattle breeds. Higher range of values of the Warner-Bratzler shear force and of the total collagen content in eland meat can be explained by different age of the experimental animals during the slaughter.

Moreover, in the study of authors Bureš et al. (2010) was presented that meat aging period of and final temperature in the meat core during the culinary preparation are important for the good scores in the evaluation of the organoleptic properties, and that eland meat can exceed beef in some cases. Content of the soluble collagen was not influenced by any of the evaluated effects. Comparable amount of the soluble collagen was present in all investigated muscles and it seems that soluble collagen was of low importance for this experiment. On contrary, content of the soluble collagen can be important factor during the meat processing especially, since collagen and soluble collagen as well has impact on the texture of final product (Feiner 2006; Kerth 2013). In addition, content of soluble collagen increased with the increasing age of animals. It can be expected, that structure of connective tissue changes with increasing age of animals. (Lepetit 2008).

Positive moderate correlation between the total collagen and WB shear force was also found ($r = 0.502$; $p<0.001$). On the other hand, authors Torrescano et al. (2003) found stronger positive correlation ($r = 0.723$; $p<0.01$) in the raw bovine muscles. It indicates, that more research would be necessary to investigate texture of eland meat more preciously.

Meat colour is an important trait for the consumer (Suman et al. 2014). Game meat is traditionally reported to be darker than a meat of farm animals due to the higher content of haem pigments (Purchas 2005) and consumer may have worse perception about darker meat. Dark colour is also associated with the muscle myopathy, namely DFD meat, which has also higher pH value (Lawrie & Ledward 2006). Higher amount of the haem pigments indicates, that the animal is more active, what is for the game typical (Hoffman et al. 2005). Remaining blood in the vessels, when blooding out is not complete, increase also the amount of haem pigments and thus it can influence the colour of meat. Lower amount of pigments can be also connected with lower age of the animals (Lawrie & Ledward 2006; Belitz et al. 2009).

Lightness (L*), redness (a*) and yellowness (b*) were not influenced by diet, but they were significantly influenced by the effect of muscle. It corresponds to the study of Volpelli et al. (2003) in which meat of the fallow deer also showed no effect of the different diet. Results correspond to the study of Torrescano et al. (2003) showing that anatomical position of the muscle and different activity of muscle parts play important role in the meat colour. But it seems, that eland muscles have lower value of redness and yellowness resulting in fact, that beef can look as darker meat. Presumably it can be also connected to higher amounts of total haem pigments in beef, as was discussed before. Redness also showed the effect of age and muscle part, when measured on 25 elands. Eland meat is redder with increasing age of animal. Results of L*, a* and b* characteristics correspond to the study of authors Bartoň et al. (2014). Colour changes and stability of colour is an important issue concerning meat producers because of the marketability of meat (Mancini 2013; Suman et al. 2014). From this point of view further research concerning eland meat aging, colour stability during storage storage and packaging conditions should be made to secure best possible marketability of the eland meat.

Two methods were used to evaluate water-holding capacity, namely filter paper press method (FPPM) and cooking losses. Both analyses showed only significant effect of 'muscle part'. Muscles LTL and SEM had the best WHC, becouse they had highest WHC measured as filter paper press method and also lowest cooking looses. Valuable cuts with lower collagen content are suitable both for the culinary and technological processing. WHC can be also influenced by intristic and extristic factors (Lawrie & Ledward 2006) as well as by the addition of food additives (Feiner 2006). For comparison, Hoffman et al. (20009) reported higherg cooking losses in impala (31.0 ± 0.46%) and in kudu (31.5 ± 0.45%) longissmus dorsi muscle. Onyango et al. (1998) reported slightly higher cooking losses measured on beef, zebra (*Equus burchelli*), oryx (*Oryx beisa*) and kongoni (*Acelaphus buselaphus*). WHC of the meat of fallow deer was unaffected by diet (Volpelli et al. 2003). It corresponds to the results of this study. Water-holding capacity is a complex issue connected to the meat structure and composition. It is also mutually influenced by pH value, meat colour or texture (Belitz et al. 2009; Hughes et al. 2014).

5.2 Organoleptic Properties of Eland Pâté

Relationship of between the panelist and liver pâté type of product was investigated in the beginning of the sensory evaluation (see 4.3.1 for more details). Positive relation to the pâté products had most of the panelists (94%) and pâtés were regularly consumed by the panelist. About two thirds of them consumed pâtés several times per month. Major part of the panelists (77%) was willing to buy product untypical with its composition despite the higher price. Hoffman & Wiklund (2006) presented in their study, that modern consumers were becoming more interested in different kind of meats and meat products.

No significant differences were found when assessing intensity of salty taste and intensity of smell. It can thus be concluded, that both effects of composition and storage did not play any role. Salt-less liver pâté products are not accepted by consumer, thus little amount of salt is needed to enhance taste and flavor of the product. Spices and herbs are added according to taste and traditions (Feiner 2006). Furthermore, amount of salt used and as well as the amount and different kinds of flavourings contribute to the great variety of pâtés, which are produced around the world (Table 14 for details).

Effect of composition was significant on intensity of off-flavour ($p < 0.0001$) when frozen materials were used. Pâtés with eland liver showed stronger off-flavour when compared to pâtés with chicken livers. Chemical changes like the proteolytic degradation and lipid oxidation occur in meat and meat products during storage (Kyzlink 1990; Belitz et al. 2009). Off-flavours can be connected to the aging of game meat, as was showed in the study of North & Hoffman (2015) and reviewed in Neethling et al. (2016). In relation to those studies, eland liver can have most likely similar effect on the product. On the other hand, based on the results of the study of Estévez et al. (2005) it can be expected, that it can be possible to mask off-flavours by the addition of flavourings to the product. Livers are more perishable than meat and it is better to process them immediately or freeze them. During freezing of liver (as well of meat) water present inside tissues turn into crystals of ice, thus capillaries used previously for transport of gall liquid are damaged. Bitter off-flavour in the finished product can be caused by gall liquid penetrating into liver tissue (Feiner 2006). The intensity of off-flavour is more intensive in beef liver (ruminant) than in chicken, and with the increasing age of animal also.

Intensity of colour significantly differed in both effects and their interaction. It was found that pâtés, with chicken livers were perceived with more intensive colour than pâtés where ruminant livers were used for processing. Pâtés made from eland liver and meat had the lowest scores in all three series. These pâtés clearly showed the effect of refrigeration storage. We suppose that game meat and especially liver from game contain higher amount of iron (Purchas 2005; Purchas & Busboom 2005), which probably explains lower intensity of colour of those batches.

Friability as an important product ability also showed differences in the effect of storage and interaction of effects, where samples with chicken livers were more compact than the pâtés made of the ruminant livers. Pâté made from eland liver and meat shoved the highest friability, most likely probably due to lower fat content which is necessary for compact structure in batch made from fresh material. Latoch et al. (2016) used inulin as replacement of fat in guinea fowl pâté. As a result, hardness and chewiness and were decreased. Pâté batch made of frozen eland material for 45 days was scored as more friable, but fat content was the highest in this batch. Normally, higher fat content of pâté is lowering hardness of the product (Estévez et al. 2005, Feiner 2006), what leads to better spreadability, but it is less suitable for a man from the dietary point of view.

Overall appearance was influenced significantly by the effect of composition, storage, and their interaction. Although fresh products did not differ significantly, effect of composition was evident after storage. Overall appearance is the trait evaluated mainly by the visual sense; the results correspond to the colour hue, intensity and pleasantness of colour. Latoch et al. (2016) used inulin as a fat replacement in their study, but no difference was found in appearance with control product. Pâté batch made of frozen eland material for 45 days was scored as more friable, but fat content was the highest in this batch. Pâtés made of the chicken liver received similar scores, as well as the pâtés made from ruminant livers, but there was higher numerical difference between chicken and ruminant liver varieties, when frozen livers were used instead of the fresh ones. Amaral et al. (2015) found also worse appearance after lamb pâté storage.

Colour hue was influenced significantly by the effect of composition, storage and their combination. The chicken liver varieties differed from ruminant liver varieties in using frozen materials. Chicken liver varieties were pinker, while eland and beef liver varieties were darker close to brown colour. Effect of storage was evident mainly in pâté made from eland liver and meat, and particularly in all varieties which was described also for pâté from foal (Lorenzo at al. 2014). Storage of meat and liver made colour hue of pâté brownish.

Overall texture significantly differs in the effect composition, storage and interaction. Samples differed according used type of liver. Samples with ruminant liver and meat had less pleasant texture, than those made with chicken livers. Texture tends to be less pleasant with freezing storage of raw materials. Uniformity of colouring was not affected nor by materials used or storage time. It can be explained by the suitable choice of technological processing (Feiner 2006).

Pleasantness of taste showed clearly significant effect of composition and storage. Pâté made from eland liver and meat showed lowest score made of fresh or frozen materials, but no differences were found between pâté where chicken liver and beef or eland meat was used. Chicken liver increased pleasantness of taste. Even pâtés with different content of fat made from fresh or frozen material has not showed any differences as was also found for taste by Latoch et al. (2016).

Pleasantness of colour was significantly influenced by the effect of composition, storage and by their interaction too. No differences were found between samples made of fresh materials just after storage. Polak et al. (2011) found improved colour in chicken liver pâté if he used pasteurisation instead of sterilisation.

Chicken liver batches showed better score in pleasantness of consistency then those batches made with the ruminant livers. This characteristic is related with the content of fat and collagen similarly as the other textural characteristics (Feiner 2006).

Moreover, pâté recipes can be modified relatively easily to fit more into the requirements of potential customers. For example, ostrich liver pâtés were prepared, and their characteristics then studied in the work of Fernández-Lopez et al. (2004). Those products were evaluated as acceptable for the consumers. Chicken livers as a by-product of the poultry industry were used successfully in the study of authors Terrasa et al. (2016) for the pâté fabrication; results of this study correspond to this study. Furthermore, sunflower oil was successfully used in their research as a replacement of pork fat. Authors Doolaege et al. (2012) studied addition of different doses of the rosemary extract and their influence on the traits of pâtés. It was found, that rosemary extract had positive effect on lipid oxidation and colour stability. Furthermore, it was possible to decrease the amount of sodium nitrite in the product without having negative impact on quality. Sodium nitrite helps to maintain stability of the colour but it has also function as a preservative and this must be taken into consideration. In the study of authors Pateiro et al. (2014) effect of the addition of natural antioxidants was studied to the pig liver pâtés. Natural antioxidants showed positive effect on shelf life and sensory traits on the studied products. It is thus possible to substitute synthetic antioxidant by the natural ones. In addition to that, authors Hawashin et al. (2016) studied properties of beef patties made with different concentrations of destoned olive cake, which is a by-product of olive oil processing industry. It was found, that destoned olive cake provided considerable antioxidative and antimicrobial benefits to patties during cold storage. It extended shelf-life of products without affecting sensory traits and some technological traits were also found better compared to products without olive cake.

It is evident that eland meat is a low-fat product (see chapter 4.1.2) and it can be considered as nutritionally valuable for human consumption similarly to the other game meat as was presented in the studies of authors Hoffman & Wiklund (2006) or Hoffman & Cawthorn (2013). Furthermore, it can be considered as valuable raw material for the further processing. Further research shall be focused on various combinations of eland meat with the other untypical raw materials. Reduction of pork fat or replacement of it with natural oils, applications of natural antioxidants or textural improvers can be suggested to obtain nutritionally valuable product suitable for small, or even big scale processing.

Eland meat was traditionally used for processing of the biltong (Van Zyl 1962; Heinz & Hautzinger 2007). Similarly, study of Kučerová (2015) showed, that eland meat can be easily processed into jerky in the small-scale conditions. In addition to that, meat from several South African game species were tested successfully for processing into fermented salami in the studies of authors Todorov et al. (2007), Van Schalkwyk et al. (2011) or Jones et al. (2015). In accordance to these studies, eland meat can be expectably processed into various products.

6 CONCLUSION

This study is presenting results on physical, chemical and technological parametres of meat in extent, which has not been published yet. Importance of this study is also a fact, that for the first known time elands were fed in the controlled haused conditions under farming system. It was thus possible to collect body measures and meat samples for the general evaluation of the carcass and meat parametres. It was possible also to evaluate growing parametres of the elands with enriched diet compared to the elands with standard diet. It was also shown, that it is possible to fabricate product from eland meat (pâté), which has suitable organoleptic properties and it is acceptable for the consumers.

Different muscles showed significant differences in physical, chemical and technological parametres except for the moisture content and content of soluble collagen.

Animals with enriched diet had better higher carcass yield and higher content of suet and separable fat. Additional energy was preferably stored into adipose tissues rather than to meat yield. No differences were found in the rest of carcass parametres.

Animals with enriched diet had higher fat conted compared to the animals with basic feed mixture diet. Meat did not differ in the rest of evaluated parametres, such are intrumental parametres, WHC, collagen and total haem pigments content. Meat from older animals were darker, but differences in textural parametres were not found.

Eland meat had suitable organoleptic properties when processed into pâté, but eland livers very not suitable for processing compared to the chicken livers. Pâtés made of frozen raw materials showed worse organoleptic properties in comparison with those made of fresh raw material.

From the nutritional point of view, eland meat can be considered as low in fat and rich in protein. Fat content in the meat of the exprimental animals is still low compared to farmed domestic livestock animals. Moreover, suet can be mechanically separated during the carcass processing.

Aging of eland meat can be recommended with special regards on the chemical, technological and organoleptic changes during this period.

It can be recomended to study other intravital factors which can potentically influence carcass and meat traits, such are age and sex of the animals.

Furthermore, additional research for chemical and technological traits (shell-life stability, textural properties etc.) of pâté can be performed. Unconventional ingredients such are different kinds of antioxidants (e.g. natural spices, essential oils) or fat replacers (vegetable oils) can be tested for the processing of eland pâté to increase potential value when marketed. Chemical and technological of traits of those products can be tested.

Further research in using eland meat for the processing of other kinds of meat products (e.g. fermented salami) can be recommend. Eland meat can be potential material for the making of so-called ‘novel foods’.

Eland meat can be considered as a valuable and interesting material for the culinary and technological processing. Experience has shown us, that eland meat can be also sold to the respected restaurants next to academic workers. Nowadays, eland meat production is not sufficient to cover demand from the potentional customers. From this perspective, study evaluating marketability of eland meat shall be made. In addition to that, extension of the farm and looking for the strategical partner can be recommended. In my opinion it would be beneficial for the higher meat production and also it shall provide better opportunities for the further scientific research.

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8 LIST OF PUBLICATIONS

Publications

Kolbábek P, Maxová P, Kouřimská L, Lukešová D, Kotrba R. 2018. Sensory evaluation of liver/meat pâté made from fresh or frozen eland meat and beef. Scientia Agriculturae Bohemica. Accepted for publication.

Conferences

Kolbábek P, Maxová P, Kouřimská L, Lukešová D, Kotrba R. Sensory evaluation of liver pâté from fresh or frozen eland meat and beef. Page 36. Proceedings of XIX. Risk Factors of Food Chain Conference, 26-28 September 2018. Szent István University. Mátrafüred (Hungary).

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9 CURRICULUM VITAE OF THE AUTHOR

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Education

Up to now	**Czech University of Life Sciences Prague** Ph.D. candidate, Tropical and subtropical agriculture Research area: *Influence of common eland (Taurotragus oryx) meat composition on its further technological processing*
2015	**Czech University of Life Sciences Prague** Received title ***Ing.***, study area ***Quality and processing of agricultural products*** Master thesis: *Composition and quality attributes of eland meat*
2012	Program Socrates Erasmus, ***study placement*** Ondokuz Mayis Üniversity (Samsun, Republic of Turkey)
2010	**Czech University of Life Sciences Prague** Received title ***Ing.***, study area ***Tropical and subtropical agriculture*** Master thesis: *Monitoring of the selected microbial parametres in the supplying lines of Danone, Inc.*

Working experience

Up to now	***Receptionist***, Dormitories of CULS Prague
2016 – 2017	***Laboratory technician***, Czech Mills Ltd., Týnec n. Labem
2013	*Shop assistant*, MAKRO Cash and Carry ČR Ltd., Praha
2008	*Tourist guide*, Museum of Vysočina region in Třebíč
2007	*Assember of the irrigation systems*, Kafka Service Ltd., Třebíč
2004	*Shop assistant*, Delta Bakeries, Třebíč

Languages

English – active in speaking and writing

French – basics

Turkish – basics

Special courses

2015	Safe nutrition: Cereals in nutrition, University of chemistry and technology Prague
2013	Safe nutrition: Foods of animal origin in nutrition, University of chemistry and technology Prague
2012	Safe nutrition: Foods of plant origin in nutrition, University of chemistry and technology Prague
2012	New EU legislation on processing and labelling of food, CULS Prague
2011	Safe nutrition: Fats in nutrition, University of chemistry and technology Prague
2011	Course of scientific work, Czech Academy of Sciences
2011	Safe Nutrition, University of chemistry and technology Prague

Other

Driving licence B

10 APPENDICES

List of Appendices

Appendix I – Overview of slaughtered animals

Animal	Date of slaughter	Slaughter age [days]	Slaughter weight [kg]
62	17.08.2010	931	369
64	15.09.2010	950	407
43	25.10.2010	1295	454
59	01.12.2010	824	395
47	24.01.2011	1055	448
45	17.08.2010	921	311
54	15.09.2010	958	323
49	25.10.2010	1322	407
60	01.12.2010	771	321
37	24.01.2010	1354	438
15	20.11.2012	2902	574
70	17.08.2011	843	220
75	26.09.2011	875	312
78	17.08.2011	829	308
85	26.09.2011	545	243
87	24.11.2011	598	254
91	24.11.2011	592	224
96	24.11.2011	562	253
107	06.02.2013	667	198
109	06.02.2013	661	340
127	28.04.2014	810	255.5
129	10.09.2014	912	188
138	10.09.2014	1825	274
145	25.09.2013	583	266
147	25.09.2013	583	290

Appendix II - Overview of eland feeding (Váňa 2010)

Eland feeding	Basic feed mixture	Feeding pellets
Ingredients		
	corn silage, Lucerne haylage, meadow hay, barley straw	dry Lucerne fodder, wheat groats, sugar beet pulp, canola and linen seeds
Chemical composition		
Crude protein	16.6%	16.1%
Lipis	2.1%	7.6%
Crude fibre	16.2%	11.0%
Mineral lick block Solsen		
	natrium (37%), calcium (1.1%), magnesium (0.6%), phosphor (0%), manganese (1000 $mg.kg^{-1}$), zinc (1000 $mg.kg^{-1}$), copper (220 $mg.kg^{-1}$), iodine (10 $mg.kg^{-1}$), cobalt (20 $mg.kg^{-1}$) and selenium (20 $mg.kg^{-1}$)	
Average amount of pellets fed daily to the experimental group of elands (n=5) [kg per animal]	15.10.2009 – 21.12.2009	2.4
	22.12.2009 – 17.01.2010	2.5
	18.01.2010 – 04.05.2010	3.3
	05.05.2010 – slaughter	5.0

Appendix III - Questions investigating relation of panelists to pâté

What is your relation to pâté?

- I like them very much.
- I like them.
- I don’t like them.

How often do you consume pâté?

- Often (once a week or more times)
- Sometimes (once to three times in a month)
- Rarely (several times during a year)
- Not at all

Would you buy some pâté for the price higher than usual, if you know, that the pâté is unusual or untypical in its composition?

Yes	No	Rather yes	Rather no	Don’t know

Appendix IV - Comparison of crude fat content in the meat samples from the two groups of elands with different nutrition [g.100 g^{-1}]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	0.52	0.13
	TB	0.48	0.13
	PP	0.77	0.13
	SEM	0.16	0.13
Experimental group (n=5)	LTL	1.04	0.13
	TB	0.86	0.13
	PP	1.43	0.13
	SEM	0.32	0.13

Appendix V - Comparison of pH value in the meat samples from the two groups of elands with different nutrition

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	5.73	0.11
	TB	5.87	0.11
	PP	6.03	0.11
	SEM	5.83	0.11
Experimental group (n=5)	LTL	5.81	0.11
	TB	5.83	0.11
	PP	5.87	0.11
	SEM	5.86	0.11

Appendix VI - Comparison of moisture content in the meat samples from the two groups of elands with different nutrition [g.100 g^{-1}]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	75.09	0.71
	TB	75.01	0.71
	PP	76.66	0.71
	SEM	76.26	0.71
Experimental group (n=5)	LTL	74.58	0.71
	TB	75.77	0.71
	PP	75.69	0.71
	SEM	75.61	0.71

Appendix VII - Comparison of crude protein content in the meat samples from the two groups of elands with different nutrition [g.100 g^{-1}]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	21.91	0.21
	TB	20.54	0.21
	PP	20.45	0.21
	SEM	21.38	0.21
Experimental group (n=5)	LTL	22.47	0.21
	TB	21.23	0.21
	PP	20.77	0.23
	SEM	22.13	0.21

Appendix VIII - Comparison of total collagen content in the meat samples from the two groups of elands with different nutrition [g.100 g^{-1}]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	0.21	0.038
	TB	0.36	0.038
	PP	0.53	0.040
	SEM	0.29	0.038
Experimental group (n=5)	LTL	0.19	0.038
	TB	0.40	0.038
	PP	0.37	0.038
	SEM	0.20	0.038

Appendix IX - Comparison of total haem pigments content in the meat samples from the two groups of elands with different nutrition [mg.100 g^{-1}]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	311.8	44.0
	TB	531.3	44.0
	PP	359.2	45.6
	SEM	342.0	43.3
Experimental group (n=5)	LTL	381.9	43.3
	TB	548.4	44.0
	PP	477.3	44.0
	SEM	414.4	44.0

Appendix X - Comparison of WHC measured as paper press method in the meat samples from the two groups of elands with different nutrition [%]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	63.81	6.93
	TB	55.96	6.93
	PP	57.30	6.93
	SEM	61.27	6.93
Experimental group (n = 5)	LTL	64.01	6.93
	TB	44.75	6.93
	PP	58.22	6.93
	SEM	55.38	6.93

Appendix XI - Comparison of WHC measured as cooking losses in the meat samples from the two groups of elands with different nutrition [%]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	18.16	1.90
	TB	25.30	1.90
	PP	25.51	1.90
	SEM	19.96	1.90
Experimental group (n=5)	LTL	18.52	1.93
	TB	27.49	1.90
	PP	27.27	1.90
	SEM	20.93	1.90

Appendix XII - Comparison of lightness (L*) in the meat samples from the two groups of elands with different nutrition

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	42.39	0.84
	TB	41.57	0.84
	PP	44.37	0.84
	SEM	41.92	0.84
Experimental group (n=5)	LTL	41.68	0.84
	TB	39.18	0.84
	PP	42.27	0.84
	SEM	41.53	0.84

Appendix XIII - Comparison of redness (a*) in the meat samples from the two groups of elands with different nutrition

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	8.92	0.76
	TB	11.90	0.76
	PP	11.80	0.76
	SEM	9.99	0.76
Experimental group (n=5)	LTL	8.60	0.76
	TB	12.55	0.76
	PP	12.68	0.76
	SEM	11.04	0.76

Appendix XIV - Comparison of yellowness (b*) in the meat samples from the two groups of elands with different nutrition

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	8.21	0.58
	TB	8.99	0.58
	PP	10.21	0.58
	SEM	9.01	0.58
Experimental group (n=5)	LTL	7.61	0.58
	TB	9.18	0.57
	PP	9.70	0.58
	SEM	8.61	0.58

Appendix XV - Comparison of texture measured as Warner-Bratzler shear force in the meat samples from the two groups of elands with different nutrition [N]

GROUP	MUSCLE PART	LSMEAN	SE
Control group (n=5)	LTL	36.65	19.28
	TB	84.55	23.21
	PP	205.94	24.10
	SEM	52.12	19.81
Experimental group (n=5)	LTL	38.79	25.74
	TB	127.00	20.19
	PP	268.60	19.37
	SEM	49.10	21.79

Appendix XVI – Protein content measured on selected muscles on 25 elands divided into three age categories [g.100 g^{-1}]

Age category	Muscle part	LSMEAN	SE
I	Sirloin	21.81	0.26
	Shoulder	20.63	0.26
	Brisket	20.48	0.26
	Topside	20.97	0.26
II	Sirloin	21.65	0.22
	Shoulder	20.85	0.23
	Brisket	20.60	0.22
	Topside	21.25	0.22
III	Sirloin	21.81	0.39
	Shoulder	20.56	0.39
	Brisket	20.44	0.39
	Topside	21.58	0.39
All animals	Sirloin	21.76	0.17
	Shoulder	20.68	0.17
	Brisket	20.51	0.17
	Topside	21.27	0.17

Appendix XVII – Content of total collagen measured on selected muscles on 25 elands divided into three age categories [g.100 g^{-1}]

Age category	Muscle part	LSMEAN	SE
I	Sirloin	0.18	0.035
	Shoulder	0.24	0.035
	Brisket	0.42	0.035
	Topside	0.23	0.035
II	Sirloin	0.20	0.031
	Shoulder	0.34	0.031
	Brisket	0.42	0.031
	Topside	0.24	0.031
III	Sirloin	0.21	0.053
	Shoulder	0.42	0.053
	Brisket	0.55	0.053
	Topside	0.42	0.053
All animals	Sirloin	0.20	0.024
	Shoulder	0.34	0.024
	Brisket	0.47	0.024
	Topside	0.24	0.024

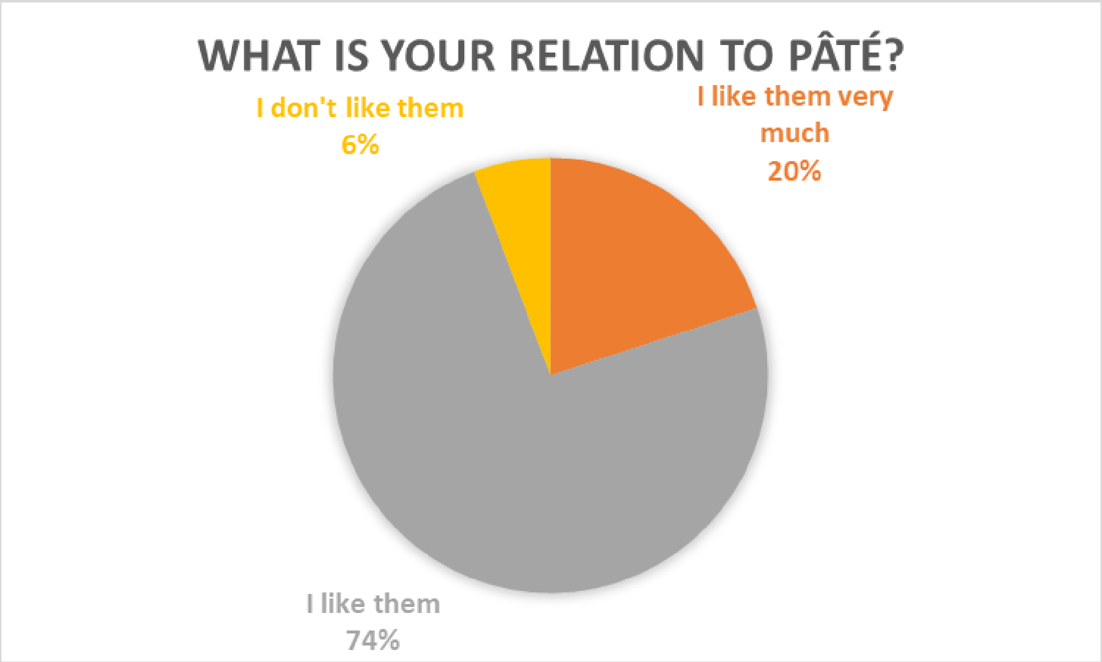
Appendix XVIII - Content of soluble collagen measured on selected muscles on 25 elands divided into three age categories [mg.100 g^{-1}]

Age category	Muscle part	LSMEAN	SE
I	Sirloin	5.52	2.87
	Shoulder	8.80	3.14
	Brisket	10.83	2.87
	Topside	8.54	3.14
II	Sirloin	3.15	2.48
	Shoulder	8.28	2.66
	Brisket	7.59	2.48
	Topside	4.23	2.66
III	Sirloin	18.45	3.51
	Shoulder	11.61	3.51
	Brisket	12.62	4.06
	Topside	8.75	4.97
All animals	Sirloin	9.04	1.72
	Shoulder	9.56	1.80
	Brisket	10.35	1.85
	Topside	7.17	2.15

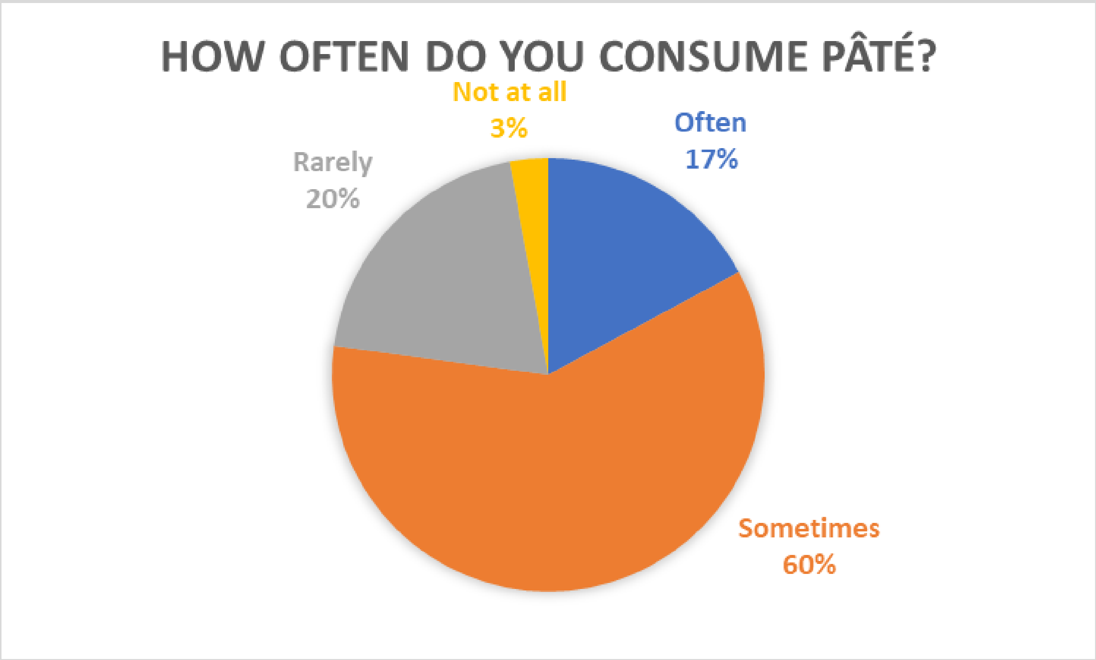
Appendix XIX – Warner-Bratzler shear force measured on selected muscles on 25 elands divided into three age categories [N]

Age category	Muscle part	LSMEAN	SE
I	Sirloin	49.85	12.89
	Shoulder	123.05	12.88
	Brisket	211.92	12.89
	Topside	77.80	11.88
II	Sirloin	40.62	11.63
	Shoulder	119.08	11.63
	Brisket	162.99	11.16
	Topside	70.55	11.16
III	Sirloin	64.10	19.33
	Shoulder	130.96	19.33
	Brisket	274.44	19.33
	Topside	43.11	19.33
All animals	Sirloin	51.52	8.66
	Shoulder	124.26	8.66
	Brisket	216.45	8.59
	Topside	63.82	8.59

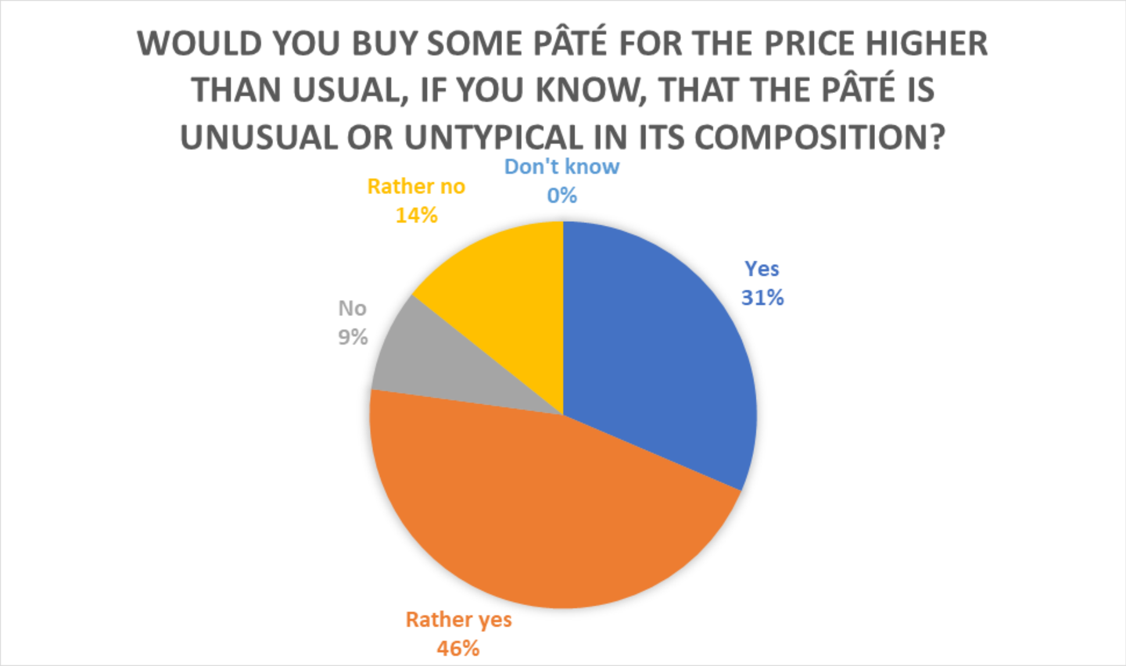
Appendix XX - Results for the question investigating panelists' relation to pâté



Appendix XXI - Results for the question investigating panelists' consumation of pâté



Appendix XXII - Results for the question investigating panelists' willigness to buy ‘unusual’ pâté



Appendix XXIII - Basic composition of produced pâtés

Pâté	Moisture content [g.100 g^{-1}]	Protein content [g.100 g^{-1}]	Fat content [g.100 g^{-1}]
1/0	64.1	13.0	21.4
2/0	64.7	13.6	20.1
3/0	66.0	13.5	19.3
4/0	64.5	13.3	20.5
1/45	57.9	10.7	29.6
2/45	58.3	10.6	29.1
3/45	46.3	15.2	37.2
4/45	47.5	15.3	35.4
1/90	57.5	10.8	25.9
2/90	63.4	10.9	24.0
3/90	57.7	11.8	29.4
4/90	59.0	11.5	28.7

Appendix XXIV - Organoleptic properties of patties made from fresh meat

Organoleptic properties	**CHL-Beef/0**		**CHL-Eland/0**		**EL-Eland/0**		**BL-Eland/0**	
	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR
Overall appearance	65.6571	3.3704	60.8857	3.3704	54.0286	3.3704	54.6000	3.3704
Pleasantness of colour	64.7143	3.4116	61.4857	3.4116	54.8571	3.4116	54.5714	3.4116
Colour hue	49.6571	3.2835	46.3429	3.2835	38.1714	3.2835	41.7429	3.2835
Intensity of colour	67.1143	3.2535	66.4571	3.2535	35.8286	3.2535	50.0286	3.2535
Uniformity of colouring	76.5143	3.6200	73.4000	3.6200	68.4000	3.6200	64.4000	3.6200
Pleasantness of smell	55.5429	3.6678	52.600	3.6678	52.4286	3.6678	52.7714	3.6678
Intensity of smell	61.8857	3.4716	56.1714	3.4716	48.8571	3.4716	49.5429	3.4716
Pleasantness of taste	58.7143	3.5893	56.6857	3.5893	37.1429	3.5893	42.6286	3.5893
Overall intensity of taste	69.0000	3.3109	64.4857	3.1309	52.9714	3.3109	56.0571	3.3109
Intensity of salty taste	59.5429	3.4941	56.7429	3.4941	47.9714	3.4941	48.1143	3.4941
Intensity of other taste	26.3429	4.3238	32.6286	4.3238	45.5714	4.3238	35.5429	4.3238
Intensity of off flavour	24.8286	4.1744	27.2000	4.1744	42.8286	4.1744	38.2000	4.1744
Pleasantness of consistency	60.0286	3.3687	53.2286	3.3687	48.8286	3.3687	45.5429	3.3687
Overall texture	69.4000	3.1247	66.9143	3.1247	48.2286	3.1247	52.8571	3.1247
Friability	72.2000	3.4120	63.3429	3.4120	56.1714	3.4120	52.6571	3.4120

Abbreviations: CHL = chicken liver; EL = eland liver; BL = cattle liver; Beef = cattle meat (neck, brisket and plate); Eland = eland meat (neck, brisket and plate).

Appendix XXV - Organoleptic properties of patties made from meat frozen for 45 days

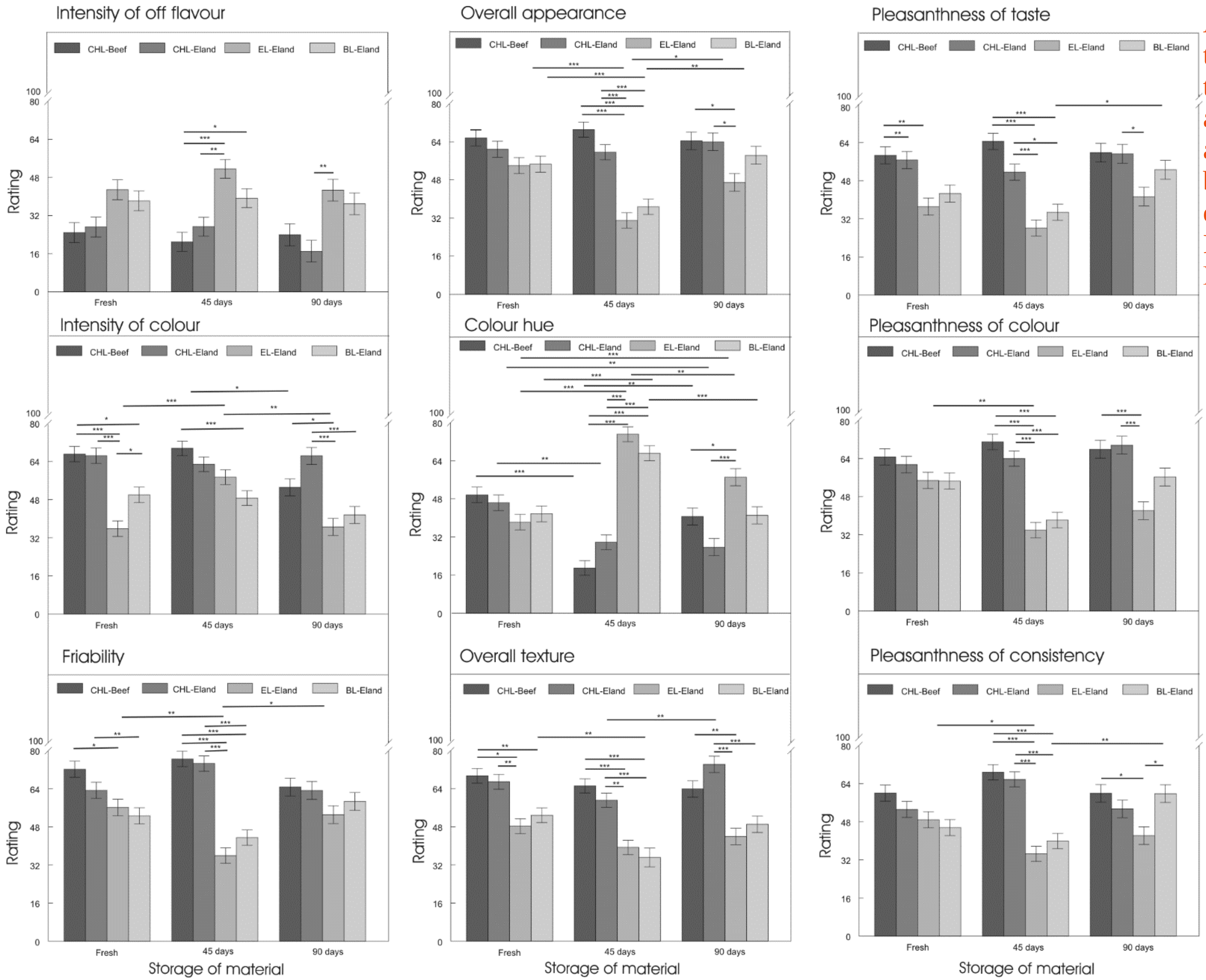
Organoleptic properties	CHL-Beef/45		CHL-Eland/45		EL-Eland/45		BL-Eland/45	
	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR
Overall appearance	69.1282	3.1929	59.6410	3.1929	31.0000	3.1929	36.7436	3.1929
Pleasantness of colour	71	3.2319	64.0000	3.2319	33.9231	3.2319	38.2051	3.2319
Colour hue	18.9744	3.1105	29.7436	3.1105	75.1282	3.1105	67.1795	3.1105
Intensity of colour	69.5385	3.0822	62.8462	3.0822	57.4359	3.0822	48.6923	3.0822
Uniformity of colouring	76.8974	3.4293	66.7436	3.4293	61.1282	3.4293	61.7179	3.4293
Pleasantness of smell	66.8974	3.4746	58.0769	3.4746	41.2564	3.4746	44.6154	3.4746
Intensity of smell	53.4872	3.2887	54.5385	3.2887	45.6923	3.2887	47.9744	3.2887
Pleasantness of taste	64.5641	3.4003	51.6154	3.4003	28.2051	3.4003	34.8205	3.4003
Overall intensity of taste	60.6667	2.9660	59.5385	2.9660	65.1282	2.9660	58.0000	2.9660
Intensity of salty taste	54.4103	3.3101	52.5641	3.3101	51.7692	3.3101	49.2051	3.3101
Intensity of other taste	22.7179	4.0961	27.9487	4.0961	46.9487	4.0961	38.9231	4.0961
Intensity of off flavour	20.9744	3.9546	27.3333	3.9546	51.5897	3.9546	39.2821	3.9546
Pleasantness of consistency	68.7949	3.1913	65.7692	3.1913	34.5128	3.1913	39.9231	3.1913
Overall texture	65.1538	2.9602	59.1538	2.9602	39.3333	2.9602	35.1026	3.9602
Friability	76.5385	3.2323	74.5897	3.2323	35.9487	3.2323	43.4872	3.2323

Abbreviations: CHL = chicken liver; EL = eland liver; BL = cattle liver; Beef = cattle meat (neck, brisket and plate); Eland = eland meat (neck, brisket and plate).

Appendix XXVI - Organoleptic properties of patties made from meat frozen for 90 days

Organoleptic properties	CHL-Beef/90		CHL-Eland/90		EL-Eland/90		BL-Eland/90	
	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR	LSMEAN	ST. ERROR
Overall appearance	64.4138	3.7027	64.0000	3.7027	46.9310	3.7027	58.3448	3.7027
Pleasantness of colour	67.8966	3.7480	69.6207	3.7480	42.1379	3.7480	56.2759	3.7480
Colour hue	40.5862	3.6072	27.6897	3.6072	57.1034	3.6072	41.0690	3.6072
Intensity of colour	53.1724	3.5743	66.3793	3.5743	36.5517	3.5743	41.5862	3.5743
Uniformity of colouring	69.3448	3.9769	73.2759	3.9769	56.9310	3.9769	71.6207	3.9769
Pleasantness of smell	64.4483	4.0294	62.5172	4.0294	53.6897	4.0294	57.9310	4.0294
Intensity of smell	58.9310	3.8138	57.0345	3.8138	47.3793	3.8138	53.6897	3.8138
Pleasantness of taste	59.7931	3.9432	59.3103	3.9432	41.3448	3.9432	52.6207	3.9432
Overall intensity of taste	58.8621	3.4396	61.3103	3.4396	56.8621	3.4396	57.2414	3.4396
Intensity of salty taste	52.6552	3.8386	52.4828	3.8386	43.5172	3.8386	57.1379	3.8386
Intensity of other taste	26.1034	4.7501	21.2069	4.7501	41.7586	4.7501	35.6897	4.7501
Intensity of off flavour	23.9310	4.5860	17.0345	4.5860	42.6552	4.5860	36.9310	4.5860
Pleasantness of consistency	59.9310	3.7008	53.4138	3.7008	42.2069	3.7008	59.7931	3.7008
Overall texture	63.8621	3.4328	74.2069	3.4328	43.9310	3.4328	49.0345	3.4328
Friability	64.7586	3.7484	63.3103	3.7484	53.1034	3.7484	58.6897	3.7484

Abbreviations: CHL = chicken liver; EL = eland liver; BL = cattle liver; Beef = cattle meat (neck, brisket and plate); Eland = eland meat (neck, brisket and plate).



Appendix XXVII - Overview of the organoleptic traits scores of twelve batches of pâté presented as LSMEANs (± SE). Asterisks above the line connecting two bars represent significant differences as follows: '*' as $P \leq 0.05$, '**' as $P \leq 0.01$, '***' as $P \leq 0.001$

Abbreviations: CHL = chicken liver; EL = eland liver; BL = cattle liver; Beef = meat of cattle (neck, brisket and plate); Eland = meat of eland (neck, brisket and plate).

Appendix XXVIII – Newborn eland calf with the ear tag

Appendix XXIX – Elands in the pen (Photo: R. Kotrba)

Appendix XXX – Elands feeding in the barn

Appendix XXXI – Slaughter place at the barn with seat for marksman and protective ballistic wall (Photo: R. Kotrba)

Appendix XXXII – Skinning of eland in the abbatoirs

Appendix XXXIII – Eland carcass processed into quarters

Appendix XXXIV – Bowl cutter Mainca processing pâté emulsion (Photo: L. Maxová)

Appendix XXXV – Final products during the sensory evaluation (Photo: P. Maxová)