PE9.38 Meat Quality and Oxidative Stability of Pre-frozen Game Meat 320.00

Katleen Raes (1) katleen.raes@howest.be, Ellen Neyrinck(1), Jan De Smet (1), Stefaan De Smet (2)
(1)University College West-Flanders
(2)Ghent University

***Abstract*—In this study, the chemical composition, fatty acid profile and oxidative stability of imported pre-frozen, vacuum-packed game meat was investigated. Under controlled conditions, 5 different game species, i.e. blesbok, impala, kudu, springbok and wildebeest, were sampled, vacuum-packed and stored frozen before analysis.**

The different game meat species showed a dry matter, crude protein and crude fat content between 22.5-25.5%, 21.5-24.5% and 0.5-2.0% respectively. The fatty acid profile of the meat was highly unsaturated with a n-3 PUFA proportion between 7 and 11%. The α-tocopherol content was generally high, varying between 2.7 and 7.5 µg/g meat. Lipid oxidation increased during chilled illuminated storage for all species except for wildebeest, while no effect was observed on protein oxidation. Kudu seemed to be the least oxidative stable game meat type.

E. Neyrinck (ellen.neyrinck@howest.be), J. De Smet (jan.de.smet@howest.be), and K. Raes (katleen.raes@howest.be) are with the Research Group EnBiChem, Department of Industrial Engineering and Technology, University College West-Flanders, Graaf Karel de Goedelaan 5, 8500 Kortrijk, Belgium (corresponding author to provide phone: 00 32 56 24 12 55; fax: 00 32 56 24 12 24; e-mail: katleen.raes@howest.be).

S. De Smet is with the Laboratory of Animal Nutrition and Animal Product Quality, Faculty of Bioscience Engineering, Ghent University, Proefhoevestraat 10, 9090 Melle, Belgium (stefaan.desmet@ugent.be)

***Index Terms*— fatty acid profile, game meat, oxidative stability**

I. INTRODUCTION

It has been estimated that in 2005 deboned meat of 160000 carcasses has been exported from South-Africa [1], of which Europe is an important target market [2].

Meat from game is normally imported in European countries as frozen, vacuum-packed cuts. This frozen storage period can be quite extensive. After thawing, these parts are cut and often sold as pre-frozen, chilled meat. It has been demonstrated that quality problems occur in long-term frozen stored meat, i.e. inferior color and the development of rancidity [pork: 3,4]. Indeed oxidation processes (color, lipid and protein) are only slowed down by storing meat at low temperatures, but they are not completely hindered [5]. In addition, some of the oxidation products are even more stable at lower temperatures and can thus propagate oxidation reactions at freezing temperatures. Oxidation processes are depending on the balance of present pro-oxidants and antioxidants. The main endogenous pro-oxidative factors in meat are polyunsaturated fatty acids, metal ions (Fe, Cu), while meat is protected against oxidation by α-tocopherol and by the activity of endogenous antioxidative enzymes (glutathione peroxidase, catalase and superoxide dismutase). Jensen et al. [4] demonstrated that the level of α-tocopherol in frozen pork was stable up to 10 months.

However, it has to be kept in mind that the storage temperature of frozen meat can fluctuate considerably during transport, distribution and storage. This could have an influence on the quality attributes of the thawed meat afterwards.

The aim of this study was to get more insight in 1) the chemical composition and fatty acid profile; and 2) the oxidative stability of pre-frozen game meat. Under controlled circumstances 5 game species were vacuum-packed, and imported frozen from South-Africa in Belgium for this purpose.

II. MATERIALS AND METHODS

Meat samples

Frozen, vacuum-packed meat cuts were imported from South-Africa by Deli-Ostrich (Wingene, Belgium). All meat samples were taken in June 2007. Male animals from five different game species, i.e. blesbok (*Damaliscus pygargus phillipsi*), impala (*Aepyceros melampus*), kudu (*Tragelaphus strepsiceros*), springbok (*Antidorcas marsupinalis*) and wildebeest (*Connochaetes taurinus*) were sampled (n = 20 per game species). Only the topside muscle was used for the analysis. Background information of feed sources was available, and time of slaughter, temperature decline of the carcasses and pH at deboning were monitored. For each game species, all 20 animals were shot and killed at 1 or 2 days by at maximum 2 different hunters.

Analysis on the meat samples were performed between October and December 2007.

Measurements

Chemical composition of the meat samples was performed using the methods as described in ISO 1442-1973, ISO 937-1978 and ISO 1444-1973 for dry matter (g/100g), crude protein (g/100g) and crude fat (g/100g) content respectively.

The content of *α-tocopherol* (µg/g meat) was measured by HPLC on a Supelcosil LC18 (25 cm x 4.6 mm x 5 µm)

at 292 nm as described by Desai [6] and Haak et al. [7].

The *Fe, Zn and Cu content* (µg/g) was determined by ICP using a multi-element standard. First, meat samples were ashed overnight at 550°C, and the ashes were dissolved in concentrated nitric acid, before analysis.

The *fatty acid profile* (g/100g FAME) was measured, after extracting the fat using chloroform/methanol [8] and preparing fatty acid methyl esters, by gas chromatography on a CPSil88 column for FAME (100 m x 0.25 mm x 0.20 µm) [9].

Oxidative stability measurements were performed after thawing the meat for 16h at 4°C. Two steaks of 2 cm thickness were taken, wrapped in oxygen permeable film and continuously illuminated (900 lux) at 4°C for 5 days. The evolution in colour $L^*a^*b^*$ parameters was followed daily using a Hunter Miniscan spectrocolorimeter. Lipid oxidation was assessed by measuring thiobarbituric reactive substances (TBARS) on day 1 and day 5 of illumination using the method of Tarladgis [10], and was expressed as µg malondialdehyde (MDA)/g meat. The thiol content was used as a measurement of the degree of protein oxidation [11] and is expressed as nmol thiol/mg protein.

Statistical analysis

One-way ANOVA was used to evaluate the effect of game species on the chemical composition parameters and fatty acid profile. Comparison of means was done using Duncan as post-hoc test ($P < 0.05$). For the oxidative stability measurements, a two-way ANOVA was used evaluating the effect of day of illumination and game species, as well as the interaction term. As the P-value for the interaction term was highly significant ($P < 0.05$), it was chosen to perform separate one-way ANOVA to analyze the effect of game species within each day of analysis, and the effect of day within game species. All analysis were done using SPSS version 15.0 for Windows.

III. RESULTS AND DISCUSSION

The chemical composition of meat from the different game species is given in Table 1. A significantly higher crude fat and lower crude protein content was observed for blesbok meat compared to the other meat types. However, it has to be mentioned that the fat content of all meat types was low, not exceeding 1.5% of fat. The chemical composition of meat of the different game species is very comparable with literature data [1].

In general, the α-tocopherol content of all game species was relatively high (at least 2.7 µg/g meat) compared to meat originating from domesticated animals, even when supplemented in the diet (e.g. beef, pork, ostrich) (Table 1). A significantly higher α-tocopherol content was observed for impala and springbok meat compared to blesbok, kudu or wildebeest. These differences are probably related to the diet of the animals. It was reported that in the vegetation of impala and springbok not only grasses but also a relatively high proportion of fruits, flowers, leaves and bushes were available, while for the other animals the diet consisted mainly of grasses. While the Zn content was not significantly different between species (15.2 ± 3.04 µg/g meat), the Cu and Fe content differed (Table 1). A significantly higher amount of Fe was measured for blesbok and springbok compared to the other game species, while the Cu content was significantly lower for blesbok, kudu and wildebeest compared to springbok. Data on the content of trace elements of game meat are rather scarce. Our data are in correspondence with data reported for ostrich [12]; pork [3]; and impala [13].

The fatty acid profile of the different meat types is given in Table 2. It is clear that these animals were fed extensively with high amounts of green plants, as seen in the relatively high proportion of n-3 fatty acids (at least 7.5%). The proportions of SFA, MUFA and PUFA are more or less equally distributed. Kudu showed the highest proportion of PUFA, and the lowest proportion of MUFA and SFA compared to the other game types. These results are in correspondence with data described in Hoffman & Wiklund [1] for different game species.

During the display period, the a*-value decreased and the TBARS-value increased significantly within all meat species, while no effect of time was observed on the thiol content ($P > 0.05$) (Table 3). Values for thiols on day 1 of illumination were already rather low, compared with literature data on e.g. pork [7] and lamb [14] . This is probably due to the fact that in the present study meat had been previously frozen, followed by thawing and illumination, whereas in most other studies fresh meat is investigated. These results could indicate that there was a considerable loss in thiol groups during the frozen storage period. From the 5 game species, wildebeest appeared to be the most oxidative stable, whereas kudu meat showed the lowest oxidative stability. In kudu meat, the a*-value decreased by 5.5 units, while TBARS increased 8-fold during the 5 days illumination period. This could be related to the lowest α-tocopherol content and the highest amount of n-3 PUFA in kudu meat compared to the other

game species. Although springbok showed a very high α-tocopherol content and the lowest n-3 PUFA proportion, the lipid oxidation was not clearly inhibited by these factors in springbok meat. The effect of the differences in the content of trace elements (Cu, Fe and Zn), cofactors for the antioxidative enzymes, on the oxidative stability measurements are not clear.

IV. CONCLUSION

Clear differences were observed between meat from different game species in chemical composition and fatty acid profile. The oxidative stability of the pre-frozen meat was dependent on the species. In general kudu meat showed the greatest lipid and color oxidation.

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TABLE 1. MEAT QUALITY CHARACTERISTICS AND TRACE ELEMENT CONTENT OF MEAT FROM DIFFERENT GAME SPECIES

	Blesbok	Impala	Kudu	Springbok	Wildebeest	SEM	P
n	14	14	9	14	10		
Dry matter (g/100g meat)	24.2[a]	24.4[a]	22.8[b]	25.1[a]	22.7[b]	0.23	0.002
Crude protein (g/100g meat)	21.7[b]	23.5[a]	24.1[a]	23.5[a]	23.2[a]	0.22	<0.001
Crude fat (g/100g meat)	1.52[a]	0.97[ab]	0.65[a]	0.97[ab]	1.03[b]	0.09	0.004
n	6	6	11	6	9		
α-tocopherol (µg/g meat)	3.83[a]	5.23[ab]	2.71[a]	7.57[b]	3.09[a]	0.47	0.005
Cu (µg/g meat)	2.09[b]	2.63[ab]	1.50[b]	3.23[a]	1.68[b]	0.18	0.011
Fe (µg/g meat)	36.4[a]	25.7[b]	24.4[b]	32.6[a]	26.6[b]	1.11	<0.001
Zn (µg/g meat)	14.3	12.6	15.1	15.2	15.6	0.52	0.142

[a,b] Means with a different superscript are significantly different (P < 0.05)

TABLE 2. FATTY ACID PROFILE (G/100G FAME) OF MEAT FROM DIFFERENT GAME SPECIES

	Blesbok	Impala	Kudu	Springbok	Wildebeest	SEM	P
n	13	13	8	14	8		
SFA[1]	33.1[a]	36.2[a]	28.4[b]	34.0[a]	34.1[a]	0.69	0.013
MUFA[2]	23.1	21.5	17.4	24.1	23.7	0.73	0.057
n-6 PUFA[3]	22.7	21.5	27.8	23.3	21.2	0.80	0.121
n-3 PUFA[4]	9.82[ab]	9.51[ab]	11.0[b]	7.69[a]	9.26[ab]	0.33	0.018
CLA	0.24[a]	0.19[a]	0.56[b]	0.34[a]	0.56[b]	0.04	0.001

[1] SFA = C12:0 + C14:0 + C15:0 + C16:0 + C17:0 + C18:0 + C20:0; [2] MUFA = C14:1c + C16:1t + C16:1c + C18:1t + C18:1c9 + C18:1c11; [3] n-6 PUFA = C18:2n-6 + C18:3n-6 + C20:3n-6 + C20:4n-6 + C22:4n-6; [4]n-3 PUFA = C18:3n-3 + C20:5n-3 + C22:5n-3 + C22:6n-3; [a,b] Means with different superscripts within a row are significantly different (P < 0.05)

TABLE 3. OXIDATIVE STABILITY MEASUREMENTS OF PRE-FROZEN MEAT FROM DIFFERENT GAME SPECIES AFTER 1 AND 5 DAYS OF ILLUMINATION

	Blesbok	Impala	Kudu	Springbok	Wildebeest	*SEM*	$P_{game\ species}$
n	6	6	11	6	10		
a*							
Day 1	11.3[a]	13.4[b]	13.9[c]	12.2[ab]	15.3[d]	*0.34*	*<0.001*
Day 5	8.60[a]	10.6[b]	8.49[a]	10.1[ab]	13.6[c]	*0.41*	*<0.001*
SEM	*0.68*	*0.65*	*0.68*	*0.38*	*0.45*		
P_{day}	*0.043*	*0.023*	*<0.001*	*0.002*	*0.047*		
TBARS (µg MDA/g meat)							
Day 1	0.55[a]	0.40[b]	0.46[ab]	0.35[b]	0.36[b]	*0.02*	*0.003*
Day 5	4.28[a]	1.80[b]	3.95[a]	2.55[ab]	0.76[b]	*0.34*	*0.001*
SEM	*0.70*	*0.28*	*0.52*	*0.41*	*0.12*		
P_{day}	*0.002*	*0.004*	*<0.001*	*0.002*	*0.102*		
Thiol (nmol thiol/mg meat)							
Day 1	53.9[a]	45.6[b]	43.4[b]	56.7[a]	49.3[a]	*1.28*	*0.002*
Day 5	55.7[a]	46.6[b]	41.7[a]	56.5[a]	47.6[b]	*1.27*	*< 0.001*
SEM	*1.54*	*1.90*	*1.31*	*1.78*	*1.34*		
P_{day}	*0.578*	*0.822*	*0.520*	*0.941*	*0.519*		

[a,b,c,d] Means with different superscripts within a row are significantly different (P < 0.05)