Quality parameters of hunted game meat: Sensory analysis and pH monitoring

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Abstract

The aim of the present research is to propose a new, quick and objective method for the certification of hunted and/or culled wild game meat quality and to monitor its origin and the hunting practices adopted by hunters. The expected deliverable is a new labelling scheme for Italian hunted wild game meat that will guarantee high quality and safety standards for consumers and will decrease transaction costs of the supply chains. During the 2015, 2016 and 2017 hunting seasons, 1,056 hunted wild ungulates were sampled. Specifically, alpine chamois (n=537), roe deer (n=113), red deer (n=342) and wild boar (n=64), which were all hunted in the VCO2-Ossola Nord hunting district (Verbania Province, Piedmont, Italy). Samples of the *longissimus dorsi* were collected to evaluate the nutritional parameters and the acid profiles of the products. As a measure of meat quality, pH values have been recorded after slaughtering by inserting a probe in the *semimembranosus* muscle. The results were categorized as DFD (pH≥6,2), intermediate DFD (5,8≤pH<6,2) and high-quality meat (pH <5,8). As explanatory variables for the quality of wild game meat, differences based on age, gender and hunting practices were considered. Concerning the latter variables, measures were collected from animals received at hunting districts control centers by trained technicians who also collected information on the hunting practices, *i.e.,* bleeding and evisceration of the carcasses and number of shots. Nutritional values showed low fat (<3 g per 100 g), low satu-rated fat (<1,5 g per 100 g) and high protein contents. Furthermore, wild game meat has high values of ω3 and CLA, ensuring a positive ω6/ω3 ratio. Differences were found in the concentrations of fat between age and gender, considering that during the mating season, adult males' weight loss can exceed 40%. Hunting practices seem to affect meat quality.

Introduction

The possibility of placing wild game meat on the market according to Reg. (EC) n. 853/2004, which considers the hunter a primary producer, represents an added value for the sustainable use of ungulates as resources in rural areas with a potential economic impact on the local economy (Gaviglio *et al.*, 2017; Gaviglio *et al.*, 2018). In recent decades, ungulates have shown a remarkable demographic increase in Italy, especially for red deer (Ramanzin *et al.*, 2010) and wild boar, which is often considered more a damage than a resource (Ferri, 1998). Game meat presents interesting nutritional and sensorial qualities. Generally, game meat has a low-fat content, although some variations related to gender, age, physiological conditions and hunting season may occur (Ramanzin *et al.*, 2010; Russo, 2005); the amount of calories and cholesterol is low, but it has good protein, iron, zinc, vitamin B12 and some polyunsaturated fatty acid contents. Several studies have shown that wild ruminant fat has a favourable ratio of ω6/ω3 fatty acids (Valencak *et al.*, 2015), with a good conjugated linoleic acid (CLA) content (Secchiari *et al.*, 2001; Phillip *et al.*, 2007). Due to both its peculiar intrinsic and extrinsic features, the consumer trend of game meat is rapidly growing (Piasentier *et al.*, 2005; Demartini *et al.*, 2018; Marescotti *et al.*, 2019).

The market availability of free ranging game meat culled according to hunting management plans requires detailed monitoring for its nutritional, sensorial and sanitary quality; moreover, monitoring is necessary to guarantee safety, quality and traceability requirements to the new game meat supply chain. The use of good hunting practices (immediate death, bleeding and immediate evisceration, proper transport) are therefore functional to guarantee low levels of microbial contamination and preserve both meat hygiene (Hoffman & Wiklund, 2006; Gill, 2007; Atassanova *et al.*, 2008; Winkelmayer & Paulsen, 2008; Paulsen *et al.*, 2011; Avagnina *et al.*, 2012; Liepina *et al.*, 2010) and sensory qualities (Postolache *et al.*, 2011; Soriano *et al.*, 2016).

The pH value of meat (initial and final pH and decrease rate of pH) is one of the most important indicators of the effect of pre-mortem stress on meat quality (Lawrie, 2006). For this reason, the implementation of this method for hunted animals could be an instrument to verify the real acidification of muscles and the right implementation of hunting best practices (Wiklund *et al.*, 2004; Lonergan *et al.*, 2010).

The decrease in pH, occurring in the early hours after death, can provide useful information on the stress conditions of the animal before shooting and bleeding procedures (Hoffman & Ferreria, 2000). Moreover, the impact of the reproductive cycle, for example, a rapid weight decrease in adult males after the mating season, may modify the pH decrease (Viganò *et al.*, 2017).

Materials and Methods

In 2015, the project "Filiera Eco-Alimentare" was initiated with the aim of promoting local game meat by improving its hygiene and health quality as well as to create an origin brand and the promotion of local food and tourism in High Ossola Valley (area of Verbania, Piedmont, Italy). In this study, the nutritional parameters of

game meat were analyzed, and the critical issues related to culling, evisceration and transport of ungulates as part of hunting management plans were assessed.

The study area was the VCO2-Ossola Nord hunting district located in the north of Verbania. The number of wild ungulates each hunter can shoot was set based on the annual census and the trend of the previous hunting season and it must be approved by the Piedmont Region. The wild ungulates were delivered on the same day of hunting to hunting district control center where morpho-biometric measurements and scientific data were collected by qualified technicians (free-lance veterinarians). For each animal species, gender, age class, time and place of shooting, type of culling, time to death (divided into three categories: dead on the spot, less than five minutes, more than five minutes), number of shots, points of entry and exit of shots, type of bleeding and evis-ceration, abdominal lesions, body condition and morpho-biometric measurements (weight, mandible and tarsus length, and trophy measurements) were collected.

Simultaneously, pH measurements and temperatures of *semimembranosus* muscles were collected with an HD2105.2 Delta OHM® instrument with a precision of ±0,001 pH units. Measurements were recorded during the same hour of collection, which could be several hours or shortly

Table 1. Grams of moisture, protein, fats, crude ash in 100 g of game meat.

g/100 g	Chamois Yearlings	Chamois Adult males	Roe deer Adult males	Red deer Yearlings	Red deer Sub-adult males	Red deer Adult males	Red deer Adult females	Wild boar Adult males
Moisture	74,52	78,10	75,00	71,68	74,10	74,26	74,39	71,55
Protein	22,40	19,10	21,90	21,70	23,30	24,10	21,90	24,70
Fats	1,40	1,38	1,95	5,09	1,06	0,25	2,32	2,26
Crude ash	1,31	1,24	1,04	1,39	1,34	1,25	1,23	1,21

Table 2. Acid composition as % of lipidic fraction.

g/100 g	Chamois Yearlings	Chamois Adult males	Roe deer Adult males	Red deer Yearlings	Red deer Sub-adult males	Red deer Adult males	Red deer Adult females	Wild boar Adult males
C 8:0			0,01					
C 10:0			0,05					0,09
C 12:0			0,01	0,26	0,37	0,52	0,35	0,10
C 14:0	1,99	1,37	2,47	5,54	6,14	5,42	5,75	1,42
C 14:1		0,01	0,07	1,31	0,79	0,84	0,91	
C 15:0	2,76	1,77	0,92	0,97	1,12	1,65	1,42	0,01
C 16:0	20,25	13,72	26,63	29,66	29,41	27,67	27,96	24,58
C 16:1	1,25	0,85	1,46	7,25	4,04	5,71	5,67	3,24
C 17:0	1,94	14,65	1,94	0,96	1,07	1,25	1,15	0,20
C 17:1	0,31	0,15	0,42	0,32	0,19	0,26	0,27	0,15
C 18:0	26,84	23,00	27,99	20,19	27,59	30,81	23,22	11,02
C 18:1 n-9	23,41	41,47	28,44	20,03	17,60	14,86	18,05	35,33
C 18:1 n-7	7,71	1,28	3,44	6,75	5,95	6,30	7,44	3,94
C 18:2 n-6	8,70	0,83	3,46	2,76	2,64	2,11	3,38	15,57
C 18:3 n-3	3,82	0,35	1,04	1,45	0,99	1,04	1,75	1,98
C 18:3 n-6	0,35	0,08	0,23	0,47	0,29	0,37	0,46	0,10
C 18:4 n-3				0,64	0,55	0,51	0,57	0,01
C 20:0	0,36	0,10	0,24	0,45	0,75	0,48	0,73	0,23
C 20:1 n-9		0,13	0,14	0,31	0,17	0,11	0,15	0,79
C 20:2 n-6				0,11			0,09	0,47
C 20:3 n-6				0,07	0,19	0,09	0,08	0,07
C 20:3 n-3				0,07			0,10	0,21
C 20:4 n-6			0,29	0,21			0,18	0,26
C 20:5 n-3				0,10			0,08	
C 22:0				0,09	0,15		0,13	
C 22:1 n-11			0,01					
C 22:2 n-6			0,01					
C 22-6 n-3				0,01				
C 24:0							0,09	
CLA	0,31	0,21	0,61					0,18

after death. During 2015, 2016 and 2017 hunting seasons, a total of 1,056 ungulates were collected (537 chamois, 113 roe deer, 342 red deer and 64 wild boars), among which 1,027 presented a complete data collection (525 chamois, 108 roe deer, 332 red deer and 62 wild boars). The pH values collected 240 minutes after culling were considered predictive of the quality of the meat according to (Hoffmann & Ferreria, 2000; Wiklund *et al.*, 2004), considering a pH >6.2 DFD, a 5.8>pH>6.2 as intermediate DFD, and a pH <5.8 as good quality. Data were analyzed with statistical software (IBM® SPSS® 21.0). For statistical purposes, variables were compared with a univariate analysis. Significance was considered for P-values <0.05.

Samples (N=8) of the *Longissimus dorsi* muscle were also collected from chamois, roe deer, red deer and wild boars to evaluate nutritional parameters and acid profiles and consequently to identify any differences between age classes and gender of the different hunted ungulates. A 150/200 g sample was collected at the game processing center the day after slaughter, refrigerated at a temperature below 4°C and delivered to the laboratory for analysis. For each sample, moisture (AOAC 950.46 B 1991), protein (AOAC 992.15 1992), fat

(AOAC 960.39 B) and crude ash (UNI 10590:1997) contents were tested. The fatty acid composition was identified by GC FID (MP-2097 rev. 0 2013 – [UNI EN 1528 – 2: 1997] + AOAC 991.39 1995).

Results

Results for nutritional values per 100 g of product show high protein content (average 22,39 g ± 1,727 std. dev.), low fat content (average 1,96 g ± 1,434 std. dev.) and an ash value average of 1,25 g ± 0,105 std. dev. (Tables 1 and 2).

The saturated fatty acid content per 100 g of product was low (1.10 g ± 0.835 std. dev.), and more specifically, a lower ratio of ω6 / ω3 (on average 2.25 ± 0.793 std. dev.) was observed in ruminant ungulates than in wild boars. In addition, differences in the concentration and acid composition between species, age classes and sex were observed. The value of fats in adult red deer males was significantly lower than in the other classes of the same species (Table 3).

Considering pH measurement as a forecasting parameter to evaluate the quality of meat, pH values were recorded within 240 minutes of culling and after 240 minutes of culling, the results were classified as good

(pH <5,8), intermediate-DFD (5.8<pH<6.2) and DFD (pH>6.2). Additionally, animals killed and managed according to best hunting practices (dead on the spot and bled immediately) were compared to those not managed according to the best practices (Table 4). The pH values recorded for the 4 species of wild ungulates were analysed. The results showed a large difference between quickly and correctly bled animals compared to those not properly bled 240 minutes after slaughter. Time to death categories did not have a significant influence on the change in individual pH, but a long time to death in association with no bleeding caused the pH values to differ (Table 5). Moreover, the effect of the time between the shot and the animal's death has a positive influence in association with good management practices (P<0.05), even if the effect could not be used as a significant single parameter in the pH analysis (Figures 1 and 2). In the first 4 hours after the slaughter, the decrease in the pH value, was faster in carcasses managed according to good practices. Furthermore, carcasses managed according to "best practices" showed pH stability, with values mostly lower than 5,8, while carcasses not managed properly showed a higher rate of decreasing pH values.

Table 3. Grams of SFA, MUFA, PUFA, ω3 e ω6 in 100 g of game meat and ω6/ω3 ratio

g/100 g	Chamois		Roe deer	Red deer				Wild boar
	Yearlings	Adult males	Adult males	Yearlings	Sub-adult males	Adult males	Adult females	Adult males
SFA	0,76	0,75	1,17	2,96	0,71	0,17	1,41	0,85
MUFA	0,46	0,61	0,66	1,83	0,30	0,07	0,75	0,98
PUFA	0,18	0,02	0,11	0,30	0,05	0,01	0,16	0,43
ω3	0,05	0,00	0,02	0,12	0,02	0,00	0,06	0,05
ω6	0,13	0,01	0,08	0,18	0,03	0,01	0,10	0,37
ω6/ω3	2,37	2,60	3,83	1,60	2,03	1,66	1,68	7,52

Table 4. Distribution of pH values recorded in different species during two intervals: within 240 minutes after slaughter and after 240 minutes after slaughter.

		<240 minutes %				≥240 minutes %			
		N.	pH≤5,8	5,8<pH≤6,2	pH>6,2	N.	pH≤5,8	5,8<pH≤6,2	pH>6,2
Chamois	Best practice	42	71,4	21,4	7,1	219	94,5	4,6	0,9
	Bad practice	47	31,9	55,3	12,8	217	72,8	23,5	3,7
Roe Deer	Best practice	27	25,9	37,0	37,0	30	96,7	3,3	0,0
	Bad practice	30	6,7	50,0	43,3	21	52,4	47,6	0,0
Red Deer	Best practice	37	59,5	27,0	13,5	139	96,4	2,9	0,7
	Bad practice	50	36,0	44,0	20,0	106	76,4	17,0	6,6
Wild Boar	Best practice	9	77,8	22,2	0,0	26	88,5	7,7	3,8
	Bad practice	5	40,0	40,0	20,0	22	63,6	31,8	4,5
All species	Best practice	115	57,4	27,0	15,7	414	94,9	4,1	1,0
	Bad practice	132	28,0	49,2	22,7	366	72,1	23,5	4,4

Discussion

Concerning the nutritional profile, wild game meat has a lower fatty acid content and higher levels of ω3, ω6 and CLA compared to farmed game animals, such as wild boar (Sales & Kotrba, 2013) and red deer (Phillip *et al.*, 2007), and other livestock as well.

Indeed, wild game meat has a good essential fatty acid content and a positive ω6/ω3 ratio, because wild fauna feeds on a variety of plants that are naturally present in its habitat (Yang *et al.*, 2015).

However, culling subjects of different sexes and ages hinders the homogeneity of game meat in terms of nutritional and sensorial qualities, as the quality of the product is influenced by the biological cycle of the species. An example is reed deer meat, with a fat concentration in adult males ten times less than average value recorded for this species (Mustoni *et al.*, 2002) due to extreme weight loss in red deer males during the mating season, which normally precedes the hunting season.

Moreover, the meat of male deer can be affected by an intense "smell", derived from sexual hormones typical of the mating season, in the weeks immediately following the mating season. Fat and sexual odor negatively affect meat quality, even if good practices in carcass management were applied.

The aim of the studies carried out as a part of the project "Filiera Eco-Alimentare"

was to identify high quality standards for game meat from hunted animals. To reach this goal, pH measurement has been suggested to be a valid method for the selection of the product after slaughter following good practices of carcass management. It has been observed that proper bleeding by the hunter with a cut directly to the thoracic cavity, can influence the decrease in pH value in the first 4 hours after culling. If bleeding is conducted in association with proper culling, which doesn't cause agony to the subject, a quality improvement in the final product (meat) has been observed. Animals culled with a nonfatal shot and/or not properly bled showed a slower pH decrease in the first hours after death.

Furthermore, after 240 minutes post-culling, carcasses that were managed using "best practices" showed pH values lower than 5,8 in 94,9% of cases, while carcasses managed in an improper way resulted in a slower rate of decrease pH values lower than 5,8.

Data collected during the study have demonstrated that carcasses managed with "best practices", but which showed pH values higher than 5,8 from 4 to 14 hours after culling, belonged to underweight animals compared to the average weight of the species according to age and gender.

Conclusions

Forecasting parameters for game meat quality are required, since its supply-chain is not supported by national guidelines. Currently, the management of hygienic and sensory quality standards is demanded to the hunters from the shot to the arrival at the slaughterhouse, however they do not always behave properly and adhere to the quality standards, even if they use good practices in the management of the carcass. Furthermore, from a commercial point of view, game meat guidelines are needed, since nutritional parameters of game meat

Table 5. Results of the univariate analysis on the effects of culling and proper bleeding on the pH variable.

	Degree of freedom	F	P-value	Partial eta-squared
Bled	1	2,935	0,031	0,891
Agony time	2	0,023	0,894	0,106
Bled * Agony time	2	0,193	0,014	0,011
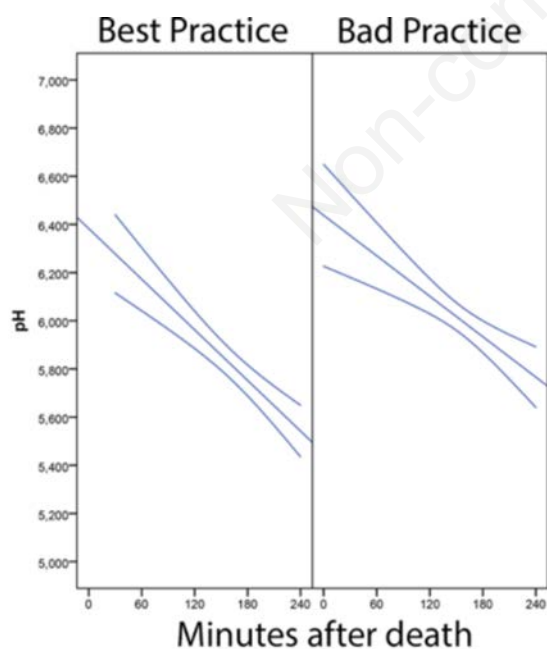
Figure 1. Best practices effect on pH decrease during four hours after slaughter (Best practices R²=0,249; Bad practices R²=0,120).
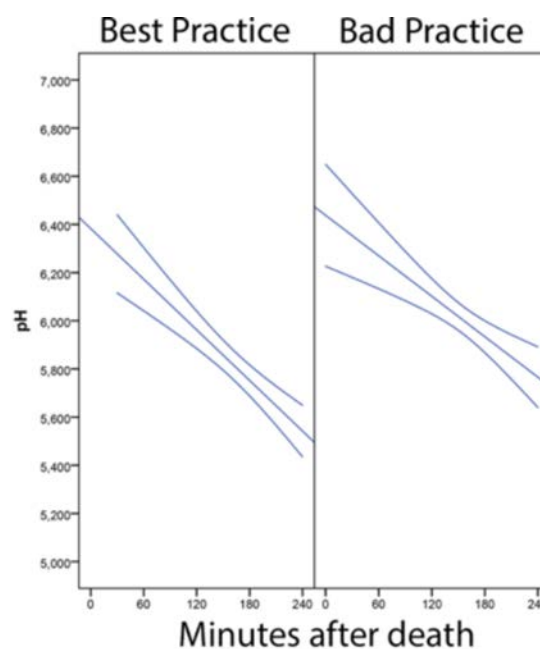
Figure 2. Best practices effect on pH decrease after four hours after slaughter (Best practices R²=0,012; Bad practices R²=0,020).

vary depending on the species, age, sex and hunting period.

In addition, since in the study area, culling and evisceration are conducted in the field by the hunters, analyses and objective evaluation criteria using low-budget and rapid techniques are needed to determine the product quality before sending the carcasses to authorized centers for meat processing.

Consumer requires that good standards are fulfilled from a hygienic, nutritional, commercial and ethical point of view. To reach this aim, data related to hunting methods, numbers of shots, and possible agony of the culled animal were collected at the hunting district control centers, where every ungulate culled during the hunting season is required to be analyzed according to territorial law. These data can provide good tools when used in combination with pH values and meat temperature; they can be useful to distinguish high quality products, and they can guarantee that the animal has been culled in accordance with ethical standards. These aspects qualify the supplier and can be used to improve culling procedures.

The pursuit of high-quality standards in wild game meat and in a well-organized supply chain may not only encourage hunters to improve their practices, but can also build a link between the consumer and the territory, thus increasing the value of natural resources and local traditions. Furthermore, a new labelling scheme for the Italian hunted game meat can be created.

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