Application of European standards for health and quality control of game meat on game ranches in South Africa

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ABSTRACT
The health and quality compliance of game carcasses (n = 295) intended for the South African export market and aspiring to comply with the strict hygiene requirements of the European Union were compared with game carcasses (n = 330) available for the local market and currently not subjected to meat safety legislation. Samples were collected in similar seasons and geographical areas in South Africa from 2006 to 2009. Aerobic plate counts (APC) of the heart blood verified that both groups possessed similar ante mortem bacterial status. For health compliance APC, tests for Escherichia coli, Salmonella spp. and Staphylococcus aureus were performed on the carcasses. Surfaces of the local carcasses were swabbed using the European Enviro-biotrace sponge technique at 3 and 72 h post mortem. Unskinned but eviscerated export carcasses in the abattoir were skinned and sampled by incision using a cork borer 72 h post mortem. Temperature and pH readings were recorded at 3 and 72 h post mortem from the longissimus dorsi muscle and the readings at 3 h differed (P = 0.035). Temperatures at 72 h were lower for local carcasses (P < 0.001) because of earlier introduction and maintenance of the cold chain. The pH readings also differed between groups at 3 and 72 h (P < 0.001). APC results for the local group exceeded the maximum permissible count (107). S. aureus results showed differences (P < 0.001), with readings from the local group being higher. The same tendency was exhibited for E. coli (P = 0.008). Imposition of hygiene guidelines for game ranchers producing meat for the local market is therefore recommended.

Keywords: bacteriological standards, chopping, export meat quality, safe game meat, trophy hunting.

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INTRODUCTION
The current health status of game meat available on the local South African market is unknown due to the fact that legislation requiring meat inspection or approved game slaughter facilities is not applied. This has raised concern and speculation as to the health status of this meat25. Any incident of a reported zoonotic disease or a case of food poisoning that may be traced to game meat will have a negative effect on the local game meat market in South Africa. The Meat Safety Act (Act 40 of 2000) (MSA) that regulates the meat industry in South Africa makes provision for 5 different regulations i.e. red meat, poultry, ostrich, game and crocodile. However, the regulation applicable to game has been in draft since 2004 (to be promulgated in the near future under the MSA). This delay is due to the need to address the hunting process that delivers dead game animals to the abattoir and not live animals as required by the MSA (T Bergh, Veterinary Public Health, Department of Agriculture, Forestry and Fisheries, pers. comm., 2009). The Game Regulation originated from the Red Meat Regulation that is applicable to domesticated animals. Further concerns from game ranchers are that such regulations will be impractical and too costly to implement on a game ranch32. Cropping and export of game meat from South Africa is done in strict accordance with the guidelines of the Veterinary Procedural Notices (VPN)21-26 issued and annually amended by the Department of Agriculture Forestry and Fisheries in conjunction with the European Union (EU) (countries of import). In contrast, the game carcasses hunted for the local market are uncontrolled and no regulations or guidelines currently apply to such carcasses. The health and quality of export and local hunted game carcasses were investigated in this study to determine how effectively these issues are addressed by the MSA and the above mentioned VPNs. Less than ideal culling and slaughtering techniques are usually associated with meat from locally hunted animals, e.g. trophy animals as opposed to the ‘ideal’ or benchmark techniques of the export game carcasses. Unfortunately, the standards of slaughter and cooling facilities available for carcasses intended for the local market are usually not on a par with the EU requirements (VPN) for carcasses intended for export. The latter are transported refrigerated and unskinned (transportation time ≤72 hours) from the ranch, where initial (partial) primary carcass inspection is done20, to the export abattoir to have the carcasses skinned, after which the final (partial) primary inspections are done21. This scenario of initial and final primary inspection is unique to game meat and secondary inspection can be performed both on the ranch and at the abattoir depending on the stage (initial or final) of primary inspection at which the carcass was detained. According to the Department of Agriculture Forestry and Fisheries, such ranches must be registered for export harvesting32. On the other hand, carcasses for the local market are usually skinned or capped (this involves the removal of the head and neck skin of a game animal so that it can be mounted for trophy purposes) directly after the hunt and transported unrefrigerated, without primary or secondary meat inspection, to the consumer or processor. The transportation time from the ranch to the processor or consumer usually exceeds 2 hours but seldom exceeds 24 hours.

It has been stated that hygiene and safety have been an issue in game meat for export/import for a long time and optimising the primary production level is the key to improving safety and shelf life of wild game meat27. The authors concluded that parts of the legislation still present questions and challenges in terms of hygiene and safety. This study therefore...
envisaged comparing a high intensity commercial cropping system typical of the export market with a low intensity hunting system typical of the local market.

It is speculated that in South Africa, especially during the hunting season, game meat contributes more than 20% towards red meat consumption. It is expected that the phenomenon will increase even more as a result of extension of the South African hunting season from 3 to almost 6 months (from the beginning of March to the end of August), coupled with the increase in the number of game farms as more and more cattle farmers are changing to more profitable game farming.

The question may be posed from a public health perspective whether the current local game meat supply systems can provide safe game meat to the consumer.

The envisaged study focused on health and hygiene procedures that are applied following the hunting phase on the ranch and did not include any processing activities away from the ranch. The study will consequently determine the hygienic quality of the meat before the onset of the final phase of processing for human consumption. This latter processing phase is usually not implemented on the ranch and is regulated in South Africa by Regulation R918 published under the Health Act (Act 63 of 1977).

The study compares the bacteriological status of the carcasses intended for export and local markets during the hunting phase (obtaining a carcass) on the ranch and the conclusions are based on this information. The aim was not to focus on specific micro-organisms, but rather to compare the general bacteriological quality of meat obtained from local and export hunting and cropping procedures.

Index or indicator microorganisms have been used to monitor the hygienic quality of water over the past 100 years and this principle has been extended to a variety of raw and processed foods. Index organisms are used as a measure of the possible presence of pathogens and have a predictive function, whereas indicator organisms are used to assess process integrity and are regarded as general hygiene markers of good manufacturing practices (GMP). For the purpose of the study, Escherichia coli, Staphylococcus aureus and Salmonella spp. were regarded as ‘index’ organisms, while the aerobic plate count (APC) was regarded as a measure of ‘indicator’ organisms.

MATERIALS AND METHODS

The procedures, readings and sample analysis were performed without consideration of the different game species but only the range of animals that were available during the study period. A breakdown of the categories of game species available in the study for the export and local market respectively is shown in Table 1.

### Table 1: Breakdown of the available category game species harvested and hunted for export and local markets respectively.

| Common name       | Scientific name                  | Category A, B or C game animals | Export | Local |
|-------------------|----------------------------------|---------------------------------|--------|-------|
| Blue wildebeest   | Connochaetes taurinus            | B                               | 19     | 30    |
| Bushbuck          | Tragelaphus scriptus             | B                               | 6      | 6     |
| Bush pig          | Potamochoerus larvatus           | C                               | 24     |       |
| Eland             | Taurotragus oryx                 | B                               | 10     |       |
| Giraffe           | Giraffa camelopardalis           | A                               | 2      |       |
| Impala            | Aepyceros melampus              | C                               | 9      | 46    |
| Kudu              | Tragelaphus steppiceros          | B                               | 55     | 41    |
| Nyala             | Tragelaphus angasii              | B                               | 15     |       |
| Oryx              | Oryx gazella                     | B                               | 2      | 21    |
| Tsessebe          | Damaicus lunatus                | B                               | 8      |       |
| Waterbuck         | Kobus ellipsiprymnus            | B                               | 14     |       |
| Burchell’s zebra  | Equus burchelli                 | B                               | 29     | 11    |
| Black wildebeest  | Connochaetes gnou                | B                               | 7      | 11    |
| Blesbuck          | Damaicus dorcas philipsi         | B                               | 35     | 8     |
| Red hartebeest    | Alcelaphus caama                | B                               | 7      | 17    |
| Springbuck        | Antidorcas marsupialis           | C                               | 122    | 32    |
| Roan              | Hippotragus equinus             | B                               | 6      |       |
| Sable             | Hippotragus niger               | B                               | 14     |       |
| Warthog           | Phacochoerus africanus           | C                               | 14     |       |
| Ostrich           | Struthio camelus                | B                               | 4      |       |
| Total             |                                  |                                 | 295    | 330   |

Of individual species but refer to a range of game animals.

### Temperature and pH measurements

Temperature readings and pH values were taken at 3 h and 72 h post mortem to establish possible quality correlations. All the measurements were taken using a portable, calibrated Tesco 205 pH and temperature meter (Unitemp, Johannesburg, South Africa). Measurements were taken and recorded directly after evisceration. The Tesco meter was calibrated between readings and taken when the probe was inserted in the middle of both longissimus dorsi muscles. A total of 2500 measurements from a total of 625 carcasses (n = 295 for export and n = 330 for local) were noted for both temperature (temp.) and pH (pH1) at the 1st and 2nd readings (temp1, pH1).

### Aerobic plate count (APC)

APC determinations were done on the carcass surfaces of the local group, (n = 330) using the Enviro-biotrace swabbing technique described in the Food and Agriculture Organization of United Nations (FAO)/World Health Organization (WHO) (1979) prescriptions, the FSIS/USDA Meat and Poultry Regulations (1996) and the Scottish Meat HACCP Regulations (Number 234 of 2002). One sponge swab was used to swipe each carcass (using 4 anatomical sites on both hind- and forequarters to obtain a sample representative of the carcass surface bacteria). Category A and B animals were sampled on the rump and neck area and category C animals on the...
perineal area from the base of the tail to the hock and the neck area. This was done by dividing the sponge into 4 quadrants and applying each quadrant to an anatomical site. The laboratory results gave an average bacteriological profile for each of the 330 M local carcasses at 3 h and 72 h. The total readings for the local group were n = 660.

The Enviro-biotrace cattle and swine test kit consists of sterilised templates, gloves, resealable sachets with 29 cm² dry sponges and glass bottles containing 10 ml peptone solution (Analytical & Diagnostic Products, CCPO, Weltevreden Park, South Africa). The dry sponges were soaked aseptically in the peptone solution and the templates were used to swab the 4 quadrants (fore- and hindquarters) of the carcass. Ten horizontal and 10 vertical swabbing movements for each of the quadrants within the confines of the USDA sterile and flexible plastic template (10 × 10 cm) ensured that the recommended carcass surface (100 cm²) was covered. Dividing the sponge into 4 sections and swiping with a clean part of the sponge surface for each quadrant of the carcass, gave a representative indication of the bacterial status of the overall carcass surface. Verification of this method was successfully done by comparison with 12 replicate samples taken simultaneously using the traditional excision sampling method (cork-borer method). Excision sampling is based on the assumption that bacteria migrate deeper to more favourable conditions than the exposed, dry meat surface. This assumption has, however, been tested and refuted by various researchers.7,12,13,17

The export carcasses (n = 295) could only be sampled at 72 h (after skinning) through excision sampling, which forms part of the export sampling protocol and was performed by on-site qualified laboratory technicians.

A total of 955 samples taken over the period 2006 to 2009 from both local (n = 330 taken at both 3 h and 72 h = 660) and export carcasses (n = 295) were subjected to the APC.

Isolation of Salmonella spp, Escherichia coli and Staphylococcus aureus

Analyses of the abovementioned samples (APC) included simultaneous analyses for Salmonella spp., E. coli and S. aureus. Over the period 2006 to 2009, a total of 625 samples (export and local group) were taken at 72 h and analysed for the 3 pathogen types.

Data analysis

The overall total data (n = 4275 readings) were used to compute the final results. Statistical analyses were done using Sigma Stat, using the t-test (Shapiro-Wilk) for normality. The Whitney Mann rank sum test was used when tests for normality failed. Differences in median values between the 2 groups (export-cropping and local-hunting) were expressed with P < 0.05 (indicating significance). The Sigma Plot 2 program was used to graphically produce the figures presented in this study.

RESULTS

The results of the comparison between APC colony forming units (CFU/ml) for heart blood sampled initially from both groups in 2006 to 2009 are illustrated in Fig. 1. The solid grey control line shows the highest acceptable level of bacteria that may be present in the heart blood. This control line indicates that a contamination level of <1 × 10³ CFU/ml is acceptable for the purposes of this study in terms of the sampling method used (M. Andrin, Capricorn Veterinary Laboratories, pers. comm., 2007). Significant differences were not found in terms of the bacterial quality of the heart blood sampled from the 2 groups.

The results of the comparison between the temperature (temp1 and temp2) values of the local and export carcasses are illustrated in Fig. 2. Horizontal lines in this figure are quality lines and not specifica-
tions lines as they do not indicate legal standards. The recommended temp2 range is indicated by the dashed grey and solid dark grey lines (−1 °C to 7 °C), recommended to be not less than −1 °C (to prevent freezing of the meat). Furthermore, the carcass temperature should be kept above 2 °C for 24 h for maturation and to reduce the risk of foot-and-mouth disease (FMD)\(^6\). There is a downward pH curve from the time of the successful shot placement to the stabilising pH2. Temperature readings and pH values noted for the 2 groups at temp1 and pH1 showed differences. Temp1 and pH1 values also differed (\(P < 0.001\)).

The results of the comparison between APC (CFU/cm\(^2\)) sampled at 72 h for the export and local groups in 2006 to 2009 are illustrated in Fig. 4. All horizontal lines are specification lines based on bacteriological standards for game meat intended for the export market\(^7\). The solid light grey line indicates the maximum level for E. coli (1997) the prescribed standard for APC is \(< 10\(^5\)\). According to FAO/WHO (1997) the prescribed standard for APC is \(= 10\(^8\)\) CFU/m\(^2\), but levels as high as \(10\(^8\)\) CFU/m\(^2\) are acceptable in the global red meat market\(^8\). The legal maximum allowed for E. coli is \(10^8\) CFU/m\(^2\) and for S. aureus 100 CFU/m\(^2\) (VPN\(^9\)). All 625 carcasses from both groups tested negative for Salmonella spp., which is in accordance with previous studies\(^5\). In addition it has been shown that when initial bacterial counts are sufficiently low, carcass tissues are typically sterile when tested at ‘ultimate’ time\(^9\). This phenomenon can be ascribed to the lag phase of bacterial growth\(^9\).

The similarity in the E. coli, Salmonella and S. aureus counts between the local

**DISCUSSION**

The results of the APC performed on the heart blood from the 2 groups were similar (\(P = 0.693\)) (Fig. 1). The blood samples should have been taken intravenously to adhere to prescribed aseptic sampling methods, but experience during the study showed that all arteries of the animal collapsed immediately post mortem and no blood could be accessed. Consequently, an incision was made into the heart to expose the ventricles for blood collection. In the process, bacteria on the exposed surface of the heart or bacteria from the environment could have been introduced into the blood sample. However, for the purpose of this study, a standardised sampling method was used with both groups and a similar 3 h bacteriological status for the 2 groups was established. The results do not support the principle of an ideal harvesting or hunting method, but they do indicate a similar initial post mortem bacteriological status. Game animals hunted with the heart as target were not included to exclude possible high bacteria counts as a result of cross contamination.

The bacteriological samples collected from both high and low intensity carcasses were compliant with the legal standards for high intensity carcasses as prescribed in the VPN\(^9\). All 625 samples should have been taken intravascularly, but experience during the study showed that all arteries of the animal collapsed immediately post mortem and no blood could be accessed. Consequently, an incision was made into the heart to expose the ventricles for blood collection. In the process, bacteria on the exposed surface of the heart or bacteria from the environment could have been introduced into the blood sample. However, for the purpose of this study, a standardised sampling method was used with both groups and a similar 3 h bacteriological status for the 2 groups was established. The results do not support the principle of an ideal harvesting or hunting method, but they do indicate a similar initial post mortem bacteriological status. Game animals hunted with the heart as target were not included to exclude possible high bacteria counts as a result of cross contamination.

The bacteriological samples collected from both high and low intensity carcasses were compliant with the legal standards for high intensity carcasses as prescribed in the VPN\(^9\). According to FAO/WHO (1997) the prescribed standard for APC is \(\leq 10^8\) CFU/m\(^2\), but levels as high as \(10^8\) CFU/m\(^2\) are acceptable in the global red meat market\(^8\). The legal maximum allowed for E. coli is \(10^8\) CFU/m\(^2\) and for S. aureus 100 CFU/m\(^2\) (VPN\(^9\)). All 625 carcasses from both groups tested negative for Salmonella spp., which is in accordance with previous studies\(^5\). In addition it has been shown that when initial bacterial counts are sufficiently low, carcass tissues are typically sterile when tested at ‘ultimate’ time\(^9\). This phenomenon can be ascribed to the lag phase of bacterial growth\(^9\).

The similarity in the E. coli, Salmonella and S. aureus counts between the local
and export groups raises questions about the necessity of strict requirements such as the VPN.

The bacterial differences at 72 h can be ascribed to the maintenance of the cold chain and dressing in the case of the export group, where the risk of bacterial multiplication/contamination is decreased. It has been noted that refrigeration had a suppressive effect on the numbers of bacteria such as *E. coli* and *Salmonella*. The export market requires that the prescribed refrigeration be applied ≤4 hours post mortem. This is in contrast to the refrigeration period applied voluntarily to the local group (any period up to 24 hours post mortem). The export group readings were lower, most probably thanks to the continuous maintenance of the cold chain. It is the normal procedure to load the carcasses in the field, after dressing and health inspection, into cold trucks set at 5°C with the carcasses being maintained at this temperature until arrival at the abattoir. Here the data logger of the cold truck is inspected and if it complies with the requirements the carcasses are offloaded into a cold room from where they are removed for skinning and further processing (C. De Villiers, Mosstrich Export Game Abattoir, pers. comm., 2008).

The pH values are currently used in the export market for quality and shelf life purposes. High pH values are indicative of high ante mortem stress levels, disease or inflammation in the carcass and are therefore recorded and noted at the export abattoir prior to processing. The higher pH values of the export group at 3 h and 72 h could be explained by the intensity of the cropping process resulting in increased stress to the animals and therefore raised pH levels. The pH readings were not associated with the bacterial numbers taken from the swabs, although it is well known that lower pH values of game meat are a deterrent to bacterial growth. The total absence of *Salmonella* and low numbers of *S. aureus*, considering the financial costs of such analyses, support the argument that testing for index/indicator organisms in the process of harvesting game carcasses should not be a regulatory requirement as intended by VPN. Such analyses could, however, be used to evaluate Good Hygiene Practices (GHP), Good Manufacturing Practices (GMP) and the Hygiene Management System (HMS) when further processing for the local market is envisaged. Leaving the skin on could be considered as a method of control for bacterial contamination during long periods of transportation. In addition, game carcasses possess less visual surface fat and marbling than domesticated animals and if these carcasses were to be skinned and left in efficient cold rooms for long periods (>24 h), drying out of the surface could occur. This will result in an unattractive appearance as well as larger yield losses during further processing. Dressing or skinnning of game carcasses should therefore ideally be conducted after the transportation of the carcasses to the abattoir and prior to processing.

It has been noted that it is of little value to predict the safety of meat based on the levels of APC and/or *E. coli* found on the carcass. The fact that *E. coli* is found commonly as a contaminant of raw meats, even when produced under hygienic conditions, casts doubt on the specified South African legal level requirements for this organism.

The observance of Good Hygiene Practice (GHP) in the different forms of game harvesting and processing will play a decisive role in determining the microbiological status of the meat. The shot placement, the time-temperature profile from shooting to evisceration and the technique of evisceration will influence the surface contamination of the carcass. Furthermore, despite the multiple wounding and contamination of muscles, the adherence to GHP will allow the production of meat that is safe for human consumption. Game meat and meat products must comply with microbiological requirements similar to those for meat from domesticated animals *i.e.* cattle and sheep. However, export abattoir records show that condemnation of carcasses is usually due to bruising and slaughter techniques in the harvesting process (C. De Villiers, Mosstrich Export Game Abattoir, pers. comm., 2008). This condemnation figure is relatively low (0.829%). To place this in perspective, a corresponding condemnation figure for the controlled red meat market (cattle, sheep and pork) in South Africa is 2.205%. These rejections are often due to disease-related conditions that render the meat unsuitable for human consumption. From this comparison it can be concluded that game meat is currently relatively free of microbiological contamination. However, in farmed game animals, as in New Zealand, zoonooses (animal diseases that infect humans) and other conditions that require condemnation could be more evident. In South Africa all game are currently indigenous wild animals and roam freely.

From the results of this study, it can be proposed that the differences in bacterial quality between meat/carcasses from the local and export group could be ascribed to the fact that GHP and GMP have been compromised in the case of local carcasses. The differences are, however, not dramatic.
enough to justify the application of the export regulations (VPNs) to the local market. For this reason the following recommendations are made: practical and affordable guidelines that emphasise the importance of meat hygiene and the integrity of the cold chain should be followed in the process of obtaining a game carcass on a game farm intended for the local market. In addition, keeping the skin intact could be considered as a method of bacterial control during extended periods of transportation and to ameliorate the negative effects of moisture loss and consequent darker meat. Legally prescribed bacteriological testing will always have a cost implication for those who produce for the local market and its application in terms of hygiene and quality of the meat can be questioned.

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