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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 export than 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 (<10^5). *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, cropping, 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 meat[27]. 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 ranch[3,27]. Cropping and export of game meat from South Africa is done in strict accordance with the guidelines of the Veterinary Procedural Notices (VPN)[21–25] 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 abovementioned 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 done[24], to the export abattoir to have the carcasses skinned, after which the final (partial) primary inspections are done[22]. 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 harvesting[21]. On the other hand, carcasses for the local market are usually skinned or caped (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 meat[15]. The authors concluded that parts of the legislation still present questions and challenges in terms of hygiene and safety. This study therefore

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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[18]. 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[4].

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[9,19,26] and is regulated in South Africa by Regulation R918 published under the Health Act (Act 63 of 1977)[20].

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)[5]. 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 stepsiceros*	B	55	41
Nyala	*Tragelaphus angasii*	B		15
Oryx	*Oryx gazella*	B	2	21
Tsessebe	*Damaliscus lunatus*	B		8
Waterbuck	*Kobus ellipsiprymnus*	B		14
Burchell's zebra	*Equus burchelli*	B	29	11
Black wildebeest	*Connochaetes gnou*	B	7	11
Blesbuck	*Damaliscus dorcas philipsi*	C	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

Sampling of heart blood

Heart blood was sampled 3 h *post mortem* from game carcasses by making a longitudinal incision into the heart to expose the ventricles. Blood was collected asepticallyinto sterile evacuated heparin blood tubes. The filled tubes were transported in an insulated container at <7 °C to a South African National Accreditation System (SANAS) accredited laboratory (Capricorn Veterinary Laboratories, Polokwane, South Africa) within 12 hours. An APC (ISO 4833; 1991 (E) MI-Meth-003) was obtained for the blood samples by pipetting decimal dilutions in dilution fluid ISO 6887 onto standard plate count agar. Heart blood samples were taken from undamaged hearts not contaminated by shot from 515 out of a possible 625 carcasses over the period 2006 to 2009. Small buck such as impala (*Aepyceros melampus*, category C) and medium-sized buck such as kudu (*Tragelaphus strepsiceros*, category B) were selected from carcasses hunted and cropped for the local and export markets. The categories of game animals are according to the MSA, which further prescribe category A *inter alia* as including big animals such as giraffe (*Giraffa camelopardalis)* and elephant (*Loxodonta africana*). The bacterial counts, however, do not reflect those 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 Testo 205 pH and temperature meter (Unitemp, Johannesburg, South Africa). Measurements were taken and recorded directly after evisceration. The Testo 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 ($temp_1$) and pH (pH_1) at the 1st and 2nd readings ($temp_2$, pH_2).

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)[10] (1979) prescriptions, the FSIS/USDA Meat and Poultry Regulations (1996) and the Scottish Meat HACCP Regulations (Number 234 of 2002)[7,29]. 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[25]. 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 cm^2 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 cm^2) 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.

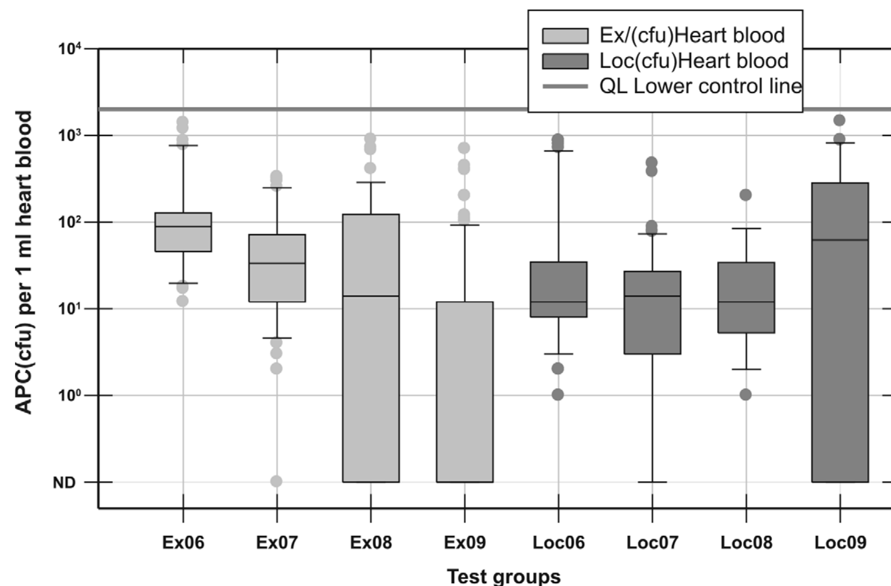

Fig.1: **Median results of APC** (CFU/mℓ) **for heart blood sampled at 'initial' time** (3 hours) ***post mortem*** **for the Ex = export and Loc = local groups for the period 2006 to 2009. The lower control line** (QL = quality line solid grey) **proposes an ideal maximum level for the amount of blood organisms** (Andrin, pers. comm, 2007)**. The T-bars indicate 5 % data outside of the normal range** (box) **and the bullets show outliers**.

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 $<1 \times 10^3$ 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 ($temp_1$ and $temp_2$) values of the local and export carcasses are illustrated in Fig. 2. Horizontal lines in this figure are quality lines and not specifica-

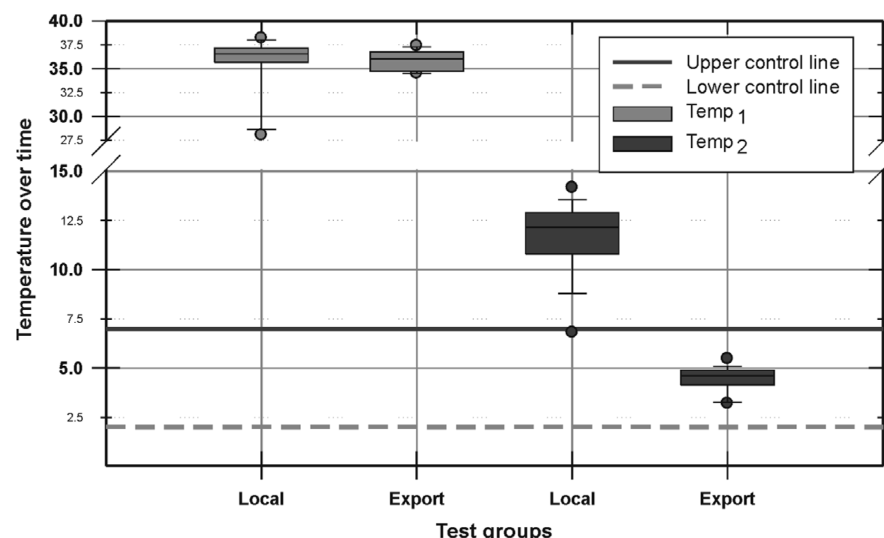

Fig. 2: **Median temperatures** ($temp_1$ and $temp_2$) **measured over time from the export and the local group from 2006 to 2009. The recommended $temp_2$ range is indicated by the dashed grey and solid dark grey lines[14]. The T-bars indicate 5 % data outside of the normal range** (box) **and the bullets show outliers.**

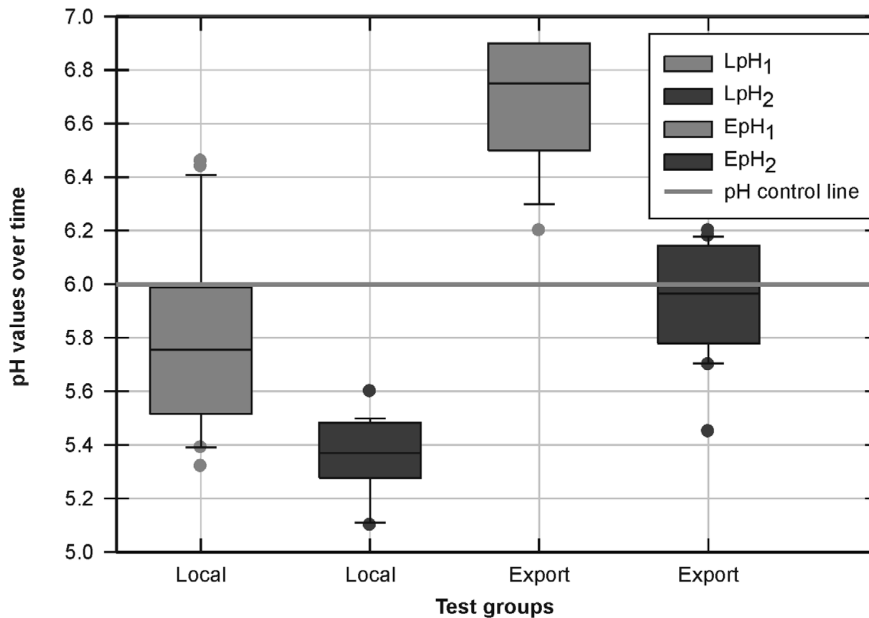

Fig. 3: **Median pH values** (pH_1 and pH_2) **measured over time from the export** (EpH) **and the local group** (LpH) **from 2006 to 2009. The solid grey line indicates the ideal pH <6.0[14]. The T-bars indicate 5 % data outside of the normal range** (box) **and the bullets show outliers.**

tion lines as they do not indicate legal standards. The recommended $temp_2$ 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)[14]. The results of the comparison between pH_1 and pH_2 values of the local and export carcasses are illustrated in Fig. 3. The solid grey line indicates the ideal pH (<6.0) that will together with the reduced temperature minimise the risk of FMD[14]. There is a downward pH curve from the time of the successful shot placement to the stabilising pH_2. Temperature readings and pH values noted for the 2 groups at $temp_1$ and pH_1 showed differences. $Temp_2$ and pH_2 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[25]. The solid light grey line indicates the maximum level for *S. aureus*. The dashed grey line indicates the maximum APC (CFU/cm^2) and the solid dark grey line the maximum *E. coli* level. The local group exceeded the specification for *S. aureus* (ND) and for APC (<10^5). No *Salmonella* were detected on any of the 625 carcasses tested.

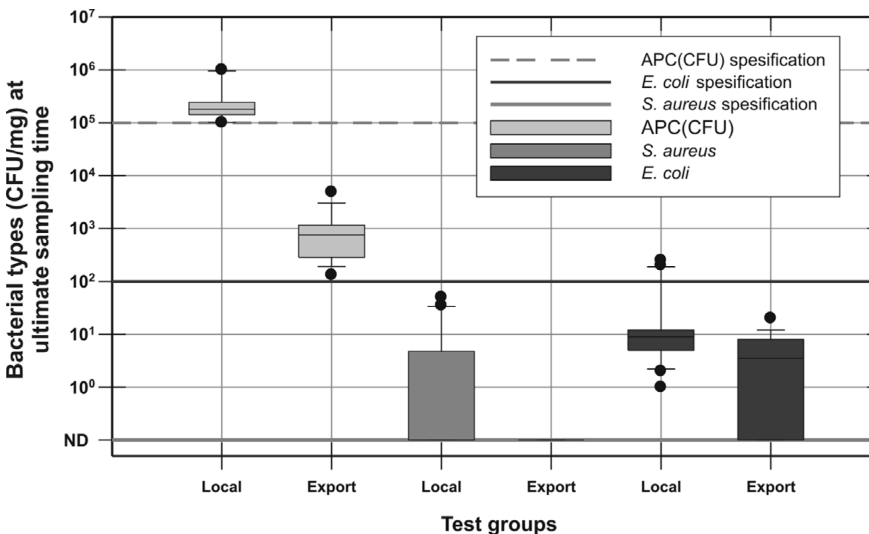

Fig. 4: **Mean results of APC** (CFU/cm^2), ***Escherichia coli*** **and** ***Staphylococcus aureus*** **at 'ultimate' time for the export** ($n = 1180$) **and the local** ($n = 1320$) **groups for the years 2006 to 2009. The grey dashed line indicates the maximum APC and the solid dark grey line the maximum** ***E. coli*** **level[25]. The local group exceeded the specification for** ***S. aureus*** (solid grey line – ND) **and for APC** (<10^5). **No** ***Salmonella*** **were detected for any of the 2 groups. A total of 2500 results from 2006 to 2009 were used to calculate the mean values in the box plot. The T-bars indicate 5 % data outside of the normal range** (box) **and the bullets show outliers.**

The overall bacterial results (CFU/cm^2) at 3 h for the local group had similar values to the results at 72 h for the export group ($P = 0.291$). However, the results at 3 h for the local group compared with 72 h for the export group showed higher levels ($P = 0.006$) of both the index and indicator bacteria tested (Fig. 5).

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[25]. According to FAO/WHO (1997) the prescribed standard for APC is ≤10^5 CFU/mℓ, but levels as high as 10^6 CFU/mℓ are acceptable in the global red meat market[6]. The legal maximum allowed for *E. coli is* 10^2 CFU/mℓ and for *S. aureus* 100 CFU/mℓ (VPN[25]). All 625 carcasses from both groups tested negative for *Salmonella* spp., which is in accordance with previous studies[2,9]. In addition it has been shown that when initial bacterial counts are sufficiently low, carcass tissues are typically sterile when tested at 'ultimate' time[11]. This phenomenon can be ascribed to the lag phase of bacterial growth[29].

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

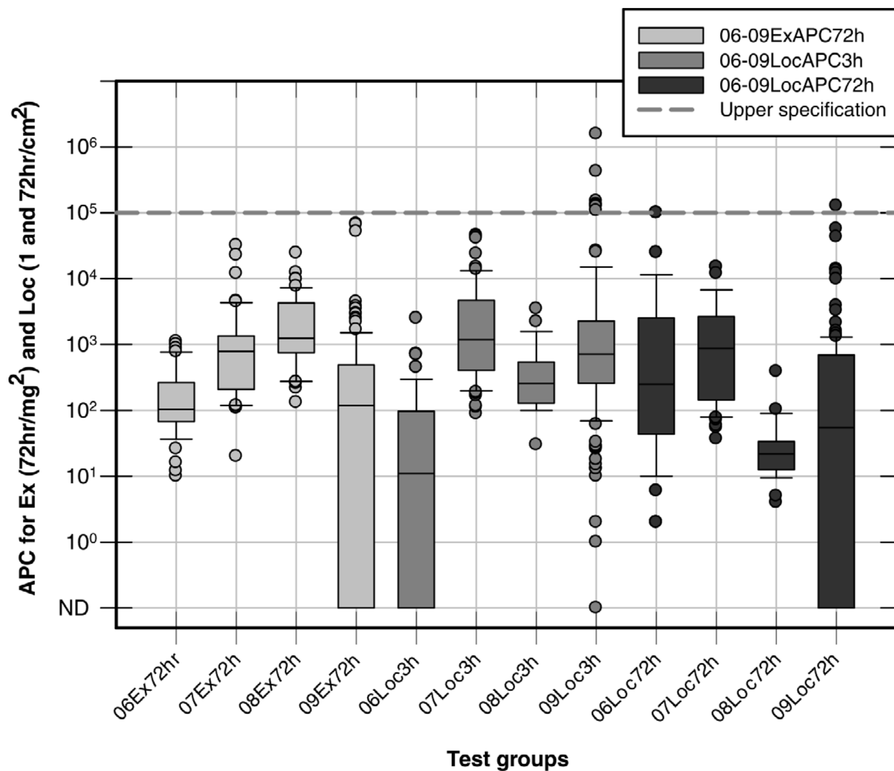

Fig. 5: **Mean results of APC** (CFU/cm²), **for the Ex = export group at ultimate time** (72 h) (*n* = 295)**, from 2006 to 2009 and the group** (Loc = local) **for both the initial** (3 h) **and ultimate time** (*n* = 660)**, from 2006 to 2009. The grey dashed line indicates the upper specification 10^5 APC** (CFU/cm²)**. A total of 955 samples were used to calculate the values in the box plot. The T-bars indicate 5% data outside of the normal range** (box) **and the bullets indicate outliers.**

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*[1]. 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 evisceration 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[11]. 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[11]. 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[28]. 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 skinning 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[6]. 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[8].

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[16]. 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 adherences to GHP will allow the production of meat that is safe for human consumption[16]. Game meat and meat products must comply with microbiological requirements similar to those for meat from domesticated animals *i.e.* cattle and sheep[6]. 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[18]. From this comparison it can be concluded that game meat is currently relatively free of microbacterial contamination. However, in farmed game animals, as in New Zealand, zoonoses (animal diseases that infect humans) and other conditions that require condemnation could be more evident[4]. 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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