The objective of the investigation was to establish the economy, efficiency, effectiveness and importance of slaughterhouses’ management by companies established through public-private partnership (PPP) process in countries that are recovering from ravages of civil war. The study focused on two slaughter houses in North Western (Somaliland) republic of Somalia. A pre-tested questionnaire was administered to the management of one privately managed and one publicly managed slaughterhouse in Somaliland. A visual and organoleptic appraisal of the two slaughterhouses was further done. To collaborate and validate the findings, 160 surface meat swab samples were collected from small ruminant carcasses slaughtered in the two slaughterhouses. The samples were analyzed at Analabs laboratories in Nairobi, Kenya for total viable counts, total coliforms count and presence of Salmonella species. Meat contamination risk factors and compliance with hygiene meat handling practices in the two slaughterhouses were identified through visual appraisal, organoleptic tests and transect walks around the slaughterhouses. The results showed that Hargeisa slaughterhouse that is managed through PPP process produced meat of high quality with low levels of contamination as opposed to Berbera slaughterhouse that was managed by the local municipality. Microbiological laboratory analysis results were in agreement with results from questionnaire administration and visual appraisal and organoleptic tests. The study concluded that in fragile states recovering from civil war, PPP is the best way out for the management of meat production facilities.
operating procedures and generic hazard analysis critical control point systems at local meat production facilities. These efforts leverage the core competencies of the meat sector stakeholders to multiply the impact of good service delivery.

Food safety is a global concern, not only because of the importance for public health, but also because of its impact on international trade. Globalization of food production and procurement makes food chains longer and more complex and increases the risk of food safety incidents. Effective and harmonized food safety systems shall manage and ensure the safety and suitability of food in each link of the supply chain [2].

To ensure food safety for consumers, high standards of management is crucial since meat is traditionally an important source of pathogenic and spoilage microorganisms. Quality meat with low levels of contamination with pathogenic and spoilage microorganisms is crucial since meat is traditionally an important source of a range of bacterial pathogens including Salmonella species, E. coli O157, Campylobacter species and Listeria which represent a significant threat to public health if not produced and processed in a hygienic manner [3,4]. To mitigate this potential public health hazards transmitted through meat, policy decisions in fragile states recovering from civil wars must consider social science factors including ideologies, economics and public opinion through establishment of public-private partnership for effective and efficient management of livestock slaughter facilities to guarantee the public of wholesome and suitable meat. Hence, the aetiology of animal health and meat safety policy is multifactorial for effective, efficient and sustainable management [5].

Applying meat food safety standards and principles to public health hazards prevention requires consideration of social issues such as attitudes toward meat producing animals and slaughter facilities, cultural and religious mores, and individuals’ willingness and capability to adopt and comply with prevention practices of good hygiene practices and strategies throughout the meat production chain [5].

It is imperative that governments, the private and public sectors, consumers and other meat sector stakeholders work in a concerted and synergic manner in this shared responsibility of assuring meat safety from farm-to-fork. Cooperation and linkages at the national, sub-regional, regional and international levels provide opportunities for synergy and maximized benefits for improved human health and economic development both at local and export levels [6]. This paper objectively appraises the economy, efficiency and effectiveness of public-private partnership in the management of local meat production facilities in Somaliland to guarantee consumers of high quality meat with low levels of contamination with pathogenic and spoilage microorganisms.

Materials and Methods

Study site

The study was carried out for a period of one year in North Western (Somaliland) state of the expansive republic of Somalia. The facilities selected for the study were Hargeisa slaughterhouse which is managed through public-private partnership and Berbera slaughterhouse that is managed by the municipality (local government) and by extension the government. The two facilities were selected based on convenience, ready accessibility and the way each is managed looking at the initial facilities and equipments that were available before Hargeisa slaughterhouse changed management from public to public-private partnership.

Data collection

This involved both qualitative and quantitative data collection methodologies.

Methodology involved reviewing of secondary data in FAO’s data base, field visits and application of semi-structured questionnaire with meat sector stakeholders in the two slaughterhouses. The survey involved key informant discussions with slaughterhouse management personnel and in-depth interviews with line ministry of livestock and municipality personnel where the selected slaughterhouses were located. This was followed by visual appraisal of livestock slaughter practices by meat producers and available livestock slaughter equipments, tools, meat transport modalities, compliance with hygiene meat handling practices during slaughter by abattoir workers and condition and state of maintenance of each slaughterhouse. Furthermore, 160 carcasses slaughtered in the two slaughterhouses were randomly selected for surface swab samples collection for microbiological analysis in Analabs laboratory in Nairobi, Kenya within 24-48 hours of sampling.

Carcass swab sampling

Eighty (80) freshly slaughtered carcasses of small ruminants (sheep and goats) were randomly selected for sampling from each of the two selected local slaughterhouses using wet non-absorbent cotton wool dipped in 0.1% peptone water diluent followed by a dry swab in the same area delineated by an aluminium template. An area of 50 cm² was delineated in the neck region of each randomly selected carcass by a sterilized aluminium template for swabbing [1,7,8]. Repeat swabbing in the same area was done using dry cotton wool. Both wet and dry cotton wool swabs were immediately placed in one sample bottle containing 5 ml of 0.1% peptone water. The bottles were immediately placed in a cool box containing dry ice and transported to Analabs laboratories in Nairobi, Kenya for analysis. A total of 160 samples were collected from the two slaughterhouses.

Laboratory analysis

All the samples were analyzed within 24-48 hours of sampling against total viable counts, total coliforms count and presence of Salmonella species.

Total viable counts (TVC)

Each of the 160 carcass swab sample was mixed thoroughly using a vortex mixer to homogenize. This was followed by serial dilutions of each sample before platting in tenfold step in 0.1% of buffered peptone water up to 10⁴ for total viable counts. One (1) ml of each dilution was transferred to a sterilized 90 mm diameter petri dish that had been earlier marked. Ten-fifteen (10-15) ml of plate count agar (PCA) tempered at 45-46°C was poured into each of the labelled 4 petri dish plates. Each plate was swirled in figure 8 to mix. The plates were incubated at 35°C for 24 hours. Plates that had 300 or less colony forming units (cfu) were selected for colony enumeration using a colony counter. The total number of colonies was determined by multiplying the enumerated colonies with the dilution factor of each plate. An average count for each dilution was determined before averaging the 2 dilution counts that were in close range to obtain total viable counts. The counts were divided by the total surface area of swabbing per carcass to give the cfu/cm² [8,9].
Total coliforms count

Total coliforms count was estimated using the Most Probable Numbers (MPN) index and 95% confidence limits for various combinations of positive results when various numbers of tubes were used. A serial 10-fold dilution of each sample homogenate was used in a 3- tube MPN series (Inocula of 0.1, 0.01, and 0.001). Serial tenfold dilution in 0.1% buffered peptone water was prepared up to 10⁻⁴ as per the anticipated coliforms density. One (1) ml aliquot of each dilution was transferred to each of the 3 tubes containing Lauryl Tryptose broth and inverted Durham tubes. The tubes were incubated at 37°C for 24 hours. Gas production which collected in Durham tubes and increased turbidity of the broth was indicative of a positive test for total coliforms. The MPN technique was used at this level to estimate the density of total coliforms in each sample. The combination acquired or generated was used to interpret the number of viable coliforms in each sample using the MPN table [8-10].

Isolation of salmonella species

Salmonella species isolation involved initial use of enrichment media of Selenite Cystine (SC) and Tetrathionate (TT) broths. One (1) ml of mixed swab sample was inoculated in 9 ml of each enrichment broths and incubated at 37°C for 24 hours. A loopful from each of the enriched overnight broth culture was streaked onto Salmonella selective media; Bismuth Sulphite (BS) agar and Xylose Lysine Desoxycholate agar (XLD) and incubated at 37°C for 24 hours. Typical salmonella species were checked for after the incubation period. Any culture that could have had colonies appearing as brown, gray, black or sometimes as metallic sheen on BS or as pink colonies with or without black centres on XLD could have been indicative of presence of Salmonella species [9].

Results

The questionnaire administration

The immediate personnel in-charge of the two identified slaughterhouses i.e. the manager of Maandeeq Company that manages Hargeisa slaughterhouse and the supervisor of Berbera local slaughterhouse were interviewed. The questions were administered in English and translated to Somali language by the local veterinarian (Dr Abdullahi Rabile Goad) since the respondents had limited knowledge of English. To maintain consistence, most of the questions were designed in a closed format. In cases where the set of expected responses was deemed not exhaustive, an option for "others: please specify" was provided [11]. Further verification of the responses was done by visitation to the slaughterhouses and carried out visual appraisal and organoleptic inspection of the slaughterhouse structures, livestock slaughter equipments, tools, availability and use of protective gear and meat transport methodologies during the wee hours of slaughter processes.

The questions were designed to identify the support derived from the government, the company established through PPP process, how funds are raised, challenges being incurred and solutions and the way forward of how to improve in the management style.

Staff establishment

Table 1 shows staff establishment for the privately and publicly managed slaughterhouses. The privately managed facility has well established organogram of duty performance by various cadres of employees right from the manager to the cleaner and watchman. It has ensured proper management of the facility to ensure efficiency and effectiveness for service delivery, promoting compliance with

| Slaughter house | Management | Staff establishment |
|-----------------|------------|---------------------|
| Hargeisa Company | 8          | 1                   | 94 (including cleaners) | 95 |
| Berbera Municipality | 0         | 1                   | 11 (including cleaners) | 12 |

Table 1: Hired staff at the 2 slaughter facilities.

| Slaughterhouse | Sheep/goats | Camels | Cattle |
|----------------|-------------|--------|--------|
| Hargeisa       | 1000-1100   | 35-40  | 55-60  |
| Berbera        | 1.12        | 7.3    | 3.9    |

| Slaughterhouse | Sheep/goats | Camels | Cattle |
|----------------|-------------|--------|--------|
| Hargeisa Daily kill | 100-130     | 2-4    | 1-2    |
| Hargeisa Slaughter/transport fee (USD) | 0.43        | 1.7    | 1.2    |

Key: Exchange rate-5800 Somaliland shillings=USD 1

Table 2: Daily kill and accompanying costs.

| Resource | Slaughterhouse | Purpose |
|----------|----------------|---------|
| Transport trucks | 10 owned, 2 rented | Transport meat, solid wastes and workers |
| Electricity generators | 4 | Adequate lights provision, pumping of water, boiling of water |
| Sewage exhausters | 1 | Emptying the 4 septic tanks |
| Boreholes | 1 | Provision of potable water |
| Water reservoir tanks | 2 overhead & 1 underground (16m² each) | 1 on ground surface level tank (10m²) |
| Water pumps | 1 | Preserving water for next day’s slaughter operations |
| Water pumps | 0 | Pumping water |

Table 3: Available resources.
hygiene meat handling practices at all levels of production chain giving confidence of value for money to clients.

Daily livestock slaughter

In Somaliland and greater Somalia, livestock species consumed include sheep, goats, camels and cattle. Table 2 details average daily livestock slaughter figures and meat transport costs from the two slaughterhouses during the survey.

Available resources

The company managed Hargeisa slaughterhouse had acquired a number of assets at the time of study as detailed in table 3 below. The slaughterhouse is managed by Maaneeq Company which was established through public-private partnership (PPP) process in May 2005 by two private investors with the support of the government and guidelines from FAO Somalia and other partnership organizations. The individuals put in an initial capital of USD 350,000. The Company started by hiring 4 meat transport trucks and the municipality contributed one water trucking tanker to supply water to the slaughterhouse. The company later placed initial public offer and 18 shareholders bought shares. It went through some teething problems until it incurred a deficit of USD 150,000 approximately. However, it currently (30th May, 2011) boasts of having a liquid cash capital of about USD 450,000 in bank besides the fixed assets.

Sources of meat contamination

Table 4 below, details various sources of meat contamination that were identified. Through the questionnaire administration, visual

| S/No | Meat contamination risk factors                  | Slaughterhouse practices | Remark                      |
|------|--------------------------------------------------|--------------------------|-----------------------------|
|      |                                                  | Hargeisa                  | Berbera                     |
| 1    | Carcass hoisting facilities                      | Yes                      | Yes                         | Full compliance |
| 2    | Demarcation between clean & dirty areas          | No                       | No                          | Both practice batch slaughter |
| 3    | Adequate light provision                         | Yes                      | No                          | Non- compliance for Berbera. Light is provided by paraffin lanterns |
| 4    | Condemnation disposal pit availability           | yes                      | No                          | Non- compliance by Berbera |
| 5    | Impervious floors & walls                        | Yes                      | Yes                         | Hargeisa has mosaic floor tiles while Berbera is smooth cement floor. |
| 6    | Are floors & walls cracked                       | No                       | Yes                         | Poor maintenance by Berbera |
| 7    | Good maintained drainage system                  | Yes                      | Poor                        | Poor compliance by Berbera |
| 8    | Stainless steel slaughter equipments             | Adequate                 | Inadequate                  | Berbera has rudimentary equipments |
| 9    | Are equipments washed immediately                | Yes                      | Yes                         | Full compliance |
| 10   | Do all personnel put on protective gear          | Yes                      | None                        | Non-compliance for Berbera |
| 11   | Is the protective gear washed immediately after use | Yes                     | N/A                         | Full compliance by Hargeisa |
| 12   | Available hand washing facilities                | Yes                      | Inadequate                  |                     |
| 13   | Is waste accumulation permitted                  | No                       | Yes                         |                     |
| 14   | Adequate cold potable water provision            | Yes                      | Yes                         | supplied by municipal tank in Berbera |
| 15   | Is there accumulated rubbish heaps in compound   | No                       | Yes                         |                     |
| 16   | Are meat loaders in protective gear              | Yes                      | No                          |                     |
| 17   | Are meat carriers washed and sanitized immediately after use | Yes                     | No                          |                     |
|      | Total                                            | Compliance-16            | Compliance-4                | Compliance-13       |

Table 4: Compliance or non-compliance with hygiene standards.

| Count | Sampling method | Acceptable (log cfu/cm²) | Marginal (log cfu/cm²) | Unacceptable (log cfu/cm²) |
|-------|-----------------|--------------------------|------------------------|----------------------------|
| TVC   | Swab            | <2.8                     | 2.8-4.30               | >4.30                      |
| Enterobacteriacea | Swab | <0.8                     | 0.8-1.8                | >1.8                       |

Table 5: EU microbiological performance criteria [8].

| Slaughter facility | No. Of samples | Acceptable (<2.8 cfu/cm²) | Marginal (2.8-4.3 cfu/cm²) | Unacceptable (>4.3 cfu/cm²) |
|--------------------|----------------|---------------------------|----------------------------|------------------------------|
| Hargeisa           | 80             | 76 (95%)                  | 4 (5%)                     | 0                            |
| Berbera            | 80             | 0                         | 27 (34%)                  | 53 (66%)                     |

Table 6: Total Viable Counts.

| Slaughter facility | No. of samples collected | Acceptable (<0.8 cfu/cm²) | Marginal (0.8-1.8 cfu/cm²) | Unacceptable (>1.8 cfu/cm²) |
|--------------------|--------------------------|---------------------------|----------------------------|------------------------------|
| Hargeisa           | 80                       | 80 (100%)                 | 0                          | 0                            |
| Berbera            | 80                       | 29 (36%)                  | 31 (39%)                  | 20 (25%)                     |

Table 7: Total coliform counts.
appraisal and organoleptic inspection during meat swab samples taking, the investigator established whether the slaughterhouse slaughter operations were compliant with hygiene meat handling standards or not. Out of the 17 meat contamination risk factors sought after, Hargeisa slaughterhouse that is managed through public private partnership observed a compliance rate of 94% and non-compliance rate of only 6%. On the other hand, Berbera slaughter facility managed by the municipality had a non-compliance rate of 76.5% and a compliance rate of 23.5%.

Microbiological laboratory results

Eighty (80) surface meat swab samples were collected from randomly selected small ruminant carcasses slaughtered from each of the two slaughterhouses. A total of 160 surface meat swab samples were collected and analyzed at Analabs laboratories in Nairobi, Kenya for total viable counts (TVC), total coliforms count and Salmonella species.

Data analysis

Total viable counts (TVC) and total coliforms count (TCC) were converted to log10 colony forming unit/cm2 (cfu/cm2) to enable grading of bacterial meat contamination levels according to EU Microbiological performance criteria [8] table 5.

Total viable counts (TVC)

From the laboratory analysis, out of 80 surface meat swab samples collected and analyzed from each slaughterhouse, 76 (95%) and 4 (5%) samples were of acceptable and marginal grades respectively from Hargeisa slaughterhouse. No sample was of unacceptable grade. On the other hand, no sample from Berbera facility was of acceptable grade. Twenty seven (34%) and 53 (66%) samples were of marginal and unacceptable grades respectively as shown in table 6.

Total coliform counts (TCC)

All 80 (100%) samples collected and analyzed from Hargeisa slaughterhouse were of acceptable grade. However, those collected from Berbera - 29 (36%), 31 (39%) and 20 (25%) samples were of acceptable, marginal and unacceptable grades respectively as indicated in table 7.

Conclusion

From the one year investigation and microbiological analysis of surface meat swab samples collected from the two slaughterhouses, it was clear that Hargeisa slaughterhouse managed by a company established through PPP process offered a service to meat consumers that was commensurate of value for their money. The meat produced in Hargeisa slaughterhouse had low levels of bacterial contamination as opposed to the publicly managed Berbera slaughterhouse. Users of Hargeisa slaughterhouse pay higher fee per animal slaughtered as compared to those using Berbera slaughterhouse but the service rendered in the former is worth the cost. The company has endeavored to control over 90% of common sources of meat contamination. They even sponsored a training workshop for 20 of their staff in addition to 20 others from the Ministry of Livestock in 2010.

The study concluded that establishment of slaughterhouse management companies through public-private partnership is a good way forward for the effective, efficient and sustainable way of managing meat production facilities in countries recovering from civil conflict though this needs further investigation in other regions.

Acknowledgements

Disclaim

The opinions expressed in this document do not represent in any way the position of FAO.

Researchers first and foremost express heartfelt appreciation to FAO Somalia Nairobo offices for availing facilities and resources to carry out the research work. We are indeed indebted to Luca Alinovi, FAO Somalia officer in charge, George Malete, the project manager of OSRO/SOM/608/EC project and Munyaa Soloman, the project manager of OSRO/SOM/007/UK programme funded by UKaid for providing all required resource material. Further acknowledged are the Minister of Livestock, Somaliland, the officer in-charge of FAO Somalia, Hargeisa office, Mohamed Jama and Dr Abdulahi Rabbile Goad who acted as the interpreter during administration of the questionnaire.

Many actors including management teams of the two slaughterhouses enabled the completion of this work are hereby acknowledged. Moreover, we acknowledge the tireless effort put in by Analabs laboratories technicians especially Mr. Duncan Ndewga and his team for faithfully carrying out the analysis work mostly at their inconvenience.

References

1. Wamalwa K, Massimo C, Onbui JN, Gathuma J (2011) Capacity Building: Benchmark for Production of Meat with Low Levels of Bacterial Contamination in Local Slaughterhouses in Somaliland. Trop Anim Health Prod [Epub ahead of print]
2. Foundation for food safety certification (2010) Food Safety System Certification 22000. Certification scheme for food safety systems in compliance with ISO 22000: 2005 and BS-PAS 220: 2008, Gorinchem, the Netherlands.
3. Declan J B, Brian B, James L (2007) The Development and or Validation of Novel Intervention Technologies to Assure Meat Food Safety, Ashtown Food Research Centre, Ashstown, Dublin 15, Ireland.
4. VerónicaS F, Kathelin MSL, Gabriela AS, Chiariini EB, Mariza L, et al. (2009) Prevalence and virulence determinants of verocytotoxigenic Escherichia coli in Brazilian bovine hides and carcasses. Advacing beef safety through research and innovation. An international conference organized by ProSafeBeef.
5. Hueston WD (2003) Science, politics and animal health policy: epidemiology in action. Prev Vet Med 60: 3-12.
6. FAO/WHO (2005) Assuring Food Safety and Quality in Small and Medium Size Food Enterprises. FAO/WHO Regional Conference on Food Safety for Africa, Harare, Zimbabwe.
7. Kang’ethe EK (1993) Hygienic Status of Bovine Carcasses from three Slaughterhouses in Nairobi Kenya. Kenya veterinarian J 17: 9-12.
8. McEvoy JM, Sheridan JJ, Blair IS, McDowell DA (2004) Microbial Contamination on Beef in relation to Hygiene Assessment based on criteria used in EU Decision 2001/471/EC. Int J Food Microbiol 92: 217-225.
9. Andrews W (1992) Manuals of Food Quantity Control, 4 Microbiological Analyses. FAO Food Nutr Pap 14: 338.
10. Siham N, Taha Mrf (2009) Superficial Bacterial Contamination of Oxine and Bovine Carcasses at El-Harrach Slaughterhouse (Algeria). European J Sci Res 38: 474-485.
11. Wesonga FD, Kitala PM, Gathuma JM, Njenga MJ, Ngumi PN (2010) An assessment of tick-borne diseases constraints to livestock production in a smallholder livestock production system in Machakos District Kenya. Livestock Research for Rural Development 22:

Submit your next manuscript and get advantages of OMICS Group submissions

Unique features:
User friendly/feasible website-translation of your paper to 50 world’s leading languages
Audio Version of published paper
Digital articles to share and explore

Special features:
200 Open Access Journals
1,500 editorial team
21 days rapid review process
Quality and quick editorial, review and publication processing
Indexing at PubMed (portal), Scopus, DOAJ, Elsevier, Index Copernicus and Google Scholar etc
Sharing Option: Social Networking Enabled
Authors, Reviewers and Editors rewarded with online Scientific Credits
Better discount for your subsequent articles
Submit your manuscript at: http://www.OMICSonline.org/submission