THE VIABILITY OF SALMONELLAE AND BOVINE CYSTICERCI IN BILTONG

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Informed trade sources estimate that 1·5 million lb. of biltong, representing 4·3 million lb. of fresh meat or about 10,000 beef carcases, are consumed annually in South Africa. Biltong, as a traditional delicacy, cannot be considered to fall under reasonably adequate public health control for a variety of reasons which are beyond the scope of this paper. Meat supplies for biltong, methods of production, processing, handling, distribution and display for sale all contribute to certain public-health hazards which lead to uncertainty regarding its safety as an article of food —which is consumed without cooking or further preparation.

These hazards may be of a chemical nature, e.g. excess nitrites, insecticides, unauthorized preservatives, or fraudulent substitution of animal species may occur. Parasitological and microbiological infections are probably the greatest general cause for concern. This paper will deal with cysticerci and salmonellae.

The nature of biltong, as processed and sold, varies considerably, as do the growth or survival of organisms in biltong, or in various parts of the same 'stick' of biltong. In order to obtain some degree of uniformity, fresh meat was processed into biltong in a standard manner, using a curing mixture of known composition. Fig. 1 indicates graphically the results of salt and moisture determinations at various stages of the process.

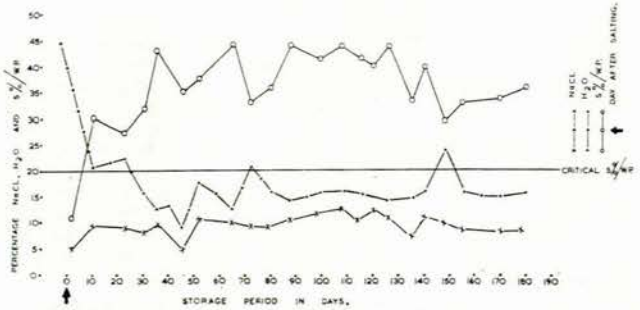

Fig. 1. Graph showing salt content, moisture content and 5%/W.P. of biltong during processing and storage (W.P.= water phase).

The same procedure was adopted for converting experimental meat into biltong, and this is referred to in this article as the 'standard manner'.

Cysticercosis

The incidence of *Cysticercus bovis* reported from various slaughter houses in South Africa varies from 0% to 19%,[1] and in the 5 larger abattoirs the average incidence is 3·9%[2] of cattle slaughtered. Antelope may be infested with various cysticerci,[3] but *C. bovis* has not been recorded and the antelope cysticerci are not known to cause taeniasis in man.

Biltong produced in the standard manner from meat heavily infested with *C. bovis* was examined. Cysticerci removed from portions after various periods following curing and drying, were subjected to an *in vitro* test for viability, based upon excystation and scolex movements after incubation in a solution of digestive enzymes and bile salts, as suggested by Anna Verster.[4] In the fresh meat and up to 15 hours after curing, all remained viable. After 40 hours only half the cysticerci examined were viable. After 136 hours, no viable cysts were found, and at this stage the biltong portion contained 27% moisture and 7·7% NaCl by weight, or 22·2% salt in the water phase.

Conclusion. Whereas consumption of infested 'greener' biltong may result in taeniasis, *C. bovis* is no longer viable in biltong 6 days after curing and containing at least 22% NaCl in the aqueous phase.

Salmonellosis

Neser *et al.*[5] reported a serious outbreak of salmonellosis in children, with one fatality, caused by consumption of biltong probably infected *in vivo* with *S. newport*. The biltong remained infected for at least 2 years. Jansen[6] isolated *S. lomita* from game biltong which had caused gastroenteritis in consumers. Bokkenheuser[7] found one out of 121 commercial samples of biltong examined to be infected with *S. poona*. He considered that the meat had been infected *in vivo*. He also found 34 samples to be contaminated with *E. coli*, indicating poor hygiene of production and possibly direct or indirect faecal contamination.

Cameron *et al.*[8] isolated *S. typhi-murium* from wildebeest calves, indicating the presence of salmonellae in game animals. Apart from the occurrence of acute salmonellosis in slaughter animals, there is the known existence of a small percentage of 'carriers' of salmonella infection which is often greatly increased by the concentration of animals at the abattoir under 'stress' conditions, e.g. in dairy cattle from 1·7 to 12%.[9] Meat may thus be infected during the life of the animal or by contamination after slaughter.

METHODS AND MATERIALS FOR EXPERIMENTAL WORK

Meat obtained from a young bovine animal that had died of experimental *S. dublin* infection was processed into standard biltong. At various intervals samples were taken, enriched in Selenite F broth and then streaked out onto MacConkey's agar. Non-lactose fermenting colonies were picked off into triple sugar iron-agar tubes and finally identified with specific antisera. *S. dublin* could readily be isolated from the biltong for 6 months, after which the supply of material was exhausted. Control strips of biltong immersed in vinegar before drying gave the same results.

In order to assess the significance of generalized and localized contamination of meat, 'green' and processed biltong with salmonellae in suspension, the material was either immersed in various suspensions of 18-hour-old cultures of common salmonellae, or otherwise locally contaminated by applying paper discs, 6 mm. in size, saturated with these suspensions, to the surface for 5 minutes. Localized contamination was also effected by placing 0·01 ml. drops of suspension on the biltong surface and allowing them to dry there. Some of the meat or biltong strips were immersed into solutions of acetic acid and vinegar to ascertain the effect of acetylation and pH reduction on the organisms. Isolation of the organisms was attempted at various stages according to the methods previously described. The results may be summarized as follows:

1. *Pre-salting Contamination*

(*a*) Where less than 2,000 *S. typhi-murium* per ml. of suspension were used, total immersion of beef strips (pH 5·8) did not lead to contamination which could be detected 3 days after curing.

(*b*) Total exposure to heavier concentrations of *S. dublin* (3 hours before curing) led to isolation of the organism up to 45 days after curing. After 59 and 65 days isolation attempts were unsuccessful. Where strips had been immersed in 7·0% and 3·5% solutions of acetic acid before drying, the surface pH had been lowered to 5·1 and 5·3, and *S. dublin* could be isolated only up to the 10th and 28th day respectively.

(*c*) Total exposure of beef strips (pH 5·7) to 20,000 *S. typhi-murium*/ml. 4 hours before salting, resulted in contamination which persisted for 12 days. By dipping the salted meat strips into full and half-strength commercial blended vinegar* before hanging to dry, the persistence of infection was reduced to 8 days, and the pH of the surface to 5·0 and 5·3 respectively.

(*d*) Meat exposed to similar contamination and kept at room temperature for 8 hours before curing resulted in biltong from which isolations of the organism were positive at 12 days but negative at 22 days later. Vinegar immersion did not affect these results in any way.

2. *Contamination of Processed Biltong*

0·01 ml. droplets of a suspension consisting of 2,000 *S. typhi-murium*/ml. on the surface of biltong 2, 38 and 41 days old resulted in contamination which persisted for 8, 8 and 1 days respectively. Immersion into vinegar before hanging to dry did not significantly influence such contaminations. (No distinction in taste or appearance of biltong which had been dipped into vinegar or water before hanging, could be ascertained.)

DISCUSSION

Levine and Fellers[10] found that acetic acid had a toxic effect on micro-organisms apart from rendering the pH of the substrate unsuitable for bacterial growth. Nunheimer and Fabian[11] found acetic acid to be bacteriostatic and bacteriocidal at pH 4·59 and 4·37 respectively when dealing with food-poisoning staphylococci. Grete Elleman[12] could render salmonellae-infected mayonnaise safe by reducing the pH thereof to 4·5 for 4 days at room temperature. Other weak organic acids did not have a similar effect.

Generally, micro-organisms require at least 18% of moisture to grow. The moisture of biltong surface probably falls below this level quite soon, but deep portions may remain moist for longer. Reference to Fig. 1 indicates that moisture content of cross-sections of biltong fails below 18% after 25 days.

Jepsen's classification[13] of salt-preserved foods accentuates the significance of the percentage of salt in the water phase of the food, and indicates that where this is more than 20%, the probability of bacterial growth and enzyme activity is slight, while the number of viable organisms will decrease on storage. At percentages varying from 10 to 20, only halophiles can develop.

In pickle containing 10 - 13% NaCl, salmonellae survive for 80 days. Jirkowsky[14] showed *S. choleraesuis, S. enteritidis* and *S. typhi-murium* to be salt tolerant to the extent of being able to grow in broth containing 14, 15 and 24% NaCl respectively, while all 3 serotypes grew on 8% salt agar.

The influence of temperature on *S. enteritidis* was recorded by Jepsen[13] as follows: at 37°, 20° and 5°C the survival times were 20 hours, 4 - 7 days and 8 - 10 weeks respectively in 25% NaCl broth of pH 6·5.

Salmonellae grow at temperatures varying from 10° to 42°C, and so may multiply in meat held at room temperature.

The pH of normal fresh beef is about 5·8 and rarely below 5·4 or over 6·0. In animals diseased or exhausted at slaughter the meat may have a pH of 6·2 - 6·8, a range favourable for bacterial growth and survival. Biltong made from fresh meat retains its pH of about 5·7.

CONCLUSIONS

1. Use of meat infected with salmonellae *in vivo* leads to biltong which remains infected for many months or even longer.

2. Meat contaminated with salmonellae several hours before salting and drying results in biltong in which the organism remains viable for at least 12 days.

3. Even local contamination of a high order does not lead to permanent establishment of salmonella on processed biltong for more than 8 days.

4. Acidification and acetylation, which does not materially affect its flavour, reduces the pH of the biltong surface to some extent and also the survival time of salmonellae contamination shortly before salting. It did not, however, reduce survival times of organisms contaminating meat several hours before salting, or after drying, or resulting from *in vivo* infection of meat.

5. The use of meat of *healthy animals* held at *low temperatures* is essential in biltong production, and care in slaughter and pre-salting procedures is necessary to avoid salmonella contaminations. Immersion of biltong strips in half or full-strength vinegar will assist in controlling low-grade localized salmonella contamination.

*Containing 4% acetic acid.

SUMMARY

In view of the volume of biltong consumed annually, the inadequate public-health control of this national delicacy may present certain hazards. Two of these are discussed and the results of a series of experimental procedures concerning cysticercosis and salmonellae-infections of meat and processed biltong are detailed. Reference is made to the beneficial effect of vinegar in the processing of biltong, and a graph is provided indicating the salt and moisture content of biltong at various stages of laboratory preparation.

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