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Physicochemical and microbiological characteristics of biltong, a traditional salted dried meat of South Africa

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ABSTRACT

The microbiological and physicochemical characteristics of several commercial beef, kudu and springbok biltong samples from South Africa were assessed in this study. Analysis of samples allowed their differentiation into 'dry' and 'moist' samples. Dry biltong showed low moisture content (21.5–25.3 g/100 g), a low water activity (0.65–0.68) and a high salt content (5.5–7.9 g/100 g), while moist biltong showed a higher moisture content (35.1–42.8 g/100 g), a higher water activity (0.85 to 0.89) and a lower salt content (3.8–5.6 g/100 g). The pH value did not vary significantly between both groups (5.00–6.26). The results showed that dry biltong presented a low total plate count (TPC) content, a high level of lactic acid bacteria (LAB) and a high level of D-lactic acid as compared to moist biltong. These results suggest that dry biltong complies with the standard hygienic quality (TPC < 7 log cfu/g in agreement with the Food Standards Agency), while moist biltong samples generally showed a low content of D-lactic acid and a low ratio LAB/TPC.

1. Introduction

Biltong is commonly known as a South African salted dried ready-to-eat meat product made from raw meat by salting, curing and drying (Lewis, Masterton, & Ward, 1957). The origin of the word is thought to derive from Dutch, *bil* referring to the posterior thigh of an animal, and *tong* to tongue-shaped fillet. Dry-curing has been the oldest method employed for the traditional preservation of meat products, against the growth of spoilage and pathogenic organisms (Burnham, Hanson, Koshick, & Ingham, 2008; Collignan, Santchurn, & Zakhia-Rosis, 2007; Naidoo, 2010; Naidoo & Lindsay, 2010). Preservation through the drying process is achieved by the extraction or binding of moisture resulting in the reduction of water activity (a_w) within the commodity (Dzimba, Faria, & Walter, 2007; Rahman et al., 2005). Currently, similar to *biltong* in South Africa, several dry-cured meat products are produced and consumed in other countries, e.g. *jerky* in North America (United States), *pemmican* in North American Artic, *charque* and *carne-de-sol* in Brazil. *Biltong* like *jerky* may be eaten raw without prior rehydration and/or cooking. The efficacy of drying as a means of preservation varies greatly due to the rate of air movement, temperature and relative humidity during the process (Burnham et al., 2008).

Over the years, biltong has become a regular commodity in the South African diet. In 2003, the annual biltong market value was estimated at between 40 and 70 million Euros (Attwell, 2003). More recently, large-scale production of beef biltong has emerged. It is readily available in South African supermarkets or in speciality shops. The product is marketed intact in 'tongues' or 'sticks' or in a comminuted form namely slices, cubes, and ground or pulverized. A number of long pieces of meat, varying from 30 to 60 cm in length, are obtained and then sliced into strips about 20–30 × 4–5 × 2.5 cm (Van der Riet, 1982).

Biltong is traditionally wind-dried in the shade during winter, or produced in a drying box with a fan at an ambient temperature not exceeding 22 °C (Burnham et al., 2008; Naidoo, 2010; Naidoo & Lindsay, 2010; Nortjé, Buys, & Minnar, 2005; Nortjé, Buys, & Minnar, 2006), even if many different methods and recipes for preparing ready-to-eat biltong exist, e.g. traditional and modern methods (Meat Board of South Africa, 1992). Traditional biltong is generally considered microbially stable due to the presence of curing salts, pH values ranging from 4.8 to 5.8 and low a_w (Attwell, 2003; Dzimba et al., 2007; Nortjé et al., 2005; Van den Heever, 1970; Van der Riet, 1982). In some cases, vinegar or nitrites are used as preservatives but the end product would not then be called traditional biltong. Wide variations in the

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end product stability and sensory quality of ready-to-eat biltong exist probably due to differences in the type of meat used, the spice mix composition, the extent of salting and drying and the use of preservatives.

However, whether microorganisms would participate in the final quality of the product has not been fully investigated. Prior (1984) intended to assess this problem using a mixture of antibiotics, which were added during the drying process of the meat. In this experience, the total bacterial count in samples incubated with the antibiotics was found to be significantly lower as compared to the control biltong. Additionally the amino acid and fatty acid composition as well as the taste of the resulting biltong were not modified by this treatment. The author concluded that microorganisms did not participate in the production process of biltong. More recently, Todorov et al. (2007) presented biltong as a meat product unfermented and prepared exclusively by salt-drying. However, none of these authors has given evidence that fermentation was not involved in the transformation process. There is limited data in the literature describing the presence and the role of lactic acid bacteria (LAB) in biltong products which might indicate that LAB are involved in the transformation and the quality of the final product (Battcock & Azam-Ali, 1998).

This study was undertaken in an attempt to characterize several commercial beef, kudu and springbok biltong samples from South Africa according to their physicochemical and microbiological characteristics.

2. Materials and methods

2.1. Origin of commercial biltong samples

Eleven different biltong products were purchased randomly from different South African supermarkets (in sealed plastic bags) and small-scale biltong makers (cling-wrapped) located in the vicinity of Pretoria and Johannesburg, South Africa. For each product, three individual sealed packets were purchased from the same shop. The name of the products used in the study was given according to the commercial labelling. Samples Beef 1 and Beef 2, as well as Kudu 1 and Kudu 2 were both from two different manufacturers. The 33 samples were delivered to the laboratory and stored at 4 °C until analysed.

2.2. Physicochemical assays

Samples were homogenised using an Ultra Turax (T25 basic IKA-WERKE, Germany) at 9500 t/min. The moisture content (MC) of the samples was determined by drying at 103 °C ± 1 °C during 24 h. The moisture content was used to classify the groups of biltong into wet and dry. The water activity (a_w) was measured using an a_w meter (FA-st1, GBX France Scientific Instrument, France) at 24 °C ± 1 °C. The sodium chloride content was determined using a Corning 926 chloride analyser (Ciba-Corning Ltd., England) after extraction in 0.3 N nitric acid according to the method developed by Collignan and Raoult Wack (1994). For pH measurements, 5 g of samples were homogenised with 45 mL distilled water in a blender for 1 min and left to stand for 30 min before measurement with a pH meter (pH 213, Hanna Instruments, USA). L- and D-lactic acid contents were determined enzymatically using Enzytec D-lactic acid and Enzytec L-lactic acid kits (SCIL, Diagnostics GmbH, Germany), which involved D- or L-lactate dehydrogenase as the discriminating enzyme (from chicken heart, Sigma). Determination was done after clarification and deproteinisation with Carrez reagents I and II (Sigma-Aldrich, France) and quantified spectrophotometrically at 340 nm (Gawehn, 1984).

2.3. Microbiological assays and strain identification

All the selective media for the microbiological assays were purchased from AES Chemunex (Bruz, France). The total plate count (TPC), lactic acid bacteria (LAB) and yeast and mould counts were determined on fresh samples. Under aseptic conditions, each biltong sample (5 g) was suspended and blended for 10 min into sterile 45 mL buffered peptone water. The suspension was serially diluted in sterile physiological saline (NaCl, 9 g/L) and plated onto selective media. For TPC, cells were plated onto plate count agar media (PCA) and incubated for 72 h at 30 °C. Man–Rogosa–Sharpe (MRS) agar was used for the enumeration of lactic acid bacteria. MRS plates were incubated at 37 °C for 48 h. Yeasts and moulds were enumerated on Sabouraud plus Chloramphenicol (SAB) and Malt agar after incubation at 37 °C for 72 h. The distinction between yeast and mould colonies is made by macroscopic examination (Barnett, Payne, & Yarrow, 2000). On SAB, yeasts develop matt colonies and a regular outline with a more or less convex surface. On malt agar, moulds develop flat or fluffy spreading colonies often with coloured fruiting or sporing structures. All analysis and identification were done in triplicate.

2.4. Statistical analysis

The mean value and standard deviation were calculated from the data obtained from three individual packets of the same product. One way ANOVA was used to test the significance of the differences between means at $p < 0.05$ of two subgroups, namely "dry biltong" (samples 1 to 4) and "moist biltong" (samples 6 to 11). All statistics were performed using Analysis ToolPak of Excel™.

3. Results and discussion

3.1. Physicochemical characteristics of commercial biltong

The mean moisture content, water activity, salt content and acidity of the different commercially available samples of biltong are presented in Fig. 1. Based on moisture content (percent water content) and a_w values, two main categories of biltong products could be distinguished. The first category (four out of eleven samples tested, i.e. numbers n°1 to 4) called 'dry biltongs', was characterized by a low moisture content varying between 21.5 and 25.3 g/100 g and a low a_w ranging from 0.65 to 0.68. These values are close to those reported by Van den Heever (1970) namely an average moisture content of 25.2 g/100 g and an average a_w value of 0.74 for the commercial biltong surveyed. Similarly, the critical a_w value reported by Van der Riet (1976) in which beef biltong is microbiologically stable is below 0.68.

The second category, called 'moist biltong' (five out of eleven samples tested, i.e. numbers n°6 to 11) had a higher moisture content, 35.1–42.8 g/100 g, and a corresponding higher water activity, ranging from 0.85 to 0.89 (i.e. higher of the critical a_w value of 0.68 in which beef biltong is microbiologically stable). These values are in accordance with those observed by Osterhoff and Leistner (1984) for such 'moist' biltong: a_w was fairly high ranging between 0.85 and 0.93, which favours growth of microorganisms including pathogens such as *Listeria monocytogenes*, *Staphylococcus aureus* and *Staphylococcus pasteuri* (Naidoo, 2010; Naidoo & Lindsay, 2010). Although these 'moist' biltong products represent a potential health risk in view of their ease of contamination by pathogens, they would satisfy today's consumers' preference for more tender, less dehydrated biltong with a relatively high (>40%) moisture content (Nortjé et al., 2005). The water contents as well as a_w values of both groups (dry and moist biltong; see Fig. 2) differed (analysis of variance $F = 344.93$ and $p < 0.001$ for water contents and $F = 81.50$ and $p < 0.001$ for a_w values). The salt content of the commercially available biltong samples showed wide variations with values ranging from 1.9 to 7.9 g/100 g. The average values for 'dry' and 'moist' biltong were 6.8 and 4.8 respectively ($F = 13.66$; $p < 0.01$). The pH of the biltong samples varied from 5.00 to 6.26 with the average values for the dry and moist groups (5.35 and 5.58, respectively) not differing. These data are in accordance with published data where pH was found to range between 4.81 and 5.83 for some biltong samples (Attwell, 2003; Dzimba et al., 2007; Nortjé et al., 2005;