EFFECTS OF THE ADDITION OF VINEGAR AND DEGREE OF DRYING ON THE PHYSICOCHEMICAL PROPERTIES OF TRADITIONAL SOUTH AFRICAN BILTONG

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The objective was to investigate the effect of the addition of vinegar and the degree of drying on the physicochemical properties of biltong and subsequently the potential influence on shelf-life stability. Their effect on salt content, water activity and pH was studied.

An approximate 50% and 65% final weight loss produced biltong with a water content of 50% and 30% and water activity above 0.81 and below 0.78 respectively. The salt content of biltong differed ($p = 0.042$) between treatment combinations showing a decrease in salt content when adding vinegar. The addition of vinegar decreased ($p < 0.0001$) the pH of the biltong.

Key Words – meat, biltong, salt content, water activity, pH

I. INTRODUCTION

Biltong is a traditional salted/dried meat product in South Africa. Biltong (whole meat pieces) is produced whereby the meat is spiced using either a salt/spice dry rub (black pepper, coriander) or a mixture of salt/spice and vinegar (Worcestershire sauce is also sometimes added) before being dried. It is made at the house hold, butcher and industry level following the same procedure although vacuum tumbling and drying in temperature controlled units are common practices for large scale manufacturing [1]. There are many products that fall under the "biltong" category other than the traditional biltong such as snack sticks, biltong crisps and biltong wheels/patties. The drying process usually takes up to 96 hours. The biltong process can result in unevenly dried products with high microbial counts, especially at a commercial level [2]. Moreover, the shelf-life of biltong is somewhat debateable as it is assumed to have a shelf-life between 3 to 6 months. There have been no scientific studies to confirm this. The shelf-life depends on various factors such as the spices used/salt amount, whether an acid is used, the degree of drying and type of packaging used, to mention a few.

Salt is essential when making biltong and is used as the "curing" agent which preserves the meat. Salting is an integral part in biltong production and influences the effectiveness of the drying period. The salt causes changes in the muscle proteins, and changes in texture, weight and water holding capacity [3] and can decrease the water activity to minimise microbial growth [4]. Vinegar is also sometimes added with its main function being to inhibit microbial growth and its secondary function being for flavour. It is well-known that the use of salt and/or an organic acid can impact the potential exclusion of pathogens and the inhibition of microbial growth in dried meat products [2, 5]. The degree of dryness (final moisture content) is also an important factor. In the industry, biltong is most commonly dried to a 50% weight loss and to accommodate for other consumer preference can be dried up to a weight loss ≤ 70%. But drying procedures vary as reflected by the wide range of moisture content and water activity in the literature.

Research has suggested the water content of biltong can range between 16.4% and 47.6% [6–8] and water activity (a_w) ranges between 0.66 and 0.97 [6–9] but it is not evident as to its related classification of biltong in terms of "moist" or "dry" biltong. Petit and others [8] have classified biltong with a a_w between 0.65 – 0.68 "dry" whilst biltong with a $a_w > 0.80$ to be "moist". Microbial growth is inhibited by a low water activity. A low water activity can be achieved by drying (removal of water) and/or the addition of salt/sugar. The salt/sugar compounds form chemical bonds with the available water and prevent it from being used by the microorganisms [10]. It has been suggested by Leistner [11] that to avoid microbial spoilage, in particularly moulds, the water activity of a product should be ≤ 0.77. Other biltong products (previously mentioned) are characteristically very dry and therefore this low water activity would be achievable and expected from such products.

The aim of this study was to investigate the moisture and salt content, water activity and pH of biltong produced using varying factors. The use of vinegar and no vinegar in the spice formulation and two levels of drying were considered.

II. MATERIALS AND METHODS

Biltong production

Frozen beef topside (*semimembranosus*) was supplied by a local supplier (Beefcor Meat Suppliers, Okahandja, Namibia). The meat was thawed at 4°C for 48 hours before use. Per replicate, the meat is cut parallel to the fibres into 192 pieces with 20 mm x 20 mm x 260 mm dimensions. Each piece weighed approximately 93 g (± 0.92) before drying. The meat pieces were mixed in a formulation of 2% (356 g) fine salt (Country Spice, Windhoek), 0.2% (35 g) course black pepper (Freddy Hirsch, Cape Town) and if vinegar was to be added, 10% (890 mL) brown spirit vinegar, 10% acidity (Freddy Hirsch, Cape Town). Four separate batches (± 4.5 kg) were made. Two batches were made with vinegar, one of which would be monitored for a targeted 50% final weight loss, the other for a targeted 65% final weight loss. Two batches were made without vinegar, one of which would be monitored for a 50% final weight loss, the other for a 65% final weight loss so as to represent the typical final moisture contents of commercial biltong. After the meat was mixed with the spices, it was tumbled in a vacuum-tumbler (Freddy Hirsch Vacuum Tumbler) for 20 min at 15 rpm. Each piece was weighed (95 g ± 1.04) and hung in a controlled drying chamber (Closwa Biltong, Okahandja, Namibia). The drying chamber parameters were kept at 25 ± 2°C, a relative humidity 30 ± 5% and an air velocity 1 ± 0.2 m/s. The samples with a final weight loss 50% (± 1.25) was removed from the dryer after ± 66 hours and the samples with a final weight loss of 65% (± 1.92) was removed from the dryer after ± 96 hours. Biltong pieces were stored per treatment under vacuum for one week at ambient temperatures (25°C) before analyses. Three replicates were conducted.

Sample preparation for analyses

Biltong pieces were sliced and homogenised in a Knifetec™ 1095 Mill (FOSS, Höganäs, Sweden) for 60 sec to ensure a representative homogenous sample was analysed.

Analytical methods

Moisture content was determined according to the AOAC [12], Method 934.01.

Salt content was determined using a Model 926 chloride analyser (Sherwood Scientific, Cambridge, UK) after a 2 h cold extraction in 0.3N nitric acid.

Water activity was measured at 25°C using an Aqualab Pa$_w$kit water activity measurement system (Decagon Devices Inc., Washington, USA).

The pH measurement was taken using a calibrated portable Crison PH25 pH meter with a glass electrode (with an automatic paired temperature reading) after homogenisation of 3 g of sample in 27 ml distilled water.

Measurements were taken after sample preparation in duplicate.

Data analyses

To test the effects of treatment combination (vinegar or no vinegar, and degree of drying) on the various measurements, one-way ANOVA were used. Fisher LSD post hoc test was used to analyse significant differences ($p \leq 0.05$) between effects and to establish similarity. Statistical analyses were done using the VEPAC module of *Statistica 7.0*. A 5% significance level was used as guideline for determining significant differences.

III. RESULTS AND DISCUSSION

The salt content of biltong, expressed on a wet basis, is expected to vary amongst the different degree of drying; when there is less moisture present, the more concentrated the salt in the biltong. The addition of vinegar is expected to alter the pH of the meat as during tumbling the surface of the meat pieces become denatured by the acid. This could also possibly influence salt penetration, as vinegar penetrates the meat faster than salt [13] thereby possibly decreasing the final salt content. The averaged physiochemical properties of biltong after drying for each treatment is given in Table 1.

Table 1 Means (±SD) of the final moisture content (MC), salt content (SC), water activity (a_w) and pH of each treatment of the biltong samples

	MC_{wb} (g/100g)	SC_{db} (g/100 g)	SC_{wb} (g/100 g)	a_w	pH
65%, No Vinegar	$32.5^c \pm 1.02$	$8.02^b \pm 0.31$	$5.38^a \pm 0.16$	$0.74^c \pm 0.03$	$5.62^a \pm 0.04$
50%, No Vinegar	$51.4^a \pm 1.43$	$9.12^a \pm 0.22$	$4.43^b \pm 0.11$	$0.81^a \pm 0.02$	$5.66^a \pm 0.04$
65%, Vinegar	$33.7^b \pm 1.11$	$5.32^c \pm 0.07$	$3.66^c \pm 0.09$	$0.78^b \pm 0.02$	$4.89^b \pm 0.11$
50%, Vinegar	$53.4^a \pm 1.01$	$7.37^b \pm 0.72$	$3.54^c \pm 0.27$	$0.83^a \pm 0.03$	$4.93^b \pm 0.13$

db: Dry basis, wb: Wet basis
[a, b, c] Means with different letters within a column are significantly different ($p < 0.05$)

As expected, the biltong dried to a 65% weight loss resulted in a final moisture content of ± 30% and biltong dried to a 50% weight loss had a final moisture content of ± 50%. These results give an indication that the biltong production process and drying was relatively constant.
The final salt content depends on the initial amount of salt used and the brining time. Most commonly ranging between 4 – 8%$_{db}$ in traditional biltong [9]. With this study the amount of salt added and brining time was kept constant for all treatments so the differences seen can be explained by the influence of vinegar and/or the degree of drying on salt content as well as the meat itself. On a dry basis, the salt content was not expected to change between the 65%, Vinegar and 50%, Vinegar biltong samples and between the 65%, No Vinegar and 50%, No Vinegar biltong samples as the addition of salt was the same throughout, as previously mentioned. Due to the large quantity of meat tumbled per batch the homogeneity of the salting could be inconsistent which could also explain the differences between the samples on a dry basis. The addition of vinegar allowed for a lowered salt content to those without added vinegar independent of the degree of drying but this is to be confirmed as the salting was shown to vary from one piece to another within a batch (Table 1).
There is no difference ($p = 0.438$) between the pH of biltong (Table 1) with differing final moisture contents but with the addition of vinegar an effect ($p = 0.000$) of the pH is seen. The pH, as expected, is higher in the biltong with no added vinegar. It has been published that biltong can have a pH 4.81 – 5.83 [6–9] which is in accordance to the data in Table 1. Petit and others [8] show results whereby 18% of the samples have a pH ≤ 5. It can be assumed to be due to the addition of an acid which is common practice in biltong production. As a result of the moisture and salt contents, the biltong

with a weight loss up to 50% had a a_w above 0.81 whilst the biltong with a weight loss up to 65% showed a lower a_w (< 0.78), falling in the usual range of dry biltong as discussed.
The interaction between water activity and pH should give an indication of the microbial profile and shelf life of a product. It also depends on the composition of the raw meat itself, the preparation (food handlers and/or equipment used) and the drying conditions. In this case, it may be postulated that the biltong with a lower water activity and lower pH (produced with vinegar and dried up to 65% weight loss) could result in a more shelf-stable product after 3 months.
However, with a still fairly high water activity (> 0.70) and a salt content between 3.5 – 5.5%$_{wb}$ it could be predicted that there will be mould growth, albeit minimal in vinegar samples, as biltong has the ideal growth conditions (water activity ≥ 0.61) and is known to be susceptible to mould growth. *Staphylococcus* strains may be present as they can grow at intermediate water activity levels (0.83) and high salt contents. Previous research has shown that *Staphylococcus* spp. can survive at high salt concentrations between 10 – 20 % and that the use of a vinegar in biltong production is not effective for inhibition of pathogenic microorganisms and *Staphylococcus* strains [5, 14, 15]. It is however known to have an effect on spoilage microorganisms and moulds due to the decline in pH. Further research would need to be conducted to confirm the microbial stability of biltong over time.

IN CONCLUSION

The moisture content, salt content and water activity are characteristics of biltong that play a role in consumer perception as well as influencing the shelf-life of biltong. The degree of drying did not influence the salt content in biltong but the vinegar may have decreased it. It would be of interest to study this aspect further by studying the penetration of salt in meat and it's drying thereafter (throughout the process from raw material to dried material) so as to test the role of vinegar on salting during tumbling in the process. If an effect between vinegar and salt penetration is confirmed, future investigations could involve using differing salt and vinegar levels and tumbling conditions. Positively, a higher degree of drying leads to a reduction in moisture and water activity which are important for shelf-life of biltong. As the addition of vinegar reduced the pH it would be of interest to study effect of these factors on microbial stability over time. This will show the influence/relationship of pH, water activity, moisture and salt content on microorganisms in a dried meat product. These results could be used as a recommendation to determine the actual shelf-life of biltong and evidence for the legal regulations in place.

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