PHYSICOCHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF A MEAT PRODUCT SIMILAR TO *CARNE-THE SOL* AND ITS SHELF-LIFE DETERMINATION

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Carne de Sol is a traditional lightly salted meat sold in large amounts in the Northeast of Brazil enjoying great popularity due to its sensorial attributes and its use as a substitute and alternative for fresh meat. According to historical records, by 1610 the product was already being sold in large quantities in the city of Salvador-Bahia (Faria, 1980).

In the traditional product the final moisture and salt contents were controlled by salting and by the duration of the exposure of the salted meat to the wind in covered areas during the night and or to sun-drying during the day. The judicious use of salting and drying allowed the production of different types of *carne-de-sol* which varied in composition and stability from a product that would need no desalting before cooking to *carne-de-sol* with moisture and salt content not very different from *charque-de-vento* (*charque*-of-the-wind), a particular type of *charque* usually made for consumption within 30 days at cattle ranches (Carvalho Jr., 2003).

During most of the 20th century, the *carne-de*-sol manufactured from hot boned beef would receive brief salting and drying to extend its shelf life at ambient temperature to around three to five days (Norman & Corte, 1985; Caldas, 1966) after which the surface turned slimy and unattractive. In recent years, however, the widespread availability of refrigeration has diminished the importance of the water activity reduction for the safe keeping of *carne-de-sol* and the average salt content of this product has been reduced by some manufacturers from 7 to 5% , 20 years ago, (Vieira Neto, 1982; Shimokomaki et al., 1987) to values as low as 2,8 to 2,4%, making desalting of the product before cooking an unnecessary step. Nowadays, in some places, the meat after being lightly salted is packaged in polyethylene bags and immediately refrigerated or frozen.

Although the reduction in salt content coupled with the use of refrigeration are steps towards increasing convenience and safety for the consumer, *carne-de-sol*, in the majority of establishments, continues to be manufactured on a small scale and under sanitary conditions that must be improved. The product is usually market in mantas without any protective packaging, exposed to ambient temperature and further contamination by traders and shoppers.

Silva (1991) studied the microbiology of 60 samples of *carne-de-sol* sold in Recife-PE from meat plants, supermarkets and street markets, being 20 samples for each establishment. No counts > 10^2/g of faecal coliforms were detected in the meat plant samples but higher counts were found in 6 samples from supermarkets and 14 samples from street markets. *E. coli* was detected in 3 samples from meat plants, in 5 from supermarkets and in 9 from street markets. *S. aureus* was detected in 23,3% of the samples; two samples from supermarkets contained type C enterotoxin strains and one type C enterotoxin strain were detected in the samples from street markets.

Costa (1999) analysing 96 samples of *carne-de-sol* found higher counts for mesophylic bacteria, molds and yeasts and faecal coliform in samples from small retailers while counts for *Staphylococcus spp* were higher in the ones from supermarkets and meat plants. The author points out that the low salt content in *carne-de-sol*, resulting in a water activity around 0,96, is sufficient to inhibit the growth of *Pseudomonas*, but favours the growth of Gram$^+$ microrganisms, such as *Staphylococcus spp.*

The production of *carne-de*-sol on a scale that would allow its distribution on a national scale calls for the introduction in its manufacture of GMP and the principles of hurdle technology, developed by Leistner (1996). This product should be manufactured with selected raw-materials, under strict control of hygiene and temperature, and have a low salt content, a low microbiological load, be packaged under vacuum and kept at low temperature, so as to have an adequate shelf-life for long distance distribution.

Objectives

To study the physicochemical characteristics of a product similar do *carne-de-sol,* manufactured under strict GMP practices, with a salt content that would not demand desalting before cooking, packaged under vacuum and to follow the microbiological and sensorial properties of the product during storage under controlled conditions, to determine its shelf-life.

Material and Methods

Raw material: refrigerated and vacuum packaged boneless inside round (m. *semimembranosus,* m. *adductor femoris* and m. *gracilis*), from a federally inspected slaughterhouse. The meat should not have a dark colour and the amount of drip in the package should be minimal. **Controls**: pH was measured using a Mettler Toledo pH meter, mod. MA 130; water activity in the Decagon Aqualab CX-2; product temperature: using a Testo data logger, mod.171-4; air temperature and relative humidity: monitoring with Testo 650 and data logger mod. 171-2; Air speed: Testo, mod 425. **Processing – Preparation of meat cuts:** The inside round was taken from a refrigeration chamber kept at 0±1°C to a boning room with air temperature adjusted to 15°C when *m. gracillis* and all superficial fat was removed. After the toilet, the meat was cut parallel to the muscle fibbers in slices 55 mm wide. **Salting** was carried out in the boning room rubbing on the meat surface 4% of a mixture containing 30% of fine grain salt (< 1 mm) and 70% medium grain salt (>1mm and <2mm). After salting, the meat was kept for four hours at 4°C in a refrigerated chamber. **Drying**: 4 hours in a fermentation chamber with air temperature and R.H. values selected so that the surface temperature of the salted meat was kept bellow 15°C. **Packaging**: at 15°C in high barrier bags (9,6 ccO_2/m^2/dia) under vacuum. **Storage**: at a maximum temperature of 4°C (3 ± 1°C). **Physicochemical analysis:** pH was measured with and insertion electrode; moisture, protein, salt and ash were carried out according to Horwitz (1980); lipids according to Bligh & Dyer (1959). **Microbiological analyses** were carried out in the raw material, the final product and during storage for seven weeks. Salmonella and sulfite-reducing clostridia counts were carried out in the raw-material and in the finished product. During storage, counts were taken for psychrotrophic bacteria, lactic bacteria, Enterobacteriaceae, molds and yeasts and *Staphylococcus aureus*. All analyses were according to Vanderzant & Splittstoesser (1992), except Enterobacteriaceae, which was by ICMSF (1978).

Results and discussion

The product composition, i.e., moisture content (70,9%), chlorides (2,89%) and water activity (0,96), are typical of a product less perishable than fresh meat, but that has to rely on hurdles provided by vacuum packaging and refrigeration to extend its shelf life. Protein content (22,06%) and fat (2,0%) are similar to the ones found in the lean portion of the beef round, while ash content (3,8%) reflects the absorption of salt. pH

values on the surface (5,6-5,8) and in the interior of samples (5,4-5,8) are similar to those found in fresh meat, reflecting that light salting has no significant effect on the pH of the final product.

Salmonella sp and sulfite-reducing clostridia counts in the raw material and the finished product were < 10 UFC/g. *Staphylococcus aureus* counts, < 100 CFU/g (est.), in the raw-material (fresh meat) and in the finished product, during the seven weeks of storage, were within the limits set by Resolution nº 12/01 (SVS, 2001). Enterobacteriaceae counts were about 10^3 CFU/g in the fresh meat and 10^2 CFU/g in the finished product during the storage tests. Molds and yeasts counts were around 10^4 CFU/g in the fresh meat and between 10^2 and 10^3 CFU/g during storage, except in the fourth week, when it reached values above 10^4 UFC/g. Psychrotrophic bacteria counts in the fresh meat were $>10^5$ UFC/g and the values for lactic bacteria were very similar. Counts for both bacteria in the finished product during the seven weeks of storage are shown in **Figure 1**. Lactic bacteria counts from the third week of storage showed values > 10^8 UFC/g and from the 5th week onwards spoilage could be detected. **Figure 1** shows that the psychrotrophic flora of the finished product vacuum packed and kept under refrigeration during storage is composed mainly by lactic acid bacteria, which according to Styles & Hasting (1991) inhibits the growth of pathogens and spoilage microorganims, extending the product shelf-life, but is responsible for the ultimate deterioration of the product .

Conclusion

The counts of spoilage and pathogenic organisms were very low in the final product and during its storage for seven weeks. The product had a shelf-life limited to four weeks due to its spoilage by lactic acid bacteria, the shelf-life extension depending on the control of the growth of this class of bacteria.

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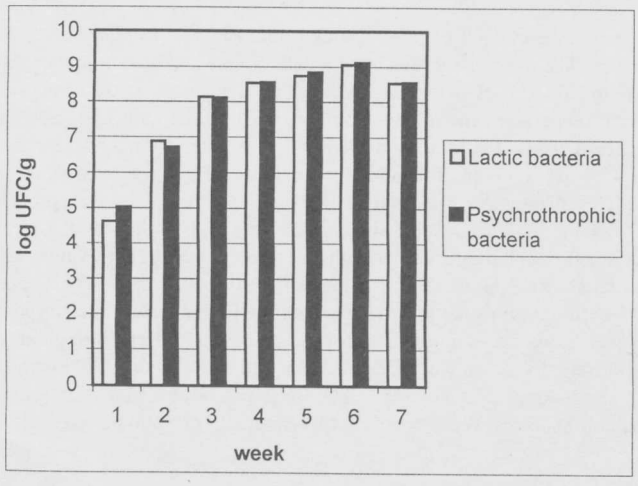

Figure 1. Lactic acid and psychrotrophic bacteria counts during storage of the vacuum packaged product stored at 4ºC.