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Joint application of antimicrobial agents on microbial flora chilled meat cattle. Use of mathematical models.

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Abstract

Objectives of this work were: i) to study the effect joint application of antimicrobial agents on microbial flora chilled meat cattle; ii) to model mathematically this microbial growth and iii) validate the models with own experimental results.
Samples were irradiated with UVC light for 5 minutes and then were added a solution of oregano oil and lactic acid (1: 1). Untreated samples were considered as control.
Gompertz model was appropriate to quantify microbial growth in all conditions studied. Meanwhile, *Pseudomonas sp* in treated samples showed no development, having to apply the linear regression model.

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Keywords: beef; UVC light; essential oils; refrigeration; mathematical models.

1. Introduction

Application of mathematical models to quantify and predict microbial growth in meat is useful tool because the control thereof is critical. One of the more frequently used models is that of Gompertz which describes the microorganism response under different factor combinations and that allows to consider parameters such as LPD, μ and MPD of the micro-organisms.

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As the industry develops new technologies to produce higher hygienic quality for increasingly competitive markets, systems must be designed to allow safeguards to be implemented in processing procedures (Coll Cárdenas, Giannuzzi & Zaritzky, 2008). In order to extend the useful life, various technologies have been implemented that acting jointly have a greater action, than if used separately, as is the case of UVC light, organic acids such as lactic acid and essential oils.

UVC light is a potent bactericidal agent, is not ionizable and when it is absorbed by proteins and nucleic acids, affects genetic material of microorganisms inducing changes in cell proliferation. Presently, UVC radiation technology is used as an alternative to chemical sterilization in food products (Chun et al., 2010; Pena et al., 2013).

Lactic acid is an acceptable decontaminant because it is a natural, non-toxic, produced naturally in meat products, and it offers the possibility of reducing the contamination of carcasses, cuts and beef products.

EOs and their components, commonly used as flavouring in the food industry, also present interesting antibacterial, antifungal and antioxidant properties (Sánchez-González et al., 2011). Plant-derived EOs have shown remarkable antimicrobial potency against spoilage and pathogenic microorganisms in meat (Jayasena & Jo, 2013). *Origanum vulgare* L. has been known as having many therapeutic properties and its antimicrobial activity has currently received a renewed interest (Souza et al., 2007).

The objectives of this work were: i) to study the effect of the combined application of antimicrobial agents on samples of beef with polyethylene low density films and stored at refrigeration temperatures, on development of spoilage microorganisms; ii) to model mathematically this microbial growth and iii) validate the models with own experimental results.

2. Materials and Methods

Meat samples and storage conditions:

Beef samples (n=28) were obtained from *Longissimus dorsi* muscle of natural pH 5.8, from steers, carcass weighing up to 240 kg, with post-mortem time of 48 h at 4°C. The pH values were determined using a peachimeter of punction Meter 6171L. The samples were cut aseptically into subsamples of 5.0 cm diameter by 1.0 cm high with a sterile scalpel (approximately 10g of meat sample). Then were placed in Petri dishes, splitting into two groups, one to be treated (irradiated with UVC light for 5 minutes (D=0.5567 J cm^{-2}) and were added of 1ml a solution of oregano oil (*Origanum vulgare* L) and lactic acid (1:1)) and other non-irradiated considered as Control. The dose was determined by a digital radiometer. Samples were packaged with polyethylene low density films of 50 μm thick and stored in controlled refrigeration cameras to 4ºC, for 24 days.

Microbiological analysis

Microbiological determinations were made using sterile swabs from the surface of meat at different storage times (0 to 24 days). Decimal dilutions using peptone water 0.1% were then performed and 1000 μl of serial dilution were placed in specific media for each microorganism: Plate Count Agar (PCA Agar) for Total Aerobic Mesophilic Bacteria; Crystal Violet, Neutral Red Bile Agar for Enterobacteriaceae and Cetrimide Agar for *Pseudomonas sp*. using the Plate Pour Procedure. Spread plates were incubated aerobically at 37ºC for 24h. Determinations were made in duplicate. For all results, an Ionomex colony counter was used to quantify these and the counts were expressed as log N (N: Colony Forming Units cm^{-2} (CFU cm^{-2}).

Mathematical modeling

One of the most recommended models is the Gompertz modified equation. From this equation, the following derived parameters were obtained: $\mu = b.c/e$ [log (CFU cm^{-2}) $days^{-1}$], with e= 2.7182; LPD= m - (1/b) [days]; MPD= a + c [log (CFU cm^{-2})]. Data fits obtained from Gompertz model were analyzed by means of Systat software (Systat Inc.12.0). It calculates the set of parameters with the lowest residual sum of squares and their 95% confidence interval.

When the microbial counts in food remain constant or decrease during storage, it's possible to use the linear regression model. It was considered that microorganisms are in a lag phase when the slope gets a value lower than 0.01 (CFU cm^{-2})$^{-1}$ $days^{-1}$, or when the difference between final counts and initial ones are lower than 0.50 log cycle. Lag phase was calculated as the time necessary to increase initial microbial counts in 0.50 log cycle (LPD = 0.50 /μ) (Coll Cárdenas et al., 2008).