COMBINED EFFECTS OF THERMAL TREATMENTS AND COMPOSITION ON *LISTERIA MONOCYTOGENES* SURVIVAL IN MEAT PRODUCTS

Vannini L.[1], Paparella A.[2], Guerzoni M.E.[1]
[1]Dipartimento di Protezione e Valorizzazione Agroalimentare, Facoltà di Agraria, Università degli Studi di Bologna, via San Giacomo 7, 40126 Bologna, Italy.
[2]Facoltà di Agraria, Università di Teramo, Via Spagna 1, 64023 Mosciano Stazione (Teramo), Italy.

Background

During the last decades the meat market has shifted from raw meats to convenience products due to the consumer's request for safer and "more natural" foods. Convenience foods are less heavily preserved (e.g. less acid, salt and sugar), less reliant on preservatives and less heavily processed. In fact, mild technologies preserve the intrinsic nutritional quality and the sensory characteristics of foods. Meat products obtained with mild technologies commonly rely on mild cooking, rapid chilling and refrigerated storage and distribution for their preservation and microbiological safety. However, some pathogens are capable of growth at refrigeration temperatures: in particular, *Listeria monocytogenes* is generally regarded as a hazard for cooked chilled foods due to its frequent occurrence in raw meats, its psychrotropic nature and a relatively high heat resistance. The efficacy of thermal processes has been evaluated traditionally on the basis of the assumption that microbial mortality is a process following a first-order kinetics. However, deviations from linearity have been observed (Peleg and Penchina, 2000; Peleg and Cole, 2000).

Objectives

The aim of this work was to study the deactivation dynamics of *Listeria monocytogenes* deliberately inoculated in poultry meat products. The combined effect of thermal treatments and product composition, particularly fat and collagen content, on the death dynamics and survival ability of *Listeria monocytogenes*, total mesophiles and *Enterobacteriaceae* were evaluated.

Methods

Minced poultry meat was added with collagen and fat in different percentages (table 1) and then inoculated with *Listeria monocytogenes* at a rate of 6 Log CFU/g. Samples of about 60 g were formed, packaged in plastic bags and subjected to heat treatments corresponding to different pasteurisation values (VP_{70}^{10}) in a steam oven. The pasteurisation value was calculated according to Cleland and Robertson (1985). Samples withdrawn at predetermined VP_{70}^{10} values ranging from 0 to 4 minutes were rapidly chilled and subjected to the enumeration of viable cells by plating appropriate dilutions on selective media for *Listeria monocytogenes, Enterobacteriaceae* and total mesophilic bacteria.

Results and discussions

Seven trials were carried out and in all cases the thermal deactivation kinetics obtained for *Listeria monocytogenes, Enterobacteriaceae* and total mesophilic bacteria under non isothermal conditions in relation to VP_{70}^{10} values did not follow a pseudo-first order kinetics. Plots of Log_{10} (CFU/g) survivors against VP_{70}^{10} gave biphasic curves whose first phase, varying between 15 and 40 seconds, was characterised by a viability loss ranging from 1 and 3.5 Log units whereas the second phase consisted of a sharper decrease in Log_{10} CFU/g followed by a tailing. This behaviour was particularly evident in samples with the highest collagen content.
The experimental data were tentatively analised with various equations including the Weibull equation (Peleg and Cole, 1998; Fernandez *et al.*, 1999). However, the equation of an hyperbole branch resulted to be the most suitable to fit the experimental data.
The comparative analysis of the experimental data outlined that the two ingredients have an significant effect on the survival of *Listeria monocytogenes*, particularly during the initial phase of thermal treatment. In fact, the transition between the first and the second phase of the deactivation curve relative to the combination 12% fat + 1.5% collagen corresponded to a VP_{70}^{10} value of 38 seconds. In samples with a lower fat content (4%), the transition point in the biphasic curve was observed at a VP_{70}^{10} value of 12 seconds. Moreover, a different deactivation behaviour was observed: in fact, the combination containing the higher fat content showed a sharper slope and a cellular viability loss corresponding to 2.5 Log_{10} CFU/g was achieved after 30 seconds. Such deactivation was attained only after 10 seconds in the samples added with 4% fat. Despite the faster viability loss of the latter, the asymptotic value of the survival curve obtained was higher (- 5.5 Log CFU/g) than that relative to the combination with 12% fat (-6.7 Log CFU/g). This result indicates that the fraction of the total population of *Listeria monocytogenes* able to survive long after the majority has been destroyed was remarkably lower in samples with the highest fat content.
The increase of collagen content resulted in a decrease of the VP_{70}^{10} value of the transition point of the biphasic curve: although this result was not apparently consistent with data obtained for fat content, it can be assumed that collagen content play an overall protective role. In fact, all curves relative to the combinations containing 1.5 and 3% collagen showed a sharper inactivation rate if compared with those having the same fat content but a higher collagen content (4.5 and 6, respectively).

Conclusions

The results obtained in this work outlined the non linearity of survival curves of *Listeria monocytogenes* which exhibited biphasic behaviour, commonly referred as "tailing", and the importance of medium composition on its inactivation kinetics.
Possible explanations for the occurrence of tailing or shoulder regions in an inactivation curve include the presence of groups or clumps of microorganisms, a subpopulation of more resistant microorganisms or proteins and fat in the medium. In fact, proteins could reduce the loss of solutes, stabilise the membrane or have a buffering effect on low pH values; fat particles could cause an indirect reduction of water activity due to the increasing solubility of water in fat at raising temperatures. Moreover, the increased heat resistance could be attributed to modifications in the viscosity or physical state of the system due to the protein gelation induced by heat treatment. It has been suggested that the thermal gelation properties of the protein matrix and the resulting physical entrapment of fats are the major contributors to meat batter stability (Gordon and Barbut, 1992).

A better understanding of the mechanisms by which comminuted meat products are formed and stabilised and of the effect which can be attributed to composition during thermal treatments is necessary in order to improve the knowledge of the complex phenomena occuring during technological processes. This information is foundamental when changes in formulations and/or processing procedures are made in order to satisfy consumer demands and allows the develompment and setting up of safer products.

Pertinent literature

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Table 1- Combinations of lipid and collagen added to poultry meat.

LIPID (%)	COLLAGEN (%)
4	1.5
4	4.5
8	3.0
8	6.0
12	1.5
12	4.5
16	3.0

Meat quality