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Aerobic microbial inactivation kinetics of shrimp using a fixed minimal ozone discharge: A fact or fib during iced storage?

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Abstract

Among researchers worldwide, the combination of preservation methods aimed to achieve improved effects on microbial inactivation of seafood products is an area of research receiving increasing interest. Globally also, the demand for high quality minimally processed food products are on the increase. Ozone treatment, three decade – long declared 'Generally Recognized As Safe' and approved as food contact sanitizing agent has evolved up to recent times where it assumes the likes of domestic food-processing facilities manufactured with environment-friendly status ensuring consumer safety. On the other hand, the subject of inactivation kinetics of seafood microorganisms following ozone treatment is still under debate. Furthermore, kinetic models remain the economical and quick approach to predict the preservation parameters. Nevertheless, there is paucity of information regards aerobic microbial inactivation of crustacean product arising from fixed minimal ozone discharge. Is the phenomenon of aerobic microbial inactivation kinetics of shrimp product subject to a fixed minimal ozone discharge during iced storage a fact or fib? To answer this, the aerobic microbial inactivation kinetics of shrimp during iced storage of up to 11 days was inspected. The process conditions comprised of a fixed ozone concentration of 100 mg/h minimally discharged at wash time of 1 min as well as iced storage of up to 11 days. Minimal ozone treatment was applied either prior to or during iced storage situations. Aerobic microbial inactivation presented significant effects during iced storage ($P<0.05$). Line of fit that could best describe the aerobic microbial inactivation kinetics showed adequacy only at the fourth order of storage time 'x' variable, which could only but account for between 75 - 96% of explained variance. Overall, aerobic microbial inactivation kinetics of shrimp using a fixed minimal ozone discharge appears quantitatively possible even though it decreases as iced storage progresses.

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Key words: Minimal ozone discharge; Aerobic microbial inactivation kinetics; Shrimp; Storage time; Ozone efficacy

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1. Introduction

Ozone treatment, three decade – long declared 'Generally Recognized As Safe' and approved as food contact sanitizing agent [1, 2] has over the years evolved up to recent times to assume the likes of domestic food-processing facilities manufactured with environment-friendly status ensuring consumer safety. In addition, such facilities are now increasingly commercially available for domestic and home use [3-6, 24-25]. A number of ozone treatment applications have involved seafood products such as mussel, jack mackerel, Japanese flounder, rockfish, salmon, sardine, shrimp, as well as turbot [2-5,7-9]. Health regulatory standards continuously press on manufacturers of ozone generating facilities to authenticate the optimum amounts of ozone required to bring about significant effects on foods to assure that residual quantities by concentration directly in contact with food products remain highly insignificant [2,6]. On the other hand, mathematical models have been used to quantitatively define the different aspects as well as dynamics in food processing with the help of theoretical analysis and experimental data. Moreover, most inactivation kinetic models have aimed to address universal concepts, identify the levels of details, the needed simplifications as well as uncertainties of inactivation [2,10]. However, considering the existence of different food preservation methods, as well as the advances of mathematical models, non-linear description of aerobic microbial inactivation kinetics needs further investigations. Equally, using a range of different parameters, non-linear models are understood to help in estimating microbial inactivation kinetics [2, 11]. Further, the subject of inactivation kinetics of seafood microorganisms following ozone treatment is still under debate [2]. Dynamics of inactivation curves have included linear, linear with tailing, sigmoidal-like, linear with preceding shoulder, biphasic, concave, bi-phasic with shoulder as well as convex. In addition, the use of kinetic models has been a quick and economical approach of predicting ozone treatment control parameters, for example, ozone concentration, gas flow rate, as well as treatment time [2, 12-14].

Globally, there is increasing interest regards combined preservative treatment methods applicable to fishery products to offer improved cold storage capabilities [29]. With regards to ozone treatment, the food technological success of ozone generating facilities especially on microbiological and related qualities as well as impact on food safety require investigations from domestic prior to industrial scale [2-6, 25-26, 28]. If pursued on the domestic scale, ozone discharge levels commence with the lowest / minima prior to the higher levels. It was on this premise that minimal ozone discharge fixed at manufacture of the employed domestic facility was applied to Pacific white shrimp. Significant effects on some characteristic qualities were achieved [3-6]. To date, little to nothing is known about aerobic microbial inactivation kinetics of shrimp using a fixed minimal ozone discharge. Specifically, whether this phenomenon is a fact or fib during iced storage is the object of this communication.

2. Experimental program

Shrimp collection as well as domestic ozone facility for this study has been previously described [3-5,18, 23, 26-27]. Specifically, the two process conditions included ozone concentration of 100 mg/h minimally discharged using wash time of 1 min fixed at manufacture of ozone facility of this work as well as iced storage of up to 11 days.

Standard aerobic plate count adapted followed a previous method [15] but with slight modifications for the minimal ozone-treated shrimp. Representative whole shrimp samples (~15 g) aseptically collected in a vertical laminar-flow cabinet and transferred to sterile plastic stomacher bag containing 135 mL of sterile peptone water (20 g of Buffered Peptone Water [CM0509] to 1 L distilled water mixed and sterilized by autoclaving for 121 °C for 20 min) (BPW CM0509: Oxoid Ltd., Basingstoke, Hampshire UK) were homogenized using a stomacher (BagMixer, Interscience Microbiology International, Frederick MD 21704, USA) for 60 s. A 15 mL aliquot of molten autoclaved commercial Plate Count Agar (PCA) (Becton, Dickson and Co., MD 21152, USA) was poured onto petri dishes and allowed to solidify. Using sterile peptone water, serial 10-fold dilution of shrimp homogenate was prepared and aliquots were spread on the surface of solidified (dry) PCA media. At the end of incubation periods (37 °C for 48 h), the number of colonies of inverted inoculated plates was counted.

Specifically, aerobic microbial inactivation of shrimp was based on minimal ozone treatment applied either prior to (Treatment 1) or sequentially (Treatment 2) during iced storage. Aerobic microbial inactivation of this work is typified using Log (N/N_0) versus iced storage time, where N_0 (CFU/g) is number of microbial numbers in untreated sample and N (CFU/g) is number of survivors determined after minimal ozone treatment, at both situations counted