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Review on Utilization of Radio Frequency Pasteurization on Different Raw Food

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Abstract: ***Recent analysis indicate that certain micro organism can survive at minimum moisture containing food for example various food powders, and ready to eat food mixes. To overcome from this Radio frequency pasteurization is an answer to them. Radio frequency pasteurization is used as an alternative for pasteurization technology in food processing industry. Especially for those who have minimum moisture content. The principle behind radio frequency pasteurization is dielectric heating of food material. It is low cost, have rapid heating power and have deep thermal penetration capacity causes better quality and extend the shelf life of food product. In this review paper various raw food material for example corn grains, black pepper, almonds, peanuts and eggs which have been treated with radio frequency pasteurization and shows there methods and extended shelf life.***

Keywords: Dielectric heating, radio frequency, pasteurization, shelf life

1. Introduction

Radio frequency (RF) heating has been used in several industries and has a great potential to be used as an alternative pasteurization technology in the food industry. Efforts have been undertaken to develop uniform heating throughout the food to ensure product safety and extend its shelf life. Among the food products, food powder is a large category of low moisture foods and generally considered as microbiologically safe due to their low water activity. However, recent outbreaks indicate that certain microbial species can survive for a significant time period in contaminated low moisture foods. For this reason, the development of effective pasteurization techniques for low moisture foods has become more of an issue. [1]

Fresh foods, such as vegetables, fruits, and aquatic products, have high water activity and are highly heat-sensitive. Thermal processing of fresh foods is often employed to extend shelf-life without chemical treatment in order to avoid any chemical residues in the preserved food. Radio frequency (RF) heating is one of the most promising heating methods applicable to fresh foods due to rapid heating, low cost, deep thermal penetration, and possibility of better quality control. This paper reviews the recent literature on applications of RF heating in fresh food processing, including cooking, microorganism reduction, disinfestation, thawing, and blanching. The heating efficiency and product quality of aforementioned applications were further discussed. Moreover, recommendations were made for future research on RF to effectively achieve enhanced thermal processing and reliable scale-up. The present study provides some useful information for the use of RF heating in industry and the future study of RF application in fresh food processing. [2]

The shelf life of foods is usually limited due to the frequent contamination by pests and microorganisms. Although low risk of pathogen contamination and no growth potential compared to those in high water activity animal-or vegetal-derived products, the low-moisture food has still significantly contributed to the total number of foodborne infections and outbreaks. Radio frequency (RF) treatments can be classified as a dielectric heating, which is a promising technology for achieving effective food pasteurization and disinfestations because of the associated rapid and volumetric heating with large penetration depth. The RF technique could be applied at low-moisture food as both the dipole dispersion and ionic conductivity may play effective roles. It can selectively heat and kill the microorganisms/ pests without damaging the agricultural product because of the large difference of dielectric loss factors between target microorganisms/pests and host foods. In this article, the low-moisture foods sterilized and disinfested by RF energy are reviewed through basic theories, dielectric properties, heating effect, and uniformity. The potential research directions for further RF heating applications are finally recommended in low-moisture foods. [4]

Basic Science behind radio frequency pasteurization-
RF processing uses dielectric heating to thermally process foods using electromagnetic waves. RF wavelengths cover the range of the electromagnetic spectrum from 3 kHz to 300 MHz. Only frequencies of 13.56 MHz, 27.12 MHz, and 40.68 MHz are permitted for use in the United States. During RF processing, dielectric materials are placed in an alternating electric field. RF energy is generated by a triode valve and applied to the food via a pair of electrodes. Dielectric heat energy is generated in the food by molecular friction as high-frequency electric fields alternate. Unlike conventional heating, dielectric heating is fast and volumetric.

RF processing can be used to process any dielectric material and most food products are dielectric. Foods contain polar molecules such as water, and these molecules have dipole moments, positive and negative charge centers that do not coincide. When placed in an electric field, polar molecules align with the field via the dipole moment phenomenon. In this way, polar molecules rotate continuously to align with the field as the field is alternated. Friction is created between the molecules, converting electromagnetic energy into heat and increasing the temperature of the food. Dissociative ions in foods also produce heat through ionic conduction whereby the ions oscillate forward and backward in the food creating friction and heat.

The electromagnetic characteristics of the food are important in determining process parameters. The two important properties are permeability and permittivity. Permeability has a very small contribution to dielectric heating and is therefore not usually considered. Permittivity is the parameter most commonly used to describe the dielectric properties of foods. It relates the reflection of electromagnetic waves at interfaces and the attenuation of the wave energy within the food. Dielectric properties of many foods have been studied by researchers and can be found in the literature. The three most popular methods to measure dielectric properties are transmission line, open-ended coaxial probe, and the resonant cavity method. It is important to remember that dielectric properties are dependent on temperature and frequency as well as the density, structure, composition, and moisture content of the food. [9]

Utilization of Radio Frequency Pasteurization on different food-

Corn Grains

Radio frequency (RF) heating has been proposed and tested to achieve a required anti-fungal efficacy on various food samples due to its advantage of deeper penetration depth and better heating uniformity. Applications of RF treatments on corn grains for controlling Aspergillus parasiticus while maintaining product quality. A pilot-scale, 27.12 MHz, 6 kW RF heating system together with hot air heating was used to rapidly pasteurize 3.0 kg corn samples. Results showed that the pasteurizing effect of RF heating on Aspergillus parasiticus increased with increasing heating temperature and holding time, and RF heating at 70 °C holding in hot air for at least 12 min resulted in 5–6 log reduction of Aspergillus parasiticus in corn samples with the moisture content of 15.0% w. b. Furthermore, thermal resistance of Aspergillus parasiticus decreased with increasing moisture content (MC) of corn samples. Quality (MC, water activity – aw, protein, starch, ash, fat, fatty acid, color, electrical conductivity and germination rate) of RF treated corn met the required quality standard used in cereal industry. Therefore, RF treatments can provide an effective and rapid heating method to control Aspergillus parasiticus and maintain acceptable corn quality. [5]

Black Pepper

Salmonella persistence in ground black pepper has caused several foodborne outbreaks and created public concern about the safety of low water activity (aw) foods. In this study, radiofrequency (RF) processing was evaluated for pasteurization of ground black pepper. Stability and homogeneity tests were done for both *Salmonella* spp. and *E. faecium* during moisture equilibration before RF heating to evaluate the inoculation method. Moisture content of samples were conditioned such that the final moisture content after RF heating reached the optimal storage moisture. RF heating was shown to provide more than 5.98 log CFU/g reduction for *Salmonella* spp. and the reduction of 3.89 log CFU/g for *E. faecium* with a 130 s of treatment time. The higher thermal resistance of *E. faecium* indicated its suitability as surrogate for *Salmonella* spp. during RF heating of ground black pepper. Piperine, total phenolics, volatile compounds, and antioxidant activity were assessed as quality parameters for ground black pepper. The results demonstrated that the RF processing provided effective inactivation of *Salmonella* spp. with insignificant ($p > 0.05$) quality deterioration. [6]

Almonds

Radio frequency (RF) treatment holds potential as a pasteurization method to control *Salmonella* in almonds without causing a substantial loss of product quality. Thermal resistance of *Salmonella* can be reduced by increasing water activity, thus a soaking process was designed prior to RF treatments. A pilot-scale 27 MHz, 6 kW RF heating system was used to rapidly heat 1.7 kg washed in-shell almonds with hot air heating at 55 °C. To achieve appropriate heating rate, constant drying temperature and short time cooling, the RF treatment protocol was obtained using an electrode gap of 13 cm for heating, 14 cm for drying, and followed by forced room air cooling of 5-cm thick samples. The results showed that almond temperatures above 75 °C at 23% moisture contents for 2–4 min RF heating could meet the requirements to achieve 5-log reduction of *Salmonella*. The RF treatment process for 20 min reduced the moisture content to 5.7% w. b. Peroxide value, fatty acids values and kernel colors of the RF treated almonds met good quality standard used by nut industry. [6]

Peanuts

In recent years, radio frequency (RF) heating is getting popular as an alternative pasteurization method for agricultural commodities and low moisture foods. Computer simulation is an effective way to help understand RF interactions with food components and predict temperature distributions among food samples after RF treatments. In this study, a computer model based on Joule heating and thermal inactivation kinetic of A. flavus was established to predict both temperature distribution and microbial reduction among peanut kernels after RF processing. For the process validation, three 2-g peanut samples inoculated with 40 μL A. flavus were placed at three representative locations among 2.17 kg peanut kernels and subjected to various processing conditions in a 27.12 MHz, 6 kW RF heating unit together with hot air system. Results showed that the average difference of the sample temperature and microbial reduction between simulation and experiment was small with RMSE values of 0.009 °C and 0.012 °C, and 0.31 log CFU/g and 0.42 log CFU/g for peanut moisture contents of 7.56% and 12.02% w. b., respectively. Nonuniform RF heating resulted in the least lethality of A. flavus at the cold spot. The validated computer model was further used to estimate microbial reduction distributions at other target temperatures based on predicted temperature profiles. This computer model may help design the RF pasteurization protocols for peanut kernels without extensive experiments in food industry [7].

Eggs

Eggs are one of the most nutritious foods available in nature. This rich nutritive environment attracts microbes to invade, feed and multiply. Salmonella enteritidis is one such microbe that is highly pathogenic and is the causative agent for the disease salmonellosis. To ensure safety of eggs, processing them without affecting their unique physical

properties is essential. In this study, the impact of radiofrequency (RF) heating on the dielectric properties (dielectric constant and dielectric loss factor) of the egg at varying temperatures (5°C-56°C) and frequency (10 MHz-3 GHz) is evaluated. This study on the dielectric parameters is essential to devise a better heating paradigm wherein there is minimal detrimental effect to the egg components. Based on the dielectric study, the heating process parameters were determined. The effect of such heat treatment on the physical properties viz. Viscosity, foam density, foam stability and turbidity of the egg white were also studied. This study was conducted to provide sufficient literature and experimental background for employing RF in pasteurization of in-shell eggs. This study showed that if careful process parameter optimization and meticulous equipment design is done, RF heating can be successfully employed to pasteurize in-shell eggs. [8]

2. Conclusions

Radio Frequency Pasteurization used in different food products which have minimum moisture content for example corn grains, black pepper, almonds, peanuts and eggs. By using radio frequency pasteurization shelf life of food products gets extend. This technique requires minimum cost, have good penetration capacity and gives safe and high quality food products as well as it is substitute for pasteurization.

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