DIELECTRIC PROPERTIES OF SELECTED PORK ORGAN MEATS AND EXPERIMENTAL PATE PRODUCT FORMULATIONS FOR CONTINUOUS FLOW MICROWAVE PROCESSING

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Abstract – Continuous flow microwave processing (CFMP) for pasteurization and sterilization is an emerging technology which has been recently commercialized for industrial production of vegetable, fruit and dairy products. There is a potential for use of CFMP for processing of specialty meat products such as pates and soft sausages with a high content of organ meats. The application of CFMP through production of specialty products for export may add value to these ingredients.

I. INTRODUCTION

Continuous flow microwave technology has been developed at North Carolina State University for sterilization of foods and biomaterials and has been commercially used over the last 5 years for production of vegetable and fruit based products (Coronel et al. 2005, Kumar et al. 2008, Steed et al. 2008). Processing of meat pates and other comminuted meat products that are commercial sterilization and thus stored and distributed under ambient (room) temperature conditions is common in Europe, Asia and other parts of the world. Currently this process represents a very small market segment in the United States. Processing and packaging of pate type products to achieve commercial sterility could be used to increase the consumption and particularly export potential of these products. Continuous flow microwave sterilization followed by aseptic packaging is one of the more recent technological developments which could provide the basis for development of these products.

In order to develop the continuous flow protocol for these new products, the dielectric properties need to be measured for all ingredients and potential formulations. These measurements have been used in both static (which are appropriate for homogeneous products) and continuous flow recirculated conditions (suited for heterogeneous and particulate-containing products), and have been reported by Coronel et al. (2008), Kumar et al. (2007) and Brinley et al. (2008). The dielectric property values have been subsequently used to develop the appropriate processes for preservation of a range of high acid and low acid products at pilot plant, semi-industrial and industrial capacity level.

In order to initiate the development of appropriate processing sequences for continuous flow microwave sterilization a detailed dielectric property measurements and analyses are needed for each considered formulation and each of its major ingredients. This paper presents the methods used and results obtained for pork trim, organs as well as three different pate formulations within the realistic temperature ranges these products will need to be subjected to achieve commercial sterility.

II. MATERIALS AND METHODS

Raw meat samples (pork lean trimmings, pork liver and pork kidney) were ground through a 12mm grinder plate prior analysis. Treatment 1 represents ground pork lean trimmings, approximately 70% lean and 30% fat. Treatment 2 represents ground pork liver. Treatment 3 represents ground pork kidneys. Pork hearts were ground and used in the formulation of the

pate, but they were not used as an individual treatment.
This ground meat was then used in the following pate formulations. Treatment 4 meat block was a 1:1:2 ratio of pork liver, pork heart and 70% lean pork trimmings. Treatment 5 meat block was a 1:1 ratio of pork heart and 70% lean pork trimmings. Treatment 6 meat block was a 1:1 ratio of pork kidney and 70% lean pork trimmings. Pates were made using these meat blocks in combination of a standard spice block, including white pepper, coriander, nutmeg and onion powder. Salt was formulated at 2% of the meat block and all treatments were cured using 6.25% sodium nitrite curing salt at a 136ppm level.
Raw mixed samples were emulsified by a Stephan Microcut MC machine (Stephan Machinery, Schwarzenbek, Germany).
Raw samples were bagged and held at 4°C until further analysis. Cook samples were prepared by depositing raw pate in a plastic cooking bag and thermally process until an internal temperature of 71°C was achieved. Cooked pate samples were stored at 4°C until dielectric properties were recovered.
Dielectric properties of the samples were measured from 10°C to 120°C using an open ended coaxial probe (HP 85070B, Agilent Technologies, Palo Alto, CA) connected to a network analyzer (HP 8753C, Agilent Technologies, Palo Alto, CA). The network analyzer was calibrated by leaving the tip of the probe in contact with air, metal, and 25ºC deionized water and measuring the dielectric properties. The dielectric properties were measured in the range of 300 to 3000MHz. The dielectric property measurement system is illustrated in Figure 1.

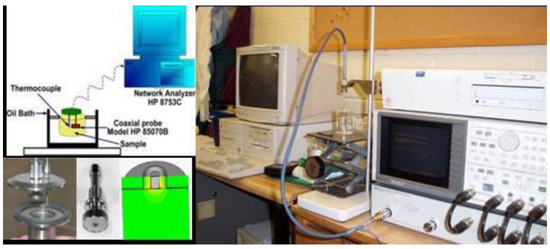
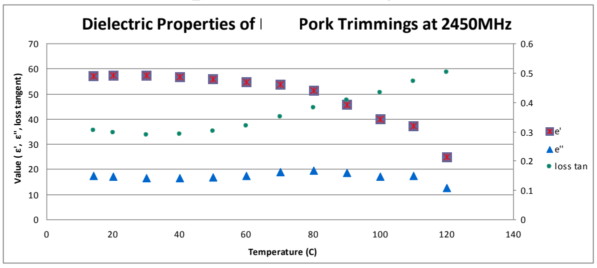


Figure 1. Instrument setup for measurement of dielectric properties in batch mode, with pressure cell and dielectric probe

Each sample was placed in a hermetically sealed stainless steel sample cup interfaced with the dielectric probe and incrementally heated in an oil bath, while taking the measurements at temperature increments of 10°C from 10°C to 120°C . From the obtained results, dielectric constant (ε'), dielectric factor (ε”) and dielectric loss tangent have been plotted for each temperature level and for 2450 MHz and 915 MHz microwave frequencies, representing the two potential ranges to be used for eventual processing.

III. RESULTS AND DISCUSSION

Results for the dielectric properties of pork trim, liver and kidney are presented in Fig. 2 through Figure 4. Dielectric properties of three pate formulations at 915 MHz and 2450 MHz are presented in Fig. 5, 6 and 7.



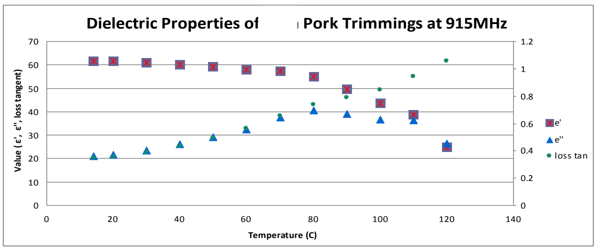


Figure 2. Dielectric properties of treatment 1, pork trimmings at 915 MHz and 2450 MHz at temperatures from 10C to 120C.

In all the analyzed cases, test ingredients and materials behaved similarly to other previously analyzed foods - dielectric constant decreased with the increasing temperature and dielectric factor increased with the increasing temperature. For analyzed test formulations, addition of salt and had a significant role, especially at 915MHz, in increasing the rate of the increase of dielectric loss tangent.

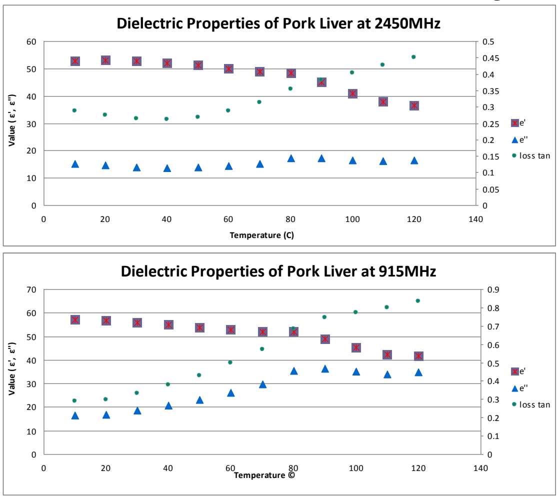


Figure 3. Dielectric properties of treatment 2, pork liver at 915 MHz and 2450 MHz at temperatures from 10C to 120C.

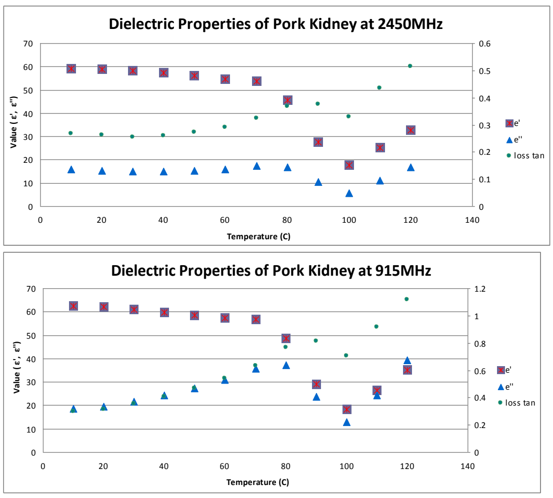


Figure 4. Dielectric properties of treatment 3, pork kidney at 915 MHz and 2450 MHz at temperatures from 10C to120C.

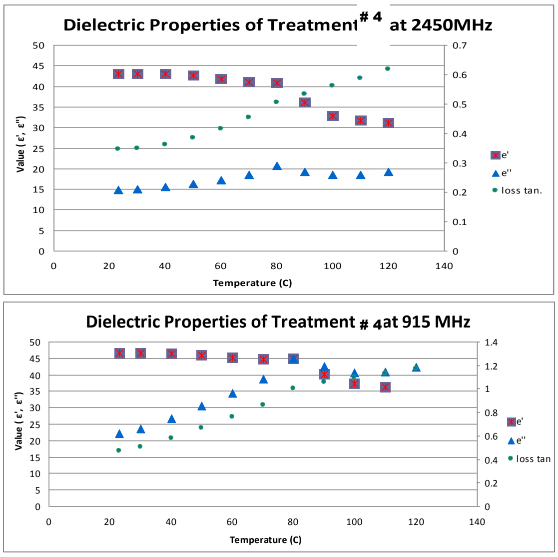


Figure 5. Dielectric properties of treatment 4, at 915 MHz and 2450 MHz at temperatures from 10C to 120C.

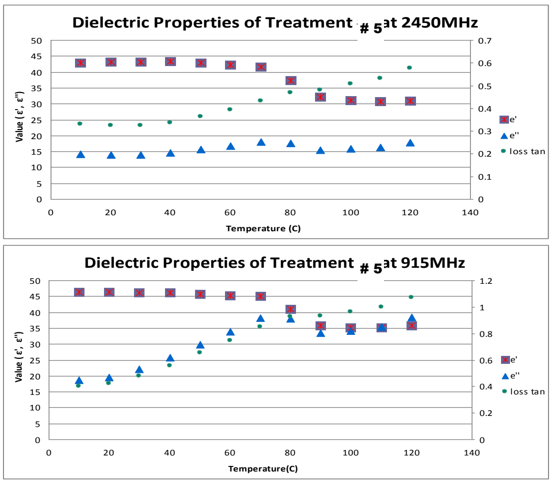


Figure 6. Dielectric properties of treatment 5 at 915 MHz and 2450 MHz at temperatures from 10C to 120C.

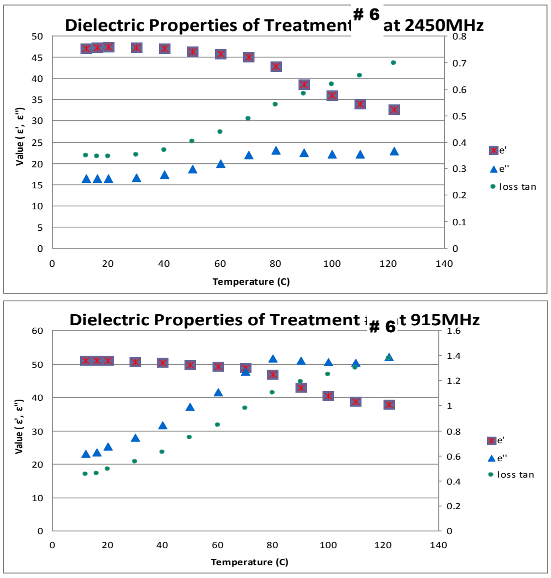


Figure 7. Dielectric properties of treatment 6 at 915 MHz and 2450 MHz at temperatures from 10C to 120C.

The increase in the dielectric loss tangent is usually associated with an increase in the rate of heating and reduction of penetration of microwaves into the processed material. This decreased depth of penetration results in the loss of heating in deeper segments of the material and occasional overheating around the edge of the flow-through conduits under continuous flow conditions.
While at 2450 MHz this trend was not as prominent as at 915, it should be taken into consideration when designing the processing systems for these types of products in the future. Reduction of salt content in experimental formulations could be potentially prove to be beneficial for the uniformity of product heating under continuous flow conditions, but would need to be confirmed both via additional dielectric property measurements for optimized formulations as well as experimentally under continuous flow heating and sterilization. These initial results indicate that the 2450 MHz microwave frequency might also be appropriate for processing of these types of products, but this also needs to be tested experimentally in future studies.

IV. CONCLUSION

Dielectric properties of pork trim, organs and pork pate products have been measured and evaluated for potential compatibility with the emerging continuous flow microwave technology for thermal sterilization of foods. Properties were measured for both industrially relevant microwave frequencies (915 MHz and 2450 MHz) and within a temperature range encompassing refrigeration (10C) to sterilization (120C). Test material properties followed the general trends observed previously for other foods. The addition of salt was related to the increase in dielectric loss tangent in test formulations, especially in the 915MHz range. Further experimental studies are recommended to define the processing parameters and ranges for these products more precisely.

V. REFERENCES

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