# EFFECT OF RADIANT ENERGY VACUUM ON PHYSICAL AND MICROBIAL PROPERTIES OF BEEF JERKY

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**Abstract –To test the feasibility of radiant energy vacuum (REV) dehydration, a technology that couples microwave cooking with vacuum pressure, on beef jerky preparation, the physical and microbial properties of the final jerky product was compared to conventional preparation methods. Physical characteristics assessed using puncture and shear tests of samples prepared using the two methods were not statistically different (P<0.05). Moisture content and water activity levels were also very similar between the two products. To test microbiological quality, samples were homogenized in a stomacher and a variety of 3M Petrifilms were used to evaluate the microbial load. Raw beef harboured low numbers of microbes, but the post-marination pasteurization/smoking step used in both treatments eliminated all culturable microorganisms tested for. To further investigate the ability of REV dehydration to kill microbes, samples were spiked with *Listeria innocua* after the pasteurization/smoking step but prior to REV dehydration. Samples were taken at different time intervals for microbial enumeration, and a decimal reduction time of 1 minute was calculated, with 99.99% of 1.98x10$^{7}$ CFU/g *Listeria* being killed in five minutes. Improved drying times were observed for jerky samples prepared using the REV method offering potential energy savings during jerky preparation.**

**Key Words – Microwave, Food Safety, Dehydration, Preservation**

## I. INTRODUCTION

In the last decade, the market for meat snacks, of which over 80% is beef based, has grown by 14% [1]. Increasing market share for shelf-stable meat products increases the need for alternate, efficient processing methods. Meat snack textural characteristics are critical for gaining consumer acceptance. The typical jerky consumer is a 35 to 54 year old male, and data indicate that if jerky were softer and easier to chew it would be more appealing to woman and children [1]. Although jerky is in high demand, little effort has been taken to optimize processing conditions. Reducing processing time would lead to a reduction in product cost and increased efficiency [3]. Texture is affected by drying jerky at high temperatures for extended periods of time, and as product quality mainly relies on textural properties, it is vital to investigate the effect of different parameters involved in its processing such as method of drying [4].

Radiant energy vacuum (REV) has been developed as a novel way of dehydrating food products. By combining microwave energy within a vacuum, a product can be dehydrated without losing its characteristic shape. REV dehydration of tomatoes has been shown to be much faster than conventional hot-air dehydration, particularly towards the end of the drying process [5]. Microwave vacuum-dehydration also caused puffing of the tomato tissue such that the dry product was half as dense as the 100% air-dried tomato. The goal of this research was to investigate the potential for this new technology to be used in the commercial production of beef jerky with a focus on sensory and microbial properties of the final beef jerky product.

## II. MATERIALS AND METHODS

*Beef Jerky Sample Preparation:* Five inside rounds obtained from a local abattoir were used for jerky preparation. The rounds were cut into strips, 3 cm x 12 cm x 0.5 cm, and individually marinated (31 g curing salt, 6 g white sugar, 2 g black pepper, 0.5 g cayenne pepper, 1.5 g ginger, 1.5 g granulated garlic, 2.5 mL lemon juice, 10 mL teriyaki sauce, 2 g maple extract, and 40 mL water for every 1kg of meat) for two days in a 4$^{o}$C cooler.

*Drying:* The marinated meat strips were placed in a single layer on wire mesh racks and placed in a Maurer-atmos smokehouse. Because the REV was not found to produce an equivalent tasting product when it is used to pasteurize the meat samples, □□□□samples were first subjected to a□ pasteurization/smoke step prior to dehydration by each of the two processes. The pasteurization/smoke step included heating the meat at 90% humidity until the surface temperature reached 71$^{o}$C, followed by twenty minutes of further drying at 80$^{o}$C and fifteen minutes of smoking at 80$^{o}$C to add flavor prior to the final dehydration step. The traditional samples were further dehydrated to 37, 34 and 31% mean moisture content after further drying in the smokehouse for 100, 130 and 160 mins; and triplicate samples of each moisture content were taken to compare to the REV process. Jerky samples were produced in triplicate by REV using a lab-scale batch 1.8 kW, 2450 MHz vacuum microwave (VM) (*nutra*REV$^{TM}$ lab Model 1.8, EnWave Corp., Vancouver, BC, Canada). Beef jerky (105 to 230g initial weight) was placed in a 27 cm. diameter perforated polyethylene drum inside the VM chamber. The drum was rotated on its horizontal axis at 6 rpm throughout the drying process. Vacuum was maintained at 4.0 kPa throughout the process and microwave power was maintained at 1.2kW , while dry air (1. 0 L/min) was flushed through the chamber to accelerate the removal of water vapor. An on-board water detector in the unit was utilized to produce jerky samples. Run times were recorded once target water loss was reached for each REV sample.

*Microbial Measures:* To determine the best conditions for stomaching jerky, jerky was stomached at a variety of conditions. Those conditions included the duration of mastication (15, 30, 60, or 90 seconds) and the presence of sand. Samples sat for fifteen minutes prior to being stomached. The diluent from each bag was serially diluted with 0.1% (w/v) peptone water. Fifty microlitres of each dilution was spread on nutrient agar plates and the plates incubated for twenty-four hours at 37$^{o}$C. In order to understand the impact of the vacuum microwave treatment on the microbiological safety of beef jerky, Aerobic count, Yeast and Mould, Enterobacteriaceae, *E. coli*/Coliform, Environmental *Listeria*, and Staph Express Petrifilms (3M) were used. The colonies on the plates were counted and the mean of the triplicates determined. In order to further test the anti-microbial ability of REV dehydration, a second set of samples were spiked with $1.98x10^{7} \pm 1.07x10^{7}$ CFU/g *Listeria innocua* (ATCC 33090) following the pasteurization/smoke step previously described, and dehydrated in the VM.

*Water Activity and Moisture Content:* Water activity, a critical parameter used to assure product safety, was measured using a Rotronic HydroLab3 Meter, Hauppauge, NY. Dried samples were crushed into small pieces and placed in the measurement cup and readings were noted. The moisture content of the samples was determined by drying 2 to 5g of pre-weighed sample in a 105$^{o}$C oven.

*Physical Measurements:* Both puncture and shear tests were performed using a Lloyd Instruments texture analyzer with a 50kN load cell (C.S.C. Force Measurement Inc. Agawam MA), with a 4 mm diameter stainless steel probe and shear blade. Jerky strips measuring 4.5-5.5 mm thick, cut into 20 x 20 mm slices, were laid over a 5 mm hole and the probe was set for 5 mm/s. The probe was programmed to punch completely through the jerky, and the force required for puncture was the value used. A shear blade was used for the shear test. Jerky samples were cut in 20 x 40 mm slices with a measured thickness between 4.5 to 5.5 mm. For each treatment, three samples were tested and the average value from each treatment was used in statistical analysis.

## III. RESULTS AND DISCUSSION

No statistically significant differences were observed in either the puncture or the shear tests between the two treatments (Figure 1, Figure 2). A

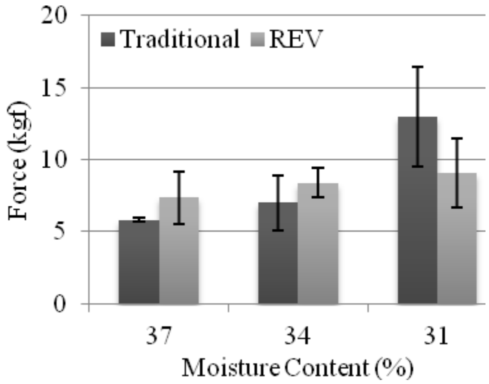


Figure 1. Comparison of puncture test results of jerky samples prepared using traditional preparation and by REV. Error bars indicate standard deviation.

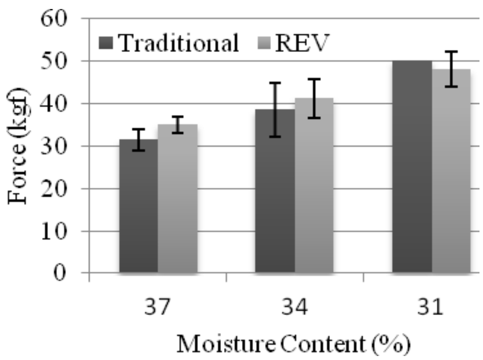


Figure 2. Comparison of shear test results of jerky samples prepared using traditional preparation and by REV. Error bars indicate standard deviation.

density decrease of more than 50% was reported for REV dried tomatoes as compared to air dried tomatoes, both at Aw of 0.43 [5], due to pores created in the tissue by steam bubbles during REV drying. Similar pores were visually observed in the jerky that was subjected to REV drying, but pores were visually absent in traditional preparations.

A general decline in water activity was observed between both the traditional and the REV jerky treatments as the moisture content decreased (Figure 3). When comparing the two preparation techniques, only samples at 37% moisture were statistically different in water activity, with REV being slightly lower. Preliminary experiments showed that stomaching samples for 90 seconds without sand was sufficient to achieve good recovery of culturable microorganisms for analysis. In all cases, the post-marination smoking step used

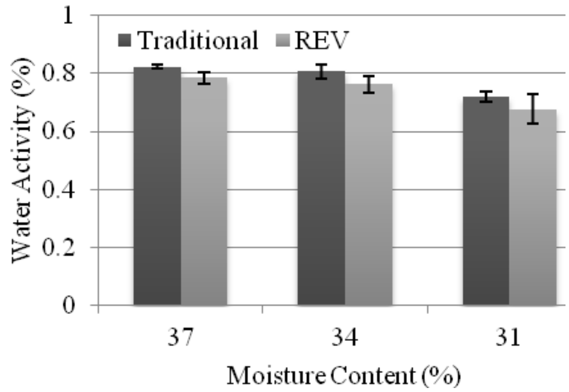


Figure 3. Comparison of water activity of jerky samples prepared using traditional preparation and by REV. Error bars indicate standard deviation.

in both treatments effectively eliminated all culturable microorganisms from samples. As such, smoked samples were spiked with *L. innocua* in order to evaluate the pasteurization abilities of the REV technology. In the spiked samples, there was a steady decline in microbial viability over time (Figure 4).

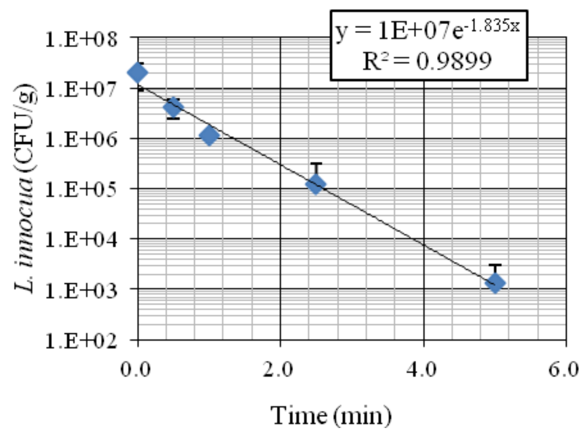


Figure 4. Microbial numbers steadily decreased during application of Radiant Energy Vacuum (REV). Error bars indicate standard deviation.

Culturable counts of *L. innocua* dropped from 2.0x10^7 (SD=1.07x10^7, n=3) to 1.4x10^3 (SD=1.71x10^3, n=3) over the course of 5 mins. This equates to a decimal reduction time of 1 minute. While no statistically significant differences were observed between treatments for either meat quality or microbial measures, it was observed that samples processed by REV were dehydrated much faster than what was observed using traditional preparation methods in smokehouses (Table 1). For example, when trying to achieve the lowest moisture content of approximately 31%, the REV process took only 4 minutes, compared to 160 minutes using the traditional smokehouse method.

Table 1. Summary of weight loss and run times for individual samples processed by REV.

| Jerky Wt. (g) | Target Wt Loss (g) | Actual Wt. Loss (g) | Total Time (s) |
|---|---|---|---|
| 105.5 | 26.63 | 27.9 | 125 |
| 127.5 | 36.51 | 34.8 | 122 |
| 124.1 | 31.32 | 30.4 | 123 |
| 167.4 | 48.09 | 46.9 | 208 |
| 207.1 | 66.18 | 68.1 | 270 |
| 194.8 | 68.00 | 69.0 | 224 |
| 204.0 | 56.18 | 56.5 | 215 |
| 201.7 | 62.04 | 61.5 | 296 |
| 214.2 | 72.33 | 72.8 | 286 |
| 218.9 | 53.51 | 50.3 | 185 |
| 200.3 | 55.84 | 51.9 | 130 |
| 228.9 | 70.99 | 70.8 | 200 |
| 181.6 | 49.29 | 46.7 | 200 |
| 181.6 | 55.31 | 56.1 | 225 |
| 177.0 | 59.26 | 58.5 | 221 |

## IV. CONCLUSION

REV dehydration as carried out in this study did not produce a more tender product according to our instrumental texture analysis than traditionally prepared jerky. Samples produced by REV were not significantly different from traditionally prepared samples in either the puncture or the shear tests. The REV was capable of reducing the microbial load on samples spiked with high levels of *Listeria*. REV technology dried the jerky product much faster than what is observed using traditional drying methods. This difference might translate into substantial energy savings in terms of processing time and merits further investigation. In addition, further sensory analysis is warranted to assess the impact of the increased porosity observed in jerky samples produced by REV, as instrumental texture analysis doesn't always agree with sensory analysis.

## ACKNOWLEDGEMENTS

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