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MICROWAVE AND HYBRID TECHNOLOGIES IN MEAT PRESERVATION

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Abstract

One of the products from secondary meat processing industries is jerky, which has good market value of $250 million per annum**.** Jerky is one of the North American dried meat product and it has been processed in traditional methods like smoke housing or home dehydrators which takes 6-10 hr for processing. As a first attempt, application of non-emissive clean microwave energy as an alternate source for the existing conventional smoke housing was studied. Along with microwave, combination of microwave and convective method has been studied. Formulation pH was changed and the effect of pH in conservation of energy and time has been studied. Physico-chemical properties of the samples were analysed and it was found from the study that lower microwave power levels have provided appealing color, appearance and textural properties though the drying time was reduced significantly. When power level increases, there is a significant reduction in drying time. Also it was found out that compared to microwave energy alone combination of microwave-convective energy has given better physico-chemical properties. Compared to conventional method, microwave heating helped in conservation of time by 75%. Also as microwave being a clean energy, environmental pollution from microwave energy utilization in jerky processing is negligible.

Keywords: Microwave drying, Meat, Preservation, microwave-convection combination drying

1. INTRODUCTION

In Canada, Red Meat industry is the largest food manufacturing sector with the annual income of \$14.6 billion thro' exports (Agri-Food Canada). Being a high moisture food (55-75% Moisture Content), meat is highly susceptible to spoilage. There is a need of proper preservation method to increase its shelf life. Siebert J.W. et al. (2000) has reported that as the preserved meat products have became a popular snack among people, more emphasis, given to the production of value-added meat product is also increasing. Drying is one of the least expensive and most effective ways of meat preservation since long back. Drying meat under conditions of natural temperatures and humidity with circulation of air and the assistance of sunshine is the oldest meat preservation method in practice (FAO 1990 c). Dried food keeps well because the moisture content is so low that spoilage organisms cannot grow. Drying is an excellent way to preserve foods that can add variety to meals and provide delicious, nutritious snacks. Less storage space results by drying helps in reduction of transportation and packing cost. Drying involves the removal of moisture from the outer layers and the migration of moisture from the inside to the outside. There are number of traditional dried meat products available in various regions; bresaola (North Italy),biltong (South Africa), bunderfleisch (Switzerland), charque (South America),pastirma (Turkey, Egypt and Armenia), odka (Somalia),qwanta (East Africa),kilishi (Nigeria and west Africa) and jerky (North America).

Jerky, a North American dried meat product has been taken for the study and this shelf-stable food product mainly relies on drying for reducing its water activity in turn to increase its shelf life. Its higher protein content and popularity have expanded the dried meat snack market to \$250 million (AAMP, 2004). Well known brand jerky costs around \$35 per pound (AAMP, 2004) which is quite expensive. This is mainly because of the long drying time it takes. Jerky is prepared by drying thin strips of lean meat to about one-half of its original weight. Jerky can be made from any form of meat; sliced or ground meat and the former one is called as whole muscle jerky and later as re-structured or formed Jerky. As per USDA (1996) recommendation, this shelf-stable product should have a moisture- protein ratio of ≤ 0.75:1 and water activity more than 0.85 to ensure the product safety.

Common method in practice for jerky processing is smoke housing. AAMP (2004) reported that this traditional method takes 6- 10 hr with 60º C for processing. Though jerky has a high demand in market, there has been no effort taken to optimize the product conditions. It is essential to optimize the process condition to reduce energy consumption. In this present study, as a first attempt, application of one of the electro-magnetic energy in jerky processing was carried out.

Microwaves fall between 100 to 5000 MHz frequencies in Electro-Magnetic Spectrum. 915MHz and 2450 MHz are the permitted frequencies for industrial and home usage by Federal

Communications Commission (FCC) (Venkatesh, M.S. & G.S.V. Raghavan, 2004) and they have also stated that in microwave heating, energy has been transferred from electro magnetic form to thermal form through interaction of the incident radiation with the molecules of the food product. The quantum energy in the microwave is responsible for creation of heat as the microwave oscillates 2450×10^6 times per second and the dipole molecules align to the electric field of the microwave at the same rate. As Microwave heating being volumetric heating, microwave energy for processing materials has the potential to offer advantages in reducing processing time, energy and enhance the overall product quality (Thostenson & Chou, 1999). Quenzer& Burns (1981) have reported that 75% energy can be saved by Microwave heating compared to conventional method. Microwave tempering or partial thawing of meat products has been already in practice (Taher,B.J. & Farid,M.M,2001) Several studies have reported that microwaves could be used for surface pasteurisation of meat. Meat treated with microwave less than 20s showed no drastic changes in appearance of physical characteristics (Cunningham,1980).. There have been no studies done on microwave drying of jerky product. In this present study, optimization of processing condition by utilizing microwave energy has been carried out. Along with microwave energy source, combination of convectional energy with microwave also has been studied.

2. MATERIAL AND METHODS

2.1. Sample Preparation

Biceps femoris muscles were taken for the study and it was stored at -30°C after the slaughter. The meat has been kept in 4°C environment for 48hrs before sample preparation. As per USDA (1996), recommendation, the meat was trimmed to lean to prevent fat being rancid while drying. The meat was first ground using a kidney plate in a meat grinder (Biro, Biro Mfd.Co, Marblehead, OH, USA).Before final grinding, the coarse ground meat has been mixed in a vacuum tumbler (H.Glass,Model-VSM-150,Frankfurt, Germany) for 2 minutes for improving uniformity. Then, the meat was ground twice, using a 1/8” blade in the meat grinder. The ingredients, given in the table 1, have been added with the ground meat to make 3 kg formulation in an Industrial Blender (Berkel BA-20, Model ARM-02) in lowest speed for 105 sec. The pHs of the sample formulations was altered by adding the common industrial acidifier Glucono Delta Lactone (GDL) to an amount of 0, 0.5 and 1% w/w to the formulation. The mixture was then stuffed into slices of 6mm thickness in an industrial handfmann Stuffer (Albert Handfmann Mfd.Ltd., model-VF-80, West Germany). The slices were then vacuum packed and stored in -1°C freezer for further processing.

Table 1: Formulations for Different Treatments (All units are in grams)

Treatment	Meat	GDL	Salt	Sugar	Praque	Sodium Eythorbate	Water
pH:5.6	2787.92	0	51.58	60	9	1.5	90
pH: 5.35	2772.92	15	51.58	60	9	1.5	90
pH: 5.15	2757.92	30	51.58	60	9	1.5	90

2.2. Drying

Drying experiments were carried out in the laboratory scale microwave oven (Model-Panasonic NNC 980W) which has a provision to dry/heat in microwave, convection and combination of convective and microwave energy. Table 2 showed the specification of the microwave oven. This microwave oven has been modified to monitor online weight loss during drying and online temperature change. One end of fibre optic probe is connected to the Universal Multi channel Instrument, FISO Technologies Inc., Quebec, CA and another end will be in contact with the drying product. Data were acquired using the software Labview 6.0 (National Instruments, Austin, TX). Microwave drying was carried out in different power levels (P2, P3 and P4) to find the effect of different power levels on drying behaviour of beef jerky. Respective wattages have been given in the table 3. Microwave-convective combination drying experiments were done with the air temperature was set to 70° C, air flow rate 1.45 m/s, microwave power level P2 and 62% weight reduction. The product temperature was monitored while drying using the online temperature monitoring device. All the experiments were conducted in three replicates.

Operating Frequency	2450 MHz
Microwave Power Consumption	12.8 Amps, 1500 W
Heater Power Consumption	12.5 Amps, 1500 W
Microwave Output	1100 W
Heater Output	1400 W
Outside Dimensions	376 mm (H) x 606 mm (W) x 491 mm (D)
Oven Cavity Dimensions	242 mm (H) x 412 mm (W) x 426 mm (D)

Table 2: Specifications of Panasonic NNC 980 W-Microwave Oven

Table 3: Wattage value of power levels

Power Level	Power (Watts)
P1	295-Pulse Microwave (7 s ON, 14 s OFF)
P2	295-Pulse Microwave (14 s ON, 7 s OFF)
P3	295
P4	392

The dried samples were vacuum packed and kept in 4 ºC, as a prevention measure from moisture loss or gain.

2.3. Shrinkage loss Analysis

Initial and final volume has been measured and shrinkage coefficient was calculated by,

Shrinkage Coefficient = $[1 – (V_f / V_i)] \times 100$

Where V_f is the final volume and V_i is the initial volume of the sample (Trujillo, F.J et al. 2005).

2.4. Moisture content Measurement

Fresh and dried samples were passed through a precision grinder for three times with screen opening size equal to 3mm and the powder was mixed thoroughly after grinding. The 5 grams of these ground samples were taken in covered aluminium dishes and placed in a vacuum at 100°C under 100 mmHg absolute pressures for about 5hours till it reaches a constant weight. Measurements were done in three replicates for each treatment. The loss in weight was measured as moisture content as per ASAE S353 (2003) method.

2.5. Water Activity Measurement

Water activity, which is the critical parameter used to assure the product safety was measured in Aqua lab water activity meter (Model CX2, Decagon Devices Inc., Washington, USA). The dried sample was crushed into small pieces and placed in water activity measurement cup and the readings were noted. Measurements were taken in three replicates.

2.6. pH Measurement

pH of the fresh and dried samples were measured using the pH meter (Accumet-Model 15, Fisher Scientific). The pH meter was first calibrated with standard buffer solutions. 20 g of sample with 80ml of distilled water was mixed thoroughly in a household type blender for 30s. Electrode was immersed in the mixed slurry and the sample pH was read.

2.7. Color Measurement

Color of the meat before and after drying will be measured to indicate the appearance change. All the color measurements will be done using Hunter lab Color Analyzer- Labscan-2 (Hunter Associates laboratory,Inc. Virginia,USA). The fresh or dried samples were placed in the 1.25 cm of area of view and D65 was used as illuminant source. CIE lab color scale (L*, a* and b*) value were recorded, where 'L' coordinate indicates lightness, which represents the greyness ranging from black (L=0) to white (L=100). 'a' represents the redness/greenness of the product. Positive of 'a' indicates the redness of the product and the coordinate 'b' indicates the yellowness (positive) or bluishness (negative). Three replicates were taken for each treatment and six readings were taken. To evaluate the effect of different drying temperature on the overall combined color of dried meat, the index ΔE as given by following equation (Tabil.et al., 2001) was calculated by taking the color of fresh meat as the base value.

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

Where $\Delta L = L - L_{base}$, $\Delta a = a - a_{base}$ and $\Delta b = b - b_{base}$, and L, a, and b are the color coordinates of the sample and L_{base}, a_{base}, and b_{base} are the color coordinates of the control sample.

2.7. Statistical Analysis

The experiment has been designed in Randomized Complete Block Design (RCBD) and all the data were analysed using factorial ANOVA test in SAS for windows V8 (SAS Institute, Cary, NC).

3. RESULTS AND DISCUSSIONS

It was noticed from the observations given in table 4. that there was a significant impact on drying time was caused by changing the pH. Figure 1 shows the time taken to dry the product to 62% weight loss in combined microwave-convectional drying. Increasing the acidity of the jerky sample formulation, leads to the decrease in the drying time. The figure 2 shows the effect of different pH on one of the drying characteristics, drying time in the combination microwave-convection drying and figure 3 shows the effect of pH on drying time with respect to different power levels in microwave drying.

Table 4 showing the effect of pH on drying time

Sl.No	Sample pH	Drying Time, min	Water Activity
1	5.6(Control)	8.00	0.77
2	5.3	7.25	0.80
3	5.15	6.50	0.82

POWER LEVEL Vs DRYING TIME

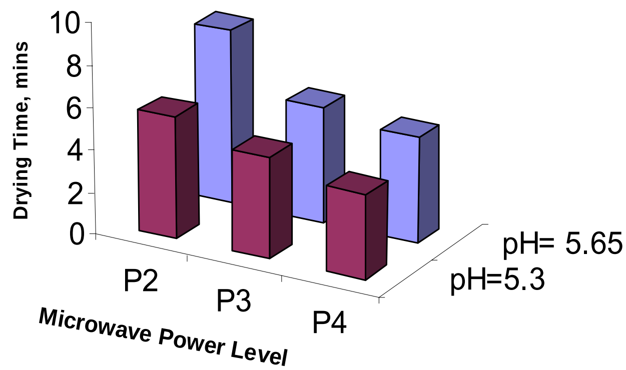

Figure 1 showing the effect of pH and Power level on drying time

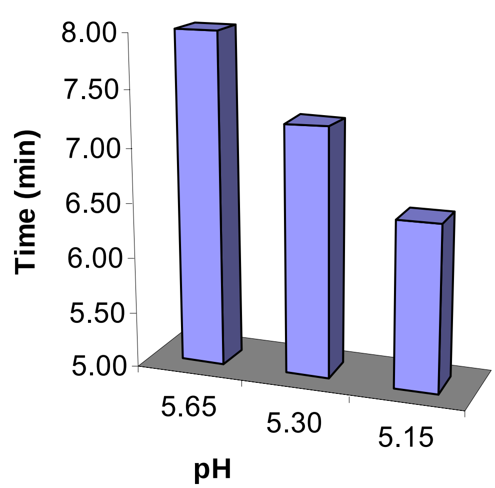

Figure 2 showing the effect of pH in combination microwave-convective Drying

Figure 3 shows the drying rate curves obtained for different samples with different pH levels. It is found from the drying curves that the pH has a significant influence in drying characteristics of beef jerky.

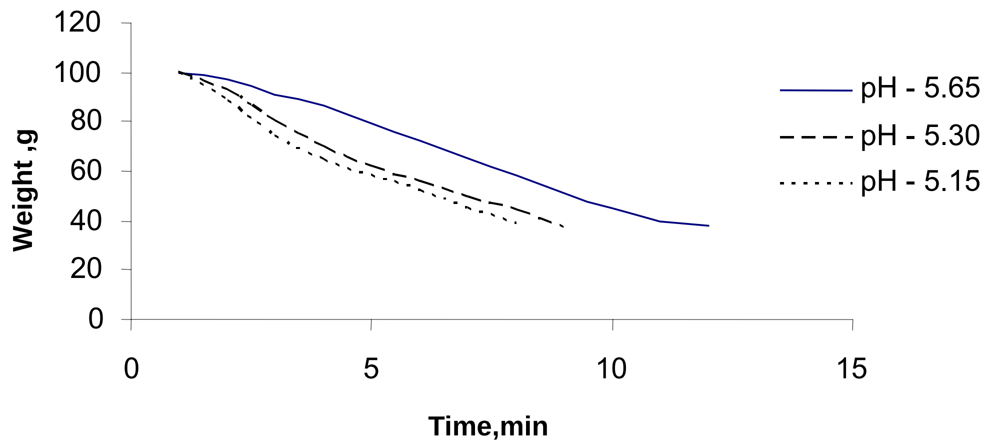

Figure 3.Showing the Microwave drying rate curves of samples having different pH

Table 5 shows the effect of pH on some of the physical properties of the jerky prepared with different pH levels. A same weight loss has showed different physical properties like water activity and moisture content among the different treatments. There was no significant difference between the final moisture content between the treatments. But, it was noticed that for the same 62% weight reduction the water activity values had a range from 0.77 to 0.85 which also falls in the Jerky product safety requirements. Regarding dimensional changes, there is no significant difference between samples having pH value 5.3 and 5.15.There was a significant difference between control samples with low pH values. From the observation showed in table 4, it is obvious that increasing the acidity of the sample has caused nearly 15% more shrinkage than control samples. In the table same alphabets shows there is no significant difference in the means.

Table 5: Physical Properties

Sl.No	Sample pH	% Weight loss	Initial Moisture Content (wb)	Final Moisture Content (wb)	Water Activity	Shrinkage Coefficient
1	5.6(Control)	62	68.37	15.42	0.77 a	45.04 a
2	5.3	62	69.57	14.50	0.80 b	61.00 b
3	5.15	62	67.47	15.82	0.82 c	60.03 b

The table 6 shows the color measurements gained after drying the Jerkies. There was significant difference between control samples and lower pH samples. But, there were no significant difference between pH levels 5.3 and 5.15.

Table 6: Color measurements

Sl.No	Sample pH	L*	a*	b*
1	5.6(Control)	32.62	13.88	6.37
2	5.3	31.67	16.97	11.63
3	5.15	29.34	17.42	13.70

4. CONCLUSION

It has been found out from the study that there is significant effect of power level in microwave drying of beef jerky. Compared to conventional processing method, microwave drying has given a significant time saving as well as energy saving. Also it was found out from the present study that pH has a significant effect on physical, chemical and drying characteristics of Beef Jerky. Other than higher shrinkage loss, lowering the pH to 5.15 has given a better physical, chemical and drying characteristics. It can be recommended from this study that microwave energy combined with other energy source like convection energy help in increasing production rate and saving energy and time in one of the meat preservation industries such as jerky processing.

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