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Physical characteristics of Frog (*Hoplobatrachus rugulosus)* leg affected by pulsed electric field

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Frog (*Hoplobatrachusrugulosus*) leg has good nutrional value with excellent flavor, texture and aroma. It's an important protein source in daily cuisine. High drip losses, low water holding capacity are major obstacles when trading this meat in local market. Pulsed electric field is one of the most innovative technologies operating at low temperature. This research inspected the effectiveness of pulsed electric field variables: numbers of pulse (250, 300, 350, 400, 450), and electric field strength (0.3, 0.6, 0.9, 1.2, 1.5 kV/cm) to drip loss of frog leg in 6 hours of handling. Results showed that electric filed strength below 0.9 kV/cm was greatly maintained more water holding capacity of frog leg during distribution by protecting protein integrity. At high number of pulse over 400, drip loss on frog leg was controlled effectively. It's suggested that the pulsed electric field as non-thermal treatment should be applied for frog leg to maintain its physical characteristics during distribution

Keywords: Drip loss, frog leg, non-thermal, physical characteristic, pulsed electric field, water holding capacity

INTRODUCTION

Frog (*Hoplobatrachusrugulosus*) is an attractive food as it's mainly collected in nature (Nguyen et al. 2018). It's commonly consumed due to its palatability (Efenakpo et al. 2016). It's considered as healthy food source based on its good nutritional value (Yatanan et al. 2016). Frog meat is highly prefered as lean meat by its adequate amino acid balance and low lipid percentage (Casali et al., 2005; Pires et al. 2006; Nobrega et al. 2007). Therefore frog meat is recommended in diets to control cholesterol, obesity, arterial hypertension, gastrointestinal disorders, convalescents (Mello et al. 2006; Nobrega et al. 2007). Frog meat can be utilized to compensate for calcium deficiency and osteoporosis, as it contains a great amount of calcium available for absorption (Paixao and Bressan, 2009).

Pulsed electric field (PEF) was an innovative processing method drawing much attention in meat processing as non-thermal treamtent to preserve the best product texture (Vorobiev and Lebovka 2008; Donsi et al. 2010; Puertolas et al. 2012; Giulia et al. 2021). PEF applied high-intensity electrical pulses (< 50 kV) for short duration times width (microseconds to milliseconds) by setting samples between two electrodes (Puertolas et al. 2016). There were three levels of electric field strengths: low intensity (<0.1 kV/cm), medium intensity (0.1÷1.0 kV/cm) and high intensity (> 1.0 kV/cm). Electric field strength (below 1.0 kV/cm) was suitable for soft material meanwhile > 1.0 kV/cm was appropriate for hard tissue (Puertolas et al. 2016). PEF induced trans-membrane potential by charging at the membrane layers (Vorobiev and Lebovka, 2008). When an electrical field was applied, it resulted in reversible and irreversible electroporation at the membrane. Reversible electroporation was suitable for biotechnological and medical purposes. Meanwhile irreversible electroporation (10–50 kV/cm) was utilized for enhancing disintegration and permeabilization (Raso et al. 2016; Wiktor et al. 2013). The efficiency of PEF relied on technical variables (electric field strength, number of pulses, time of treatment) and food matrix (Puertolas et al. 2012; Vorobiev and Lebovka 2008). PEF has capability to cause microtextural modification leading to the enhancement of meat quality. Different literatures mentioned to application of PEF on pork, beef, poultry (Baldi et al. 2020). PEF is used alone or couple with another method to synergistically improve product quality, microbial inactivation, and extracting recovery (Bhat et al. 2019; Gomez et al. 2019). PEF has not significant impact on water holding capacity, color and lipid oxidation (Arroyo et al. 2015; McDonnell et al. 2014; Suwandy et al. 2015b). Objective of our study was to examine the effectiveness of pulsed electric field treatments (numbers of pulse, electric field strength) on physical quality (drip loss or water holding capacity) of frog leg during distribution.

MATERIALS AND METHODS

2.1 Material

Frogs were naturally collected in local farm, Nga Nam district, SocTrang province, Vietnam. Frogs were processed quickly to obtain their leg under PEF equipment.

2.2 Researching method

Frog legs were treated by PEF equipment in different numbers of pulse (250, 300, 350, 400, 450), and different values of electric field strength (0.3, 0.6, 0.9, 1.2, 1.5 kV/cm) within 2 minutes. The treated frog legs were kept in plastic bag ready for distribution. They were sampled after 6 hours of distribution at ambient temperature to evaluate drip loss (%). Drip loss (%) = [(initial weight − weight after storage)/initial weight] × 100.

2.3 Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTSAND DISCUSSION

Table 1 presented the effect of numbers of pulse (250, 300, 350, 400, 450) by the pulsed electric field (PEF) treatment on drip loss (%) of frog leg. It's obviosly noticed that PEF significantly reduced drip loss (%) on frog leg compared to control. At high number of pulse over 400, drip loss on frog leg was controlled effectively. Our findings were similar to others in different reports. The numbers of pulse exerted a remarkable effect on the drip loss of chicken meat (Giulia et al. 2021). Improvement of the water holding properties was noticed on pollock fillets by electric field strength 1.2–2.0 kV/cm, pulse number 20 (Gomez et al. 2019). PEF treatment had differential effect on water holding capacity of beef loins (Bekhit et al. 2016). Number of pulse could be adjusted on the basis of the geometry and distance of the working electrodes, the voltage delivered, and the conductivity of the material applied (Ricci et al. 2018). Alahakoon et al. (2017) proved the improvement of the tenderness in collagen-rich meat by PEF treatment.

Table 2 illustrated the efficiency of electric field strength (0.3, 0.6, 0.9, 1.2, 1.5 kV/cm) by the pulsed electric field (PEF) treatment on drip loss (%) of frog leg. It's clearly realized that PEF significantly electric filed strength below 0.9 kV/cm was greatly maintained more water holding capacity (less drip loss) of frog leg during distribution by protecting protein integrity.

Table 1: Numbers of pulse to drip loss (%) of frog leg after 6 hours of distribution

Numbers of pulse	0	250	300	350	400	450
Drip loss (%)	7.29±0.04^{a}	2.12±0.01^{b}	1.69±0.03^{bc}	1.05±0.02^{c}	0.75±0.00^{cd}	0.58±0.01^{d}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2: Electric field strength (kV/cm) of frog leg after 6 hours of distribution

Electric field strength (kV/cm)	0	0.3	0.6	0.9	1.2	1.5
Drip loss (%)	7.29±0.04^{a}	0.75±0.00^{d}	1.32±0.02^{cd}	1.78±0.00^{c}	2.35±0.01^{bc}	2.79±0.03^{b}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

Our findings were similar to others in different reports. Low-intensity PEF treatments greatly reduced drip loss in chicken breast fillets (Gomez et al. 2019). Moisture entering the lipid bilayer might be trapped into the pores, thus leading to a reduced drip loss. Low intensity PEF treatments induced proteins' conformational changes causing a modification of interactions between polar and apolar amino acids, hence improving the interactions between proteins and water molecules (Giulia et al. 2021). High-intensity PEF caused irreversible electroporation inducing an accumulation of drip loss by protein denaturation, myofibril fragmentation, cell rupture and leakage of cell fluids into extracellular spaces (Gudmundsson and Hafsteinsson, 2001). O'Dowd et al. (2013) utilized low PEF electric fields on beef muscle to reduce weight loss. Suwandy et al. (2015) confirmed that PEF is suitable to tenderize beef muscle.

CONCLUSION

Pulsed electric field is a non-thermal innovative technology widely applied in food industry. This research successfully found out the effect of pulsed electric field variables: numbers of pulse and electric field strength to drip loss of frog leg in 6 hours of handling. PEF treatment could be utilized as an innovative method to improve water holding capacity of frog meat. The application of PEF technology to frog processing would be highly favorable due to the low energy requirement and quick processing time.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

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