

HYDRODYNAMIC SHOCK WAVE: DECREASING BROILER BREAST AGING TIME

by
Kimberly I. Meek

Chairman: James R. Claus

Department of Food Science and Technology

(ABSTRACT)

The broiler industry faces the inability to effectively eliminate or significantly reduce the aging time required during the processing of broiler breast meat. Early boning results in breast meat that is unacceptable in tenderness. The breast meat must age on the carcass for 4 to 7 hours postmortem which increases labor, refrigeration, and storage costs. Additionally, during storage, considerable weight is lost from the breasts due to purge.

The Hydrodyne process is a unique technology that utilizes a small amount of explosive to create a shock wave in an enclosed specially designed tank filled with water. In a fraction of a millisecond, the shock wave passes through the water and objects that are a mechanical impedance match to the water. The meat's cellular components are instantaneously ruptured, thereby improving meat tenderness.

This research was designed to include two related objectives. The first objective was to determine the effects of different combinations of explosive level and distance of explosive to meat surface for tenderizing early de-boned broiler breasts using the Hydrodyne process, based on instrumental shear force measurements. The Hydrodyne process was imposed (24 hours post-mortem) on broiler breasts (*Pectoralis superficialis*) removed immediately after initial chilling (approximately 45 minutes post-mortem; early

de-boned, Hydrodyne treated; HYD) and were compared to early de-boned, non-Hydrodyne treated breasts (EB) and aged control breasts (CA). An explosive level and distance combination of 350 g at 20 cm (pressure front of 25,700 psi) produced a 28.3% improvement in tenderness (HYD; 4.3 kg shear force) over the EB (6.0 kg shear force) broiler breasts. Additionally, this treatment combination reduced the peak force required to shear the HYD samples (4.3 kg) to a statistically similar level as the CA broiler breasts (3.1 kg).

The second objective was to evaluate meat quality characteristics including tenderness, sensory, purge and cooking losses, breast thickness, and color characteristics of early de-boned broiler breasts treated with the most effective explosive amount and distance combination using the Hydrodyne process determined in objective 1. Based on the results from the first objective, four replications of EB broiler breasts were treated with the Hydrodyne process (350 g at 20 cm) 24 hours post-mortem over two subsequent weeks. Shear and sensory samples were analyzed on cooked 1.0-cm wide strips taken from the medial section of each breast. Cooking loss was determined on samples analyzed for sensory traits. pH was measured on raw CA and EB samples to determine a baseline. Additionally, the pH samples were used to determine purge loss and plumpness of each treatment. Color was determined on individual raw and cooked breasts.

Warner-Bratzler and Lee-Kramer shear values for CA (1.6 kg; 6.0 kg*mm/g, respectively) were different ($P<0.05$) from both HYD (3.8 kg; 11.0 kg*mm/g, respectively) and EB breasts (4.7 kg; 12.1 kg*mm/g, respectively). Furthermore, HYD were not different ($P>0.05$) than EB breasts. Part of this lack of tenderness improvement, unlike that found in objective 1, may be related to the initially more tender EB breasts

used in this objective. CA breasts resulted in higher scores for the sensory characteristics of tenderness, moisture release initial and sustained, and flavor compared to HYD and EB. HYD breasts were lower than EB controls only in initial moisture release. The HYD and EB samples were not different ($P>0.05$) in tenderness, sustained moisture release, and flavor. pH values for CA (5.86) were higher ($P<0.05$) than EB (5.71) breasts. Purge loss was not affected by HYD or by boning treatment ($P>0.05$). Cooking loss was higher ($P<0.05$) for HYD (22.2%) compared to CA (20.6%). The raw HYD breasts were less red ($P<0.05$) than the CA breasts. Cooked color of HYD breasts was similar ($P>0.05$) to CA breasts for CIE a^* and CIE b^* and was darker (CIE L^*) on the skin side.

EB breasts with significant tenderness problems can be tenderized by the Hydrodyne process based on instrumental shear results. However, higher levels of explosive may be required to optimize the tenderness improvement of EB breasts that vary significantly in initial tenderness. Incorporation of this technology, once optimized, on an industry production level would benefit poultry processors in reducing or eliminating broiler breast aging.

ACKNOWLEDGEMENTS

The completion of this project would not be possible with the strong support and guidance of many colleagues and friends. I would like to thank Dr. James Claus for maintaining a strong commitment to excellence in research with his attention to detail and valuable interpretation skills. Dr. Susan Duncan helped me greatly with professional guidance and friendship. Drs. Morse Solomon and Norman Marriott were willing participants with professional advise. Michele Marini and Steven Kathman helped me tremendously to overcome my statistical ineptness to create a successful thesis.

Harriet Williams, Mark Price, and John Chandler have been an invaluable resource contributing to the success of this project. Their technical help as well as their humor kept my project rolling. Mark Price's expertise will be sorely missed.

Thanks to my friends, Melanie and Marsha who stood by me during the good times and the bad. They also stayed late through the evenings during the analyses to help maintain my sanity. Thanks for all of the dinners and delivered lunches to keep my project moving forward. The Collegiate 4-H Club provided extracurricular activities and uplifting encouragement to help ease my tensions. Special thanks to Karen, who wept, cheered and helped keep my motivation moving in the right direction. Kimberly brought new light and humor to my life just when I needed a lift. Dr. Nancy Jack helped me to stand up for my beliefs and realize that my goals are the most important. My Mom and Dad always encouraged my efforts and believed in me even when I lost faith.

A million thanks to my beloved Sierra, Charlie, and Merlin for their unconditional love, long walks, gallops through the fields, and friendly purrs goodnight. My love and respect goes to Dean for his continuous emotional support and constant motivation during the highs and lows of this project. His patience, love, and respect helped me maintain my strength. Also Dean helped me realize that one belief will help you through anything-- faith in God.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	ii
ACKNOWLEDGMENTS	v
TABLE OF CONTENTS	vii
LIST OF TABLES AND FIGURES.....	ix
1.0 Introduction.....	1
2.0 Literature Review	6
2.1 Meat Tenderness.....	6
2.1.1 Factors affecting tenderness.....	6
2.1.2 Tenderness measurements	9
2.2 Tenderization Methods	11
2.2.1 Aging	11
2.2.2 Electrical Stimulation	13
2.2.3 Ultrasonic Techniques	16
2.2.4 Hydrostatic Pressure.....	17
2.2.5 Hydrodynamic Pressure.....	17
2.3 References	26
3.0 Quality and sensory characteristics of post rigor, early de-boned broiler breast meat tenderized using a hydrodynamic shock wave	31
3.1 Abstract	31
3.2 Introduction	32
3.3 Materials and Methods.....	36
3.3.1 Sample Preparation and Treatment.....	36
3.3.2 Sample Cookery	38
3.3.3 Shear Force Measurements	39
3.3.4 Sensory Evaluation	40
3.3.5 Purge Losses and pH	42
3.3.6 Breast Plumpness.....	42
3.3.7 Cooking Loss	43
3.3.8 Instrumental Color.....	43
3.3.9 Statistical Analysis.....	44
3.4 Results and Discussion.....	45
3.4.1 Shear Force Measurements	45
3.4.2 Sensory Evaluation	49
3.4.3 Plumpness.....	50
3.4.4 pH and Purge Loss.....	50

	<u>Page</u>
3.4.5 Cooking Loss.....	51
3.4.6 CIE L*a*b* Color.....	51
3.5 Summary and Conclusions	53
3.6 References.....	54
Appendix A.....	67
Appendix B	72
Vita	73

List of Tables and Figures

<u>Chapter 2: Literature Review</u>	<u>Page</u>
Figure 1..... Schematic representation of the Hydrodyne tank.	20
Figure 2..... Explosive suspended in tank with broiler breast placed in bottom center of the tank.	21
Figure 3..... The explosive is detonated and the primary wave front formation occurs first.	21
Figure 4..... The gas sphere (secondary wave front) evolves.	21
Figure 5..... Reflection of wave front.	23
Figure 6..... Intersection of reflected and remaining portion of the incoming wave front.	23
 <u>Chapter 3: Comprehensive Testing</u>	
Table 1..... Warner-Bratzler shear peak force values for Hydrodyne treated skinless early de-boned broiler breasts, companion early de-boned (no treatment) breasts, and aged (control) breasts cooked to 78°C	58
Table 2..... Mean Warner-Bratzler (WBS) and Lee-Kramer (LK) shear force values for Hydrodyne treated (350 g explosive at 20 cm) skinless early de-boned broiler breasts, companion early de-boned (no-treatment) breasts, and aged (control) breasts	59
Table 3..... Mean sensory values for flavor (FLV), initial moisture release (IMR), sustained moisture release (SMR), and tenderness (TEND) of Hydrodyne treated skinless early de-boned broiler breasts, companion early de-boned (no treatment) breasts, and aged (control) breasts evaluated by a trained sensory panel	60
Table 4..... Plumpness for skinless early de-boned broiler breasts and companion Hydrodyne treated (350 g explosive at 20 cm) breasts	61

	<u>Page</u>
Table 5.....	62
Purge and cooking losses for Hydrodyne treated (350 g explosive at 20 cm) skinless early de-boned broiler breasts, companion early de-boned (no treatment) breasts, and aged (control) breasts after 24 hours storage at 4°C	
Table 6.....	63
Raw color (CIE L*a*b*) for Hydrodyne treated (350 g explosive at 20 cm) skinless early de-boned broiler breasts, companion early de-boned (no treatment) breasts, and aged (control) breasts for skin and bone sides of the breasts	
Table 7.....	64
Raw color (CIE L*a*b*) for the skin and bone sides of Hydrodyne treated (350 g explosive at 20 cm) skinless early de-boned broiler breasts, companion early de-boned (no treatment) breasts, and aged (control) breasts	
Table 8.....	65
Cooked color (CIE L*a*b* values) differences for Hydrodyne treated (350 g explosive at 20 cm) skinless early de-boned broiler breasts, companion early de-boned (no treatment) breasts, and aged (control) breasts for skin and bone sides of the breasts	
Table 9.....	66
Cooked color (CIE L*a*b* values) of the skin and bone sides of Hydrodyne treated (350 g explosive at 20 cm) skinless early de-boned broiler breasts, companion early de-boned (no treatment) breasts, and aged (control) breasts sous-vide cooked to an internal temperature of 78°C	