บทความวิจัย

ผลของการใช้ความดันสูงต่อลักษณะทางกายภาพของเนื้ออกไก่หมักน้ำเกลือ
Effect of High Pressure Processing on Physical Properties of Brined Chicken Breasts

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บทคัดย่อ

เทคโนโลยีความดันสูงมีส่วนช่วยเพิ่มความนุ่มให้เนื้อสัตว์ ความดันที่ระดับ 100 200 300 เมกะปาสคาล เวลา 10 นาที ถูกนำมาใช้เพื่อศึกษาเนื้ออกไก่หมักน้ำเกลือที่ความเข้มข้นร้อยละ 10 และ 20 (เนื้ออกไก่หมักพร้อมปรุง) จากนั้นให้ความร้อนที่ระดับพาสเจอร์ไรส์ 90±2 องศาเซลเซียส นาน 20 นาที (เนื้ออกไก่หมักพร้อมรับประทาน) ผลที่ได้พบว่าเนื้ออกไก่หมักพร้อมปรุงผ่านความดันที่ 200 เมกะปาสคาล ช่วยให้เนื้ออกไก่หมักน้ำเกลือที่ความเข้มข้นร้อยละ 10 มีเนื้อสัมผัสที่แข็งแต่ยืดหยุ่นมากกว่าที่ความเข้มข้นร้อยละ 20 อย่างมีนัยสำคัญทางสถิติ ($p \leq 0.05$) และเมื่อความดันเพิ่มขึ้นที่ระดับ 300 เมกะปาสคาล พบว่าเนื้ออกไก่หมักน้ำเกลือที่ความเข้มข้นร้อยละ 10 มีค่าแรงต้านต่อการเคี้ยวมากกว่าเนื้ออกไก่หมักที่ความเข้มข้นร้อยละ 20 อย่างมีนัยสำคัญทางสถิติ ($p \leq 0.05$) ค่าความสว่าง (L*) ของเนื้ออกไก่หมักน้ำเกลือพร้อมปรุงที่ความเข้มข้นร้อยละ 10 และ 20 มีค่าเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p \leq 0.05$) เมื่อความดันสูงขึ้นที่ 300 เมกะปาสคาล สำหรับความดัน 200 และ 300 เมกะปาสคาล มีผลต่อค่าความเป็นสีแดง (a*) ของเนื้ออกไก่หมักน้ำเกลือพร้อมรับประทานที่ความเข้มข้นร้อยละ 10 และ 20 ($p \leq 0.05$) ค่า ความเป็นกรด-ด่าง ของเนื้ออกไก่หมักน้ำเกลือพร้อมปรุงที่ความเข้มข้นร้อยละ 10 และ 20 มีค่าเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p \leq 0.05$) เมื่อให้ความดัน 300 เมกะปาสคาล

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ABSTRACT

High Pressure Processing (HPP) is a promising way to tenderize meat. HPP treatment at 100, 200 and 300 MPa for 10 min was employed to study 10% and 20% brined chicken breasts (RTC meats), thereafter HPP pasteurization treatment at 90±2 °C for 20 min (RTE meats). The results showed that pressure treatment above 200 MPa induced significantly ($p \leq 0.05$) the RTC meat texture for 10% brine with harder but higher springiness than 20% brine. The chewiness showed higher in 10% brine than 20% brine at 300 MPa. Meat color was significantly effected ($p \leq 0.05$) by HPP at 300 MPa with increasing L* value for both 10% and 20% RTC meats. The redness (a*) value only affected RTE meats for 10% and 20% RTE when the pressure increased to 200 and 300 MPa. A significant ($p \leq 0.05$) increase was found in 10% and 20% RTC meats when treated with 300 MPa.

Keywords: high pressure processing (HPP), ready-to-cook (RTC), ready-to-eat (RTE), brined chicken breast, texture characteristic

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INTRODUCTION

In recent years, ready-to-cook (RTC) and ready-to-eat (RTE) foods have come to replace most traditional cooking and food preparations. Ready-to-cook (RTC) foods have been developed as an alternative to home-cooked meals and only require preparations such as reheating and cooking before consumption. Ready-to-eat (RTE) food items are already cooked, packaged and ready to be consumed. RTC and RTE food products are generally based on fruits, vegetables, meat, poultry, and fish [1]. The growth of poultry consumption has increased due to a rising individual consumption and population growth, resulting in the creation and development of meat products [2]. Poultry meat contributes to high-quality protein and contains healthy fatty acids. The important factor of chicken breast characteristics is the tenderness that has a relation to the overall organoleptic properties for consumers [3]. Marinated or brined chicken breasts have become an important part of the poultry industry due to the expansion of the consumer markets and the demand for RTE meals [4-6]. There are two types of treatments for making meat more tender: chemical and physical. Chemical treatment is performed by the addition of enzymes and food additives. Physical treatment is processed by a mechanical tenderizer, injector, and tumbler. Brine helps to dissolve myofibril proteins in meats and reduces the muscle fibers from contracting tightly. This is commonly used as a way to tenderize the meat and increase juiciness because myofibril proteins dissolve in high ionic strength brines and contribute a gel formation to hold water [6]. Meat containing approximately 12%, 15% or 30% brine solution consisting of water, salt, phosphate, and other flavor ingredients is often complemented by tumbling (~30 min) or injection to increase moisture and juiciness [6-7]. A tumbled chicken marinade for 15, 30 and 45 min was found to significantly increase the appearance and overall acceptability at a higher tumbling time [8].

High pressure processing (HPP) is a successful alternative to non- thermal processing technology and recognized as a gentler preservation for food and has a minimal impact on sensory quality and nutritional value, but ensures food safety [9]. Manufacturers of fresh foods with a short shelf life can benefit from HPP. HPP technology meets the prerequisite standard for improving meat quality traits such as color, texture characteristics, protein microstructure, and shelf life. Moreover, the treatment significantly improved water retention and the rate of chicken breast cooking loss [10]. Commercially, HPP is a pasteurization process that applies ultra-high pressure between 100 MPa and 600 MPa. The products are processed in a closed system and conveyed by a liquid medium, usually water. According to the isostatic system, pressure passes through a confined fluid at any point equally in the system regardless of object shape or size [11]. Normally, HPP treatment is conducted at 100, 200, and 300 MPa for 5 and 10 min to improve the texture quality of chicken breast meat. A level of pressure between 100 and 200 MPa helped to tenderized chicken breast fillets,

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whereas the hardness property increased when the elevated pressure was 300 MPa in the same samples [12]. The objective of this study was to investigate the effects of HPP treatment at 100, 200, and 300 MPa for 10 min on the physical properties of RTC and RTE brined chicken breasts. Two different brine percentages (10% and 20%) followed by tumbling for 45 min before HPP treatments were also studied. The pasteurization was conducted at 90±2 °C for 20 min for HPP-treated RTE products.

MATERIALS AND METHODS

1. Materials

The skinless and boneless chicken breasts were sponsored by CPF (Thailand) Public Co., Ltd chicken processing factory. The ingredients of the brine solutions (tapioca starch, salt, and white pepper) used in the experiment were food grade and purchased from a local market.

2. Sample preparation

The chicken breasts were trimmed into pieces (100±5 g) with the tendon removed. The brine uptake of chicken breast weight was 10% and 20% brine solutions containing water, tapioca starch and pepper powder, then a tumbler-marinated process applied for 45 min (Foma Comini Tumbler Model). Thereafter Brined chicken breasts were packed individually in a high-pressure bag (Polyethylene + Nylon 70) and vacuum sealed (Audionvac 151H^{TM}). The samples were stored at 4 °C after preparation before being tested in the laboratory at Science Park (Naresuan University, Thailand).

3. HPP conditions

Samples were pressurized in a 5 L model of a high pressure machine (BaoTou KeFa High Pressure Technology Co., Ltd (KEFA), China). The Individual packs of brined chicken breasts were treated at 100, 200, and 300 MPa for 10 min. Control samples were subjected to 0.1 MPa at 4±1 °C. The samples were placed in a HPP vessel then submerged in a water-based hydrostatic fluid medium. The initial temperature of the samples was equilibrated to 4±1 °C. The internal temperature before pressurization was 25±2 °C in the high pressure vessel and at 30±2 °C after pressurization. After pressurization, all individual packs of brined chicken breasts, called RTC samples, were stored in a refrigerator until the sample analysis was performed. Other HPP-treated samples were heated in pasteurization step called RTE samples.

4. Pasteurization

After HPP treatment, samples were heated in a water bath at 90±2 °C for 20 min. This pasteurization time was chosen because it was sufficient to reach the core temperature (85±2 °C) for chicken breasts. Thereafter the cooling step for the chicken breast samples was applied in a water bath (25±2 °C) for 10 min. Then individual sample packs were dried and stored in a refrigerator at 4 °C, before sample analysis.

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5. Texture profile analysis

Texture profiles were used for hardness, springiness, cohesiveness, and chewiness to evaluate the texture characteristics of RTC and RTE brined chicken breasts after HPP treatments by using TA.XT. Plus Texture Analyzer (Stable Micro System, UK) equipped with a cylinder radius probe (∅ 36 mm). Samples were cut into cubes ($1.5 \times 1.5 \times 1.5$ cm^3) and each sample was subjected to 3 repetitions. The test speed was 2.0 mm/s and the trigger force was 10 g. The level of compression was set at 75% with time interval of 5.0 s between two compressions.

6. Color and pH measurement

The color values of lightness (L*), redness (a*), and yellowness (b*) of the chicken breasts were measured with indicated positions of lower and upper parts using UltraScan® VIS (Hunter Associates Laboratory, Virginia, USA). The pH values of the chicken breast samples were measured in 3 repetitions using a portable pH meter (Mettler Toledo S2 Seven2Go™) with a pH Electrode LE427 at room temperature (25 ± 1 °C).

7. Statistical analysis

The experiments applied a 3 × 2 factorial design with pressure levels at 100, 200, and 300 MPa and brine percentages of 10% and 20%. The One-way analysis of variance (ANOVA) was carried out using SPSS statistics 23.0 software (SPSS Inc., Chicago, IL, USA). Results were expressed as mean values and standard deviations of the triplicate experiments. Differences between means were assessed using Tukey's test, the significance being assigned at $p \leq 0.05$.

RESULTS AND DISCUSSION

The effects of high pressure processing (HPP) at 100, 200, and 300 MPa on the physical properties of RTC and RTE brined chicken breasts with different brine percentages of 10% and 20% were investigated.

1. Effects of HPP on texture analysis

The texture profiles were assessed as hardness, springiness, cohesiveness and chewiness as shown in Table 1 and Table 2 for RTC and RTE brined chicken breasts respectively. For RTC samples with 10% and 20% brined chicken breasts, an increasing pressure from 100 to 300 MPa had no significant affected on all four texture attributes (hardness, springiness, cohesiveness and chewiness), except the 10% brined sample, where springiness trended to increase with an increasing pressure at 300 MPa. The hardness was lower in 20% brined chicken breasts than 10% brined chicken breasts at pressure 100 and 300 MPa (Table 1). The effect of HPP treatment on springiness of RTC samples showed a significantly higher value at 10% brine solution than at the 20% brine solution (Table 1). The chewiness of RTC brined chicken breasts at 10% brine showed it to be chewier than 20% brine at 300 MPa (Table 1). Guo et al. [13] reported that salt concentration had impacted flavor, firmness and juiciness due to changes in the functional properties of gel formations explained by the gel microstructures and transformations among the secondary structure of proteins. The products with sodium chloride content had an influence on the formation of the pressure-induced gelation of meat proteins

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that resulted in improving meat texture. The tenderness of meat increased when low pressure levels at 100-200 MPa were applied to meat, whereas pressure level at 300 MPa increased hardness in chicken breast fillets [12]. Many researchers reported that the hardness profile increased significantly with an increase of pressure because HPP could strengthen the intermolecular disulfide bonds in meat and facilitated the denatured protein [10, 14]. At pressure levels of 300 MPa the chewiness between 10% and 20% brine was significantly different and an improvement of chewiness was found in 20% brine, RTC meat. These results showed a similarity to the report of Kruk et al. [15] who found an improvement of duck meat chewiness when HPP treatment increased to 300-600 MPa. For RTE samples, HPP treatments showed no significant effect on the hardness for 20% brine (Table 2) whereas the hardness showed a significant affect for 10% brine, between RTE control and pressure treated at 200 and 300 MPa. However, the control RTE sample for 10% brine was significantly less cohesive and chewy than samples treated at 300 MPa, whereas RTE for 20% brine solution showed no significant affect between the control and other HPP treatments (Table 2).

2. Effects of HPP on color attributes

One of the most important attributes of any white meat appearance is color. Color values of the RTC and RTE brined chicken breasts after pressure treatment were shown in Table 1 and Table 2 respectively. Chicken breasts containing a low content of myoglobin appeared slightly pinkish to yellow color. The initial meat color differences affected the lightness (L*) of RTC and RTE brined chicken breast. The lightness (L*) values of the RTC with 10% and 20% brine ranged from 55.23±1.54 to 66.20±1.89 (Table 1). HPP treatment at 300 MPa had a significant effect on the lightness for RTC with 10% and 20% brine. Carlez et al.[16] also mentioned that pressure at or above 200 MPa caused a whitening effect to meat. HPP at higher pressure levels mainly induced protein denaturation and caused color changes in meat such as chicken, beef, pork and lamb due to the modification of myoglobin molecules [17]. The redness values (a*) of RTC brined chicken breasts did not significantly change as the pressure increased. The lightness (L*) values of the RTE with 10% and 20% brine ranged from 73.35±4.17 to 77.86±1.59 (Table 2). Lightness was not significantly affected by increasing the pressure levels for 10% and 20% brine of RTE samples. Measurements of the L* value were lower in RTE with 10% brine compared with that of 20% brine at 100 MPa. Zhuang and Bowker [18] reported that the lightness of chicken breast after brining depended on the brine concentration and the initial raw meat color. Brine increased the pH in chicken breast leading to a lower intensity of scattered light and a higher light transmittance into the muscle fibers. HPP treatments at 200 and 300 MPa significantly showed an increase in the redness values (a*) for 10% brine but significantly decreased in 20% brine for RTE chicken breasts. Smith and Young [19] reported that generally in the meat cooking process, marinating broiler meat has been shown to increase the lightness and decrease the redness. Based on the yellowness values

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(b*) results obtained of RTC and RTE controls, increasing HPP to 200 and 300 MPa resulted in non-significant values (p>0.05). According to the report of Radovčić et al. [12] HPP had less effect on yellowness (b*) of chicken breast meat, where the yellowness remained unchanged or increased slightly.

3. Effects of HPP on pH

The pH values of RTC and RTE chicken breasts showed no significant change for 10% and 20% brine at a pressure of 200 MPa and 100 MPa (Table 1 and Table 2). However, increasing HPP to 300 MPa resulted in a significant increase of the pH values (p≤0.05) of RTC chicken breast for both 10% and 20% brine (Table 1). According to the research of Sazonova et al. [20] the pH of meat such as pork, beef, lamb, chicken and tuna depended on pressure levels and became slightly higher with increased pressure levels. HPP increased ionization with the loss of acid groups in meat and promoted protein denaturation [21].

Table 1 Effect of HPP treatments for 10 min on the physical properties of different RTC brined chicken breasts (Mean±SD)

Property	% brine	Control	HPP treatment		
			100 MPa	200 MPa	300 MPa
Hardness	10	5.13 ± 0.84^{aA}	5.93 ± 1.41^{aA}	6.83 ± 3.82^{aA}	7.34 ± 1.32^{aA}
	20	5.80 ± 1.97^{aA}	4.27 ± 1.17^{aB}	5.29 ± 1.56^{aA}	4.81 ± 1.43^{aB}
Springiness	10	0.35 ± 0.05^{bA}	0.42 ± 0.05^{abA}	0.40 ± 0.07^{abA}	0.47 ± 0.13^{aA}
	20	0.39 ± 0.09^{aA}	0.35 ± 0.07^{aB}	0.40 ± 0.06^{aA}	0.35 ± 0.04^{aB}
Cohesiveness	10	0.16 ± 0.04^{aA}	0.17 ± 0.06^{aA}	0.20 ± 0.07^{aA}	0.17 ± 0.04^{aA}
	20	0.18 ± 0.06^{aA}	0.17 ± 0.04^{aA}	0.16 ± 0.05^{aA}	0.16 ± 0.04^{aA}
Chewiness	10	0.30 ± 0.14^{aA}	0.44 ± 0.25^{aA}	0.53 ± 0.30^{aA}	0.65 ± 0.44^{aA}
	20	0.44 ± 0.27^{aA}	0.26 ± 0.13^{aA}	0.34 ± 0.21^{aA}	0.30 ± 0.17^{aB}
L*	10	58.01 ± 2.54^{bcA}	59.42 ± 1.98^{bA}	55.23 ± 1.54^{cB}	66.20 ± 1.89^{aA}
	20	55.51 ± 1.07^{bB}	57.26 ± 2.13^{bA}	57.6 ± 1.74^{bA}	65.96 ± 0.34^{aA}
a*	10	3.54 ± 0.68^{aA}	3.75 ± 0.99^{aB}	3.57 ± 0.84^{aA}	4.40 ± 0.48^{aA}
	20	4.17 ± 1.36^{aA}	3.95 ± 0.94^{aA}	4.09 ± 0.95^{aA}	3.67 ± 0.38^{aB}
b*	10	13.28 ± 1.88^{aA}	11.26 ± 0.66^{bA}	12.48 ± 1.27^{abA}	12.54 ± 0.8^{abA}
	20	12.96 ± 1.27^{aA}	11.80 ± 1.78^{aA}	12.21 ± 1.16^{aA}	11.60 ± 0.85^{aA}
pH	10	5.78 ± 0.05^{bA}	5.79 ± 0.02^{bA}	5.77 ± 0.05^{bA}	6.05 ± 0.04^{aA}
	20	5.78 ± 0.03^{bA}	5.82 ± 0.06^{bA}	5.80 ± 0.08^{bA}	6.09 ± 0.06^{aA}

^{a,b} Different letters in the same row indicate a significant difference (p≤0.05).

^{A,B} Different letters in the same column of the same property indicate a significant difference (p≤0.05).

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Table 2 Effect of HPP treatments for 10 min and pasteurization at 90±2 °C for 20 min on the physical properties of different RTE brined chicken breasts (Mean±SD)

Property	% brine	Control	HPP treatment		
			100 MPa	200 MPa	300 MPa
Hardness	10	7.83 ± 1.65^{bA}	9.2 ± 1.73^{abA}	9.92 ± 1.61^{aA}	9.8 ± 1.49^{aA}
	20	8.38 ± 1.78^{aA}	7.78 ± 2.33^{aA}	9.53 ± 2.46^{aA}	9.43 ± 3.73^{aA}
Springiness	10	0.56 ± 0.08^{aA}	0.56 ± 0.05^{aA}	0.54 ± 0.04^{aA}	0.59 ± 0.07^{aA}
	20	0.57 ± 0.1^{aA}	0.52 ± 0.06^{aA}	0.57 ± 0.05^{aA}	0.53 ± 0.08^{aA}
Cohesiveness	10	0.27 ± 0.05^{bA}	0.28 ± 0.04^{abA}	0.3 ± 0.04^{abA}	0.32 ± 0.04^{aA}
	20	0.27 ± 0.07^{abA}	0.26 ± 0.05^{bA}	0.33 ± 0.04^{aA}	0.31 ± 0.05^{abA}
Chewiness	10	1.23 ± 0.49^{bA}	1.47 ± 0.44^{abA}	1.62 ± 0.33^{abA}	1.9 ± 0.51^{aA}
	20	1.31 ± 0.49^{abA}	1.1 ± 0.49^{bA}	1.81 ± 0.64^{aA}	1.69 ± 0.89^{abA}
L*	10	73.79 ± 0.64^{aB}	74.06 ± 1.17^{aB}	74.96 ± 1.87^{aA}	73.35 ± 4.17^{aA}
	20	77.86 ± 1.59^{aA}	76.66 ± 1.64^{aA}	76.07 ± 1.41^{aA}	75.20 ± 1.09^{aA}
a*	10	1.89 ± 0.05^{bB}	2.38 ± 0.21^{abA}	2.51 ± 0.19^{aA}	2.5 ± 0.58^{aA}
	20	2.69 ± 0.21^{aA}	1.77 ± 0.42^{abA}	2.24 ± 0.42^{bA}	1.9 ± 0.25^{bA}
b*	10	14.95 ± 0.39^{bA}	16.53 ± 0.49^{aA}	14.98 ± 0.85^{bA}	14.14 ± 0.56^{bA}
	20	15.21 ± 0.29^{bA}	12.61 ± 0.97^{aB}	13.92 ± 0.97^{bB}	12.85 ± 1.74^{bB}
pH	10	6.26 ± 0.14^{aA}	6.28 ± 0.03^{aB}	6.29 ± 0.06^{aA}	6.27 ± 0.09^{aA}
	20	6.38 ± 0.03^{aA}	6.33 ± 0.05^{aA}	6.27 ± 0.06^{aA}	6.29 ± 0.04^{aA}

$^{a, b}$ Different letters in the same row indicate a significant difference ($p \le 0.05$).

$^{A, B}$ Different letters in the same column of the same property indicate a significant difference ($p \le 0.05$).

CONCLUSIONS

The physical properties of brined chicken breasts showed that changes were affected by the percentage of the brine solution and HPP treatments. For RTC brined chicken breasts, HPP treatment at 300 MPa for 10 min affected the lower hardness and springiness in 20% brined meat more than 10% brined meat. Increasing the pressure level to 300 MPa affected the color by increasing L* value for both 10% and 20% brine RTC samples. The effects of HPP on the pH of meat showed no significant difference ($p>0.05$) between 10% and 20% brine for RTC brined chicken breasts. HPP treatments at 100, 200 and 300 MPa for 10 min showed no significant effect on the texture attributes (hardness, springiness, cohesiveness and chewiness) for RTE brined chicken breasts for 10% and 20% brine. The pH increased significantly ($p \le 0.05$) when treated with a pressure of 300 MPa in RTE brined chicken breasts, for 10% and 20% brined meat. A recommendation for a future study on the tenderness of cooked chicken marinade with various HPP levels and HPP times needs to be investigated. Additionally, sensory evaluation of RTE brined chicken breasts should be undertaken to determine consumer acceptability.

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