International Food Research Journal 19(4): 1449-1455(2012)
Journal homepage: *http://www.ifrj.upm.edu.my*

Effects of marinating ingredients on physicochemical, microstructural and sensory properties of golek chicken

Komoltri, P. and *Pakdeechanuan, P.

Department of Food Science and Nutrition, Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani, 94000, Thailand

Article history

Received: 14 January 2012
Received in revised form: 16 April 2012
Accepted:16 April 2012

Keywords

Marinating ingredients
meat microstructure
golek chicken
ayam golek

Abstract

Marination directly affects the texture and flavor of meat and is important for product yield. This research investigated the effects of various marinating solutions on the physicochemical, microstructural and sensory properties of golek chicken, a popular dish in Malaysia, Indonesia and southern Thailand. Non-marinated meat (Tr1-control) was compared with five marinating treatments: distilled water (Tr2); sodium chloride (Tr3); a mixture of sodium chloride and sodium tripolyphosphate (STPP) (Tr4); a mixture of sodium chloride, STPP and citric acid (Tr5); and a mixture of sodium chloride, STPP and sodium bicarbonate (Tr6). Marinating meat in Tr3–Tr6 resulted in higher water-holding capacity and cooking yield, as well as lower shear force value and cooking loss, when compared to Tr1 and Tr2 ($p<0.05$). Marination in Tr6 increased the pH to 7.86 in raw chicken meat and to 7.02 in golek chicken, resulting in greater water-holding capacity and cooking yield ($p<0.05$) compared to other marinating treatments. Scanning electron micrographs of raw chicken meat marinated in Tr5–Tr6 clearly showed swelling of muscle fibers due to the absorption of marinating solution; this was also evident in the meat after cooking and grilling at 175 °C for 40 min. The Tr6 marinade produced the highest cooking yield, 112.14% ($p<0.05$); the second-highest was with Tr5 (110.95%). However, golek chicken obtained from Tr6 had lower hardness and chewiness, as measured by a texture analyzer. When some sensory characteristics of golek chickens were evaluated using a 7-point hedonic scale, it was found that Tr6 had lower overall acceptance scores than Tr5. In addition, the surface of the Tr6-treated meat was slightly dark due to the effect of sodium bicarbonate, which resulted in less acceptable appearance. Therefore, a combination of sodium chloride, sodium tripolyphosphate and citric acid (Tr5) was suggested as the optimal marinating ingredients for the golek chicken process since it improved the textural property of meat after cooking, increased cooking yield (99.58% for Tr1 vs 110.95% for Tr5), and received the highest overall acceptance ($p<0.05$).

Introduction

Golek is a popular traditional Muslim food, made from chicken or fish mixed with golek curry paste and then roasted until cooked. In the golek process, high temperature during roasting has a significant effect on meat quality, and consequently on consumer acceptance; it results in increasing of tenderness and juiciness as well as higher product yield – a very important consideration for an industrial meat product.

Marination is a traditional method widely used to improve meat quality before thermal processing. The advantages of marination are that it increases product yield, reduces water loss during cooking (Alvarado and McKee, 2007), and improves the tenderness of meat. Two of the most common ingredients in marinating solutions are sodium chloride and some type of phosphate (Barbut *et al*., 1989). Both of these can help to increase water-holding capacity (WHC) due to an increase in electrostatic repulsion of myofibrillar proteins (Rust, 1987); this enlarges the space between actin and myosin filaments, allowing more water to be retained in the muscle (Lawrie, 1991). Another marinating ingredient is organic acid, which is commonly used in culinary technique (Aktas *et al*., 2003). Acid marination affects tenderness in three potential ways: 1) pH-induced

*Corresponding author.
Email: *patcharin.psu@gmail.com*

swelling of muscle fibers and/or connective tissue; 2) accelerating or additional proteolytic weakening of muscle structure; and 3) increasing solubilization of collagen upon heating (Offer and Trinick, 1983; Offer and Knight, 1988; Ertbjerg *et al*., 1999; Aktas *et al*., 2003). Another effective curing ingredient is sodium bicarbonate; it has a high potential to reduce drip loss and shear force (Kauffman *et al*., 1998; Wynveen *et al*., 2001; Bertram *et al*., 2008), and improves the yield of cooked meat (Sheard and Tali, 2004; Bertram *et al*., 2008).

The objective of this study was to determine the effects of marinating ingredients on the physicochemical, microstructural and sensory properties of golek chicken breast meat after marinating raw meat in different marinade solutions at 4 °C for 2 h.

Materials and Methods

Sample preparation

Chicken breast meat used in this study ("broiler" breed) was purchased from a fresh market in Pattani Province, Thailand. Prior to processing, the meat was washed, and then skin, external fat and connective tissue were removed. Meat samples were trimmed and weighed into 120 g portions. The approximate moisture, fat and protein contents of the raw meat were measured following AOAC procedures (AOAC, 2000); pH value was determined according to the method of Wattanachant *et al*. (2004).

Marination treatment

Six different marinating treatments were prepared. Non-marinated meat (Tr1) served as a control. For the other treatments, raw chicken meat was marinated in: distilled water (Tr2); 5% sodium chloride (NaCl) (Tr3); 5% NaCl and 1% sodium tripolyphosphate (STPP) (Tr4); 5% NaCl, 1% STPP and 0.02% citric acid (Tr5); and 5% NaCl, 1% STPP and 3% sodium bicarbonate ($NaHCO_3$) (Tr6). Marinating chemicals for Tr3–Tr6 were dissolved in distilled water and prepared in a ratio of meat:solution of 1:2 (w/w). Meat samples for all treatments were chilled at 4 °C for 2 h, drained in a sieve for 5 min, and then immediately analyzed for pH, water-holding capacity (WHC) and shear force value. After marinating, meat samples were steam cooked until an internal temperature of 70 °C was reached. The samples were then analyzed for cooking loss and shear force value.

Processing of golek chicken

Cooked meat samples of all treatments were coated with golek curry paste. The ingredients for making golek curry paste consisted of 7.3% chilli, 4.4% garlic, 10.0% red onion, 0.8% ginger, 15.7% plam sugar, 34.5% coconut milk, 22.0% water, 1.8% salt, 1.5% fish sauce, 1.4% rice flour, 0.5% tamarind and 0.2% coriander seed. After that, the golek chickens were grilled at 175 °C for 40 min in an electric oven. During grilling, golek curry paste was occasionally coated on the meat three times.

pH value

The pH value of meat samples was determined according to the method of Wattanachant *et al*. (2004). Meat samples were homogenized with distilled water at a ratio of 1:5 (w/v). The pH value was measured using a combined glass electrode pH meter (SevenEasy™; Mettler-Toledo, Columbus OH, USA).

Water-holding capacity index

The water-holding capacity index of meat samples was determined according to a modified method of Zheng *et al*. (1998). Meat samples were cut and divided into two portions. One portion was analyzed for moisture content (AOAC, 2000) and the other was chopped and wrapped with nylon net and three pieces of filter paper (Whatman No. 4). The wrapped sample was centrifuged at 3000 x g for 20 min using a Rotina 420 R benchtop centrifuge (Hettich, Tuttlingen, Germany). The percentage ratio of the sample weight difference before and after centrifuging was used to determine the content of free water. The difference between moisture content and free water content was described as the water-holding capacity index.

Cooking loss

The meat samples were slightly blotted with paper towels and weighted, and then steam cooked to an internal temperature of 70 °C. The cooked meats were slightly blotted with paper towels and weighted. Cooking loss was calculated as follows:

$$\% \text{ cooking loss} = [(w1-w2)/w1]x100$$

where w1=weight before cooking, and w2=weight after cooking.

Cooking yield

Each portion of golek chicken breast meat was weighed. The following equation was used to calculate the cooking yield:

$$\% \text{ cooking yield} = (w4/w3)x100$$

where w3= initial weight before marinating, and w4= golek chicken weight.

Shear force value

A Meat samples of 1.0 x 2.0 x 0.5 cm (w x l x d) was cut parallel to the muscle fiber. Shear force was determined using a TA.XTplus texture analyzer

(Stable Micro Systems, Surrey, UK) equipped with a Warner-Bratzler shear apparatus; the results were analyzed according to the method of Wattanachant et al. (2004). The cross-head speed was 2 mm/s and a distance between blade bottom and base plate was 1.5 cm. Samples of each treatment were measured in 12 replicates. The highest peak of the shear force profile was expressed as shear force value (Newton).

Texture profile analysis (TPA)

Texture profile analysis (TPA) was performed according to the method of Li (2006), with slight modification. Sample of golek chicken was cut into 1.5-cm cubes. Textural properties (hardness, springiness, cohesiveness and chewiness) of golek chicken meat were measured using a TA.XTplus texture analyzer fitted with a 5-mm-diameter P/5 stainless steel cylindrical probe set a compression speed at 0.5 cm s^{-1} and 75% strain. Hardness, springiness, cohesiveness and chewiness were calculated from the resultant force-deformation curves.

Microstructure of meat

The microstructure of meat was determined using a scanning electron microscope (SEM) according to Wattanachant *et al*. (2005), by a method modified from Palka and Daun (1999). Meat samples, raw marinated meat and golek chicken meat from all treatments, were cut into pieces approximately 1.0 x 1.0 x 0.5 cm in size. Fixation of samples was performed by soaking in 2.5% glutaraldehyde in 0.1 M phosphate buffer, pH 7.3, for 2 h at room temperature. After that, the sample was then rinsed with distilled water and dehydrated in a graded ethanol solution series 25, 50, 75, 95% and absolute ethanol (twice) for 1 h in each solution. The sample was dipped in liquid nitrogen and immediately cut with a razor blade. The specimen was then dried using liquid carbon dioxide. Dried specimen was attached to aluminum stubs and coated with gold, and then examined and photographed with a scanning electron microscope (Quanta 400; FEI, Czech Republic) using an accelerating voltage of 10 kV. Micrograph and video print of transverse section was taken at 500x magnification.

Sensory evaluation

Golek chicken samples from all treatments were heated in an 850 W microwave oven (NN-8655; Panasonic, Osaka, Japan) for 1 min and then prepared for serving by cutting into approximately 2.0 cm cubes. Samples were labeled with a random three-digit number and then served to panelists. Thirty panelists were used to evaluate appearance, texture, taste and overall acceptance of golek chicken using a 7-point hedonic scale.

Statistical analysis

All data were subjected to analysis of variance (ANOVA). Significant differences between the treatments were analyzed by Duncan's multiple range test (DMRT) at a 5% probability level ($p<0.05$).

Results and Discussion

Physicochemical properties of marinated raw chicken breast

The approximate composition and pH of raw chicken breast meat used in this study were as follows: moisture content, 76.09 ± 0.41%; protein, 21.56 ± 0.18%; fat, 3.11 ± 0.59%; and pH, 6.56 ± 0.04. After marination, samples of all treatments were evaluated for pH, water-holding capacity (WHC), cooking loss and shear force value, before and after cooking. The effects of marinating ingredients are shown in Table 1. Tr4–Tr6 marinated meat had higher pH and WHC and lower cooking loss compared to the control (Tr1) and Tr2 ($p<0.05$). These results were attributed to the function of each marinating ingredient. Marinating ingredients, i.e., sodium chloride accounted for the rise in solubility of meat proteins, as well as the increase of ionic strength (Hamm, 1994; Offer and Knight, 1988; Medynski *et al*., 2000). Sodium bicarbonate and STPP increased the number of ions, which reacted with the protein and increased hydration (Wynveen *et al*., 2001; Sen *et al*., 2005). In addition, a combination of two or more of these ingredients has been reported to result in a lower cooking loss than when ingredients are used singly (Sheard and Tali, 2004). This could be due to the greater number of ions that cause electrostatic repulsion, which enlarges the space between the thin and thick filaments of muscle fiber; resulting in higher water uptake into the muscle (Lawrie, 1991) and improving WHC. Similarly, in this study, meat marinated in a combination of NaCl/STPP/$NaHCO_3$ (Tr6) showed the highest pH value and WHC when compared with meat treated with NaCl or with a combination of NaCl/STPP ($p<0.05$). Marinated meat in Tr6 had a pH of 7.86 which much higher than the pI (isoelectric point); the charge of protein in the meat caused an increase in water absorption ($p<0.05$) and resulting in high WHC and less cooking loss. These results were in agreement with a previous study by Sheard and Tali (2004), who reported that pork loin injected with a mixture of NaCl/STPP/$NaHCO_3$ showed higher WHC and lower cooking loss, compared with other combinations of marinating ingredients.

Shear force values (before and after steam cooking) of chicken meat marinated in different

Table 1. Effect of marinating ingredients on physicochemical properties of marinated chickens after chilling at 4°C for 2 h and steam cooked

Treatment	pH	WHC (%)	Cooking loss (%)	Shear force (N)	
				Raw meat	Cooked meat
Tr1	6.35±0.03^{d}	62.76±0.79^{e}	26.44±0.73^{b}	8.38±0.59^{a}	17.46±0.65^{a}
Tr2	6.48±0.06^{c}	63.82±0.22^{e}	30.46±0.69^{f}	8.10±0.54^{a}	14.48±0.72^{c}
Tr3	6.27±0.02^{e}	67.50±0.59^{d}	25.02±0.70^{c}	7.19±0.55^{bc}	14.92±0.48^{b}
Tr4	6.59±0.03^{b}	73.16±0.86^{c}	23.80±0.44^{d}	7.51±0.60^{b}	10.33±0.36^{d}
Tr5	6.41±0.05^{c}	75.50±0.92^{b}	21.29±0.95^{e}	7.02±0.78^{c}	10.49±0.34^{d}
Tr6	7.86±0.03^{a}	79.11±0.48^{a}	17.14±0.79^{a}	7.22±0.81^{bc}	10.64±0.54^{d}

Mean within different letters in the same column are significantly different ($p<0.05$), n=6 for pH, WHC and cook loss value, n=12 for shear force value.
Tr1-non marinated (Control),
Tr2-soaked meat in distilled water,
Tr3-marinated meat in 5% NaCl,
Tr4-marinated meat in 5% NaCl + 1% STPP,
Tr5-marinated meat in 5% NaCl + 1% STPP + 0.02% Citric acid,
Tr6-marinated meat in 5% NaCl + 1% STPP + 3% $NaHCO_3$.

Table 2. Effect of marinating ingredients on pH value, cooking yield and shear force value of golek chickens

Treatment	pH	Cooking yield (%)	Shear force (N)
Tr1	6.34±0.03^{e}	99.58±0.96^{e}	21.07±0.85^{a}
Tr2	6.38±0.01^{d}	100.32±0.56^{e}	19.10±0.81^{b}
Tr3	6.43±0.01^{c}	104.90±0.60^{d}	16.12±0.60^{c}
Tr4	6.52±0.01^{b}	109.61±0.88^{c}	14.02±0.70^{d}
Tr5	6.49±0.01^{b}	110.95±0.83^{b}	13.64±0.71^{d}
Tr6	7.02±0.03^{a}	112.14±0.38^{a}	12.13±0.79^{e}

Means within column with different letters are significantly different ($p<0.05$), n=6 for pH and cook yield, n=12 for shear force value.
Tr1-non marinated (Control),
Tr2-soaked meat in distilled water,
Tr3-marinated meat in 5% NaCl,
Tr4-marinated meat in 5% NaCl + 1% STPP,
Tr5-marinated meat in 5% NaCl + 1% STPP + 0.02% Citric acid,
Tr6-marinated meat in 5% NaCl + 1% STPP + 3% $NaHCO_3$.

Table 3. Effect of marinating ingredients on textural properties of golek chickens

Treatment	Hardness(N)	Springiness	Cohesiveness	Chewiness (N)
Tr1	16.91±0.83^{a}	1.02±0.03^{ab}	0.40±0.81^{ab}	6.59±0.88^{a}
Tr2	14.10±0.73^{b}	1.02±0.04^{ab}	0.43±0.08^{a}	6.71±0.85^{a}
Tr3	14.32±0.87^{b}	1.02±0.31^{ab}	0.38±0.05^{b}	5.46±0.71^{b}
Tr4	13.85±0.92^{b}	1.03±0.07^{ab}	0.40±0.03^{ab}	5.74±0.83^{b}
Tr5	12.68±0.89^{c}	1.05±0.08^{a}	0.41±0.04^{ab}	5.38±0.76^{bc}
Tr6	11.87±0.81^{d}	1.00±0.01^{b}	0.42±0.05^{a}	4.91±0.54^{c}

Means within column with different letters are significantly different ($p<0.05$), n=12.
Tr1-non marinated (Control),
Tr2-soaked meat in distilled water,
Tr3-marinated meat in 5% NaCl,
Tr4-marinated meat in 5% NaCl + 1% STPP,
Tr5-marinated meat in 5% NaCl + 1% STPP + 0.02% Citric acid,
Tr6-marinated meat in 5% NaCl + 1% STPP + 3% $NaHCO_3$.

solutions are shown in Table 1. The shear force values of raw meat marinated in Tr3–Tr6 were significantly lower than those of non-marinated meat (Tr1) and meat soaked in distilled water (Tr2) ($p<0.05$). This was due to the absorption of marinade solution into the muscle, leading to an increase in water content. Increasing of WHC was also clearly observed in marinated meat. Shard and Tali (2004) found that the reduction in shear force can be attributed to weakening of the myofibrillar structure due to higher water content. The shear force values of cooked meat marinated with phosphate combined with other ingredients (Tr4–Tr6) were significantly lower than those of meat marinated without phosphate (Tr3) ($p<0.05$). STPP exhibits a polyionic character. The increase in polyionic properties enables phosphates to attach to positive sites on protein molecules, leading to an improvement of protein solubility and enhanced water binding (U¨nal *et al*., 2006). Similarly, Prestat et al. (2002) found that meat enhanced with 0.4% STPP and 0.4% salt had significantly lower ($p<0.05$) shear force value compared to non-enhanced meat.

Physicochemical properties of golek chicken

The pH, cooking yield and shear force values of cooked golek chicken breast meat are shown in Table 2. The pH values of Tr1–Tr5 golek chicken were similar to those of marinated raw meat which pH of Tr6 was the highest ($p<0.05$). The increasing of pH value may be due to the function of STPP and $NaHCO_3$ which could increase ionic strength (Sen *et al*., 2005). During steaming, the first step in preparing golek, the surface of the meat is denatured and water is retained within the muscle. Tr3–Tr6 golek chicken had higher cooking yield compared to Tr1-Tr2 ($p<0.05$). This result was due to the function of marinating ingredients, resulting in increasing of ionic strength and net negative charge improving the water holding capacity and water absorption. After undergoing golek processing, this positive result was still apparent, and resulted in higher cooking yield compared to non-marinated meat. Tr6 marinated raw meat had high WHC, and consequently had the highest cooking yield of 112% ($p<0.05$) when it was processed into golek. Non-marinated golek chicken breast meat (Tr1) had the highest shear force value compared with other treatments ($p<0.05$) due to the greater density of muscle fibers; fiber density decreased when meat was marinated. This was in accordance with Baublits *et al*. (2006), who reported that untreated beef muscle had the highest ($p<0.05$) shear force value while muscle enhanced with STPP/NaCl had the lowest ($p<0.05$) shear force. The decrease of shear force value may be a function of the impact of salt on increasing of protein solubilization and water retention (Baublits *et al*., 2006), or a function of the action of phosphate on actomyosin disassociation (Trout and Smith, 1983; Baublits *et al*., 2006).

Texture profile analysis (TPA)

Texture profile analysis (TPA) results are shown in Table 3. No significant differences in springiness and cohesiveness were found when comparing treatments ($p>0.05$). Golek chicken from non-marinated meat (Tr1) exhibited the highest hardness ($p<0.05$) while the one from NaCl/STPP/$NaHCO_3$ (Tr6) had the lowest value ($p<0.05$); this was due to water retention within the muscle fibers. These

Table 4. Effect of marinating ingredients on sensory properties of golek chicken (7-point hedonic scale)

Treatment	Appearance	Texture	Taste	Overall acceptance
Tr1	4.94±0.73^{ab}	4.28±0.89^{b}	4.72±0.89^{b}	4.61±0.85^{b}
Tr2	5.11±0.83^{a}	4.67±0.69^{b}	4.78±0.81^{b}	4.56±0.86^{b}
Tr3	5.06±0.87^{a}	4.44±0.70^{b}	5.17±0.86^{ab}	4.56±0.86^{b}
Tr4	5.00±0.84^{a}	5.44±0.78^{a}	5.44±0.92^{a}	5.50±0.51^{a}
Tr5	5.17±0.79^{a}	5.56±0.70^{a}	5.50±0.86^{a}	5.61±0.61^{a}
Tr6	4.56±0.70^{b}	5.39±0.85^{a}	4.94±0.87^{b}	5.39±0.78^{a}

Means within column with different letters are significantly different ($p<0.05$), n=30 panelists.
Tr1-non marinated (Control),
Tr2-soaked meat in distilled water,
Tr3-marinated meat in 5% NaCl,
Tr4-marinated meat in 5% NaCl + 1% STPP,
Tr5-marinated meat in 5% NaCl + 1% STPP + 0.02% Citric acid,
Tr6-marinated meat in 5% NaCl + 1% STPP + 3% $NaHCO_3$.

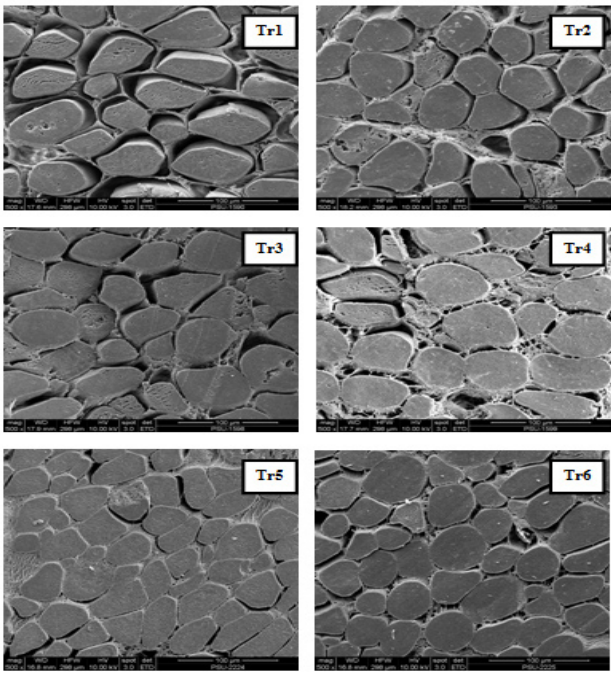

Figure 1. Scanning electron micrograph of transverse sections of raw chicken breast chilled at 4°C for 2 h.
Tr1-non marinated (Control), Tr2-soaked meat in distilled water,
Tr3-marinated meat in 5% NaCl, Tr4-marinated meat in 5% NaCl+1% STPP,
Tr5-marinated meat in 5% NaCl + 1% STPP + 0.02% Citric acid,
Tr6-marinated meat in 5% NaCl + 1% STPP + 3% $NaHCO_3$.

results were supported by shear force value, cooking yield and cooking loss.

Microstructure of marinated raw chicken breast and golek chicken

Microstructural properties of the six treatments of chicken – marinated raw meat chilled at 4 °C for 2 h, and cooked meat, after processing into golek chicken were determined using a scanning electron microscope (SEM). Marinating had an obvious effect on the microstructure of marinated raw meat (Figure 1). For non-marinated meat (Tr1), the muscle fibers were separated from the sheaths of the endomysium as a result of moisture loss during chilling. Swelling of muscle fibers was observed in meat marinated

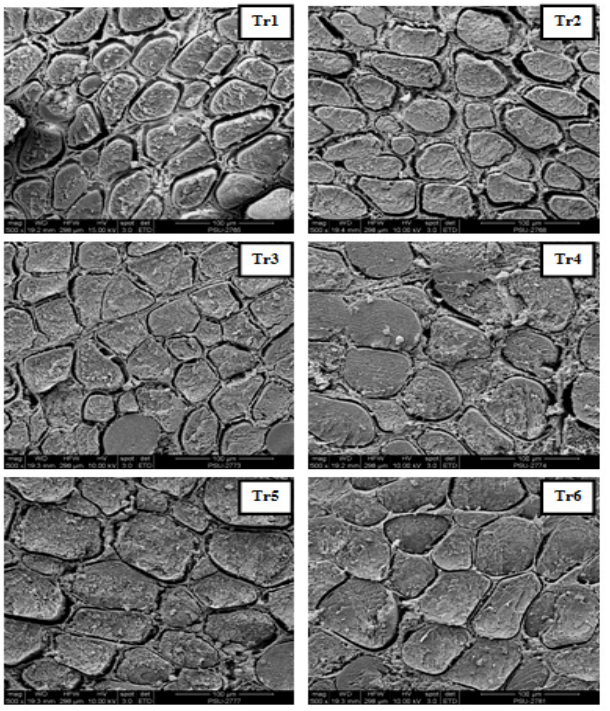

Figure 2. Scanning electron micrograph of transverse sections of golek chickens grilling at 175°C.
Tr1-non marinated (Control), Tr2-soaked meat in distilled water,
Tr3-marinated meat in 5% NaCl, Tr4-marinated meat in 5% NaCl+1% STPP,
Tr5-marinated meat in 5% NaCl + 1% STPP + 0.02% Citric acid,
Tr6-marinated meat in 5% NaCl + 1% STPP + 3% $NaHCO_3$.

with NaCl (Tr3), NaCl/STPP (Tr4), NaCl/STPP/citric acid (Tr5) and NaCl/STPP/$NaHCO_3$ (Tr6). However, the muscle fibers of Tr5 and Tr6 were more swollen compared to meat marinated with NaCl and NaCl/STPP because of an increased in water-holding capacity and water retention within the muscle. These results could be observed by the appearance of narrower gaps between muscle fibers. The swelling of muscle fibers due to the action of marinating ingredients is caused by electrostatic repulsion of ions, so that charged binding sites are exposed (Rust, 1987). Electrostatic repulsion increases the spaces between the thin and thick filaments, resulting in a greater amount of water that can be retained in the muscle (Lawrie, 1991).

The microstructure of golek chicken is presented in Figure 2. The gaps between muscle fibers of non-marinated meat (Tr1) and Tr2 are clearly larger than those of marinated chickens. This could be ascribed to lower water retention and/or water absorption by the muscle fibers, as indicated by WHC, cooking loss and cooking yield. Swelling of muscle fibers was evident in Tr4–Tr6 marinated meat. These results were similar to the microstructure of marinated raw chicken meat. Marination of meat increases the water content within muscle fibers due to the absorption of the marinade solution. Furthermore, the polyions of

STPP can attach to positive charges of proteins and water molecules, resulting in increasing of water-holding capacity (Shahidi and Synowiecki, 1997; Wongwiwat *et al*., 2010).

Sensory evaluation

The sensory properties of golek chickens were evaluated by 30 panelists, using a 7-point hedonic scale. The results of the sensory evaluation are shown in Table 4. In terms of appearance, golek chicken marinated with NaCl/STPP/$NaHCO_3$ (Tr6) had the lowest acceptance score compared with the other treatments ($p<0.05$) because of slightly darkening of the meat surface than those other treatments; this was probably due to the denaturation of muscle protein from the reaction with $NaHCO_3$. For texture and overall acceptance, golek chicken obtained from meat marinated with STPP (Tr4–Tr6) marination had significantly higher scores than those samples marinated without STPP (Tr3), including meat soaked in distilled water (Tr2) and the control (Tr1) ($p<0.05$). This could be a result of the synergism of NaCl and STPP, which causes improved providing better water absorption and WHC of poultry meat (Young et al., 1996). However, the highest acceptance scores was for the golek chicken from marinated in NaCl/STPP/citric acid (Tr5). This could be related to the function of organic acid, which degrades myofibrillar proteins and softens stromal proteins (Burke and Monahan, 2003)

Conclusions

Marinating chicken meat before processing into golek chicken influenced the texture and cooking yield of the product. A combination of NaCl/STPP/citric acid at 4°C for 2 h was found to be the optimal marinating treatment for golek chicken, resulting in high WHC, tender texture, pleasing appearance, low cooking loss and acceptable cooking yield.

Acknowledgments

The authors would like to thank Halal Food Science Center, Prince of Songkla University, Thailand for the financial support.

References

Aktas, N., Aksu, M. I. and Kaya, M. 2003. The effect of organic acid marination on tenderness, cooking loss and bound water content of beef. Journal of Muscle Foods 14: 181-194.

Alvardo, C. and Mckee, S. 2007. Marination to improve functional properties and safety of poultry meat. Journal of Applied Poultry Reserch 16: 113-120.

AOAC. 2000. Official Methods of Analysis. 16th ed. Association of Official Analytical Chemists. Arlington, VA.

Barbut, S., Draper, H. H. and Hadley, M. 1989. Lipid oxidation in chicken nuggests by meat type, phosphate, and packaging. Journal of Food Protection 52: 55-59.

Baublits, T. R., Pohlman, W. F., Brown, H. A., Yancey, J. E. and Johnson, B. Z. 2006. Impact of muscle type and sodium chloride concentration on the quality, sensory and instrumental color characteristics of solution enhanced whole-muscle beef. Meat Science 72(4): 704–712.

Bertram, C. H., Meyer, L. R., Wu, Z., Zhou, X. and Anderson, J. H. 2008. Water distribution and microstruction in enhanced pork. Journal of Agricultural and Food Chemistry 56: 7201-7202.

Burke, M. R. and Monahan, J.F. 2003. The tenderization of shin beef using a citrus juice marinade. Meat Science 63: 161-168.

Ertbjerg, P., Mielche, M. M., Larsen, L. M. and Moller, A. J. 1999. Relationship between proteolytic changes and tenderness in prerigor lactic acid marinated beef. Journal of the Science of Food and Agriculture 79: 970-978.

Hamm, R. 1994. The influence of pH on the protein net charge in the myofibrillar system. Proceeding of the 47th Reciprocal Meat Conferenc, p. 5-9. Chicago: American Meat Science Association.

Kauffman, R. G., Laack, R. L. J. M., Russell, R. L., Pospiech, E., Cornelius, C. A., Suckow, C. E. and Greaser, M. L. 1998. Can pale, soft, exudative pork be prevented by postmortem sodium bicarbonate injection. Journal Animal Science 27: 310-315.

Lawrie, R. A. 1991. Meat Science. 5th ed. Pergamon Press. New York, NY.

Li, C.-T. 2006. Myofibrillar protein extracts from spent hen meat to improve whole muscle processed meats. Meat Science 72: 581-583.

Medynski, A., Pospiech, E. and Kniat, R. 2000. Effect of various concentrations of lactic acid and sodium chloride on selected physico-chemical meat traits. Meat Science 55: 285-290.

Offer, G. and Knight, P. 1988. The structural basis of water-holding in meat. Part1:general principles and water uptake in meat processing. In Development in Meat Science 4: 63-71.

Offer, G. and Trinick, J. 1983. On the mechanism of water holding in meat : The swelling and shrinking of myofibrils. Meat Science 8: 245-281.

Palka, K. and Duan, H. 1999. Changes in texture, cooking losses, and myofibrillar structure of bovine M.semitendinosus during heating. Meat Science 51: 237-243.

Prestat, C., Jensen, J., Robbins, K., Ryan, K., Zhu, L. and McKeith, F. K. 2002. Effects of enhancement solution on characteristic of cooked, reheated pork chops. Journal of Muscle Foods 13: 279-288.

Rust, R. E. 1987. Science of Meat and Meat Products. 3rd ed. Food and Nutrition Press Inc. Trumbull, CT.

Sen, R. A., Naveena, M. B., Muthukumar, M., Babij,

Y. and Murthy, K. R. T. 2005. Effects of chilling, polyphosphate and bicarbonate on quality characteristics of broiler breast meat. British Poultry Science 46: 451-456.

Shahidi, F. and Synowiecki, J. 1997. Protein hydrolyzate from seal meat as phosphate alternatives in food processing applications. Food Chemistry 60: 29-32.

Sheard, R. P. and Tali, A. 2004. Injection of salts, tripolyphosphate And bicarbonate marinade solution to improve the yield and tenderness of cooked pork loin. Meat Science 68: 305-311.

Trout, G. R. and Schmidt, G. R. 1983. Utilization of phosphates in meat products. In Proceeding of The 36th reciprocal meat conference. (24-27pp.), Fargo, ND.

U¨nal, B. S. Erdogdu, F. and Ekiz, I. H. 2006. Effect of temperature on phosphate diffusion in meats. Journal of Food Engineering 76: 119-127.

Wattanachant, S., Benjakul, S. and Ledward, D. A. 2004. Composition, color, and texture of Thai indigenous and broiler chicken muscles. Poultry Science 83: 123-128.

Wattanachant, S., Benjakul, S. and Ledward, D. A. 2005. Effect of heat treatment on change structure and properties of Thai indigenous chicken muscles. Food Chemistry 93: 337-348.

Wongwiwat, P., Wattanachant, S. and Siripongvutikorn, S. 2010. Effect of phosphate treatment on microbiology, physicochemical changes of spent hen mu scle marinated with TomYam paste during chilled storage. Journal Science Food Agricultural 90: 1293-1299.

Wynveen, E. J., Bowker, A. L., Grant, A. L., Lamkey, J. M., Fennewalk, K. J., Henson, L. and Gerrard, D. E. 2001. Pork quality is effected by early postmortem phosphate and bicarbonate injection. Journal of Food Science 66: 886-891.

Young, L. L., Northcutt, J. K. and Lyon, C. E. 1996. Effect of stunning time and polyphosphates on quality of cooked chicken breast meat. Poultry Science 75: 677-681.

Zheng, M., Huang, W, Y., Nelson, O. S., Bartley, G. P. and Gates, W. K. 1998. Dielectric properties and thermal conductivity of marinated shirmp and channel catfish. Journal of Food Science 63(4): 668-672.