

Effect of egg type and storage conditions on the quality of crispy Thai pancake (Thong Phap)

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Abstract

Eggs were stored within 24 h after laying at $4\pm 2^\circ\text{C}$ and $28\pm 2^\circ\text{C}$ for 25 days (d). Egg quality was monitored during cold and room temperature storage for producing Thong Phap. Longer storage time led to an increase in weight loss and pH, while the Haugh Unit (H.U.) and viscosity of the egg white decreased. Eggs stored at a higher temperature, particularly duck eggs, exhibited faster parameter changes. The main protein types in duck and chicken egg whites determined by SDS-PAGE were ovalbumin, ovotransferrin, and ovomucin. Microbial standards indicated that the shelf life of duck eggs was lower than chicken eggs. Na, P, and K contents of duck egg white were higher than a chicken egg, while storage temperature and time did not significantly affect mineral content.

Keywords: egg white; quality; mineral; protein; cold storage; room temperature storage

Introduction

Bird eggs are a cheap protein source containing high essential amino acids. They are used in main courses, desserts, and drinks as well as ingredients for various types of prepared food (Kaewmanee *et al.*, 2009). In Thailand, three types of bird eggs chicken, duck, and quail are widely consumed (Nys and Guyot, 2011). Eggs are classified as high-protein food like milk, fish, and meat. They have low-fat content and contain minerals and vitamins (Jirangrat *et al.*, 2010; Kaewmanee *et al.*, 2009; Lomakina and Mikova, 2006).

Generally, bird eggs without a cracked shell and laid in good condition can be kept for 2–3 weeks at room temperature and longer under refrigeration (Jirangrat *et al.*, 2010). Egg freshness quality is determined by the Haugh Unit (H.U.). As freshness decreases the viscosity of the egg white reduces and becomes watery with weight loss,

CO₂ loss, and increased pH (Akyurek and Okur, 2009; Huang *et al.*, 2012). Egg protein patterns from size, affect functional properties such as gelling and foaming ability during storage. Foaming of protein is related to its viscosity, leading to cooling ability (Özer and Cansu, 2020; Ramamurthy and Krishnan, 2022).

Thong Phap is a traditional crispy Thai snack, normally made from eggs mixed with flour, coconut milk, and Palmyra palm sugar. However, no scientific data are available on optimal egg type and freshness to produce this product. People with a high prevalence of chronic kidney disease (CKD) must control various nutritional components including minerals and fat. This experiment determined the quality changes in duck and chicken eggs during storage at $4\pm 2^\circ\text{C}$ and $28\pm 2^\circ\text{C}$. Egg white from eggs stored under each condition was used to make Thong Phap and the product was evaluated for quality.

Materials and Methods

Materials

Newly laid duck and chicken eggs were sourced. Duck eggs were bought from a farmer in Singhanakorn district, Songkhla Province while chicken eggs were obtained from the Faculty of Natural Resources, Prince of Songkla University. The eggs were transported to the Food Technology Department within 24 h. Other ingredients consisted of tapioca flour (Fish, Kriangkrai Co., Ltd., Thailand), rice flour (Bangkok Interfood Co., Ltd.), coconut milk (Chaokoh, Theppadung Coconut Co., Ltd., Thailand), and Palmyra palm sugar (Taltai, Part., Ltd., Thailand). Chemicals to evaluate the microbiological properties including peptone water, tetrathionate (TTH) broth, Rappaport-Vassiliadis (RV) medium, brilliant green with novobiocin (BGN) agar, and xylose lysine Tergitol 4 (XLT4) agar were purchased from BD and Logo (Becton, Dickinson, France).

Methods

Whole egg preparation

The eggs were washed and dried on tissue paper for 10 min. Then, half of the eggs were stored in a plastic box without a cover at room temperature ($28 \pm 2^\circ\text{C}$) and the other half were refrigerated ($4 \pm 2^\circ\text{C}$). Eggs kept for 0, 5, 10, 15, 20, and 25 days (d) were used for the experiments.

Weight loss

Fifteen eggs of each type and storage condition were weighed on each testing day using an analytical balance to determine the weight loss (Akter *et al.*, 2014).

Haugh Unit

The eggs were cracked open and a digital Haugh tester was used to measure the Haugh Unit (H.U.). The height of each egg was recorded and the H.U. was calculated using the following equation (Alshaikhi *et al.*, 2020).

$$\text{H.U.} = 100 \log_{10} (\text{H} - 1.7\text{W}^{0.37} + 7.6)$$

where, H = egg white height (mm) and W = egg weight (g)

Egg white preparation

Fifteen chicken and duck eggs from each storage condition were cracked and the egg yolk was separated using a spoon, with only the egg white used for analysis.

pH

The pH of the egg white was measured using a pH meter (Sartorius AG, Docu-pH+ Meter, Gottingen, Germany).

Viscosity

Egg white (300 mL) of each type was determined for viscosity on measurement days using a rheometer (Rheostress RS100, Haake, Karlsruhe, Germany) as a function of shear rate (Souza and Fernández, 2013; Spada *et al.*, 2012).

Protein pattern

The protein patterns of duck and chicken egg whites from each storage day were determined following the method of Kaewmanee *et al.* (2009) using 4% stacking gel and 12% separating gel. The egg white was mixed with 10% SDS and heated at 85°C for 1 h before analysis of protein concentration by the Biuret method (Rojas *et al.*, 2019), using bovine serum albumin (BSA) as the standard. A broad range molecular weight protein marker (10–250 kDa) and sample concentration at 15 $\mu\text{g/mL}$ protein were loaded into the gel. The electrophoresis was conducted using a Bio-Rad Mini-Protean II system with a constant voltage of 200 V/plate. The gel was stained with Coomassie Blue R-125 in 25% methanol and 10% acetic acid for 1 h, and then subsequently destained with 40% methanol and 10% acetic acid.

Microbiological quality

Total viable counts for *E. coli* (Feng *et al.*, 2020) and *S. aureus* (Tallent *et al.*, 2016) were carried out, while *Salmonella* spp. was determined using the standard U.S. FDA (2008) method.

Mineral content

The egg white was dried in a hot air oven at 65°C for 24 h and kept in a closed plastic container in a desiccator until used. Dried egg white powder from each condition was determined for mineral content (Na, P, and K) using an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) with a Perkin Elmer Optima 4300DV (Lante *et al.*, 2006).

Thong Phap preparation

Egg white containing a total viable count lower than 10^4 CFU/g sample with no *E. coli*, *S. aureus*, and *Salmonella* spp. detected in a sample of 25 g was selected to produce Thong Phap. The formulation of Thong Phap consisted of egg white, flour, Palmyra palm sugar, coconut milk, and water at 39.11%, 32.42%, 12.62%, 14.85%, and 1.00%, respectively. The egg white, flour, and Palmyra palm sugar were mixed before adding the coconut milk and water. The mixture was well-mixed into a slurry, and then 1 teaspoon (5 mL) was heated in a Thong Phap machine at 150°C for 50 to 65 s until the water was no longer vaporized. The product was folded in half, then folded again into quarters, and cooled at room temperature for one minute. Finished products were packed in a locked box

and kept at ambient temperature before analysis. Texture analysis was conducted on the product without folding.

Texture profile analysis

Fifteen pieces of unfolded Thong Phap were subjected to texture profile analysis (TPA) using a texture analyzer (TA-XT2i, Stable Micro Systems, Surrey, England) with an HDP/90 perforated platform and a 50 kg load cell at a speed of 1 mm/s. The samples were placed on the base of the instrument and evaluated for fracturability, brittleness, and hardness.

Statistical analysis

All measurements were recorded 10 times, except for pH and mineral content which were repeated five times and reported as mean ± standard deviation. A factorial design (2x2x7) was applied to determine the physical and

chemical properties, while the paired samples t-test was used to compare the results of the two storage temperatures. Samples of different egg types were analyzed using the independent t-test. All data were subjected to analysis of variance, with Duncan's multiple range test used to determine significant differences among means. Analysis of variance was performed for regression using a mathematical model, with significant differences defined at $p<0.05$.

Result and Discussion

Weight loss of whole egg

Weight loss of duck and chicken eggs stored in a cold room and at room temperature related to increased storage temperature and time ($p<0.05$) is shown in Figure 1. Spada *et al.* (2012) reported that whole egg and egg white consisted of 75% and 83% moisture content, respectively. At higher storage temperatures, weight loss was more

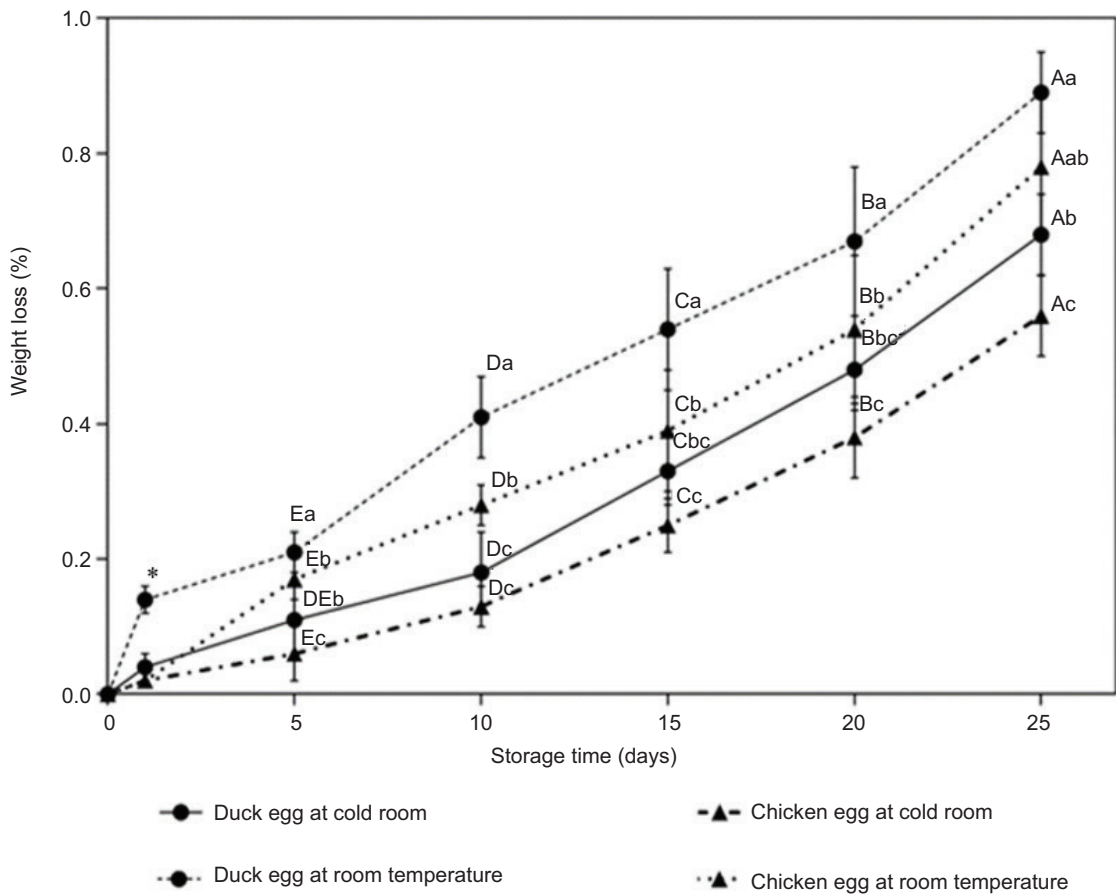


Figure 1. Weight loss of duck eggs and chicken eggs at different storage days and temperatures; different uppercase letters indicate significant differences between treatments ($p<0.05$); different lowercase letters indicate significant differences between treatments ($p<0.05$); * mean significant differences of duck egg at cold room temperature (DC), chicken egg at cold room temperature (CC), duck egg at room temperature (DR), and chicken egg at room temperature (CR) at day 0 (Fa, Ea, Fa, and Fa) and day 1 (EFb, Eb, Ea, and Fb), respectively.

pronounced. Weight losses of chicken and duck eggs stored at room temperature ($28 \pm 2^\circ\text{C}$) for 25 d were 4.04% and 4.34%, respectively. A significant difference in weight loss was noticed at room temperature after 1 d storage for duck eggs and 5 d storage for chicken eggs. Higher weight loss at higher temperatures indicated increased dehydration (Akter *et al.*, 2014). During storage, moisture and CO_2 evaporate through the eggshell (Akter *et al.*, 2014; Grashorn, 2016). As more water and CO_2 evaporated, weight loss and pH increment increased; therefore, egg quality was reduced. Results indicated that duck eggs lost more weight faster compared with chicken eggs due to the thickness of the shell membrane, thickness of the eggshell, and pore size. Generally, the eggshell is porous and can exchange gas, while the two shell membranes (inner and outer) connecting to the eggshell prevent bacterial contamination (Maysuoka *et al.*, 2019). Hargitai *et al.* (2011) reported that shell thickness was affected by nutrition intake, especially calcium, with better nutrition producing a thicker shell. Akyurek and Okur (2009)

reported that the thickness of the shell membrane, egg-shell thickness, and pore size were affected by bird age. Young birds produced thicker shells with smaller pore sizes than older hens that lacked calcium carbonate.

Haugh Unit of whole egg

Newly laid eggs had thick and thin zones of egg white after cracking. The Haugh Unit (H.U.) is used to measure the freshness of a bird egg (Akter *et al.*, 2014). The higher the H.U., the fresher the egg. At longer storage time the egg white became flatter and thinner. Statistical analysis indicated that the H.U. value mainly depended on storage temperature and time. Results revealed that duck eggs lost their freshness faster than chicken eggs, in line with higher weight loss due to higher eggshell porosity. The H.U. value decreased as storage time increased, as shown in Figure 2, with carbonic acid converting to form CO_2 . Higher CO_2 loss gave reduced egg white height,

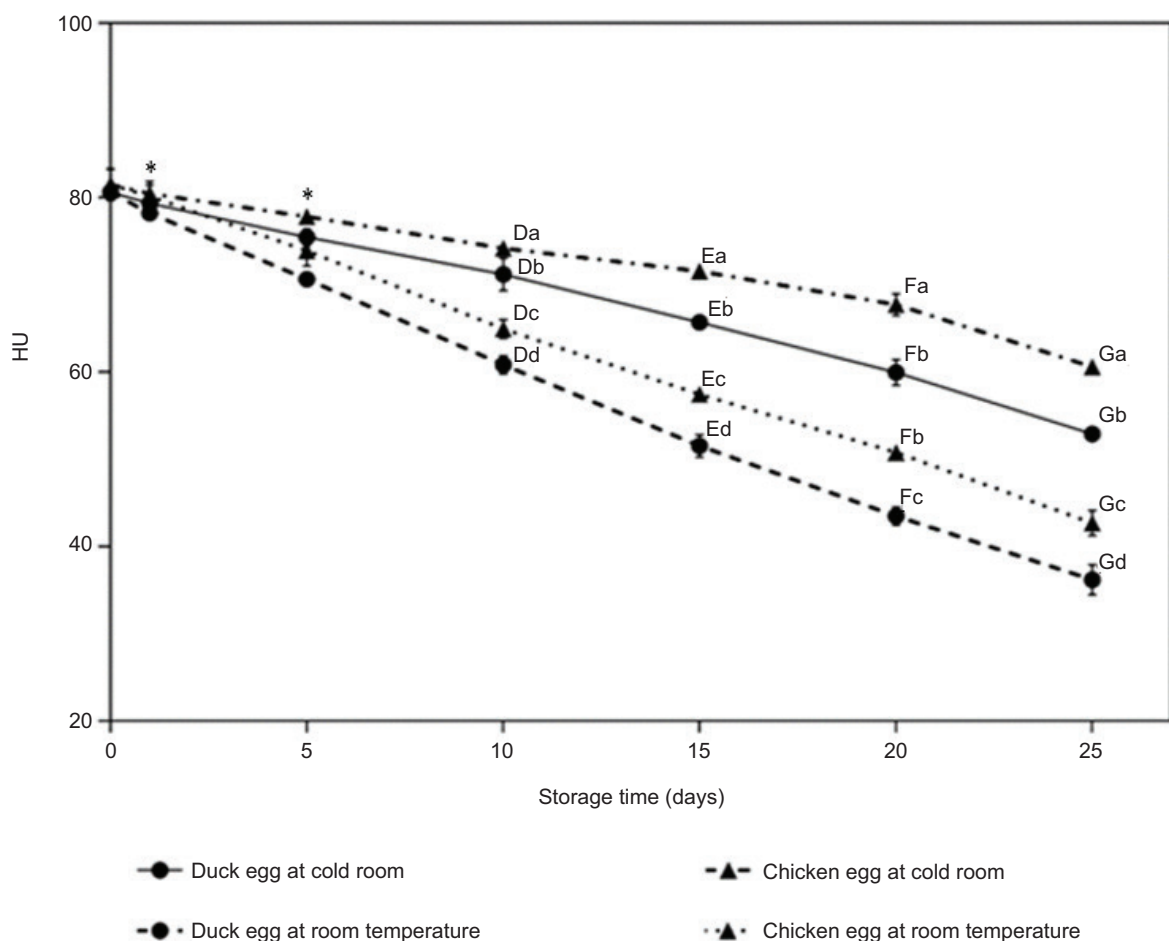


Figure 2. Haugh Unit values of duck eggs and chicken eggs at different storage days and temperatures; different uppercase letters indicate significant differences between treatments ($p < 0.05$); different lowercase letters indicate significant differences between treatments ($p < 0.05$); * mean significant differences of duck egg at cold room temperature (DC), chicken egg at cold room temperature (CC), duck egg at room temperature (DR), and chicken egg at room temperature (CR) at day 0 (Aa, Aa, Aa, and Aa), day 1 (Bb, Bb, Bc, and Ba), and day 5 (Cb, Ca, Cd, and Cc), respectively.

with decreased viscosity and thickness (Kocetkovs *et al.*, 2022). Lysozyme is an antibacterial enzyme that functions with ovomucin to make the egg white viscous (Mine and Zhang, 2013; Wang *et al.*, 2019). The lysozyme enzyme is activated at a pH value of around 8 and proteolysis occurs which also facilitates CO₂ loss (The Poultry Site, 2014), while increased water in the system leads to reduced viscosity. The egg yolk absorbs water from the egg white and its size increases. Enlargement and weakness of the vitelline membrane occur, giving a flat yolk (The Poultry Site, 2014). The Thai Agricultural Commodity and Food Standards (2010a;b) grades eggs following the USDA into three groups based on freshness. H.U. ≥ 72 is AA, 60–71 is A, and < 60 is B. Results showed that duck eggs were AA during the first 10 d and 5 d when kept in the cold room ($4\pm 2^\circ\text{C}$) and at room temperature ($28\pm 2^\circ\text{C}$), respectively while chicken eggs were AA during the first 15 d and 5 d stored in the cold room ($4\pm 2^\circ\text{C}$) and at room temperature ($28\pm 2^\circ\text{C}$), respectively.

Egg white

pH

The pH of the egg white increased as storage time and temperature increased, as shown in Figure 3 ($p<0.05$). The pH of both chicken and duck eggs kept at room temperature significantly increased as storage time increased. Interestingly, the initial pH of duck eggs was higher than chicken eggs, possibly related to blood characteristics. Fresh eggs contain CO₂ which dissolves and forms carbonate, bicarbonate, carbonic acid, and gas inside the eggshell, giving a neutral pH of egg white (Banerjee *et al.*, 2011). Gas is transmitted into the air through pore canals along with water, with a pH shift to the alkaline range. Banerjee *et al.* (2011) reported the pH of fresh chicken eggs as 7.6 to 8.5, while Chaiyasit *et al.* (2019) reported the initial pH of duck eggs at 9.0. During storage, proteolysis of egg white occurs, leading to quality deterioration, with the pH of albumen increasing and becoming more

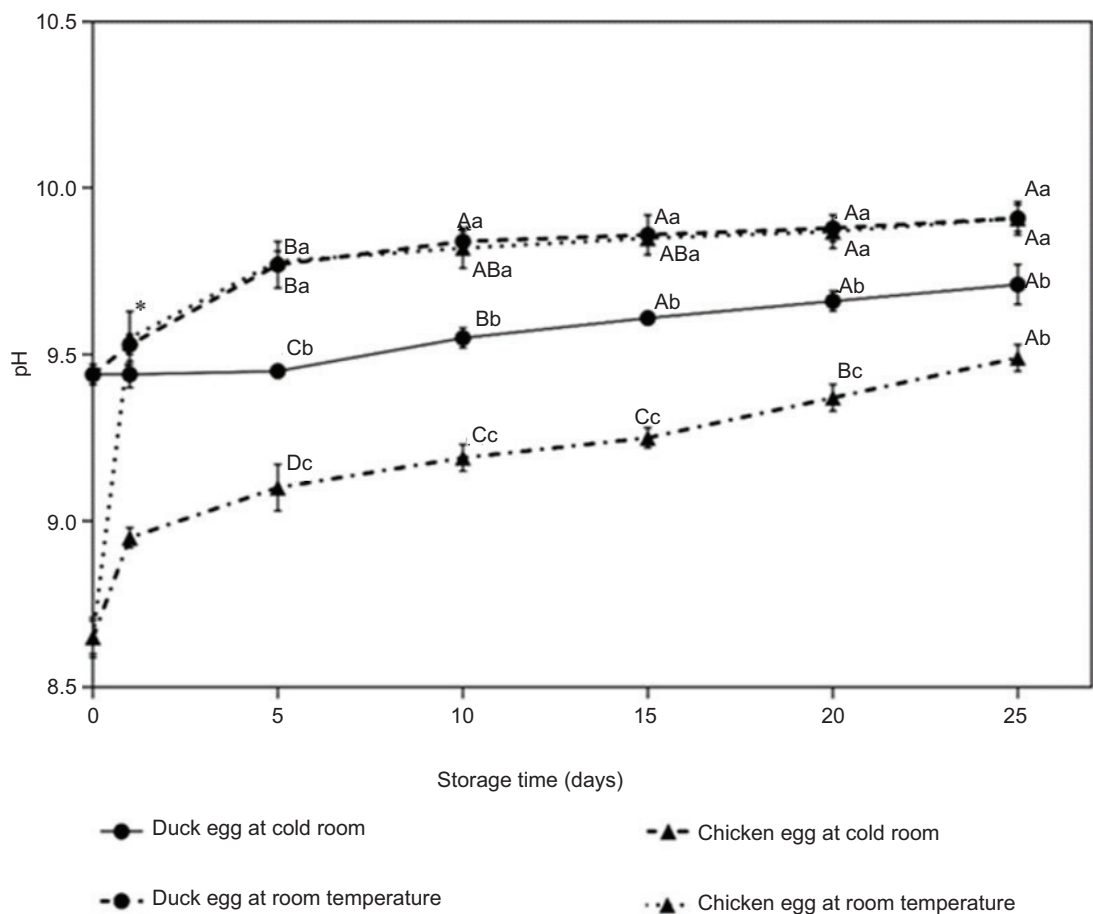


Figure 3. pH of egg white from duck eggs and chicken eggs at different storage days and temperatures; different uppercase letters indicate significant differences between treatments ($p<0.05$); different lowercase letters indicate significant differences between treatments ($p<0.05$); * mean significant differences of duck egg at cold room temperature (DC), chicken egg at cold room temperature (CC), duck egg at room temperature (DR), and chicken egg at room temperature (CR) at day 0 (Ca, Fb, Da, and Db) and day 1 (Cb, Ec, Cab, and Ca), respectively.

alkaline (Akter *et al.*, 2014). Egg quality, as determined by the H.U. value, decreases along with functional properties including viscosity, gelling, and foaming ability (Akter *et al.*, 2014).

Weight loss, H.U., and pH values showed that chicken eggs were of higher quality and had longer shelf life than duck eggs due to three factors: (1) cuticle maturity, (2) eggshell thickness, and (3) eggshell membrane. The cuticle is a thin organic layer coating the eggshell that reduces porosity and inhibits microbial invasion (Liu *et al.*, 2016; Munoz *et al.*, 2015). Munoz *et al.* (2015) reported that the cuticle was not constant, based on chicken maturity. Young hens (<25 w) and old hens (>40 w) have less amounts of cuticle than hens aged 35 w. Similar, to this experiment, eggs were obtained from ducks aged 40 w and hens aged 35 w; therefore, duck eggs might have reduced cuticle, shell, or shell membrane thickness. The eggshell membrane is a layer covering the

inside of the egg which is related to lysozyme function. The initial pH of duck eggs was around 9, while the initial pH of chicken eggs was around 8, thus lysozyme activation to hydrolyse the eggshell membrane in duck eggs was faster than in chicken eggs (Liu *et al.*, 2016).

Viscosity

Viscosity decreased during storage with increasing time and temperature ($p < 0.05$) (Figure 4). Chaijan (2011) reported that during storage egg white became thinner, with proteolytic enzyme activity leading to reduced viscosity. During storage, the function of ovomucin-lysozyme which determines the viscosity in albumen also destabilized. When pH increased, because of CO_2 escaping into the air, the viscosity of the egg white declined (Kocetkovs *et al.*, 2022). Lower H.U. values indicate reduced viscosity. The initial viscosity of duck eggs was higher than chicken eggs ($p < 0.05$) because of less water content (Chaiyasit *et al.*, 2019; Mine and Zhang 2013)

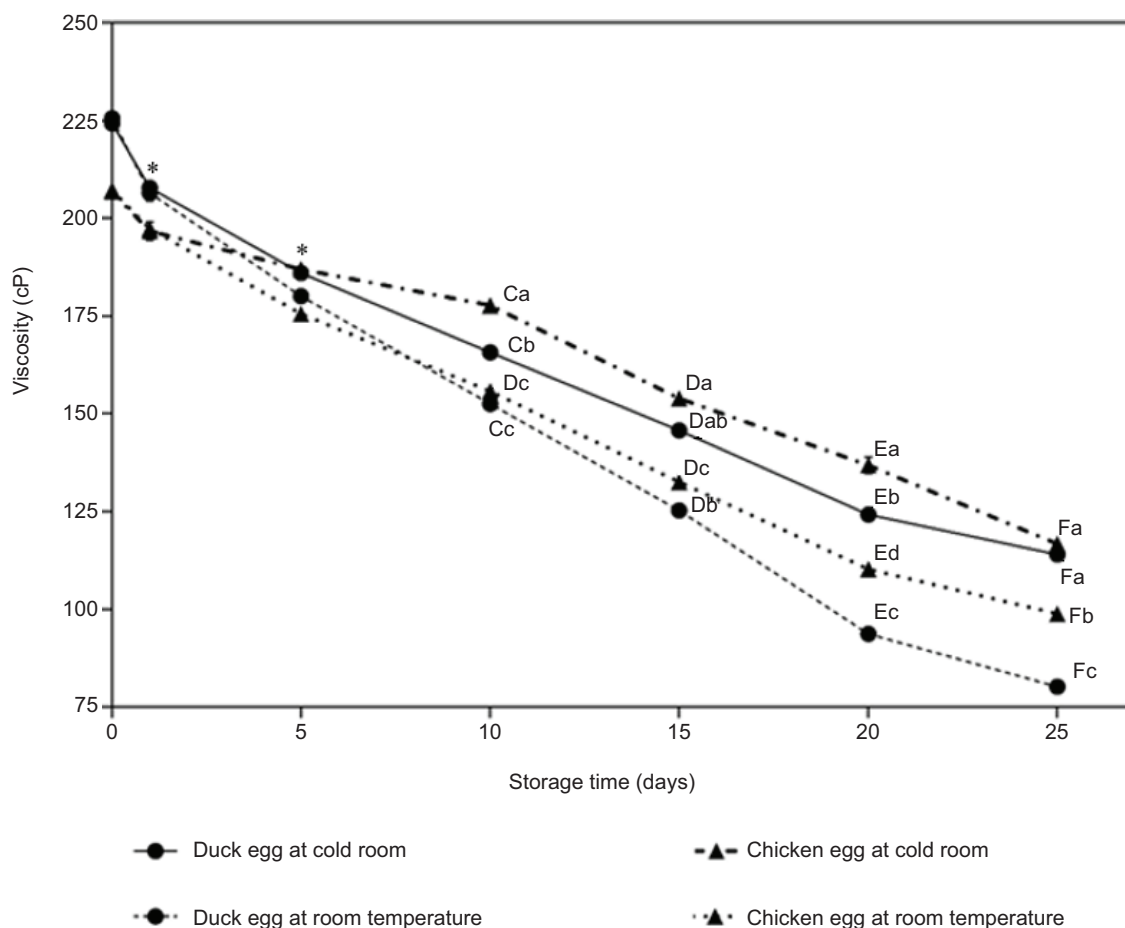


Figure 4. The viscosity of egg white from duck eggs and chicken eggs at different storage days and temperatures; different uppercase letters indicate significant differences between treatments ($p < 0.05$); different lowercase letters indicate significant differences between treatments ($p < 0.05$); * mean significant differences of duck egg at cold room temperature (DC), chicken egg at cold room temperature (CC), duck egg at room temperature (DR), and chicken egg at room temperature (CR) at day 0 (Aa, Ab, Aa, and Ab), day 1 (Aa, Bb, Aa, and Bb), and day 5 (Ba, BCa, Ba, and Ca), respectively.

and high albumen content, as explained later. The viscosity of duck eggs significantly declined to lower than chicken eggs after storage for 5 d because the proteolytic enzyme activity of duck eggs was higher compared with chicken eggs, as mentioned earlier.

Protein pattern

Figure 5 shows the protein patterns from SDS-PAGE analysis of duck and chicken egg whites stored at 4°C and room temperature at 0, 1, 5, 10, 15, 20, and 25 d. Both egg white types contained proteins with molecular weights (MWs) of 47, 77, and 220 kDa; however, MWs of 80 and 110 kDa were only found in duck egg white. Ovalbumin (MW 47 kDa) was a major component (54%), concurring with Kaewmanee *et al.* (2009) and Mine and Zhang (2013). Ovotransferrin or conalbumin with MW 76–80 kDa normally bind with metal ions and form protein-metal complexes resistant to denaturation (Baharuddin *et al.*, 2020; Alleoni, 2006), while the protein with MW 110 kDa was ovomucin (Mine and Zhang, 2013). Protein with MW of 220 kDa found in egg white as

ovomucin was related to thickness and viscous properties (Mine and Zhang, 2013; Wang *et al.*, 2019). The SDS-PAGE analysis showed that larger molecules became smaller, indicating proteolytic characteristics during storage (Barać *et al.*, 2013).

Generally, H.U., viscosity, and SDS-PAGE results agreed and supported each other. Higher H.U. values indicated lower viscosity and lower molecular weight.

Mineral content

Mineral contents including sodium, phosphorus, and potassium of egg white are shown in Table 1. Storage at two different temperatures did not result in any change in mineral content because the elements in the minerals were not sensitive to time and temperature. Egg white was not a good source of compounds compared with egg yolk, while duck egg white was higher in sodium and potassium compared with chicken egg white. The important nutrition in egg whites is protein (Mine and Zhang, 2013). Therefore, CKD patients should eat egg

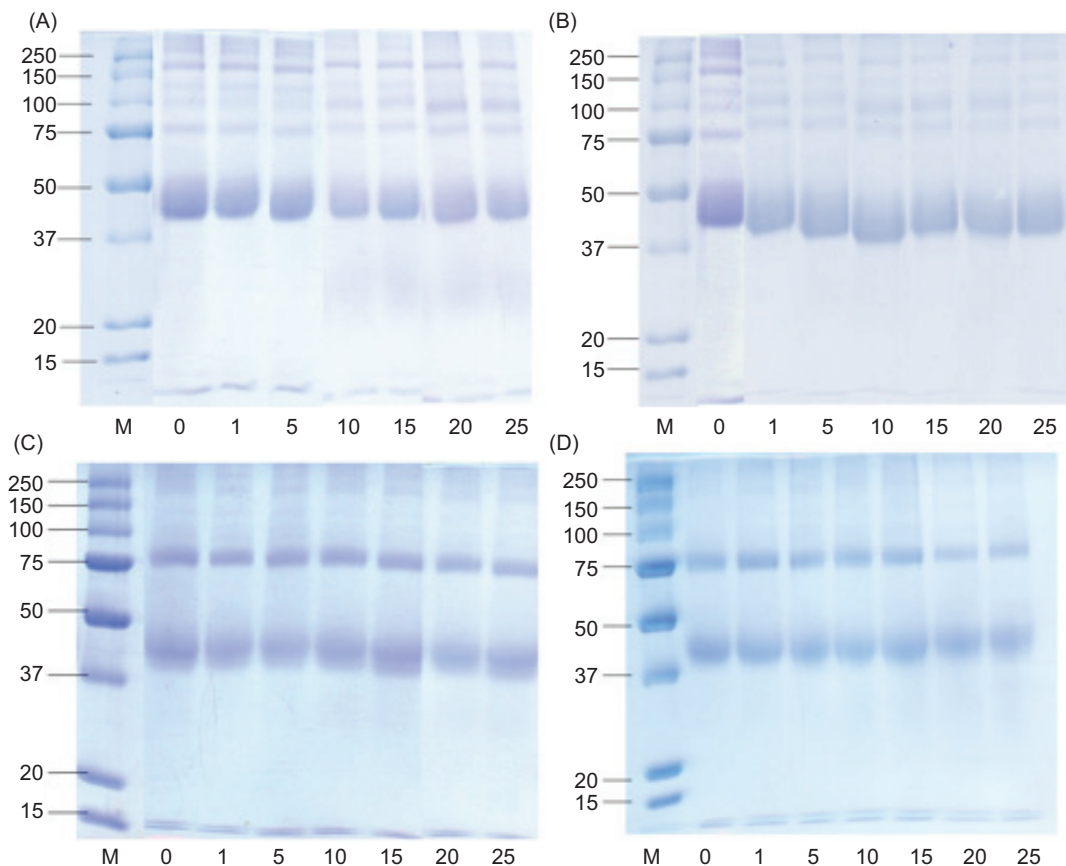


Figure 5. SDS-PAGE pattern of egg white protein from duck eggs and chicken eggs at different storage days and temperatures. Duck egg white stored at cold room temperature (4±2°C) (A) and room temperature (28±2°C) (B), and chicken egg white stored at cold room temperature (4±2°C) (C) and room temperature (28±2°C) (D) on 4–12% Bis-Tris gel stained with Coomassie brilliant blue. Lane 1–7: egg white protein at 0, 1, 5, 10, 15, 20, and 25 d; M: molecular weight standard.

Table 1. Mineral content (mg/100 g DW) of egg white from duck eggs and chicken eggs at different storage days and temperatures.

Storage condition	Day	Duck eggs			Chicken eggs		
		Na	P	K	Na	P	K
Cold room	1	179.00±1.00 ^{AaX}	12.23±0.02 ^{AaX}	155.00±2.65 ^{BaX}	147.67±2.08 ^{BaX}	8.99±0.56 ^{BaX}	169.00±2.65 ^{AaX}
	End*	179.00±1.00 ^{AaX}	12.20±0.04 ^{AaX}	153.00±2.00 ^{BaX}	147.33±1.53 ^{BaX}	8.75±0.73 ^{BaX}	168.67±2.08 ^{AaX}
Room temperature	1	181.33±1.15 ^{AaX}	12.213±0.02 ^{AaX}	155.33±1.53 ^{BaX}	149.00±2.65 ^{BaX}	8.98±0.61 ^{BaX}	163.00±2.65 ^{AaX}
	End*	179.33±1.53 ^{AaX}	12.213±0.01 ^{AaX}	154.33±1.53 ^{BaX}	149.00±3.6 ^{BaX}	8.84±0.51 ^{BaX}	165.33±2.08 ^{AaX}

*The end-of-day storage of duck eggs at cold room temperature, duck eggs at room temperature, chicken eggs at cold room temperature, and chicken eggs at room temperature were 15 d, 10 d, 20 d, and 15 d, respectively. Different uppercase case superscripts in the same mineral type indicate significant differences in egg types ($p<0.05$). Different lowercase superscripts in the same mineral type indicate significant differences in temperature ($p<0.05$). Different superscripts^(X-Y) in the same mineral type indicate significant differences in storage days ($p<0.05$).

whites from chicken eggs to prevent ingestion of excess minerals that could harm the kidneys.

Microbial growth

Microbial growth in egg white types tended to increase as storage time and temperature increased. At the higher temperature, the increase in microbial content was more pronounced. According to the Department of Agriculture (2005), the level of total viable count (TVC) must not be over 10^6 CFU/g sample with no *Salmonella* sp. In this study, *E. coli* and *S. aureus* were also measured for contamination control. Results showed that no *Salmonella* sp., *E. coli*, or *S. aureus* were detected even when TVC increased from 10^3 to 10^4 CFU/g (Table 2), indicating that the practical

technique used during storage was good enough to not break the eggshell, and sanitation before and after harvesting the eggs was fair. Chicken eggs had a longer shelf life compared with duck eggs. The shells of duck eggs are thicker and should have a longer shelf life. However, the sanitation of small duck farmers cannot be comparable to professional chicken farms. Duck farms in Thailand are mainly small-scale enterprises, while chicken farming is a large commercial business controlled by the Veterinary Department. As previously mentioned, duck eggs were obtained from ducks aged 40 w with thinner eggshells and shell membranes than eggs from chicken. However, both chicken and duck eggs kept at room temperature ($28\pm2^\circ\text{C}$) for 14 d were classified as fair B grade quality.

Table 2. Microbial counts (CFU/g) of egg white from duck eggs and chicken eggs at different storage days and temperatures.

Storage condition	Day	Duck eggs				Chicken eggs			
		TVC	<i>Salmonella</i> sp.	<i>E. coli</i>	<i>S. aureus</i>	TVC	<i>Salmonella</i> sp.	<i>E. coli</i>	<i>S. aureus</i>
Cold room	0	<10	ND	ND	ND	<10	ND	ND	ND
	1	<10	ND	ND	ND	<10	ND	ND	ND
	5	<250	ND	ND	ND	<10	ND	ND	ND
	10	4.3×10^2	ND	ND	ND	<30	ND	ND	ND
	15	9.3×10^3	ND	ND	ND	9.6×10^2	ND	ND	ND
	20	$>10^4$	ND	ND	ND	1.75×10^3	ND	ND	ND
	25	$>10^4$	ND	ND	ND	$>10^4$	ND	ND	ND
Room temperature	0	<10	ND	ND	ND	<10	ND	ND	ND
	1	<10	ND	ND	ND	<10	ND	ND	ND
	5	4.7×10^2	ND	ND	ND	<250	ND	ND	ND
	10	1.03×10^3	ND	ND	ND	1.47×10^2	ND	ND	ND
	15	$>10^4$	ND	ND	ND	9.7×10^3	ND	ND	ND
	20	$>10^4$	ND	ND	ND	$>10^4$	ND	ND	ND
	25	$>10^4$	ND	ND	ND	$>10^4$	ND	ND	ND

ND means not detected.

Thong Phap production

Slurry viscosity

The slurry viscosity of each egg type and storage condition is shown in Figure 6, with a decrease as storage time increases ($p < 0.05$). This result is related to the viscosity of egg whites. At day 0, the slurry from duck egg whites had a higher viscosity than chicken egg whites because duck egg whites contained ovomucin with two molecular weight ranges (110 and 220 kDa), while chicken egg whites contained only 110 kDa (Alleoni, 2006; Mine and Zhang, 2013). Slurry viscosity in both duck and chicken egg whites decreased along with aging.

The TVC of egg white must not exceed 10^4 CFU/gram with no *Salmonella* sp., *E. coli*, and *S. aureus* detected. Results showed that duck eggs could be kept at cold room temperature and room temperature longer than 15 and 10 d, while chicken eggs kept at the same conditions

longer than 20 and 15 d, respectively were not safe to eat. Hence, eggs of these ages were selected for the next study.

Texture of Thong Phap

The texture of Thong Phap presented a fracturability and hardness as shown in Table 3. As mentioned earlier, the fracturability indicated is measured as the first bite force to rupture the sample (Duizer, 2001) and reflects crispness, while hardness is the force required for breaking (Bruwer *et al.*, 2007; Duizer, 2001), indicating strength or stickiness. An increase in product fracturability was noticed with longer storage time due to decreased functional properties of protein as viscosity and protein pattern which is related to H.U. By contrast, reduced fracturability in duck eggs was due to the higher protein content, especially ovomucin.

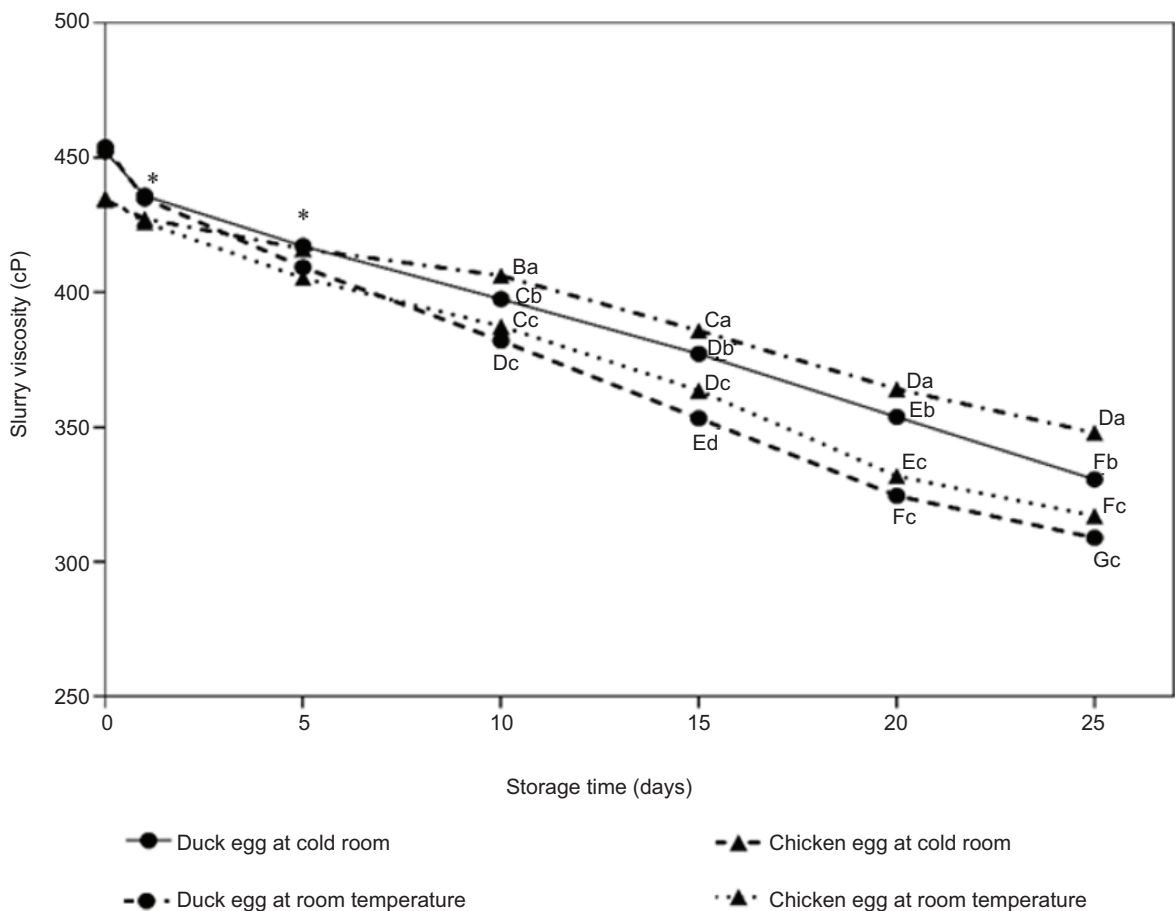


Figure 6. Viscosity of Thong Phap slurry made from duck egg white and chicken egg white at different storage days and temperatures; different uppercase letters indicate significant differences between treatments ($p < 0.05$); different lowercase letters indicate significant differences between treatments ($p < 0.05$); * mean significant differences of duck egg at cold room temperature (DC), chicken egg at cold room temperature (CC), duck egg at room temperature (DR), and chicken egg at room temperature (CR) at day 0 (Aa, Ab, Aa, and Ab), day 1 (Ba, ABa, Ba, and Aa), and day 5 (Ba, ABa, Cab, and Bc), respectively.

Table 3. Fracturability and hardness (N) of Thong Phap made from duck egg white and chicken egg whites at different storage days and temperatures.

Egg condition	Cold room		Room temperature	
	Fracturability	Hardness	Fracturability	Hardness
Duck egg at day 1	16.86±1.13 ^{AaX}	19.89±1.02 ^{AaX}	16.64±1.11 ^{AaX}	19.69±0.94 ^{AaX}
Duck egg at the end of storage	17.73±0.94 ^{AaY}	19.07±0.91 ^{AaX}	17.80±0.90 ^{AaY}	19.26±1.16 ^{AaX}
Chicken egg at day 1	17.78±1.15 ^{BaX}	19.14±1.22 ^{AaX}	17.79±0.96 ^{BaX}	19.39±0.93 ^{AaX}
Chicken egg at the end of storage	18.75±0.94 ^{BaY}	18.94±0.87 ^{AaX}	18.62±0.75 ^{BaY}	18.82±0.78 ^{AaX}

*The end-of-day storage of duck eggs at cold room temperature, duck eggs at room temperature, chicken eggs at cold room temperature, and chicken eggs at room temperature were 15 d, 10 d, 20 d, and 15 d, respectively. Different superscripts (^{A-B}) in the same texture indicate significant differences in egg types ($p<0.05$). The same superscript (^a) in the same texture indicates the non-significant differences in temperatures ($p>0.05$). Different superscripts (^{X-Y}) in the same texture indicate significant differences in storage days ($p<0.05$).

Thong Phap selection

The Thong Phap product was aimed at CKD patients in stages 1–3 who required 0.6–0.8 g/kg body weight of essential amino acids (The Nephrology Society of Thailand, 2012; The Nephrology Society of Thailand, 2015). Thong Phap produced from duck egg whites contained protein at 4.74 g/serving size, while the product prepared from chicken egg whites contained protein at 4.64 g/serving size (4 pieces, 52 g) (Table 4). When compared with RDI, one serving of Thong Phap from duck and chicken egg whites contained protein of 13.17% and 12.89% of RDI and was classified as a source of protein (at least 12% of the energy value of the food is provided by protein) (European Commission, 2012). Costing of the product (Table 5) indicated that duck eggs were more expensive compared with the product produced from chicken eggs. Hence, chicken eggs were chosen to produce Thong Phap. To guarantee product quality, 20 d of storage of chicken eggs was selected for further study.

Conclusions

Storage time affected egg quality with increased weight loss, pH, and microbiological load but lower H.U. and viscosity. The shelf life of duck eggs based on microbial quality under cold storage and room temperature storage was 15 and 10 d, respectively while the shelf life of chicken eggs was 20 and 15 d, respectively. Different egg types and storage conditions affected Thong Phap quality. Chicken eggs stored for 20 d at 4°C were suitable for producing Thong Phap. However, a sensory evaluation must be conducted before launching the product.

Acknowledgments

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Table 4. Protein quantity of egg white for producing Thong Phap per 52 g serving size.

Egg type	Protein content (g)	Protein content compared with RDI (%)
Duck eggs	4.74	13.17
Chicken eggs	4.64	12.89

Table 5. Quantity and cost of egg white to produce Thong Phap per 52 g serving size.

Characteristic		Duck eggs	Chicken eggs
Weight	Whole egg content (g)	65	70
	Egg white content (g)	35 (53.85%)	45 (64.29%)
	Egg white content (egg/kg slurry)	425	425
	Egg white (egg/kg slurry)	12	9
	Whole egg (Baht/egg)	5	3.90
Cost	Egg white (Baht/kg slurry)	60	35.10
	Times	X	0.6X

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