



## Consumer Attitudes Toward Storing and Thawing Chicken and Effects of the Common Thawing Practices on Some Quality Characteristics of Frozen Chicken

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**ABSTRACT:** In this study, a survey was conducted to both evaluate the consumers' general attitudes for purchasing and storing the raw chicken and determine the thawing practices used for defrosting frozen chicken at home. About 75% of the consumers indicated purchasing chicken meat at least once a week or more. Furthermore, the majority (82.16%) of those who stored at least a portion of the raw chicken stated freezing the raw chicken meat at home. Freezing the chicken meat was considered to have no effect on the quality by 43.49% of the consumers while 56.51% thought that freezing had either negative or positive effects on the quality. The survey study indicated that top five most commonly used thawing practices included thawing on the kitchen counter, thawing in the refrigerator, thawing in the warm water, thawing in the microwave, and thawing under tap water. In addition, an experimental study was conducted to determine the effects of these most commonly used thawing practices on some quality characteristics of the chicken meat including pH, drip loss, cooking loss, color analysis and textural profile analysis. Although, L\* value for thawing on the kitchen counter was the lowest, after cooking, none of the thawing treatments have a significant effect on the color values. Thawing in the microwave produced the highest drip loss of 3.47% while the lowest drip loss of 0.62% was observed with thawing in the refrigerator. On the other hand, thawing in the microwave and refrigerator caused the lowest cooking loss values of 18.29% and 18.53%, respectively. Nevertheless, there were no significant differences among textural parameter values of the defrosted and then cooked samples using the home based thawing practices, indicating similar quality characteristics among the samples. (**Key Words:** Consumer Preference, Poultry, Chicken, Freezing, Thawing, Quality)

### INTRODUCTION

In the last decade, chicken meat has experienced a notable increase in production worldwide from 58.6 million metric tons in 2000 to 96.3 million metric tons in 2013. During the same period, chicken meat production in Turkey was almost trebled and Turkey became the world's 10th largest chicken meat producer with 1,758,476 metric tons of production in 2013 while the chicken meat production was only 634,939 metric tons in the year 2000 (Food and Agriculture Organization, 2015). Thus, the chicken meat has become the most important form of animal protein in

Turkey since per capita chicken meat consumption increased from 9.69 kg to 20.53 kg between 2001 and 2013 whereas per capita red meat consumption was around 12.7 kg in 2013 (BESD-BIR, 2013; Gul and Uzun, 2014). Magdelaine et al. (2008) stated that several main factors to explain attractiveness of poultry meat by the consumers including relatively low and competitive price, absence of cultural or religious obstacles and dietary and nutritional (protein) qualities. In addition, income level of the consumers, socioeconomic and demographic factors, seasons, food safety and quality, personal choices and habits were considered among the effective factors on the demand for chicken meat in Turkey (Aral et al., 2013).

Sengul et al. (2002) studied level of chicken meat consumption and consumption pattern of the consumers in Sanliurfa province, Turkey. They indicated that poultry

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meat was purchased once a week by 43.4% of the consumers, once in every two weeks by 34.3% of the consumers and once a month by 13.5% of the consumers. In another study, consumers' purchase rates of the chicken meat were 31.25%, 15%, and 9.5% for once a week, once in every two weeks and once a month, respectively in Bingol province, Turkey (Inci et al., 2014). U.S. Department of Agriculture Food Safety and Inspection Service (USDA-FSIS) recommended that fresh poultry meat needs to be cooked, frozen or discarded within 1 to 2 days of cold storage after purchasing (USDA-FSIS, 2013a). Even though the freezing is a well-known and widely used practice to prolong shelf-life of the meats, effects of the freezing and thawing on the quality of the meats continue a significant problem due to the complex physical, chemical, and biochemical changes during the processes including melting of ice crystals, relaxation of lipids, and relaxation/ proteolysis of proteins (Liu and Chen, 2001). Water fraction of the meat is the main constituent affected by freezing and thawing. To minimize the tissue damage and drip loss, freezing rate and formation of small ice crystals are critical during the freezing of the meats (Leygonie et al., 2012; Akhtar et al., 2013). However consumers merely have a control over the freezing process at home since freezer unit of the most household refrigerators maintain temperatures around  $-18^{\circ}\text{C}$  to  $-20^{\circ}\text{C}$ . On the other hand, several thawing practices that may have different effects on quality of chicken meat could be used by consumers at home including thawing in a refrigerator, thawing on counter at room temperature, thawing in warm water, thawing under tap water and thawing in a microwave (USDA-FSIS, 2013a, b).

Even though there were several studies conducted to determine the factors affecting the chicken meat consumption and consumer preference in Turkey, limited data were available related with consumers' handling of raw chicken meat after the purchase and possible effects of the handling practices on the quality of the chicken meats (Uzundumlu et al., 2011a,b; Durmus et al., 2012; Senturk and Guler, 2012; Aral et al., 2013; Senturk, 2015). Therefore the objective of this study was to determine the effects of the most common thawing practices used by the consumers at home on some quality characteristics of the chicken meat. To be able to reach this objective, a survey was conducted to both estimate the consumers' general attitudes for purchasing and storing the raw chicken and identify their thawing practices to defrost their frozen chicken before cooking. Then, further laboratory experiments were performed to determine the effects of the most commonly used home based thawing practices derived from the survey study on some quality characteristics of the frozen chicken meat.

## MATERIALS AND METHODS

### Consumer survey

The data was collected using a questionnaire which was conducted to investigate the consumer attitudes toward freezing chicken meat for the storage and then thawing before the cooking at home. The consumers were surveyed in January to February 2015 in Cukurova district of Adana Province, Turkey. Ungrouped one stage random likelihood sampling method based on households was used to determine the sample size (Akbay et al., 2007; Uzundumlu et al., 2011a,b; Aydin and Kilic, 2013; Uzundumlu and Birinci, 2013):

$$n = t^2 [1+(0.02) (b-1)] \times pq / e^2 \quad (1)$$

where  $n$  represents the sample size,  $t$  represents the significance level (assumed to be 95% with the table value of 1.96),  $b$  represents the stage of sampling (which is equal to 1),  $p$  represents the probability of the examined situation occurring ( $p = 0.5$  was used for the absence of preliminary information related consumers' attitudes toward freezing chicken meat for storage and thawing at home),  $q$  represents the probability of the examined situation not occurring ( $q = 1-p$ ), and  $e$  represents the accepted error (assumed to be 5%). Since  $b$  equal to 1, the Eq. 1 was transformed to the following equation:

$$n = (t^2 \times pq) / e^2$$

$$n = (1.96^2 \times 0.5 \times 0.5) / 0.05^2 = 384$$

The survey was administered outside the selected supermarkets carrying raw poultry products. The questionnaire was designed for an intercept survey requiring only a few minutes to be completed by the customers who were willing to participate in the survey. The questionnaire asked questions to collect information regarding consumers' general behavior for purchasing and storing the raw chicken meat, consumers' attitude toward the effects of freezing on the quality of the chicken meat and the thawing methods used by the consumers to defrost their frozen chicken meat before cooking that was stored in the freezer unit of a refrigerator at home.

### Experimental procedures

An experimental study was performed using skinless chicken breast meats by following the results derived from the survey study. Raw broiler breast meats were obtained from a retail market and transported to the laboratory within one hour in an insulated container. The fillets were individually placed in medium size refrigerator bags and then placed in a freezer at  $-20^{\circ}\text{C}$  for 72 hours to simulate

the freezing chicken meat at home conditions.

Following the three days of frozen storage, bagged chicken breast samples were subjected to five different home-based thawing practices which were derived from the results of the survey study. The samples thawed until the temperature in the center of the meats reached to 0°C. The thawing practices used in the experiment were as follows: i) thawing in a refrigerator (+4°C, 24 hours); ii) thawing on a counter at room temperature (22°C, 6 hours); iii) thawing in warm water (37°C, 40 minutes); iv) thawing in a microwave (180 W, 10 to 13 minutes); and v) thawing under tap water (20°C, 1 hour). After thawing, the samples were subjected to several analyses to determine home-based thawing practices on some quality characteristics of the frozen chicken meats including pH, drip loss, cooking loss, color analysis and textural profile analysis.

### pH

The pH values of thawed chicken breasts were measured in slurries prepared by blending 10 g of the samples with 50 ml of distilled water in a homogenizer for 60 s. The pH meter (S220, Mettler-Toledo, LLC, Columbus, OH, USA) was calibrated prior to the measurements using pH 4.0 and 7.0 reference buffers. Duplicate readings were taken for each sample.

### Drip loss

Drip loss of the chicken breast samples were determined by recording initial weight of the samples before freezing at -20°C and then recording the weights of the samples thawed with various methods until the temperature in the center of the meats reached to 0°C. Calculation for drip loss was as follows:

$$\text{Drip loss (\%)} = \frac{[(\text{Initial weight} - \text{Weight after thawing}) / \text{Initial weight}] \times 100}{}$$

### Cooking loss

Weights of the thawed chicken breast samples were recorded before cooking. The samples then cooked to an internal temperature of 74°C on an electrical grill (Tefal Easy Toast, Groupe Seb, Istanbul, Turkey) and cooled for 10 minutes before weighing the cooked sample. Calculation for cooking loss was as follows:

$$\text{Cooking loss (\%)} = \frac{[(\text{Initial weight} - \text{Weight after cooking}) / \text{Initial weight}] \times 100}{}$$

### Color analysis

Color space values of L\* (lightness), a\* (redness), and b\* (yellowness) for the outer surfaces of samples were obtained using a Konika Minolta Colorimeter (CR-400,

Minolta C., Ramsey, NJ, USA) calibrated to a standard white tile after the colorimeter port was covered with clear plastic film. Random readings were taken at three locations on the outer surface of the thawed skinless chicken breast samples prior to cooking and then after cooking (Benli et al., 2011; Benli et al., 2015).

### Texture profile analysis

Textural parameters were determined using a texture analyzer (Model TA – XT Plus, Stable Microsystems, Godalming, England). Core samples (3cm diameter, 0.8cm height) from cooked (74°C) samples were prepared and axially compressed (50 kg load cell and crosshead test speed 1 mm/s) to 50% of their initial height in a double compression cycle. Hardness (kg) was the maximum force required to compress the sample, springiness (D2/D1) was the ability of sample to recover its original form after the deforming force was removed (D1 was the initial compression distance and D2 was the distance detected for the second compression), cohesiveness (A2/A1) was the extent to which the sample could be deformed prior to rupture (A1 was the total energy required for the first compression and A2 was the total energy required for the second compression), gumminess (hardness×cohesiveness) was the force needed to disintegrate a semisolid sample to a steady state of swallowing, chewiness (springiness×gumminess) was the work needed to chew a solid sample to a steady state of swallowing (Petraçci et al., 2014). Four core samples were used for each replication.

### Statistical analyses

The responses to the survey questions were analyzed to calculate the descriptive statistics and frequency tables. Statistical analyses of data were performed with SPSS software version 20 (IBM SPSS Statistics, Armonk, NY, USA). Analysis of variance (One-way ANOVA) procedures were applied and Tukey multiple comparison test was used to determine the significant differences for the data obtained in the experimental study. All experiments were replicated three times for collecting the data.

## RESULTS AND DISCUSSION

### Consumer survey

The questionnaire asked questions to collect information regarding consumers' general behavior for purchasing and storing the raw chicken meat, consumers' attitude toward the effects of freezing on the quality of the chicken meat and the thawing methods used by the consumers to defrost their frozen chicken meat before cooking that was stored in the refrigerator at home.

The data regarding some of the chicken meat purchase habits and income levels of the participants are presented in

**Table 1.** Questions related to consumers' chicken meat purchase habits and income levels

Questions	N	%
Q1. Who is responsible for purchasing chicken meat in your household?		
Mother	169	44.01
Father	95	24.74
Adult children	25	6.51
Mother and Father together	85	22.14
Other	10	2.60
Total	384	100
Q2. How often do you purchase chicken meat from supermarkets or retail markets?		
Once in every 2-3 days	75	19.53
Once a week	141	36.72
Once in every two weeks	104	27.08
Once a month	41	10.68
Other	23	5.99
Total	384	100
Q3. What is the average monthly income of your household? <sup>1</sup>		
1500 (\$ 575) or less	46	11.98
1500 (\$ 575) - 3000 (\$ 1150)	205	53.39
3000 (\$ 1150) or more	132	34.38
No answer	1	0.26
Total	384	100

Q1, question 1; Q2, question 2; Q3, question 3; N, number of the participants.

<sup>1</sup> Values in Turkish Lira (TL) per month. Average exchange rate for the period: TL 1.00 = USD 0.3833.

Table 1. Among 384 consumers surveyed within the scope of the study, 44.01% indicated that “mother” was the primary person for buying the chicken meat from grocery in the household while 24.74% and 22.14% of the consumers indicated that “father” and “mother-and-father together” were responsible for purchasing the chicken meat in the family, respectively. While 6.51% of the consumers also reported that adult children were the main purchaser, 2.60% of the consumers specified that either they purchased the chicken meat by themselves since they live alone or in some cases grand-parents were the primary buyers in the household.

Four different time intervals were defined to determine how often consumers purchase chicken meat (Table 1). The percentage of the consumers reported purchasing chicken meat at, “once a week”, “once in every two weeks” and “once a month” were 36.72%, 27.08%, and 10.68%, respectively. Only 19.53% of the consumers reported buying chicken meat in every 2 to 3 days which in most cases may not require freezing but only require chilling for the storage of the chicken meat before consuming. In contrast, Inci et al. (2014) reported that 34.25% of the consumers were purchasing chicken two to three times a week while 31.25% of the consumers in once a week, 15% of the consumers once in two weeks and 9.5% of the consumers once a month in Bingol Province, Turkey. In another study, Sengul et al. (2002) reported that poultry meat was purchased once a week by 43.4% of the

consumers, once in every two weeks by 34.3% of the consumers and once a month by 13.5% of the consumers in Sanliurfa province, Turkey. A study related to buying habits of poultry meat in the selected countries of Central and Eastern Europe indicated that 15%, 33%, and 19% of the consumers purchased poultry meat several times a week while 33%, 34%, and 25% once a week and 28%, 18% and 23% two to three times a month in Slovenia, Bosnia and Hercegovina, and Serbia, respectively (Vukasovic, 2010)

The average monthly incomes of the participants were defined in three different categories including lower, middle and higher income levels (Table 1). Of the participants, 53.39% reported having a middle income level while 34.38% reported having a higher and 11.98% reported having a lower income level. Senturk (2015) studied the effect of national income level on the demand of foods from animal origins for the period of 2003 through 2013 in Turkey. It was concluded that the demand for the foods from animal origins had increased depending on increases in income levels in Turkey.

Table 2 presents the consumers' general attitude toward storing the raw chicken meat. While 29.95% of consumers indicated using only fresh chicken meat, 70.05% of the consumers reported having a general attitude of storing either some portion or all of the raw chicken meat (59.63% and 10.42%, respectively). Furthermore, the majority (82.16%) of those who stored at least a portion of the raw chicken stated freezing the raw chicken meat at home.

**Table 2.** Questions related to consumers' attitudes toward storing the raw chicken

Questions	N	%
Q4. What is your general attitude toward storing the raw chicken?		
I use only fresh chicken meat	115	29.95
I use some portion of the raw chicken as fresh but store the rest	229	59.63
I store all the raw chicken meat due to purchasing in bulk	40	10.42
Total	384	100
Q5. How do you store the raw chicken meat that wasn't consumed after purchasing? <sup>1</sup>		
I store the raw chicken refrigerated without freezing for a few days	45	16.73
I store the raw chicken frozen	221	82.16
Other	3	1.11
Total	269	100

Q4, question 4; Q5, question 5; N, number of the participants.

<sup>1</sup> Question 5 was asked of only respondents who indicated storing chicken meat at home (Question 4). Therefore, the number of respondents to Question 5 was 269.

Similarly, 84.6% of meat and 62.9% of poultry purchased in New Zealand was fresh (rather than frozen), and the majority (approximately 64%) of fresh meat and poultry was frozen at home (Gilbert et al., 2007). Only about 16.73% of consumers stored the raw chicken in refrigerator for a few days while 1.11% reported that they cook the chicken meat before storing. USDA-FSIS also suggested that fresh poultry should be cooked or frozen at home within 2 days following the purchase (USDA-FSIS, 2013a).

Consumers' attitude regarding effects of the freezing on the quality of the chicken meat is presented in Table 3. Among the all participants in the study, 43.49% thought that freezing had no effect on the quality whereas 36.20% and 20.31% of the consumers (a total of 56.51%) reported that freezing had either negative or positive effects on the quality, respectively. In addition, 387 choices were made by those who thought that freezing had an effect on the quality for indicating affected attributes (a total of 217 consumers). Of the choices, 42.64% was taste and odor, 31.78% was appearance and color, 22.74% was hardness and 2.84% was

other as thought among the affected quality parameters of the raw chicken with the freezing. Leygonie et al. (2012) also reported that freezing, frozen storage and thawing would have influence on some quality parameters of meat including appearance, texture, flavor, color, microbial activity and nutritive value.

Table 4 provides the percentages of the choices for the thawing methods used by the consumers who stored raw chicken meat by freezing at home. Among the 319 choices made by those who defrosted the frozen chicken at home, 31.66% of choices was thawing on the kitchen counter, 26.64% of choices was thawing in the refrigerator, 14.42% of choices was thawing in the warm water, 13.17% of choices was thawing in the microwave, 7.21% of choices was thawing under tap water, 5.33% of choices was cooking without thawing and 1.57% of choices was other practices including combining two or more methods. Similarly, Gilbert et al. (2007) also stated that thawing at room temperature for up to 12 h was the most favored method for defrosting frozen meat and poultry at home in New Zealand.

**Table 3.** Questions related to consumers' opinion about the effects of the freezing on the quality of the chicken meat

Questions	N	%
Q6. Do you think that freezing has an effect on quality of the raw chicken meat?		
Yes - I think that freezing has a positive effect on the quality	78	20.31
Yes - I think that freezing has a negative effect on the quality	139	36.20
No - I think that freezing has no effect on the quality	167	43.49
Total	384	100
Q7. What kind of effects do you think that freezing has on the quality of the chicken meat? <sup>1,2</sup>		
Hardness	88	22.74
Taste and odor	165	42.64
Appearance and color	123	31.78
Other	11	2.84
Total	387	100

Q6, question 6; Q7, question 7; N, number of the participants or choices.

<sup>1</sup> Question 7 was asked of only respondents who indicated that freezing has an effect on the quality of the raw chicken meat (Question 6). Therefore, the number of respondents to Question 7 was 217.

<sup>2</sup> The respondents were allowed to select multiple answers.

**Table 4.** Question to identify consumers' thawing practices to defrost their frozen chicken meat before cooking

Question	N	%
Q8. What the thawing method do you use more often to defrost the frozen chicken at home? <sup>1,2</sup>		
Thawing in the refrigerator (12 -24 hours)	85	26.64
Thawing on the kitchen counter	101	31.66
Thawing in the warm water	46	14.42
Thawing under tap water	23	7.21
Thawing in the microwave	42	13.17
Cooking without thawing	17	5.33
Other	5	1.57
Total	319	100

Q8, question 8; N, number of the choices.

<sup>1</sup> Question 8 was asked of only respondents who indicated storing chicken meat at home (Question 4). Therefore, the number of respondents to Question 8 was 269.

<sup>2</sup> The respondents were allowed to select multiple answers.

Even though perishable foods including chicken meat are safe while frozen, when thawing the outer layer of the food could become warmer than 4°C, bacteria that may have been present before freezing can begin to multiply and may lead to foodborne illness. Thus, the USDA-FSIS only recommended three safe ways for thawing the perishable food including in the refrigerator, in the cold water, and in the microwave conversely thawing on the counter and in the hot water were not recommended (USDA-FSIS, 2013b). However, Kosa et al. (2015) reported that about one-quarters of consumers don't use recommended safe thawing methods for raw poultry, in addition, less than 11% of those who thaw in cold water put the raw poultry in a recommended sealed container or plastic bag while submerged in cold water and changed the water every 30 min. Similarly, the counter-top or ambient thawing reported that favored by the almost 50% of the consumers due to the simplicity despite the known risk of microbial spoilage (Akhtar et al., 2013). Nevertheless, Ingham et al. (2005) stated that thawing equal or less than 1,670 g of whole chicken at equal or less than 30°C for equal or less than 9 h and thawing more than 453 g of ground beef portions at equal or less than 22°C for equal or less than 9 h were not mainly hazardous practices. The present study also indicated that thawing on the kitchen counter and in the

warm water (a total of 46.08% of choices) reported as generally used thawing practices to defrost chicken meat at home by the consumers.

### Experimental study

The survey study indicated that top five most commonly used thawing practices included thawing on the kitchen counter, thawing in the refrigerator, thawing in the warm water, thawing in the microwave, and thawing under tap water. Thus, an experimental study was conducted using raw chicken breast meats by following the results derived from the survey study to determine the effects of these most commonly used thawing practices on some quality characteristics of the chicken meat.

L\* a\* b\* (lightness, redness, yellowness, respectively) values were statistically analyzed to determine differences among the home based thawing treatments derived from the survey study for "after thawing" and "after cooking" measurements (Table 5). After thawing, the initial mean L\* values changed from 50.65 to 55.49 and L\* value for thawing on the kitchen counter was significantly lower ( $p < 0.05$ ) when compared to thawing in the refrigerator and warm water. Droval et al. (2012) indicated that appearance, texture, juiciness, and flavor of the meat are among the main quality attributes and the initial selection by

**Table 5.** Color values of chicken breast the samples after defrosting using home based thawing practices and cooking

Thawing treatments	L*±SD		a*±SD		b*±SD	
	After thawing	After cooking	After thawing	After cooking	After thawing	After cooking
Refrigerator	55.49±1.15 <sup>a</sup>	81.86±2.37 <sup>a</sup>	2.53±1.01 <sup>a</sup>	2.18±0.86 <sup>a</sup>	6.89±1.45 <sup>a</sup>	15.61±2.92 <sup>a</sup>
Kitchen counter	50.65±0.23 <sup>b</sup>	82.64±1.58 <sup>a</sup>	1.60±0.24 <sup>a</sup>	2.73±0.50 <sup>a</sup>	6.09±1.82 <sup>a</sup>	15.97±0.58 <sup>a</sup>
Warm water	55.03±2.8 <sup>a</sup>	80.42±0.57 <sup>a</sup>	1.41±1.00 <sup>a</sup>	1.98±0.35 <sup>a</sup>	6.83±0.95 <sup>a</sup>	17.51±1.56 <sup>a</sup>
Microwave	54.68±1.81 <sup>ab</sup>	83.95±1.11 <sup>a</sup>	0.55±0.90 <sup>a</sup>	1.85±0.93 <sup>a</sup>	5.82±2.12 <sup>a</sup>	17.27±1.09 <sup>a</sup>
Tap water	52.09±0.35 <sup>ab</sup>	83.24±0.27 <sup>a</sup>	1.73±0.77 <sup>a</sup>	2.26±0.50 <sup>a</sup>	7.41±2.12 <sup>a</sup>	17.08±1.90 <sup>a</sup>

Refrigerator, thawing in a refrigerator (+4°C, 24 hours); Kitchen counter, thawing on a kitchen counter at room temperature (22°C, 6 hours); Warm water, thawing in warm water (37°C, 40 minutes); Tap water, thawing under tap water (20°C, 1 hour); Microwave, thawing in a microwave (180 W, 10 to 13 minutes); SD, standard deviation.

<sup>a,b</sup> Means with different superscript letters are significantly different ( $p < 0.05$ ) within the same column.

consumers is mostly depended on the appearance of the meat. Although extremely dark or light colors in meat have been reported as a negative quality characteristic, variations in color among skinless breast fillets could be more important for the quality than the absolute color of the meat (Fletcher, 1999). Therefore, in this study  $L^*$  values indicated that skinless chicken breasts became just slightly darker after thawing on kitchen counter, and that these changes might be detected by the consumers before cooking. After cooking mean  $L^*$  values were between 80.42 and 83.95 and there were no significant differences among  $L^*$  values of home based thawing practices. The Initial mean  $a^*$  values of the thawed samples were between 0.55 and 2.53 and after the cooking the values changed from 1.85 to 2.7. The initial mean  $b^*$  values were between 5.82 and 7.41 for after thawing and changed from 15.61 to 17.51 for after cooking. In this study, none of the thawing treatments have a significant effect on  $a^*$  and  $b^*$  values of chicken breast meats regardless of the time of measurement (after thawing or after cooking). Zhuang and Savage (2013) reported average  $L^*$ ,  $a^*$ , and  $b^*$  values of 56.7, -0.2, and 11.2, respectively for raw broiler breasts collected from the production line and used in their study. Furthermore, Lee et al. (2008) also reported that color values of commercial breast meat products representing several brands and various industry practices (chilling or enhancement procedures) ranged from 52.9 to 55.6, 8.1 to 11.1, and 17.9 to 22.5 for  $L^*$ ,  $a^*$ , and  $b^*$ , respectively. Thawing for 3 days at 4 °C has been shown to cause a reduction in  $L^*$  value in the pale chicken breast fillets and an increase in the dark fillets, however was not effective on  $L^*$  values of normal fillets. In addition, similar to the present study, cooking has been reported to further increase  $L^*$  value and reduce the differences in  $L^*$ ,  $a^*$  and  $b^*$  between groups (Galobart and Moran, 2004).

Average pH values of the samples following the thawing treatments ranged from 6.07 to 6.20 (Table 6). The amount of glycogen present in the muscle is highly related to the ultimate pH of meat. Changes in the ultimate pH were reported directly affecting the amount of drip loss with altering the electrostatic repulsion between the thick and thin filaments in the meat (Yu et al., 2005). In the present study, there were no significant differences among the mean pH values after defrosting the samples using home based thawing practices indicating a similar effect on drip loss of the samples.

Nevertheless, average drip loss values of the samples were significantly different ( $p < 0.05$ ) following the thawing treatments (Table 6). Thawing in the microwave resulted in a higher drip loss of 3.47% among the chicken breast samples. Statistical analysis of the data indicated that thawing on kitchen counter produced a similar drip loss (1.47%) while thawing in tap water, warm water and

**Table 6.** pH, drip loss and cooking loss values of chicken breast the samples after defrosting using home based thawing practices

Thawing treatments	pH±SD	Drip loss±SD (%)	Cooking loss±SD (%)
Refrigerator	6.10±0.10 <sup>a</sup>	0.62±0.16 <sup>b</sup>	18.53±0.22 <sup>b</sup>
Kitchen counter	6.07±0.10 <sup>a</sup>	1.47±0.40 <sup>ab</sup>	19.61±0.76 <sup>ab</sup>
Warm water	6.14±0.04 <sup>a</sup>	0.93±0.25 <sup>b</sup>	22.64±0.85 <sup>a</sup>
Microwave	6.20±0.08 <sup>a</sup>	3.47±1.48 <sup>a</sup>	18.29±2.36 <sup>b</sup>
Tap water	6.18±0.03 <sup>a</sup>	1.14±0.37 <sup>b</sup>	22.60±1.02 <sup>a</sup>

Refrigerator, thawing in a refrigerator (+4°C, 24 hours); Kitchen counter, thawing on a kitchen counter at room temperature (22°C, 6 hours); Warm water, thawing in warm water (37°C, 40 minutes); Tap water, thawing under tap water (20°C, 1 hour); Microwave, thawing in a microwave (180 W, 10 to 13 minutes); SD, standard deviation.

<sup>a,b</sup> Means with different superscript letters are significantly different ( $p < 0.05$ ) within the same column.

refrigerator caused lower ( $p < 0.05$ ) drip losses of 1.14%, 0.93%, and 0.62%, respectively. The water in meat could exist in bound, immobilized and free forms. A large portion of water in muscle (88% to 95%) found in the free space between the thick and thin filaments within the myofibrils while a small percentage of the water (5% to 12%) was held extracellularly outside the fiber wall or between myofibril in the muscle. Several factors would have effect on the water-holding ability of the meat including pH, sarcomere length, ionic strength and development of rigor influence due to the alteration of the cellular and extracellular components (Aberle et al., 2001; Yu et al., 2005). Similar to this study, the microwave thawing of 35 minutes to reach 0°C reported increasing the drip loss of the meat to within the same range of ambient air thawing (5 to 7 h), conversely thawing in the refrigerator reported resulting in the highest drip loss (Leygonie et al., 2012). Yu et al. (2005) were also reported that thawing chicken breast and leg samples at 18°C had the highest drip loss when compared to the samples that were thawed at 0°C and chilled to 2°C.

There were significant differences ( $p < 0.05$ ) among average cooking loss values of the defrosted samples after cooking to an internal temperature of 74°C on an electrical grill (Table 6). The cooking loss values of the chicken breast samples in the range of 18.29% – 22.64%. Thawing in the microwave and refrigerator produced significantly ( $p < 0.05$ ) lower cooking loss of 18.29% and 18.53%, respectively while thawing on kitchen counter produced a similar cooking loss of 19.61%. Conversely, thawing the chicken breast samples in tap water and warm water caused higher cooking loss of 22.60% and 22.64%, respectively. Zhuang and Savage (2013) reported that cooked broiler breast fillets prepared directly from a frozen stated or prepared from a thawed state exhibited significantly different cooking loss values of 21.2% and 19.0%, respectively. In another study, cook loss values of two air-chilled commercial broiler breast meat products (13.5% to

**Table 7.** Texture profile analysis of chicken breast the samples after defrosting using home based thawing practices and cooking

Thawing treatments	Hardness (kg/g)	Springiness	Cohesiveness (kg/g)	Gumminess	Chewiness (kg/g)
Refrigerator	7.98±1.02 <sup>a</sup>	0.64±0.04 <sup>a</sup>	0.65±0.01 <sup>a</sup>	5.26±0.66 <sup>a</sup>	3.42±0.62 <sup>a</sup>
Kitchen counter	8.14±0.59 <sup>a</sup>	0.65±0.01 <sup>a</sup>	0.64±0.01 <sup>a</sup>	5.23±0.43 <sup>a</sup>	3.43±0.31 <sup>a</sup>
Warm water	7.65±0.60 <sup>a</sup>	0.67±0.02 <sup>a</sup>	0.67±0.02 <sup>a</sup>	5.10±0.30 <sup>a</sup>	3.41±0.24 <sup>a</sup>
Microwave	7.33±0.46 <sup>a</sup>	0.65±0.03 <sup>a</sup>	0.63±0.01 <sup>a</sup>	4.61±0.24 <sup>a</sup>	3.00±0.28 <sup>a</sup>
Tap water	7.88±1.71 <sup>a</sup>	0.64±0.01 <sup>a</sup>	0.65±0.02 <sup>a</sup>	5.14±1.00 <sup>a</sup>	3.31±0.68 <sup>a</sup>

Refrigerator, thawing in a refrigerator (+4°C, 24 hours); Kitchen counter, thawing on a kitchen counter at room temperature (22°C, 6 hours); Warm water, thawing in warm water (37°C, 40 minutes); Tap water, thawing under tap water (20°C, 1 hour); Microwave, thawing in a microwave (180 W, 10 to 13 minutes); SD, standard deviation.

<sup>a</sup> Means with different superscript letters are significantly different ( $p < 0.05$ ) within the same column.

19.1%, respectively) were found significantly lower than that of water-chilled products (18.7% to 24.1%) (Lee et al., 2008). In contrast, Yu et al. (2005) stated that thawing chicken breast and leg meat at 18°C and 0°C or chilling them to 2°C did not produced different cooking loss values.

Finally, texture profile analysis of the chicken breast samples after defrosting using home based thawing practices and cooking is presented in Table 7. Average hardness values of the samples ranged 7.33 to 8.14 kg/g while springiness ranged 0.64 to 0.67, cohesiveness ranged 0.63 to 0.67 kg/g, gumminess ranged 4.61 to 5.26 and chewiness ranged 3.00 to 3.43 kg/g. Nevertheless, there were no significant differences among textural parameter values of the defrosted and cooked samples using the home based thawing practices. Similarly, Shrestha et al. (2009) determined that the samples of thawed chicken breasts in hot water (60°C) and in refrigerator couldn't be distinguished by sensory panelists in a triangle test. On the other hand, thawing pre-rigor frozen chicken breasts at 0°C were found having a lower shear value than samples thawed at 18°C due to prevention of the thaw shortening (Yu et al., 2005). Leygonie et al. (2012) also stated that freezing and thawing increases the tenderness of meat when measured with peak force due to the loss in membrane strength caused by the ice crystal formation.

## CONCLUSION

The survey study indicated that the preference of the thawing practices used by the consumers included thawing on the kitchen counter (31.66%), thawing in the refrigerator (26.64%), thawing in the warm water (14.42%), thawing in the microwave (13.17%), thawing under tap water (7.21%), cooking without thawing (5.33%) and other (1.57%). Although there were significant differences among the thawing treatments for drip loss and cooking loss values, the experimental study revealed that defrosting frozen chicken meat using the most common home based thawing practices produced similar color and textural profile values among the cooked samples. Based on the survey and the experimental study, consumers should be further educated

and recommended to use safe thawing methods in Turkey.

## CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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