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EFFECT OF VARIOUS THAWING METHODS ON SENSORY AND PHYSICO-CHEMICAL PROPERTIES OF IMPORTED FROZEN BEEF

Short title: Effect of thawing methods on imported frozen beef

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ABSTRACT

This study aimed to assess the physical, sensory, and chemical changes that occurred to imported frozen beef meat following defrosting. Four meat thawing methods regularly used in everyday life are employed, which are: room temperature, tap water, refrigeration, and microwave. Results revealed that the most rapid way was microwave (1.7 minutes), then using water of the tap, and then defrosting at temperature of the room, while refrigerator took longer duration. Regarding drip loss, frozen beef samples that were thawed at 4°C in the refrigerator had the least amount of drip loss. (1%), while using tap water in thawing caused the highest drip loss value (5%). The only method that reduced the ability of meat to hold water was microwave thawing. For sensory characteristics, there is no difference between beef samples in color or consistency after all thawing methods. Following all thawing procedures, the levels of Thiobarbituric acid reactive substance (TBARS) in all of the examined meat samples remained below 0.9 mg MDA/kg. Also, TVB-N values of all examined samples remained below 20 mg/100 g, which are compatible with Egyptian Standards Specifications (E. S. 1522/2018). Hence, it has been concluded that the ideal way to thaw frozen meat is to use refrigerator thawing, as it provides less drip loss and less weight loss, but there are some drawbacks, such as a longer thawing time.

Keywords: Imported frozen beef, Thawing, Sensory, Physico-chemical.

INTRODUCTION

Protein, iron, zinc, selenium, vitamin niacin, phosphorus, and potassium are all found in frozen imported meat. With a constantly constantly growing population and a dearth of locally produced animal protein, our country, Egypt, is one of the major importers of frozen meat.

To maximize meat's durability, preserve safety, and enhance quality, it is usually stored frozen. (Leygonie *et al.*, 2012). However, the physical and chemical processes occured during thawing of meat

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can have just as much of an influence on the quality of the product as preservation. The formation of ice crystals during freezing damages the meat's ultrastructure, and the consequent concentration of solutes alters the biochemical processes that occur at the cellular level, which in turn affects the meat's physical quality standards. (Leygonie *et al.,* 2012).

Meat that has been frozen for later use must be adequately thawed before consumption. Once frozen meat is defrosted, a number of different events occur, including a proliferation of microbes, a reduction in weight due to loss of drip, alterations in color, an impact on water holding capacity, an increase in rancidity, protein oxidation, denaturation of protein, and softening of tissues. (Xia *et al.,* 2012; Kim *et al.,* 2013).

Although modern defrosting techniques for frozen meat, such as vacuum defrosting (Cai *et al.,* 2018), ultrasonic defrosting (Shi *et al.,* 2019), radio frequency defrosting (Bedane *et al.,* 2017), and microwave defrosting (Choi *et al.,* 2017), reduce oxidation processes and shorten defrosting times, they still have some drawbacks. High pressure, ultrasonic, ohmics, and radio frequency can all cause protein denaturation, uneven defrosting, and alterations in structure (Wu *et al.,* 2017). Ultrahigh-pressure requires expensive equipment (Huang *et al.,* 2017). High-voltage electrostatic field defrosting poses a safety issue due to its high output voltage (Qian *et al.,* 2019); Microwave defrosting techniques cannot accommodate metal packaging (Zhang R *et al.,* 2019) and cause uneven defrosting, protein denaturation, and conformational changes (Wu *et al.,* 2017). These flaws make these methods constrained and prevent their application in some circumstances.

Compared to refrigeration or freezing, the thawing process has received less attention (Li *et al.,* 2019), and scientific information for consumers about the suitable thawing methods is scarce. Hence, the present research was undertaken to assess the time taken for the meat to thaw by different thawing methods and to compare the effect of these methods on the sensory and certain physico-chemical characteristics of beef.

MATERIALS AND METHODS

1. Collection of samples:

A total of 170 samples divided into 5 experimental groups (control, refrigerator, tap water, room temperature and microwave) each group contain 34 samples (about 100±2 g weight for each sample) of Brazilian frozen beef meat were collected randomly from Assiut University Hospitals and University cities - Assiut University from May till November 2022; with no restrictions considering age or production date. The collected samples were transferred in an ice box directly to the laboratory of Meat Hygiene Section, Department of Food Hygiene, Faculty of Veterinary Medicine, Assiut University. wrapped in moisture-impermeable poly-ethylene bags and kept frozen at - 18°C in a deep freezer (SFD220NF, Electrostar, 186 liter).

2. Preparation of samples:

Frozen beef samples were defrosted till the temperature of the core reached 0±1 °C. In this experiment, the four widely used thawing techniques were employed as follows:

1. Thawing in the refrigerator (Sharp Refrigerator, No Frost, 385 Liter, 2 Doors – Black SJ-48C(BK), Egypt) at 4±1°C (R).
2. Room temperature thawing (RM).
3. Tap water thawing (TW).
4. Microwave thawing (MT) [900 Watt, sharp, R-750MR(S)].

After defrosting, beef samples were evaluated physicochemically and sensory, and frozen beef muscle samples that had not been defrosted were used as control and evaluated physicochemically and sensory. The thawed samples and control samples

were heated for sensory evaluation, and all results were used for statistical analysis.

Determination of pH (A.O.A.C., 1990 with slight modification):
Using a portable pH meter (AD12 Waterproof pH-TEMP Pocket Tester, Hungary), electrometric methods were used to measure samples ph. 5 gm of sample blended separately with 45 ml of distilled-deionized water. Before taking a pH measurement, the pH meter was calibrated using standard buffers (7).

Determination of drip loss (Kim *et al.*, 2013):
When the temperature of the core of meat reaches 0±1°C, loss of drip (%) can be estimated.

loss of drip percentage = [(weight before defrosting − weight after defrosting) / weight before defrosting] × 100

Water holding capacity (Hung and Zayas 1992):

- 0.3 g of sample (W1) was put between acrylic plates and filter paper. One kilogram of weight was put on sample for ten minutes. The sample was again weighted (W2).

- WHC % = $\frac{W1 - W2}{W1} \times 100$

Estimation of loss of cooking (Rahman *et al.*, 2014 with slight modification):
In accordance with particular defrost procedures, the weight of the sample is determined before and after cooking by heating it up in a water bath (LK LAB, Korea), cooling it, and then estimating the loss of cooking. 10±1grams of sample were weighed, wrapped in resistant-to-heat foil paper, and placed inside an 80°C water bath for a duration of thirty minutes. According to Sultana et al., (2008), the temperature of the core reached 75–80 °C after 30 min. surface of the sample was dried out and sample was weighed.

Loss of cooking percentage = [(sample weight before cooking – sample weight after cooking) / sample weight before cooking] × 100.

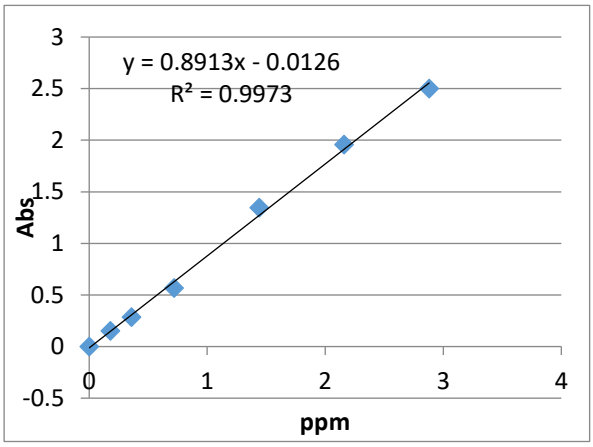
Assessment of sensory characteristics (Alkhanky *et al.*, 2015):
sensory assessment was based on color, odor, and consistency (finger pressing) with a scale of 9 points. Each panelist was asked to assign a numerical value ranging from 1 to 9 **(**l=dislike extremely, 9=like extremely**)**. After cooking the defrosted and control samples sensory assessment was conducted by a six-person panel chosen among the students of post-graduates at the Department of Food Hygiene, the Veterinary Medicine Faculty, university of Assiut.

Determination of moisture (A.O.A.C., 1995):
Samples weighing 5 grams were minced and dried for 24 hours at 65 °C in a hot air oven (FINE TECH).

$$\text{Moisture content\%} = \frac{W1\text{-}W2 \times 100}{Ws}$$

Where:
Before drying, the sample's weight was W1. The weight of the sample following drying is W 2. Ws is the sample weight.

The estimation of Thiobarbituric acid reactive substances (TBARS) according to Ahn *et al.* (2008):
Three g of sample were used, and the absorbance of the sample was measured at 531 nm on a spectrophotometer (Thermo Scientific Evolution 300 UV-Visible Spectrophotometer, England) against a blank. The content of thiobarbituric acid reactive substances for each sample was estimated using the standard curve and reported as milligrams of malondialdehyde (also known as MDA) for each kilogram of meat, keeping in mind that the dilution factor of the sample was 6. [(Sample absorbance + 0.0126) /0.8913]X 6 is the formula for the estimation of the level of Thiobarbituric acid-reactive substances in the sample.



Total volatile basic nitrogen (TVBN) estimation according to Egyptian Standards (E.S. 63/9, 2006):

To the distillation flask, 10 grams of meat sample had to be weighed and put directly into it; two grams of magnesium oxide, 300 milliliters of distilled water, and a few drops of antifoaming agent were also added to avoid excessive foaming. On the distillation equipment, a distillation flask was placed. 25 ml of a 2% boric acid solution and a few drops of screened methyl red indicator have been transferred to a recipient flask. After heating the distilling flask, the process of distillation began and lasted for twenty-five minutes, followed by titration of the resulting distillate against 0.05 M (0.1 N) sulfuric acid until the end point (faint pink color). The same processes were used to create a blank sample, but without meat sample. After recording the quantity of 0.1 N sulfuric acid used up during titration, TVBN was computed using the following equation: (Titration-blank) x 14.

Statistical evaluation.

- The software program Graph Pad Prism, version 8.0.2 (263), was used for every statistical evaluation.
- To analyze the gathered data, one-way analysis of variance (ANOVA) was employed. The acquired results were exhibited as mean± standard deviation.
- Tukey's multiple range tests were used to compare groups when differences were found to be significant at P< 0.05.

RESULT

Table 1: Statistical results of thawing time (minutes) of 100 gm Brazilian frozen beef.

Methods	Min	Max	Mean	Std. Error of Mean	P. value
Microwave	0.3330	4.000	1.721	0.1986	<0.0001****
Tap water	5.000	78.00	32.50	4.064	
Room temperature	34.00	342.0	159.5	17.06	
Refrigerator	69.00	598.0	352.0	27.75	

Table 2: Statistical results of pH by various thawing methods.

Methods	Min	Max	Mean	Std. Error of Mean	P. value	*According to E. S. 1522/2018
Control	5.2	5.6	5.4	0.02234	<0.0001****	
Microwave	5.6	6.4	5.9	0.04229		Within limit
Tap water	5.3	6.4	5.9	0.04723		Within limit
Room temperature	5.6	6.5	5.9	0.04250		Within limit
Refrigerator	5.6	6.5	6	0.03900		Within limit

*E. S. 1522/2018 established that the pH must be between 5.4 and 6 in frozen meat sample.

Table 3: Statistical results of drip loss% by various thawing methods.

Methods	Min	Max	Mean	Std. Error of Mean	P. value	*According to E. S. 1522/2018
Microwave	0.1500	5.388	2.412	0.2293	<0.0001****	Exceeds limit
Tap water	1.000	10.25	5.113	0.4468		Exceeds limit
Room temperature	0.4951	9.282	3.338	0.3784		Exceeds limit
Refrigerator	0.0001100	4.346	1.302	0.1804		Acceptable and Within limit

*E. S. 1522/2018 established that the drip loss must not exceed 1% in frozen meat.

Table 4: Statistical results of WHC by various thawing methods.

Methods	Min	Max	Mean	SE	P. value
Control	20.59	58.33	41.07	1.558	0.0333*
Microwave	4.667	57.14	34.01	1.767	
Tap water	21.47	60.94	38.58	1.507	
Room temperature	10.73	54.46	36.56	1.543	
Refrigerator	12.23	60.73	37.27	1.540	

Table 5: Statistical results of cooking loss% by various thawing methods.

Methods	Min	Max	Mean	Std. Error of Mean	P. value
Control	29.02	58.83	38.45	1.146	0.2129
Microwave	19.17	47.18	37.82	1.001	
Tap water	19.67	46.46	36.51	1.117	
Room temperature	24.61	49.52	38.98	0.9996	
Refrigerator	26.00	49.66	39.88	0.9546	

Table 6: Results of sensory estimation following the use of various defrost techniques.

Methods	Color	Consistency	Odour	Std. Error of Mean	P. value
Control	9	9	7.676	0.2452	<0.0001****
Microwave	9	9	5.941	0.4114	
Tap water	9	9	8.424	0.1154	
Room temperature	9	9	8.588	0.1126	
Refrigerator	9	9	8.548	0.1121	

Table 7: Statistical results of moisture by various thawing methods.

Methods	Min	Max	Mean	Std. Error of Mean	P. value
Control	61.06	82.67	75.17	0.7797	0.8628
Microwave	67.51	83.08	75.93	0.5897	
Tap water	69.45	82.63	75.98	0.5635	
Room temperature	59.58	87.43	75.54	0.8536	
Refrigerator	66.76	81.92	75.21	0.5367	

Table 8: Statistical results of thiobarbituric acid-reactive substances following using different defrosting techniques.

Methods	Min	Max	Mean	SE	P. value	*According to E. S. 1522/2018
Control	0.1322	1.513	0.7	0.05725	0.2137	Within limit
Microwave	0.03641	1.460	0.6	0.06074		Within limit
Tap water	0.2280	1.408	0.6	0.04997		Within limit
Room temperature	0.05557	1.936	0.8	0.07949		Within limit
Refrigerator	0.05557	2.108	0.6	0.08357		Within limit

E. S. 1522/2018 established that the Thiobarbituric acid must not exceed (0.9 mg malondialdehyde /kg) of frozen meat sample.

Table 9: TVB-N (mg/100g meat) value by various thawing methods.

Methods	Min	Max	Mean	Std. Error of Mean	P. value	*According to E. S. 1522/2018
Control	2.800	32.20	14	1.422	0.1185	Within limit
Microwave	5.600	37.80	18	1.431		Within limit
Tap water	5.600	32.76	18	1.328		Within limit
Room temperature	4.200	37.80	19	1.540		Within limit
Refrigerator	2.800	37.80	18	1.520		Within limit

*E. S. 1522/2018 established that the total volatile nitrogen must not exceed 20 mg/100g of frozen meat sample.

DISCUSSION

Freezing fresh meat is an important technique used in the exporting and importing of meat because it prolongs the meat's shelf life, maintains its quality for as long as possible (Kim *et al.,* 2018), and lowers the rate of metabolism during prolonged preservation, transportation, and purchase (Choi *et al.*, 2017).

Thawing time:

The findings in Table 1 showed that all approaches had significantly different defrost times ($p<0.05$). Microwave thawing was the quickest method and thawing time ranged from 0.3330 to 4.000 min. with a mean 1.721±0.199 min, which is lower than the results of Chandirasekaran and Thulasi (2010) and Kim *et al.* (2013). The quality of the meat that has been frozen is harmed by quick defrosting because there is more myofibril disintegration. Jung (1999) and Zahir (2021) concluded that higher intensity, an elevated number of bands showing that more harm occurs to protein molecules that compose meat, structure impairment, disintegration, and the production of tiny protein peptides that influence the meat's nutrients and usefulness all occurred after defrosting the meat by using the microwave, While refrigerator thawing recorded the longest thawing time which ranged from 69.00 to 598 with a mean 352.0±27.75 min. which is similar to the results of Balpetek and Gürbüz (2015) and lower than that recorded by Kim *et al.* (2013). Tap water thawing time ranged from 5 to 78 min. with a mean of 32.50±4.064 min., which is similar to the results of Balpetek and Gürbüz (2015). Room temperature thawing time ranged from 34.00 to 342 min. with mean 159.5±17.06 min. which is similar to the results of Balpetek and Gürbüz 2015, and less than the data mentioned by Kim *et al.* (2013).

PH:

pH directly affects meat color, ability to hold water, and the force of shear according to Guo *et al.* (2021). The control sample pH in the present experiment ranged from 5.200 to 5.600 with a mean of 5.400±0.02234 (Table 2). Comparing with control samples pH after all thawing methods were higher than control samples and this difference was statistically significant ($P < 0.05$). The pH range for meat that was defrosted by refrigeration at 4°C±1 was 5.600 to 6.500 with a mean of 6.026±0.04 which is in agreement with Chandirasekaran and Thulasi 2010, Balpetek and Gürbüz (2015), Rahman *et al.* (2015), Lakehal *et al.* (2023), Hassan *et al.*, (2011). pH after microwave thawing ranged from 5.600 to 6.400 with a mean of 5.974±0.0423 which were in accordance with Chandirasekaran and Thulasi (2010). pH after tap water thawing ranged from 5.300 to 6.400 with a mean of 5.915±0.047 similar to Rahman *et al.* (2015) in freeze–thaw cycle 1 and Jo *et al.* (2014). PH after room temperature thawing ranged from 5.600 to 6.500 with a mean of 5.926±0.043 which is similar to the observation of Chandirasekaran and Thulasi 2010 and higher than Rajan *et al.* (2017). According to Zhu *et al.* (2019); and Leygonie *et al.* (2012), pH did not alter after defrosting.

The Egyptian Standard Specification 1522/2018 published by Organization for Standardization and Quality Control in Egypt established the pH of frozen beef must be between 5.4 and 6 (E. S. 1522/2018). After all, defrosting ways definitive pH ranging from 5.4 to 6, which was not influenced by the freeze and similar to this, other research performed by Ahnström *et al.* (2006) and Kim *et al.* (2015) found that postmortem aging and/or freezing had little to no effect on the beef pH, regardless the technique of aging and/or length of aging.

Drip loss:

According to Leygonie *et al.* (2012), freezing and defrosting both affect how much drip is released (drip loss and/or thaw loss). The loss of drip following all thawing techniques in

this study differed significantly ($P < 0.05$) as indicated in Table 3. The refrigerator defrost technique caused the least level of loss of drip, and ranged from 0.00011% to 4.346 with a mean of 1.3020.18%., which is compatible with Egyptian Standards Specifications (E.S. 1522/2018) and similar to the results of Chandirasekaran and Thulasi 2010, Zahir (2021), Kim *et al.* (2013) and Kim and Kim (2016). The extreme loss of drip occurred following tap water defrosting and ranging from 1.000% to 10.25% with a mean of 5.11±0.45% which agrees with Rahman *et al.,* 2014 and Rahman, *et al.* (2015) outcomes in freeze–thawing cycle 1 and Jo *et al.* (2014), but it was higher than the results of Zahir (2021). When the loss of drips is elevated, it signifies that the muscle fiber is losing water-soluble nutrients (Kim *et al.,* 2013). Loss of drip after meat defrosting at room temperature ranged from 0.4951% to 9.282% with a mean of 3.338±0.38% which is similar to the observation of Chandirasekaran and Thulasi (2010), Zahir (2021), Met *et al.* (2013). Loss of drip following microwave defrosting ranged from 0.1500 to 5.388 with a mean of 2.412±0.23% which is in agreement with Chandirasekaran and Thulasi (2010), Zahir (2021) and Kim *et al.* (2013). Loss of drip following defrosting by refrigerator did not significantly differ from loss of drip following microwave thawing methods ($P < 0.05$), which is in agreement with the findings of Chandirasekaran and Thulasi (2010). While Kim *et al.* (2013) discovered that microwave defrost caused the least level of loss of drip from loin and round in beef when compared to room temperature, refrigeration, and cold water defrost. Between the other defrosting approaches, the loss of drip following them differed significantly ($p<0.05$) in this study. This outcome made it clear that, compared to other defrosting techniques, using a refrigerator or microwave to defrost beef samples caused a lower loss of drip. According to Leygonie *et al.* (2012), a major quality issue in the meat processing business is fluid loss as exudate as it leads to the ability of meat to hold water is lost. Fluid that is primarily made up of proteins and water and that can be evacuated from a piece of meat with no mechanical effort other than gravitation is generally referred to as loss of drip. (The loss of weight is referred to as a loss of drip).

Compared to other meat quality attributes, loss of drip is time-bound.

According to the Egyptian Standard Specification 1522/2018, the drip loss must not exceed 1% in frozen meat (E. S. 1522/2018).

WHC:

Table 4 illustrates that WHC was reduced only after using microwave in meat thawing compared to control samples, and this reduction was significant ($P < 0.05$). While other thawing techniques did not significantly alter WHC, comparing with control samples ($P < 0.05$).

WHC of control sample ranged from 20.59 % to 58.33% with a mean of 41.07±1.56%. WHC after microwave thawing ranged from 4.667% to 57.14% with a mean of 34.01±1.77% similar to the results of Zahir (2021) (39.1%) and lower than Kim *et al.* (2013) (62.2%). WHC after tap water thawing ranged from 21.47% to 60.94% with a mean of 38.58±1.51 similar to the results of Zahir (2021) (39.12%), and lower than the results of Rahman *et al.* (2015) in the first freeze-thaw cycle, Jo *et al.* (2014) and Rahman *et al.* (2014) in the first freeze-thaw cycle. WHC after room temperature thawing ranged from 10.73% to 54.46% with a mean of 36.56±1.543% similar to the results of Zahir (2021) (31.97%) and lower than the values recorded by Kim *et al.* (2013) (61.8%). WHC after refrigerator thawing ranged from12.23% to 60.73% with a mean of 37.27±1.540 nearly similar to the results of Zahir (2021) (34.62%); and lower than the outcomes of Kim *et al.* (2013) (60.7%) and Rahman *et al.* (2015).

Cooking loss:

According to Zhan *et al.* (2018) and Guo *et al.* (2021) defrosting and cooking losses are important parameters that influence the quality of meat. Table 5 illustrates that no thawing technique significantly changed the amount of cooking loss ($P < 0.05$) comparing with control samples and cooking loss of control ranged from 29.02% to 58.83 with mean 38.45±1.146. Cooking loss after microwave thawing ranged from 19.17% to 47.18% with a mean of 37.82±1.001 similar to the findings of Zahir (2021) (39.32%) and Sillva *et al.* (2017), while higher than the findings of Chandirasekaran and Thulasi (2010) and lower than Kim *et al.* (2013) (52.0%) in loin muscle; Lakehal *et al.* (2023). Cooking loss after tap water thawing ranged from 19.67% to 46.46% with a mean of 36.51±1.117%, which concur with the outcomes of Jo *et al.* (2014), and Rahman *et al.* (2015) while higher than Zahir (2021) (15.78%) results. Cooking loss after room temperature thawing ranged from 24.61% to 49.52% with a mean of 38.98±0.9996% which is nearly similar to Zahir (2021) (34.59) findings and Kim *et al.* (2013) (34.7%) while higher than, Sillva *et al.* (2017) and Chandirasekaran and Thulasi (2010). Cooking loss after Refrigerator thawing ranged from 26% to 49.66% with a mean 39.88±0.955% which is similar to Kim *et al.* (2013) (43.7%), Kim and Kim, (2016) while higher than the findings of Chandirasekaran and Thulasi (2010) and Zahir (2021) findings (27.882) and lower than findings of Rahman *et al.* (2015) in freeze-thaw cycle 1.

Leygonie *et al.* (2012) reported that moisture loss related to cooking did not differ significantly for beef samples that were either fresh or frozen, as well as for samples that were frozen and defrosted at various paces. According to Vieira, *et al.* (2009) the melted state of the fat and the protein degradation lead to the emission of water, which is chemically bound during cooking.

Sensory evaluation:

1. Color:

The quality of the meat is compromised by color, which additionally impacts the decision of customers to buy meat. In the present investigation, there was no change in the color of meat samples after applying defrosting processes when compared to the control samples and all take score 9 which is extremely like and that is consistent with the outcomes of Zahir (2021), Rahman *et al.* (2014), in cycle 1, Jo *et al.* (2014) and Kim and Kim (2016).

2. Odor:

The present study revealed that after cooking the highest score of odor was after room temperature thawing which is similar to the findings of Zahir (2021). There was a significant difference in odor after thawing with microwave comparing with control samples and score was lower than control. No significant difference in odor after thawing with tap water comparing with control samples. a significant difference in odor after thawing at room temperature and by using refrigeration comparing with control samples and scores were higher than control scores.

3. Consistency:

There is no difference in meat samples consistency in the present investigation after all thawing methods comparing with control samples and all take score 9 which is extremely like.

Content of moisture:

According to Leygonie *et al.* (2012) the quantity and placement of moisture in beef tissue alter as a result of freezing and defrosting. According to outcomes in Table 7, the content of moisture of meat samples after all thawing methods has not changed significantly ($p<0.05$) comparing with control samples. The range of control samples' moisture percentages was 61.06 to 82.67 with a mean of 75.2±0.8. Moisture content after microwave thawing ranged from 67.5 to 83.1 with a mean of 75.9±0.6 which is

similar to the results of Zahir 2021 (69.19%), Kim *et al.* (2013) (74.7% in round) and Sillva *et al.* 2017. Moisture content after tap water thawing ranged from 69.5 to 82.6 with a mean of 76±0.6 similar to the results of Zahir, 2021 (76.7%). Moisture content of meat samples after room temperature thawing ranged from 59.6 to 87.4 with mean75.5±0.9 similar to the results of Balpetek and Gürbüz (2015), Zahir 2021 (75.41), KIM *et al.* (2013) and Sillva *et al.* (2017). Moisture content of meat samples after refrigerator thawing ranged from 66.8 to 81.9 with a mean of 75.2±0.5% which is similar to the results of Zahir 2021 (76.67%), Balpetek and Gürbüz 2015, Kim *et al.*, 2013, Sillva *et al.*, 2017 and Ziani *et al.* (2018).

Content of reactive substances with Thiobarbituric acid:

According to Liao *et al.* (2020), unpleasant alterations in quality attributed to lipid oxidation involve alteration in color, flavor decline, and decreased nutritional value. This study demonstrated that no a significant difference in Thiobarbituric acid reactive substance (TBARS) content in meat samples after all thawing methods comparing with control samples (Table 8). TBARS of control samples ranged from 0.13 to 1.51 with a mean of 0.71±0.06 which resembles the data of Ebrahim-Hemmat *et al.* (2012). TBARS value after microwave thawing ranged from 0.04 to 1.46 with a mean of 0.59±0.06 which resembles the outcomes of Zahir 2021, Lakehal *et al.* (2023) and Sillva *et al.* (2017). TBARS value after tap water thawing ranged from 0.23 to 1.41 with a mean of 0.64± 0.05 which resembling the outcomes of Rahman *et al.* (2015) in freeze-thaw cycle-1, Zahir 2021 and Lakehal *et al.* (2023). TBARS value after room temperature thawing ranged from 0.06 to 1.94 with a mean of 0.79±0.08 resembling the outcomes of Zahir 2021, Lakehal *et al.* (2023), Deng *et al.* **(**2020), and Sillva *et al.* (2017). TBARS value after refrigerator thawing ranged from 0.06 to 2.10 with a mean of 0.62±0.08 resembling the outcomes of Rahman *et al.* (2015) in freeze-thaw cycle-1, Rahman *et al.* (2014) in freeze-thaw cycle-1, Zahir 2021, Lakehal *et al.* (2023), Hassan *et al.* (2011) and Sillva *et al.* (2017).

According to Lakehal *et al.* (2023), neither thawing of beef by using refrigerator nor at room temperature changed the content of Thiobarbituric reactive substances comparing with fresh beef ($P > 0.05$), but either defrosting meat by using water immersion or microwave significantly raised the content of Thiobarbituric reactive substances ($P<0.05$).

In this study after all thawing approaches, each meat sample undergoing examination had a level of the reactive substances to Thiobarbituric acid that was less than 0.9 mg MDA/kg and compatible with Egyptian Standards Specifications (E. S. 1522/2018).

Total Volatile Base Nitrogen (TVBN):

According to Kruk *et al.* (2011), volatile basic nitrogen (VBN) can serve as an indicator of the freshness of meat since it is related to the conversion of protein to basic nitrogen as a result of microbe metabolic processes and endogenous proteolysis. (Table 9) illustrates that thawing methods in this investigation did not alter significantly the total volatile basic nitrogen compared with control samples ($P < 0.05$). control samples content of total volatile basic nitrogen ranging from 2.8 to 32.2 with a mean of 14±1.4 similar to Rajan *et al.* (2017) and Ebrahim-Hemmat *et al.* (2012). TVBN after microwave thawing ranged from 5.6 to 37.8 with a mean of 18.3 ± 1.4. TVBN after tap water ranged from 5.6 to 32.8 with mean17.6±1.3. TVBN after room temperature thawing ranged from 4.2 to 37.8 with a mean 19±1.5 resembling data of Deng et al. (2020) and Rajan *et al.* (2017). TVBN after refrigeration ranged from 2.8 to 37.8 with a mean of 18 ± 1.5 which is similar to Ren *et al.* (2021) and Hassan *et al.* (2011). In this study, mean TVB-N values of all examined samples remained below 20 mg/100 g. which are compatible with Egyptian Standards Specifications (E. S. 1522/2018).

In general, thawing always induces quality losses in frozen meat such as color deterioration, texture changes, and loss of nutrients (Qian *et al.*, 2019), in addition to water loss (Xia *et al.*, 2012). Meat quality can be harmed by defrosting which involves the defrost pace and way as well as fluctuations in temperatures, according to Zhang *et al.* (2021). Hence, suitable defrosting codes decrease deterioration of frozen meat's quality according to Cai *et al.* (2019). Consumers will benefit from the study's findings in terms of the influence that various thawing techniques have on the quality of meat and the implementation of suitable techniques for safely thawing frozen foods.

CONCLUSION

According to this study, thawing meat by using refrigerator resulted in the lowest drip loss percentage compared with thawing meat at room temperature, using tap water and not differs significantly from microwave thawing. WHC after meat defrosting by using the refrigerator has not changed compared with the control sample, while microwave thawing cause decrease in ability of meat to hold water. Although pH of meat following defrosting by using refrigerator was higher than control samples, it still did not change significantly comparing with defrosting at room temperature, using tap water, or using a microwave. Also, meat defrosting using refrigerator did not result in a significant change in cooking loss or moisture content comparing with control samples. Moreover, meat that has been defrosted by refrigeration shows superior sensory evaluation. Therefore, it was established that refrigeration thawing at 4°C is a suitable method for thawing frozen meat and minimizes quality loss due to freezing. Hence, this achieved results assist customers in selecting the appropriate thawing technique to minimize damage and preserve the meat's quality.

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تأثير طرق الذوبان المختلفة على الخواص الحسية والفيزيائية والكيميائية للحوم الأبقار المجمدة المستوردة

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في هذه الدراسة، تم استخدام أربع تقنيات لذوبان اللحوم الأكثر شيوعًا في الحياة اليومية: إذابة اللحوم في الثلاجة، في الميكروويف، في درجة حرارة الغرفة، وإذابة اللحوم باستخدام مياه الصنبور، لتقييم التغيرات الفيزيائية والكيميائية والحسية في لحوم الأبقار المجمدة المستوردة بعد الذوبان. أظهرت النتائج أن وقت ذوبان لحم البقر في الميكروويف كان أسرع طريقة (١,٧ دقيقة) متبوعًا بإذابة مياه الصنبور ثم الذوبان في درجة حرارة الغرفة بينما استغرق الذوبان في الثلاجة مدة أطول. فيما يتعلق بفقد التنقيط (كمية السائل المنفصل)، أظهرت النتائج أن اللحوم المذابة في الثلاجة عند ٤ درجات مئوية تميزت بأقل قدر ممكن من فقدان كمية السائل المنفصل (١٪)، بينما تسبب ذوبان اللحوم باستخدام مياه الصنبور في أعلى قيمة خسارة للسائل المنفصل (٥٪). بالنسبة للخصائص الحسية، لا يوجد فرق معنوي بين جميع عينات اللحوم في اللون والملمس بعد كل طرق الذوبان. قيم حمض الثيوباربيتوريك (TBA) لجميع العينات التي تم فحصها بعد جميع طرق الذوبان ظلت أقل من ٠,٩ مجم MDA / كجم. أيضًا، ظلت قيم المركبات النيتروجينية الكلية الطيارة (TVB-N) لجميع العينات التي تم فحصها أقل من ٢٠ مجم / ١٠٠ جرام والتي تتوافق مع المواصفات القياسية المصرية للحوم المجمدة م. ق. م. رقم ١٥٢٢ لسنة ٢٠١٨ م. وبالتالي، فقد تم التوصل إلى أن أفضل طريقة لإذابة اللحوم المجمدة هي استخدام الثلاجة عند درجة ٤ درجة مئوية حيث أنها تقلل من فقدان التنقيط (كمية السائل المنفصل) وبالتالي تقلل من فقدان وزن اللحوم، ولكن هناك بعض العيوب البسيطة مثل وقت الذوبان الأطول.