PAPER

QUALITY OF BROILER CHICKEN MEAT DURING FROZEN STORAGE

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ABSTRACT

The objective of the study was to assess the influence of frozen storage (1mth and 8 mth) and thawing methods on the breast meat quality of broiler chickens. Tests revealed significant changes in meat quality in defrosted raw breast muscles as well as in those subjected to thermal treatment. Defrosting by using microwave oven proved to be more useful for breast muscles stored for a period of eight months regarding the volume of drip loss, ash content of the raw breast muscles as well as the cooking loss, desirable aroma, and the brittleness of meat subjected to thermal treatment.

Keywords: breast muscles, broiler chickens, freezing storage, quality, thawing methods

1. INTRODUCTION

The poultry meat market is a classic example of a market displaying increased diversification. Poultry meat remains a valuable component of human diet with its consumption in Europe steadily rising. Fast growing broiler chickens are dominant in poultry meat production due to their efficient feed use (AUGUSTYŃSKA-PREJSNAR *et al.*, 2014). The choice of poultry is greatly influenced by its nutritive and sensorial values, as well as its low price, bountiful supply, varied assortment, price relative to that of red meat and other animal products. The high popularity of poultry meat is also determined by its culinary values and the ease of preparation. In addition, the promotions and advertising methods, as well as the increasing awareness of the nutritive value of foods and proper dietary practice enhance the attractiveness of poultry meat as a food.
Quality issues have attracted greater attention in the much saturated market of meat products. A specific characteristic of meat products is their short shelf life (BENLI, 2016).
Majority of the poultry meat for culinary purposes in home markets is offered as frozen meat. Freezing is the most commonly applied method in managing its excess production. An accruing benefit of freezing in respect of the transportation of chilled meat is its possibility of prolonged storage as well as its greater handling flexibility in both retail and wholesale trade. Freezing of meat effects quality changes that are direct consequences of freezing processes and frozen storage (AKHTAR *et al.*, 2013). The frozen state does not entirely eliminate the bio-physicochemical processes taking place in meat, but only minimizes them. Freezing results in the slowing down or halting of post-slaughtering meat maturity processes, while in-meat water freezing and crystallization processes become intensified (LEYGONIE *et al.*, 2012, GAMBUTEANU *et al.*, 2013). The quality of frozen stored meat depends on on-going changes both during the initial pre-freezing and in later stages of freezing treatment and storage. The quality of frozen products depend on the quality of the primary material, adequate freezing parameters, storage conditions, stability of storage temperature and its duration as well as the applied thawing methods (ALI *et al.*, 2016; CHEN *et al.*, 2017; FERNANDES *et al.*, 2016).
The last stage in the chilling technological process is thawing, aimed at restoring the meat's properties to conditions similar to that of fresh meat. The procedural parameters like temperature and efficient thawing play significant roles during this stage. The thawing process is acclaimed to be more difficult to control than the freezing process. Any improprieties in the thawing process may result in quality deterioration (ZHANG *et al.*, 2017). Thawing in atmospheric air has become a popular method applied in meat thawing. The growing role in industry-led deep freezing of meat products necessitates the application of modern and fast methods of meat thawing in order to shorten the process and have a better control of its parameters. The microwave thawing procedure does fulfil this criteria (CHWASTOWSKA and KONDRATOWICZ, 2005).
The aim of the study was to assess the influence of frozen storage duration and thawing methods on the breast muscles quality of broiler chickens.

2. MATERIAL AND METHODS

The research materials were breast muscles obtained directly after slaughtering of minimum 36-day old ROSS 308 broiler chickens. The chickens were reared on litter and fed on complete standard feed mixtures (Starter, Grower and Finisher), for broiler chickens with full access to water supply. The average weight of slaughtered chickens was 2.30kg. The slaughter and dissection of chickens was carried out under prevailing production specifications at a local slaughterhouse. Breast muscles (*musculus pectoralis*)

were manually cut out from the chilled carcasses (ZIOŁECKI and DORUCHOWSKI, 1989). The samples (n=80 and mean weight of 200±50g) were weighed (balance type ED 423S-0CE, accuracy 0,001g, company Sartorius Mechatronics, Poland) labelled and vacuum packed in polyethylene bags. The meat was subjected to freezing at -20°C and were stored in deep freeze conditions in freezer compartments (GN 3056 of Liebherr Company, Germany) over a 1 month period for group I and 8 months for group II. On completing the storage period the samples from group I (n=40) and group II (n=40) were thawed in atmospheric air and in a microwave oven. The atmospheric air method involved thawing the sample under atmospheric conditions in refrigerated cabinet (FKv 36110, from Liebherr company, Germany) at 4°C without removing them from the bags until the samples achieved internal temperature of 4°C±1°C. The thawing process with a microwave involved placing the samples in a microwave oven (type 29Z013, 800 W, Zelmer Company, Poland) and subsequently subjected electromagnetic wave treatment over a 5 minute period. The samples internal temperature was 0°C±1°C after thawing, but was 5°C ±1°C on its outer Surface. The sample's internal temperature was stabilized at 4°C ±1°C.

The laboratory assessment of raw breast muscles from group I (n=20) and group II (n=20) covered the following: volume of drip loss, pH, water-holding capacity, chemical composition (protein, fat, and mineral salts content) as well as the meat's colouration and brittleness. The volume of drip loss was determined by placing the sample in a cuvette fitted with a 5 mm thick grid spacer to prevent the leakage from getting in contact with the sample. The amount of leakage was calculated by the difference in weight before freezing and after thawing process using the formula:

$$W_r(\%) = \left(\frac{M_1 - M_2}{M_1}\right) \times 100\%$$

where: Wr - the amount of drip loss (%), M_1 - sample weight before freezing (g), M_2 - sample weight after thawing (g) (MARCHEL *et al.*, 2013).

pH measurements were undertaken using a pH-meter fitted with a dagger electrode (HI 99163, Hanna Instruments, USA) calibrated with DuraCal buffer solutions: pH 4.01, pH 7.00. (Hmilton Bonaduz AG, Switzerland). The water-holding capacity (WHC) was determined based on the volume of free water squeezed from sample (280-300mg) using the Whatman no 2 filter papers and 2kg load for 5 minutes (GRAU and HAMM, 1953). WHC was calculated on the basis of the mass difference of the sample before squeezing to the mass of the sample after squeezing in relation to the sample weight before squeezing x 100%. The nitrogen content was determined using Kjeldah method (Foss Tecator, Höganäs, Sweden), and converted to protein using a multiplying factor of 6.25. The fat content was determined using Soxhlet method (Büchi Extraction System B-811 apparatus, Flawil, Switzerland). After drying the samples (5g±0.001g) at 105°C, they were subjected to extraction using n-hexan as the solvent. The fat amount was determined by weighing after the solvent has been separated. Total ash content was measured after the complete mineralization of 5g of the meat sample at 550-6505°C in a muffle Carbolite oven type AAF1100, Hope Valley, UK. The colour of the raw meat's cross-section was assessed using the Chrome Meter colorimeter (Konica Minolta Osaka, Japan), fitted with a CR 400 head (ø=11mm) set at illumination levels compatible with D_{65}, calibrated with Konica Minolta calibration plate (observer 2°, illuminant D_{65}, Y=93.5, x=0.3160, y=0.3324). The readings of measurement results and their conversion in real time was achieved in the CIE LAB (CIE, 1978) colorimetric system, where L* represents brightness, a* - relative redness, on red-green axis, b * - relative yellowness, on yellow-blue axis. Three repetitions were performed for each sample. The brittleness was assessed by measuring the share force (F_{max}), using the

Zwick/Roell BT1-FR1.OTH.D14 resistance machine (Zwick CmbH & Co. KG. Ulm, Germany), using a Warner-Bratzler V-blade knife with a head speed of 100 $mm \cdot \cdot min^{-1}$ and initial force of 0.2 N. Meat portions with cross-sectional diameter of 100 mm^2 and 50 mm in length were subjected to cutting. After the thawing of samples from both group I (n=20) and group II (n=20) they were weighed (balance type ED 423S-0CE, accuracy 0,001g, company Sartorius Mechatronics, Poland) with accuracy of 0.1g and then subjected to boiling at a ratio 1:2 (meat/ water) until the attainment of meat internal temperature of 805°C±25°C. Assessments of physicochemical properties after cooking were conducted in the same way to those applied for the raw breast muscles. Cooking losses were calculated based on the differences in weight prior to and after thermal treatment. The sensory assessment of the quality of thawed breast meat was conducted using the scaling method (BARYŁKO-PIKIELNA and MATUSZEWSKA 2009). A five-point scale assessment was applied, covering such quality indicators as the meat's aroma and flavour (especially its desirability and intensity), juiciness, brittleness and general appearance (1 point being the lowest score, and 5 points being the highest). In order to conduct the sensory assessment, the thermally treated samples were cooled to 205°C±25°C, cut into 1.5 cm thick slices, perpendicular to the run of meat fibers and then placed in plastic containers. The samples were randomly assessed after they had been encoded. The sensory assessment process was conducted, in two repetitions, by a 7-member assessment team with proven sensory sensitivity, trained in accordance with ISO 8586-2:2008 and ISO 8587:2006 standards.
The results obtained were statistically analysed using the Statistica 13.1 (STATSOFT, INC. 2018) program, taking account of the arithmetic mean ($\bar{x}$), standard deviation (SD), standard mean error of measurement (SEM), and the principal effect, namely (C - impact of storage duration, R - influence of thawing method, C x R - impact of storage duration and thawing method), using the two-factor analysis of variance ANOVA. The significance of differences between the mean values within groups was verified using the Tukey test. Statistically significant differences were assumed at a significance level of $p<0.05$, while the lack of significance was designated with „ns" (statistically not significant).

3. RESULTS AND DISCUSSION

The freezing process leads to the denaturation of myofibril proteins, which results in the deterioration of meat functional properties. As a result of the water transformation phase, there is increased concentration of ions, ionic strength, as well as pH changes (ALI *et al.*, 2015). The current studies have indicated significant ($p<0.05$) influence of frozen storage duration on the pH value (Table 1). According to CHWASTOWSKA-SIWIECKA (2011) and LEYGONIE *et al.* (2012) the pH of broiler chicken breast muscles in appropriate conditions decreases along with the prolongation of frozen storage. Likewise, results obtained by ALI *et al.* (2015), CHEN *et al.* (2017) and WEI *et al.* (2017) have indicated significant declines in pH value of breast muscles over subsequent weeks of frozen storage. SANTOS KUMAR *et al.* (2014), however, noted rising pH values of breast muscles of broiler chickens obtained from varied sources, stored frozen. The current studies did not indicate any significant ($p>0.05$) influence of thawing methods on the pH value. Similar results for the thawing methods, but with varying intensity of microwaves, were obtained by KIM *et al.* (2011) for broiler chickens breast muscles, CHWASTOWSKA-SIWIECKA *et al.* (2013) for rabbit meat, while CHWASTOWSKA and KONDARTOWICZ (2005) obtained same for pork meat. Drip loss is a watery solution that issues from frozen meat without the application of any external force serving as a significant indicator of the quality of meat subjected to frozen storage (GAMBUTEANU *et al.*, 2013; LEYGONIE *et al.*, 2012). It is acclaimed that the volume of meat leakages while being thawed using various

methods may serve as one indicator of the degree of damage to meat muscle tissues during freezing and also as an indirect evaluation of various thawing methods (CHWASTOWSKA and KONDRATOWICZ, 2005).

Table 1. Physicochemical properties of frozen raw breast muscles, including the frozen storage duration and thawing methods ($\bar{x}\pm$ s).

Traits	Frozen storage duration, months				SEM	Impact		
	(Group I)		(Group II)					
	Thawing method							
	atmospheric air	microwave oven	atmospheric air	microwave oven		C	R	C x R
pH	6.00±0.02	5.91±0.03	5.84±0.18	5.87±0.17	0.01	*	ns	ns
Drip loss (%)	3.34±0.30	2.78±0.1	5.04±0.28	4.74±0.35	0.14	*	*	*
Water-holding capacity (%)	15.58±1.37	16.11±1.54	18.34±2.47	17.72±1.23	0.20	*	ns	ns
Colour L*- lightness	53.12±2.30	52.07±2.48	50.32±1.85	50.60±2.04	0.49	*	ns	n
a*- redness	1.76±0.66	1.98±0.51	2.21±0.88	3.30±0.79	0.07	*	*	s*
b*- yellowness	6.06±1.07	6.58±1.39	7.32±1.28	8.04±1.62	0.18	*	*	ns
Fmax (N)	13.56±2.02	15.12±1.96	11.86±1.88	13.98±2.44	0.25	*	*	ns
Crude protein (%)	23.84±1.13	23.75±1.04	24.04±0.65	23.92±0.58	0.08	ns	ns	ns
Fat (%)	1.16±0.16	1.19±0.12	1.18±0.20	1.17±0.16	0.04	ns	ns	ns
Ash (%)	1.15±0.10	1.21±0.15	1.13±0.18	1.15±0.12	0.02	*	*	ns

Explanations: ($\bar{x}$ ± s) arithmetic mean±standard deviation, Group I - 1 month freezing storage (n=20) , Group II - 8 months freezing storage (n=20); atmospheric air (n=10), microwave oven (n=10); C - impact of frozen storage duration; R - impact of freezing method; C x R - impact of frozen storage duration and freezing method; *- statistically significant differences $p<0.05$; ns- differences statistically not significant.

The current studies have shown the significant ($p<0.05$) influence of frozen storage duration, thawing methods, including the interplay of these factors on the volume of drip loss (Table 1). The volume of drip loss increases proportionately with frozen storage duration. The study finding corroborates those obtained by ALI *et al.* (2016) with samples thawed in atmospheric air. Studies by WEI *et al.* (2017) indicated lower values for this factor, although with a similar increasing trend of the value for drip loss and with an 8-month long frozen storage. The current studies have shown that the amount of drip loss of breast muscles using the microwave method was significantly ($p<0.05$) lower than in case of meat thawed in atmospheric air. The results obtained are similar to those obtained by OLIVEIRA *et al.* (2015) in studies conducted using the same thawing methods on breast meat of broiler chickens and by CHWASTOWSKA *et al.* (2013) on rabbit meat as well as by CHWASTOWSKA and KONDRATOWICZ (2005) on pork meat. YU *et al.* (2005) has posted that the amount of drip loss is influenced by the thawing temperature, with the amount increasing with the growing temperature.

The current studies have indicated significant ($p<0.05$) impact of frozen storage duration on the water-holding capacity of the breast muscles. The results of measurements for the meat water-holding capacity, determined using the forced leakage method point to the existence of dependency between changes in the meat properties and the amount of drip loss. Greater rate of water loss during frozen storage stage limited the amount of forced

leakage from the meat, which could translate to mean better water absorption during prolonged meat storage, irrespective of the thawing method applied. The findings of the study corroborate those obtained in studies by WEI *et al.* (2017) conducted on the breast muscles of broiler chickens as well as those by CHWASTOWSKA and KONDRATOWICZ (2005) conducted on pork meat.

An important criterion of the meat's technological quality is its colour. The degree of change in colour of frozen meat relies mainly on the availability of atmospheric oxygen and depends on the conditions of frozen storage (AKHTAR *et al.*, 2013). The results of colour assessment of raw breast muscles after the freezing stage, considering the frozen storage duration as well as the thawing methods are illustrated in Table 1. The studies have demonstrated that a 8-month frozen storage duration resulted in a significant ($p<0.05$) reduction of L* (brightness) parameter, which corroborates the study findings of WEI *et al.* (2017). However, ALI *et al.* (2016) and GALOBART and MORAN (2004) demonstrated the impact of shorter frozen storage duration on the increased L*(brightness) and b*(yellowness) parameters. The current study demonstrated significant ($p<0.05$) impacts of both the duration of frozen storage and thawing methods on the colour saturation in favour of a*(redness) and b*(yellowness). A darker colouration was characteristic of breast muscles stored over a 8-month period and thawed using a microwave method in contrast to breast muscles stored for a month duration and thawed using the atmospheric air method. Similar values for the a*(redness) parameter were obtained by KIM *et al.* (2011), using the microwave thawing method on the breast muscles of broiler chickens. A similar trend in colour change during a shorter frozen storage period was posted by CHWASTOWSKA and KONDRATOWICZ (2005) that conducted studies on pork meat thawed using the same methods. Colour change in post thermally treated meat depend on the level of myoglobin denaturation as well as the level of temperature applied for the thermal treatment (ZHUANG and SAVAGE, 2010). The colour assessment of post thermally treated meat indicated that frozen storage lead to increased L*(brightness) but a decline b*(yellowness) parameters (Table 2). Similar results were obtained by GALOBART and MORAN (2004). The studies demonstrated a significant ($p<0.05$) influence of thawing methods on the colour saturation towards redness while retaining the tendency of being similar to raw meat.

The current studies have demonstrated the significant ($p<0.05$) influence of both the frozen storage duration and thawing methods on the share force of raw breast muscles (Table 1). It was demonstrated that the brittleness of raw meat measured by its share force increased with the frozen storage duration. The research findings correspond to those of ŚMIECIŃSKA *et al.* (2015) conducted on turkey breast muscles. In SHANKS *et al.* (2002) and FAROUK *et al.* (2003) opinions, the process of frozen storage increases the brittleness of meat, especially in case of unprocessed meat. Changes in the meat's brittleness during the frozen storage could be attributable to protein changes in the meat tissue (LEE *et al.*, 2008). GAMBUTEANU *et al.* (2103) argue that the brittleness of poultry meat depend on the thawing methods applied. The current study have demonstrated a significantly ($p<0.05$) less share force was characteristic of both raw breast muscles, thawed in atmospheric air and subjected to thermal treatment compared to those thawed using microwave method (Tables 1 and 2). Similar findings were obtained by OLIVEIRA *et al.* (2015), who evaluated the brittleness of breast muscles applying the same thawing methods. The thawing temperature, according to YU *et al.* (2005), has impacts on the brittleness of broiler chickens breast muscles in which lower share force was characteristic of those samples thawed at lower temperatures. The brittleness of post thermally treated meat depends on the quality of the initial raw material, type of thermal treatment as well as the heating duration and temperature (AKHTAR *et al.*, 2013). The current study did not identify any significant ($p>0.05$) impact of frozen storage duration on the brittleness of

post thermally treated breast muscles. However, LEE *et al.* (2008) observed increasing toughness in breast muscles stored frozen and boiled.

Table 2. Physicochemical properties of defrosted breast muscles subjected to thermal treatment, including the frozen storage duration and thawing methods ($\bar{x} \pm s$).

Traits	Frozen storage duration, months				SEM	Impact		
	(Group I)		(Group II)					
	Thawing method							
	atmospheric air	microwave oven	atmospheric air	microwave oven		C	R	C x R
Cooking loss (%)	23.47±1.13	25.98±0.44	26.23±1.05	28.21±1.05	0.15	*	*	*
Colour								
L*- lightness	80.79±1.04	81.64±0.84	82.71±0.42	82.68±0.77	0.56	*	ns	ns
a*- redness	1.27±0.15	1.45±0.13	1.28±0.09	1.50±0.07	0.02	ns	*	ns
b*- yellowness	13.08±0.20	12.91±0.37	11.13±0.16	10.80±0.35	0.04	*	ns	ns
Fmax (N)	19.58±2.36	20.01±1.14	18.04±1.84	19.36±1.74	0.27	ns	*	ns
Crude protein (%)	30.95±0.71	29.54±0.83	31.02±0.65	30.62±0.51	0.15	ns	ns	ns
Fat (%)	1.26±0.16	1.25±0.12	1.24±0.20	1.23±0.16	0.08	ns	ns	ns
Ash (%)	1.29±0.10	1.30±0.15	1.23±0.20	1.26±0.18	0.03	*	ns	ns

Explanations: ($\bar{x} \pm s$) arithmetic mean±standard deviation, Group I - 1 month freezing storage (n=20), Group II - 8 months freezing storage (n=20); atmospheric air (n=10), microwave oven (n=10); C- impact of frozen storage duration; R- impact of freezing method; C x R - impact of frozen storage duration and freezing method; *- statistically significant differences $p<0.05$; ns- differences statistically not significant.

AKHTAR *et al.* (2013) and GAMBUTEANU *et al.* (2013) postulate that protein metabolism which takes place under specific conditions during the freezing process is not significant and are limited only to minor loss of proteins and amino-acids as a result of drip loss. Frozen storage induces protein carbonylation, carboxylation as well as the formation of Schiff bases in chicken meat (UTRERA and ESTEVEZ, 2013). The current study did not indicate any significant ($p<0.05$) influence of the duration of frozen storage and freezing methods on the total protein, and fat content in the raw meat (Table 1). These findings are corroborated by those from WEI *et al.* (2017) study. KIM *et al.* (2011) did not demonstrate the impact of applied thawing methods on the protein content in raw breast muscles. BUSTAMANTE-VARGAS *et al.* (2016), however, observed that greater protein losses were noted during thawing using microwave than in atmospheric air. Protein losses increased proportionately with increasing freezing temperature. Deep freezing storage can result in muscle proteins forming into gel, which is associated with a higher solubility of meat protein in frozen meat compared to fresh meat (FAROUK *et al.*, 2003). The afore-mentioned dependency was observed in studies by ŚMIECIŃSKA *et al.* (2015), that indicated increased total and soluble protein content following a 6-week long deep freeze storage of turkey breast muscles. Both the deep storage and thawing procedures affect the activity of endogenous proteolytic enzymes responsible for the degradation and relaxation of muscle protein structures of meat tissues (FAROUK *et al.*, 2003). Studies conducted by CHAN *et al.* (2011) noted increased content of soluble protein in frozen vacuum-packed turkey meat, stored for 3 weeks and thawed in atmospheric air at 4°C. Both CHWASTOWSKA and KONDRATOWICZ (2005) demonstrated the effect of freezing storage and both thawing methods on the total protein and ash content of raw pork meat.

Higher protein content, but lower ash content was demonstrated in meat stored for a 3-month period and thawed using the atmospheric air method. The current study also demonstrated the influence of deep freeze storage on the ash content of raw breast muscles (Table 1).

The observed decrease in ash content during the 8-month long deep freeze storage in breast muscles was due to increased meat leaks in the process of thawing, thus resulting in greater loss of minerals. The thermal treatment of raw meat leads to changes in its nutrient content (AKHTAR *et al.*, 2013). The current studies demonstrated similar change tendencies in the nutrients of breast muscles thawed and subjected to thermal treatment as in raw meat (Table 2). A significant ($p<0.05$) influence of the storage duration, thawing methods as well as their interactions on the volume of cooking loss was observed. Higher cooking losses were observed following the 8-month long deep freeze storage in meat thawed using the microwave method. Similar results for an 8-month long deep freeze storage were obtained by WEI *et al.* (2017) in breast muscles thawed using atmospheric air method. CHEN *et al.* (2017) and ŚMIECIŃSKA *et al.* (2015), on the other hand, observed slight decreases in thermal leakages during the last phase of the freezing process. A similar trend was demonstrated in studies conducted by CHWASTOWSKA and KONDRATOWICZ (2005) on pork meat stored deep frozen over a 3-month period. YU *et al.* (2005) found that the volume of thermal leakage varied in relation to the thawing temperature applied. The magnitude of the thermal leakage has a huge influence on the quality characteristics of culinary meat and the yield of the finished product (OLIVIER *et al.*, 2015).

Several changes affecting sensory qualities may take place in meat and its allied products stored frozen. Such changes should be explained by way of the physical (recrystallization, denaturation, freeze-thawing burns), chemical (hydrolysis, auto-oxidation) as well as microbiological and enzymatic (hydrolysis, oxidation, dehydration) transformations. The extent of such transformations depends on the temperature and duration of freezing, including the conditions of storage (AKHTAR *et al.*, 2013; GAMBUTEANU *et al.*, 2013). The sensory properties of breast muscles subjected to thermal treatment following the freezing period, depending on the duration of the deep freeze storage as well as the thawing methods are presented Table 3.

Table 3. Sensory properties of breast muscles after thermal treatment, including the frozen storage duration and thawing methods ($\bar{x} \pm s$).

Traits	Frozen storage duration, months				SEM	Impact		
	(Group I)		(Group II)					
	Thawing metod							
	atmospheric air	microwave oven	atmospheric air	microwave oven		C	R	C x R
Odour intensity	3.67±0.46	3.67±0.48	3.58±0.49	3.42±0.49	0.05	ns	ns	ns
Flavour intensity	4.48±0.47	4.55±0.43	3.37±0.36	3.53±0.50	0.05	*	ns	ns
Odour desirability	3.83±0.37	3.75±0.43	3.67±0.44	3.58±0.49	0.04	ns	ns	ns
Flavour desirability	4.05±0.50	4.80±0.37	3.33±0.48	3.40±0.49	0.05	*	*	ns
Juiciness	4.42±0.49	4.68±0.49	3.17±0.32	3.20±0.37	0.04	*	*	ns
Tenderness	3.88±0.49	3.74±0.47	3.78±0.45	3.68±0.49	0.05	ns	ns	ns

Explanations: ($\bar{x} \pm s$) arithmetic mean±standard deviation, Group I - 1 month freezing storage (n=20) , Group II - 8 months freezing storage (n=20); atmospheric air (n=10), microwave oven (n=10); C- impact of frozen storage duration; R- impact of freezing method; C x R - impact of frozen storage duration and freezing method; *- statistically significant differences $p<0.05$; ns- differences statistically not significant.

Sensory scale:
odour; flavour intensity: 1- negatively changed, 2- moderately changed, 3- typical, weak; 4- typical, strong, 5- typical, very strong; odour; flavour desirability: 1- not desirable, 2- fairly desirable, 3- desirable, 4- very desirable, 5- highly desirable; juiciness: 1- very dry, 2- dry, 3- slightly juicy, 4- juicy, 5- very juicy; tenderness: 1- very hard, 2- hard, 3- slightly tender, 4- tender, 5- very tender.

The current studies have demonstrated that a significantly ($p<0.05$) lower intensity of taste desirability and less juiciness was characteristic of meat following a 8-month deep freeze storage. A similar trend in sensory changes was demonstrated in studies conducted by ŚMIECIŃSKA *et al.* (2015) and SANTOSH KUMAR *et al.* (2014), where the prolongation of the deep freeze storage was associated with the deterioration of the taste and juiciness of broiler chickens' meat. The microwave thawing method has, in the current studies, been shown to be more suitable than the atmospheric air method in respect of taste desirability and juiciness of broiler chickens' meat.

4. CONCLUSIONS

Long deep freeze storage (8 mth) resulted in significantly ($p<0.05$) higher drip loss, pH decline, darker colouration (less value of L* parameter and higher saturation toward redness and yellowness), reduced ash content and improved brittleness, measured by the shear force in broiler chicken meat. Deep freeze storage also resulted in significant ($p<0.05$) changes in the raw meat following the thermal treatment. Long frozen storage contributed to the increased cooking losses, increased saturation of the L*(brightness) parameter and reduction in the b*(yellowness) tone as well as a decrease in ash content and reduced sensory properties compared to the 1-month long frozen storage duration. Raw breast muscles that has been thawed using the microwave method was characterized by a significantly ($p<0.05$) lower drip loss, higher saturation toward redness (a*) and yellowness (b*), higher ash content but with less brittleness compared with breast muscles thawed using atmospheric air. Significantly ($p<0.05$) higher cooking losses, higher saturation toward redness (a*) and higher shear force were characteristics of breast muscles thawed using the microwave method and subjected to thermal treatment compared to meat thawed in atmospheric air. The sensory assessment of breast muscles subjected to thermal treatment following its freezing has demonstrated that microwave is, for reasons of taste desirability and juiciness of meat, a more suitable thawing method ($p<0.05$) than atmospheric air.

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