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Effects of Different Thawing Methods on the Freshness Quality of Fish

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Özet: ***Farklı çözdürme yöntemlerinin balığın tazelik kalitesine etkisi.*** Bu çalışmada üç faklı eritme yönteminin, üç farklı balık türü et kalitesi üzerine etkisi karşılaştırılmıştır. Üç eritme yöntemi arasındaki farkları tespit etmek için kimyasal kalite analizleri ve duyusal kalite analizleri kullanılmıştır. Donmuş örneklerin eritilmesinde yavaş (buzdolabı), orta derecede hızlı (çeşme suyu) ve hızlı (mikrodalga) olarak nitelenen üç farklı eritme yöntemi kullanılmıştır. Tüm türlerde çeşme suyu kullanılarak yapılan eritme yöntemi kimyasal ve duyusal analizlere dayanarak en iyi sonucu vermiştir.

Anahtar Kelimeler: Eritme, kalite kontrol, mikrodalga, balık, renk ölçümleri.

Abstract: In this study the effects of three thawing methods on the flesh quality of three fish species were compared. Chemical quality analysis and sensorial quality methods were used to determined the differences between three thawing methods. The frozen samples were thawed using these three methods; slow (refrigeration), intermediate fast (tap water) and fast (microwave) thawing methods. The tap water thawing method showed the best results for all samples, in terms of chemical and sensorial quality of thawed samples.

Key Words: Thawing, quality control, microwave, fish, color measurements.

Introduction

Melting of frozen water in food products is defined as thawing. This phase change requires energy, and takes place at a constant temperature for pure water. For mixtures of water, fat, protein and ashes (i.e. foodstuffs) changes in phase will take place at a thawing temperature. Thawing is the opposite physical process to that of freezing. The heat flow is reversed and instead of extracting heat from the product, heat is directed into it. Although these are opposite processes, thawing is more difficult to carry out with respect to predictability and controllability. The food processing industry depends on a continuous and safe supply of raw materials, in order to utilize processing equipment better to improve production planning and to create stable and secure working environments for employees. Raw fish and fish fillets can be contaminated with microorganisms and chemicals.

However, as soon as frozen raw fish and fish flesh products begin to thaw, any bacteria that may have been present before freezing can begin to multiply again when the temperature increases to their growth range. Since spoilage bacteria begin to multiply at -5˚C vs. pathogen multiplication at -2.2˚C, any problems associated with thawing fish should be the result of spoilage bacteria multiplication. This is in fact the case. The FDA model food code (1999) recommends that food be thawed in the refrigerator or in flowing water, but provides no research to show that these methods of thawing are required to ensure safety. Thawing food, such as poultry carcasses, in the refrigerator can be inefficient and time consuming, in addition to occupying refrigeration space required for other food items. This procedure may also lead to the risk of cross-contamination of ready-to-eat food stored in the refrigerator if this type of food comes in contact with the drip from the raw food. On the other hand, the USDA, applying the research of Klose et al. (1968), has never enforced restrictions on thawing at room temperature in food processing plants and allows food to be thawed in this manner.

Fish normally lose some weight on thawing; this drip loss may amount to up to 5% for properly frozen and cold stored white fish, though it can be considerably more if insufficient attention is paid to the thawing procedure. Very little, if any, of this loss is directly attributable to the thawing process itself; some can be accounted for by changes in the nature of the flesh during cold storage; some can be due to the melting of any glaze that has been coated onto the fish. Fish that have been frozen before the onset of rigor may complete the rigor process after thawing if the changes have not already taken place gradually during cold storage; this effect is usually more obvious with fillets than whole fish, the fillets contracting noticeably in length. It may be necessary to thaw pre-rigor fillets slowly in order to avoid distortion or shrinkage. On the other hand, the question "Which thawing method is the best for preserving quality" should be answered.

In this study the effects of thawing methods on quality of three different fish species were compared. Chemical quality analysis and sensorial quality methods were used to determined the differences between thawing methods. The frozen samples were thawed by three methods which were represented as fast (microwave) thawing moderately, fast (tap water) and slow (refrigeration) methods.

Material and Methods

Samples were taken from an industrial processing factory. Samples species included sardine (*Sardina pilchardus,* Walbaum, 1792), gilthead sea bream (*Sparus aurata*, Lin., 1758) and anchovy (*Engraulis encrasicolus,* Lin., 1758). Each species were known to have been stored for 3 months at -24°C. The samples were transported from the factory to the laboratory with a frigorific vehicle (-18,-24°C). Each of the three selected frozen fish species were thawed by three different methods these were fast (microwave) thawing, intermediate (tap water); and slow (refrigeration) modes. For each thawing method 1 kg of each fish species were used for each thawing method. The first thawing method was rapid thawing using a microwave oven (White Westinghouse) in defrost mode for 15 minutes. The second group was placed in a plastic pan and placed under running tap water (water temperature was determined 17.2±1.2°C during the process) for 24 minutes to achieve an intermediate thawing rate. The flow rate of water was maintained low to avoid agitation of the fish flesh. The last group was placed into a refrigerator (the average temperature of the refrigerator was as 2.18±2.25°C during the process) and allowed to thaw slowly for 24 hours. The initial temperature of the samples were -18.2±1.2°C for anchovy, -17.1±0.3°C for sardine, -18.08±0.9°C for sea bream samples respectively. At the end of the processes the final temperatures of the samples were determined at 3.2±1.3°C for anchovy, 3.9±1.1°C for sardine, 2.4±1.6°C for sea bream samples respectively. The inner temperatures of the samples were determined by using a Testo 110 Model thermometer.

Trimethylamine (TMA $100g^{-1}$) analysis was carried out according to the method proposed by AOAC, (1984). Total volatile basic nitrogen (TVB-N) was determined according to the method of Vyncke (1996). Thiobarbituric acid (TBA) was determined according to the method proposed by Tarladgis et al. (1960). The pH value was recorded using a Hanna 211 model pH meter (Cluj-Napoca, Romania), the glass electrode being applied directly to the homogenate (5g of fish/5ml distilled water, Lima dos Santos et al. (1981). The homogenate was prepared by using an ultraturax homogenizer (Yellow line, DI 25 Basic, Staufen, Germany). The ultraturax was dipped into the solution at 1 minute.

The colorimeter operates by the spectral method described in DIN 5033 (Deutsches Institut für Normung, CIE 95, 2000) using the 45/ 0º circular viewing geometry, the sample was illuminated with polychromatic light encircling it at an angle of 45º, with the optical unit observing the reflected light from a horizontal angle (0º) towards the sample surface. The Spectro-pen® is a genuine grading colorimeter measuring the visible spectral range (400 to 700 nm) at intervals of 10 nm. A 10º standard observers and a D65 illuminant were used. The PC-software "Spectral – QC" for Windows (Spectral-QC Operating Instructions Version 3.6, Dr. Bruno Lange GmbH & Co. KG, 4/2002, Dusseldorf, Germany) was used for data processing. Before measuring each lot, the colorimeter was calibrated against a white standard (LZM 229). The color was measured on homogenates prepared from the fish samples. For each batch 3 samples were taken. Samples were minced separately in a Kitchen Aid KPMS Professional meat grinder (St. Joseph, Michigan, USA), equipped with 2 cm grinding blades and a metallic screen with 4 mm diameter circular holes. The pooled mince was placed in a plastic petri dish. A smooth surface was required and the mince should be a nearly uniform color. Color measurement was repeated ten times using different parts of this surface each time. In the CIE Lab system L^*denotes lightness on a 0 to 100 scale from black to white; a^*, (+) red or (-) green; and b^*, (+) yellow or (-) blue (Schubring, 2002). The total color difference, ΔE^* was calculated. ΔE^* is a single value which takes in to account the difference between L*, a* and b* of the sample.

Sensory evaluations of the three different thawing methods investigated were performed by five trained panelists. Two samples which were thawed by different methods were compared at a time. Sensorial attributes evaluated included; appearance, firmness, eye cornea, eye form, gill smell and gill color.

SPSS (SPSS, 1999, Version 9.0. Chicago, IL, USA) software was used to search for significant differences between mean values of the different methods. Differences between the means were analyzed by one-way analysis of variance (ANOVA) followed by Tukey and Duncan tests. The results are presented as means ± SD.

Results and Discussion

The pH value of fish meat has a very strong effect on connective tissue. With an increase in pH value in fish tissue, enzymes become active. Varlik et al. (1993) regarded the pH values of 6.8 -7.0 as the acceptable limit for fish. This shows that pH alone is not a suitable quality indicator for fish but could be a reason for comparisons.

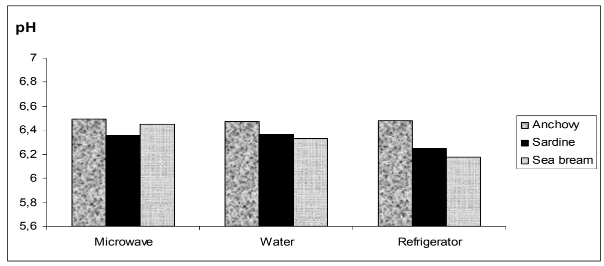

Figure 1. pH values of the thawed samples.

According to Figure 1, for every thawing method no difference was observed between anchovy samples. Anchovy also showed the highest pH values. In sardine samples, for microwave and tap water techniques no difference was observed. In the anchovy group refrigeration showed higher result.

Trimethylamine (TMA) is a very reactive molecule which makes a molecular connection from the inner cell to the outer cell via protein chains. Because of the presence of formaldehyde (FA), quality decreases and protein denaturizing occurs (Auborg, 1993). TBA index is a widely used indicator for the assessment of the degree of lipid oxidation (Nishimoto et al. 1985). As expected in the fatty species (anchovy and sardine) higher TBA values were observed than in sea bream. In a comparison of TBA values in anchovy fast thawing showed us better and lower results than intermediate and slow thawing techniques. On the other hand in sardines TBA values determined were very similar for each technique and no significant differences were observed. In sea bream samples lower TBA values were determined than the other species, that may be the reason of the lower fat content of sea bream. When we compare the results for sea bream, each thawing method showed significantly different values. And as shown in Table 1 thawing of sea bream using tap water showed the highest value.

Table 1. TBA (mg malonaldehyde kg^{-1}) values of thawed samples.

TBA	Anchovy	Sardine	Sea bream
Microwave	3.92±0.38^{a}	3.59±0.10^{a}	1.35±0.19^{a}
Water	5.89±0.63^{b}	3.58±0.59^{a}	2.54±0.12^{b}
Refrigerator	5.67±0.31^{b}	3.97±0.50^{a}	1.00±0.06^{c}

Arithmetic means and standard deviation, different superscript letters between rows represents significant differences (p<0.05). n=3.

TVB-N is a spoilage index for fish and seafood (FAO, 1986). The FAO has indicated that samples with less than 25 mg N $100g^{-1}$ TVB-N value are 'perfect quality', samples with up to 30 mg N $100g^{-1}$ TVB-N value are 'good quality', samples with up to 35 mg N $100g^{-1}$ TVB-N are 'marketable quality' and the samples with more than 35 mg N $100g^{-1}$ TVB-N value are indicated as 'spoiled' (Schormuller, 1968; Ludorff and Meyer, 1973). Almost all volatile amines can be separated and Total Volatile Basic Nitrogen (TVB-N) includes all volatile amines. TVB-N values of the samples were determined at less than 25 mg N $100g^{-1}$. When we compared the thawing methods no statistically differences ($p>0.05$) were observed.

Table 2. TVB-N (mg TVB-N $100g^{-1}$) values of thawed samples.

TVB-N	Anchovy	Sardine	Sea bream
Microwave	10.64±0.45^{a}	9.75±0.44^{a}	10.22±0.33^{a}
Water	11.12±0.25^{a}	10.34±0.26^{a}	11.97±0.77^{a}
Refrigerator	10.70±0.54^{a}	10.32±0.16^{a}	9.79±0.54^{a}

Arithmetic means and standard deviation, different superscript letters between rows represents significant differences (p<0.05). n=3.

TMAO is an osmoregulating agent in salt water fish muscle. Despite its occurrence limited amounts TMA also can be used as a secondary parameter for determining spoilage for fish. In fresh fish TMA-N values should be close to 1 mg N $100g^{-1}$ more than 8 mg N $100g^{-1}$ for spoiled samples (FAO, 1986). TMAO (which is thought as the most important source of FA) is a natural component of fish and can be found in a lot of sea fish muscle. DMA and FA are produced by enzymatic degradation of TMAO. In sample anchovy each method showed significantly different results however as shown in table 3, thawing via refrigeration exhibited the highest value when compared with microwave and tap water thawing. Tap water technique preserved the fish muscle better than other techniques as shown in table 3 (lowest TMA-N value). In sardines significantly different ($p<0.05$) results can be seen (Table 3). According to the results of TMA-N in sardine values, the refrigeration technique seems better than microwaving or tap water. But in anchovy and sea bream the values of TMA-N in refrigerator technique were both higher tap water and microwave. In a comparison of techniques in for the sea bream samples, microwave technique showed the lowest TMA-N values. No significant differences were observed between the fast method (microwave technique) and the intermediate method (tap water).

Table 1. TMA-N (mg TMA-N $100g^{-1}$) values of thawed samples.

TMA-N	Anchovy	Sardine	Sea bream
Microwave	0.75±0.13^{a}	0.96±0.04^{a}	0.92±0.10^{a}
Water	0.16±0.05^{b}	0.63±0.05^{b}	1.37±0.18^{ab}
Refrigerator	1.68±0.10^{c}	0.36±0.07^{c}	1.69±0.30^{b}

Arithmetic means and standard deviation, different superscript letters between rows represents significant differences (p<0.05). n=3.

Color values are shown in Figure 2. The CIELAB color scale is an approximately uniform color scale. In a uniform scale, the differences between points plotted in the color space correspond to visual differences between colors plotted. The L* axis runs from top to bottom. The maximum L*is 100, represents a perfect reflecting diffuser. In the current study no significant differences were observed ($p>0.05$) between groups L* values. The a*and b* axes have no specific numerical limits according to the CIELAB color scale. Positive a* has known as red and negative represent green, all measurements has given values from green side. b* values has known as yellow when positive and blue when negative hence for all measurements, measurement of b* value yellow was observed. There were no significant differences observed ($p>0.05$) between the groups. The color results show that no color differences occurred as a result of the thawing method applied. The color changing values of the samples can be seen in Figure 2. In sardine and sea bream the refrigerator groups was found to be higher in ΔE* value. In the anchovy group thawing with microwave was found to be highest.

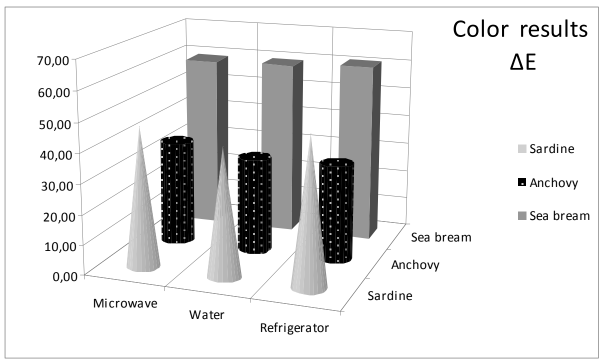

Figure 2. Color changing values of the thawed samples. Total color change (ΔE) was calculated with equation (*HunterLab, 1996*): $\Delta E=\sqrt{(\Delta L^2+\Delta a^2+\Delta b^2)}$.

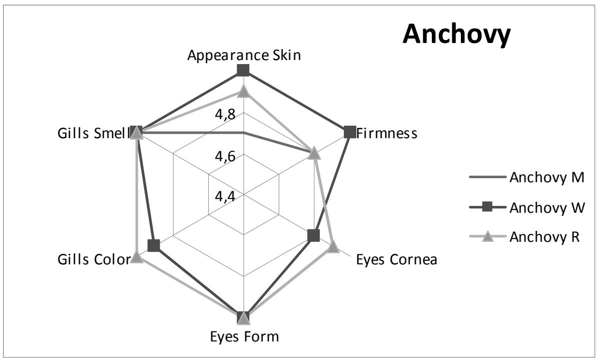

Figure 3. Sensorial panel results of anchovy. M: Microwave thawing, W: Tap water , R: refrigerator

According to the sensorial panel tap water thawing method showed the higher scores on the attributes for firmness, appearance of skin and smell of gills. The microwave and refrigeration techniques showed similar scores except for skin appearance. The panelists preferred the refrigeration thawing technique and this group showed higher scores than for the microwave technique. In this species the panelist showed a preference for the tap water thawing technique.

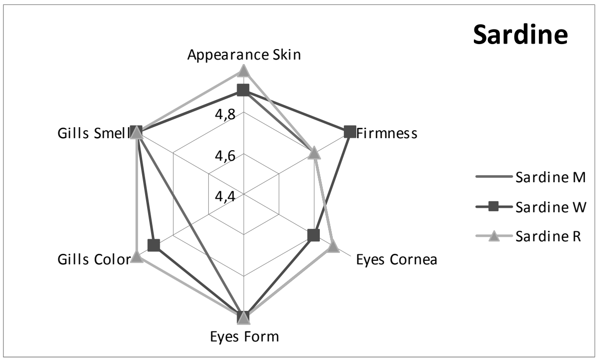

Figure 4. Sensorial panel results of Sardine. M: Microwave thawing, W: Tap water , R: refrigerator

According to the panelist tap water thawing method scored highest for the attributes of firmness, eye form and smell of gill. No significant difference was observed between the techniques in the attributes of form of eye and smell of gill. As it was shown in Figure 4, for sardines; the refrigeration thawing technique showed the highest scores, with the exception of the firmness parameter, the panelists preferred refrigerator thawing techniques over the other techniques.

As it can be seen in Figure 5, the microwave thawing technique was not preferred by the panelist for sea bream. This method received the lowest scores for each of the attributes. Again, in sea bream, panelists preferred refrigerator thawing technique in every case with the exception of firmness. The overall perception of the panelists was that in anchovy the tap water technique was the best. For sardine and sea bream however, panelists preferred the refrigerator thawing techniques denoted by the amount of the highest scores for each technique.

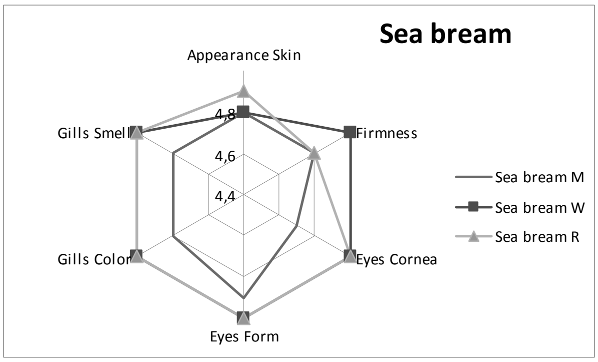

Figure 5. Sensorial panel results of Sea bream. M: Microwave thawing, W: Tap water , R: refrigerator

Conclusion

According to the chemical quality analysis results, tap water thawing method gave better results in anchovy and sea bream samples due to their TMA results. On the other hand no difference was detected between the thawing techniques in TVB-N values of samples. According to the sensorial panel, panelists awarded the highest scores for tap water thawing method over the other techniques.

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