Pak. j. sci. ind. res. Ser. B: biol. sci. 2026 **69B**(3) 108-114 https://doi.org/10.52763/PJSIR.BIOL.SCI.69.3.108.114

Evaluation of the Effect of Storage at 4 °C on Quality Properties of Canned Meat

Ashraf Omar Khashroum[a]*, Shamaail A. Saewan[b], Hani Jameel Hamad[c], Zaher Al-Bashabsheh[d], Zaid Kh. Khidhir[e], Hussain Muhaldin[e], Rinas Muhammed[e], Zryan Kawa[e] and Zryan Nwry[e]

[a]Department of Plant Production and Protection, Faculty of Agriculture, Jerash University, Jordan
[b]Department of Food Science and Nutrition, Faculty of Agriculture, Jerash University, Jordan
[c]Department of Clinical Nutrition and Dietetics, Faculty of Allied Medical Sciences, Philadelphia University, Jordan
[d]Department of Clinical Nutrition and Dietetics, Faculty of Allied Medical Sciences, Al al-Bayt University, Jordan
[e]Department of Animal Science, College of Agricultural Engineering Sciences, University of Sulaimani, Kurdistan Region, Iraq

(received April 2, 2024; revised December 18, 2024; accepted January 3, 2025)

Abstract. This study aimed to determine changes in chemical composition, chemical properties and sensory traits of canned meat after storage at 4 °C for five days. The study samples were five brands of canned meat commercially available in the markets in Sulaimani Governorate in Iraq. The meat containers were opened and the meat quality was evaluated. Afterward, the meat samples were kept in cool storage for five days. Laboratory tests were made after the cans were opened five days after cold storage. The laboratory assessment results indicated that the storage period had no significant effect on the moisture of any of the sample canned meat brands. However, it had a significant effect on the protein percentages in brands B, C, D and E, which dropped after storage. In addition, the analysis uncovered that storage had significantly increased the fat percentage of two of the meat brands, namely, B and C and there was a significant decrease in the ash percentage of two other brands, C and D, which decreased after five days of storage. In the meantime, the storage period did not significantly affect the total volatile basic nitrogen (TVBN) values in any of the studied brands. Further, storage had a significant effect on the thiobarbituric acid (TBA) concentrations in only one brand, that is, A, which increased after storage for five days. On the other hand, the outcomes of sensory evaluation pointed out that there were statistically significant differences between the five sample canned meat brands in flavour, tenderness and overall acceptability. The colours of the brands B, C, D and E were not significantly different from one to another, but significantly different from the colour of brand A.

Keywords: chemical properties, sensory traits, canned meat, climate change, storage

Introduction

Canning meat, poultry, game and fish is a practical way of preserving quality sources of protein. Home-canned products are safe, tender and flavourful when preserved correctly. To ensure good quality, only meat, poultry, game and fish trimmed with gristle, bruised spots and fat are to be used. When processing home-produced meat, it should be chilled immediately after slaughter to prevent spoiling. Meat is easier to handle when it is cold. For thorough chilling, it should be kept at a temperature below 40 °F until the time to prepare it for canning and it ought to be canned within a few days after slaughter. However, if it is to be held for longer than a few days, then it should be frozen before processing at 0 °F or lower until canning time. If frozen meat is to be thawed before canning, then it should be thawed in a refrigerator at a temperature of 40 °F or lower until most of the ice crystals have disappeared (USDA, 2024).

Canned meat is an emulsion-type, cured meat product that is sterilized by heat and has a shelf-life of about three years at ambient temperature (JSMO, 1998). It is a popular food item in many countries. It is also used in fast foods (Al-Bachir and Mehio, 2001). The basic raw material is either beef or poultry in chopped or comminuted form. Additional ingredients may include spices, soya protein, starch, nitrite, salt, ascorbate and phosphate (Abdullah, 2007). Meat can be contaminated with foodborne human pathogens and is a highly perishable type of food. Therefore, heat treatment of

*Author for correspondence; E-mail: askshb@yahoo.com

the canned product is essential for its safety and stability, and it must be sufficient to ensure that no microbiological hazard arises during storage (Botta *et al*., 2023; Ostoja *et al*., 2002). The quality of canned products is strongly influenced by the temperature, time of processing and fat content of the meat. If too severe, heat treatment can cause denaturation of protein and changes in product appearance, water-binding capacity and tenderness (Vasconcelos-Filhoa *et al*., 2021; Pena-Ramos and Xiong, 2003).

The bad handling, storing and marketing processes of the meat are considered as one of the important factors affecting the meat quality and shelf life, that have dramatic effects on chemical and physical changes of the meat like lipid oxidation which leads to various changes in colour, flavour, odour and nutrient value, which has negative effect on human health and safety (Lawrence *et al*., 2004). According to the Hammad *et al*. (2019) study, the results showed a change in canned meat content after 4.5 months of storage. In addition, Shafi *et al*. (2020) showed that the protein content was decreased after 90 days of storage.

This study hypothesizes that after opening a can of canned meat, the meat quality starts to deteriorate with time. So, this study aimed to determine changes in chemical composition, chemical properties and sensory traits of canned meat stored at 4 °C for five days.

Materials and Methods

The study samples were five different canned meat brands commercially available in markets of Sulaimani Governorate in Iraq. The meat cans were opened and the quality of the meat was assessed. Thereafter, the meat samples were kept in cool storage for five days. Laboratory tests were made right when the cans were first opened and five days after storage. In addition to sensory evaluation, three meat quality parameters were examined: (1) chemical composition, (2) the thiobarbituric acid (TBA) concentration and (3) the total volatile basic nitrogen (TVBN) value.

Chemical composition. ***Moisture content*****.** Moisture content is indicated by the weight loss after the sample is dried in a convection oven at 105 °C for 6 h (AOAC, 1999). The Moisture content was calculated as follows:

Moisture content (%)=(initial weight-final weight)/ initial weight)×100

Protein content**.** Protein percentage was determined in this study in terms of the nitrogen content of the meat using the micro-Kjeldahl method (AOAC, 1999). The protein percentage was calculated as follows:

Protein%=nitrogen%×6.25

Fat content**.** The percentage of fat in the meat samples was estimated by taking a known mass of dried samples and extracting it with diethyl ether using the Soxhlet apparatus. The amount of fat was, then, calculated based on the method described in (AOAC, 1999).

Ash content**.** Ash content of the meat was determined according to the method presented in (AOAC, 1999) by burning a known mass of meat in a muffle furnace at 550 °C for 16 h. The ash percent was determined according to the following equation:

$$Ash\% = (W_1/W_2) \times 100$$

where:

W_1=mass of ash (g) and W_2=initial mass (g)

Total volatile basic nitrogen (TVBN). Total volatile basic nitrogen (TVBN) was estimated according to the method described in (Malle and Poumeyrol, 1989). In brief one hundred grams of each minced meat sample were mixed for 1 min with 200 mL of 7.5% trichloroacetic acid (TCA) in the blender. Then the mixture was filtered and 25 mL of the filtrate was transferred to the macro-Kjeldahl distillation apparatus. After that a volume of 5 mL of 10% NaOH solution was added to the distillation flask and distillation was initiated. The distillate was collected in 15 mL of 4% boric acid and titrated with 0.05 N H_2SO_4 using bromocresol green-methyl red as an indicator. The blank consisted of 25 mL of 7.5% TCA only. The TVBN value was estimated using the following equation:

$$\text{TVBN (mg/100 g sample)} = \frac{(V_1 - V_0) \times 0.14 \times 2 \times 100}{M}$$

where:

V_1=volume (in mL) of 0.05 M H_2SO_4 solution for sample, V_0=volume (in mL) of 0.01 M H_2SO_4 solution for blank and M=mass of sample in gram.

Thiobarbituric acid (TBA) concentration. The TBA concentrations were determined following the method described in (Witte *et al*., 1970). According to this method, twenty grams of each meat sample were blended with 50 mL of cold solution containing 20% TCA in 2 M phosphoric acid. The resulting slurry was transferred quantitatively to a 100 mL volumetric flask and diluted

to 100 mL using distilled water. Then it was homogenized by shaking. A 50 mL portion of this homogenized slurry was filtered through Whatman No.1 filter paper. Thereafter, five milliliters of filtrate were transferred to a test tube and 5 mL of fresh TBA solution (0.005 M) was added to it. Meanwhile, the blank was prepared by mixing 5 mL of distilled water with 5 mL of TBA. The tubes were fitted with stoppers and the solution was mixed and kept in the dark for 15-17 h at room temperature to develop the colour reaction.

Absorbance (A). The absorbance of the coloured solution was read at the wavelength of 530 nm by using a spectrophotometer (Shimdzu, Japan). The TBA concentration, which is expressed in this paper as mg malonaldehyde (MDA)/Kg muscle was estimated by multiplying the A reading by a factor of 5.2 factor as follows:

TBA concentration (mg MDA/Kg muscle) = $A_{530} \times 5.2$

Sensory evaluation. The meat samples were cooked in the oven at 176 °C for 8.5 min until reaching an internal temperature of 70 °C, then served warm at 60 °C to eight trained arbitrators (Murphy and Zerby, 2004). Muscle samples that were subjected to different treatments were evaluated in each session. The order of samples was randomized in the assessment session and water was served after each sample assessment. The arbitrators rated each sample for different attributes on a five-point scale, ranging from 1 to 5, where the higher scores indicate greater preference and vice versa.

Analysis of data. Differences between the sample canned meat brands in the mean values of the examined variables were tested statistically for significance using one-way analysis of variance (ANOVA). In the cases when this analysis revealed significant differences in group means, Duncan's Multiple Range *post hoc* test was conducted to define the specific differences between the pairs of means and identify the similar and different groups. On the other hand the effect of storage on the quality of the canned meat was examined using the paired-sample, *t*-test because the time groups to compare were only two: right before storage and after five days of storage. All statistical tests were performed in the statistical analysis software (SAS) environment at the 0.05 level of significance (α=0.05). Accordingly, probabilities less than 0.05 imply significant differences while other probabilities pinpoint insignificant differences.

Results and Discussion

As Table 1 shows the moisture percentages of the non-stored meat and the corresponding meat samples stored for five days differed, however, insignificantly. Brand C recorded the lowest moisture percentages in both periods (66.18% and 65.98%), respectively, while brands D and E had the highest percentages before storage (68.50% and 69.81%), respectively and after storage (69.72% and 69.48%), respectively. It can be argued that storage can, in the long run result in reduced moisture content (Xiong *et al*., 1999). The present finding accords with the results of Baker *et al*. (2012), who found no significant change in meat moisture content with storage period, while Rashid and Khidhir (2021) found the highest moisture percentages recorded

Table 1. Chemical composition of canned meat brands before storage and after storage at 4 °C for five days (mean ± standard deviation)

Canned meat brand	Moisture %		Protein %		Fat %		Ash %	
	0 day	5 days	0 day	5 days	0 day	5 days	0 day	5 days
A	66.176±0.983 a A	65.984± 0.739 a A	27.381±0.040 a A	28.841±0.605 a A	4.704±0.551 a A	3.905±0.568 a A	1.011±0.568 a A	1.406±0.287 ab A
B	64.898±0.185 ab A	64.282±1.013 ab A	24.106±0.150 b A	20.880±1.244 b A	4.256±0.912 a A	6.989±0.547 b B	2.712±0.016 b A	2.156±0.168 a A
C	63.294±0.843 b A	62.473±0.704 b A	24.685±0.923 b A	21.746±0.759 bc B	4.367±0.744 a A	7.111±0.103 b B	2.861±0.306 b A	1.320±0.431 b B
D	68.502±0.074 c A	69.721±1.745 c A	24.491±0.308 b A	21.288±0.298 bc B	4.659±0.312 a A	5.701±0.256 bc A	2.865±0.810 b A	1.783±0.246 ab B
E	69.806±1.056 c A	69.475±0.970 c A	29.746±0.691 c A	22.571±0.631 c B	4.012±1.163 a A	5.482± 0.352 c A	1.324±0.175 a A	1.843±0.048 ab A

*Different small letters indicate canned meat brands with significantly different means (P<0.05); **Different capital letters indicate storage periods with significantly different means (P<0.05).

in Tuna meat from the second treatment (15 °C) (68.10%) from 0 day, while the lowest moisture percentages recorded in Tuna meat from the third treatment (25 °C) (54.28%) after 120 days of storage. The results of our experiment were not consistent with (El Lahamy and Mohamed, 2020) results, which explained that the moisture percentage of canned Chela fish was (76.56%) at 0 day of storage, after 30 days storage period these values decreased to (68.13%).

Moreover, Table 1 points out that brands A, B, C and D did not differ significantly in mean protein content. Meantime, the mean protein content of brand E was significantly different from the mean protein content of each of these canned meat brands. The lowest protein percentages were associated with brand B before storage (24.11%) and after five days of storage (20.88%). On the contrary, the highest percentages were con-comitant to brand E before storage (29.75%) and brand A after five days of storage (28.84%). Storage had a significant negative effect on the protein percentages in brands B, C, D and E, which dropped after five days of storage. This result is consistent with results reported in (Al-Obaidi, 2005), where the protein content of canned beef ranged from 20.28% to 21.17%. In the current study, the percentages of protein in brand B before storage and five days thereafter were 24.11% and 20.88%, respectively (Table 1). On the other hand, the highest percentages were observed in brand E before storage (29.75%) and brand A after storage for five days (28.84%). The storage period had a significant negative effect on the protein percentage in brands B, C, D and E. This finding agrees with results reported for canned beef meat (Al-Obaidi, 2005). In general, the extent of denaturation of both sarcoplasmic and myofibrillar proteins increases with the length of storage. On the other hand, a similar result was observed by Amaral *et al*. (2015). The decrease in protein percentage in our experiment with an increased storage period, corresponds with the study of Rashid and Khidhir results.

Significant differences in the mean fat percentages were detected between all five canned meat brands (Table 1). After five days of storage, the mean fat percentages in brand A differed significantly from the corresponding percentages in the remainder brands. The highest fat percentage was recorded in brand C (7.11%). In contrast, the lowest percentage was found in brand A (3.90%). Storage only affected the fat percentages in brands B and C, which increased after five days of storage. It is worth mentioning that the fat percentages reported in Table 1 fall within the range of fat content (0.37-8.0%) determined by many researchers (Chuaynukool *et al*., 2007; Wattanachant *et al*., 2004). The differences in fat content in the inspected samples may be ascribed to differences in genetic and non-genetic factors as was highlighted in a similar previous study (Bogosavljevic-Boskovic *et al*., 2010). The results of Selmi *et al*. (2008) showed that the flesh's total fat increased significantly to reach a level of (18.5%). This is due to the incorporation of olive oil into the Tuna flesh. Such level remained constant over the 6 months of storage at ambient temperature.

The percentages of ash in the sample canned meat brands are provided in Table 1. Before storage, significant differences in mean ash content were observed between brands A and E and the rest canned meat brands (B, C and D), which did not differ significantly from one the other in mean ash percentage. The highest ash percentage was recorded in brand D (2.86%) whereas the lowest percentage was detected in brand A (1.01%). After five days of storage, the ash percentages in brands A and C differed significantly from those in the other three brands. Hence, brands A and C constitute one group while the rest brands make up another with significantly higher mean ash percentages. The highest ash percentage in this period was found in brand B (2.16%) whereas the lowest percentage was recorded in brand C (1.32%). The ash percentages decreased in brands B, C and D, but increased in brands A and E, with storage. Some previous studies reported a non-significant decrease in ash percentage with storage time (Ziauddin *et al*., 1994). Our study's ash results are comparable to those of the study by (Hammad *et al*., 2019), which discovered that the ash percentage was 1% after 0 days and dropped to 0.60% after 4.5 months of beef storage.

Values of the TVBN for the sample canned meat brands are listed in Table 2. Early in the study before storage, the mean TVBN values did not differ significantly among the canned meat brands while after five days of storage, the mean TVBN values for brands A and E were almost similar but they differed significantly from the mean values for brands B, C and D. The highest TVBN value after five days of storage was found in brand B (21.16 mg N/100 gm) while the lowest value was observed in brand E (16.45 mg N/100 gm). Storage did not significantly influence the TVB.N values in the five study brands (Table 2). The amount of total volatile nitrogen in meat is thought to be an indicator of meat deterioration and is linked to the degradation of proteins

(Rashid and Khidhir, 2021). These values lie within the allowable limits in Iraq and the international specification.

Table 2 also uncovers that, before storage the mean TBA concentrations in brands A, B, C and D were comparable and significantly lower than the mean TBA concentration in brand E. The highest mean TBA concentration was detected in brand E (1.62 mg MDA/Kg meat), whereas the lowest concentration was associated with brand A (0.74 mg MDA/Kg meat). After five days of storage, the mean TBA concentrations in brands B, C, D and E were close to one the other and significantly lower than the mean TBA concentration in brand A. The highest concentration was found in brand A (1.72 mg MDA/Kg meat), while the lowest value was reported in brand C (1.04 mg MDA/Kg meat). Therefore, storage had a statistically significant impact on the TBA concentration in brand A only, which grew after five days of storage. This may be due to the increase in TBA values in meat during storage might occur due to oxidation of fats rich in unsaturated fatty acids (Rashid and Khidhir, 2021). These concentrations were lower than 2 mg MDA/Kg meat as recommended by COSQC (1979). The increase in TBA concentration with storage time is consistent with lipid oxidation (Anand *et al*., 1999).

The outcomes of the sensory evaluation of the five canned meat brands are given in Table 3. There were significant differences in flavour, tenderness and overall acceptability among the five meat brands, while the colour values of brands B, C, D and E were somewhat close to one the other, the colour value of brand A was significantly lower than that of any of them. The highest colour value characterized brand E (4.60), while the lowest value was concomitant to brand A (2.40). Brands B, C, D and E also had higher mean juiciness values

Table 2. Chemical characteristics of canned meat brands before storage and after at 4 °C for five days (mean ± standard deviation)

Canned meat brand	TVBN (mg N/100 gm)		TBA (mg MDA/Kg meat)	
	0 day	5 days	0 day	5 days
A	17.885±0.042 a A	19.275±1.731 ab A	0.738±0.095 a A	1.716±0.669 a B
B	16.778±0.822 a B	21.159±1.350 a A	0.762±0.062 a A	1.040±0.427 b A
C	17.326±1.325 a A	18.791±0.677 bc A	0.788±0.004 b A	1.028±0.193 c A
D	16.745±0.463 a A	17.183±0.259 c A	0.741±0.004 a A	1.058±0.158 b A
E	17.771±1.108 a A	16.452±0.146 c A	1.619±0.253 b A	1.048±0.033 b A

*Different small letters indicate canned meat brands with significantly different means (P<0.05); **Different capital letters indicate storage periods with significantly different means (P<0.05).

Table 3. Sensory evaluation of canned meat brands before storage and after storage at 4 °C for five days (mean ± standard deviation)

Canned meat brand	Colour	Flavour	Tenderness	Juiciness	Overall acceptability
A	2.400±0.548 a	3.400±0.894 a	3.800±0.447 a	2.800±0.837 a	3.200±0.447 a
B	4.400±0.894 b	3.800±0.447 a	4.000±1.225 a	3.400±0.548 ab	3.800±0.837 a
C	3.600±0.894 b	3.800±0.837 a	4.200±0.837 a	3.600±0.548 ab	4.000±1.000 a
D	3.600±0.894 b	4.000±0.707 a	4.000±0.707 a	3.400±0.548 ab	4.000±0.707 a
E	4.600±0.548 b	4.000±1.000 a	4.200±0.837 a	4.200±0.837 b	4.000±1.000 a

*Different small letters indicate canned meat brands with significantly different means (P<0.05).

than brand A. The highest juiciness value was recorded in brand E (4.20), while the lowest value was observed in brand A (2.80). Significant differences in tenderness, flavour and juiciness due to the effect of genetics were reported in (Lu *et al*., 2025; Al-Rubeii *et al*., 2000), respectively.

Conclusion

This study aimed to determine the changes in the chemical composition, chemical properties and sensory qualities of canned meat after storage at 4 °C for five days. The results of the laboratory evaluation indicated that the storage period did not have a significant effect on the moisture content of any of the canned meat brands in the sample. In general, there was a significant effect on the protein contents in most of the samples, which decreased after storage. In addition, concerning the results of the fat percentage and ash percentage, we can conclude that the results were variable between the samples and there was no general trend after five days of storage. At the same time, the storage period did not significantly affect the values of total volatile basic nitrogen (TVBN) in any of the studied brands. On the other hand, the results of the sensory evaluation indicated that there were statistically significant differences between the five canned meat brands in the sample in terms of flavour, tenderness and overall acceptability. We can also conclude from this study that there were no effects of storage on the colours of the studied meat samples.

Conflict of Interest. The authors declare that they have no conflict of interest.

References

Abdullah, B.M. 2007. Properties of five canned luncheon meat formulations as affected by quality of raw materials. *International Journal of Food Science and Technology*, **42:** 30-35.

Al-Bachir, M., Mehio, A. 2001. Irradiated luncheon meat: microbiological, chemical and sensory characteristics during storage. *Food Chemistry*, **75:** 169-175.

Al-Obaidi, D.A.A. 2005. Study some quality and bacteriological characters of frozen and canned beef imported to Iraq through 2003-2004. *M.Sc. Thesis*, 75 pp., University of Baghdad, Baghdad, Iraq.

Al-Rubeii, A.M.S., Hermiz, H.N., Al-Rawi, A.A. 2000. Chemical composition and palatability traits of ovine carcasses in different genetic groups. *The Iraqi Journal of Agricultural Sciences*, **31:** 669-680.

Amaral, D.S., Silva, F.A.P., Bezerra, T.K.A., Arcanjo, N.M.O., Guerra, I.C.D., Dalmás, P.S., Madruga, M.S. 2015. Effect of storage time and packaging on the quality of lamb pâté prepared with 'variety meat'. *Food Packaging and Shelf Life*, **3:** 39-46.

Anand, S.K., Pandey, N.K., Verma, S.S. 1999. Effect of sodium hypophosphite decontamination and modified microbial profile of chicken carcasses under refrigerated storage. *Indian Journal of Poultry Science*, **34:** 280-284.

AOAC, 1999. *Association of Official Analytical Chemists*. Official methods of analysis, 213 pp., Washington DC., AOAC International, 2275 Research Blvd, Suite 300, Rockville, Maryland, USA.

Baker, C.G.J., Ranken, M.D., Kill, R.C. 2012. *Food Industries Manual, Springer Science and Business Media*, 650 pp., published by Books by Blackie Academic and Professional, (an Imprint of Chapman and Hall), London, UK. URL: https://books.google.jo/books?id=VM3gBwAAQBAJ

Bogosavljevic-Boskovic, S., Mitrovic, S., Djokovic, R., Doskovic, V., Djermanovic, V. 2010. Chemical composition of chicken meat produced in extensive indoor and free range rearing system. *African Journal of Biotechnology*, **10:** 9069-9075.

Botta, C., Franciosa, I., Coisson, J.D., Ferrocino, I., Colasanto, A., Arlorio, M., Cocolin, L., Rantsiou, K. 2023. Beef carcass microbiota after slaughtering and primary cooling: A metataxonomic assessment to infer contamination drivers. *Food Research International*, **174:** 113466.

Chuaynukool, K., Wattanachant, S., Siripongvutikorn, S. 2007. Chemical and physical properties of raw and cooked spent hen, broiler and thai indigenous chicken muscles in mixed herbs acidified soup (Tom Yum). *Journal of Food Technology*, **5:** 180-186.

COSQC, 1979. Central Organization for Standardization and Quality Control, independent government agency (established by Law no.54 of 1979), Ministry of Planning, Al-Jaderiya, Baghdad, Iraq. (URL: https://mop.gov.iq/en/central-organization-for-standardization-and-quality-control)

El Lahamy, A.A., Mohamed, H.R. 2020. Changes in fish quality during canning process and storage period of canned fish products: review article.

Global Journal of Nutrition and Food Science, **3:** 1-7.

Hammad, H., Ma, M., Damaka, Elkhedir, A.E., Jin, G., Jin, Y., Abdegadir, W.S., Abdegadir, M.A. 2019. Effect of freeze and re-freeze on the chemical composition of beef and poultry meat at storage period 4.5 months (SP4. 5). *Journal of Food Processing and Technology*, **10:** 2-6.

JSMO, 1998. Jordan Standards and Metrology Organization. Jordanian standard (79: 1998) meat and meat products–canned luncheon meat, Amman, Jordan. URL:https://eservice.jsmo.gov.jo/en/Standards/IcsAmfn/6712010

Lawrence, T.E., Dikeman, M.E., Hunt, M.C., Kastner, C.L., Johnson, D.E. 2004. Effects of enhancing beef longissimus with phosphate plus salt or calcium lactate plus non-phosphate water binders plus rosemary extract. *Meat Science*, **67:** 129-137.

Lu, Z., Yaqin, Y., Qinhui, W., Shi, N., Yang, H., Chunming, T., Zongcai, T. 2025. Decoding the effects of brining time on the sensory quality, physicochemical properties and flavour characteristics of marinated grass carp meat. *Food Chemistry X*, **25:** 102081.

Malle, P., Poumeyrol, M. 1989. A new chemical criterion for the quality control of fish: trimethylamine/total volatile basic nitrogen (%). *Journal of Food Protection*, **52:** 419-423.

Murphy, M.A., Zerby, H.N. 2004. Pre-rigor infusion of lamb with sodium chloride, phosphate and dextrose solutions to improve tenderness. *Meat Science*, **66:** 343-349.

Ostoja, H., Cierach, M., Konopko, H., Majewska, K. 2002. Effect of addition of grit made of crude and expanded amaranth seeds on the quality of canned Meat. *Nahrung/Food*, **46:** 270-275.

Pena-Ramos, E.A., Xiong, Y.L. 2003. Whey and soy protein hydrolysates inhibit lipid oxidation in cooked pork patties. *Meat Science*, **64:** 259-263.

Rashid, N.J., Khidhir, Z.K. 2021. Impact of different storage temperatures on canned meat Characteristics. *Euphrates Journal of Agriculture Science*, **13:** 28-37.

Selmi, S.L., Monser, L., Sadok, S. 2008. The influence of local canning process and storage on pelagic fish from Tunisia: fatty acid profiles and quality indicators. *Journal of Food Processing and Preservation*, **32:** 443-457.

Shafi, J., Waheed, K.N., Zafarullah, M., Mirza, Z.S., Yaqoob, S.S. 2020. Effect of icing on quality of silver carp during frozen storage. *Journal of Food Processing and Preservation,* **44:** 14654.

USDA, 2024. *US Department of Agriculture, Complete guide to home canning*, 388 pp., National Center for Home Food Preservation, Georgia, USA.

Vasconcelos-Filhoa, P.T., Costa, H.H.A., Vega, W.H.O., Sousa, L.C.O., Parente, M.O.M., Landim, A.V. 2021. Effects of dietary energy content and source using by-products on carcass and meat quality traits of cull ewes. *Animal*, **15:** 100035.

Wattanachant, S., Benjakul, S., Ledward, D.A. 2004. Composition, colour and texture of Thai indigenous and broiler chicken muscle. *Poultry Science*, **83:** 123-128.

Witte, V.C., Krause, G.F., Bailey, M.E. 1970. A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. *Journal of Food Science*, **35:** 582-585.

Xiong, Y.L., Ho, C.T., Shahidi, F. 1999. Quality characteristics of muscle foods. In: *Quality Attributes of Muscle Foods*, 1-10 pp., Springer, Boston, MA, USA. https://doi.org/10.1007/978-1-4615-4731-0_1

Ziauddin, S.K., Rao, D.N., Ramesh, B.S., Amla, B.L. 1994. Effect of freezing, thawing and frozen storage on microbial profiles of buffalo meat. *Journal of Food Science and Technology*, **30:** 465-467.