EFFECT OF DIFFERENT STERILIZATION MODES UPON THE QUALITY CHARACTERISTICS OF LOW-FAT MEAT PÂTÉS

MOMCHILOVA, M[1]., Petrova, T[1]., Gradinarska D [2]., Yordanov D[2].

[1] Institute of Food Preservation and Quality, Plovdiv, Agricultural Academy of Bulgaria.
[2]Department of Meat and Fish Technology, University of Food Technologies, Plovdiv, Bulgaria

Abstract: The present work studies the effect of different sterilization modes upon the quality characteristics of meat pâté with a nutritional profile improved by fat reduction and enrichment with inulin and lentils. The changes in the texture and color parameters, the emulsion stability and the oxidative changes in the lipid fraction of low fat pâtés obtained under five sterilization modes, i.e. 111℃ for 24 min, 121℃ for 24 min, 111℃ for 70 min, 121 ℃ for 70 min, and 116℃ for 47 min were evaluated. The lowest emulsion stability was registered in the sample with the most intensive sterilization conditions and the highest temperature applied, viz. sample 4 (98.94%). It was found that there was a relationship between hardness and sterilization mode, as well as between the temperatures applied and the formation of primary and secondary lipid oxidation products. The increase in the hardness values was more pronounced in the samples obtained under the milder sterilization conditions, while a decrease in the hardness index was observed under the most severe sterilization conditions used for sample 4.

Keywords: inulin, lentil flour, texture, emulsion stability, thermal effect

INTRODUCTION

In food preservation through heat sterilization, the set temperature is not achieved at once and simultaneously in the entire volume of the canned food (Teixeira et al., 1969; Flambert et al., 1977). The degree of heat treatment applied is directly proportional to the antimicrobial effect (Nitsch & Vuković, 2002; 2003; 2006; FAO, 2010), but the quality characteristics of the end products are affected by the temperature applied, the treatment duration and the fat content. Heat treatment that is too intensive may result in protein denaturation, in undesirable changes in the product appearance, texture and taste, and in reduction of its water holding capacity (Penaramos and Xiong, 2002).

Meat pâtés are made from poultry, beef or pork, liver and fat tissue. Apart from being a source of saturated fatty acids and cholesterol, these components are the reason for the higher calorific value of the products in which they are included (Lorenzo et. al., 2014; Ozvural & Vural, 2008). The fat reduction in meat products is often accompanied by technological and commercial problems in their production. A main reason is the fact that fats determine to a considerable extent the texture and taste of the end product (García et al., 2006;

Choi et al., 2013). Therefore, the choice of components to be used for fat substitution that could compensate for the changes in the sensory parameters of low-fat products is of great importance. Prebiotic inulin is a functional additive that has a future in this respect (Roberfroid, 2010; Shoaib, 2016).

The aim of this study was to evaluate the sterilization mode effect on the texture and color parameters, emulsion stability and oxidative changes in the lipid fraction of meat pâtés having a lower fat content.

MATERIALS AND METHODS

Pâté making: The meat pâté production was based on the use of a modified recipe including the following main ingredients: deboned turkey meat: 30%, chicken liver: 10%, egg mélange: 18%, inulin: 12.5%, soft fat: 11.25%, cornstarch: 2%, lentil flour: 1.25%, cooking salt: 1.5%, sodium nitrite: 0.005%, polyphosphates: 0.2%, black pepper: 0.3%, nutmeg: 0.05%, coriander: 0.15%, and drinking water: 15%. The Orafti®HPX inulin used was provided by ARTEMIS OOD, Sofia, representatives of Beneo-Orafti Ltd., Belgium. The inulin was added during cutting in the form of a gel obtained through hydration in a 1:4 (w/v) ratio as described by Latoch *et al.* (2016). The filling mass prepared was heated to 70ºC and filled manually into cans having a size of H=26.5 mm and D=99 mm. The pâté prepared in this way was sterilized in a laboratory autoclave at four different modes: 111℃ for 24 min, 121℃ for 24 min, 111℃ for 70 min, 121 ℃ for 70 min, and 116℃ for 47 min.

Texture Profile Analysis (TPA): The texture profile analysis (TPA) of the ready product was made using a TA-XT.Plus texture analyzer (Stable Micro Systems, Surrey, GB). The cylinder used in this study was 51.75 mm in height and 30.37 mm in diameter, at sample height of 40 mm (quantity: 30 g). The samples were compressed twice, with a 5-second interval between the two compression cycles, at a rate of 2 $mm.s^{-1}$. The Hardness [N], Adhesiveness [Nmm], Cohesiveness and Friability [N] values were obtained as described by (Bourne, 1978).

Color metrics: The color parameters were determined spectrophotometrically using a Minolta Chroma meter (model CR 410, Osaka, Japan) according to the CIELab system.

Emulsion stability: The method described by Ockerman (1985) and Zorba et al. (1993) was used for the evaluation of the meat emulsion stability.

Determination of oxidative changes: The peroxide quantity was determined using the method described by Hornero-Méndez et al. (2006), and the thiobarbituric acid reactive substances (TBARs) were determined according to the method described by Sörensen &

Jörgensen (1996). The lipid extraction from the samples for the analysis of the peroxide quantity was performed according to the method of Bligh & Dyer (1959).

Statistical analysis: The statistical processing of the data obtained was made using the Statgraphics 16 software. The experiments were conducted with threefold repetition, and the data in the tables and graphs are arithmetic means of the indicators measured. Statistically significant differences were found at probability less than 0.05.

RESULTS AND DISCUSSION

Fig. 1 shows the thermograms during sterilization of the pâté samples, and the lethal effect (L_0) of the different samples is shown in Table 1.

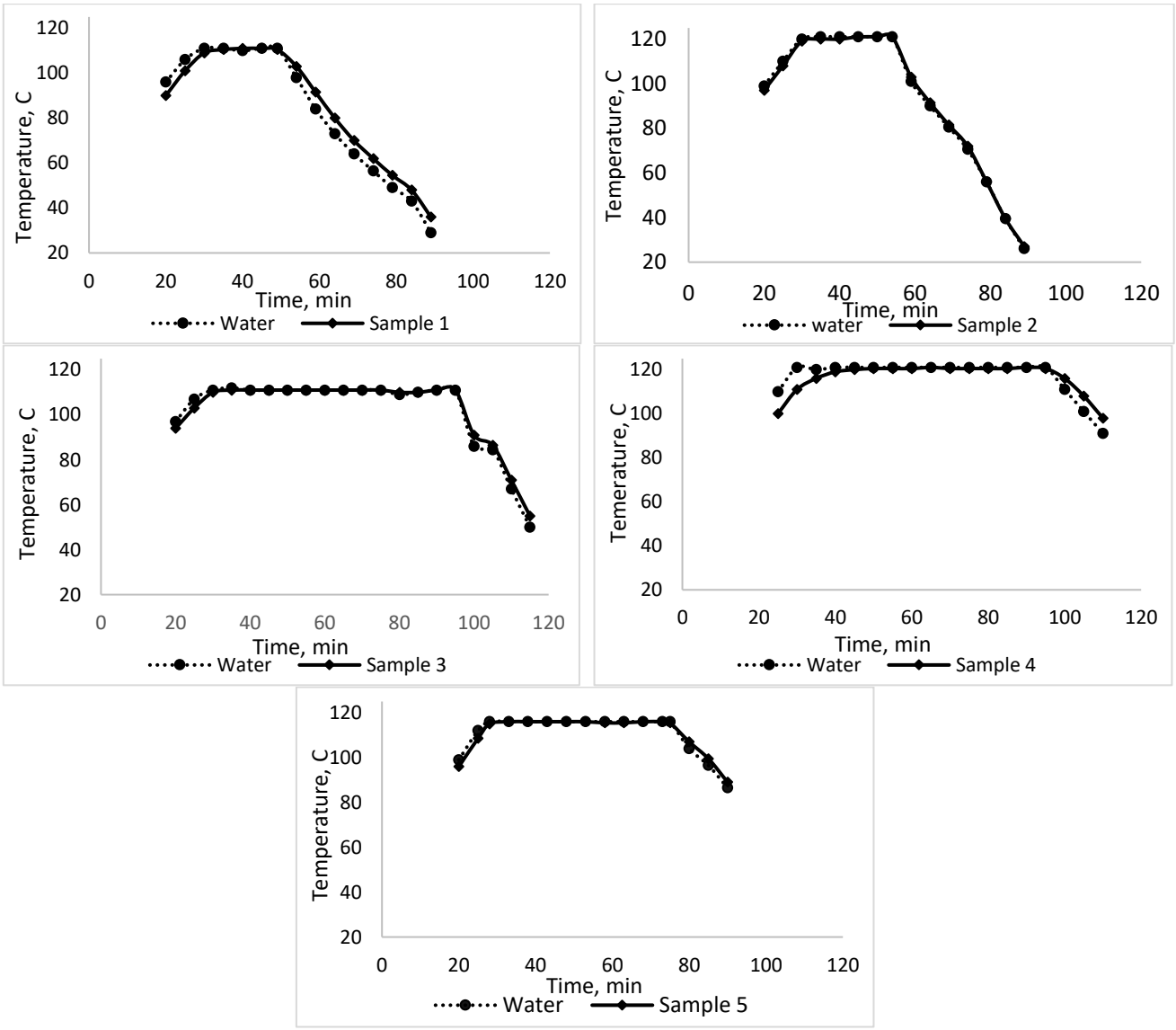

Figure 1. Heating curves of the pâté samples under different sterilization conditions

Table 1. Actual lethality of the meat pâtés sterilized under different conditions

Sample	1	2	3	4	5
L_{121}^{10}	2.57 min	24.79 min	6.52 min	55.51 min	15.74 min

Texture analysis

Texture is one of the most important qualitative parameters of food, and suitable instrumental methods of analysis have been developed for its assessment (Ivanov, G et al., 2018). The experimental data on hardness demonstrated that there were significant differences between individual samples ($P < 0.05$) (Table 2). The results indicated that the decrease in hardness was directly proportional to the increase in the actual sterilization effect (Table 1), the higher temperature and longer sterilization time leading to a product of lower hardness. These results were also in good correlation with the emulsion stability data obtained.

Table 2. Effect of sterilization conditions on the texture parameters, emulsion stability and lipolytic changes of the pâté samples

Sample / **Parameter**	**1**	**2**	**3**	**4**	**5**
Hardness, N	62.02±3.78d	33.84±1.41bc	30.3±3.06b	23.91±1.96a	34.26±3.47c
Adhesiveness, Nmm	48.57±4.46b	27.53±7.8a	26.61±7.03a	19.82±3.36a	24.54±5.05a
Cohesiveness	0.25±0.03a	0.25±0.03a	0.27±0.04a	0.22±0.03a	0.25±0.06a
Friability, N	15.19±1.47c	8.56±0.71b	8.1±1.62b	5.36±0.95a	8.38±1.32b
Peroxide content, $meqO_2.kg^{-1}$ fat	0.18±0.01a	0.22±0.01ab	0.4±0.00c	0.43±0.05c	0.23±0.02b
(TBARs), $mg.kg^{-1}$ pate	1.27±0.02a	1.32±0.03b	1.33±0.02b	1.54±0.02d	1.48±0.02c
Emulsion stability, %	99.79±0.02d	99.97±0.02e	99.66±0.02c	98.94±0.02a	99.51±0.02b

a-d – the values within the same column bearing a common letter designation did not differ statistically ($P > 0.05$)

Lipolytic changes: The data on the formation of primary lipid oxidation products showed a considerable peroxide increase in the samples with the longest thermal processing, whereas sample 1 exhibited the lowest peroxide generation. A similar trend was observed in the secondary products of oxidation reactions in the lipid fraction of the samples expressed by the TBARs indicator. The lowest malondialdehyde quantities were accumulated in the sample subjected to the mildest sterilization conditions, i.e. 111ºC for 24 min. Contrariwise, the largest MDA quantities were formed and accumulated in sample 4, where the sterilization process was longer and the temperature was higher (121ºC). Similar results were obtained by other authors as well (Al-Abdullah & Al-Majali, 2011). These data are in conformity with Pither's report (2003) that more intensive heat treatment had a negative effect on the biological value of meat products.

Emulsion stability: According to Kim et al. (2001), the formation of a stable gel, hence a stable meat emulsion, is affected by several factors, temperature and heat treatment time being the most important ones. The lowest emulsion stability was found in the sample

with the strongest actual sterilization effect, whereas the highest values were reported for samples 2 and 1, where the retention time at the set temperature was the shortest (Table 2). The heat treatment degree together with the changes in the protein fraction probably altered the structure of the hydrocarbon chains in the lentils and inulin added, thus affecting their ability to stabilize the meat emulsion.

Color metrics: According to Jiménez-Colmenero et al. (2010), meat products having a lower fat content demonstrate higher brightness values, which may be due to the greater dispersion of light. On the other hand, Cáceres et al. (2004) reported that the inulin added to meat products imparted glossy features similarly to fats. The present study established that the increase in the sterilization effect resulted in a decrease in color brightness (Table 3). According to Jaeger et al. (2010), in foods subjected to heat treatment the darkening usually results from the Maillard reaction occurring between reducing sugars and amino acids. A further reason may be the different emulsifying and related water retention capacity of the samples under different sterilization conditions connected to the optical properties of food.

Table 3. Effect of the sterilization conditions on the color parameters and color stability of the pâté samples

Sample	(L*)	(a*)	(b*)	(C)	(h)	(ΔEab)
1	57.10+0.60c	4.99+0.29b	11.61+0.35a	12.64+0.42a	66.75+0.75b	1.36+0.006d
2	56.49+0.24b	4.31+0.1a	12.75+0.15b	13.46+0.13bc	71.33+0.54d	0.83+0.006b
3	56.23+0.24b	4.99+0.14b	11.9+0.2a	12.91+0.15ab	67.24+0.86bc	0.69+0.006a
4	52.50+0.43a	5.78+0.06c	12.64+0.94b	13.9+0.88c	65.36+1.36a	1.36+0.006d
5	56.31+0.36b	5.02+0.1b	12.61+0.19b	13.57+0.2c	68.3+0.36c	1.29+0.0065c

a-d – the values within the same column bearing a common letter designation did not differ statistically (P > 0.05)

Changes resulting from the sterilization effect achieved were also observed in the red and yellow color component values for individual samples. The red component value (a*) followed the trend of rising along with the increase in the sterilization time and temperature, which was somewhat contradictory to the reported oxidative changes in lipids and myoglobin pigments (Fuentes et al., 2010, Ganhão et al., 2010). This could be attributed to the different time and rate of the reactions involved in the formation of nitrosomyoglobin and its subsequent denaturation to nitroso-hemo-chromogen under the different sterilization conditions indicated by the different heating curves of the filling mass for the pâté samples (fig.1). The results obtained for b* demonstrated that the yellow component was less affected by the sterilization time than by the temperature applied.

The data on the color hue (h) showed statistically significant differences ($P < 0.05$) between individual samples, and this parameter was mainly affected by the sterilization time. The ΔE values measured at the beginning and after two hours of exposure of the opened can

samples to light and oxygen were indicative of the color stability over time. The values obtained varied from 0.69 to 1.36, the most stable sample being the one sterilized at 111 ℃ for 70 minutes ($L_{121}^{10} = 6{,}52$ min), and the most unstable ones being samples 4 (111 ℃ for 24 minutes) and 1 (121 ℃ for 70 minutes), which exhibited the highest and the lowest values of L_{121}^{10}.

Conclusion

The analysis of the results showed that the more intensive sterilization modes led to better texture parameters compared to the milder sterilization conditions. With regard to the heat treatment effect on the primary and secondary lipid peroxidation products, the longer treatment at higher temperatures was found to result in the accumulation of larger quantities of oxidated products. Shorter treatment at lower temperatures had the weakest effect on the color parameters and emulsion stability. Nevertheless, it is worth mentioning that treatment that is too short is undesirable from the point of view of the red coloring of the pâté and the preservation of the samples after opening.

References

Al-Abdullah, B., & Al-Majali, A. (2011). Effects of fat content and heat treatment on the chemical and sensory characteristics of canned luncheon meat. Jordan Journal of Agricultural Sciences, 173(799), 1-18.

Bligh E.G., W.J. Dyer (1959). A rapid method of total lipid extraction and purification. *Canadian Journal of Biochemistry and Physiology*, 37 (8), 911-917.

Bourne M.C. (1978). Texture profile analysis. Food Technology, 32, 62-66.

Cáceres E., M.L. Garcıa, J. Toro, M.D. Selgas (2004). The effect of fructooligosaccharides on the sensory characteristics of cooked sausages. Meat science, 68 (1), 87-96.

Choi Y.S., K.S. Park, H.W. Kim, K.E. Hwang, D.H. Song, M.S. Choi, C.J. Kim (2013). Quality characteristics of reduced-fat frankfurters with pork fat replaced by sunflower seed oils and dietary fiber extracted from makgeolli lees. Meat Science, 93 (3), 652-658.

FAO 2010. Canning/Sterilization of meat products – Principles of food canning (www.fao.org).

Flambert C.M.F., J. Deltour, R.W. Dickerson, K. Hayakawa (1977). Lethal effect of food temperature on linear portion of a heating or cooling curve. Journal of Food Science, 42, 545-546.

Fuentes, V., Ventanas, J., Morcuende, D., Estévez, M., & Ventanas, S. (2010). Lipid and protein oxidation and sensory properties of vacuum-packaged dry-cured ham subjected to high hydrostatic pressure. Meat Science,85(3), 506–514.

Ganhão, R., Morcuende, D., & Estévez, M. (2010).Protein oxidation in emulsified cookedburger patties with added fruit extracts: Influence on colour and texture deterioration during chill storage. Meat Science,85(3), 402–409.

Hornero-Méndez D., A. Pérez-Gálvez, M.I. Mínguez-Mosquera (2001). A rapid spectrophotometric method for the determination of peroxide value in food lipids with high carotenoid content. Journal of the American Oil Chemists' Society, 78 (11), 1151-1155.

Ivanov, G., Bogdanova, A., & Zsivanovits, G. (2018). Effect of ripening temperature on the texture of cow milk Kashkaval cheese. Progress in Agricultural Engineering Sciences, 14(s1), 69-78.

Jaeger, H., Janositz, A., & Knorr, D. (2010). The Maillard reaction and its control during food processing. The potential of emerging technologies. Pathologie biologie, 58(3), 207-213.

Jiménez-Colmenero F., F.J. Sánchez-Muniz, B. Olmedilla-Alonso (2010). Design and development of meat-based functional foods with walnut: Technological, nutritional and health impact. Food Chemistry, 123 (4), 959-967.

Kim Y., M.N. Faqih, S.S. Wang (2001). Factors affecting gel formation of inulin. Carbohydrate Polymers, 46 (2), 135-145.

Latoch, A., Glibowski, P., & Libera, J. (2016). The effect of replacing pork fat of inulin on the physicochemical and sensory quality of guinea fowl pate. Acta Scientiarum Polonorum Technologia Alimentaria, 15(3), 311-320.

Lorenzo J.M., M. Pateiro, M. Fontán, J. Carballo (2014). Effect of fat content on physical, microbial, lipid and protein changes during chill storage of foal liver pâté. Food Chemistry, 155, 57-63.

García L. M., E. Cáceres, M. Dolores Selgas (2006). Effect of inulin on the textural and sensory properties of mortadella, a Spanish cooked meat product. International Journal of Food Science & Technology, 41 (10), 1207-1215.

Nitsch P., Vuković I. 2002. Computer procedure for the quick determination of the f-value based on the Gaussian integration. Fleischwirtschaft 82 (11):122-123

Nitsch P., Vuković I. 2003. Determining F-values through the Internet. Fleischwirtschaft 83 (8):34-35.

Nitsch P., Vuković I. 2006. Calculation of F-values at the cooling-step of heating process of cans. Fleischwirtschaft, 86 (1):89-92.

Ockerman H.W. (1985). pH measurement (2nd ed.). Quality control of post mortem muscle tissue (Vol. 2). Columbus, OH: The Ohio State University of inulin. European Food Research and Technology, 220, 466-471.

PenaRamos, E.A. and Xiong, Y.L. 2002. Whey and soy protein hydrolysates inhibit lipid oxidation in cooked pork patties. Meat Science, 64: 259 – 263.

Pither R.J. 2003. Canning – Quality changes during canning. In Encyclopedia of Food Sciences and Nutrition (Second Edition). Eds. B. Caballero, P. Finglas, F. Toldra, Academic Press, Cambridge, pp. 845-851.

Roberfroid, M. Inulin-Type Fructans: Functional Food Ingredients. The Journal of Nutrition, 2010, 2493-2502.

Shoaib, M., Shehzad, A., Omar, M., Rakha, A., Raza, H., Sharif, H., Shakeel, A., Ansari, A., Niazi, S. Inulin: Properties, health benefits and food applications. Carbohydrate Polymers, 2016, 147, 444-454.

Sørensen G., S.S. Jørgensen (1996). A critical examination of some experimental variables in the 2-thiobarbituric acid (TBA) test for lipid oxidation in meat products. Zeitschrift für Lebensmitteluntersuchung und-Forschung A, 202 (3), 205-210.

Stoforos N.G. (2010). Thermal process calculations through Ball's original formula method: a critical presentation of the method and simplification of its use through regression equations. Food Engineering Reviews, 2 (1), 1-16.

Teixeira A.A., J.R. Dixon, J.W. Zahradnik, G.E. Zinsmeister (1969). Computer determination of spore survival distributions in ther mally-processed conductionheated foods. Food Technology, 23 (3), 78-78.

Zorba O., H.Y. Gokalp, H. Yetim, H.W. Ockerman (1993). Model system evaluations of the effects of different levels of K2HPO4 NaCl and oil temperature on emulsion stability and viscosity of fresh and frozen Turkish style meat emulsions. Meat Science, 34 (2), 145-161.