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AKADÉMIAI KIADÓ

Comparison of raw materials for meat products

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ABSTRACT

Animal food, especially meat, has played an important role in the history of mankind. Different meats can be used in the production of meat products. In addition to lean meats, mechanically deboned meat (MDM) and mechanically separated meat (MSM) can also be used in meat products. However, the latter does not qualify as meat due to damage to the muscular structure due to the high pressure applied during the separation, therefore cannot be included in the meat content of products.

The aim of our experiment was to compare whole, minced meat, MDM and MSM from turkey (raw and in the form of meat paste). Technofunctional tests (water-holding and -binding capacity), color measurement, chemical composition (moisture, protein and fat content), electron microscopic recording, rheological properties show that the quality of MSM is inferior to other meat raw materials. These properties can also result in the production of lower quality products.

KEYWORDS

meat, mechanically separated meat, mechanically deboned meat, comparative analysis

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INTRODUCTION

Meat is the processed and certified skeletal muscle of mammals and poultry for human consumption. According to Regulation (EC) No. 853/2004, meat is the edible parts of the following animals, including blood: pigs, cattle, calves, poultry (e.g. chickens, hens, ducks, geese, turkeys), other warm-blooded animals (sheeps, rabbits, goats, horses, etc.), wild animals (wild boar, deer, cervids, wild rabbits, etc.) and ratites (ostriches).

In addition to lean meat, meat removed from bones can also be used in meat products, according to the provisions of the Requirement No. 1-3/13-1 of the Codex Alimentarius Hungaricus:

- Mechanically deboned meat (MDM), the production operation is limited to the mechanical removal of the bone from the boned meat and is not intended for the further extraction of meat from the bone remaining after boning.
- Mechanically separated meat (MSM) is a product obtained after boning from fresh, fleshy bones or poultry which have been removed by mechanical means in such a way as to damage or modify the muscular structure. This does not qualify as meat.

When a slaughtered animal is cut, about 5% of the meat remains on the bones. At least 6% of meat, 12–25% of fat, and 17–19% of protein (of which 25% is connective tissue) remain after manual bone cleansing. Extracting this manually would be very labor and time consuming (Wittmann, 1977). This meant savings of around £ 9 million in Britain in the 1970s (Newman, 1981).

Mechanical equipment for extracting meat left on fleshy bones and enabling time-consuming methods of cutting and boning appeared after the World War I. The bone to be separated is placed in a basket with a perforated wall where it is put under great pressure. As a result, the meat is squeezed out of the holes and the compressed bone can be removed separately. However, it is inevitable that at this high pressure, bone fragments will also be transferred to the separation. The separators operate at high pressures (300–470 bar), with a temperature rise of 2–9 °C during operation, depending on the equipment (Wittmann, 1977).

Of course, the higher the pressure, the higher the yield, but the poorer the quality of the meat. The meat obtained is pasty, with a bone content of around 1% and a calcium content of 0.1% for pork, and have a higher pH compared to hand-boned meat (Demos and Mandigo, 1995) and is therefore sensitive to oxidation, advising that its temperature should not exceed 10 °C because strong lipid oxidation coincides with heme protein oxidation (Wittmann, 1977). More and better quality separations can be obtained from bones with higher meat content.

The basis of the method was developed in Japan in the early 1940s for removing and separating fish meat (Trindade et al., 2004; Oliveira et al., 2015). According to Regulation (EC) No. 853/2004, MSM cannot be made from poultry skins, neck skin and heads. Bone-in meat packaged for up to 3 days at 2 °C can be used as raw material. The regulation stipulates a shelf life of 3 months when stored at −18 °C. It is important that MSM can only be used in heat-treated products.

MSM does not qualify as meat due to its unfavorable chemical (high fat and calcium content) and functional (poor water binding) properties. The composition and name of the product must also include ‘mechanically separated meat (MSM)’. Previously, this was also classified as meat, but – due to its unfavorable properties – its use in meat products was maximized by 10% (Req. No. 1-3/13-1 of the Codex Alimentarius Hungaricus). Of course, it can also be used in larger quantities for the production of a product, but in this case the product cannot be called e.g. bologna sausage, vienna sausage. Figure 1 shows the definition of meat.

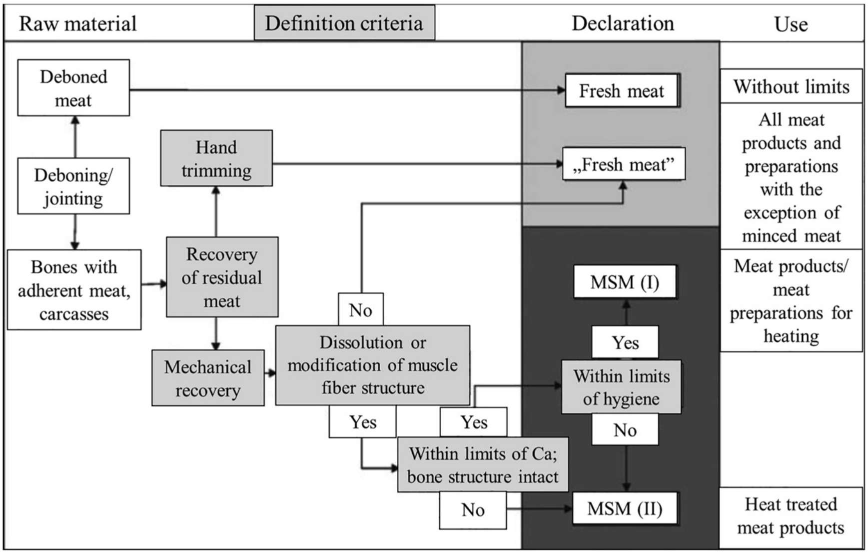

Fig. 1. The definiton of meat (EFSA, 2013). MSM: Mechanically separated meat

In terms of consumer risk, EFSA compared poultry and pork MSM samples with fresh and minced meat and other meat products processed with non-MSM technology. From a microbiological point of view, there is no significant difference, although the risk of microbial proliferation increases with damage to muscle fibers due to high pressure. Chemical, histological (molecular), molecular, structural, and flow parameters were studied to distinguish between MSM and non-MSM products. Based on the available data, calcium and (as yet unconfirmed) cholesterol concentrations were the only chemical characteristics that could distinguish MSM products from non-MSM. Based on the reported data, a model has been developed to determine whether or not a product is made with MSM technology based on its calcium content. According to Regulation (EC) No. 2074/2005, if the calcium content of the product is 100 mg/100g, then according to the developed model, the product is MSM with a probability of 93.6%. However, based on the calcium content alone, it is not yet possible to distinguish between low-pressure MSM products and otherwise processed meat products, so other validated tests are needed to determine this. Histological features include microscopic observation of different tissues and their changes. This appears to be a promising method to screen for MSM products, but further studies are needed to confirm this (EFSA, 2013).

MATERIALS AND METHODS

Materials

We obtained our samples from Gallfood Ltd. (Kecskemét, Hungary). The samples obtained were whole turkey drumsticks, minced turkey drumsticks (particle size: 3 mm), mechanically deboned meat made from turkey drumsticks and MSM made from turkey backs.

Methods – raw materials

Water-holding capacity. Water-holding capacity (WHC) was determined by the following method. 0.5–1 g of samples – whole meat, minced meat, MDM and MSM – was placed on dried filter paper. The samples were placed between glass plates and were weighed at 1,000 g for 5 min. Then the weight of the pressed meat was measured. Measurements were performed on three repeats. The pressing loss was calculated using the following formula:

$$\text{Pressing loss}(\%) = 100 - \left(\frac{\text{weight of meat after pressing}}{\text{weight of meat before pressing}} \cdot 100\%\right)$$

Water-binding capacity. Water-binding capacity (WBC) was determined by two methods. To determine the cooking loss, the $2 \times 2 \times 2$ cm samples were heat-treated in an airtight plastic bag until a core temperature of 72 °C was reached. In determining the roasting loss, two sides of the $2 \times 2 \times 2$ cm samples were heat-treated in a contact grill heated to 170 °C for 5 min. Measurements were performed on three repeats. The cooking and roasting loss was calculated using the following formula:

$$\text{Cooking/Roasting loss}\,(\%) = 100 - \left(\frac{\text{weight of meat after heat treatment}}{\text{weight of meat before heat treatment}} \cdot 100\%\right)$$

pH. The pH of the samples was measured with a Testo 206 (Testo SE & Co. KGaA, Titisee-Neustadt, Germany) (three repeats).

Water activity. The water activity of the samples was measured with a NOVASINA LabMaster AW (Novasina AG, Switzerland) (three repeats). The tempering unit built into the instrument ensures a constant temperature (25 °C), so that the water activity of the samples was determined under the same conditions.

Chemical composition. The chemical composition of the samples was measured with a FOSS FoodScan 2 Lab (Hilleroed, Denmark) (five repeats). The samples were homogenized with a Bosch MFW67450 (Munich, Germany) meat grinder using a 3 mm grinder hole disc. The instrument measured the following characteristics: moisture content, fat content, saturated fatty acid content (SFA), protein content, collagen content, salt content, carbohydrate content, ash content. Of these, the results for moisture content, fat content, and protein content were shown in the results section.

Color stability. The color stability of the samples was measured (in CIELab color space) with a Minolta CR-400 (Osaka, Japan). Minced, MDM and MSM samples were used for the measurement. The measurement lasted for 120 min, measured every 10 min (five points). During the measurement, commercial meat display coolers were simulated. The samples were continuously cooled from below. The samples were also under lighting. The illumination level was 700 lx. Half of the samples were uncovered, and the other half were covered with foil (to avoid changes caused by oxygen).

Scanning electron microscopy (SEM). Preparation: 1 g of samples – whole meat, minced meat, MDM and MSM – were fixed in glutaraldehyde (2.5 g 100 g^{-1}) for 24 h in 0.1 M phosphate buffer (pH 7.0). After fixing the ethanol dehydration, the samples were freeze-dried and spray-coated according to the method of Cao et al. (2012). The prepared samples were tested on a FEI Quanta 3D Two-Beam Scanning Electron Microscope (Hillsboro, Orlando, USA) at 5 °C, 700 Pa and 100% relative humidity.

Methods – meat paste

Sample preparation (dilution). In each case, 100 g of sample (minced, MDM and MSM) and 0 mL, 10 mL, 20 mL, 30 mL, 40 mL, 60 mL, 80 mL, and 100 mL of water were used to prepare the meat paste. Paste production was performed for 20 s with an Ambiano Electric Mini Chopper (500 W, Münster, Germany).

Color measurement. The surface color of the meat pastes (minced meat, MDM and MSM) containing different amounts of added water (in CIELab color space) was measured with a Minolta CR-400 (Osaka, Japan) (five parallel measurements). The obtained color characteristics were used to determine the color stimulus difference (ΔE^*), which was determined by the following formula (Hill et al., 1997):

$$\Delta E^*_{ab} = \sqrt{\left(\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}\right)},$$

where ΔE^*_{ab} is the color stimulus difference, L^* is the degree of lightness, a^* is the red color intensity and b^* is the yellow color intensity.

Examination of the rheological properties. Viscosity characteristics were tested with an Anton Paar Physica MCR 92 viscometer (Graz, Austria). The temperature of the sample was 10 °C, the frequency was 10 Hz, the amplitude was increased to 0.05–100%, the gap was 1 mm, and the diameter of the measuring head was 25 mm. Using the amplitude sweeping method, 3 parallel measurements were performed with a sheet-to-sheet arrangement, with a sheet diameter of 23 mm. Measured characteristics: modulus of storage (G′) and loss (G″) and shear stress (τ). From these values, the end of the linear viscoelastic region (τ_{LVE}) and the shear stress (τ_M) at the intersection of the G′ and G″ curves were determined (yield strength).

Methods – statistical analysis

Statistical analysis was performed using IBM Statistics 27 (Armond, New York, USA) software. The significance level was 5% ($P < 0.05$). Data were normalized by Shapiro-Wilk test. Levene test was used to determine equality of variance. The differences were assumed to be equal in all cases. ANOVA was used for statistical analysis of variance. We determined which groups differed significantly by Tukey HSD post hoc test. Microsoft 365 Excel (Redmond, Washington, USA) was used for graphical representation.

RESULTS AND DISCUSSION

Results and discussion – raw materials

Water-holding capacity. The results of the pressing losses of the samples are shown in Fig. 2. It can be seen from this that there is a significant difference between the samples ($P < 0.001$), the lowest value is given to the whole turkey drumstick meat (0.54 ± 0.380), so this sample has the highest water-holding capacity value. This was followed by minced turkey drumsticks (1.69 ± 0.050) and turkey drumstick MDM (5.27 ± 0.540). Most of the water was lost by MSM due to compression (10.76 ± 0.330).

Water-binding capacity. From the results of the cooking loss (Fig. 3a) it can be stated that there is a significant difference between the samples due to cooking ($P < 0.001$). The smallest loss was for minced meat (21.12 ± 0.760), followed by whole turkey drumstick meat (24.09 ± 0.460), MDM (27.00 ± 0.120). MSM had the highest cooking loss and thus the smallest water-binding capacity (37.14 ± 0.290) of the samples. Observing the results of the roasting loss (Fig. 3b), it can be read that there is a significant difference between the samples ($P < 0.001$). The trend was similar in cooking test. Minced meat had the best water-binding property - the lowest roasting loss (36.40 ± 0.795), followed by whole meat (38.81 ± 0.535), MDM (41.19 ± 0.295) and MSM (42.41 ± 0.295).

pH. In Fig. 4 it is shown that there is a significant difference between the pH values of the whole meat and other samples ($P < 0.001$). Whole turkey drumstick meat has the lowest value (6.29 ± 0.020). This is followed by MSM (6.42 ± 0.020), MDM (6.44 ± 0.044) and minced sample (6.46 ± 0.025), respectively, with no significant difference between the different meat types.

Water activity. The values of the water activity of the samples are presented in Fig. 5, which shows that there is a significant difference between the whole and minced meat and the other samples ($P < 0.001$). Minced meat (0.954 ± 0.003) and whole meat (0.955 ± 0.003) had the lowest water activity, so these samples contained less free water, which could be a medium for the growth of microorganisms. There is no significant difference between MDM (0.963 ± 0.004) and MSM (0.963 ± 0.003).

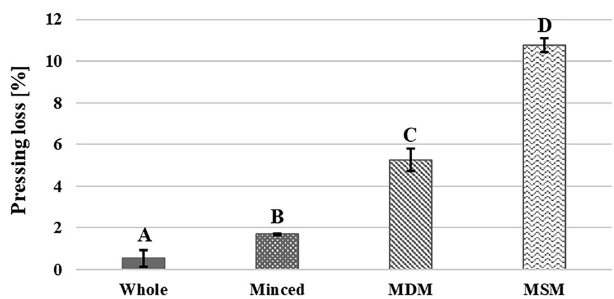

Fig. 2. Weight loss due to compression of the samples. MDM: Mechanically deboned meat, MSM: Mechanically separated meat. Capital letters above the bars show significant difference ($P < 0.05$)

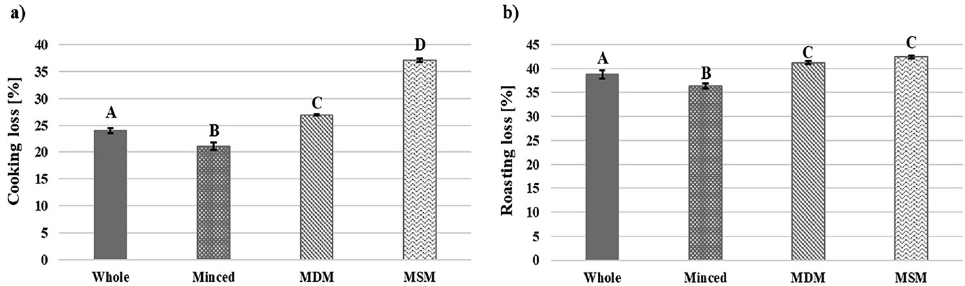

Fig. 3. Cooking (a) and roasting (b) loss of samples. MDM: Mechanically deboned meat, MSM: Mechanically separated meat. Capital letters above the bars show significant difference ($P < 0.05$)

Chemical composition. There is a significant difference ($P < 0.001$) between the fat contents of the samples (Fig. 6a). Minced meat had the lowest fat content (4.12 ± 0.017), and this value was not much higher for MDM (5.24 ± 0.114). The sample with the highest fat content was MSM (20.90 ± 0.029). There is also a significant difference between the moisture content values of the samples (Fig. 6b) ($P < 0.001$), the highest value was that of minced meat (74.87 ± 0.012). This was followed by MDM (74.30 ± 0.036) and MSM (61.33 ± 0.037). The trend shows that there is an inverse relationship between moisture content and fat content. There is also a significant difference between the protein content results of the samples (Fig. 6c) ($P < 0.001$). The highest protein content was in minced meat (20.82 ± 0.032), followed by MDM (20.54 ± 0.033) and MSM (14.27 ± 0.038). Thus, it can be seen that the trend in protein content follows the trend observed for moisture content (inverse proportion to fat content can be detected).

Color stability. Figure 7 (a) shows the change in the degree of lightness of the samples over time. The uncovered samples became darker and darker than the covered ones ($P < 0.05$), their lightness decreased more. It was found that the lightest sample at the beginning was MSM, followed by minced meat and MDM.

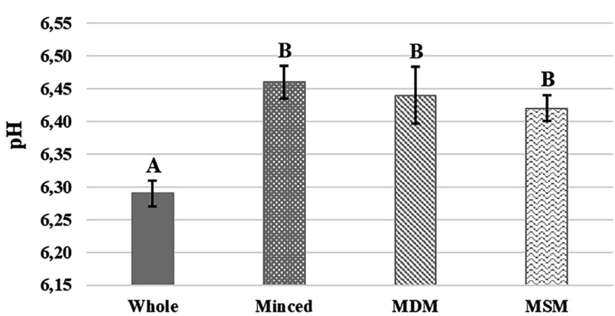

Fig. 4. The pH values of samples. MDM: Mechanically deboned meat, MSM: Mechanically separated meat. Capital letters above the bars show significant difference ($P < 0.05$)

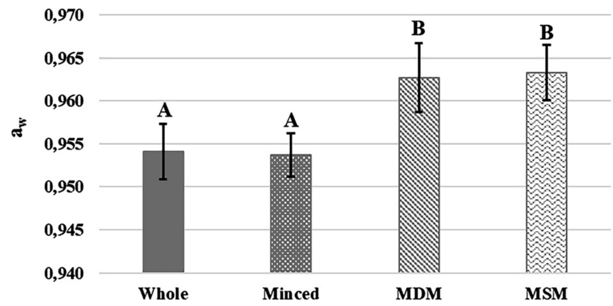

Fig. 5. Water activity of samples. MDM: Mechanically deboned meat, MSM: Mechanically separated meat. Capital letters above the bars show significant difference ($P < 0.05$)

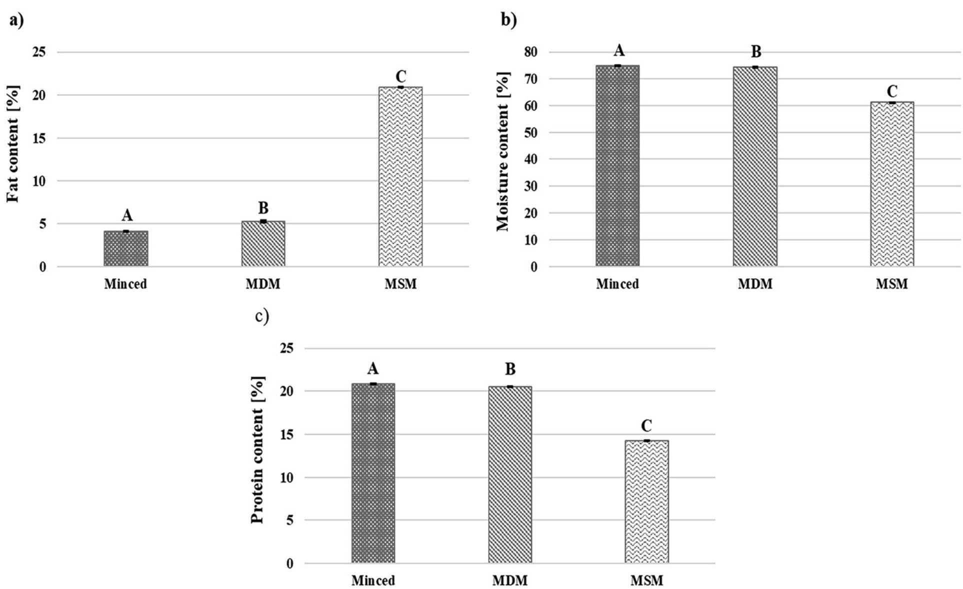

Fig. 6. Chemical composition of the samples. a) fat content, b) moisture content, c) protein content. MDM: Mechanically deboned meat, MSM: Mechanically separated meat. Capital letters above the bars show significant difference ($P < 0.05$)

Figure 7 (b) shows the change in the red color intensity of the samples over time. From the trend of the meat samples it can be stated that the uncovered samples became more and more reddish compared to the covered ones ($P < 0.05$), their color intensity value increased more. It was found that the most red sample at the beginning was MSM, followed by MDM and minced meat.

Figure 7 (c) shows the change in the yellow color intensity of the samples over time. It can be stated that the uncovered samples became more and more yellowish compared to the covered ones ($P < 0.05$), their color intensity value increased more. It can be seen that the most yellow sample at the beginning was MSM, followed by minced meat and MDM.

Overall, the uncovered samples darkened, reddened, and turned yellow due to contact with air. In addition, MSM was lighter, redder, and yellower in color compared to MDM and minced meat.

Scanning electron microscopy (SEM). In Fig. 8 (a), the fibers of the whole turkey drumstick meat can be seen. The other figures (Fig. 8 (b), (c) and (d)) show the results of the various processing operations (mincing, mechanical deboning and separation). Electron micrographs of MSM show a complete change in muscle structure compared to minced meat and MDM. This may be due to the high pressure applied during the separation.

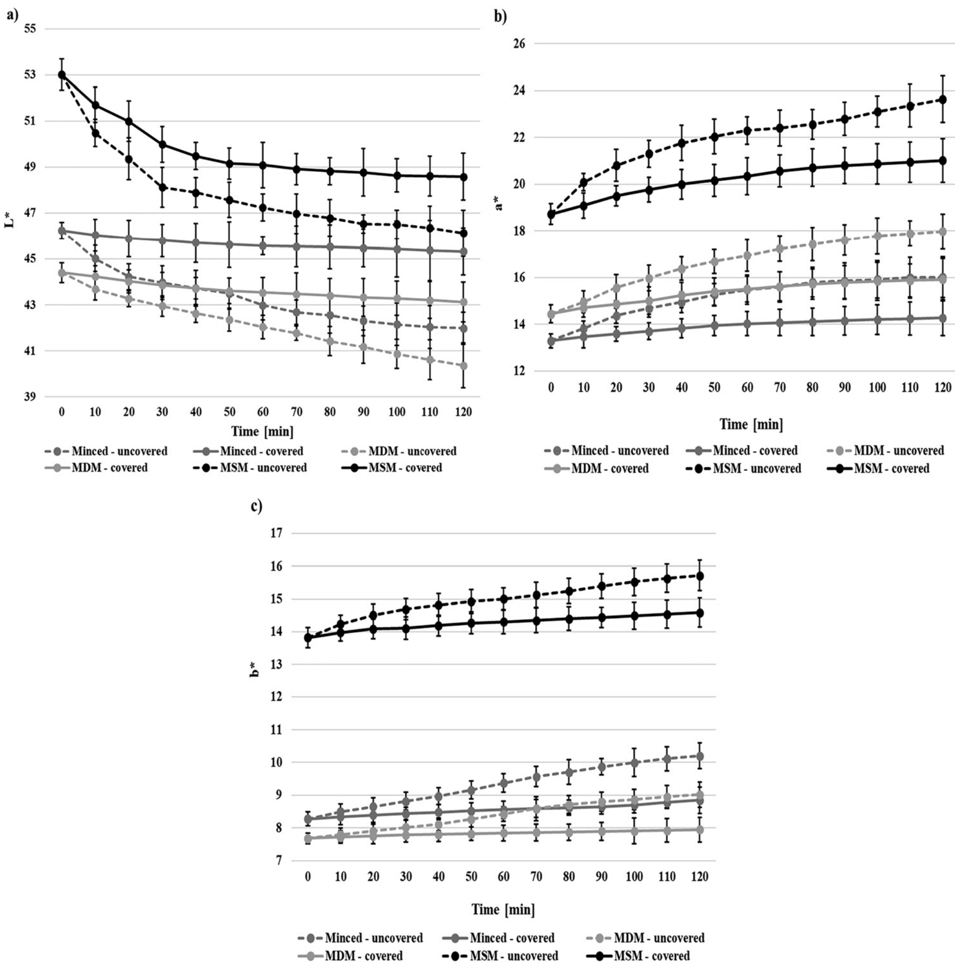

Fig. 7. Examination of the color stability of the samples. a) degree of lightness (L^*), b) red color intensity (a^*), c) yellow color intensity (b^*). MDM: Mechanically deboned meat, MSM: Mechanically separated meat

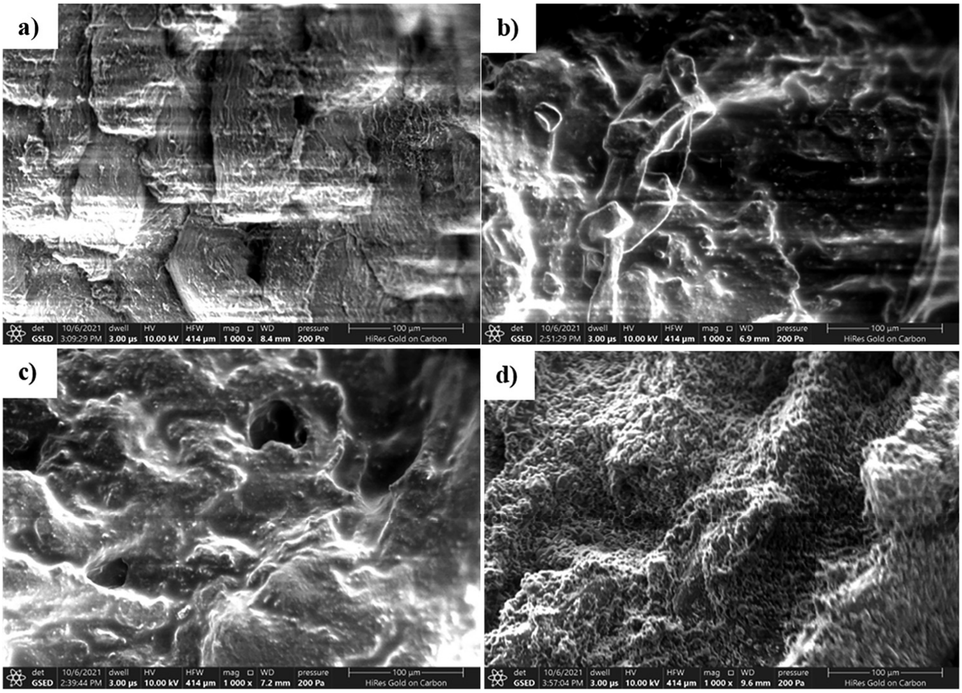

Fig. 8. Electron micrographs of the samples. a) whole, b) minced, c) MDM: Mechanically deboned meat, d) MSM: Mechanically separated meat

RESULTS AND DISCUSSION – MEAT PASTE

Color measurement

Figure 9 (a) shows the effect of the amount of water added on the lightness of the meat pastes. Based on the trend, it can be said that the different meat pastes became lighter with increasing amount of water ($P < 0.05$).

Figure 9 (b) shows the effect of the amount of water added on the red color intensity of the meat pastes. Increasing the amount of water shows a decrease in the red color intensity of the pastes ($P < 0.05$).

Figure 9 (c) shows the effect of the amount of water added on the yellow color intensity of the meat pastes. From the trend it can be observed that the yellow color intensity of the pastes decreased with increasing water volume ($P < 0.05$).

Overall, the pastes became lighter and less red and yellow as the amount of water added increased.

Table 1 shows the pairwise color stimulus differences for meat pastes made by adding different amounts of water and their evaluation. Based on this, it can be concluded that there is no visible difference between any two meats. In addition, by increasing the amount of water added to the meat pastes, the visibly large or well noticeable color difference is all the more

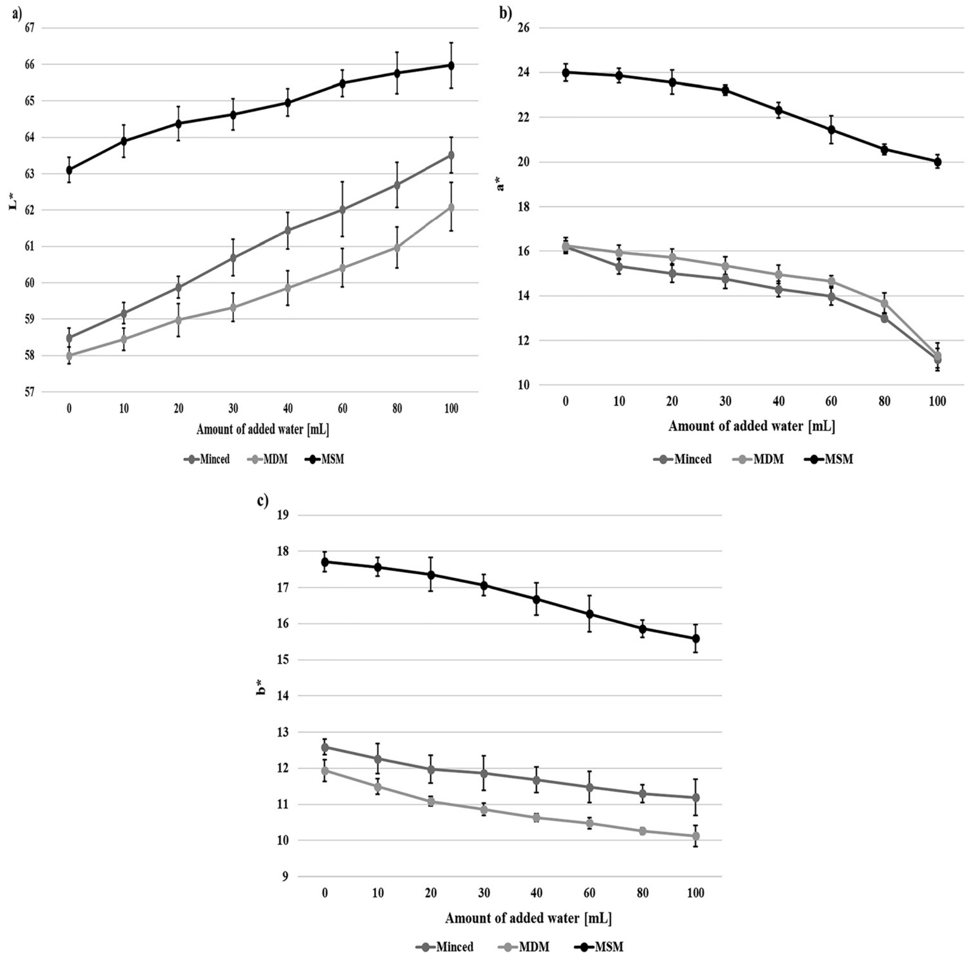

Fig. 9. Color characteristics of the prepared meat pastes. a) degree of lightness (L^*), b) red color intensity (a^*), c) yellow color intensity (b^*). MDM: Mechanically deboned meat, MSM: Mechanically separated meat

characteristic. Furthermore, it can be seen that in the case of MSM meat paste, there is no apparent large color difference between the two samples, in contrast to the sample made from MDM and minced meat.

Examination of the rheological properties

In Fig. 10 it is shown that the storage modulus (G') of meat pastes decreases with increasing amount of added water, i.e. it becomes less and less elastic. In Fig. 10 it is shown that the value of the initial storage modulus of the meat paste made of MDM is the highest, followed by the meat paste made of minced meat and MSM ($P < 0.05$). MSM meat paste is considered to be the least flexible, to which more additives must be added to produce the right quality paste.

Table 1. Values and evaluation of color stimulus differences between different meat pastes. JND: Just Noticeable Difference, ND: Noticeable Difference, WND: Well Noticeable Difference, LD: Large Difference. MDM: Mechanically deboned meat, MSM: Mechanically separated meat

Amount of added water of meat pastes [mL]		Minced		MDM		MSM	
		ΔE^*	Evaluation	ΔE^*	Evaluation	ΔE^*	Evaluation
0	10	1.16 ± 0.232	JND	0.70 ± 0.116	JND	0.81 ± 0.114	JND
	20	1.93 ± 0.246	ND	1.39 ± 0.283	JND	1.39 ± 0.281	JND
	30	2.73 ± 0.397	ND	1.93 ± 0.212	ND	1.83 ± 0.178	ND
	40	3.62 ± 0.297	WND	2.61 ± 0.321	ND	2.70 ± 0.195	ND
	60	4.32 ± 0.560	WND	3.23 ± 0.350	WND	3.77 ± 0.335	WND
	80	5.44 ± 0.362	WND	4.27 ± 0.404	WND	4.72 ± 0.271	WND
	100	7.26 ± 0.444	LD	6.64 ± 0.495	LD	5.34 ± 0.312	WND
10	20	0.83 ± 0.071	JND	0.69 ± 0.177	JND	0.61 ± 0.300	JND
	30	1.67 ± 0.228	ND	1.23 ± 0.118	JND	1.10 ± 0.101	JND
	40	2.56 ± 0.231	ND	1.92 ± 0.220	ND	2.07 ± 0.207	ND
	60	3.26 ± 0.476	WND	2.55 ± 0.247	ND	3.17 ± 0.394	WND
	80	4.33 ± 0.416	WND	3.60 ± 0.308	WND	4.16 ± 0.158	WND
	100	6.12 ± 0.263	LD	6.03 ± 0.445	LD	4.79 ± 0.221	WND
20	30	0.85 ± 0.210	JND	0.57 ± 0.082	JND	0.52 ± 0.356	JND
	40	1.73 ± 0.215	ND	1.26 ± 0.054	JND	1.53 ± 0.217	ND
	60	2.43 ± 0.460	ND	1.89 ± 0.151	ND	2.62 ± 0.142	ND
	80	3.52 ± 0.421	WND	2.98 ± 0.137	ND	3.63 ± 0.388	WND
	100	5.36 ± 0.233	WND	5.48 ± 0.334	WND	4.27 ± 0.296	WND
30	40	0.89 ± 0.156	JND	0.70 ± 0.110	JND	1.03 ± 0.204	JND
	60	1.60 ± 0.278	ND	1.34 ± 0.213	JND	2.12 ± 0.452	ND
	80	2.72 ± 0.373	ND	2.42 ± 0.195	ND	3.12 ± 0.146	WND
	100	4.64 ± 0.070	WND	4.93 ± 0.353	WND	3.76 ± 0.220	WND
40	60	0.71 ± 0.270	JND	0.65 ± 0.187	JND	1.10 ± 0.289	JND
	80	1.85 ± 0.235	ND	1.74 ± 0.093	ND	2.10 ± 0.302	ND
	100	3.81 ± 0.212	WND	4.29 ± 0.315	WND	2.74 ± 0.254	ND
60	80	1.19 ± 0.316	JND	1.15 ± 0.223	JND	1.01 ± 0.510	JND
	100	3.21 ± 0.302	WND	3.75 ± 0.388	WND	1.65 ± 0.434	ND
80	100	2.04 ± 0.434	ND	2.60 ± 0.262	ND	0.64 ± 0.160	JND

In Fig. 11 it is shown that the loss modulus value (G″) of meat pastes decreases with increasing amount of water, i.e. the paste becomes less and less viscous. In Fig. 11 it is shown that the value of the initial loss modulus of the meat paste made from MDM is the highest, followed by the meat paste made from minced meat and MSM. Thus, MSM meat paste is considered to be the least viscous ($P < 0.05$).

For the three types of meat paste, the loss modulus is initially less than the storage modulus, so their quotient is less than 1, which means that is a solid material despite of added water.

In Fig. 12 (a-c) it is shown that the value of the shear stress (τ) of the meat pastes decreases with increasing amount of water added, i.e. the paste becomes less and less resistant to the shear strain. In Fig. 12 (a-c) it is shown that the final shear stress value of the meat paste made of MDM is the highest, followed by the meat paste made of minced meat and MSM ($P < 0.05$). So the least shear strain is required for MSM paste.

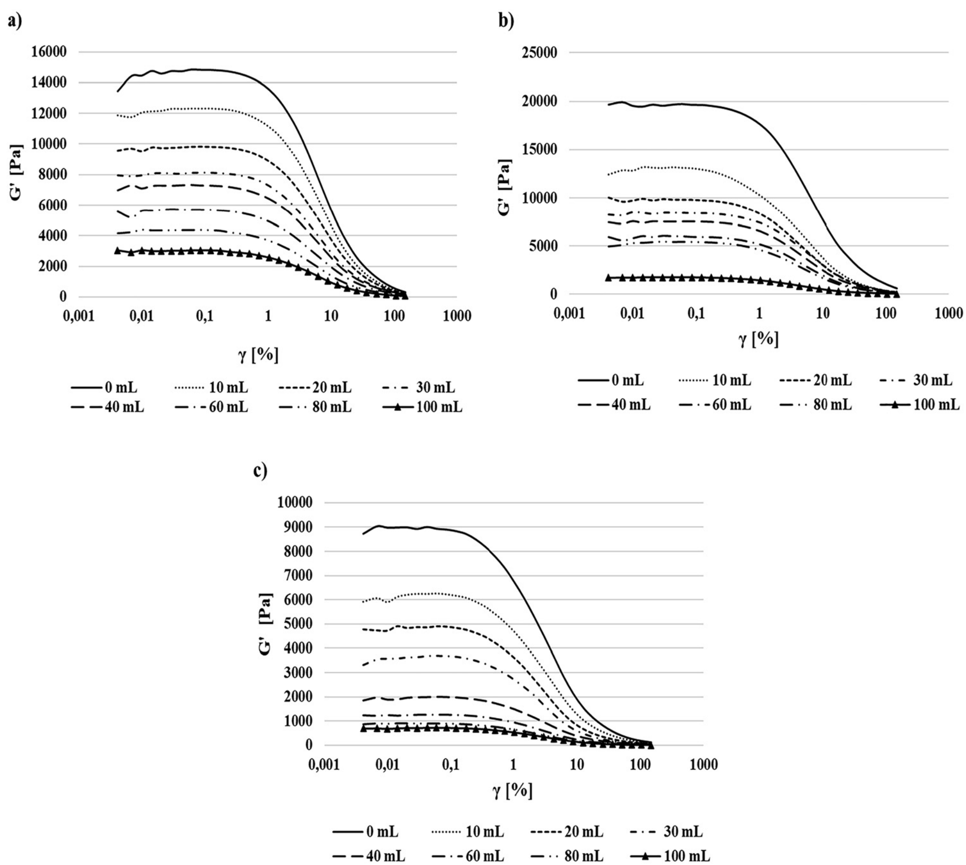

Fig. 10. Storage modulus values (G′) of meat pastes with different amounts of added water as a function of shear strain (γ). (a) minced meat, (b) MDM: Mechanically deboned meat, (c) MSM: Mechanically separated meat

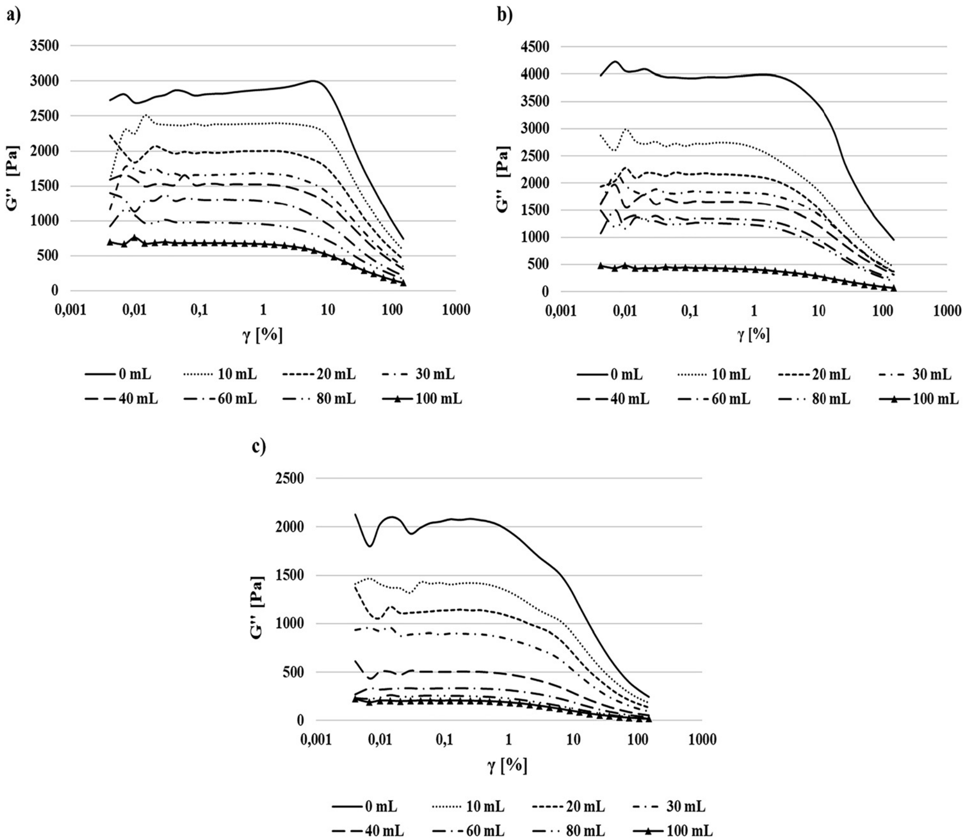

Fig. 11. Loss modulus values (G″) of meat pastes with different added amounts of water as a function of shear strain (γ). (a) minced meat, (b) MDM: Mechanically deboned meat, (c) MSM: Mechanically separated meat

In Fig. 13 (a) it is shown that the end values of the linear viscoelastic region (τ_{LVE}) of meat pastes made from the same meat raw material decrease as a function of the amount of water added. This suggests that the samples are becoming less and less resistant. Among the meat raw materials, MSM is the least resistant compared to the other two samples ($P < 0.05$).

In Fig. 13 (b) it is shown that the yield strength values (τ_M) of meat pastes made from the same meat raw material decrease as a function of the amount of water added. That is, less and less strain is required for the samples to assume viscous properties. Among the meat raw materials, it can be observed that MSM requires less strain to achieve these properties compared to the other two samples ($P < 0.05$).

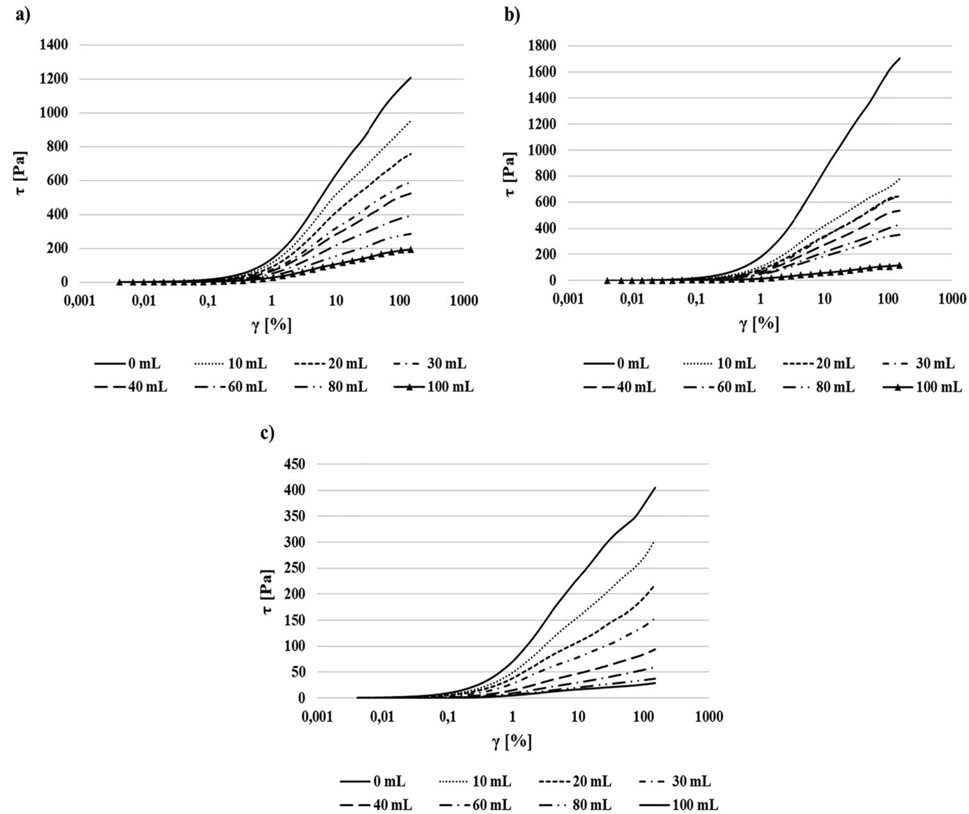

Fig. 12. Shear stress values (τ) of meat pastes containing different amounts of added water as a function of shear strain (γ). (a) minced meat, (b) MDM: Mechanically deboned meat, (c) MSM: Mechanically separated meat

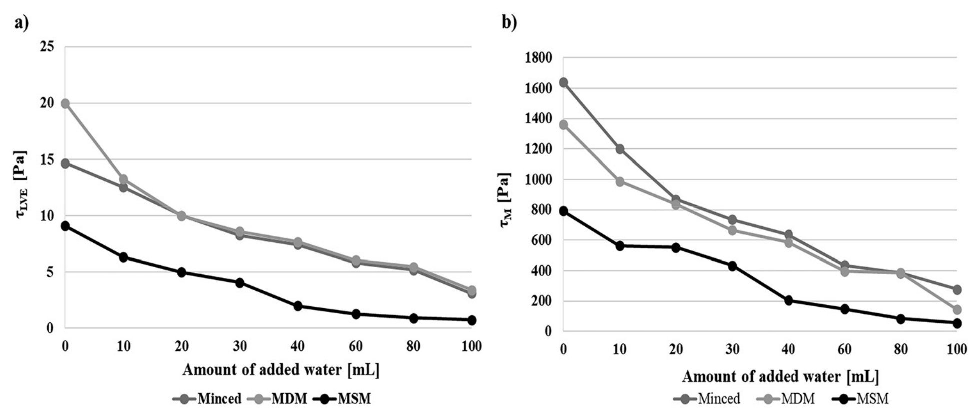

Fig. 13. The values of a) end of linear viscoelastic region (τ_{LVE}), b) yield strength (τ_M) of the prepared meat pastes. MDM: Mechanically deboned meat, MSM: Mechanically separated meat

CONCLUSION

Summarizing our results, it can be stated that MSM differs from whole meat, minced meat and MDM both in the raw state and as a raw material for meat paste. Water activity and pH results are not significantly different from MDM. However, differences in key properties can be detected. In terms of technofunctional properties – water-holding and water-binding capacity –, MSM has worse properties due to high levels of muscle cell destruction. It had higher pressing, cooking and roasting loss compared to the other samples. Electron micrographs of MSM show a complete change in muscle structure compared to minced meat and MDM (cause: high pressure applied). In the case of surface color characteristics, it can be observed that MSM is a lighter, redder and yellower color both in the raw form and in the form of meat paste. You cannot keep these properties stable over time. The rheological properties (e.g. elasticity) of MSM meat paste are less favorable than those of other raw materials. These properties can also occur during the production of meat products occur which needs to be offset e.g. with natural additives or physical effect (high pressure).

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