EFFECT OF STARTER CULTURES AND FREEZE-DRIED PARSNIP ON THE MEAT FERMENTATION PROCESS

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Abstract - Seeking to evaluate the impact of freeze-dried parsnip and different starter cultures on the meat fermentation process, the changes of pH, colour characteristics and pigments content in the meat batters made with 3.0 % of freeze-dried parsnip and different starter cultures during fermentation process were studied. It was determined that incorporation of parsnip and different starter cultures to the meat had positive effect on the fermentation process. At the end of fermentation the pH values of meat batters with parsnip decreased to the 4.93 – 4.97, while, in the case of meat batters without parsnip the pH was in the range of 5.31 – 5.37. There was no significant effect of added parsnip on the redness value a* of meat batters, but due to the light colour of freeze-dried parsnip, it was effect on the lightness and yelowness of the meat batters. The incorporation of parsnip has positive effect on the formation of myoglobin forms (oxymyoglobin, nitrosomyoglobin) responsible for the colour of fermented meat products. Meat batters with freeze-dried parsnip and starter culture containing *S. carnosus*, *S. xylosus* and *P. pentosaceus* were characterised by the lowest metmyoglobin content - 52,99 %, at the end of fermentation process in comparison with other meat batters.

Key Words – parsnip, meat fermentation, pigment

I. INTRODUCTION

The colour of meat muscle depends on the content of myoglobin and the relative content of its forms which are changing during technological process of meat products [1]. Sodium or potassium nitrite is widely used during meat curing because it can react with myoglobin (Mb) to form a characteristic pink colour; contributes to the cured-meat flavour; inhibits unwanted bacteria, particularly *Clostridium botulinum* and delay the development of oxidative rancidity [2, 3]. The chemical reactions leading to the cured meat pigment are a complex series of processes involving microbially, enzymatically and/or chemically catalysed steps, which depend on pH, pigment concentration, redox potential, curing agent distribution, temperature and relative humidity [4]. Because of potential toxicity of nitrite, natural or synthesised alternatives to nitrite or nitrate have been developed. Vegetables are one of the main sources of nitrates; they also contain high amounts of vitamins (especially vitamin C) as well as other compounds with good antioxidative properties. Parsnip (*Pastinaca sativa L.*) contain average amounts of nitrates and is a good source of polyacetylenes such as falcarinol, falcarindiol, panaxydiol and methyl-falcarindioal, B group vitamins, vitamin K and vitamin C [5, 6]. However, no research has been conducted on the utilization of parsnip products as a source for indirect addition of nitrate and nitrite.

One more factor having effect on the colour formation of fermented meat products is the starter cultures containing different amounts of microorganisms with the nitrite and nitrate reduction properties.

The aim of this study was to evaluate the impact of freeze-dried parsnip and different starter cultures on the changes of pH colour and pigments content in the meat during fermentation process.

II. MATERIALS AND METHODS

Lyophilization of vegetables: chopped parsnip roots were frozen at minus 18 ^{o}C temperature. Frozen vegetables were dried using a vacuum of 4.0 mbar, which at the end of drying was reduced to 0.50 mbar. Lyophilized vegetables were crushed to powder-like state.

5 different meat batters (M_1 – M_5) were prepared (Table 1). The chopping of raw materials and mixing of added ingredients were done in a cutter (KILIA, Neumunster, Germany). Samples M_1 and M_2 were treated as control samples made

with different starter cultures; samples M_3 – M_5 were made with freeze-dried parsnip and different starter cultures.

Table 1 Recipe of meat batters, kg

Ingredients	M_1	M_2	M_3	M_4	M_5
Lean pork	9.73	9.73	9.43	9.43	9.43
Salt (NaCl)	0.27	0.27	0.27	0.27	0.27
Freeze-dried parsnip	-	-	0.30	0.30	0.30
S. xylosus and *S. carnosus*.	0.01	-	-	0.01	-
S.carnosus, S.xylosus and P.pentosaceus	-	0.01	-	-	0.01

Meat batters were fermented 4 days in the camber *Ing* Climas CIR 322/HR (Spain) at temperature +24 °C.

pH was measured by placing pH probe N 1048A directly into homogenized samples (WTW 3110 pH-meter, WTW GmbH, Weilheim, Germany). Color was measured by a chroma meter (CR-410 Konica Minolta). NOMb content in the meat batters were determined using the method of Hornsey (1956) [7].

The determination of the proportions of oxymyoglobin, myoglobin, and metmyoglobin in meat samples, was based on the different absorbance spectra of these three molecules. Absorbance measurements were carried out after pigment extraction with Na phosphate buffer (pH 6.8) from meat samples. The proportions (%) of oxymyoglobin, myoglobin, and metmyoglobin were calculated according to Tang (2004), using the following equations [8]:

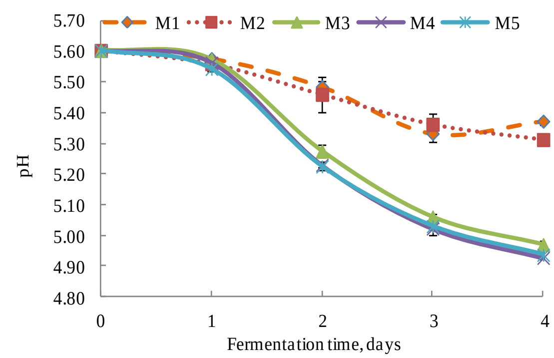
$DeoMb = (-0.543R_1 + 1.594R_2 + 0.552R_3 - 1.329) \times 100$, %
$OxyMb = (0.722R_1 - 1.432R_2 - 1.659R_3 + 2.599) \times 100$, %
$MetMb = (-0.159R_1 - 0.085R_2 + 1.262R_3 - 0.520) \times 100$, %
where: $R_1 = A_{582}/A_{525}$, $R_2 = A_{557}/A_{525}$, $R_3 = A_{503}/A_{525}$

III. RESULTS AND DISCUSSION

pH values of fermented meat products are dependent on the methabolitic activity of microorganisms and the amount of carbohydrates [9].

The decrease of pH values of control samples (M_1 ir M_2) was insignificant ($p < 0.05$) after 4 days of fermentation and were in the range of 5.31 – 5.37 (Fig.1). In the samples made with freeze-dried parsnip the decrease of pH was more intensive and at the end of fermentation the pH values were in the range of 4.93 – 4.97. This difference could be due to the presence of reducing sugars in the added freeze-dried parsnip, which were fermented by starter cultures and natural meat microorganisms to the lactic acid.

Figure 1. Changes of pH value during fermentation of meat batters



It was determined that replacing 3 % of meat proteins by re-hydrated freeze-dried parsnip in the meat batter caused the higher lightness (L* 53.78 – 55.17) and yelowness (b* 14.31 – 14.74) values of meat batters in comparison with control samples (L* 52.05 – 52.35 and b* 12.72 – 13.18). The reason of such difference in the colour of meat batters could be the high value of the lightness of freeze-dried parsnip; L* was 92.30. During fermentation process the lightness of control samples increased insignificantly (L* at the end of process was 53.43 – 53.62), however, L* values of meat batters with the freeze-dried parsnip considerably increased and were in the range of 59.26 – 60.15 at the end of fermentation process. The negative relationship was determined between the values of ligtness and pH. Whereas, D.S. Tsoukalas et al (2011) in their study on the fermented sausages with the addition of freeze-dried leek, presented positive correlation between these values during fermentation [10].

Unlike the lightness, the values of yelowness significantly ($p < 0.05$) decreased during fermentation process in all samples. Similar results were reported by Perez-Alvarez et al. (1999) who found out that b* values of traditional Spanish sausages (without addition of vegetables) decreased during fermentation and ripening of sausages [11]. The decrease of yelowness in fermented meat products is caused by the utilization of oxygen due to the activity of microorganisms as well as by the reduction of oxymyoglobin [12]. At the end of fermentation process the higher b* values were registered in the samples made with the addition of parsnip (b* 10.12 – 10.35), in comparison with control samples (b* 8.33 – 8.52) and was due to the colour of freeze-dried parsnip.

The tendencies of changes of redness were very similar in all the samples of meat batters. The decrease of redness was recorded up to the 3rd day of fermentation and was followed by the increase in a* values; in the case of meat batters with freeze-dried parsnip at the end of fermentation a* values were in the range of 13.69 – 14.36, while, in the control samples a* values reached 15.37 – 16.40. The lower redness of meat batters with freeze-dried parsnip can be explained by quit low a* value of freeze-dried parsnip, which was only 1.94.

Already after the 1st day of fermentation the significant increase in metmyoglobin concentration and decrease in oxymyoglobin concentration was determined in all samples due to the reduction of oxygen content, when formation of metmyoglobin from the oxymyoblobin took place [13]. After 4 days of fermentation of meat batters with *S. xylosus*, *S. carnosus* and *P. pentosaceus*, the amount of metmyoglobin was lower in comparison with meat batters fermented by staphylococci only (Fig. 2).

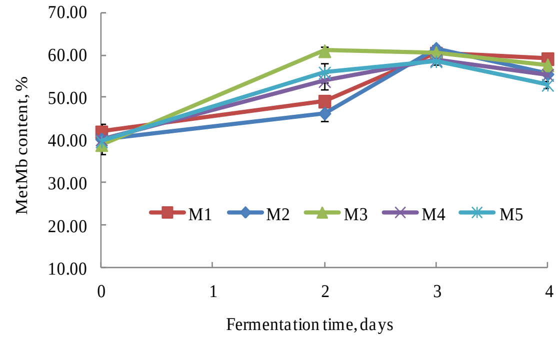
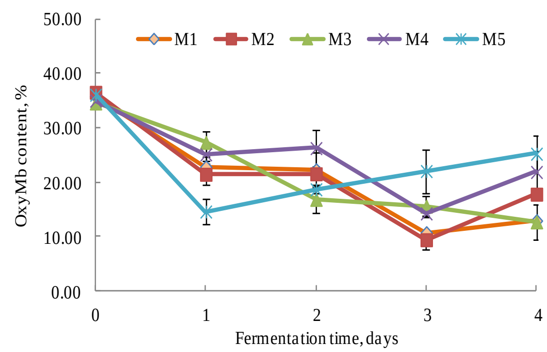


Figure 2. MetMb content in meat batters during fermentation

The lowest metmyoglobin content - 52,99 %, was determined in the sample M5, which contained freeze-dried parsnip and 3 different microorganisms in the starter culture. At the end of fermentation process the amount of brightly red oxymyoglobin was 2 times higher in the samples made with the addition of freeze-dried parsnip and starter cultures (M4 and M5) in comparison with the control sample.

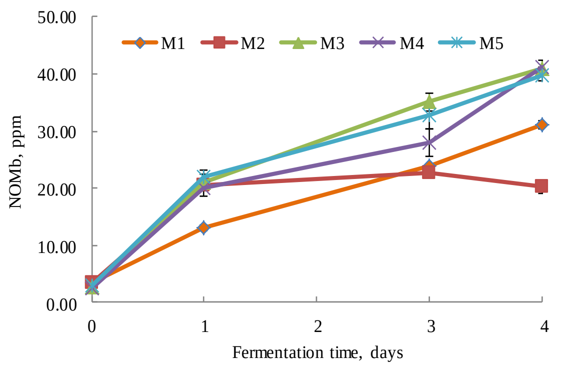
Figure 3. OxyMb content in meat batters during fermentation



The measurements of deoxymyoglobin content in the samples during fermentation process showed that in the samples M_1, M_2 and M_3 its content increased from 19.89 - 20.68 % to 26.85 – 28.07 %. While, in the samples made with the addition of freeze-dried parnsnip and starter cultures (M4 and M5) the decrease of deoxymyoglobin concentration from 21.02 – 21.58 % to 18.50 – 20.43 % was recorded.

The acceleration of formation of nitroso pigments was recorded in all samples after the 1st day of fermentation (Fig. 4). Later, the differences between control samples and those made with freeze-dried parsnip emerged. At the end of the fermentation process the highest amount of nitrosopigments was determined in the samples with freeze-dried parsnip (39.73 – 41.18 ppm), while in the control samples it was in the range of 20.16 – 31.13 ppm. The presence of nitrates in the freeze-dried parsnip could have the impact on such results. Nitrates were converted to the nitrites by the action of starter and natural meat microorganisms and after several intermediate reactions the nitroso myoglobin was formed. More stable and more red colour of meat batters made with the addition of freeze-dried parsnip could be a result of ascorbic acid and the other compounds with antioxidative properties which were added together with freeze-dried parsnip [14].

Figure 4. Amount of cured pigments (NOMb) (ppm) in meat batters during fermentation



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REFERENCES

1. Karamucki, T., Jakubowska, M., Rybarczyk, A. & Gardzielewska, J. (2013). The influence of myoglobin on the colour of minced pork loin. Meat Science 94: 234-238.
2. McClure, B. N., Sebranek, J. G., Kim, Y. H. & Sullivan, G. A. (2011). The effects of lactate on nitrosylmyoglobin formation from nitrite and metmyoglobin in a cured meat system. Food Chemistry 129: 1072-1079.
3. Sindelar, J. J., Terns, M. J., Meyn, E. & Boles, J. A. (2010). Development of a method to manufacture uncured, no-nitrate/nitrite-added whole muscle jerky. Meat Science 86: 298-303.
4. Chasco, J., Lizaso, G., & Beriain, M. J. (1996). Cured colour development during sausage processing. Meat Science 44(3): 203-211.
5. Santamaria, P. Nitrate in vegetables: toxicity, content, intake and EC regulation Review. (2006). Journal of the Science of Food and Agriculture 86:10-17.
6. Zidorn, C., Johrer, K., Ganzera, M., Schubert, B., Sigmund. E., M., Mader, J., Geil, R., Ellmerer, E., P., Stuppner, H., (2005). Polyacetylenes from the Apiceae vegetables, carrot, celery, fennel, parsley and other cytotoxic activities. Journal of Agricultural and Food Chemistry 53: 2518-2523.
7. Hornsey, H. C. (1956). The colour of cooked cured pork. Estimation of nitric oxidehaem. Pigments. Journal of the Science of Food and Agriculture 7: 534-540.
8. Tang, J., Faustman, C., & Hoagland, T. A. (2004). Krzywicki revisited: Equations for spectrophotometric determination of myoglobin redox forms in aqueous meat extracts. Journal of Food Science 69 (9): C717-C720.
9. Farnworth, E. R. (2008). Handbook of fermented functional foods, second edition. New York:CRC Press by Taylor & Francis.
10. Tsoukalas, D.S., Katsanidis, E., Marantidou, S. & Bloukas, J.G. (2011). Effect of freeze-dried leek powder (FDLP) and nitrite level on processing and quality characteristics of fermented sausages. Meat Science 87: 140-145.
11. Perez-Alvarez, J. A., Sayas-Barbera, M. E., Fernendez-Lopez, J. & Aranda-Catala, V. (1999). Physicochemical characteristics of Spanish-type dry-cured sausage. Food Research International 32: 599-607.
12. Hu¨seyin Bozkurt, H., & Bayram, M. (2006). Colour and textural attributes of sucuk during ripening. Meat Science 73(2): 344-350.
13. Bekhit, A.E.D., Faustman, C. (2005). Metmyoglobin reducing activity. Meat Science 71: 407-439.
14. Fernández-Ginés, J. M., Fernández-López, J., Sayas-Barberá, E. & Pérez-Alvarez, J. A. (2005). Meat products as functional foods: a review. Journal of Food Science 70(2): 37-43.