The study of properties of a raw meat product during salting by brines

Irina Kyshenko[1], Oleksandr Donets[1], Yulia Kryzhova[2]

1 - National university of food technology, Kyiv, Ukraine
2 - National university of life and environmental of Ukraine, Kyiv, Ukraine

Keywords:

Meat
Brine
Colour
Pigment
Myoglobin

Article history:

Received 12.05.2014
Received in revised form 17.06.2014
Accepted 30.06.2014

Corresponding author:

Yulia Kryzhova
E-mail:
yuliya.kryzhova@mail.ru

Abstract

Introduction. The mechanism of forming of the coloured descriptions of the model meat systems is investigational with low maintenance of myoglobin on the stage of salting on the change of the coloured descriptions of meat raw material in the process of salting.

Materials and methods. Determination of relative content of myoglobin and its derivatives was performed by reflectivity spectroscopy spectrophotometer SF-18, the total content of pigments - pigments meat first extraction of water, acetone and hydrochloric acid, followed by extraction by photokolorimeter at a wavelength of 540 nm with respect to hydrochloric acid acetone; color intensity - the photoelectric KF-77 at a wavelength of 540 nm against distilled, the determination and colored integral characteristics - Cary 50 spectrophotometer.

Results and discussion. The expediency of using technology-based dyes of meat preparations hemoglobin slaughtered animals Vepro 70 Col R Red Apro and as components of multi brine for color correction ham products with high injection and with different levels of myoglobin in the meat raw. Rational drug concentrations of hemoglobin (Vepro 70 Col P and Apro Red) color for meat with a fat content of 10% was respectively 0.5% and 0.6%, while the use of 0.05% Sodium Erythorbate and 0.006% sodium nitrite.

Conclusions. The results recommended for modern production technologies ham products using intensification methods of salting.

Introduction

The development of new and improvement of existing technologies, improvement of manufactured products quality, namely, the exclusion of the using or minimizing various toxic substances is an urgent problem in a meat-processing industry.

Creation of cured-meat products with a high level of safety needs improving some core processes of production using some intensive cost-effective ways to influence the feedstock. In this regard, it is necessary to study the question of colour-correcting of whole muscle meat products of a high level injection, using some intensive methods of salting in combination with colour-correcting components of multicomponent brines. However, the analysis of the Ukrainian meat market shows that there are a lot of cured-meat products with the salt-brine level of 60% and 80% 'economy class' among them, in meat formula of which there are connective animal albumens and food hydrocolloids, i.e. the proportion of without myoglobine raw materials, contained in the finished product, exceeds 15 – 20%. During colour correcting of such products, as the results of research and practical experience have shown, staining power of sodium nitrite is not enough to produce the traditional red-pink colour. In this regard, it is appropriate to search for mixture with a more expressive red-pink variety, which would provide an opportunity to obtain the desired colour for products with a high level of the brine system injection in dependence to quantitative scope of hemoglobin.

There are almost always some contradictions as for the use of sodium nitrite salting process. Europe may introduce a ban on its use and we are, the Ukrainians, also can get rid of it. To do such step is easy, but what nitrite will be replaced is a rather complex issue. The list of colouring substances, that are allowed by the Ukrainian Government, for using them as food colouring additives, has more than 30 namings. But most of them can not be used in the manufacture of meat products for a number of reasons. Firstly, the colourant formation of model meat system is outlying for this type of sausage or meat products. Secondly, this is instability of colourant properties in the process of meat production.

The aim of the pilot experiment was to investigate the mechanism of formation of the coloured meat characteristics models with low myoglobin at the stage of curing with the inclusion to the feature-rich brine colloidal systems some nitrite salts instead of sodium nitrite and natural colourants (Apro Red and Vepro 70 Col P ('Viadi' company, the Netherlands), to change coloured characteristics of the raw meat products during salting.

In accordance with the objectives and tasks of the scientific paper, there has been studied the characteristics of the formation of the coloured raw meat products during salting using nitrite salts composed of multifunctional brine in an amount that is an equivalent to the content of sodium nitrite (20 g per 100 l), that in conversion is 3.5 % of nitrite salts to the mass of brine. Insufficient amount of salt was supplemented by vacuum, as it has a higher degree of sodium chloride (99.84%), while a small amount of insolubles, compared with unrefined type of food salt (rocksalt, deposited salt, solar salt).

Materials and methods

The object of the study was a longitudinal muscle of the back (L. Dorsi), which was obtained from the cooled lean beef of the 2nd category fatness with the autolysis period of 48 hours, pH 6.2 ± 0.01, weight pieces – 300 g. Drinking tap water (pH 7.8-8.0) was used for the brine preparation. The prepared raw product was injected by single-needle syringe by staggered scheme with a step 2.5×10-3m of different brines composition (Table 1).

Table 1

Brine composition for injection

Title	Components amount, a kilo for 100 l of brine		
	brine 1 (control)	brine 2	brine 3
Sodium nitrite	0.02	-	
Nitrite salt		3.5	3.5
Vacuum salt	7	3.5	3.5
Sodium tripoly phosphate	0.30	0.30	
Phosphates (E450iii, E 451i)			0.30
Water	92.68	92.70	92.70
Total brine	100	100	100

According to the traditional technology, sodium nitrite was brought in at the rate of 20 g per 100 l of the brine. In the process of 80% introduction of the brine into the mass of unsalted raw nitrite, the concentration will be 0.016 g per 1 kg of raw meat. According to the technological instructions for using nitrite salt of 'DANSK SALT A/S' company (Denmark), for producing the whole muscle chopped products, it is used as a part of the brine in an amount 5.4% (for the same amount of the brine). Taking into account, that 100 g of nitrite salts contains 0.57 g of NaNO2, the amount of sodium nitrite is 30.78 g per 100 liters of the brine (0.12 g per 1 kg of raw products). With account of the presence of nitrites in the raw products, the entering of such a high number of them is a key problem due to toxicity and the possibility of carcinogenic nitrosamines formation.

In the process of the salted meat products a specail attention is paid to the temperature, as one of the main factor of the quality products. In the process of chopped meat products the temperature in raw muscle thickness was 4 °C, the base brine temperature was in the range between 0 ... 2 °C, which was achieved by the addition some ice in the brine. After the injection with the aim of substances perequation for salting the whole volume of a piece, the raw product was subjected to cyclic by the scheme that was proposed by A. A Borisenko and others [8]. Salted raw massaging was carried out in the following, selected by us, a reasonable program (15 min – rotation, 15 min – pause (6 rotations per minute), the depth of the vacuum massager at least 90%. The duration of the raw meat beef massaging process was 6 hours.

In order to explore the possibility of using colourants as the part of the multicomponet brines with the level more than 80%, and using as the part of the brines of connective tissue proteins and food hydrocolloids for amplification of the pink part of the spectrum, on the next phase of the research we studied the properties of the natural colourant on the base of animals' blood hemoglobin. As the objects we selected: natural, based on blood hemoglobin of slaughtered animals, colourant – Red Apro ('TEHRRO', Russia), Vepro 70 Col P ('Viadi' company, the Netherlands). The working range of concentrations for these substances has been selected in accordance with the recommendations of technological companies-manufacturers.

Based on the results of the study of the composition and main physical and chemical characteristics of hemoglobin preparations (Vepro 70 Col P, Apro Red), which showed the principal possibility of their use as components of multicomponent brines, there were carried out some simulations, the aim of which was to determine the environmental conditions that are optimal for the manifestation of the colouring effect of the selected colourants in the spectrum, which corresponds to a consumer's image about the colourant of the whole muscle meat products. Taking into account, that in the molecules of

hemoglobin or myoglobin as prostatic groups protoporphyrin IV is included, the formation of the red nitric oxide pigment is the same. Myoglobin goes into combination of red when interacting with the nitric oxide, and the rate of the reaction and the mass fraction of pigment formed depends on the amount of myoglobin content of metallic molds and oxidation-reduction potential of the system. In this regard, some analytical and experimental selections and justification of the required number of the nitrite salts and reducing substances were conducted.

It is known, that nitrous acid, which is formed during the hydrolysis of sodium nitrite, while absence in the environment and reducing agent and oxidizing agent, is decomposed into oxide and nitrogen dioxide, so along with the nitric oxide pigment appear metpihmenty [9]. Therefore, as a reducing reagent, we have used dietary supplements traditionally used to a more equal colourant of meat and maximum utilization of the nitrite in the process of the colour formation and colour stabilizing of the raw meat product – food acids and their salts (ascorbic acid, sodium askorbinat, sodium erythorbate, citric acid) and sugars (sucrose, glucose, maltose, dextrose, lactose), intermediate products of anaerobic decomposition of which are formed by the enzyme of bacteria, which have a significant reducing effect. Glucose has better regenerative properties than sucrose, but quickly involved in oxidative transformations, thus it should be used only at the short-term salting. At the high-temperature of processing glucose enters into Mayer's reaction with amino groups of protein, which negatively reflected on the nutritive value and the colour of the product [9].

As the maximum concentrations of these components some standarts of their layings using the nitrite salting were selected (sodium nitrite – $\leq$ 5 mg%, food acids – <5%, sugar – <1.5%), which were gradually decreased to determine the rational conditions for the formation of reaction of the nitric oxide pigments with maximum involvement of hemoglobin. During the studies the type and the value of the reductant were varied in the system. In assessing of the compositions effectiveness, which are created as the model systems, there were used gels and emulsions based on protein products of animal origin ProGel C-95. The colour assessment in the first stage was carried out visually.

The determination of relative content of myoglobin and its derivatives was performed by the method of reflectiving spectroscopy with the help of the SF-18 spectrophotometer.

The content of total pigments was determined by the common method that is based on the meat extraction, first by water and then by muriatic acetone, followed by photocolourimetry at a wavelength of 540 nm with regard to muriatic acetone.

The colorfastness was found out by determining the optical density of the nitric oxide pigment extracts before and after exposure of the product in the light.

The colour intensity of model systems was determined by KF-77 photoelectric spectrophotomete at a wavelength of 540 nm with respect to the distillate.

The definition of spectra and integral coloured characteristics was performed on a Cary 50 spectrophotometer.

The content of nitric oxide pigment was determined by nitric oxide pigment extraction with aqueous acetone followed by further determination of the optical density of the solution on a spectrophotometer at a wavelength of 540 nm with regard to 80% of aqueous acetone.

Results and discussion

Literature data analysis [1, 2, 3, 4, 5, 6, 7] and our own experimental studies revealed that the formation of the meat colouration begins during the process of salting. The reaction of nitric oxide pigment occurs intensely at pH 5.5-6.0. At more than pH 6.0 of the meat, the nitric oxide pigment reaction reaction (NOMb) runs at a slower speed. However, the lowering of the pH of the meat does not provide the maximum manifestation of functional and technological properties of muscle proteins and stability NOMb, which was formed – it is more stable at high pH values [2, 5, 9]. Significant influence on the meat colouration has the temperature. During the process of the traditional salting and cold smoking, 40 – 50% of the nitric oxide pigment NOMb is formed.

The experimental data analysis about the effect of multicomponent brines with high pH on the formation of coloured characteristics of the raw meat product during the salting (Table 2) indicates that the use of nitrite salts leads to more intense nitric oxide pigment formation and, consequently, to a smaller residual nitrite content in the product. After machine processing the content of nitric oxide pigment for the control sample corresponds 42.13% (Table 2).

Table 2

The influence of multicomponent brine composition on nitric formation in the beef after meat tumbling process

Sample title	General pigment, optical depth	Composition of NO-pigment, % to general pigment	Amount of remained nitrite
Brine 1 (control)	0.460	42.13	6.22
Brine 2	0.580	47.53	6.08
Brine 3	0.610	48.12	5.78
	mcp= ± 0.054	mcp= ± 0.20	mcp= ± 0.05

The introduction to the composition of ingredients for the nitrite salt pickling nitrite, upon obtaining of which the nitrite sprayed in crystals, promotes their more rapid enrichment in the test items (11.4 – 12.4%) compared with controls. However, the using as a part of selected phosphate of the brine mixture it was marked maximum amount – 48.12%. The studies confirm that the increase in the intensity and colour stability under the influence of the multicomponent brines with high pH is due to the creation of reducing conditions in the meat system, which prevent or delay the metmyoglobin formation. This is due to the ability of phosphate mixture to influence on reducing activity of oxidative enzymes. The described effect is confirmed by A. A. Borysenko's studies [1].

The raised level of the nitric oxide pigment improves the interaction of myoglobine with the nitrite, causing the reducing of its residual amount. With the same initial injection level of sodium nitrite in the all samples (10 mg % by weight of raw material meat product) its reducing proceeded at different rates: in the control to 6.22 mg/100g of the product, in the sample under investigation, which containied the nitrite salt, in equal conditions there was a rapid transformation of the nitrite: its residual amount after salting reached 6.08 mg/100g. However, using for the preparation of the brine along with the nitrite salt phosphate mixture (E450iii, E451li), the minimum rate is 5.78 mg/100 g in the test piece. Thus, using for salting in the brine composition of multicomponent nitrite salt instead of nitrite sodium linked with the mechanical processing of the raw meat product not only

speeds the process up of fixing a stable colour, but also can reduce the residual content of sodium nitrite in the product.

The obtained data, pH and 'general hemoglobin content' are shown in Table 3. All these indicate that the pH of experimental drugs for hemoglobin is: Apro Red – 5.84 and Vepro 70 Col – 6.0. Taking into account, that the pH level of the model meat systems, for colourant stabilizing of which is proposed to use these colourants, the last stage of the salting should make 6.2 ... 6.4, we can assume, that the use of colourant Apro Red and Vepro 70 Col P their colouring ability will not be fully reflected, because of the shift in pH of 0.6 units and 0.4 units, respectively.

Table 3

Key physical-chemical characteristics of the colourants on the blood pigment basis

Colourant title	pH (m±0,05)	Deliquescence, %, (m±3,5)	Mass fraction 'general hemoglobine', %,
Apro Red	5.84	45.0	81.0
Vepro 70 Col P Brine 2	6.00	75.0	76.0

A high content of researched colourants (80%) of 'total hemoglobin', which is the second pigment, that corresponds along with the mioglobine for the colour formation process in the raw meat product, indicates about a potential opportunity of the efficient using of hemoglobin to provide the required red-pink colour for model meat systems with high levels of injection and changes in levels of myoglobin in the composition of model meat systems. Taking into account that the met-form of blood pigment that gives the finished product a brownish-gray colour, has low solubility, the presence of high levels of solubility in the experimental preparations suggests that the stock Vepro Col 70 contains a small number of metmyoglobin.

The discussion about data, presented above, shows a high potential of hemoglobin drugs (Vepro 70 Col P and Apro Red) with their possible use as colourants of red and pink range. However, for the manifestation of their colouring properties, it is necessary to make a purposeful choice of additional ingredients, their concentrations and ratios, which allow preventing the oxidation and destruction of the hemoglobin molecule, and can contribute to the formation of the nitric oxide pigment.

The results of initial studies indicate that the most suitable colour can be seen when making 0.3 – 0.4% of blood pigment colourants (Vepro 70 Col P) in the presence of the nitrite salt (0.001 – 0.006%).

For gels and protein-fat emulsions in a ratio of protein preparation:fat:water – 1:20:10 obtaining of the pink colour provides a composition containing pigment blood colourants (Vepro 70 Col P, Apro Red), sodium nitrite (nitrite salt) and isoascorbate Na (1:0,01:0,1; 1:0,01:0,12 respectively) when the number of input 0.5% and 0.6% by weight of the system. The correlation that facilitates effective manifestation of the properties of selected blood pigment colourants, there was successfully tested in the laboratory for modifying the colour of protein suspensions, gels and meat model systems.

At the final stage of the simulation there were performed some spectrophotometric analysis (Table 4) of aqueous solutions colourants Vepro 70 Col P and Apro Red and protein-fat emulsion-based animal protein ProGel C-95 + Vepro 75, which was painted with their help.

The spectral characteristics of solutions and emulsions showed that Vepro 70 Col P awards Red Apro for 'lightness', which at the background of low rate of 'redness' results to a light yellow-brown solution.

Table 4

Spectral characteristics of food coloured solvent and coloured model meat systems

№ п/п	Colourant title	Concentration, %	Colour coordinates CIELab		
			L (lightness)	a (redness)	b (yellowness)
Solutions					
1	Vepro 70 Col P	0.5	23.18	24.97	29.99
2	Apro Red	0.5	50.39	2.70	33.40
Emulsions					
3	Vepro 70 Col P	0.3	67.93	5.20	16.00
4	Apro red	0.3	77.99	2.32	16.80
5	Vepro 70 Col P	0.6	61.45	5.41	16.14
6	Apro Red	0.9	68.59	4.85	17.94

During the spectrophotometric estimation of the protein and fat emulsion, which was coloured with the help of the studied colourants, the analysis of the results showed that the dosage of colourants in the amount of 0.3% was the most appropriate colour system containing Vepro 70 Col P for which exactly this concentration was defined as the rational one during the sensory research. Using this concentration resulted to getting systems which are characterized by a very high rate of 'lightness' and 'yellowness' and a low value of 'redness'. Therefore, experiments were carried out with increasing content Vepro 70 Col P to 0.6%, and Apro Red to 0.9%, which made it possible to adjust the color emulsions.

Thus, the results of spectrophotometric studies allowed to conclude that the most significant colour correction effect in shaping the pink-red hue of the model emulsions has Vepro 70 Col P. Based on these data we can conclude that, although the blood pigment colourants are not significant in buffering capacity in the acidic conditions, they are able to make a stabilizing effect on the pH of alkaline systems, which includes multi brines for injection of the raw meat product.

Conclusions

- The results of the model studies allow to predict that for practical use in technology-based colourants of meat preparations on the base of drug blood hemoglobin of slaughtered animals Vepro 70 Col P and Apro Red by their physical and chemical characteristics, they can be recommended as a multifunctional brine for colour correction products of chopped products with high levels of injection and with different levels of myoglobin in the meat system that can be designed to provide the inherent colour for hams of an 'economy group', which include without myoglobine raw product.
- The using of nitrite salts instead of the traditional sodium nitrite leads to more nitric oxide pigment, which leads to obtain a finished product with a lower content of residual nitrite and better colour performance than in the equivalent administered sodium nitrite.

- Justified and defined the rational drug concentration of hemoglobin (Vepro 70 Col P and Apro Red) for colouring the meat of a fat content to 10%, which was respectively 0.5% and 0.6%, while the use of 0.05% isoascorbate Na and 0.006% of sodium nitrite, which are for colour correction of the salty products with different levels myoglobineless materials.

References

1. Borisenko L.A. (2004), *Intensifikacija processov posola mjasnyh solenyh izdelij*, Stavropol'.
2. Vedernikova I.V. (2004), *Razrabotka cvetoobrazujushhih kompozicij na osnove preparata gemoglobina, PhD Thesis*, Moscow.
3. Kas'janov G.I. (2000), Teoriticheskie osnovy formirovanija cvetovyh harakteristik mjasnyh pashtetov, *Izvestija vuzov. Pishhevaja promyshlennost'*, 4, pp. 24-28.
4. Mokeeva A.N. (2001), Krasiteli iz prirodnogo syr'ja dlja uluchshenija cveta i kachestva produktov pitanija, *Pishhevye ingredienty. Syr'e i dobavki*, 1, pp. 18 – 19.
5. Nechaev A.P. (2001), *Pishhevaja himija*, Sankt-Peterburg.
6. Popovich N.A. (2002), K ocenke opasnosti primenenija sinteticheskih pishhevyh krasitelej, *Sovremennye problemy toksikologii*, 2. pp. 11 – 13.
7. Cofrades S. (2000), Plazma protein and soy fiber content effect on bologna sausage properties as influenced by fet level, *Journal of Food Science*, 65(2), pp. 281 – 287.
8. Padro-Gonzalez J.E., Perez-Sempere Matarredonna J., Alvarruiz-Bermejo (2000), Quality control in the meat industry: Application of the HACCP system in the manufacturing line of fresh sausages, *Food Technology: Process and package*, 19, pp. 21 – 27.
9. Feiner G. (2006), *Meat products handbook, Practical science and technology*, CRC Press, Washington.
10. Suman S.P., Joseph P. (2014), *Chemical and physical characteristics of meat | Color and Pigment, Encyclopedia of Meat Sciences (Second Edition)*, pp. 244-251.
11. Shahidi F.,. Samaranayaka A.G.P, Pegg R.B. (2014), Curing | Brine Curing of Meat, *Encyclopedia of Meat Sciences (Second Edition)*, pp. 416-424
12. Krause B.L., Sebranek J.G., Rust R.E., Mendonca A. (2011), Incubation of curing brines for the production of ready-to-eat, uncured, no-nitrite-or-nitrate-added, ground, cooked and sliced ham, *Meat Science*, 89, pp. 507-513.
13. Sun W.Q., Zhou G.H.,. Xu X.L, Peng Z.Q. (2009), Studies on the structure and oxidation properties of extracted cooked cured meat pigment by four spectra, *Food Chemistry*, 115(2), pp. 596-601.
14. Budnik N.V., Korovina M.V., Gagach I.I. (2014), Analysis of turkey as a raw material for use in the development of the formulation of meat products, *Journal of Food and Packaging Science, Technique and Technologies*, 3(4), pp. 20-23.
15. Cristina Popovici (2013), Soxhlet extraction and characterisation of natural compounds from walnut (Juglans regia L.) by-products, *Ukrainian Food Journal*, 2(3), pp. 328-336.
16. Aliño M., Grau R., A. Fernández-Sánchez, A. Arnold, J.M. Barat (2010), Influence of brine concentration on swelling pressure of pork meat throughout salting, *Meat Science*, 86(3), pp. 600-606.
17. Iryna Shtyk, Tetiana Ivanova, Olena Didiuk (2013), High-quality indexes and biological value of meat of wild zoons, *Ukrainian Food Journal*, 2(2), pp. 157-162
18. Youling L. Xiong (2005), Role of myofibrillar proteins in water-binding in brine-enhanced meats, *Food Research International*, 38(3), pp. 281-287.
19. Mykola Golovko, Maksym Serik, Tetiana Golovko, Valentyn Polupan (2014), Micro structural characteristics of minced meat products from use of protein-mineral additive, *Ukrainian Food Journal*, 3(2), pp. 243.