Journal of Agricultural Sciences
Vol. 49, No 2, 2004
Pages 193-203

UDC: 637.56:62.404.8
Original scientific paper

EXAMINATION OF SOME FUNCTIONAL PROPERTIES OF SILVER CARP (*HYPOPHTHALMICHTHYS MOLITRIX VAL.*) AND CARP (*CYPRINUS CARPIO LIN.*) MEAT

D. Živković[1], V. Perić [1] and Marija Perunović[1]

Abstract: Waterbinding ability (WBA), held water (HW) and gel-forming properties of silver carp (*Hypophthalmichthys molitrix Val.*) and carp (*Cyprinus carpio Lin.*) meat were examined in this paper. Two variants of fish meat gels: A with 50% of meat and B with 60% of meat were examined at temperatures: 70, 75, 80, 85 and 90 °C.

The variant A of silver carp meat gels has shown the maximum of WBA and HW at 80 °C, and the variant B at 75 °C. In both variants of carp meat gels slow increase of WBA and HW with rise of temperature to 80°C was established. Silver carp meat gels have had better WBA than control gels (beef and poultry meat), and carp meat gels have better HW, but somewhat worse WBA than control gels.

In gels of variant A of silver carp meat the highest module of elasticity (6.862 N/cm^2) was found at thermal treatment at 85 °C, but statistically significant differences in relation to other temperatures were not established. In variant B, with the rise of temperature, the module of elasticity increases; statistically significant differences were established among gels treated at 70 °C and others. Differences between variants A and B were statistically significant at all examined temperatures. Meat gels of silver carp have significantly lower module of elasticity compared to control gels.

Under conditions of our experiment the module of elasticity of carp meat was below measuring limit.

Key words: silver carp meat, carp meat, waterbinding ability, held water, gelling ability (module of elasticity).

---

[1] Dušan Živković, PhD, Assistant Professor, Vladimir Perić, PhD, Professor, Marija Perunović, M.Sc., Assistant Lecturer, Faculty of Agriculture, 11081 Belgrade-Zemun, Nemanjina 6, Serbia and Montenegro

The investigation is a part of the project BTN 0701 financed by the Ministry of Science, Technologies and Development of the Republic of Serbia.

Introduction

Non-conventional technological processes in fish processing are becoming increasingly present thanks to the possibilities they offer, in respect of assortment and rational (economical) usage of raw material, and they are based on minced fish meat or surimi as a raw material (Schubring et al., 1993).

The texture of final product is obtained by heat denaturation and formation of three-dimensional protein gel net.

Rheological characteristic and quality of final product are determined by functional characteristics of raw material, (Kim et al., 1986), and it is possible to improve them with additives, and/or by conditions of heat treatment, (Hamann et al., 1990).

Waterbinding ability, as meat basic functional property and rheological properties of protein gels (strength and elasticity) are closely related , and they are in the function of type and concentration of protein, temperature and time of heating, concentration of NaCl, pH, and ionic strength of the system (Anne-Marie Hermansson,1982; Hickson et al., 1982).

Fish meat functional properties are determined by quantity and state of myosine and they can significantly differ among each fish species (French et al.,1988; Živković, 2002).

Instability of myosin, in vivo and post mortem, influences functional characteristics of fish meat and final product quality too. (Crupkin et al., 1988; Bechtel and Parish, 1983).

A serious problem related to fish meat gels texture is caused by a group of heat-activated muscle proteinases which bring about texture degradation called the “modori” phenomenon. Kinoshita et al., (1990), and Toyohara et al., (1990) quoted four, for the time being, known proteinases at temperatures of 50^{o} and 60^{o}C, respectively.

Materials and Methods

Silver carp (*Hypophthalmichthys molitrix Val.*) and carp (*Cyprinus carpio Lin.*) meat was used for this investigation. Average fish mass was between 2 and 4 kg. Fishes were kept in a refrigerator (+4 ^{o}C) till slaughtering.

Slaughtering and preliminary processing were done 6 to 8 hours after catch, in a usual way (scales were removed and carcass was gutted, washed and drained). After filleting and skinning meat was ground through a Ø 4 mm end plate. Beef and poultry meat, used as control variants, were also ground through a Ø 4 mm end plate. Samples were homogenized, packed in polyethylene bags and frozen at -18 ^{o}C.

Homogenates were prepared in a laboratory blender from frozen meat (around -4^{0}C), cooled water (4 ^{o}C), common salt and polyphosphate preparation

Tari K2 (Giulini Chemie, GMBH). Samples homogenization was done at the speed of 3000 rpm, until the temperature of 11^{0}C was attained.

Prepared homogenates were carried in glass tubes Ø 30 mm and thermally treated during 30 min at the following temperatures : 70, 75, 80, 85 i 90^{o}C. After heat treatment the obtained gels were kept in a refrigerator (4^{o}C) over night.

Variant A of homogenates (gels) in the ratio of meat: water + additives - 50:50 was prepared of 160 g meat, 150g water, 9.6g common salt and 0.96g polyphosphate preparation. Variant B of homogenates (gels) in the ratio of meat: water + additives - 60:40 was prepared of 160g meat, 98.2g water, 9.6g common salt and 0.96g polyphosphate preparation.

Elasticity of cylinders (base diameter 11 mm and height 10 mm), cut out from cooled gels was measured with Hőepler consistometar at load axle of 250g.

Elasticity (module of elasticity) – E was calculated by using the following formula:

$$E = \frac{P x\ h}{V} (N/cm^2)$$

P- load (N)
h – height of cutout (cm)
V – measured shortening (cm)

Waterbinding ability was determined as held water according to the method of Foegeding and Ramsey (1986):

$$\text{g held water per g dry matter} = \frac{\text{(total water in a sample)} - \text{(free water in a sample)}}{\text{(dry matter in a sample)}}$$

The analyses of basic chemical composition as well as the analyses of water content and dry matter content in gels were carried out by the following methods:

- water content JUS ISO 1442
- protein content JUS ISO 937
- total fat content JUS ISO 1443
- total ash content JUS ISO 936

The obtained results were analyzed statistically using Student t- test, in program ANOVA-MANOVA, Stat. Soft. Inc 1995., Microsoft.

Results and Discussion

The results of chemical composition examination of silver carp and carp meat presented in figs. 1 and 2 showed very significant differences, especially in protein and lipid content. Protein content in silver carp meat was 28% higher than in carp meat, and lipid content was 380% higher in carp meat than in silver carp meat. These differences in chemical composition are consequences of a marked influence of species (Sidvell at al., 1974; Iwasaki et Harada, 1985).

Waterbinding ability of silver carp meat gels, expressed as % of separated water, is presented in graph 1. With an increase of temperature from 70^{o} to 75^{o}C, % of separated water decreases. Gels of variant B had the lowest % of separated water just at the temperature of 75^{o}C, and then with the increase of temperature opposite reaction was noticed. In variant A % of separated water decreased to the temperature of 80^{o}C and then had a similar tendency as variant B. Almost the same trend was ascertained by Anne-Marie Hermansson and Mara Lusicano (1982) for beef plasma gels. In relation to control gels produced of beef meat (both variants) and variant A of poultry meat, both variants of silver carp meat gels had significantly lower % of separated water, namely higher WBA. Water-binding ability of variant B of poultry meat gels was the best concerning that % of separated water was the lowest (10.49%).

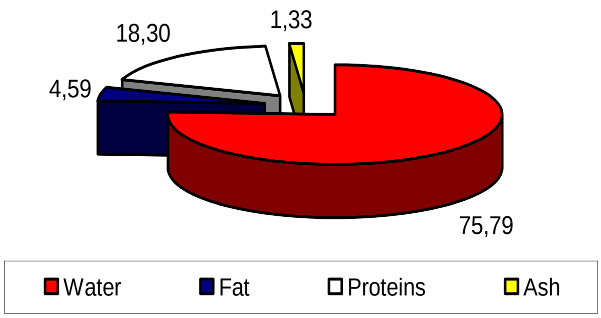


Fig. 1.- Chemical composition of silver carp meat (%)

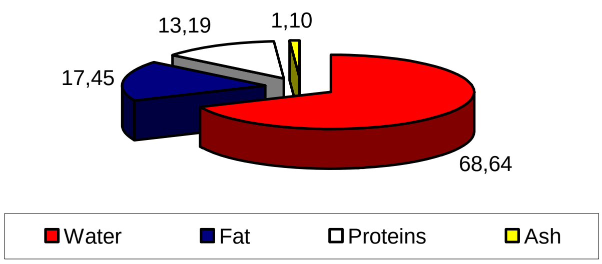
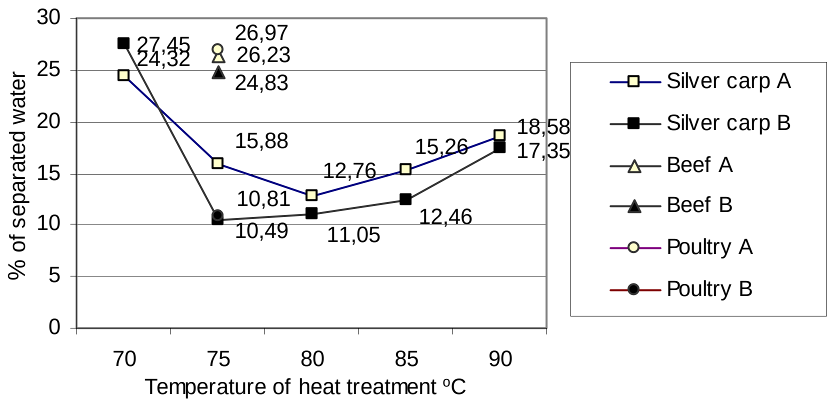
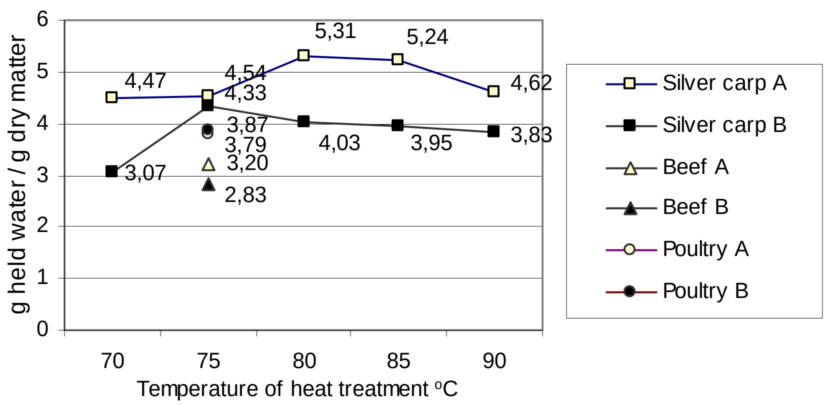


Fig. 2.- Chemical composition of carp meat (%)

Silver carp meat gels held water better then control gels, especially compared to beef meat gels (graph 2). In variant A of silver carp meat, HW slightly increases in the interval of 70 – 75°C, and then more intensively at 80°C. At cited temperature, 1 g of dry mater binds 5.31 g of water, which is the highest value established for silver carp meat. With further increase of temperature HW decreases. In variant B of silver carp meat gels, HW increases 41% with the rise of temperature from 70 to 75°C, but it is somewhat lower than in variant A at the same temperature. With further increase of temperature during heat treatment, HW slightly and steadily decreases. This occurrence of inferior functionality related to WBA in gels with higher protein content (variant B) at temperatures higher than temperatures of gelation, Anne-Marie Hermansson and Mara Lucisano (1982) explained by very strong protein-protein interaction which caused ruptures and pressing out of water from gel.



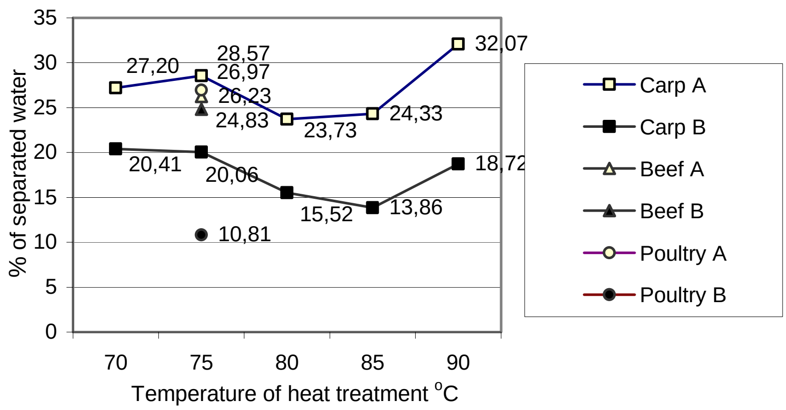
Graph. 1. - Water binding ability of silver carp meat (by Foegeding and Ramsey)



Graph. 2. - Held water ability of silver carp meat (by Foegeding and Ramsey)

Regarding the results presented in graph. 3, it can be seen that carp meat gels had the best water binding ability at temperature interval between 80 and 85 °C, which is for about ten degrees higher than temperatures at which the best WBA was obtained for silver carp meat. This trend could be explained by somewhat shorter period of exposition of mentioned gels (treated at 80 and 85°C) to temperatures between 50 and 60°C, at which modori inducing proteinases (MIP) are activated. Hamman et al. (1990) cited this possibility and accented the activity of MIP, especially in carp meat. Carp meat gels of variant A show lower water binding ability than control gels. However, it can be concluded that variant A of carp meat gels generally had very good water binding ability. Only variant B of poultry meat was superior over variant B of carp meat.

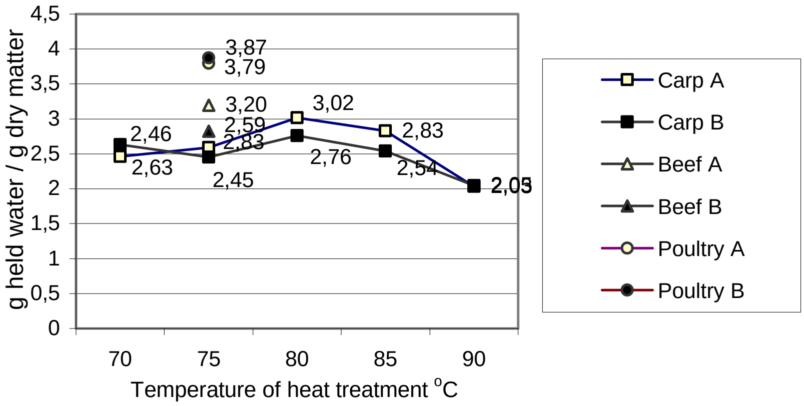
The results for held water ability presented in graph. 4 also point out that optimal temperature of heat treatment of fish meat gels was 80 °C. It was noticed that significantly lower held water ability of carp meat (2.03 to 3.02 g held water/g dry mater) in relation to silver carp meat (3.07 to 5.31 g held water/g dry mater). This difference was probably not only the consequence of negative protein/water ratio in carp meat, but also the consequence of decrease of protein functionality. The results of gel elasticity examination pointed to this assumption. The elasticity of all carp meat gels variants were low and below the measuring border of the instrument.



Graph. 3. - Water binding ability of carp meat (by Foegeding and Ramsey)

The results of silver carp meat gels elasticity examination are presented in table 1. Both variants of gels (A and B) had a low module of elasticity at the temperature of 70°C, (gels A were not measurable), which pointed out that temperature of gelation of this type of meat protein is somewhat higher (about

75°C). At temperature interval, from 75 to 90 °C, in variant A similar values of E were established, and the existing differences were not get statistically confirmation of significance.



Graph. 4.- Held water ability of carp meat (by Foegeding and Ramsey)

It variant B statistically significant difference was established ($P<0.01$) between gel elasticity treated at 70 °C, and others.

Gel elasticity of variant B is significantly higher ($P<0.05$ and $P<0.01$) than gel elasticity of variant A treated at the same temperature.

T a b. 1.- Influence of temperature of heat treatment and composition on elasticity of silver carp meat gels (module of elasticity E - N/cm^2)

	70°C	75°C	80°C	85°C	90°C
Gels A	-	6.345^{c}	6.197^{d}	6.862^{c}	6.001^{d}
Gels B	5.800^{a}	8.161^{bc}	8.766^{bd}	8.749^{bc}	8.739^{bd}

$^{a\ b}$ Means in the same row with different superscript are significantly different ($P<0.01$, d.f.= 8)
^{c} Means in the same column with the same superscript are significantly different ($P<0.05$, d.f.= 8)
^{d} Means in the same column with the same superscript are significantly different ($P<0.01$, d.f.= 8).

Comparison of the results for elasticity of silver carp meat gels and control gels, presented in table 2, shows significantly better rheological characteristics of control gels than silver carp meat gels and similar data reported by H a m a n n at al. (1990). However, if we compare variant B of fish meat gels and variant A of control gels, we can state very similar or even better characteristic of fish meat gels. These results lead to the conclusion that silver carp meat, with little increase of protein concentration, can be successfully used for obtaining a meat system or meat emulsion.

T a b. 2.- Elasticity of meat gels, depending of raw material composition*

	Silver carp meat	Beef meat	Poultry meat
Gels A	6.345^{a}	8.666^{b}	7.657^{b}
Gels B	8.161^{c}	12.588^{d}	13.134^{d}

[a b] Means in the same row with different superscript are significantly different (P<0.01, d.f.= 8)
[c d] Means in the same row with different superscript are significantly different (P<0.05, d.f.= 8
* temperature of heat treatment, t = 75°C

C o n c l u s i o n

Silver carp meat is characterized by exceptional waterbinding ability, even better than that of beef and poultry meat. The best water binding ability was established at temperature interval from 75° to 85 °C.

Silver carp meat gel-forming ability and gel elasticity were also very good, but somewhat inferior to gel-forming ability and gel elasticity of control gels.

Silver carp meat, with little increase of protein concentration, can be successfully used for obtaining a meat system or meat emulsion.

Carp meat had good waterbinding ability, but somewhat worse than water binding ability of beef and poultry meat.

Carp meat gels elasticity was very low, which makes this meat inferior to silver carp meat.

R E F E R E N C E S

1. ANOVA-MANOVA, Stat.Soft. inc 1995., Microsoft.
2. B e c h t e l , P.J., and P a r r i s h , jr. F.C. (1983): Effect of post-mortem storage and temperature on muscle protein degradation: Analysis by SDS gel electrophoresis. J. Food Sc. Vol.48, 294-295.
3. C r u p k i n , M., M o n t e c c h i a , Claudia and T r u c c o , R.E. (1988): Seasonal variations in gonado-somatic index, liver-somatic index and miosin/actin ratio in actomiosin of mature hake (*Merluccius hubsi*). Comp. Biochem. Physiol. 89 A: 845.
4. F o e g e d i n g , E.A. and R a m s e y , S.R. (1986): Effect of gums on low-fat meat batters. J. Food Sc. Vol.51, 33-38.
5. F r e n c h , J.S., K r a m e r , D.E. and K e n i s h , J.M. (1988): Protein hydrolysis in coho and sockeye salmon during partially frozen storage. J. Food Sc. Vol. 53, 1014-1017.
6. H a m a n n , D.D., A m a t o , P.M., W u , M.C., and F o e g e d i n g , E.A. (1990): Inhibition of Modori (gel weakening) in surimi by plasma hydrolisate and egg white. J.Food Sci. Vol. 55, 3, 665-669.

7. Hermansson, Anne-Marie (1982): Gel characteristics-structure as related to texture and waterbinding of blood plasma gels. J.Food Sci. Vol. 47, 1965-1982.
8. Hermansson, Anne-Marie and Lucisano, Mara (1982): Gel characteristics-waterbinding properties of blood plasma gels and methodological aspects on the waterbinding of gel sistems. J Food Sc. Vol. 47, 1955-1960.
9. Hickson, D.W., Dill, C.W., Morgan, R.G., Sweat, V.E., Suter, D.A., and Carpenter, Z.L. (1982): Rheological properties of two heat-induced protein gels. J.Food Sci. Vol. 47, 783-786.
10. Iwasaki, M. and Harada, R. (1985): Proximate and amino acid composition of the roe and muscle of selected marine species. J Food Sc. Vol. 50, 1585-1587.
11. JUS ISO 936.
12. JUS ISO 937.
13. JUS ISO 1442.
14. JUS ISO 1443.
15. Kim, B.Y., Hamann, D.D., Lanier,T.C., and Wu, M.C. (1986): Effects of freeze-thaw abuse on viscosity and gel forming properties of surimi from two species. J.Food Sci. Vol. 51, 951-954.
16. Kinoshita, M., Toyohara, H. and Shimizu, Y. (1990): Proteolytic degradation of fish gel (Modori-phenomenon) during heating process. Refrigeration Science and Technology -Chilling and freezing of new fish products. Issued by International institute of refrigeration, Aberdeen, 61-67.
17. Schubring, R., Mieth, G., and Schneider Ch .(1993): Raw material effects on the freeze structurization of comminuted fish. Refrigeration sci. and technology, Aberdeen267-275.
18. Sidwell, V.D., Foncanon, P.R., Moore, N.S. and Bonnet, J.C. (1974): Composition of the edible protein of raw (fresh and frozen) crustaceous, finfish, and molluscs. 1. Protein, fat, moisture, ash, carbohydrate, energy value, and cholesterol. Marine Fish Rev. 36:21.
19. Toyohara, H., Kinoshita, M., Shimizu, Y. (1990): Proteolytic degradation of threadfin-bream meat gel. J Food Sc. Vol. 55, 259-260.
20. Živković, D. (2002): Kvantitativna i kvalitativna svojstva mesa pojedinih vrsta slatkovodnih riba. Doktorska disertacija, Poljoprivredni fakultet, Beograd.

Received February 12, 2004
Accepted September 16, 2004

ISPITIVANJE NEKIH FUNKCIONALNIH SVOJSTAVA MESA TOLSTOLOBIKA (*Hypophthalmichthys molitrix Val.*) I ŠARANA (*Cyprinus carpio Lin.*)

D. Živković[1], V. Perić[1] i Marija Perunović[1]

R e z i m e

Nekonvencionalni tehnološki procesi, u preradi ribe, postaju sve zastupljeniji zahvaljujući mogućnostima koje pružaju u pogledu asortimana i racionalnom (ekonomičnom) iskorišćenju sirovine, i baziraju se na usitnjenom ribljem mesu ili surimiju kao sirovini.

Kvalitet finalnog proizvoda uslovljen je funkcionalnim karakteristikama sirovine, kao što su sposobnost vezivanja vode i sposobnost geliranja i/ili uslovima toplotnog procesa.

U ovom radu ispitivane su sposobnost vezivanja vode (SVV) i zadržavanja vode (HW) i sposobnost geliranja mesa belog tolstolobika (*Hypophthalmichthys molitrix Val.*) i šarana (*Cyprinus carpio Lin.*). SVV, HW i sposobnost geliranja varijanti gelova sa 50 i 60% mesa (A i B) ispitivane su na temperaturama: 70, 75, 80, 85 i 90 ^{o}C.

Varijanta A gelova od mesa tolstolobika pokazuje maksimalnu SVV i HW na 80^{o}C, a varijanta B na 75^{o}C. Obe varijante gelova od mesa šarana pokazuju blago povećanje SVV i HW sa porastom temperature do 80^{o}C. Gelovi od mesa tolstolobika pokazuju znatno bolju SVV od kontrolnih gelova (goveđe i pileće meso), a gelovi od mesa šarana bolju HW, ali nešto lošiju SVV od kontrolnih gelova.

Kod varijante gelova A od mesa tolstolobika najveći modul elastičnosti 6.862 N/cm^{2} utvrđen je pri toplotnoj obradi na 85^{o}C, međutim, nisu utvrđene i statistički značajne razlike u odnosu na ostale temperature. Kod varijante B, sa povećanjem temperature povećava se i modul elastičnosti, statistički značajne razlike utvrđene su između gelova tretiranih na 70^{o}C, i ostalih. Razlike između varijanti A i B su statistički značajne na svim ispitivanim temperaturama. Gelovi od mesa tolstolobika imaju statisički značajno manji modul elastičnosti, u odnosu na kontrolne gelove.

[1] Dr Dušan Živković, docent, dr Vladimir Perić, redovni profesor, mr Marija Perunović, asistent, Poljoprivredni fakultet, 11081 Beograd-Zemun, Nemanjina 6, Srbija i Crna Gora

Rad je realizovan u okviru projekta BTN 0701 koji je finansiran od strane Ministarstva za nauku, tehnologije i razvoj Republike Srbije.

Meso tolstolobika može se, uz manje povećanje koncentracije proteina, uspešno koristiti za izradu rekonstituisanih mesnih sistema ili mesnih emulzija.

Elastičnost gelova od mesa šarana je vrlo mala, što ga čini inferiornim u odnosu na meso tolstolobika.

Primljeno 12. februara 2004.
Odobreno 16. septembra 2004.