FUNCTIONALITY OF SILVER CARP (*HYPOPHTHALMICTHYS MOLITRIX*) IN COMMINUTED SAUSAGE

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Abstract – The aim was to compare the effects of salt-phosphate ingredients and calcium alginate binders on the functional properties of carp-based sausages. A series of finely comminuted sausages were prepared and cooked before measuring yield, pH, water activity, bind strength and water holding capacity values. The most significant finding was noted in bind strength values before and after a brief period of frozen storage. Values for calcium alginate treatments were lower than salt-phosphate treatments prior to storage, but increased to become equal after storage. Other functional results showed minimal differences and thus it may be concluded that carp-based sausages may be produced successfully using both traditional sausage-making techniques and cold-set techniques.

Key Words – bind strength, calcium alginate, carp yield

I. INTRODUCTION

Silver (*Hypophthalmicthys molitrix*) and bighead (*Hypophthalmicthys nobilis*) carp were reportedly imported to the U.S. in the 1970s by the aquaculture industry as a means to control unwanted plant growth in commercial fish ponds [1]. Some escaped captivity and have initiated an invasion of the major waterways that has resulted in these non-native fish becoming two of the most abundant species in Missouri's large rivers and streams [2]. Research has generally focused on abatement, exclusionary techniques, and limited control measures for these species because they are not considered viable for commercial fisheries. Through a series of projects, we have developed several carp-based products for zoo animals [3, 4] and human food [5] in an attempt to demonstrate marketable products that would justify commercial harvest on a scale that would significantly reduce the population of these invasive species. An obstacle to the production of carp-based products is the presence of small bones that preclude many consumers from choosing these fish for home-preparation. Boneless carp filets are more appealing, but they generate considerable waste which is only suitable for production of restructured, surimi-like, or sausage products that are unfamiliar to many American consumers. Our approach is to utilize a blend of familiar ingredients and processing methods to make value-added items worthy for commercial operations to implement. In this case, the objective was to compare functional properties of sausage products made from silver carp using traditional heat-set techniques in comparison to cold-set techniques.

II. MATERIALS AND METHODS

Silver carp (*Hypophthalmichthys molitrix*) were harvested on two dates (12/7/09 and 5/5/10) from the Missouri River between the Hartsburg Access and the Highway 54/63 bridge at Jefferson City, Missouri as part of a United States Geological Survey (USGS) study documenting the age, sex, weight, and condition of fish in the major rivers of Missouri. The carp (N=45 for rep 1 and N=37 for rep 2) were eviscerated and stored on ice for transport to the University of Missouri where they were filleted, weighed, labeled, placed in Ziploc™ freezer bags and stored in a freezer at -18°C for later evaluation. In preparation for a surimi-manufacturing experiment [5], the filets were thawed in a refrigerator at 4°C for 24 hr, tempered under cool running water for 2 hr, placed in a stainless steel colander and washed/rinsed with tap water to eliminate undesirable odors, water soluble proteins, and other constituents. The filets were wrapped in two layers of cheesecloth (1 m^2) and pressed in a stainless steel vertical sausage stuffer (L.E.M. Products, Inc., Harrison, OH) to dewater fish. The fish was further washed and dewatered twice in a similar manner except that the final wash water contained 0.3% sodium chloride. Portions unneeded for the surimi project were placed in Ziploc™ freezer bags, labeled, and returned to a freezer at -18°C for use in this experiment.

The procedures for making experimental sausages and all laboratory techniques for measuring functional properties are used routinely in our meat processing course and described in a self-published laboratory manual [6]. Preparation of carp sausages began by thawing samples (9 or 10 per replicate) overnight (18 hours) in a refrigerator at 4°C. Each sample still had visible ice crystals before the packages were opened, the contents were minced through a plate with 0.32 cm diameter aperatures, and the ground flesh was mixed together. The ground fish was then divided into 5 portions and allocated to one of five treatments shown in Table 1. The experiment was replicated three times.

Table 1. Formulas and codes for carp sausage treatments.

Fish only (F)	400 g carp
Fish with water (FW)	400 g carp, 40 mL distilled water (DW)
Salt and phosphate (SP)	400 g carp, 40 mL DW, 4.8 g NaCl, 1.2 g phosphate[1]
Calcium alginate (CA):	400 g carp, 40 mL DW, 2.4 g Na alginate[2], 2.4 g lactic acid[3], 1.2 g CaCO3
Calcium alginate overnight (CAO)	400 g carp, 40 mL DW, 2.4 g Na alginate , 2.4 g lactic acid, 1.2 g CaCO3

[1] Brifisol 512, B.K. Giulini Corp.
[2] Sodium alginate FD 155, Danisco Grinsted
[3] Encapsulated lactic acid, Danisco USA

The weighed carp was placed in a Cuisinart food processor and chopping began. The dry ingredients and water were added through the filler tube and thoroughly chopped for 2 min. The prepared matrix was distributed evenly into eight polypropylene centrifuge tubes with i.d. of 2.5 cm using a caulking gun with a 5 cm reusable PVC tube stepped down to 2.5 cm with a reducer coupling. The combined sample and tube weight for three previously weighed tubes was recorded for yield calculations. A 10 g sample of raw matrix was saved for pH determination and all eight were set aside in a holding rack until the other treatments were similarly prepared. All tubes were placed in a hot water bath starting at 75°C and held until the internal product temperature reached 65°C (approximately 15 min). The water level was monitored to match the fish level in each tube.

The cook yield of product was determined based on results from three tubes per treatment. A thin metal spatula was used to dislodge product from the centrifuge tubes and any residual fat or water was discarded. The surface of each product was blotted and then weighed. A 10 g portion was removed and assigned for pH determination. For both raw and cooked product pH, a slurry was prepared using 10 g of sample with 90 mL of deionized water in a glass jar and an Oster home blender on high speed. The slurry was gently decanted onto seine to separate the main solids and then filtered on a Buchner funnel fitted with Whatman #5 filter paper until enough filtrate was collected for pH determination. A calibrated Mettler Toledo FE-20 pH meter was used according to manufacturer's instructions and the two standard buffer method (4.00 and 7.00). The pH electrode was immersed into the filtered solution and a value recorded to the nearest 0.01.

For texture measurement, samples were tempered to room temperature (22°C) and then cut into 1 cm thick disks. The sections were tested on a Stevens-LFRA Texture Analyzer fitted with a TA-8 probe (0.635 cm sphere) operating at a speed of 2 mm/sec through a distance of 20 mm following contact of the sample. The maximum penetration force (g) for five (5) sections per sample was recorded. One set of data was collected on the day of cooking and a second set was collected after a week of frozen storage (samples were thawed to room temperature prior to this retesting).

The water holding capacity (WHC) of each treatment sample was determined by using a modified Carver Press Method. An accurately measured (0.5±0.01g) sample was placed on Whatman filter paper (#5) which had been stored in a chamber above saturated KCl overnight. Duplicate samples were placed between two sheets of Plexiglas and compressed for 5 min at 5000 psi (34.5 MPa). The inner circle containing the meat film and outer circle representing the expressible juice was traced and subsequently measured to determine the area. The water holding capacity was reported as the ratio of the expressible juice area to the meat film area.

Moisture content was determined using a vacuum oven and duplicate samples of accurately weighed product (5±0.01 g) heated at 86-88°C to a constant weight (about 22 hours).

III. RESULTS AND DISCUSSION

The silver carp harvested for this project were also used for the preparation of surimi in a separate study [7] but the yield of boneless carp filet has not been reported. The yield data were tracked by gender and date of harvest as shown in Table 2. There appeared to be a difference with higher yield in the winter harvest and a small advantage for males compared to females, but the variability in trimming and deboning on separate dates obscured any statistically significant differences.

Table 2. Yield of boneless carp filets sorted by gender and harvest.

		Female		
		Weight, g	Filet, g	Yield, %
Harvest 1	avg	2786.6	465.7	17.02
	stdev	570.21	140.93	4.95
	N	29		
Harvest 2	avg	3493.0	504.2	14.43
	stdev	427.65	102.53	2.26
	N	16		
		Male		
		Weight, g	Filet, g	Yield, %
Harvest 1	avg	3481.3	593.8	17.21
	stdev	540.01	166.64	4.67
	N	25		
Harvest 2	avg	3480.7	525.9	14.91
	stdev	767.32	146.09	2.05
	N	12		

The most significant findings in this project were found in the bind strength values of different formulations of comminuted carp sausages before and after a short period of frozen storage (Table 3). As expected, products without binding ingredients (F and FW) had the lowest nominal values for bind strength immediately after manufacture. The treatment with salt and phosphate (SP) that simulated traditional emulsified sausage was found to have the greatest resistance to penetration among all treatments on initial measurement. The initial bind strength for the treatments with calcium alginate (CA and CAO) was lower ($P<0.05$) than for the SP treatment but the overnight period to allow cold-set gelation of the calcium alginate did not affect the values. There was a dramatic increase in bind strength value after freezing and thawing for all treatments except the SP one. After thawing, all treatments were statistically similar except the treatment with water only (FW) which was lowest in the bind strength value.

Table 3. Bind strength values of carp sausages[1] before and after frozen storage.

Code	Initial Bind, g	Bind After Freeze/Thaw, g
F	124.1±3.31^{c}	186.1±22.97^{a}
FW	88.9±13.50^{d}	136.7±23.92^{b}
SP	248.6±6.59^{a}	233.8±11.33^{a}
CA	144.1±23.23^{bc}	236.5±47.10^{a}
CAO	152.4±21.91^{b}	200.5±11.86^{a}

[1]Average ± standard deviation

The other parameters measured in this project included water activity, pH (raw and cooked), WHC, and moisture content. There were some statistical differences detected among the treatments but they were minor and consistent with expectations for all except for WHC. For water activity, the values for all treatments were between 0.987 and 0.993 (stdev = 0.003). The average pH for raw product was 6.67 (range = 6.53-6.77±0.136) and for cooked product was 6.68 (range = 6.53-6.68±0.103). The moisture content averaged 76.2% (range = 75.5-77.3±0.97). The WHC as determined by a press method revealed the only obvious difference which was the F, FW, and SP treatments were similar (4.4-4.9±0.63) and significantly greater than for both calcium alginate (CA and CAO) treatments (2.1±0.10) which were the same as each other. The difference was attributed to the larger expansion of the fish product area under pressure when the hydrocolloids were included in comparison to the carp, water and salt treatments.

Previous research conducted in our lab has emphasized either production of carp-based products for zoo animals [8, 9] or surimi-like products [7]. The use of calcium alginate with ground carp (filets) has also been shown to be effective as a binder in restructured products [10]. None of these simulated the manufacture of more traditional sausage products. Even though parameters such as bind strength and other functional values were reported, it is not possible to draw direct comparisons in performance of carp due to the great differences in formulation. Future efforts to standardize the measurements and test the effects of selected ingredients in sausage products can be pursued.

IV. CONCLUSIONS

This project reflected the development and functionality of more traditional comminuted sausage products and how a traditional salt-phosphate system compares to a cold-set calcium alginate system. There were few differences in the chemical and composition characteristics but the bind strength values confirm that diversity of texture can be achieved using alternative nonfish ingredients. The study demonstrates that sausage based on the harvest of an undesired invasive species (silver carp) has potential to be manufactured into value-added products.

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