Composition, Nutritive Value, and Sensory Attributes of Fish Sticks Prepared From Minced Fish Flesh Fortified With Textured Soy Proteins

WILMON W. MEINKE, GUNNAR FINNE, RANZELL NICKELSON, and ROY MARTIN

ABSTRACT—The composition, nutritive value, and sensory attributes of fish sticks produced from minced fish flesh were investigated for various species fortified with textured soy protein. The use of a constant ratio of minced fish protein to textured soy protein (3.3:1) resulted in fish sticks with good sensory characteristics and nutritive value. Lysine and methionine were approximately 20 percent lower in soy-supplemented fish sticks compared with sticks prepared from pure minced fish flesh from the same species. All samples tested, except for walleye pollock and walleye pollock with textured soy protein, had significantly better protein efficiency ratios than casein.

Wilmon W. Meinke was with the Protein Research and Development Center and Gunnar Finne and Ranzell Nickelson are with the Seafood Technology Section, Department of Animal Science, Texas A&M University, College Station, TX 77843. Roy Martin is with the National Fisheries Institute, 1101 Connecticut Ave., Washington, DC 20036.

Introduction

Mechanically deboned fish flesh has become an important product to the seafood processing industry. The deboned flesh, which can be produced from either filleting waste or scaled, headed, and eviscerated carcasses of underutilized finfish species, is normally frozen into blocks which are then cut into fish sticks, fish portions, or other fabricated forms. The major problem with such products is the difference in texture between the natural flakiness of fish fillets compared with the more amorphous conditions of fabricated forms produced from minced flesh. To alleviate this, the industry formulated minced fish flesh with various additives such as hydrocolloids (Clark, 1982), polyphosphates (Brotsky and Swartz, 1982), gelling proteins (Decker et al., 1982), and soy proteins (Duersch, 1982) to create products with acceptable sensory attributes.

This research has determined the effect of texturized soy protein (TSP) on the composition and nutritive properties of fish sticks produced from minced fish flesh of different species. Our specific objectives were to: 1) Determine the relationship between moisture and TSP content in minced fish-TSP blends and 2) determine the proximate composition and nutritive value of minced fish-TSP sticks.

Experimental Procedures

Raw Materials

Minced flesh from walleye pollock, *Theraga chalcogramma*, and Atlantic cod, *Gadus morhua*, was supplied in frozen blocks by a commercial fish processing plant. The pollock flesh had been minced from headed and eviscerated carcasses, whereas the minced cod blocks were produced from deboning "V-cuts" and other trimmings from a filleting operation. No information on the time, location, and harvesting techniques for these two species was available from the supplier.

The underutilized species (spot, *Leiostomus xanthurus*, and Atlantic croaker, *Micropogonias undulatus*), caught incidentally during shrimping in the Gulf of Mexico (Meinke, 1974), were obtained from shrimp trawlers off the Texas coast. After being landed and separated from the shrimp, these fish were immediately iced and stored in ice chests overnight for processing the next day. Upon arrival at the Texas Agricultural Experiment Station, Texas A&M University, Corpus Christi, Tex., the fish were scaled, headed, eviscerated, and mechanically deboned as described by Finne et al. (1980). After deboning, the minced fish preparations were frozen as 1-pound blocks in wax-coated cardboard boxes using a plate freezer. The boxes were wrapped in plastic wrap and stored in a chest freezer at −30°C until the minced flesh was processed into fish sticks. All samples were in frozen storage less than 2 months before being processed.

The batter and breading materials used for coating the fish sticks were the same as those used commercially. Two textured soy flour samples (TSF I and TSF II) and a textured soy concentrate (TSC) were obtained from commercial sources.

Fish Stick Preparation

Frozen blocks of minced flesh were

Table 1.— Proximate analyses of raw minced flesh preparations, TSP, batter, and breading material.

Item	Percent composition				
	Moisture	Protein	Oil	Ash	Crude fiber
Pollock	83.36	15.83	0.19	1.02	0
Cod	83.44	15.38	0.13	1.38	0
Croaker	78.65	17.10	3.76	0.98	0
Spot	76.56	17.34	5.84	1.02	0
TSF I	10.70	50.30	0.84	5.40	2.42
TSF II	9.88	51.23	0.32	6.36	2.13
TSC	8.25	66.03	0.12	6.58	3.74
Batter	10.49	4.75	1.24	2.53	0.24
Breading	7.06	10.13	1.84	5.40	0.11

Table 2.— Composition of minced flesh-TSP blends.

Fish-TSP blends	Percent minced flesh	TSP dry (%)	Hydration ratio (H_2O:TSP)	Protein ratio (Flesh:TSP)	Blend assays	
					Moisture (%)	Protein (%)
Pollock-TSF I	78	6.4	2.4:1	3.3:1	80	15.9
Cod-TSF I	78	6.4	2.4:1	3.3:1	80	15.7
Cod-TSF II	78	6.4	2.4:1	3.3:1	80	15.7
Cod-TSC	78	5.1	3.4:1	3.3:1	82	15.8
Croaker-TSF I	70.5	6.4	3.5:1	3.3:1	78	15.5

broken into small chunks and ground while semi-frozen, using a Hobart[1] food grinder, fitted with an end plate drilled with 5 mm holes. Hydrated crumbles of TSP were added to the ground flesh and mixed with a spatula. This minced fish-TSP mixture was passed through the Hobart grinder to insure proper blending and compressed into aluminum pans which were sealed and placed in a freezer at −30°C.

Fish sticks, measuring 8.9×2.2×0.8 cm, were cut from the frozen blends using a band saw. The sticks were battered by immersion in a mix composed of five weights of dry batter and seven weights of water. Excess batter was allowed to drain from the sticks. The drained sticks were then put into a plastic bag containing excess breading material and shaken. This process covered the sticks with an even layer of breading material. The final battered and breaded sticks, which on a prefried basis contained 38-39 percent coating, were refrozen and kept in frozen storage until needed for sensory evaluations.

For sensory evaluations, the fish sticks were fried in vegetable oil at 190°C for 3-4 minutes (essentially to a uniform golden brown color). The fried sticks were served, while warm, to a trained, nine-member sensory panel and each member evaluated each sample for juiciness (9 = extremely juicy, 1 = extremely dry), flavor (9 = extremely desirable, 1 = extremely undesirable), texture (9 = extremely desirable, 1 = extremely undesirable), and overall satisfaction (9 = extremely desirable, 1 = extremely undesirable).

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Analytical Methods

Proximate and Amino Acid Composition

All proximate analyses were performed according to official AOAC methods (Horwitz, 1975). For determination of amino acids other than tryptophan and cystine, the samples were digested in 6 N hydrochloric acid in a stream of dry nitrogen. The amino acid composition of the hydrolysates was determined using a Beckman 150 C amino acid analyzer. Cystine was determined as cysteic acid by the method of Moore (1963) and tryptophan from barium hydroxide hydrolysates according to Slump and Schreuder (1969).

Protein Efficiency Ratios

Protein efficiency ratio (PER) assays were conducted by using 10 rats per sample over a 4-week growth period. The basal diet contained 80 percent starch, 10 percent combined corn oil plus fish oil supplied by the test samples, 5 percent Alphacel, 4 percent mineral mixture (USP XIV), and 1 percent vitamin mixture (General Biochemicals). Diets containing 10 percent protein (N×6.25) from finely ground sampling material or casein were prepared at the expense of the starch of the basal diet. Experimental PER values were calculated as grams of weight gained per gram of protein intake over a 28-day feeding period.

Statistical Analyses

All data were examined statistically by analysis of variance (ANOVA) and Duncan's Multiple Range Test.

Results and Discussion

The proximate composition of the various fish flesh preparations, soy samples, batter, and breading materials is shown in Table 1. The most likely explanation for the high moisture content of the pollock and cod samples compared with the moisture content of freshly prepared minced flesh from croaker and spot, is that these two species were captured in early spring close to spawning time.

To establish levels of TSP and moisture which would give fabricated sticks sensory attributes comparable to sticks prepared from frozen fish blocks, a number of initial screening experiments were conducted. During this phase, TSP content was varied from 1.6 to 13.2 percent of moisture-free TSP based on the final TSP-fish flesh blend. Hydration ratios, water to moisture free TSP, were also varied from 0:1 to 4.8:1. After reviewing the initial data, we decided to use a constant ratio between minced flesh protein and TSP protein of 3.3:1. By using this ratio and by varying the hydration to different moisture levels, it was possible to produce minced flesh-TSP blends with similar protein content but with moisture levels ranging from 77 to 82 percent.

The composition and sensory evaluations of the breaded fish sticks produced from the different TSP-fish blends are shown in Tables 2 and 3, respectively.

As Table 3 shows, there were some differences in the sensory perception of the different combinations. The cod-TSC and cod-TSF I sticks rated numerically higher in overall satisfaction. The low flavor score for the croaker blend could most likely be attributed to the high oil content of this species. Croaker had a fat content of 3.76 percent compared with only 0.19 and 0.13 percent for pollock and cod flesh.

Sensory evaluations of unsupplemented minced fish sticks are shown in Table 4. During this study, pollock and cod sticks were cut from both the original industrial blocks and from experimental blocks. The experimental blocks were prepared by first grinding chunks of the original fish blocks and then compressing the ground fish into pans. Sticks prepared from minced spot were severely downgraded with regard to flavor which again was most probably due to the high oil content.

Table 5 shows the proximate composition of the various TSP-minced fish sticks. As is evident, raw fish sticks formulated from different fish flesh-TSP combinations were very similar with regard to moisture content. Also, the fried sticks showed only small differences in moisture (50.7-53.6 percent), protein (12.7-14.1 percent), and oil (12.1-16.0 percent). The low moisture and high oil content for fried pollock-TSF I could be a reflection of a low water binding capacity of the minced pollock flesh. This was in agreement with the control fish sticks shown in Table 4 where pollock was given a low rating on the basis of both texture and overall satisfaction.

The essential amino acid distribution of the experimental minced flesh preparations is shown in Table 6. The second-column values are means of calculated amino acid contents for pollock-TSP, cod-TSP, and croaker-TSP battered and breaded fish sticks. The calculated amino acid values were based on means of duplicate essential amino acid assays of each ingredient. Only

Table 3.—Mean[1] sensory scores of fish sticks prepared with different TSP's and different minced fish flesh.

Fish and TSP	Juiciness	Flavor	Texture	Overall satisfaction
Pollock-TSF I	6.9^{ab}	6.5^{ab}	6.8^{ab}	5.9^{bc}
Cod-TSF I	6.6^{ab}	6.5^{ab}	6.8^{ab}	6.8^{a}
Cod-TSF II	6.5^{b}	6.0^{bc}	6.5^{b}	5.8^{c}
Cod-TSC	7.0^{a}	6.9^{a}	6.8^{ab}	6.9^{a}
Croaker-TSF I	6.2^{b}	5.8^{c}	7.0^{a}	5.9^{bc}

[1]Means with a common superscript letter in columns are not different ($P > 0.05$).

Table 4.—Mean[1] sensory scores of control fish sticks.

Fish stick	Juiciness	Flavor	Texture	Overall satisfaction
Pollock[2]	5.5^{d}	5.5^{b}	4.8^{c}	5.2^{c}
Pollock[3]	6.7^{bc}	5.6^{b}	5.1^{b}	5.4^{bc}
Cod[2]	7.1^{ab}	7.4^{a}	7.3^{a}	7.3^{a}
Cod[3]	5.8^{cd}	5.9^{b}	5.7^{b}	5.9^{b}
Croaker[3]	7.8^{a}	7.2^{a}	7.3^{a}	7.2^{a}
Spot[3]	6.6^{bc}	4.3^{c}	7.1^{a}	5.1^{c}

[1]Means with a common superscript letter in columns are not different ($P > 0.05$).
[2]Prepared from commercially processed blocks.
[3]Prepared from experimentally processed blocks.

Table 5.—Proximate composition of supplemented fish sticks.

Stick formulation[1]	Proximate composition (%)					
	Moisture		Fried			
			Protein		Oil	
	Raw	Fried	Wet basis	Dry basis	Wet basis	Dry basis
Pollock-TSF I	65.2	50.7	12.7	25.8	16.0	32.4
Cod-TSF I	65.2	52.9	13.6	28.8	12.1	27.8
Cod-TSF II	65.2	53.6	13.0	28.0	12.6	27.2
Cod-TSC	66.1	52.4	13.5	28.4	12.9	27.0
Croaker-TSF I	63.9	51.1	14.1	28.8	14.2	29.0

[1]Ratio of flesh protein to TSP protein in blends = 3.3:1

Table 6.—Essential amino acid composition of minced flesh and minced flesh-TSP battered and breaded sticks.

Amino acid	Amino acid composition[1]		
	Minced flesh[2]	Sticks[3]	Ratio sticks: flesh
Isoleucine	4.60 ± 0.37	4.48 ± 0.23	0.97
Leucine	8.02 ± 0.45	7.92 ± 0.31	0.99
Lysine	9.20 ± 0.10	7.43 ± 0.05	0.81
Phenylalanine	3.93 ± 0.27	4.22 ± 0.15	1.07
Methionine	3.12 ± 0.16	2.46 ± 0.11	0.79
Threonine	4.18 ± 0.14	3.88 ± 0.11	0.93
Tryptophan	1.24 ± 0.12	1.23 ± 0.11	0.99
Valine	5.05 ± 0.27	4.92 ± 0.17	0.99

[1]Grams of amino acid per 16 g of nitrogen.
[2]Amino acid assays are means of duplicate runs on each minced flesh: Pollock, cod, croaker, and spot.
[3]Amino acid values are means based on pollock-TSP, cod-TSP, and croaker-TSP sticks.

Table 7.—Protein efficiency ratio estimations[1].

Test sample	Protein intake (g)	Weight gain (g)	PER	
			Exptl.[2]	Corr.[3]
Minced flesh				
Pollock	37.23 ± 2.76	122.7 ± 8.92	3.18 ± 0.13^{c}	2.50
Cod	38.88 ± 3.32	132.7 ± 10.23	3.34 ± 0.16^{ab}	2.69
Raw sticks				
Pollock-TSF I	37.11 ± 3.37	126.4 ± 12.75	3.41 ± 0.13^{a}	2.68
Cod-TSF I	37.65 ± 3.24	129.0 ± 13.13	3.43 ± 0.14^{a}	2.69
Croaker-TSF I	39.72 ± 2.93	137.0 ± 14.80	3.44 ± 0.16^{a}	2.71
Fried sticks				
Pollock-TSF I	35.31 ± 3.91	115.9 ± 13.23	3.28 ± 0.15^{bc}	2.58
Cod-TSF I	37.25 ± 2.70	126.3 ± 13.52	3.38 ± 0.15^{ab}	2.66
Casein standard	35.50 ± 2.72	112.9 ± 8.92	3.18 ± 0.16^{c}	2.50

[1]Data based on 10 rats per sample.
[2]Means with a common superscript letter are not different ($P > 0.05$).
[3]Corrected to casein PER of 2.5.

lysine and methionine levels were appreciably lower in the TSP supplemented sticks compared with minced fish flesh. The concentrations of these two amino acids in supplemented fish sticks were approximately 80 percent of their content in unsupplemented sticks.

Table 7 shows the PER for raw minced flesh, raw supplemented sticks, fried supplemented sticks, and casein which was tested as a standard. All test samples except for the raw pollock and fried pollock-TSF I combination had significantly better PER values than casein.

This study has shown that the concept of using a constant ratio of minced flesh to textured soy protein of 3.3:1 is a reasonable approach to produce fish sticks of uniform composition, sensory attributes, and protein nutritive values.

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Literature Cited

Brotsky, E., and W. E. Swartz. 1982. Use of polyphosphates in minced fish. *In* R. Martin (editor), Third national technical seminar on mechanical recovery and utilization of fish flesh, p. 299-311. Natl. Fish. Inst., Wash., D.C.

Clark, R. 1982. Hydrocolloid applications in fabricated minced fish products. *In* R. Martin (editor), Third national technical seminar on mechanical recovery and utilization of fish flesh, p. 284-298. Natl. Fish. Inst., Wash., D.C.

Decker, C. D., S. K. Holt, and D. B. Westerling. 1982. Gelling proteins. *In* R. Martin (editor), Third national technical seminar on mechanical recovery and utilization of fish flesh, p. 324-347. Natl. Fish. Inst., Wash., D.C.

Duersch, W. 1982. Development and utilization of textured soy proteins and foods. *In* R. Martin (editor), Third national technical seminar on mechanical recovery and utilization of fish flesh, p. 312-323. Natl. Fish. Inst., Wash., D.C.

Finne, G., R. Nickelson, R. Quimby, and N. Connally. 1980. Minced fish flesh from nontraditional Gulf of Mexico finfish species: Yield and composition. J. Food Sci. 45:1327-1329.

Horwitz, W. (editor). 1975. Official methods of analysis of the Association of Official Analytical Chemists, 12th ed. Assoc. Off. Anal. Chem., Wash., D.C., 1,094 p.

Meinke, W. W. 1974. The potential of the bycatch from shrimp trawlers. *In* R. Kreuzer (editor), Fishery products, p. 233-237. Fish. News (Books) Ltd., Lond.

Moore, S. 1963. On the determination of cystine as cysteic acid. J. Biol. Chem. 238:235-237.

Slump, P., and H. A. W. Schreuder. 1969. Determination of tryptophan in foods. Anal. Biochem. 27:182-186.