The Effect of Washing on the Quality Characteristics of Minced Fresh Croaker, *Micropogon undulatus*, Held in Frozen Storage

JAMSHYD G. RASEKH, MELVIN E. WATERS, and V. D. SIDWELL

Introduction

Croaker, *Micropogon undulatus*, makes up more than half of the industrial bottomfish landings from the Gulf of Mexico (Roithmayr, 1965), exceeding the present demand of this fish for human consumption. Small croaker, less than 0.5 pound, have not been used as a food fish, primarily because of the high preparation cost and the lack of convenient product forms for the consumer. Consequently, croaker are used primarily in pet food. To better utilize this resource for human consumption, new products must be developed and introduced to the market.

In recent years, mechanically deboned fish has been used in a variety of food products. The scarcity of frozen fillet blocks made from cod and haddock and the increasing demand for fish sticks and fish portions have resulted in production of minced fish by foreign countries for marketing in the United States (Miyauchi et al., 1975; Teeny and Miyauchi, 1972; and Whitaker, 1972).

In our laboratory, during 1975, we tested the quality of mechanically separated minced fish muscle made from several underutilized species, primarily croaker. We found that to produce an acceptable frozen minced product from croaker, it would be necessary to improve quality factors such as color and texture. This is exemplified in the Japanese process for making surimi (a semi-processed fish protein used in manufacturing kamoboko), i.e., washing of the minced flesh with chilled water before mixing with condiments and later freezing. The washing is to remove blood, soluble pigments, fat, and prooxidant materials, thereby improving color and stabilizing the functional properties during frozen storage.

The first phase of the earlier investigation (Rasekh et al., 1976) indicated that the color of minced croaker could be improved by washing the product with cold tap water for 2 minutes, using a 2:1 (w/w) ratio of water to fish. The loss of total solids from pre-frozen minced croaker after washing was 3.7 percent of the weight of the product. The purpose of this study was to determine the effect of washing minced fresh croaker on the chemical, microbiological, physical, and organoleptic properties of the product during long-term frozen storage.

J. Rasekh, M. Waters, and V. Sidwell are with the Southeast Fisheries Center Charleston Laboratory, National Marine Fisheries Service, NOAA, Charleston, SC 29412. This paper is contribution number SEFC 80-28C from the Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Charleston, SC 29412.

ABSTRACT—Minced fish was prepared from freshly caught croaker, Micropogon undulatus, *harvested from the western Gulf of Mexico. A portion of the minced flesh was washed for 2 minutes with tap water employing a ratio of 2:1 (w/w) of water to fish. Unwashed flesh served as the control. The washed flesh was drained until the final weight was approximately 3 percent more than the weight of the product before washing.*

Washed and unwashed flesh was prepared as minced blocks, placed in frozen storage, and evaluated periodically. Chemical, physical, microbial, and organoleptic analyses were conducted to determine the effect of washing on product quality during the 12 months of storage. Overall results indicated that the keeping quality of washed minced croaker blocks was superior to that of unwashed blocks. Improved flavor and odor scores of washed samples corresponded with lower TBA (thiobarbituric acid) values. Washing caused toughening of the texture in raw samples as measured objectively. The loss of total solids after washing was about 5.4 percent. There was no apparent difference in total aerobic plate counts between washed and unwashed fresh and frozen minced fish. Twelve months of frozen storage, however, reduced the TAPC (Total Aerobic Plate Count) 95 percent.

Experimental

Sample Preparation

Atlantic croaker were caught from coastal waters of the western Gulf of Mexico and processed into the minced form within a few hours after catch. The fish was first scaled, headed, gutted and thoroughly washed to remove the various organs, blood, debris, etc., from the gut cavity. The fish was then passed through a Bibun[1] separator (perforated drum with 5 mm diameter holes) to separate fish muscle from skin and bones.

Washing

Duplicate slurries consisting of 30 kg of tap water (18°C) and 14.5 kg of minced croaker (2:1 w/w ratio) were prepared. Each slurry was agitated in a 150-liter container for 2 minutes. After allowing the mixture to settle for 8 minutes, the water and soluble solids were decanted, and the flesh drained on cheesecloth placed over a screen. The average weight of the replicate samples after washing and draining was 15.0 kg (approximately a 3 percent increase). The washed samples were packed in 1-pound, wax-coated food cartons (7.5 × 21.5 × 3 cm) and frozen at −40°C in a plate freezer. A sample of unwashed minced fish was packaged and frozen in the same manner as the washed samples. After 24 hours, the cartons of washed and unwashed minced fish were removed from the plate freezer and

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

overwrapped with polyethylene. A portion of the unwashed sample was stored at −40°C and used as a standard reference sample for organoleptic evaluations. The remaining portions of the unwashed sample and the washed samples were stored at −18°C for further study. The unwashed sample, stored at −18°C, served as the control. Washed and unwashed samples were evaluated after 0, 3, 6, and 12 months of storage.

Loss of Total Solids

The drained water obtained from the washing of minced fish muscle was thoroughly mixed and a 20 ml sample taken and dried overnight in an aluminum dish at 98°C. The loss of total solids was calculated from the average of triplicate samples.

Chemical Analysis

Proximate analysis was performed according to the AOAC method (AOAC, 1970). Fat was measured according to the SAK method (Smith et al., 1964). Thiobarbituric acid (TBA) determination was performed as a measure of oxidative rancidity using Vyncke's method (Vyncke, 1972). Total volatile nitrogen (TVN) and trimethylamine-nitrogen (TMA-N) were determined as described by Cobb et al. (1973). Fatty acid profiles were obtained by gas chromatography on methylesters of the sample (Gauglitz and Lehman, 1963). Amino acids were determined with a Beckman automatic amino acid analyzer (Moore et al., 1958).

Functionality Measurement

The color of minced croaker was measured on both raw and cooked samples using a Hunter Color and Color Difference meter model 25 (Kramer and Twigg, 1966). A 120 g sample was placed in a clear plastic cup and the cup placed on a piece of glass over the color meter. The cup was covered with a black cover and the color values "L", "a", and "b" were measured. Only L values are reported. The color meter was standarized with a standard plate having the values of L = 92.8, a = −0.8, and b = −0.7.

The texture of the raw and cooked minced croaker was measured by the Kramer Shear Press (Kramer and Twigg, 1966) using a 3,000-pound pressure ring and a standard shear cell. For the raw material, 140 g of minced fish was placed in the standard cell and shear force values recorded. Cooking consisted of placing 170 g of sample in a glass container covered with aluminum foil and heating in an oven at 230°C for 30 minutes. After draining over a screen (Tyler, 425 μm) for 5 minutes, 140 g of cooked sample were subjected to the evaluation described above.

Cooking loss was determined by weighing the sample after cooking and draining it for 5 minutes. Results are reported as the percentage of liquid lost after cooking.

The amount of expressed water was determined by collecting and weighing the water released during the shearing process. Expressed water was calculated as the percentage of liquid released from the sample during shearing based on the weight of the sample before shearing. The pH of the minced sample was measured by placing the pH electrode directly into the flesh.

Sensory Evaluation

Frozen minced fish blocks were cut into 0.5-inch sticks, battered, breaded, and deep-fat fried in peanut oil for 2 minutes at 190°C. The sticks were cooled, wrapped in aluminum foil, and refrozen. The sticks were removed from frozen storage and heated in an oven at 204°C for 20 minutes. Samples were served to a taste panel consisting of 10 judges and quality assessed on appearance, flavor, and texture. Organoleptic quality factors were scored against the standard reference sample on a five-point scale, on which a three-point score was judged to be equal to standard reference sample, five points represented "like better" than standard and one point represented "like less" than standard sample.

Microbiological Examination

The total aerobic plate count (TAPC) was determined on washed and unwashed minced flesh before freezing (fresh samples) and after 0 and 12 months of frozen storage (frozen samples). The analyses were conducted according to the Manual of Products and Laboratory Procedure (BBL, 1973) for dairy products with the following modifications. Twenty-five g of fish were added to 225 ml of phosphate buffer, and the mixture was blended for 2 minutes. Appropriate serial dilutions were prepared and plated out on Standard Methods Agar. The fresh samples were incubated at 20°C for 72 hours and the frozen samples were incubated at 35°C and 20°C for 48 and 72 hours, respectively. Values are reported as an average of three analyses.

Results and Discussion

Loss of Total Solids

The percent loss of total solids, based on the weight of the minced fish before washing from two replicates, are shown in Table 1. After 2 minutes of washing, the average loss of solids was 5.37 percent. The value for each sample is the average of three determinations.

Chemical Analysis

In Table 2 we show the results of pH and proximate analyses of the unwashed and washed minced croaker from two replicate samples after 0 and 12 months of storage. Little differences

Table 1.—Loss of total solids from average of two replicate samples of washed minced croaker.

	Loss of total solids		
	Replications		
Sample	1 (Percent)	2 (Percent)	Average (Percent)
1	4.82	5.92	5.37
2	5.32	5.74	5.53
3	4.17	6.23	5.20
Average	4.78	5.96	5.37

Table 2.—Proximate analysis of unwashed and washed minced croaker from average of two replicates at 0 and 12 months of frozen storage.

		Proximate analysis					
Sample	Mo. of storage	pH	Protein	Moisture	Ash	Fat	NPN
			(%)	(%)	(%)	(%)	(%)
Unwashed	0	6.4	19.6	73.7	0.5	4.6	2.5
	12	6.3	19.5	75.0	0.5	5.0	1.4
Washed	0	6.5	17.0	77.0	0.9	4.4	1.9
	12	6.6	16.7	77.6	1.0	4.7	0.5

existed in values between the washed and unwashed samples for all factors evaluated, except NPN (nonprotein nitrogen). The small differences may be attributed to sample size and sensitivity of methods used rather than real difference. However, the slight increase in moisture content of the washed sample coincides with the observation made earlier during the washing procedure. The values for NPN's were lower for the washed sample at 0 months of storage and further decreased after 12 months.

The amino acid content of unwashed and washed minced croaker and the percent loss of amino acids (due to washing) at zero time storage are shown in Table 3. The percent amino acids of the washed sample was corrected for the approximately 3 percent increase in moisture. All amino acid values of the washed samples were lower than those of the unwashed samples except for glutamic acid and methionine, which were equal. The greatest loss was noticed for valine, glycine, and histidine and in that order. Overall, the total amino acids were about 1.1 percent lower for the washed samples as compared with the unwashed samples.

The fatty acid profile of unwashed and washed minced croaker at 0 and 12 months of storage is shown in Table 4. The results indicate that, initially (0 months storage), there was no apparent difference between the fatty acid profile of unwashed and washed samples. A comparison of the fatty acid profile of unwashed samples before and after storage showed that the saturated fatty acids, such as 14:0 and 16:0, 16:1 and 18:1, were somewhat lower after 12 months of storage. Also some polyunsaturated fatty acids, such as 18:1ω9, were lower after storage. Other polyunsaturated fatty acids, such as 18:2ω9, 22:4ω6, 22:5ω6, and 22:6ω3, increased appreciably after storage. The fatty acid profile of washed samples varied considerably betwen 0 and 12 months of storage. For example, fatty acid 16:0 decreased from 29.5 to 13.6 percent; fatty acid 22:4ω6 increased from 1.4 to 2.3 percent and 22:6ω3 increased from 2.3 to 5.1 percent. Variability was not confined to the polyunsaturated fatty acids.

Table 3.—Amino acid content of unwashed and washed minced croaker from two replicate samples at 0 months of storage.

Amino acids	Amino acid content		Percent loss
	Unwashed	Washed	
	(%)	(%)	(%)
Lysine	1.95	1.86	4.6
Histidine	0.46	0.41	10.9
Ammonia	0.25	0.22	12.0
Arginine	1.20	1.18	1.7
Taurine	0.21	Trace	—
Aspartic acid	2.08	2.02	2.9
Threonine	0.93	0.92	1.1
Serine	0.81	0.80	1.2
Glutamic acid	3.27	3.17	0
Proline	0.77	0.74	3.9
Half cystine	Trace	—	—
Glycine	0.95	0.84	11.6
Alanine	1.21	1.16	4.1
Valine	1.26	0.96	23.8
Methionine	0.64	0.64	0
Isoleucine	0.90	0.87	3.33
Lucine	1.68	1.62	3.57
Tyrosine	0.73	0.72	1.4
Phenylalanine	0.80	0.76	5.0
Glucosamine	—	—	—
Total	20.1	18.99	

[1]Corrected for the approximate 3 percent increase in moisture.

Table 4.—Fatty acid profile of unwashed and washed minced croaker at 0 and 12 months of storage.

Fatty acids	Fatty acid profile			
	0 mo. of storage		12 mo. of storage	
	Unwashed	Washed	Unwashed	Washed
	(%)	(%)	(%)	(%)
14:0	2.0	1.8	1.7	1.9
16:0	29.0	29.5	23.3	13.6
16:1	16.3	15.6	12.4	15.0
18:1	7.0	7.3	5.3	5.8
18:1ω9	20.3	20.8	15.7	17.9
18:2ω9	0.3	0.3	1.5	1.0
20:0	0.2	0.2	0.5	0.6
18:4ω3, 20:1, 18:4ω3	3.9	4.6	4.0	3.0
20:5ω3	4.4	4.3	7.4	5.9
22:4ω6	1.5	1.4	2.6	2.3
22:5ω6	0.3	0.2	1.6	1.3
22:5ω3	3.1	3.3	3.5	3.6
22:6ω3	2.5	2.3	6.0	5.1

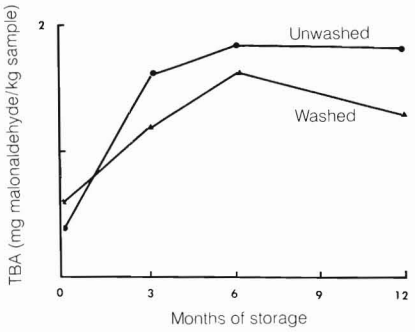

Figure 1.—Thiobarbituric acid (TBA) values of raw (unwashed and washed) minced croaker during 12 months of storage at −18°C.

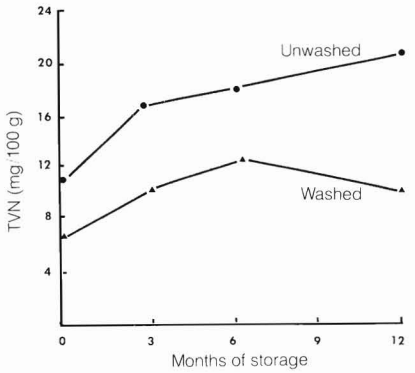

Figure 2.—Total volatile nitrogen (TVN) values of raw (unwashed and washed) minced croaker during 12 months of storage at −18°C.

The TBA values increased for both unwashed and washed samples during storage up to 6 months and there was little further change up to 12 months of storage. Washed samples showed lower TBA values during the entire storage period, indicating less oxidative rancidity development during storage (Fig. 1).

Figure 2 shows the production of total volatile nitrogen (TVN) for washed and unwashed raw minced croaker. Washed samples of raw minced croaker showed less TVN during storage than unwashed samples, indicating that materials responsible for the production of TVN were partly removed during the process of washing (Fig. 2).

TMA-N was determined on all samples during frozen storage. The amount of TMA was too small to be detected, indicating there was no significant bacterial spoilage.

Functionality Analysis

The objective determination of texture for raw and cooked samples before and after washing during frozen storage is shown in Figures 3 and 4. The shear force values of unwashed raw minced croaker increased as the months of storage increased. The values for the raw washed samples decreased after 3 months of storage and did not change appreciably after 6 and 12 months of storage. The washed sample had a much firmer texture than the unwashed

sample. For cooked croaker the shear values of washed samples decreased after 3 and 6 months of storage, then increased slightly after 12 months. The shear values of cooked unwashed samples decreased considerably after 3 months and decreased only slightly thereafter. The texture of unwashed cooked samples was much firmer than washed samples.

Although results of the objective color analyses are not shown, washed raw samples exhibited lighter color than unwashed raw samples, and there was little change in color of either sample during storage. Cooked samples (washed and unwashed) demonstrated much lighter color than raw samples. There was no appreciable difference in color between cooked washed and unwashed samples and the values did not change during storage.

The cooking loss for unwashed and washed samples is shown in Figure 5. The loss for washed samples was about 1.5 times greater than unwashed samples and both samples paralleled each other during storage.

The percent of expressed water of the raw washed sample increased slightly after 3 months of storage, further increased after 6 months, then decreased after 12 months to about the same level as that of initial storage. The raw unwashed sample decreased after 3 months of storage, increased after 6 months to about the level of initial storage, then decreased after 12 months to the same level as 3 months of storage (Fig. 6). The cooked washed sample exhibited slightly higher values than the unwashed sample and both samples paralleled each other after initial storage. The cooked washed sample decreased very slightly and the unwashed sample increased after 3 months of storage. Both samples decreased after 6 months, then increased after 12 months of storage.

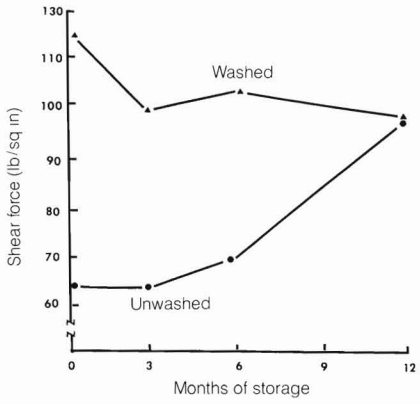

Figure 3.—Shear force values of raw (unwashed and washed) croaker during 12 months of storage at −18°C.

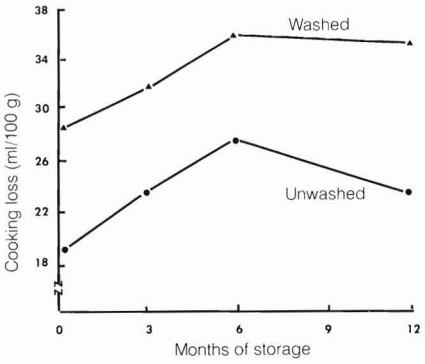

Figure 5.—The cooking loss of unwashed and washed minced croaker during 12 months of storage at −18°C.

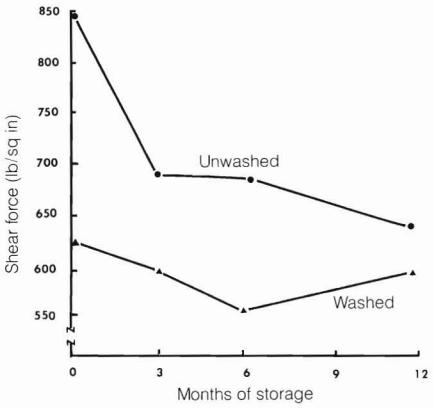

Figure 4.—Shear force values of cooked (unwashed and washed) minced croaker during 12 months of storage at −18°C.

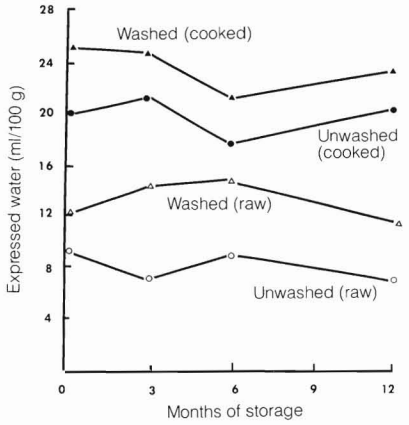

Figure 6.—The expressed water of raw and cooked (unwashed and washed) minced croaker during 12 months of storage at −18°C.

Organoleptic Analysis

The organoleptic evaluation of washed and unwashed samples for flavor, texture, and appearance is shown in Figure 7. The results indicate that washed samples maintained a better flavor than unwashed samples during storage. The texture of the washed sample was rated firmer than the unwashed sample at 0 and 6 months of storage. However, at 3 and 12 months the washed sample rated slightly lower than the unwashed sample which may not represent a real difference. Also, the appearance of washed samples received much higher scores than unwashed samples. This was due mainly to the improvement of color from washing, even though the fish sticks made from washed flesh shrunk considerably after cooking.

Microbiological Evaluation

The TAPC of fresh samples (before freezing) of washed and unwashed minced flesh was 4.3×10^5 and 2.4×10^5, respectively. Counts on the frozen samples were 1.9×10^5 for the washed sample and 2.7×10^5 for the unwashed sample after 0 months of storage. The values for both washed and unwashed samples were 1.2×10^4 after 12 months storage. There was no apparent difference in TAPC values between washed and unwashed fresh and frozen minced fish. Also, there was no difference between the fresh samples (washed and unwashed) and the frozen samples (washed and unwashed) stored for 0

months. However, there was approximately a 95 percent reduction in counts during frozen storage (12 months). There was no difference in counts between the two incubation temperatures of TAPC plates for the frozen samples. TAPC of all samples were in an acceptable range for commercial frozen minced fish blocks (Licciardello and Hill, 1978).

Conclusions

The quality parameters of washed minced croaker blocks are better than those of unwashed minced blocks during 12 months of frozen storage. The slight loss of protein as a result of washing is minor compared to the beneficial effects offered by the procedure. Washing improved the flavor and appearance and, for the most part, texture as judged by a sensory panel. Washing the flesh also decreased the TBA values and TVN content during frozen storage. The color of raw and cooked minced flesh was improved by washing. Washing minced flesh did not lower the TAPC, and the values were within an acceptable range for commercial frozen minced fish blocks. Functional properties of minced croaker—texture, expressed water, and cooking loss—changed after washing due to a higher moisture content of the washed flesh and loss of some of the soluble protein responsible for water absorption properties during washing. Further work is needed to evaluate methods or additives that would prevent the loss of functional properties of the product due to washing. Additionally, economic and marketing studies are needed to demonstrate commercial feasibility of the washing process.

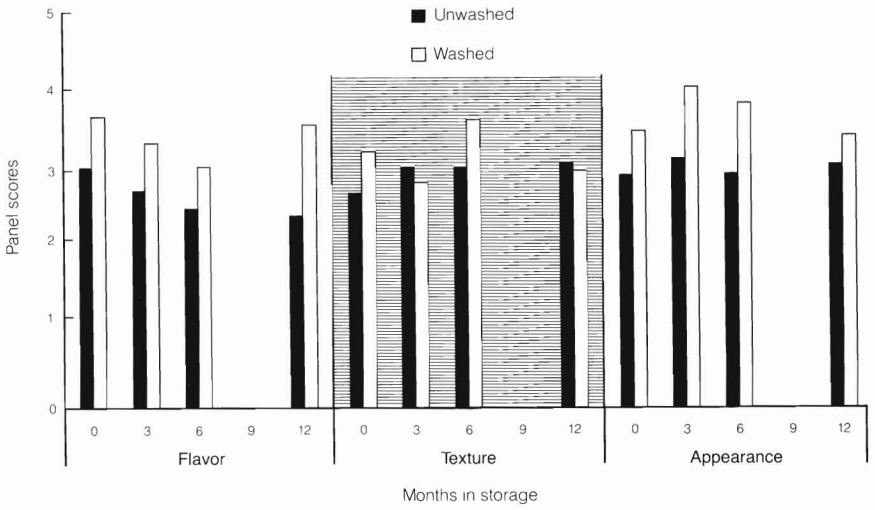

Figure 7.—The effect of washing on the flavor, texture, and appearance of fish sticks made from minced croaker.

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