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Standardization of Production of Fish Sausage from Unwashed Mince Blend of Low Cost Marine Fish

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Abstract

A new method for utilization of unwashed mince (UM) mixture of low-cost marine fish (LMF) in cooked sausage is described. Textural qualities of heat-induced gels of six different mince blends from the individual unwashed minces of five LMF viz., red jewfish, sea catfish, horse mackerel, jeweled shad and skipjack tuna were investigated. Blend B3 having greater contribution from low-fat white-fleshed red jewfish and sea catfish obtained best-textured gel and sausage in terms of instrumental gel strength and sensory parameters ($p > 0.05$). In order to improve the textural and sensory qualities of the sausage prepared from B3, suitable types and levels of ingredients and cooking methods were evaluated. Gels prepared with modified starch and soy protein isolate had distinctly ($p < 0.5$) improved gel strength and cook loss values. Sausage prepared with autoclave cooking at 115°C for 15 min. obtained best texture and good mouth feel compared to conventional cooking (90°C for 20 – 60 min.), broiling (for 20 -60 min.), two-step heating (incubation at 50°C for 1 hr and cooking at 90°C for 30 min.) and dip-frying in oil (for 10 - 30 min). Instrumental gel strength ($p < 0.05$) and sensory chewiness/rubberiness ($p > 0.05$) were lower in sausage prepared from B3 when compared to imported fish sausage. Instrumental gel strength, sensory attributes and cook loss of the sausage prepared from B3 by different cooking methods were higher in the order of autoclave cooking > frying > two-step heating > boiling > broiling. Peroxide and thiobarbuturic acid values and aerobic plate count of the sausages after 7 days at 4°C were almost identical in all cooking process ($p > 0.05$) but distinctly lower ($p < 0.05$) than that of commercial fish sausage. Results of the study suggested that good quality stable fish sausage could be prepared from UM blends of LMF.

Introduction

Low-cost marine fishes (LMF) in Bangladesh waters are mostly small meso-pelagic or pelagic species, like small croakers, anchovies, scads or clupeids etc.

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Individual catch size of these species is too small (BBS 2006) to run a sustainable product line, but their mixed lot can make a significant volume to produce any heat processed value-added product on commercial basis. Blending of different fish minces often produce low quality products because of interactions of proteins, lipids and enzymes of different origins and natures. Therefore, improvement of the gel quality of blended mince is necessary before going to manufacture any heat-processed product from it.

Fast foods are being popularized in Bangladesh and the business is expanding very fast (Nowsad 2000a). Fish sausage is a major item of new generation fast food, because of overwhelming young generation craze for its superb taste, fabricated texture, brilliant colour and high nutritional quality. As a convenient food, it is becoming increasingly popular among the working people too. Fish sausage prepared from the mince blend of LMF would be able to serve a good taste and nutrition to such people at cheaper price.

Heat-processed gel type products are generally produced from the washed mince or surimi to achieve high textural and sensory qualities (Shimizu et al. 1981). During this washing process more than 50% of the mince are washed out which are valuable proteins, lipids and minerals- very useful for the consumer health (Ishioroshi et al. 1982; Babbitt et al. 1985; Park et al. 1996). Removal of such valuable nutrients in the name of improvement of textural quality is thought to be a serious wastage of resource. In this study efforts were made to utilize unwashed mince of LMF in fish sausage production, instead of washed mince or surimi. Manufacture of stable fish sausage from the mince blend of LMF would enable proper utilization of such resource, reduction of post-harvest loss and increment of the price of the underutilized marine harvest.

Materials and Methods

Fish

Five LMF, viz., red jewfish (*Johnius argentatus*), small sea catfish (*Tachysurus thalassinus*), horse mackerel (*Megalaspis cordyla*), jeweled shad (*Ilisha filigera*) and skipjack tuna (*Sarda orientalis*) were used in this study. These marine species have limited use in commercial production, are low priced in the market and therefore, abundantly available in the coastal regions.

Collection of raw materials

The fishes were purchased from the Kawran Bazar wholesale fish market in Dhaka. The fishes were in iced condition during purchase. Immediately after purchase they

were re-iced with newly crushed ice in an insulated icebox. The average weight of red jewfish, sea catfish, horse mackerel, jeweled shad and skipjack tuna were 0.34 ± 0.04 , 1.10 ± 0.19 , 0.44 ± 0.04 , 0.91 ± 0.25 and 1.30 ± 0.22 kg, while the length were 12.05 ± 1.5 , 21.0 ± 1.74 , 12.40 ± 2.4 , 18.3 ± 3.22 and 19.52 ± 2.1 cm, respectively. After they were brought to the laboratory the fishes were quickly frozen and stored at -25°C .

Preparation of mince blend

Frozen fish was thawed in cool water for 6 hours. After dressing and washing, skinned fishes were filleted and minced by a mechanical mincer (MK-G3NS, Matsushita Electric Co., Japan.). A 1-mm orifice diameter sieve was used to remove small bones and connective tissues from the muscles. Five individual fish minces were blended in six different compositions (B1, B2, B3, B4, B5 and B6) as in table 1. All the procedures from the dressing/eviscerating of fish to filling of paste into the casing were done at $4 - 5^{\circ}\text{C}$.

Selection of mince blend

Six mince blends were separately ground with 2.5% NaCl and 20% water, stuffed into polyvinylidene chloride casing (Krehalon casing, Kureha Chem. Co. Japan, 3.0 cm diameter), cooked at 90°C for 60 min and the gel thus formed was evaluated for the textural quality of the blends.

Preparation of fish sausage

Due to best gelling ability obtained, fresh unwashed mince blend B3 was used for the preparation of fish sausage. Red chili, onion, garlic, ginger, cinnamon, clove and black pepper were dried in hot air oven at 60°C for 24 hr, ground with a mechanical grinder to make powder and sieved by a fine mesh metallic sieve. The seven spices were powdered and mixed together at a proportion of 30:20:20:10:5:5:10, respectively and kept airtight in the refrigerator as spice-mix. Blend B3 was ground with 2.5% NaCl, 1.6% sugar, 1.5% spice-mix and 2% cow fat. A 6% modified starch and 2% soy protein isolate (SPI) were added to the ground paste to improve the textural quality of the sausage. Grinding was done for a total period of 20 min. The ground paste was stuffed into a sausage casing (Krehalon casing, 2.8 cm diameter, Kureha Chemical Co., Japan) by a manual stuffer, both ends of the casing were sealed with cotton twine after removing any air bubbles from the casing and cooked by different methods to obtain fish sausage.

Cooking methods

Fish sausage was prepared by two-step heating, conventional cooking, broiling, dip frying in oil and autoclave cooking. For two-step heating, stuffed fish sausage was

incubated at 50°C for 60 min in a water bath before cooking at 90°C for 20, 30, 40 and 60 min. Conventional cooking was done by heating the sausage at 90°C for 20, 30, 40 and 60 min. For broiling, steam of boiling water in a closed pan was allowed to pass out through a hole at the center of the lid and the stuffed sausage, after wrapping by cotton cloth, was put on steam for 20, 30, 40 and 60 minutes. For frying, stuffed sausage boiled for 10 min was uncovered and directly fried in dip-vegetable oil for 5, 10, 20, 30 and 40 minutes. For autoclave cooking, a laboratory autoclave (Model: YX280A, Sunshen Medical Instrument Co. Shanghai, China) was used. Sausage was cooked at 115°C for 10, 15, 20, 30 and 40 minutes under 15 lbs. inch⁻² pressure. To avoid bursting of synthetic casing, sausage was kept in a heat-stable polypropylene coated metallic wire-mesh box inside the autoclave well above the water level.

Quality tests

Instrumental gel strength

Gel strength of new fish sausage was measured through the puncture test. Puncture test was carried out by a food rheometer (SIMPLIFIED RHEOMETER, designed and developed by [Nowasad et al. 2000a](#)) on the test sample (2.0 cm height) at a table speed of 10 cm per min. with a spherical plunger (6 mm diameter). The breaking strength in g and the breaking deformation in cm were calculated from the chart of a potentiometric recorder. Gel strength (GS) denotes the product of breaking strength and breaking deformation, expressed as g × cm.

Cook loss

A known amount of sausage paste in a synthetic tube was cooked by different methods. The cooked sausage was blotted on a blotting paper and reweighed. Cook loss (%) was calculated from the ratio of the weight of cooked and uncooked sample.

Sensory test

A trained panel of nine persons with students, teachers and staff of the Department of Fisheries Technology of BAU provided the sensory tests ([Nowasad et al. 2000a](#)). Prior to testing, panelists were familiarized with the properties of meat gel and fish sausages and the instructions relating to the scoring of the sample. Pretests were done with selected samples to familiarize the panelists with the measurement procedure. Three discs of a gel (0.5 cm thick) were supplied to each panelist to recognize every attribute. Chewiness/rubbriness (C/R) was defined as the amount of effort the panelists had to exert in chewing to prepare the sample for swallowing. The quality was evaluated by the numerical scores up to 10, where 1= not chewy/rubbery; 10= extremely chewy/rubbery ([Szczeniak et al. 1963](#)).

Folding test

A folding test was carried out by folding a 2-mm thick sausage disc into halves and quarters as described in [Nowasad et al. \(2000a\)](#). The scale was 4 = no crack when folded into quarter, 3 = no crack when folded into half but crack when folded in quarter, 2 = crack when folded into half, 1 = broke and split into halves.

Biochemical and microbiological tests

The peroxide value (POV), expressed in terms of milliequivalents of free iodine per kilogram of fat, was determined by titrating iodine liberated from potassium iodide with sodium thiosulphate solution according to the modified method of [Kim \(1992\)](#). The TBA value, expressed in terms of milligrams of Malonaldehyde per kilogram of meat sample, was also determined by the modified method of [Kim \(1992\)](#).

Aerobic plate count was done by consecutive decimal dilution technique according to [AOAC \(1990\)](#) and expressed in terms of colony forming unit (CFU) per gram of sample.

Statistical analysis

Simple correlation analysis and student's t-test were done to compare the data ([Shil and Debnath 1992](#)).

Results and Discussion

Gel strength of six mince blends is presented in Table 1.

Table 1. Ratios of mince blends and their gelling performance

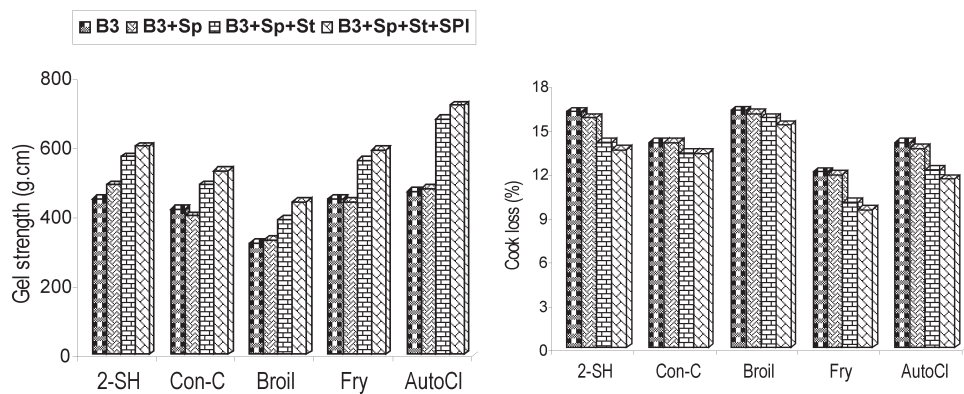
Fish	% share of individual mince in the mince blend					
	B ₁	B ₂	B ₃	B ₄	B ₅	B ₆
Red jewfish	20	20	30	15	15	20
Sea catfish	20	30	20	15	20	15
Horse mackerel	20	20	20	20	15	15
Jeweled shad	20	15	15	20	20	30
Skipjack tuna	20	15	15	30	30	20
Gel strength (g.cm) of the blend* ¹	360±38	380±42	430±65	326±54	330±35	310±40

*¹ Mince blends were ground with 2.5% NaCl, stuffed into casing, cooked at 90°C for 60 min and the gel thus formed was subjected to puncture test.

Gel strength of the blends varied in great extent due to the compositional differences of individual minces. Among the six blends tested, blend B3 showed maximum gelling performance, where higher proportion of the minces came from red

jewfish, sea catfish and horse mackerel. In a previous study, individual minces of red jewfish and sea catfish showed higher gelling ability. Additional heating experiments were conducted with the blend B3 to find out the optimum-heating schedule for attaining maximum textural quality of the product. The data are presented elsewhere (Nowsad et al. 2007). Both unwashed and washed mince blend B3 were stuffed into plastic casing and incubated at different temperatures from 35°-55°C and then cooked at 90 - 100°C. Most of such products showed optimum gelling ability at 50°C for 1 hour incubation and further cooking at 90°C for 30 min (Nowsad et al. 2007). The gelling performance of the mince blends was significantly lower compared to individual fish minces in all of those heating schedules. But the gel strength of the blend B3 was still strong enough to be formulated into heat-processed products if compared to the mince of other meat sources like poultry or spent hen (Nowsad et al. 2000b,c). Based on such results (Nowsad et al. 2007), unwashed mince blend B3 was used to prepare cooked sausages during the successive experiments of the present study. Likewise, during the two-step heating experiment, those optimized heating schedule (50°C for 1hr.; 90°C for 30 min) was applied.

Before investigating the effects of different cooking methods on the quality of sausage prepared from blend B3, quality improvement of the mince blend by ingredients and spices was searched. Fig. 1 shows that addition of spice-mix neither improved, nor reduced the gel quality.

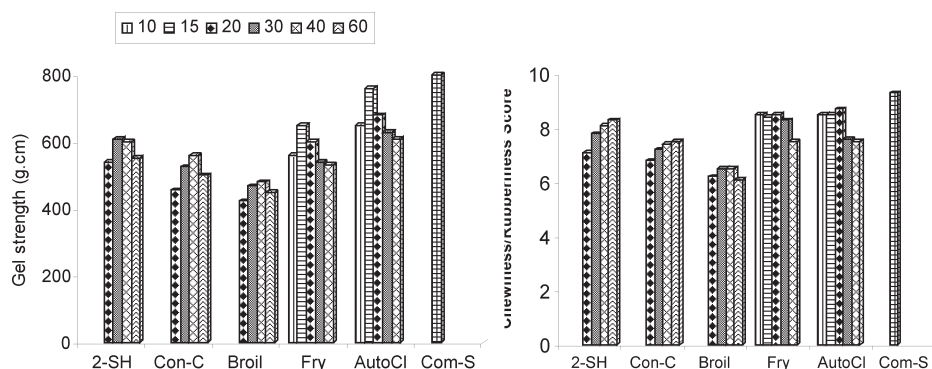


B3= blend no 3; Sp = spice-mix; St= modified starch; SPI= soy protein isolate; 2-SH= two-step heating, Con-C= conventional cooking; Broil= broiling; Fry= frying in oil; AutoCl= autoclave cooking.

Figure 1. Textural quality enhancement of fish sausage due to spice-mix, modified starch and soy protein isolate

Addition of starch significantly ($p < 0.5$) improved the gel strength and reduced the cook loss in all cooking methods. Addition of SPI further improved the gel by enhancing gel strength and reducing cooking loss. Starch is commonly added to fish mince-based heat processed products to improve the texture and to allow more water retention without losing the textural quality (Okada and Yamazaki 1957). Alvarez et al. (1990) found a very cohesive gel from chicken meat extruded with cornstarch. Higher cooking yield and reduced cook loss of such gels were solely derived from the water binding property of starch and SPI (Nowsad et al. 2000c; Yang and Froning 1992).

In conventional process, spicy cooked sausage is generally prepared by cooking the stuffed sausage casing at 90°C for 60 min. In the present experiment, a two-step heating, broiling/steaming, dip frying in oil and autoclave cooking were compared with conventional cooking. Fig. 2 shows the textural quality of fresh cooked sausage prepared under such cooking methods.



*10, 15, 20, 30, 40 and 60 are heating times in minutes

Figure 2. Textural quality of fresh spice sausage prepared under different cooking

Gel strength of the sausage was improved in two-step heating compared to conventional cooking and broiling. In the manufacture of heat-processed fish products produced from washed fish mince or surimi, two-step heating has been considered to have tremendous gel enhancing effects (Ishioroshi et al. 1982; Niwa et al. 1991; Nowsad et al. 1999; Park et al. 1996). Salt-ground fish mince paste added with ingredients if incubated at 30-50°C for 1-2 hours before final cooking at 90-100°C, the gel strength is increased by about 1.5 to 2 folds (Niwa et al. 1991). Reppond et al. (1995) noticed a 3-fold increment of gel strength in set and cooked products due to two-step heating treatment of Pacific herring. Improvement in gel strength was also evident in beef and pork gels when cooked at 80°C for 20 min after a preheating at 60°C for 90 min (Park et al. 1996). At low temperature around 30-50°C in fish, helical tail portion of myosin heavy chain unfolds and helps in intense cross-linking of proteins during high cooking temperature around 80-95°C (Ishioroshi et al. 1982; Park et al. 1996).

Two-step heating was found to have good synergistic effects on texture improvement and shelf life development of fish sausage too (Nowsad et al. 2000a). During the present study, however, frying in oil and autoclave cooking were found to be superior to two-step heating in the texture development of fish sausage. Many authors found frying as a good method of stable spice sausage preparation (Pripwai et al. 2004). In the present experiment, autoclave cooking was done at 115°C, because earlier studies proved this temperature schedule to be best with unwashed fish mince blends (Nowsad et al. 2007). Raj and Chandrasekhar (1986) also proposed an autoclave temperature of 115.6°C (for 20 min) to be best for fish sausage preparation.

In case of conventional cooking, best sausage in terms of gel strength was obtained by cooking at 90°C for 40 min. Cooking at 90°C for 60 min produced low quality product compared to those cooking at the same temperature for 40 min. However, sensory C/R value was higher in the sausage prepared by cooking for 60 min. Broiling produced low quality sausage compared to conventional cooking in terms of both the gel strength and sensory attributes in all heating periods tested. When the ground paste was made into sausage by applying two-step heating, frying in oil or autoclave cooking, improved textural and sensory qualities were achieved. Two-step heating clearly produced better quality sausage compared to conventional cooking ($p < 0.5$). Sausage quality was further improved when uncovered sausage sticks were dipfried in oil. Higher textural and sensory attributes were found in 15 minutes of dip frying. Autoclave cooking produced best quality sausage among the five cooking methods tested. Further, autoclave cooking at 115°C for 15 min gave the best schedule where maximum instrumental and sensory attributes were achieved. Autoclave cooking produced better gel at all the tested time periods compared to those of other cooking methods. The results are in agreement with Raj and Chandrasekhar (1986) who observed improved texture and longer shelf life of fish sausage by autoclave cooking at 115.6°C. Sausage casing was found to burst out at higher temperature (120-125°C) or longer time period inside the autoclave, probably due to pressure cooling as also confirmed by Raj and Chandrasekhar (1986). Another reason might be due to the adherence of synthetic tube to the heated stainless steel wall of autoclave. Use of heat-stable polypropylene coated metallic wire-mesh box to keep the sausage inside the autoclave was found to reduce the incidence of bursting. The wire mesh box was kept well above the water level inside the autoclave. In terms of gel strength, autoclave cooking produced the best sausage followed by frying, two-step heating, conventional boiling and steaming.

Chewiness/rubberiness (C/R) values corresponded well with the gel strength of the sausage (Fig. 2). The C/R value is generally used to express a sensory quality that makes a balance between the softness and firmness of a muscle based texture-dependent product. Fish sausage was not a Japanese style kamaboko type product, but since it was

produced from the fish mince by heat processing, it attained some kamaboko type elastic texture, while incorporation of spices and fats made it more chewy and juicy compared to kamaboko. Due to combination of such opposite traits (firmness due to network formation by polymerization of proteins and softness due to presence of fats and ingredients), the C/R values were able to express the sensory characteristic of sausage very well. To express the accurate score, however, the panelists were very careful in each bite during the panel test. Sensory judgments corresponded very well with the instrumental texture values (Fig. 2). Sausage prepared by dip frying and autoclave cooking obtained similar type of higher C/R values followed by those prepared with two-step heating, conventional cooking and steaming. Commercial fish sausage purchased from the market was, however, found to be best in terms of both gel strength and C/R values compared to the sausage prepared from unwashed mince blend by different cooking methods.

Cook loss and folding test scores of the sausage prepared by five cooking methods have been presented in table 2. Cook loss values showed more or less similar trend as those of GS and C/R values and were found to be lower in the order of frying < autoclave cooking < conventional cooking < two-step heating < broiling. In all heating methods, sausage sticks were cooked by covering with casing except frying where necked sticks were directly fried in oil after a boiling treatment of covered stick for 10 min. Moisture removed from the sausage due to cooking effect was directly drained into the oil during frying in such case.

Table 2. Cook loss and folding test score of sausage prepared under different cooking

Attributes	2-step heating* ¹				Conventional cooking (min)				Broiling (min)			Frying (min)				Autoclaving* ²										
	20		30		40		60		20		30		40		60		10		15		20		30		40	
FT (score)	4	4	4	4	3	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
CL (%)	16.2	13.8	14.0	14.8	13.3	13.5	13.7	13.9	16.1	15.8	15.9	16.0	10	10.4	11.0	10.4	11.0	10.5	10.0	11.2	11.5	12.5	12.8	12.9	13.0	13.1

*¹After incubating at 50°C for 1 hour, stuffed sausage was cooked at 90°C for given time.

*² Stuffed sausage was autoclave-cooked at 115°C for given period (min).

Folding test score was almost similar in all the sausage prepared by different cooking methods, except in conventional cooking for 20 min. and in broiling for 20-30 min. FT could not differentiate the qualities of different sausage due to lack of precise evaluation indices for such product. But FT values suggested that sausage prepared by such cooking methods could be of acceptable quality, as also understood from the sensory C/R values (Fig. 2).

Table 3 shows the POV and TBA values and aerobic plate count of the sausage at the 7th day of storage at 4°C.

Table 3. Quality of fresh spice sausage under different cooking compared to commercial fish sausage

Parameters	2-step heating	Conventional Cooking	Broiling	Frying	Autoclaving	Commercial Fish Sausage
POV (mmoles/kg fat)	4.6 ^a	5.3 ^a	4.9 ^a	5.2 ^a	5.0 ^a	7.4 ^b
TBA (mg/kg meat)	0.43 ^a	0.55 ^a	0.63 ^a	0.35 ^a	0.48 ^a	1.3 ^b
APC x 10 ⁴	2.9 ^{ab}	3.3 ^{ab}	3.5 ^{ab}	1.8 ^a	2.0 ^a	6.2 ^b

POV = Peroxide value; TBA = Thiobarbuturic acid; APC = Aerobic plate count

Different superscripts in a same row differ significantly ($p < 0.05$). Both POV and TBA values were almost identical in all cooking methods but distinctly lower ($p < 0.5$) than that of commercial fish sausage. Aerobic plate count on the 7th day at 4°C was in acceptable range in all-cooking methods. The results suggested that unwashed mince blend of LMF could be used in fish sausage preparation by applying high cooking temperature like autoclaving, dip frying in oil or two-step heating.

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