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Quality improvement of silver carp fingers by optimizing the level of major elements influencing texture

Shaviklo, A. R. and Fahim, A.

Iranian Fisheries Research Organization, National Fish Processing Research Center, Anzali, Guilan, Iran

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Abstract

A three-component Mixture Design was used to investigate the effect of different components of breadcrumbs, textured soy protein (TSP) and low-methoxyl pectin and their interactions on textural properties of an existing fish finger. The result indicated that the pectin had a more notable influence than TSP and breadcrumbs on all textural parameters as pectin proportion increased. At a higher proportion (0.9 - 1.2%), pectin improved essentially hardness, cohesiveness, springiness, gumminess, and chewiness of fish fingers measured by instrumental texture analysis. But sensory properties of formulated prototypes were decreased in this range of pectin. The optimum region consisted of 2 mixtures containing 5.35% TSP, 10.35% breadcrumbs and 0.3% pectin; and 4.8% TSP, 10.6% breadcrumbs and 0.6% pectin. The results indicated that prototypes containing 0.6% pectin were more stable than the other fish fingers during 6-month storage. The texture parameters obtained by instrumental methods were also strongly correlated with those obtained from sensory analysis.

Introduction

A need for development of innovative and unique high quality fish products using the greatest possible efficiency, experience and new knowledge is permanently present in the Iranian seafood industry. This goal can be achieved by continued development of new value-added products and by taking advantage of present processing equipment and knowledge (Shaviklo, 2007; Shaviklo and Rafipour, 2012). The aquaculture industry is currently the most important sub-sector of fisheries in Iran and its rapid development has attracted considerable attention in recent years. Since the potential for marine capture fisheries is limited, aquaculture is considered as the sector with good potential to increase animal protein (Salehi, 2011). More than 90% of aquaculture productions in Iran comes from fresh water cultures, mostly Chinese carp. Seafood consumption per capita in Iran is lower than that reported for world average (Shilat, 2012). In recent years, besides aquaculture developing plans, several studies have been done on how to increase the per capita fish consumption. The findings show that production of value added products is the best way to increase seafood consumption (Shaviklo, 2011). Total production of warm water species in the country was about 60000 MT, in 2011 (Shilat, 2012). Production of formulated fish products from cultured fish provides an excellent use of cultured fish (Shaviklo, 2006, 2007; Elyasi *et al*., 2010).

Besides increasing of fishery production and utilization, the market for ready-to-eat (RTE) seafood have been growing rapidly in the Near East including Iran for the last years. They have been driven by consumer demand for convenience food, value for money and increasing product awareness (Shaviklo and Rafipour, 2012; Euromonitor, 2013). Production of fish finger from silver carp mince was commercialized in Iran in recent decade with success (Shaviklo, 2006). Changing in consumer preferences and expectations leads industry to reformulate/ develop new products or to apply new ingredient (Velasco and Williams, 2011; Hathwar *et al*., 2012). Several ingredients such as polysaccharides were examined for quality improvement of formulated seafood products including fish fingers. In view of structural and functional properties of polysaccharides, pectin is probably one of the most interesting cell wall polymers because of numerous industrial applications (Van Buren, 1979). Structurally, pectin represents a group of heterogeneous polysaccharides of substantial diversity depending on its botanical origin (Huisman *et al.*, 2001). From a technical point of view, pectin which is extracted from apples, citrus, sunflowers and sugar beet increase the solubility, emulsification, gelation and foaming properties (Mishra *et al*., 2001; Nubia *et al*., 2008; Biswas *et al*., 2011). It has also been used as a cryoprotectant in surimi (Sych *et al*., 1990; Ueng and Chu, 1996). Pectin at 1% improved the mechanical properties of surimi gels from silver carp (*H. molitrix*) (Barrera *et*

*Corresponding author.
Email: *shaviklo@gmail.com*
Tel: +98 1812352091; Fax: +98 1812352089

al., 2002) and sole (*Cyclopsetta chittendenii*) (Uresti *et al*., 2003). No studies exist in the application of pectin to formulated/restructured products from silver carp mince/surimi.

The increasingly competitive environment, leads food industry more emphasis than ever on developing and sustaining new products. New food product development is defined as improving upon the existing product or producing new types of products. These must match both product functionality and consumer needs and desires in the most innovative way possible. Reformulating of the existing products is carried out to meet the needs of consumers' expectations and may benefit the company (Perry and Cochet, 2009). However, formulated new fish products using new ingredients, such as pectin, can be used for the purpose of reaching young consumers (Cardoso *et al*., 2009). Texture assessment is often an important step in developing a new food product or optimizing processing variables. Both instrumental measurements and sensory evaluation methodes are used in food texture research to assess texture parameters (Meullenet, 1998; Hyldig, 2007). The process can be usually be accomplished comparatively inexpensively and within a relatively short development time (Moskowitz *et al*., 2006). The objective of this paper was to improve textural properties of an existing fish finger through optimizing the level of major elements including pectin influencing texture and to study quality changes of the prototypes during 6-month storage at -18°C. This information helps to motive process or product improvement or develop new product ideas.

Materials and Methods

Raw materials

Fresh silver carp (*Hypophthalmichthys molitrix*) with total weight 20 kg (25 individuals) were obtained in June from a local fish market (Rasht, Guilan, Iran) and transported by ice (1:1) to National fish processing research centre (NFPRC, Anzali, Guilan, Iran). Individual fishes (weight range: 620 - 930 g) were gutted, dressed and filleted manually and minced by employing a mechanical deboner (Baader model 694, Lubeck Germany). Breadcrumbs, Textured soy protein (TSP) and low methoxyl citrus pectin were obtained from the Amoon Shirin Part Company, (Karaj, Iran), Zardaneh soy protein (Esfehan, Iran) and Sigma-Aldrich Co., (St. Louis, MO, USA) respectively. Fresh onion, fresh garlic, salt, spices, vegetable oil, dried vegetable, wheat flour and corn flour were purchased from a local market (Anzali, Guilan, Iran).

Fish finger preparation

Three fish finger prototypes including control (existing product) were formulated separately. Silver carp mince and other ingredients (mixtures containing pectin and control) were mixed with a kitchen blender (Panasonic, MJ. W176P, Japan). The fish fingers formed manually using a plastic former, followed by battering (30% wheat flour, 10% corn flour and 60% cold water) and breading (conventional breadcrumbs, Amoon Shirin Part Company) and deep frying (for 30 s at 180ºC in sunflower oil) using a pilot processing line (Convenience Food Systems, Bakel, The Netherlands). fried prototypes were individually quick frozen at -40˚C for 20 min and packed in polyethylene bags, sealed and stored at -18˚C. During the storage the frozen prototypes were removed from the freezer and were put in a refrigerator for thawing overnight before the measurements.

Chemical compositions

Proximate composition was determined according to Association of Analytical Chemists (AOAC, 1990) methods. Crude protein content was determined using the Kjeldahl method (Kjeltex System-Texator, Sweden). Crude lipid content was determined by the Soxhlet method (Soxtec System-Texator, Sweden) (AOAC, 1990). Ash content was determined by heating samples overnight at 550°C. The moisture content was determined by drying samples for 4 h at 105°C until constant weight was achieved. The peroxide value (PV) was determined by the modified AOAS method (1990) and expressed as milliequivalent of oxygen per kilogram of lipid. Total volatile basic nitrogen (TVBN) was determined according to Pearson (1975).

Texture analysis

The textural evaluation of fish fingers was carried out by sensory and instrumental analysis. Sensory attributes were evaluated by 10 experts (6 females) at NFPRC (Anzali, Guilan, Iran) who had been selected according to the general guidance of the International Organization for Standardization (ISO, 1983) for the selection, training and monitoring of assessors. Sensory evaluation was performed in a well-constructed and controlled sensory facility. The average age of the panellists was 28 years, ranged from 22 to 45 years and they were familiar with the sensory analysis methods. The panellists had experiences in sensory evaluation of RTE seafood and they were trained during two sessions to evaluate attributes of the samples using the quantitative descriptive analysis method (Meilgaard *et al*., 2007). A list of sensory lexicon (Table 1) to describe the

Table 1. Lexicon for sensory texture analysis of silver carp fingers (adapted from Shaviklo *et al*., 2010; Kasapis 2012)

Sensory attribute	Scale (0-100)	Definitions
Softness	firm: soft	Softness in the first bite.
Cohesiveness	low: high	The ability of the sample to stick together during chewing. Place the sample in the mouth and chew 2-4 times between the molars: Low (the sample disintegrates into many small pieces) , High (it stays together)
Juiciness	dry: juicy	When chewing: Dry (sample draws liquid from the mouth), Juicy (Samples give away liquid)
Adhesiveness	low: high	The force required to remove the sample from the roof of the mouth after chewing: Low (the sample falls), High (it requires force to be applied by the tongue to remove it).
Chewiness	low: high	The net energy required to chew the test sample to the point required for swallowing it.
Overall palatability	dislike: like	How much do you like the product overall?

Table 2. Experimental design for optimizing 3 main components* of fish fingers and sensory responses

Run	Component 1: Breadcrumbs (%)	Component 2: Textured soy protein (%)	Component 3: Pectin (%)	Response 1: Softness	Response 2: Juiciness	Response 3: adhesiveness	Response 4: cohesiveness	Response 5: chewiness	Response 6: overall palatability
1	9.90	4.90	1.20	85.32	79.2	34.58	49.15	75.41	60.71
2	9.80	5.60	0.60	85.32	79.2	34.58	49.15	75.25	60.71
3	8.80	6.00	1.20	66.25	75.6	41.26	47.51	70.36	89.27
4	10.35	5.35	0.30	79.65	69.89	26.25	47.08	72.24	55.95
5	11.00	5.00	0.00	77.21	75.32	25.85	41.67	68.36	51.23
6	11.00	3.80	1.20	69.87	78.25	32.51	47.15	65.47	58.65
7	8.80	6.00	1.20	70.32	70.25	24.57	51.65	71.51	60.32
8	11.00	4.40	0.60	80.25	68.98	28.51	58.52	69.21	61.25
9	10.00	6.00	0.00	57.08	37.08	35.41	47.93	49.45	59.36
10	11.00	5.00	0.00	51.25	30.81	32.92	42.91	50.12	66.05
11	9.90	4.90	1.20	43.32	67.89	29.36	43.46	65.41	85.12
12	10.60	4.50	0.90	75.41	65.32	39.60	36.66	70.32	68.32
13	9.40	6.00	0.60	51.26	42.07	40.12	47.61	52.23	57.65
14	11.00	3.80	1.20	63.25	32.92	32.5	46.25	63.02	80.35

*The 3 mixture components, breadcrumb, textured soy protein and pectin, made up a total of 16% of the actual formulation, with the complement being fish mince (75%), fresh onion (2.9%), fresh garlic (1%), salt (1.3%), spices (0.3%), dried parsley (1%) and vegetable oil (2.5%) used to make up 100% of the formulation.

Table 3. Experimental design for optimizing 3 main components* of fish fingers and instrumental texture responses

Run	Component 1: Breadcrumbs (%)	Component 2: Textured soy protein (%)	Component 3: Pectin (%)	Response 1: I. Hardness	Response 2: I. Cohessiveness	Response 3: I. Springiness	Response 4: I. Gumminess	Response 5: I. Chewiness
1	9.90	4.90	1.20	25.31	0.65	0.22	15.21	18.65
2	9.80	5.60	0.60	22.34	0.63	0.2	13.25	16.32
3	8.80	6.00	1.20	26.23	0.64	0.23	15.14	17.98
4	10.35	5.35	0.30	28.33	0.66	0.22	14.90	18.12
5	11.00	5.00	0.00	27.25	0.71	0.21	14.85	18.65
6	11.00	3.80	1.20	24.64	0.59	0.21	13.65	17.89
7	8.80	6.00	1.20	29.55	0.62	0.23	15.32	18.55
8	11.00	4.40	0.60	18.61	0.43	0.17	12.65	15.32
9	10.00	6.00	0.00	17.56	0.45	0.18	12.98	14.89
10	11.00	5.00	0.00	25.66	0.59	0.21	13.54	17.21
11	9.90	4.90	1.20	29.35	0.56	0.24	15.98	17.98
12	10.60	4.50	0.90	17.91	0.5	0.18	12.42	14.65
13	9.40	6.00	0.60	25.73	0.56	0.19	14.14	15.21
14	11.00	3.80	1.20	23.52	0.54	0.18	13.98	14.65

*The 3 mixture components, breadcrumb, textured soy protein and pectin, made up a total of 16% of the actual formulation, with the complement being fish mince (75%), fresh onion (2.9%), fresh garlic (1%), salt (1.3%), spices (0.3%), dried parsley (1%) and vegetable oil (2.5%) used to make up 100% of the formulation.

intensity of each attribute using an unstructured scale was adapted and modified from Shaviklo *et al*. (2010) and Kasapis (2012). All sample observations were conducted according to general guidance of ISO for the design of test rooms (ISO, 1988). Fresh/thawed prototypes were heated for sensory evaluation by putting them in a hot-air oven (Convotherm OEB/OGB, Eglfing, Bavaria, Germany) at 270 ± 2˚C for 3 min. All prototypes were coded with 3-digit random numbers and presented to the panellists on a tray in individual booths. Orders of serving were completely randomized in duplicate. Water was provided between evaluations to cleanse the palate. The panellists evaluated the samples without information about the storage time and product types, using the list of sensory lexicon developed during training and above mentioned protocol. They were asked to evaluate each sample by deep sniffing alone and then by consuming the test sample. They rinsed their mouths with water after tasting each sample and they were asked to rest 2-3 minutes between 2 evaluations (Shaviklo and Rafipour, 2012). Sensory properties of the formulated fish fingers during 6-month storage at -18 ºC were evaluated with 1 month intervals.

The TPA was carried out using a texture analysis machine (Stable Micro System, Model TA-XT2, Texture Expert, Surrey, UK), operating software Texture Expert. The prototypes were equilibrated to room temperature for 2 h prior to the texture measurement. Fish fingers were subjected to two cycle compression at 50% compression using the texture analyzer with a 70 mm TPA compression plate attachment moving at a speed of 127 mm/min (Bourne, 1978; Bryant *et al*., 1995; Cheret *et al*., 2005). The profile analysis was considered hardness (N), cohesiveness, springiness, gumminess and chewiness. Each analysis was carried out in 3 replicates. Hardness was defined by peak force during the first compression cycle. Cohesiveness was calculated as the ratio of the area under the second curve to the area under the first curve. Springiness was defined as a ratio of the time recorded between the start of the second area and the second probe reversal at the time recorded between the start of the first area and the first probe reversal. Chewiness was obtained by multiplying hardness, cohesiveness and springiness. Gumminess was obtained by multiplying hardness and cohesiveness. Adhesiveness was the negative area under the curve obtained between cycles (Pons and Fizsman, 1996; Meullenet *et al*., 1998). Cohesiveness, springiness, gumminess, and chewiness do not have units.

Experimental design and statistical analysis

Statistical software package Design-Expert (version 7.0.0, State-Ease, Minneapolis, MN, USA) was applied to construct as well as to analyze the design. A 3-component D-optimal Mixture Design (Oliveria *et al*., 1995; Cunha *et al*., 1997) was applied to optimize the mixture components. A mixture experiment is a special type of response surface experiment in which the factors are the components of a mixture and the response is a function of the proportions of each ingredient. The mixture components consisted of breadcrumbs (X1), TSP (X2), and pectin (X3). With 3 components, the experimental region is a triangle where each of the three vertexes corresponds to a mixture that is made up of a pure component. The upper and lower boundaries of the high-impact ingredients in the mixture were 8.8 - 11.0% breadcrumbs (X1), 3.6-8.0% TSP (X2), and 0.0 - 1.2% pectin (X2), which added up to a total of 16% of the mixture design. Other ingredients which made up a total of 84% of the actual formulation were: silver carp mince (75%), fresh onion (2.9%), fresh garlic (1.0%), salt (1.3%), spices (0.3%), dried parsley (1.0%) and vegetable oil (2.5%). Accordingly, 14 representative recipes (1-14) were prepared (Tables 2 & 3). Means and standard deviations (SD) were calculated for sensory, instrumental, and chemical compositions data using the statistical program NCSS 2007 (NCSS, UT, USA). The program was used to calculate multiple comparisons using Duncan's test to determine if the prototypes were different. Significance of difference was defined at the 5% level. Pearson correlation coefficients were also generated to describe the relationship between TPA parameters, and sensory characteristics using linear regression and correlation procedure. Dependent variables included softness, cohesiveness, juiciness, adhesiveness, chewiness and overall palatability and TPA parameters of hardness, cohesiveness, springiness, gumminess and chewiness, were independent variables. PanelCheck software (version V1.3.2, Matforsk, Ås, Norway) was applied to monitor panellists performance and to analyse sensory data using principal component analysis (PCA).

Results and Discussion

Chemical compositions

Silver carp mince used for product development contained 17.3% protein, 78.8% moisture, 2.8% fat, and 1.1% ash. No significant difference was found in proximate compositions of existing and formulated products (Table 4). TVBN and peroxide values of fish fingers increased during storage (Table 5). The increase was significant among storage times not among the prototypes. Peroxide value for formulated fish finger containing 0.6% pectin was lower than that observed for the existing product and the formulated product containing 0.3% pectin. However, until 6-month storage the TVBN and peroxide values were lower than the standard limits for formulating seafood products (20 mg/100 gN TVBN & 5 meq/kg peroxide) (Shaviklo and Rafipour, 2012). Low

Table 4. Proximate analysis (%) of silver carp mince and fingers

Sample	Protein	Moisture	Fat	Ash	Carbohydrate
Silver carp mince	17.26±1.21^{a}	78.81±0.91^{a}	2.82±0.32^{b}	1.11±0.10^{b}	0.0^{b}
Existing fish finger (control)	13.01±0.51^{b}	59.32±1.01^{b}	7.02±0.21^{a}	3.33±0.17^{a}	17.43±0.87^{a}
Formulated Fish finger (1)	13.23±0.43^{b}	59.51±0.96^{b}	6.90±0.14^{a}	3.12±0.30^{a}	17.32±0.51^{a}
Formulated Fish finger (2)	13.54±0.62^{b}	59.60±0.77^{b}	7.11±0.53^{a}	3.01±0.28^{a}	16.83±0.49^{a}

Values are means of 3 analyses. Different Superscripts denote significant differences within a column ($p < 0.05$). (1): Mixture 1 containing 5.35% TSP, 10.35% breadcrumbs and 0.3% pectin; (2): mixture 2 containing 4.8% TSP, 10.6% breadcrumbs and 0.6% pectin.

Table 5. TVBN and proxide values of fish fingers during 6-month storage at -18°C

Parameters		M0	M1	M2	M3	M4	M5	M6
TVBN (mg N/100 g)								
Existing fish finger (control)	**	13.6±0.11^{d}	13.8±0.49^{d}	14.9±0.81^{c}	15.8±0.88^{c}	17.2±0.87^{b}	18.4±0.69^{ab}	19.2±0.87^{a}
Formulated Fish finger (1)	***	14.1±0.13^{d}	14.0±0.60^{d}	14.7±0.76^{c}	16.1±0.61^{c}	16.8±0.91^{b}	17.7±0.81^{a}	18.3±0.76^{a}
Formulated Fish finger (2)	**	13.9±0.98^{d}	14.2±0.56^{d}	15.4±0.87^{c}	16.8±0.75^{c}	17.2±0.78^{b}	18.8±0.95^{a}	19.0±0.71^{a}
		NS	NS	NS	NS	NS	NS	NS
Peroxide value (meq/ kg)								
Existing fish finger (control)	**	0.0^{e}	0.0^{e}	0.51±0.10^{d}	1.11±0.11^{c}	2.01±0.15^{b}	2.61±0.21^{b}	4.71±0.34^{aA}
Formulated Fish finger (1)	*	0.0^{f}	0.0^{f}	0.42±0.08^{e}	0.93±0.05^{d}	1.84±0.17^{c}	2.22±0.17^{b}	3.61±0.21^{aA}
Formulated Fish finger (2)	***	0.0^{f}	0.0^{f}	0.39±0.06^{e}	0.85±0.07^{d}	1.49±0.21^{c}	1.85±0.16^{b}	2.02±0.28^{aB}
		NS	NS	NS	NS	NS	NS	**

Values are means of 3 analyses. Different lower-case letters in the same row denote the significant differences. Different upper-case letters in the same column denote significant differences between products. ($^{*}p < 0.05$, $^{**} < 0.01$, $^{***} < 0.001$). M0-M6 indicates storage months. NS, not significant ($p > 0.05$). (1): Mixture 1 containing 5.35% TSP, 10.35% breadcrumbs and 0.3% pectin; (2): mixture 2 containing 4.8% TSP, 10.6% breadcrumbs and 0.6% pectin.

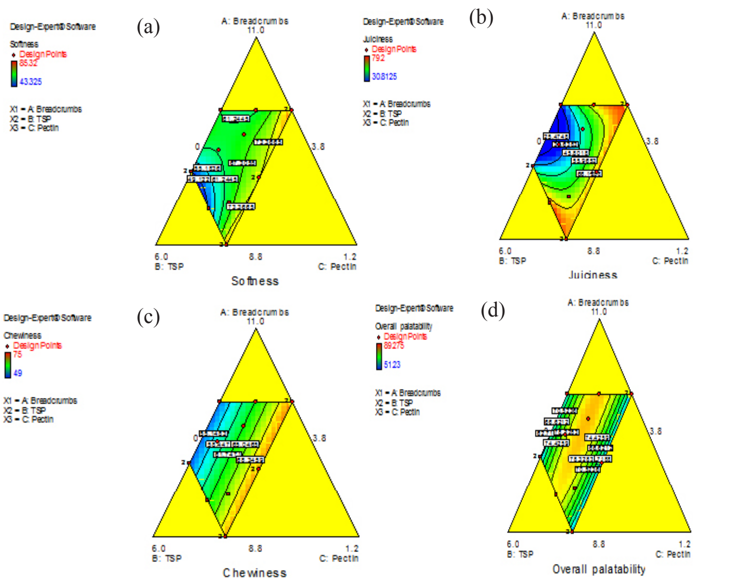

Figure. 1. Mixture response surface contour plots displaying the combined effect of TSP, breadcrumbs and pectin on sensory texture profile. (a) softness; (b) juiciness; (c) chewiness; (d) overall palatability.

Table 6. Correlation coefficient between instrumental texture data (x) and sensory texture data (y)

Dependent variables (sensory data)	Independent variables (instrumental texture) Hardness	Cohesiveness	Springiness	Gumminess	Chewiness
Softness	0.52±0.05	0.35±0.01	0.50±0.04	0.55±0.05	0.34±0.02
Cohesiveness	0.58±0.03	0.45±0.03	0.53±0.02	0.68±0.03	0.35±0.04
Juiciness	0.74±0.05	0.58±0.05	0.67±0.01	0.77±0.06	0.49±0.04
Adhesiveness	0.67±0.03	0.57±0.04	0.64±0.02	0.72±0.04	0.43±0.02
Chewiness	0.43±0.05	0.29±0.02	0.40±0.03	0.55±0.03	0.17±0.01
Overall palatability	0.74±0.04	0.57±0.05	0.71±0.06	0.77±0.07	0.82±0.06

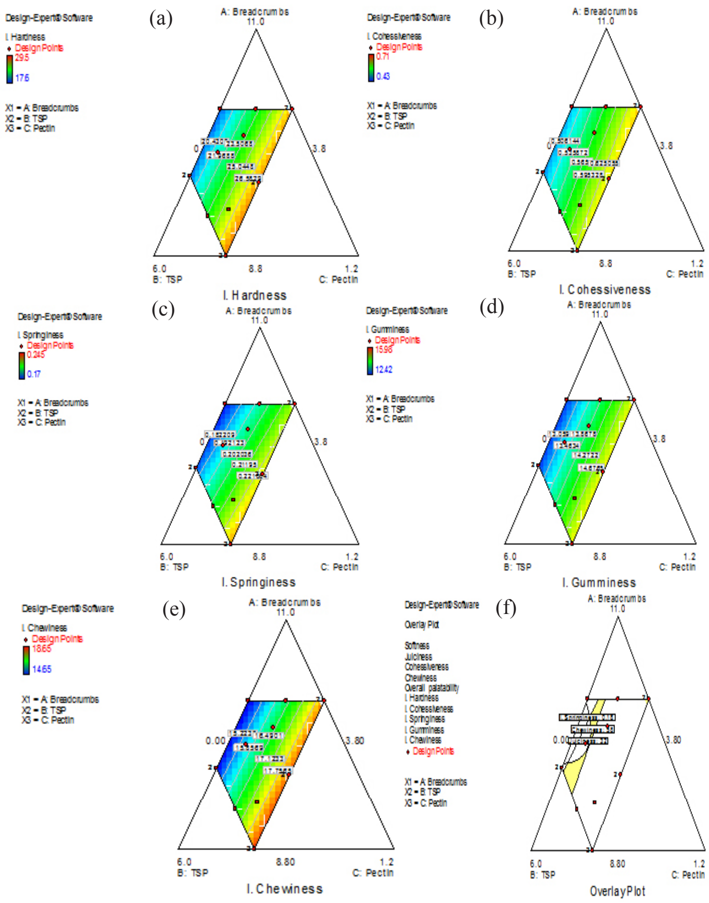

Figure 2. Mixture response surface contour plots displaying the combined effect of TSP, breadcrumbs and pectin on instrumental texture profile. Overlay plot indicates the optimum region (left side of the contour) with the optimum scores of sensory and instrumental texture profiles. (a) hardness; (b) cohessiveness; (c) gumminess; (d) springiness; (e) chewiness; (f) overlay plot

TVBN and peroxide values denote the stability of the prototypes against spoilage and oxidation due to freezing storage and eliminating oxygen (Fawzya *et al.*, 1996) which is an important issue in seafood processing and quality control (Plavsic *et al.*, 2010; Shaviklo and Rafipour, 2012). Although pectin is believed to play an important role as food thickening agent, its role as an antioxidant was rarely reported. It is reported that the pectin can be applied for a natural antioxidant in food, or as an antioxidant food (Du *et al.*, 2009). This may explain the lowest content of peroxide value of the prototype with 0.6% pectin.

Texture analysis

The experimental design with independent variables and the related observed sensory and instrumental responses for the fish finger prototypes are given in Tables 2 and 3. Significant differences were found for softness, juiciness, chewiness and overall palatability. Mixture response surface contour plots (Figure 1) display that the three independent factors, affect sensory properties of fish fingers significantly. As the level of TSP, breadcrumbs and pectin increased, the softness, juiciness and overall palatability of the product decreased (Figures 1 a, b, d) and chewiness increased (Figure 1 c). Significant differences were also observed for instrumental hardness, cohesiveness, gumminess, springiness and chewiness. Mixture response surface contour plots (Figure 2), indicates that the understudy mixtures influenced the TPA characteristics. All parameters were increased by increasing the ratio of TSP, breadcrumbs and pectin (Figures 2 a-e). The Pearson correlation coefficients in Table 6 indicate the strength of correlations between sensory attributes and instrumental parameters while developing polynomial functions for predicting sensory profile from instrumental data (Moskowitz, 1993; Coelho *et al.*, 2007). As expected, sensory attributes including softness, cohesiveness, juiciness, adhesiveness, chewiness and overall palatability are well correlated with TPA parameters (Table 6). However, cohesiveness, and chewiness, gives low degrees of correlation. This could be due to difficulties in quantifying those parameters in sensory profiling, or to the need for improved methods of quantifying them in instrumental profile (Drake *et al.*, 1999; Coelho *et al.*, 2007). The results are in agreement with the other works (Li *et al.*, 1998; Coelho *et al.*, 2007; Carlos *et al.*, 2009). To obtain the optimum region, an overlay plot was provided using the low and high scores of sensory and instrumental responses. The optimum region (contour's left side in Figure 2f) was obtained from the software (Design-Expert) calculation. It consists of 2 mixtures containing 5.35% TSP, 10.35% breadcrumbs and 0.3% pectin; and 4.8% TSP, 10.6% breadcrumbs and 0.6% pectin. The formulated products containing optimized mixtures were developed and stored frozen to study quality changes and to select the best prototype.

Scores for instrumental textural parameters of existing and formulated fish fingers during 6-month storage are presented in Table 7. Hardness, cohesiveness and springiness of formulated fish finger (mixture 1) and existing product were changed significantly during 6-months storage at -18°C.

Table 7. Average instrumental texture profile for fish finger prototypes stored for 0-6 months at -18°C

Parameters		M1	M2	M3	M4	M5	M6
Hardness							
Existing fish finger (control)	*	20.31±1.03^{bA}	19.45±1.23^{bA}	20.68±1.98^{bA}	21.02±2.87^{bB}	17.03±0.97^{bB}	16.23±0.85^{bB}
Formulated Fish finger (1)	**	23.32±1.45^{bA}	22.42±.01^{bA}	23.68±2.34^{bA}	24.12±1.78^{bA}	23.01±1.56^{bA}	20.68±1.34^{bB}
Formulated Fish finger (2)	NS	28.32±2.11^{a}	28.12±2.45^{a}	27.92±2.54^{a}	29.02±1.78^{a}	29.68±1.65^{a}	28.94±2.04^{a}
		**	**	***	*	***	**
Cohesiveness							
Existing fish finger (control)	**	0.62±0.11^{bA}	0.64±0.09^{bA}	0.59±0.07^{bA}	0.54±0.09^{bA}	0.39±0.04^{bB}	0.40±0.08^{bB}
Formulated Fish finger (1)	*	0.71±0.06^{bA}	0.64±0.08^{bA}	0.62±0.09^{bA}	0.53±0.05^{bB}	0.47±0.08^{bB}	0.43±0.07^{bC}
Formulated Fish finger (2)	NS	0.83±0.08^{a}	0.80±0.07^{a}	0.82±0.06^{a}	0.79±0.08^{a}	0.80±0.09^{a}	0.78±0.07^{a}
		*	***	**	***	**	**
Springiness							
Existing fish finger (control)	***	0.49±0.19^{cA}	0.44±0.11^{cA}	0.48±0.09^{bA}	0.39±0.03^{cB}	0.31±0.14^{cB}	0.28±0.03^{cB}
Formulated Fish finger (1)	**	0.62±0.09^{bA}	0.62±0.05^{bA}	0.55±0.04^{bA}	0.56±0.15^{bA}	0.51±0.06^{bA}	0.43±0.07^{bB}
Formulated Fish finger (2)	NS	0.78±0.04^{a}	0.75±0.04^{a}	0.80±0.07^{a}	0.77±0.05^{a}	0.74±0.08^{a}	0.70±0.06^{a}
		**	***	**	*	***	**
Guminess							
Existing fish finger (control)	NS	13.31±1.03^{b}	13.45±1.23^{b}	13.68±1.68^{b}	13.02±1.87^{b}	12.73±0.97^{b}	12.23±0.85^{b}
Formulated Fish finger (1)	NS	14.32±0.45^{b}	14.42±0.01^{b}	13.68±1.34^{b}	13.12±1.78^{b}	13.01±1.56^{b}	12.68±1.34^{b}
Formulated Fish finger (2)	NS	16.32±1.11^{a}	15.12±1.45^{a}	16.22±1.54^{a}	15.82±1.78^{a}	15.68±1.65^{a}	15.94±1.04^{a}
		**	**	*	**	***	*
Chewiness							
Existing fish finger (control)	NS	15.31±1.03^{c}	15.45±1.21^{c}	15.18±1.98^{c}	14.82±1.87^{c}	14.33±0.97^{c}	14.23±0.85^{c}
Formulated Fish finger (1)	NS	17.32±1.35^{b}	17.42±.51^{b}	17.08±1.34^{b}	16.82±1.74^{b}	16.61±1.51^{b}	15.68±1.14^{b}
Formulated Fish finger (2)	NS	19.32±1.11^{a}	20.12±1.35^{a}	18.92±1.34^{a}	18.62±1.78^{a}	18.08±1.35^{a}	17.94±1.04^{a}
		***	***	**	**	***	*

Values are means of two duplicate evaluations by the 10-member sensory panel. Different lower-case letters in the same column denote significant differences between products. Different upper-case letters in the same row indicate significant difference during storage time (* $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$). M0–M6 indicates storage months. NS, not significant ($p > 0.05$). (1): Mixture 1 containing 5.35% TSP, 10.35% breadcrumbs and 0.3% pectin; (2): mixture 2 containing 4.8% TSP, 10.6% breadcrumbs and 0.6% pectin.

Table 8. Average sensory scores (scale: 0-100) for fish finger prototypes stored for 0-6 months at -18°C

		M0	M1	M2	M3	M4	M5	M6
Softness								
Existing fish finger (control)	*	51.26^{bA}	53.21^{Ab}	58.13^{bA}	48.63^{bA}	50.31^{Ab}	40.13^{bB}	37.52^{bB}
Formulated Fish finger (1)	NS	60.32^{a}	63.43^{a}	56.31^{a}	59.52^{a}	55.76^{a}	59.37^{a}	53.98^{a}
	NS	66.25^{a}	69.65^{a}	60.32^{a}	59.28^{a}	60.47^{a}	58.45^{a}	56.74^{a}
		**	*	*	*	*	*	*
Cohesiveness								
Existing fish finger (control)	**	32.19^{bA}	34.21^{bA}	30.75^{bA}	29.62^{bA}	30.29^{bA}	24.54^{bAB}	19.32^{bB}
Formulated Fish finger (1)	NS	34.16^{b}	37.47^{b}	33.54^{b}	38.12^{b}	29.25^{b}	30.36^{b}	27.23^{b}
Formulated Fish finger (2)	NS	46.25^{a}	42.34^{a}	48.47^{a}	39.28^{a}	41.09^{a}	38.74^{a}	39.28^{a}
		***	**	**	*	***	**	**
Juiciness								
Existing fish finger (control)	*	30.81^{bA}	29. 65^{bA}	32.83^{bA}	31.02^{bA}	28.65^{bA}	22.47^{bA}	18.75^{B} 1^{b}
Formulated Fish finger (1)	NS	37.51^{b}	35.32^{b}	39.41^{b}	37.51^{b}	30.54^{b}	32.45^{b}	29.47^{b}
Formulated Fish finger (2)	NS	54.23^{a}	52.45^{a}	56.41^{a}	50.57^{a}	48.41^{a}	49.25^{a}	47.33^{a}
		**	*	***	*	**	**	***
Adhessiveness								
Existing fish finger (control)	NS	32.19^{b}	30.13^{b}	34.02^{b}	29.11^{b}	30.65^{b}	27.45^{b}	28.34^{b}
Formulated Fish finger (1)	NS	34.21^{b}	35.32^{b}	32.25^{b}	36.21^{b}	29.87^{b}	30.56^{b}	27.26^{b}
Formulated Fish finger (2)	NS	47.12^{a}	50.23^{a}	49.19^{a}	43.41^{a}	45.62^{a}	39.17^{a}	40.42^{a}
		*	**	***	**	***	**	*
Chewiness								
Existing fish finger (control)	**	52.09^{bA}	50.23^{bA}	51.21^{bA}	47.54^{bA}	44.09^{bA}	46.23^{bA}	38.79^{bB}
Formulated Fish finger (1)	***	54.32^{bA}	57.02^{bA}	51.24^{bA}	53.54^{bA}	47.76^{bA}	44.43^{bA}	40.37^{bB}
Formulated Fish finger (2)	NS	63.87^{a}	66.02^{a}	59.54^{a}	63.67^{a}	60.34^{a}	57.32^{a}	54.17^{a}
		**	*	**	**	***	*	**
Overall palatability								
Existing fish finger (control)	***	66.52^{cA}	64.54^{cA}	67.32^{cA}	61.23^{cA}	58.43^{cA}	56.12^{cA}	47.43^{cB}
Formulated Fish finger (1)	NS	78.51^{b}	75.45^{b}	71.89^{b}	73.43^{b}	70.24^{b}	71.61^{b}	69.23^{b}
Formulated Fish finger (2)	NS	89.75^{a}	91.76^{a}	85.67^{a}	82.32^{a}	84.65^{a}	81.23^{a}	80.11^{a}
		***	***	**	**	***	*	**

Values are means of two duplicate evaluations by the 10-member sensory panel. Different lower-case letters in the same column denote significant difference among products. Different upper-case letters in the same row indicate significant difference during storage time (* $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$). M0–M6 indicates storage months. NS, not significant ($p > 0.05$). (1): Mixture 1 containing 5.35% TSP, 10.35% breadcrumbs and 0.3% pectin; (2): mixture 2 containing 4.8% TSP, 10.6% breadcrumbs and 0.6% pectin.

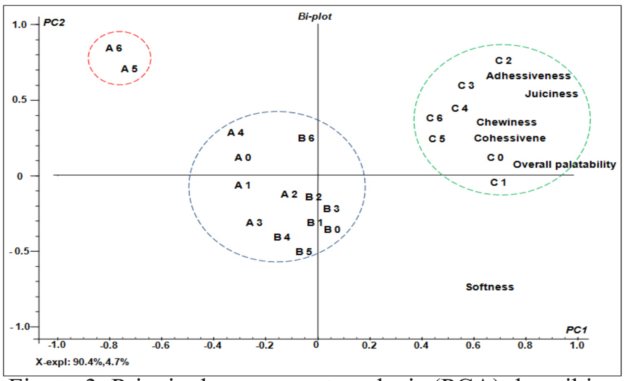

Figure 3. Principal component analysis (PCA) describing sensory quality scores of fish fingers stored 6 months at -18˚C as evaluated by a trained sensory panel. (A) existing product (control). (B) formulated fish finger containing mixture with 0.3% pectin. (C) formulated fish finger containing mixture with 0.6% pectin. Numbers 0 to 6 indicate storage months.

Gumminess and chewiness of all prototypes did not change during storage. TPA parameters of formulated fish finger containing 0.6% pectin were stable during storage and this prototype was significantly different from the control and formulated fish finger with 0.3% pectin (Table 7).

Results from the analysis of variance (ANOVA) of 6 sensory attributes (softness, juiciness, adhesiveness, cohesiveness, chewiness and overall palatability) rating of the existing and the formulated fish fingers during 6-month storage summarized in Table 8. The intensity of each sensory attributes in all fish fingers except existing product (control) did not change significantly during 6-months storage at -18°C. Significant differences were only found between formulated fish fingers containing 6% pectin and the control and formulated fish fingers with 0.3% pectin in softness, cohesiveness, juiciness, adhesiveness, chewiness and overall palatability (Tables 8). Human perception of palatability of formulated products is derived from a complex interaction of sensory and physical processes during chewing (Meilgaard *et al*., 2007). Of the various subjective characteristics determining seafood palatability, juiciness is the most important (Jeremiah, 1982). However, the effect of storage and product on sensory attributes can be seen on the PCA in Figure 4 which explains 95.1% of the variation in the data. The control (A) and formulated fish finger (B) are located in the centre of the plot indicating sensory similarities between these prototypes. Formulated fish finger (C) was characterized by adhesiveness, cohesiveness, juiciness, chewiness parameter, and overall palatability thus demonstrated on the upper right side of the plot, and differs from the other two prototypes analysed by being apart from each other, on the right quadrant (Figure 3).

The observed changes in sensory and instrument properties of control and pectin contained samples also may reveal different behaviour of pectin, proteins and water in the different structure (Noel *et al*., 2007). Covalent protein-pectin interactions have been induced between protein and pectin, improving the functional properties of some proteins 'i.e' gelling, solubility, emulsifying and foaming properties (Sych *et al*., 1990; Mishra *et al*., 2001). Pectin-pectin interactions are also responsible for the improvement of textural properties (Barrera *et al*., 2002). However, the decrease in the textural properties might be associated with an increase in pectin-water interactions, inducing the swelling of the pectin and causing a disruptive effect on the gel structure (Uresti *et al*., 2003).

Conclusions

Reformulating of the existing silver carp fingers to improve textural properties indicated that the intended mixtures could influence the textural properties of the prototypes. applying pectin in the fish finger formulation improved texture properties and palatability of the prototypes. Texture parameters obtained by instrumental methods were strongly correlated with those obtained from sensory analysis. Formulated fish finger containing 0.6% pectin denoted the most stability and palatability scores during storage. Since, formulated fishery products are among the popular RTE food with a long history of manufacturing. Therefore, reformulating of the existing products to improve sensory attributes is a useful approach to stay on the market. However, the success of a new product involves coordinated efforts between various departments at a food processing plant (Hathwar *et al*., 2012).

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