IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 12, Issue 3 Ver. II (March. 2018), PP 11-16
www.iosrjournals.org

Instrumental Texture Profile Analysis (ITPA) of red tilapia mince gel (*Oreochromis sp*.) added with chitosan and phosphate salts

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Abstract: *Red tilapia surimi gels (directly heated and kamaboko gels) containing 0.4-2.0% (w/w) chitosan and 0.05-1.0% (w/w) sodium tripolyphosphate were evaluated for textural characteristics and colour. Irrespective of setting temperature, 1.2% chitosan added gels exhibited highest gumminess and hardness whereas 0.4% addition resulted into more elastic gels in both type and highest whiteness in kamaboko gel. In both gels, TPP addition up to 0.1% resulted into harder gels whereas springiness was slightly increased in kamaboko gels but no affect was observed in directly heated gels. In kamaboko gels, highest cohesiveness was obtained in gels with 1% TPP. In kamaboko gel, Highest L value was observed in kamaboko gels containing 0.1% TPP addition ($p<0.05$). Addition of 0.4% chitosan improved gel colour. In contrast, in directly heated gels, the addition of TPP either decrease or did not exhibit any effect on lightness, yellowness or whiteness of gels. High lightness and high whiteness was exhibited by gels with 0.8% and 1.6% addition of chitosan, respectively, in directly heated gels. The combination of additives and gelling treatment appeared to offer increased technological possibilities with improved textural characteristics and colour in the gelled product.*

Key words: *red tilapia, mince gel, textural properties, colour, chitosan, TPP*

Date of Submission: 21-03-2018 Date of acceptance: 07-04-2018

I. Introduction

The development of traditional as well as fabricated foods derived from surimi-a concentrated myofibrillar protein are attributed to the fish structural proteins. Its unique gelling properties make it useful as food base in seafood analogues [1]. Gelation of fish paste in presence of additional polymeric materials reduces the critical concentration of protein needed for gelation of the primary gelling agent. Gelation is either inhibited or enhanced and the texture of a gel can be very different from gels formed by single components [2].

Use of chitosan as additives has been shown to increase gel strength to low quality surimi of walleye Pollock [3]; prevent lipid oxidation in fish gel either alone [4,5] and/or in combination with microbial TGA in pressure induced gel of mackerel [6]; improve texture [1] and gelling properties [7]. The concentration and the degree of acetylation in chitosan plays major role in exerting the lipid oxidation in fish gels.

Phosphates have been widely accepted as potential additives in fish and sea food to improve the functional properties by increasing the water holding of the gel as well as better solubilization of myofibrillar proteins [8]. Phosphates in combination with calcium chloride, has been reported to increase gel strength in bigeye snapper surimi by increasing the water holding capacity of surimi gel [9].

Freshwater aquaculture can make a significant contribution to bridging the widening gap between demand and supply of fishery products in Asia, in the face of declining capture fisheries production and growing population. Among the cultured freshwater fishes, Tilapia aquaculture is rapidly growing worldwide with an annual production exceeding 1,526,188 metric tons (mt) in 2003 [10]. Despite of its large production, utilization of tilapia fish mince and washed mince is rather limited. The information regarding gelling properties of tilapia meat mince added with various functional additives is needed to develop sea-food base analogues. The present study aimed to investigate the effect of chitosan and sodium tripolyphosphate (TPP) on the gelling properties of fish mince from red tilapia, a species extensively cultured in Malaysia.

II. Materials and methods

Materials

Live red tilapia (*Oreochromas sp*) weighing about 500 g was purchased from a local retail market in Selangor, Malaysia. Fishes were headed, gutted and washed. Skin and bones were removed with a deboning machine (Ban Hing weight and measure, Kuala Lumpur, Malaysia) with a drum having 4 mm diameter perforations. The washed mince meat was packed in polyethylene bags and stored in the freezer (-20°C) until needed. Commercial chitosan (low molecular weight, 75-85% deacetylation) was obtained from Aldrich. Sodium tripolyphosphate (technical grade, 85%) was supplied by Sigma-Aldrich Company (USA).

Mixing of additives and mince gel preparation

For the preparation of gel, the frozen mince meat was thawed at room temperature and the moisture content of the mince was adjusted to 80% [11]. The fish mince (50 g) was placed in a chilled mortar and mixed with 2.5% NaCl for 4 min using a pestle. Chitosan was added at concentrations of 0.4-2.0% (w/w) and sodium tripolyphospate was added at concentration of 0.05-1.0% (w/w). The respective mixture was then chopped for 5 min at 4°C in a Waring blender to obtain a homogeneous sol. Directly heated gels were prepared by heating the sol at 90°C for 20 min while kamaboko gels were prepared by incubating the sol at 40°C for 30 min, followed by heating at 90°C for 20 min. [9]. Both types of gels were cooled in iced bath for 15 min and stored at 4°C for 24 hour prior to analysis.

Instrumental Textural profile analysis (ITPA)

Kamaboko and directly heated gels were evaluated in three replicate cylinders (2 cm in diameter and height). Texture Profile Analysis (TPA) was carried out using the TA-XT2 texture analyzer (Stable Microsystems, Surrey, England) attached with 5 kg load cell and at a test speed of 2.0 mm/sec. Texture Expert (Version 1.17) computer program by Stable Micro System (Surrey, England) was used for data collection and profile output. Samples were subjected to 75% deformation with a 50 mm diameter Aluminum cylinder probe (P/50). The texture parameters obtained from TPA curves were hardness (kg), adhesiveness (g cm), cohesiveness (dimensionless), gumminess (kg) and springiness (mm).

Colour measurement

Surimi gel color was determined using a Minolta Chromameter (model CR- 300, Minolta Co., Ltd., Osaka, Japan). L (lightness), a (redness/greenness) and b (yellowness/blueness) were measured and whiteness was calculated as described by [12] as follows:

$$\text{Whiteness} = 100- [\{100-L^*\}^2 + a^{*2} + b^{*2}]^{1/2}$$

Statistical analysis

Mean values from the three measurements for TPA samples were analyzed using SAS package Version 8.2 [13]. For the degree of variation and significance of difference, it was based on the analysis of variance (ANOVA) to determine if significant differences ($p \leq 0.05$) existed between treatments.

III. Results and discussion

Textural Properties

Fig 1(a-d) shows the effect of chitosan on the textural properties of kamaboko (K) and directly heated gels (DH). From the result, hardness of the kamaboko gel from tilapia mince was found to be 58.10 % greater than that of directly heated gels. Similar observation was made by [14] where 47.17% increase of breaking force was observed/found for kamaboko gel than that of directly heated gels from sardine (*Sardinella gibbosa*).

Irrespective of gel type, 1.2% addition of chitosan produce harder gels and 0.4% addition produce more elastic gels. Further increase in concentration did not increase the gel elasticity. Chitosan addition was found to have no affect on the gel cohesiveness in kamaboko and significantly increased with 0.4% addition. 1.2% chitosan addition gave highest gumminess, value for both types of gels. Mao and Wu [7] also reported higher hardness, chewiness and springiness values in kamaboko gels made with grass carp at concentration of 1% chitosan. Other authors have also reported that 1-1.5% chitosan can enhance heat-induced gel formation, increasing gel strength of surimi in low quality walleye Pollock surimi gels [3] and surimi from barred garfish [15]. In this study, chitosan addition was found to have no affect on the gel cohesiveness in both types. In case of gumminess, chitosan addition caused increased value for both types of gels except for 1.6% and 2.0% in directly heated gels.

In chitosan added kamaboko gels, significant correlation was found in hardness and cohesiveness values ($r=0.897$, $p<0.05$) and moderate positive correlation with gumminess ($r=0.741$, $p>0.05$) and springiness($r=0.500$, $p>0.05$). Springiness also moderately correlated with cohesiveness ($r=0.460$, $p>0.05$) and gumminess($r=0.354$, $p>0.05$). Higher degree correlation was found between cohesiveness and gumminess($r=0.897$, $p<0.05$).

In directly heated gels with added chitosan, hardness value was highly correlated with cohesiveness ($r=0.888$, $p<0.05$) and gumminess ($r=0.876$, $p<0.05$) and moderately correlated with springiness ($r=0.632$, $p>0.05$). Springiness also highly correlated with cohesiveness($r=0.823$, $p<0.05$) and moderately correlated with gumminess ($r=0.747$, $p>0.05$). High degree correlation was found between cohesiveness with gumminess ($r=0.981$, $p<0.01$).

Addition of 0.05% and 0.1% TPP did not show any significant affect on gel hardness ($p<0.05$) (Fig. 2(a-d). At 0.05% level, Julavittayanukul et al. [9] also found no effect on breaking force or hardness of kamaboko gels for bigeye snapper. Addition of 0.4% TPP resulted into harder gels and no improvement was noticed upon further addition. TPP addition had no affect on springiness in kamaboko gels and was increased after 1% addition in directly heated gels. For bigeye snapper kamaboko gels, only 0.05% TPP addition caused increase in deformation [9]. Both cohesiveness and gumminess in kamaboko gel varied significantly from control with 1% addition of TPP. Cohesiveness increased significantly in gels added with 1% TPP only whereas gumminess increased significantly with the addition 0.1% to 0.7% TPP ($p<0.05$) in directly heated gels.

Correlation among TPA parameters was found different in case of TPP addition in kamaboko gels. Hardness value was moderately correlated with gumminess($r=0.540$, $p>0.05$). and cohesiveness($r=0.317$, $p>0.05$); whereas negative correlation was observed with springiness ($r=-0.102$, $p>0.05$). Moderate correlation was found between springiness and cohesiveness ($r=0.591$, $p>0.05$) as well as springiness and gumminess($r=0.579$, $p>0.05$). Gumminess was highly correlated with cohesiveness($r=0.947$, $p<0.01$) when TPP was added in kamaboko gels.

In directly heated gels added with TPP, moderate correlation between hardness and springiness ($r=0.588$, $p>0.05$), hardness and gumminess ($r=0.738$, $p>0.05$) and gumminess and springiness($r=0.593$, $p>0.05$) were observed. Cohesiveness was negatively correlated with hardness ($r=-0.298$, $p>0.05$), springiness($r=-0.694$, $p>0.05$) and gumminess($r=-0.605$, $p>0.05$).

Color measurement

Color of the products is one of the important factors in deciding their value. Table 1 and Table 2 show the effect of colour in kamaboko and directly heated gels of tilapia mince added with chitosan and TPP, respectively. Kamaboko gels added with chitosan exhibited highest L value (97.70-98.67) than TPP. However, no significant differences were observed when increased concentration of chitosan (0.4% to 2%) was added. Lowest yellowness was exhibited in chitosan added gels (1.52-5.39) than that of control (12.22). Gels containing 0.4% chitosan exhibited highest whiteness value than other concentrations. Even though, all values were higher than the control, further addition above 0.4% chitosan decreased gel whiteness in kamaboko gels (Table 1). Lightness (L) of directly heated gels increased by the addition of chitosan up to 1.6% and significant differences between gels with different concentration of chitosan were not observed. Yellowness (b) didn't affect by the addition of chitosan. Gel whiteness with 0.8% chitosan was highest of all the treatments. The whiteness of gels containing chitosan were not significantly different but was higher than that of TPP.

In kamaboko gels containing TPP, L value increased significantly up to 0.1% addition ($p<0.05$) after which the value didn't vary significantly between gels containing 0.4 to 1% TPP (Table 2). Yellowness had no effect by adding 0.05 and 0.1% TPP. Further addition of TPP from 0.4 to 1% caused decrease in yellowness ($p<0.05$). The concentration of TPP had no obvious effect on the whiteness of gels. In directly heated gels, addition of TPP didn't have any affect on lightness (L), yellowness (b) and whiteness of gels ($p>0.05$).

IV. Conclusion

In this study, kamaboko gels without additives exhibited better textural properties than that of directly heated gels. More elastic gel was obtained in gels containing 0.4% chitosan in kamaboko gel whereas for directly heated gels, 1.2% chitosan exhibited highest springiness. The results indicate that 0.4% chitosan addition in tilapia kamaboko gels can produce more elastic gel compared to gels without additives. In kamaboko gels, addition of 0.4% chitosan produced gel with high lightness, low yellowness and high whiteness. Addition of TPP showed no effect on gel whiteness. In contrast, in directly heated gels, high lightness and high whiteness was exhibited by 0.8% and 1.6% addition of chitosan, addition of TPP either decrease or did not have any effect of lightness, yellowness or whiteness of gels. Quality of red tilapia surimi gel would be improved by the addition of food grade additives. Chitosan seems to be the better than TPP used in this study.

Acknowledgements

The authors would like to acknowledge the facilities as well as scientific and technical assistance provided by the Faculty of Food Science and Technology, Universiti Putra Malaysia during this stud

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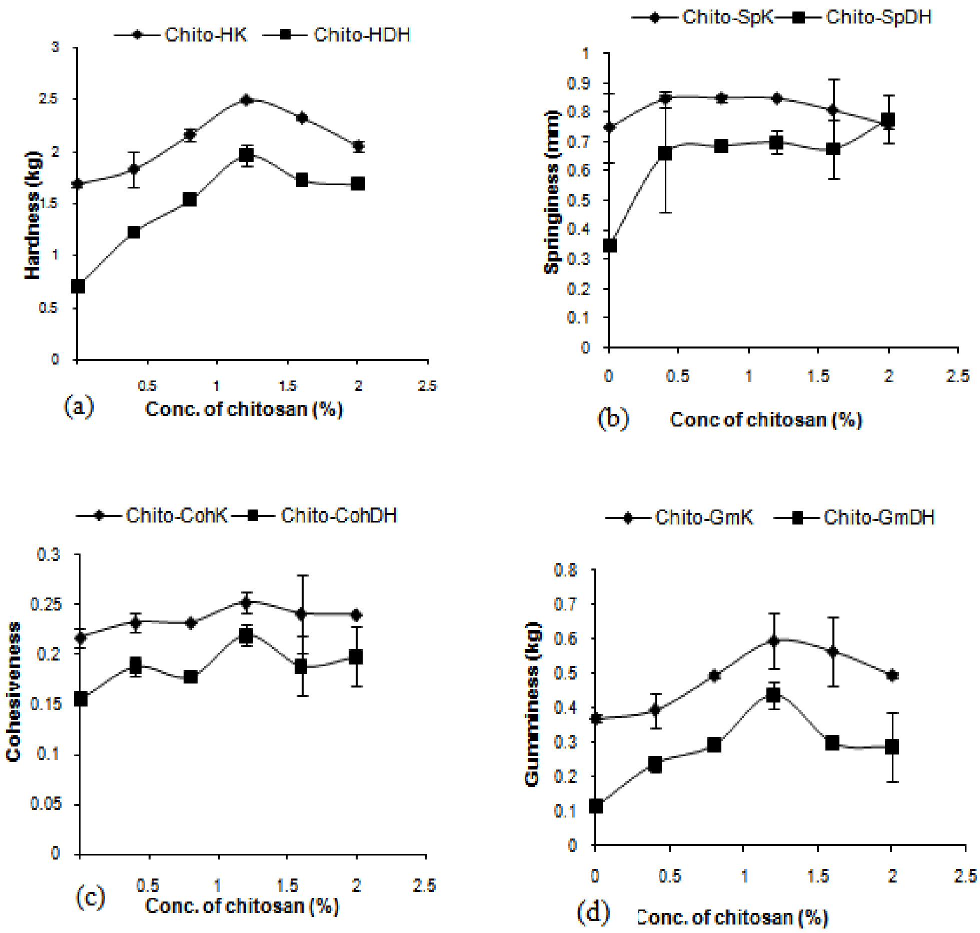

Fig 1. Effect of **chitosan** on the textural properties of kamaboko (K) and direct heated (DH) gels of red tilapia mince meat. (a) Hardness, (b) springiness (c) cohesiveness and (d) gumminess

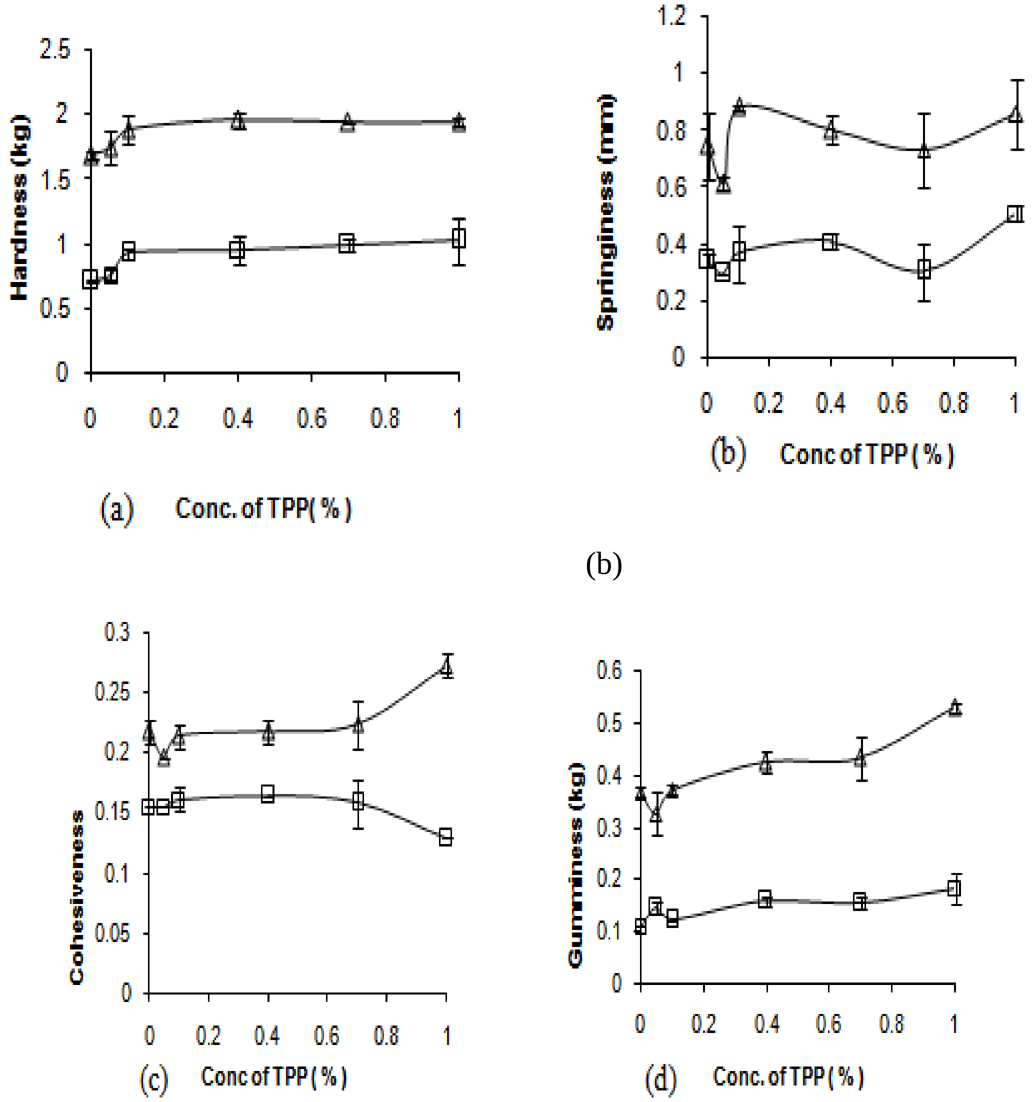

Fig 2. Effect of **TPP** on the textural properties of kamaboko (K) and direct heated (DH) gels of red tilapia mince meat. (a) Hardness, (b) springiness (c) cohesiveness and (d) gumminess

Table 1 Color L*, b* and whiteness values in kamaboko and directly heated gels of tilapia mince added with different concentration of chitosan.

Type of gel	Conc of Chitosan (%)	*L**	*b**	*Whiteness*
Kamaboko gel	0	74.49±4.48a	12.22±0.03a	71.67±4.01a
	0.4	97.74±0.09b	1.52±0.03b	97.27±0.09b
	0.8	98.33±0.06c	3.485±0.63c	96.02±0.53cb
	1.2	98.67±0.59dc	4.645±0.86dc	94.82±0.91db
	1.6	97.70±0.30ebc	5.39±0.03ed	94.10±0.09ed
	2	98.07±1.00fbc	4.45±0.37fc	95.07±0.05fc
Directly heated gel	0	78.02±0.47a	12.16±0.01a	74.88±0.42a
	0.4	95.85±0.02b	3.92±0.07b	94.28±0.04b
	0.8	97.64±0.24c	2.75±0.12c	96.32±0.07c
	1.2	95.20±0.05d	1.9±0.07d	94.82±0.02d
	1.6	98.17±0.06ef	4.185±0.09eb	95.42±0.07ef
	2	97.11±0.10fbc	2.765±0.63f	95.98±0.36fc

*Mean± SD from triplicate measurements

a-f Mean within a column with different alphabet denotes significant difference ($p<0.05$)

Table 2 Color L*, b* and whiteness values in kamaboko and directly heated gels of tilapia mince added with different concentration of TPP

Type of gel	Conc of TPP (%)	*L**	*b**	*Whiteness*
Kamaboko gel	0	74.49±4.48a	12.22±0.03a	71.67±4.01a
	0.05	80.40±0.55b	12.31±0.16a	76.85±0.38b
	0.1	80.35±0.36cb	12.2±0.01ba	76.86±0.30ab
	0.4	78.49±0.60ab	11.14±0.11c	75.75±0.48ab
	0.7	78.68±0.12a	11.71±0.34dc	75.65±0.06a
	1.0	78.52±0.14a	11.25±0.57ec	75.74±0.38ab
Directly heated gel	0	78.02±0.47a	12.16±0.01a	74.88±0.42a
	0.05	77.11±0.47a	10.96±0.21b	74.61±0.34ab
	0.1	79.61±0.18b	12.39±0.48cb	76.13±0.10ac
	0.4	79.55±0.59a	11.73±0.13dc	76.42±0.45ad
	0.7	77.87±0.16a	11.51±0.31ebd	75.04±0.28a
	1.0	77.67±0.27a	11.89±0.12fcd	74.69±0.29a

Mean± SD from triplicate measurements

a-f Mean within a column with different alphabet denotes significant difference ($p<0.05$)

Dr. Amal Kumar Ghosh. "Life and Environment – Sequence and Pre conditions." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 12.3 (2018): 11-16.