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Effects of egg white and sodium ascorbate on gelation properties of lesser sardine (*Sardinella* spp.) Surimi

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Abstract
Surimi is a stabilized myofibrillar protein concentrate that is blended with cryoprotectants for a longer frozen storage life. In the present study, the effects of egg white powder (EWP) and sodium ascorbate (SA); both individually and in combination at different levels on the gelation and sensory properties of gels from surimi of lesser sardine (*Sardinella spp.*) were analysed. The addition of EWP and SA affected both the gelation and colour characteristics of surimi. EWP was added at concentrations of 0.5%, 1%, 1.5% and SA at concentrations of 0.1%, 0.2% and 0.3% and in combinations: 0.5% EWP with 0.1 and 0.2% SA and 1% EWP with 0.1 and 0.2% SA. The addition of EWP significantly increased the gel strength (*P* value >0.05) over the values of samples without EWP. However, addition of EWP and SA had no effect on whiteness (*P* value >0.05). Addition of SA at concentrations of 0.1%, 0.2% and 0.3% showed noticeably lesser values of gel strength than EWP. Among the combinations of EWP and SA evaluated at 0.5%EWP+0.1%SA, 0.5%EWP+0.2%SA, 1%EWP+0.1%SA and 1%EWP+0.2%SA for gel strength; higher values were observed for sample with 0.5%EWP+0.2%SA. There was decrease in gel strength as the levels of SA increased. Therefore, the addition of combination 0.5%EWP and 0.1%SA is considered as optimum for achieving satisfactory value of gel strength of lesser sardine surimi.

Keywords: Surimi, gelation, egg white, sodium ascorbate, lesser sardine

Introduction
Surimi is the wet concentrate of myofibrillar proteins obtained from fish flesh that has been mechanically deboned, water-washed, mixed with cryoprotectants, and frozen [19]. Important functional properties of proteins are hydration, solubility, water retention, gel forming ability, emulsification and foaming capacity. Denaturation of protein, especially myofibrillar protein, occurs during frozen storage and causes deleterious effect on surimi. To avoid these effects, cryoprotectants are added to surimi before freezing [16].
Gel formation is an important functional property of surimi. Gel strength of surimi is affected by various physical conditions and also by heating temperatures and period [2]. To improve gelation characteristics of surimi, such as texture and colour, ingredients like starch, hydrocolloids, muscle proteins, non-muscle proteins, food grade chemical compounds and enzymes are added [18, 6].
Egg white is the most common available food grade inhibitor. It contains protease inhibitors, Cystatin and Ovomucoid [20]. It is added to surimi based products to modify textural properties of the resulting gel [22]. It is an enzyme inhibitor which inhibits "modori" stage (gel-softening phenomenon) during the gelation process and to make products more elastic [7]. Egg white also contributes to the structure of surimi gels by filling interstitial spaces in the fish protein networks [14].
Sodium ascorbate (SA) is also considered as a gel-strengthening ingredient in surimi based products. Its function is to increase cross-linkages through oxidation of sulphydryl (–SH) groups in proteins [9]. It can improve gel cohesiveness and sensory firmness of fiberized products with a maximum strengthening effect at 0.2% level [10].
Various compounds and cryoprotectants like phenolic compounds, sugars, polyols, protein hydrolysates, hydrocollides,cross-linking agents are used to increase gel strength and whiteness of surimi. Phenolic compounds like tannic acid [11], oxidised ferulic acid, oxidised tannic acid, oxidised catechin, oxidised caffeic acid [1]; sugars and polyols like lactitol, litesse,

surcrose, sorbitol [23], lactitol, maltodextrin, palatinit, polydextrose, terhalose [15], terhalose and sodium lactate [25]; protein hydrolysates (fish protein and casein hydrolysate) and hydrocollides (pectin, sodium alginate, lambda and iota carrageenan) [24]; protein additives like egg white, soy protein isolate, potato starch [7], egg albumen [22], egg white [12, 5]; cross-linking agents like sodium ascorbate [21, 10, 6] and transgultaminase [6, 21] have been used to increase the quality characteristics of surimi.

Realizing the need to use protein additive like egg white and cross-linking agents like sodium ascorbate to increase texture properties of gel for the present study was carried out.

2. Material and methods

2.1 Raw materials

Surimi with additives (4% sugar and 0.2% polyphosphates) of lesser sardine was obtained from Gadre marine export, Ratnagiri. The ingredients used in the surimi formulation were of food grade dry egg white powder purchased from Gadre marine export and sodium ascorbate from Molychem. Before freezing, cryoprotectants (sugar and polyphosphates) and additives (egg white and Sodium ascorbate) were added in surimi as detailed in Table 1. Surimi added with cryoprotectants but without additives served as control. The surimi was minced with additives in a silent cutter or 3min. After addition of additives, surimi was frozen at -40 ^{0}C and stored at -18 ^{0}C.

Table 1: Different concentration of additives added in surimi.

Additives	Concentration
Egg white	0.5%, 1.0%, 1.5%
Sodium ascorbate	0.1%,0.2%,0.3%
Combination	0.5%EWP+0.1%SA, 0.5%EWP+0.2%SA, 1.0%EWP+0.1%SA 1.0%EWP+0.2%SA

2.2 Surimi gel preparation

Frozen surimi was thawed at 4 ^{0}C for 3–4 h. Then partially thawed surimi at 2 ^{0}C, was chopped for 5 min with sodium chloride @ 3% in a silent cutter. This chopped surimi was used for gel preparation. The temperature of the surimi sol was kept below 10 ^{0}C to avoid denturation of protein. The surimi sol was stuffed into a polyvinylidine casing (2.5 cm diameter) and both ends were sealed tightly. The gels were prepared by setting the sol at 40 ^{0}C for 30 min in a water bath, followed by heating at 90 ^{0}C for 20 min. The gels were then cooled in ice water and stored at 4 ^{0}C overnight before analysis.

2.3 Texture analysis

The texture of surimi gel was measured by a rheo tex meter (Sun Scientiic co.ltd, Japan). Chill stored gels were equilibrated and tested at room temperature. Five cylinder-shaped samples of 2.5 cm in length were prepared from each gel. The breaking force (gel strength) and deformation (elasticity or cohesiveness) were measured by using the texture analyser equipped with a cylindrical plunger (5 mm diameter; 60 mm per min penetration speed). Measurements were taken in triplicates.

2.4 Whiteness measurement

Whiteness was measured using a colour analyser (Nippon Denshoku Industries. co, ltd, Japan). Measurements of L* (lightness), a* (red hue to green hue), and b* (yellow hue to blue hue) were made on five replicate samples of each gel. The whiteness was calculated using the following equation [13]:

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

2.5 Statistical analysis: All analyses were carried out in triplicates and data expressed as means ± standard deviations. Analysis of variance (ANOVA) were carried out to assess significant differences between means (p<0.05).

3. Results and discussion

Table 2: Gel strength and whiteness values for different gel samples.

Sr no.	Gel samples	Gel strength (g/cm)	Whiteness values
1.	Control	69±1.52	33.80±0.01
2.	EWP%		
	0.5	982±1.52	29.37±0.01
	1.0	1281±2.08	28.9±0.04
	1.5	1560±0.90	28.05±0.02
3.	SA%		
	0.1	72±1.00	32.55±0.01
	0.2	89±1.15	31.37±0.08
	0.3	74±0.8	31.21±0.02
4.	EWP+SA%		
	0.5+0.1	1224±2.15	28.58±0.01
	0.5+0.2	1251±1.35	28.01±0.03
	1.0+0.1	1094±1.96	26.71±0.01
	1.0+0.2	992±1.37	26.2±0.05

The experiment shows that the gel strength values of surimi added with EWP at concentration of 0.5%, 1%, and 1.5% were 982 g/cm, 1281g/cm and 1560 g/cm respectively and 72, 89, and 74 g/cm at SA levels at concentrations of 0.1, 0.2 and 0.3% respectively. Whereas higher gel strength value was observed in combination of 0.5%EWP+0.2%SA followed by combination 0.5EWP+0.1%SA. There is a significant difference (p value > 0.05) in gel strength values of EWP when compared to SA, and control.

The gel strength values of EWP showed a 20-fold increase over the control samples having gel strength of 69 g/cm. In EWP added samples there was an increase in gel strength with increase in levels of EWP while in SA added samples there was decrease in gel strength as the levels of SA was increased. Addition of SA at the levels of 0.1%, 0.2% and 0.3% showed noticeably lesser values of gel strength than any concentration of EWP.

EWP is a protein additive that not only acts as a functional binder during gel formation in surimi but also is a protease inhibitor [6], they also reported that the addition of SA and EWP expect 0.1%SA and 1.%EWP increased the breaking force as compared to control samples.

EWP at different levels (1%, 2%and 3%) were used for increasing the functional properties of surimi prepared from common carp and found that EWP potentially increased the quality characteristics of surimi and among three levels surimi with 3% EWP had higher gel strength of 2833.62g/mm than control samples with gel strength of 1168.81g/mm [7] whereas, adding egg white up to 3% increased the gel strength of lizard fish surimi regardless of heating conditions [3].

Increase in gel strength of surimi prepared from lizardfish due to addition of 3% egg albumen was reported. The gel strength of surimi with 3% egg albumen is 113.56g/cm which is greater than the control having gel strength of 94.68 [22].

This increase in gel strength of surimi samples with egg white is due contribution of egg white towards the structure of surimi gels by filling of the interstitial spaces in fish protein network as reported by [14].

The addition of EWP significantly increased the gel strength (*P* value >0.05) over the values of control samples. Addition of SA at levels of 0.1%, 0.2% and 0.3% shows noticeably lesser values of gel strength than EWP.

It was reported that SA significantly improved gel cohesiveness and sensory firmness of Alaska pollock surimi with maximum strength effect at a 0.2% level. He explained that the gel-strengthening effect of SA is due to cross-linking through of SH to S-S bond. He also explained that excessively high level of SA (>0.2%) hinders the formation o S-S bond due to presence of ascorbate in reduced form which results in decrease of gel strength [10]. Similar results were seen in present study where maximum gel strength among the different concentration of SA was seen at a concentration level of 0.2%SA whereby gel strength decreased when concentration was increased.

Among the combinations of EWP and SA evaluated at concentration levels of 0.5%EWP+0.1%SA, 0.5%EWP+0.2%SA, 1%EWP+0.1%SA and 1%EWP+0.2%SA for gel strength; higher values were observed for sample with 0.5%EWP+0.2%SA. There was decrease in gel strength as the levels of SA increased. The gel strength values were 72, 89, and 74 g/cm at SA concentration levels of 0.1, 0.2 and 0.3% respectively. It was found that, the addition of 0.5%EWPand 0.1%SA is considered as optimum level for achieving satisfactory value of gel strength of lesser sardine surimi.

Besides other characteristics, such as gel strength, pH, water content, colour is also one of the important characteristics used for grading surimi [4].

Whiteness value of control sample was more than that of EWP and SA. Surimi with different concentrations of EWP% had the lowest whiteness than control and SA samples, while there was not much difference between control and SA sample values. Whiteness values of all surimi samples ranged from 26.2 to 33.80. Among the whiteness values o all the surimi samples, whiteness of SA samples were high than that of EWP samples and combinations. The addition of SA and microbial transglutaminase (MTGase) satisfactorily improved the whiteness of samples (*P*<0.05), while as addition of EW and beef plasma protein (BPP) lowered the gel whiteness. This was because the colour of the gel was governed by the type of additive. EWP is yellow in colour, BPP is yellow brown, where as SA and MTGase are white in colour and thus have different in L*, a* and b* values [6].

Addition of 1% dried egg white (DEW) and 1% frozen egg white (FEW) into Alaska pollock surimi reduced the lightness and whiteness values of the resulting surimi gel [17] whereas, [3] found that addition of EWP had no effect on the whiteness of lizardfish surimi gels which were prepared under different heating conditions. Also [9] added three types of egg white protein (regular dried egg white (REW), special dried egg white (SEW), and liquid egg white (LEW) to Alaska pollock and found that all types of EW significantly reduced the whiteness of the resulting surimi gels compared to the control sample.

In the present study, whiteness values of both the additives (EWP&SA) in different concentrations and in combination did not show any significant difference as compared to control but there was a little bit decrease in the whiteness value of samples with different concentrations of additives as compared to control.

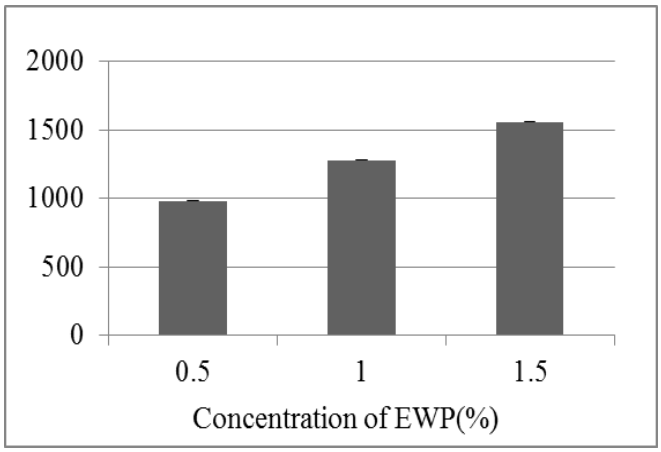

Fig 1: Effect of EWP on gel strength of lesser sardine surimi.

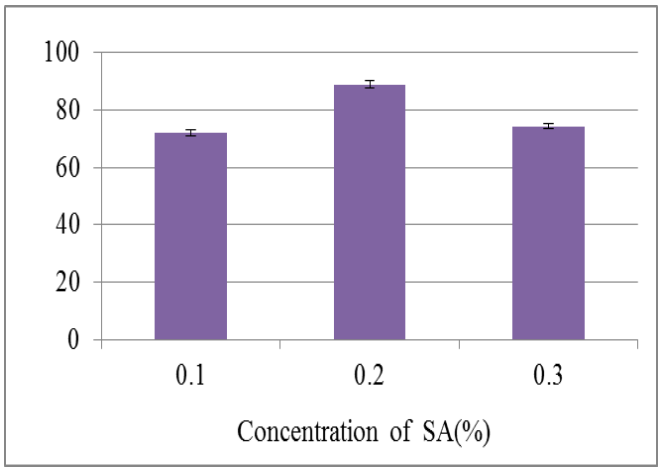

Fig 2: Effect of SA on gel strength of lesser sardine surimi.

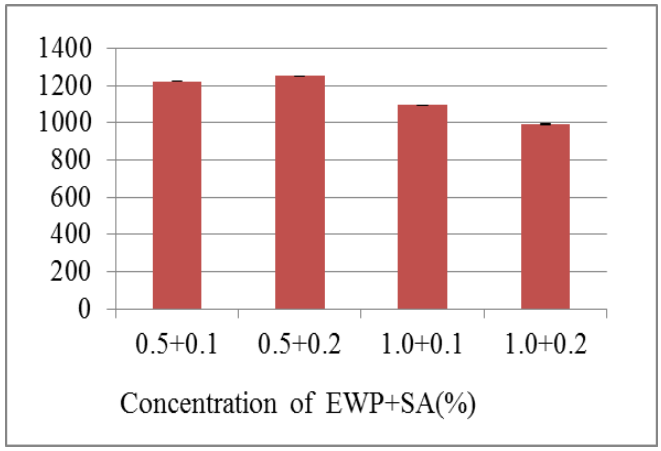

Fig 3: Effect of EWP and SA combinations on gel strength of lesser sardine Surimi

4. Conclusion

The gel strength of lesser sardine increased with increase in EWP levels and decreased with increase in SA concentrations. Among the two additives EWP gave higher values of gel strength than SA. However, among the combinations, significantly higher values were observed for sample added with 0.5%EWP+0.2%SA. Addition of 0.5%EWP and 0.1%SA is considered as optimum level for achieving satisfactory value of gel strength of lesser sardine surimi.

Additions of SA and EWP individually and in different combination in surimi increased gel strength to a great extend but did not significantly affected whiteness values. However whiteness values of SA surimi samples were higher than EWP and combination surimi samples.

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