



## Nutritional and physical characteristics of noodles incorporated with green seaweed (*Ulva reticulata*) and fish (*Pangasianodon hypophthalmus*) mince

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### ABSTRACT

Nutritional and physical properties of noodles incorporated with green seaweed (*Ulva reticulata*) puree and fish (*Pangasianodon hypophthalmus*) mince were evaluated. Four lots of noodles were prepared using different formulations viz., control noodle without adding seaweed puree or fish meat (C); noodle with 20% cooked pangasius fish meat (T1), noodles with 20% seaweed puree (T2) and noodles with 10% seaweed puree and 10% cooked pangasius fish meat (T3). Proximate composition, cooking properties, textural and sensory qualities of noodles were assessed. Results indicated that addition of green seaweed puree increased the crude fibre content of noodles. Crude fibre content was higher in T2 (2.62±0.18%) followed by T3 (1.71±0.06%). Cooking time for noodles varied between 6.80±0.71 and 9.15±0.21 min and cooking loss was significantly ( $p<0.05$ ) higher for noodles with 20% seaweed puree. Significantly higher water absorption was noticed in noodles with 20% green seaweed puree, which led to softer and spongier textural intensities of the noodles. Although T2 showed lower score for colour values, its overall score for flavour and taste was higher compared to control and other treatments. The results indicate that incorporation of green seaweed puree in noodles has positively influenced the flavour as well as fibre content and hence, it can be used to enrich the fibre content of noodles.

Keywords: Crude fibre, Fish mince, Green seaweed, Noodles, *Pangasianodon hypophthalmus*, *Ulva reticulata*

### Introduction

In recent years, use of seaweeds as a functional or nutritional ingredient in food products is gaining importance among the researchers worldwide. Seaweeds have been widely consumed as food since ancient time in Asian countries including China, Japan and Korea. Edible seaweeds are rich in polysaccharides, proteins, minerals and vitamins but low in lipid content (1-3% algal dry weight) with high amount of certain long chain polyunsaturated fatty acids (Fleurence, 1999; Ruperez *et al.*, 2002; Dawczynski *et al.*, 2007; Bocanegra *et al.*, 2009). They also act as antioxidants and antimicrobial compounds (Kuda *et al.*, 2005; Gupta *et al.*, 2010). The potential of seaweed as a source of iron, iodine, dietary fibre and as salt replacer has been demonstrated (Goni *et al.*, 2000; Chang and Wu, 2008; Gupta and Abu-Ghannam, 2011).

Noodles are popular food products worldwide, especially in South-east Asia. According to the report by World Instant Noodle Association (2014), the annual production of noodles was 105.65 billion packs in 2013 and is increasing at a rate of 3% per year since 2010. Even though, noodles are a popular fast food item, those

available in the market generally have low nutritional value in terms of dietary fibre, minerals and vitamins which are lost during wheat flour refinement (Ojure and Quadri, 2012). Hence, recently, the manufacturers as well as researchers are constantly focusing on improving the nutritional quality of noodles (Verardo *et al.*, 2009; Vijayakumar, 2010; Kim *et al.*, 2014). Addition of seaweed to noodles can be a promising technology for enriching its dietary fibre and mineral content as well as for promoting seaweed as a food component in places where seaweed consumption is unpopular. Indian waters are rich sources of various edible seaweeds; however, its use has been traditionally limited to extraction of phycocolloids and production of fertilisers. Hence it is necessary to explore the possibilities of use of seaweed as a food ingredient in frequently consumed and self stable products like noodles.

*Ulva reticulata* is a green seaweed that grows abundantly in Indian marine waters but there has been only very little exploitation of this seaweed species. Pangasius (*Pangasianodon hypophthalmus*) meat has high nutritive qualities, excellent sensory properties and is amenable for development of convenience products (Silva *et al.*, 2002; Rao *et al.*, 2013). However, fish meat has negligible content of dietary fibre. The present study was

envisaged to nutritionally enrich noodles by incorporating green seaweed and pangasius fish mince, either alone or in combination and to evaluate the nutritional and physical properties of the noodles developed.

## Materials and methods

### Preparation of noodles

*U. reticulata* was collected from Visakhapatnam Coast, Andhra Pradesh. Seaweed was handpicked, washed thoroughly with potable water to remove epiphytes and foreign particles and then ground to make seaweed puree. *P. hypophthalmus* was procured from the local fish market and mince was prepared in laboratory under hygienic conditions and was cooked by steaming for 15 min. Other ingredients for noodles were procured locally.

Four lots of noodles were prepared using different formulations (Table 1) *viz.*, control containing noodle without seaweed puree or fish meat (C); noodles with 20% cooked pangasius fish meat (T1), noodles with 20% green seaweed puree (T2) and noodles with 10% green seaweed puree + 10% cooked pangasius fish meat (T3). All the ingredients were mixed lot-wise to make dough and the dough was sheeted, rolled and passed through cutting blades of commercial noodles making machine to obtain noodle strands of desired width. Noodles were steam cooked and dried at 50°C in mechanical dryer for bringing down the moisture content below 10%.

Table 1. Formulation of dry noodles with and without green sea weed puree

Ingredients	Type of noodles			
	C	T1	T2	T3
Refined wheat flour (%)	82	62	62	62
Corn flour (%)	5	5	5	5
Tapioca starch (%)	10	10	10	10
Salt (%)	3	3	3	3
Cooked Pangasius fish meat (%)	-	20	-	10
Green-seaweed ( <i>U. reticulata</i> ) puree (%)	-	-	20	10
Water (ml per 100 g dry noodle mix)	40	30	30	30

C - Control containing noodle without seaweed puree or fish meat; T1- noodle with 20% cooked pangasius fish meat; T2 - noodles with 20% green seaweed puree; T3 - noodles with 10% green sea weed puree and 10% cooked pangasius fish meat

Table 2. Five point attributes scale for descriptive sensory profile of cooked noodles

Sensory parameters	Sensory scores				
	1	2	3	4	5
Colour	Light cream	Cream	Light green	Green	Dark green
Roughness	Very smooth	Smooth	Slightly rough	Rough	Very rough
Firmness	Very soft	Soft	Slightly firm	Firm	Very firm
Stickiness	Non sticky	Mildly sticky	Moderately sticky	Sticky	Very sticky
Starchy mouth coating	Non starchy	Mildly starchy	Moderately starchy	Starchy	Very starchy

### Proximate composition, crude fibre content and cooking quality

Moisture, protein, fat, carbohydrate and crude fibre content of the noodles were determined as per standard methods (AOAC, 1990). Cooking time, cooking loss and water absorption were analysed as per AACC (1995).

### Sensory analysis

Descriptive sensory profile of the cooked noodles was assessed by the method described by Bhat and Sharma (1989) with minor modifications. Descriptive sensory profile on firmness, colour, stickiness, roughness and starchy mouth coating were done using a 5 point attribute scale as presented in Table 2. Overall acceptability of the cooked noodles was evaluated to indicate preference on 9 point hedonic scale as described by Amerine *et al.* (1965), where '1' represents 'dislike extremely' and '9' represents like extremely.

### Texture profile and colour analysis

Texture profile analysis (TPA) of cooked noodles were conducted with a texture analyser (TA Plus, Lloyd Instruments, Ametek, UK) equipped with a 50 N load cell. For measuring TPA, 5 strands of cooked noodles were arranged parallel on the measuring platform and compressed twice with cylindrical probe of 10 mm dia. From the force time curve, parameters such as hardness (N), cohesiveness, springiness (mm), gumminess (N) and chewiness (Nmm), were determined. Colour values *viz.*, L\* (lightness), a\* (positive value signify red; negative value signify green), b\* (positive value signify yellow, negative value signify blue) values were measured using Hunter's colourimeter (ColorFlex EZ, Hunter Lab).

### Statistical analysis

Variations in nutritional and physical properties of noodles were analysed using one way analysis of variance (ANOVA) at 5% level of significance followed by Tukey's test in Statistical Package for Social Science (SPSS) version 16.0 (IBM).

## Results and discussion

### Proximate composition and crude fibre of noodles

Proximate composition and crude fibre of different types of noodles were analysed (Table 3). Moisture content of noodles varied from  $7.68 \pm 0.11$  to  $9.41 \pm 0.06\%$ . Significantly ( $p < 0.05$ ) higher level of moisture content was observed in T2 as compared to other treatments and this might be due to the high water holding capacity of dietary fibre present in seaweed (Gomez-Ordóñez, 2010). In addition, the sulfate group located on the surface of polysaccharides will absorb moisture during dough formation. Even though not significant ( $p > 0.05$ ), moisture content of T3 was higher than that of C and T1. Dewi (2011) also reported that addition of seaweeds powder and puree in noodles increased the moisture content. There was a significant difference ( $p < 0.05$ ) in protein content of different types of noodles prepared and values ranged from  $3.43 \pm 0.39$  to  $7.66 \pm 0.48\%$  dry weight (dw). As expected, higher protein content was found in T1 *i.e.*, noodles made with 20% cooked meat of pangasius followed by T3, where 10% cooked meat of pangasius was added. Protein content of noodles containing seaweed puree was significantly ( $p < 0.05$ ) lower to that of T1 and T3. Protein content decreased in wet noodles when proportion of seaweeds substitution was raised (Yap and Chan, 2001; Dewi, 2011). Addition of pangasius fish mince significantly influenced the fat content of noodles. Highest amount of fat was noticed in noodles with 20% fish meat (T1) followed by noodles made with 10% fish meat plus 10% seaweed puree (T3). Higher fat content in T1 and T3 could be attributed to high content of fat in pangasius fish meat (Rao *et al.*, 2013). There was no fat present in control and T2, indicating that the fat content of seaweed and other ingredients used for noodles

preparation may be negligible. In general, seaweeds are having very low level of fat (Dawczynski *et al.*, 2007).

Carbohydrate content also varied significantly ( $p < 0.05$ ) between different types of noodles with control having the highest and T1 the lowest carbohydrate content among the samples analysed. Results (Table 3) show that there was a significant ( $p < 0.05$ ) increase in crude fibre content in noodles incorporated with seaweed puree ( $2.62 \pm 0.18\%$  dw). Similar results were reported by Suryaningrum *et al.* (2003); Chang and Wu (2008) and Dewi (2011). Higher amount of dietary fibre in seaweed, can help to lower blood cholesterol levels, reduce the risk of cardiovascular disease and obesity as well as colon cancer (Anderson *et al.*, 2009). In addition, dietary fibre is known to overcome constipation problems and slow down sugar absorption rate that helps to reduce the risk of diabetes (Brownlee, 2011).

### Cooking quality of noodles

Cooking time for noodles varied from  $6:80 \pm 0.71$  to  $9:15 \pm 0.21$  min, without any significant difference between the different types of noodles prepared during the present study (Table 4). Cooking time optimised in our study was comparable or lower to those reported for branded noodles (9:3 min, Vijayakumar *et al.*, 2010). Cooking loss is a measure of the amount of solids lost into the cooking water and considered as a vital indicator of overall cooking performance of noodles by manufacturers and consumers. Cooking loss (%) was significantly higher for noodles with 20% seaweed puree ( $10.93 \pm 0.85\%$ ) followed by those containing 10% seaweed puree (Table 4). Similar results have been reported by Prabhaskar *et al.* (2009) for 30% seaweed incorporated pasta. Lowest cooking loss was noticed in noodles

Table 3. Nutritional composition of noodles with and without green seaweed puree

Noodles	Moisture (%)	Protein (% dw)	Carbohydrate (% dw)	Fat (% dw)	Crude fibre (% dw)
C	$7.68 \pm 0.11^a$	$3.43 \pm 0.39^a$	$61.29 \pm 0.06^c$	$0.00 \pm 0.00^a$	$1.50 \pm 0.01^b$
T1	$7.69 \pm 0.29^a$	$7.66 \pm 0.48^c$	$56.94 \pm 0.00^a$	$0.77 \pm 0.30^b$	$1.05 \pm 0.00^a$
T2	$9.41 \pm 0.06^b$	$3.75 \pm 0.35^{ab}$	$57.20 \pm 0.08^{ab}$	$0.00 \pm 0.00^a$	$2.62 \pm 0.18^c$
T3	$8.37 \pm 0.19^a$	$5.20 \pm 0.08^b$	$57.3 \pm 0.08^b$	$0.37 \pm 0.11^{ab}$	$1.71 \pm 0.06^b$

Results are mean $\pm$ SD. Values within a row with different superscript are significantly different ( $p < 0.05$ )

Table 4. Cooking quality of noodles with and without green seaweed puree

Cooking quality	Cooking time (min)	Cooking loss (%)	Water absorption (%)
C	$9.15 \pm 0.21^a$	$9.37 \pm 0.01^{bc}$	$311.57 \pm 2.08^c$
T1	$7.65 \pm 0.92^a$	$7.03 \pm 0.42^a$	$311.92 \pm 0.12^b$
T2	$8.00 \pm 0.00^a$	$10.93 \pm 0.85^c$	$350.79 \pm 0.71^d$
T3	$6.80 \pm 0.71^a$	$8.20 \pm 0.23^{ab}$	$289.49 \pm 0.73^a$

Results are mean $\pm$ SD, values within a row with different superscript letters are significantly different ( $p < 0.05$ )

containing 20% fish mince, which could be attributed to the binding capacity of myofibrillar protein fractions. Table 4 shows that higher water absorption (%) was found in noodles with 20% green seaweed puree ( $350.79 \pm 0.71\%$ ) which could be attributed to the water absorption capacity of dietary fibre and polysaccharides. Results of the present study are in agreement with Chang and Wu (2008) who also observed increase in water absorption capacity in green seaweed incorporated Chinese egg noodles.

Cooking loss and water absorption differed significantly ( $p<0.05$ ) but there was no significant difference ( $p>0.05$ ) of cooking time among different types of noodles.

#### Colour values and texture profile analysis

The results showed significant difference ( $p<0.05$ ) in colour values (L,  $a^*$  and  $b^*$ ) of the different types of noodles (Table 5). The L values of noodles significantly ( $p<0.05$ ) decreased with addition of 10 and 20% seaweed puree, which indicates decrease in the noodle whiteness. Cooked noodles had lower L values compared to raw noodles, moreover, decrease in L value in cooked noodles made with 20% seaweed puree was significantly higher ( $p<0.05$ ) than other noodles (C, T1 and T3). Results indicated that  $a^*$  value of noodles with 10% seaweed puree ( $-0.33\pm 0.03$ ) and 20% seaweed puree ( $-1.14\pm 0.04$ ) become significantly greener due to incorporation of green seaweed puree.  $a^*$  value of cooked noodles with 20% seaweed decreased from  $-1.14\pm 0.04$  to  $-1.4\pm 0.02$ , whereas,  $a^*$  remained same for raw and cooked noodles with 10% seaweed puree. There was significantly ( $p<0.05$ ) higher intensity of redness in noodles with 20% fish meat. Except in T1, yellowness ( $b^*$ ) of cooked noodles increased as compared to raw noodles in C, T2 and T3.

Texture profile analysis of noodles indicated that hardness of control noodles was significantly higher than those containing fish mince (Table 6). Addition of seaweed puree reduced the hardness values compared to control. This could be due to the increased water absorption capacity of seaweed incorporated noodles while cooking, resulting in lower force required for compressing the same. Incorporation of fat rich pangasius meat might have negatively affected the hardness of noodles. Lowest

hardness was found in seaweed with 10% seaweed and 10% fish. There was no significant difference ( $p<0.05$ ) in springiness and chewiness value among the different types of noodles.

#### Sensory evaluation

Descriptive sensory profile of optimally cooked noodles using a 5 point attribute scale is presented in spider web plot (Fig. 1). Colour of C and T1 differed significantly ( $p<0.05$ ) from the colour of T2 and T3. Colour of noodles become greener with increasing concentration of seaweed puree. Both the seaweed incorporated noodles *i.e.*, T2 ( $4.00\pm 0.71$ ) and T3 ( $3.67\pm 0.87$ ) were found to have green to light green colour while C and T1 were light cream to cream in colour, respectively. Sensory score of colour of cooked noodles correlated with L,  $a^*$  and  $b^*$  values measured using Hunter's colourimeter. In terms of roughness, T3 and T2 were found to be smooth to slightly rough because of the presence of grainy particles of seaweeds on noodles surface whereas C and T1 had smoothness scores of  $1.78\pm 0.67$  and  $2.11\pm 0.78$ , respectively which indicates smooth to very smooth surface. Firmness ranged between  $1.89\pm 0.78$  to  $2.78\pm 0.97$  and T2 was found to be slightly firmer as compared to other treatments. In terms of stickiness, T3 (noodles with 10% fish meat + 10% seaweed puree) was adjudged to be moderately sticky. However, there was no significant difference among C, T1 and T2. Starchy mouth feel was lower in green seaweed incorporated noodles.

The mean scores of acceptability test of optimally cooked noodles (Fig. 2) demonstrated that control noodles had the highest score in terms of colour and appearance characteristics followed by noodles with 20% cooked fish meat. Noodles incorporated with 20% green seaweed

Table 5. Colour values of noodles with and without green seaweed puree

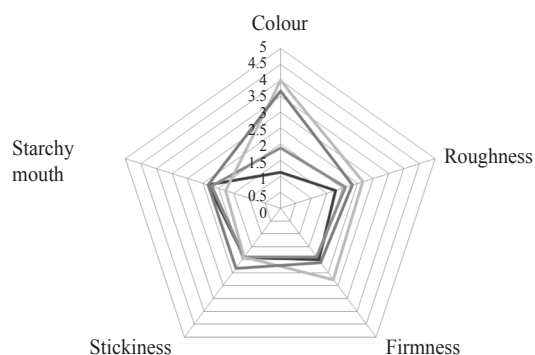
Noodles	L		$a^*$		$b^*$	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
C	$86.18\pm 0.01^d$	$74.23\pm 0.01^d$	$0.76\pm 0.0^c$	$0.74\pm 0.01^c$	$13.37\pm 0.25^a$	$16.07\pm 0.05^a$
T1	$80.54\pm 0.29^c$	$72.03\pm 0.03^c$	$2.13\pm 0.13^d$	$1.75\pm 0.01^d$	$18.05\pm 0.02^b$	$18.41\pm 0.00^b$
T2	$74.00\pm 0.04^a$	$58.67\pm 0.04^a$	$-1.14\pm 0.04^a$	$-1.4\pm 0.02^a$	$19.66\pm 0.13^c$	$23.40\pm 0.14^d$
T3	$78.88\pm 0.14^b$	$66.15\pm 0.07^b$	$-0.33\pm 0.03^b$	$-0.3\pm 0.01^b$	$18.45\pm 0.01^b$	$22.89\pm 0.01^c$

Results are mean $\pm$ SD, values within a row with different superscript letters are significantly different ( $p<0.05$ )

Table 6. Textural profile analysis of noodles with and without green seaweed puree

Noodles	Hardness (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (N mm)
C	$18.19\pm 1.40^b$	$0.06\pm 0.01^b$	$0.69\pm 0.03^a$	$0.89\pm 0.25^b$	$0.62\pm 0.20^a$
T1	$11.21\pm 0.99^a$	$0.02\pm 0.01^a$	$0.34\pm 0.10^a$	$0.17\pm 0.08^a$	$0.06\pm 0.04^a$
T2	$15.54\pm 0.88^b$	$0.04\pm 0.01^{ab}$	$0.32\pm 0.35^a$	$0.64\pm 0.23^{ab}$	$0.24\pm 0.30^a$
T3	$10.44\pm 0.77^a$	$0.03\pm 0.01^{ab}$	$0.49\pm 0.08^a$	$0.13\pm 0.08^{ab}$	$0.18\pm 0.08^a$

Results are mean $\pm$ standard deviation. Values within a row with different superscript letters are significantly different ( $p<0.05$ )



— Control, — Noodle with 20% fish meat, — Noodle with 20% seaweed,  
— Noodle with 10% fish meat and 10% seaweed

Fig. 1. Descriptive sensory profile of optimally cooked noodles

puree showed the lowest score for colour property. However, the noodles containing 20% seaweed puree had the highest score in relation to flavour attribute and taste.

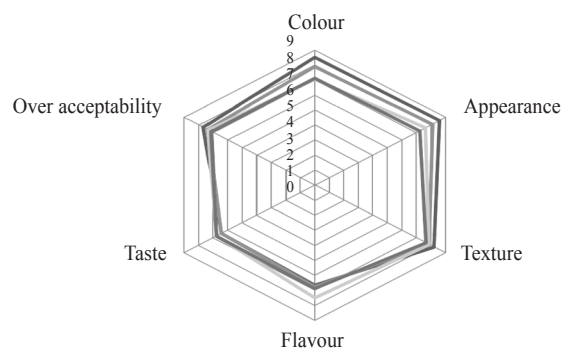
Results of the present study revealed that incorporation of green seaweed (*U. reticulata*) puree increased the moisture, crude fibre content and water holding capacity of noodles. Moreover, addition of seaweed did not negatively influence the textural properties of cooked noodles. Noodles containing 20% w/w green seaweed puree was considered as acceptable in terms of flavour attribute and taste. Addition of fish mince also demonstrated a positive effect on the nutritional properties of noodles, with minimum alteration on textural and cooking attributes. In brief, the study indicated that *U. reticulata* and pangasius fish mince can be considered as potential ingredients for developing healthy noodles products.

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— Control, — Noodle with 20% fish meat, — Noodle with 20% seaweed,  
— Noodle with 10% fish meat and 10% seaweed

Fig. 2. Overall acceptability of optimally cooked noodles

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