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The Effect of Seaweed Powder on Physicochemical Properties of Yellow Alkaline Noodles

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ABSTRACT: Seaweeds contain high levels of minerals, vitamins, essential amino acids, indigestible carbohydrates, and dietary fiber. The objective of this study was to compare Spirulina seaweed yellow alkaline noodles made with different levels of green seaweed to make Yellow alkaline noodle products of high nutritional quality with rich fiber content. Green seaweed powder (Spirulina) was incorporated in different proportions (0, 5, 10, 15%) in noodles. Proximate compositions (protein, fiber, ash, fat, moisture), pH, color, textural intensities, cooking properties (Cooking yield, Cooking loss), and sensory qualities of noodles were evaluated. The results of noodle formula development showed that as the amount of Spirulina seaweed powder increased, the stickiness of the noodles decreased and the appearance became darker. The crude fiber contents of Spirulina seaweed yellow alkaline noodles increased by the addition of Spirulina seaweed powder. Thus, edible seaweeds such as Spirulina might be used as a food supplement to improve the nutritional recommended daily intake.

Keywords: *Cooking Yield, Noodles, Nutrition, Seaweed, Texture.*

Introduction

Noodles came to China as early as 5000 BC and spread to other Asian countries such as Japan, Thailand, Korea and Malaysia. Today, noodles are one of the favorite food products and consumed by many people of all ages (Keyimu, 2013; Martin *et al.*, 2004). Alkaline noodles basically are made from wheat flour, water, salt and alkaline salt water. Alkaline noodles are widely used in Malaysia, Singapore, Indonesia, Thailand, Taiwan and Hong Kong (Fu, 2008; Sandhu & Kaur, 2010; Yousif *et al.*, 2012). Seaweeds contain high levels of vitamins, minerals, indigestible carbohydrates, essential amino acids, and dietary fiber. Seaweeds are valued marine plants and have been consumed in Asia since ancient times (Chapman & Chapman, 1980; Nisizawa *et al.*, 1987). In Asia, seaweeds have been used for centuries in the preparation of salads, soups and also as low-calorie foods. Seaweeds have become a major food ingredient in products especially in Japan, Korea and China. The multifaceted uses of these plants in food, agriculture, pharmaceuticals and medicine chemical and textile industries have been well recognized (Dhargalkar & Kavlekar, 2004). Most of the Europeans and Americans use processed seaweeds as additives in their food preparation (Ismail& Tan, 2002). Spirulina (Blue-green algae) is used as a source of dietary protein, B-vitamins, and iron and also used for weight loss, depression, stress, hay fever, fatigue, anxiety, diabetes, and other women's health issues. Blue-green algae are commonly found in tropical or subtropical waters that have high-salt content, but some types grow in large fresh water lakes. Fiber is a type of carbohydrate that the body can't digest and although most

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of carbohydrates are broken down into sugar molecules, fiber cannot be broken down into sugar molecules and instead it passes through the body undigested. Dietary fiber is found in plants such as seaweeds (Maningat & Seib, 2010). While all the plants contain some fiber, plants with high fiber concentrations are generally the most practical source and fiber-rich plants can be eaten directly or alternatively might be employed information of processed foods (Chandalia *et al*., 2000; Henrikson, 1989).

Materials and Methods

Green Spirulina seaweed was collected from Bushehr, Iran. According to the method described by Keyimu (2013), the seaweed was soaked in tap water over night, then cleaned and rinsed with running water to remove the remaining salt and residues and then freeze-dried. Dry seaweed powder samples were stored in bags in desiccators at room temperature until used. After the preparation of Spirulina seaweed powder (SSP),the noodles were prepared in the laboratory according to the method described by (Yeoh, 2012). The basic ingredients for noodle preparation were; wheat flour (50g), alkaline salt (1g), salt (1g), and water (30g). Control yellow alkaline noodles were prepared from 100% wheat flour. Three noodle samples were prepared by substituting wheat flour with 5%, 10% and 15% Spirulina seaweed powder. The compositions for the seaweed noodles and the control are presented in Table 1. Alkaline salt (9:1 sodium and potassium carbonate) was dissolved in water, and then added to the dough noodles. Materials for noodles and cross-linking treatments were incorporated by a mixer (Kitchen Aid,141 USA). The mixture was then mixed at low speed and the speed was raised gradually to the maximum level and finally the speed was reduced after ten minutes of mixing. The dough was removed and placed in a plastic bag for sheeting with a pasta machine (Shule) followed by passing in the noodle machine to produce desired shape. Noodles were slitted in such ways that are not broken easily during tensile analysis. Noodles produced were coated with a thin layer of flour to prevent them from sticking together.

- *Proximate Analysis*

Each noodle sample was evaluated for moisture, crude protein, crude fat, crude fiber, and ash contents according to (AOAC, 2003) the Official methods of analysis of the Association of Official Analytical Chemists. All measurements were expressed on dry weight basis and performed in triplicate order.

- *pH measurement*

The pH was measured by using Metter-Toledo Delta 320 pH meter. The cooked noodle strands (5g) were homogenized with 50 ml deionized water for 5 min. The homogenized suspension was allowed to stand for 30 min and filtered prior to pH measurement of the filtrate (Yeoh *et al*., 2011).

- *Color analysis*

The color of the noodles was determined by using a colorimeter (Model CM-3500d, Konica Minolta Corp., Ramsey, N.J, USA) equipped with D65 illuminant using the CIE 1976 L^* lightness, a^*redness-greenness and b^* yellowness-blueness color scale. Measurements were arranged in random position on the surface of the noodle strands (Yeoh *et al*., 2011).

- *Cooking properties of SS yellow alkaline noodles*

Cooking yield and cooking loss of the noodles were determined as described by (Akanbi *et al*., 2011; Foo *et al*., 2011). Precisely 30 g of the noodles were added to about 300 ml boiling water for 10 min. The cooked noodles were drained and rinsed for

5 min and then waited. Cooking loss was determined by evaporating to dryness the combined cooking and rinsed water in a pre-weighed glass beaker in an oven at 110˚C for 24h. The residue was weighed after cooling in a desiccator and reported as cooking loss.

Cooking yield (g) = weight of noodles after cooking (g) – weight of noodles before cooking (g) (1)

Cooking loss (%)= $\frac{remaining\ solid\ weight \times 100}{weight\ of\ noodles\ before\ cooking}$ (2)

- SS yellow alkaline noodle firmness

The firmness of cooked noodles was measured by using a Texture Analyzer, TA. XT2 Plus (Stable Micro Systems, Surrey, England) with a 5 kg load cell attached with a 1 mm flat Perspex knife blade according to the AACC method (American Association of Cereal Chemists). The used settings were: *Mode:* Measure force in compression, *Option:* Return to start, *pre-Test Speed:* 4.0 mm/s, *Test Speed:* 1.0 mm/s, *Post-Test Speed:* 1.0 mm/s, *strain:* 70 %, *Trigger type:* Auto. The cooked noodles were cut in small pieces in length and five noodles strands were placed side-by-side, straight and flat and were place at the center under the compression blade. The firmness value was taken from the peak of a force-time graph.

- Tensile test for SS noodles

Tensile strength of noodle strands was evaluated by using Texture analyzer, TAXT model (Stable Micro Systems Surrey, UK) fitted with a 5 kg load cell. Ring calibration was performed prior to the measurement. The distance of the probe move apart was set at 15 mm. The setting used were: *Mode:* Measure force in tension; *Option:* Return to start; *Pre-test speed:* 3.0 mm/s; *Test speed:* 3.0 mm/s; *Post-test speed:* 5.0 mm/s; *Distance:* 100 mm. The cooked noodles strands were cut into 200 mm long. The width and thickness of the strand were determined at three different locations using a manual micrometer (Dial Thickness Gauge Mitutoyo MI 7305, Japan). The tensile strength was calculated as:

$$a = \frac{F}{A} \quad (3)$$

where *a* is the tensile strength (Pa), *F* is the peak force (N) and A is the cross-sectional area of the noodle strand (m^2) (Foo *et al.*, 2011; Gan *et al*., 2009).

- Statistical analysis

All the analyses in this study were run in triplicate order and the data were analyzed statistically using SPSS version 19. The results were analyzed by comparing the means using one-way analysis of variance (ANOVA) and Duncan`s multiple range test was used to determine significant difference (P<0.05) among different formulations.

Results and Discussion

- Proximate analysis of seaweed yellow alkaline noodles

Crude fiber, fat, and protein contents of yellow alkaline noodles were affected by the levels of SSP. Table 1 shows the proximate composition of Spirulina seaweed noodles. The results indicated that at higher moisture

Table 1. Proximate composition of seaweed noodles.

Sample	Fat (%)	Protein (%)	Fiber (%)	Moisture (%)	Ash (%)
0%	1.40 ± 0.02^d	12.66 ± 0.01^d	1.46 ± 0.06	33.63 ± 0.05^d	0.03 ± 0.04^d
5%	2.05 ± 0.01^c	13.65 ± 0.02^c	3.55 ± 0.00	39.05 ± 0.02^c	0.89 ± 0.08^c
10%	2.68 ± 0.04^b	14.41 ± 0.01^b	3.84 ± 0.02	40.56 ± 0.01^b	1.09 ± 0.03^b
15%	2.78 ± 0.08^a	14.46 ± 0.00^a	4.09 ± 0.00	44.03 ± 0.01^a	1.20 ± 0.08 ^{a}

Means in the same column with different superscripts are different (p<0.05).

content in seaweed yellow alkaline noodles, the level of Spirulina powder increased. Samples without added SSP showed lower moisture content and as the levels of SSP increased, moisture contents increased (Table 1) up to 44.03 %. This might be due to high levels of SSP which increases the water absorption and water holding capacity of fibers and polysaccharides in seaweed during the dough formation. Addition of SSP in yellow alkaline noodles resulted in higher fat contents in this study. Protein contents were higher for yellow alkaline noodles with additional SSP than those of samples without SSP, where the network produced by the gluten is reduced. The crude fiber contents in Spirulina Seaweed yellow alkaline noodles were significantly increased with higher levels of SSP. Fiber measurements of the control noodles (without SSP) were 1.46 %. The control sample showed the lowest value of ash, while the noodles containing 15% SSP had the highest values of ash. The high concentrations of ash and crude fiber contents in Seaweed yellow alkaline noodles are in agreement with the findings by Chang and Wu (2008). Seaweed is low in calories and rich in dietary fibers, minerals and vitamins (Jimenez & Sanchez, 2000; Huang and Liao, 2003), therefore, it is expected that fiber and ash contents increase as SSP is incorporated in noodles.

- *Effect on pH and color*

pH values after cooking are shown in Figure 1. The pH for alkaline noodles depending on the added ingredients is within the range of pH 9 to 11 (Fu, 2008*;* Park *et al*., 2003). The results of ANOVA for pH showed that different samples have significant influence on the value of pH ($p<0.05$). It is clear that SSP level had an influence on the pH values of the yellow alkaline noodles. The pH values of the studied noodles were in the range of 7.19 to 12.01, which were lower than the typical range of commercial yellow alkaline noodle and this might be possibly due to the presence of SSP and typical range of Spirulina seaweed pH.

Color is an important parameter for alkaline noodles, because, usually the consumer`s first opinion of noodle is based on light yellow color (Bejosano & Corke, 1998; Hatcher *et al*., 2004). The color characteristic of Spirulina seaweed yellow alkaline noodles are shown in Table 2. The results showed that different samples significantly influenced the value of color. For a yellow alkaline noodle, high lightness (L*) and moderate yellowness (b*) are desirable. Generally, for all the samples in this study, L*, a* and b* values decreased significantly ($P<0.05$) with increasing concentration of SSP, which indicated a decrease in the yellow alkaline noodles brightness. It was probably due to the reaction of SSP which can change the molecular structure of the matrix of samples and show different responses to the light. The hygroscopic properties of SSP might absorb some water and moisture that could cause darker color. Moreover, there were significantly lower intensity of redness and higher greenness by increasing SSP content which was indicated by increase in a* values.

- *Cooking properties of SS yellow alkaline noodles*

Cooking quality of noodles could be defined by measuring the cooking yield. Cooking loss is the most important parameter for cooking quality of noodles (Foo *et al*., 2011; Li & Vasanthan, 2003). Yellow alkaline noodles without additional SSP showed lower cooking loss. Cooking loss for SS yellow alkaline noodles increased considerably as the levels of SSP increased. The highest cooking loss was found in the samples which were made of 15% SSP. The results were consistent with the report by Charles *et al*. (2007). The degree of cooking loss is dependent on the starch gelatinization (Liu *et al.*, 2009; Sung & Stone, 2005) and cooking loss in this study increased by increasing the level of SSP and decreasing level of wheat flour and gluten matrix. High dietary fiber in seaweeds during noodles cooking led to the absorption of more water in to the gelatinized matrix structures of noodles that could result in higher cooking loss and water uptakes in this study (Figure 2).

Tensile strength and firmness are important parameters to define the quality of the noodles (Han *et al.*, 2011). Cooked alkaline noodles must have elasticity and firmness. Wheat flour protein content can have an effect on the texture of noodles. (Yeoh *et al.*, 2011). The addition of SSP decreased the firmness and increased the tensile strength of the yellow alkaline noodle samples. This might be due to the water absorption property of SSP and as the SSP addition level was increased, the viscoelastic property was improved. This led to more activity of SSP and decreased the firmness but tensile strength increased respectively up to 10% (Figure 3).

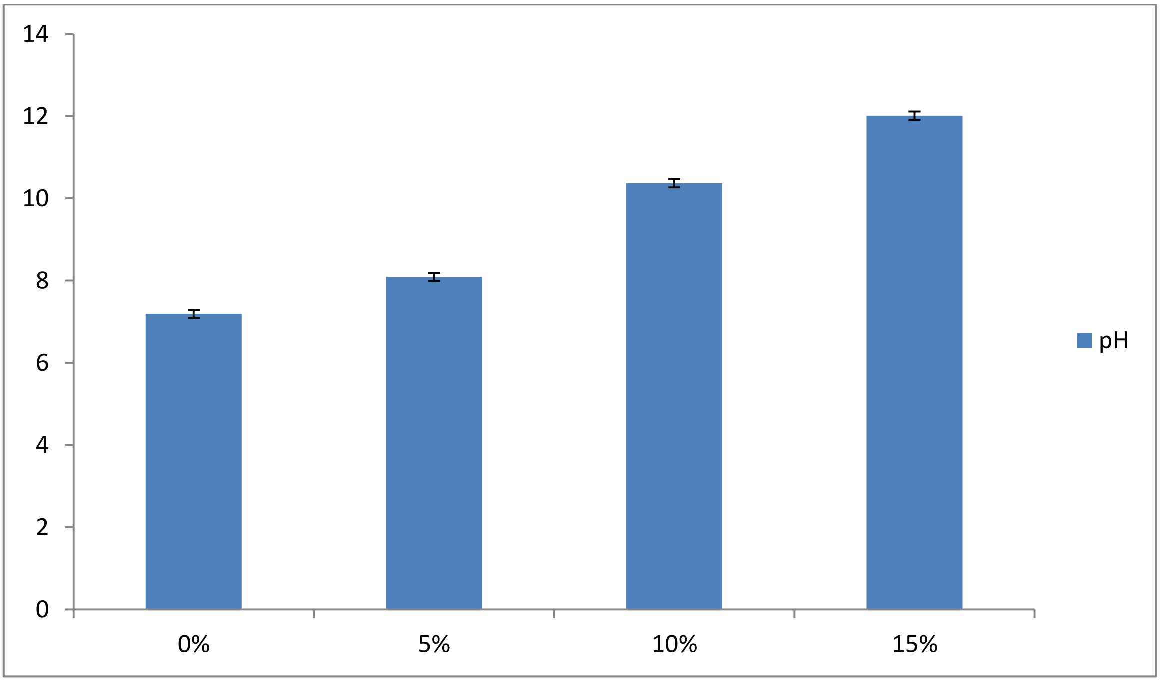

Fig. 1. pH values of SS yellow alkaline noodle

Table 2. Color characteristics of SS yellow alkaline noodles

Sample	L*	a*	b*
0%	48.09 ± 0.26[a]	-2.31 ± 0.08[d]	3.09 ± 0.02[a]
5%	43.51 ± 0.2[b]	0.06 ± 0.06[c]	1.78 ± 0.29[b]
10%	43.70 ± 0.21[b]	1.34 ± 0.09[b]	0.40 ± 0.00[d]
15%	40.36 ± 0.07[c]	2.35 ± 0.05[a]	0.42 ± 0.03[c]

Means in the same column with different superscripts are different ($p<0.05$)
L* = lightness (0 = black, 100 = white), a* = redness/greenness (+ = red, - = green),
b* = yellowness/blueness (+ = yellow, - = blue)

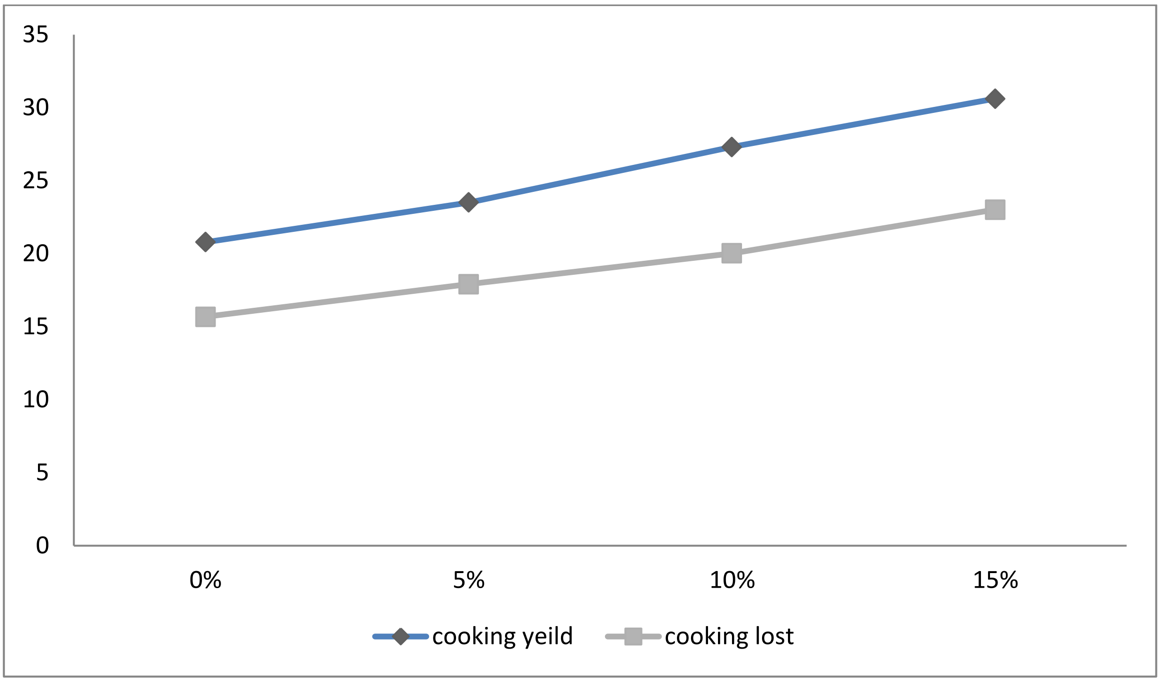

Fig. 2. Cooking properties of SS yellow alkaline noodle

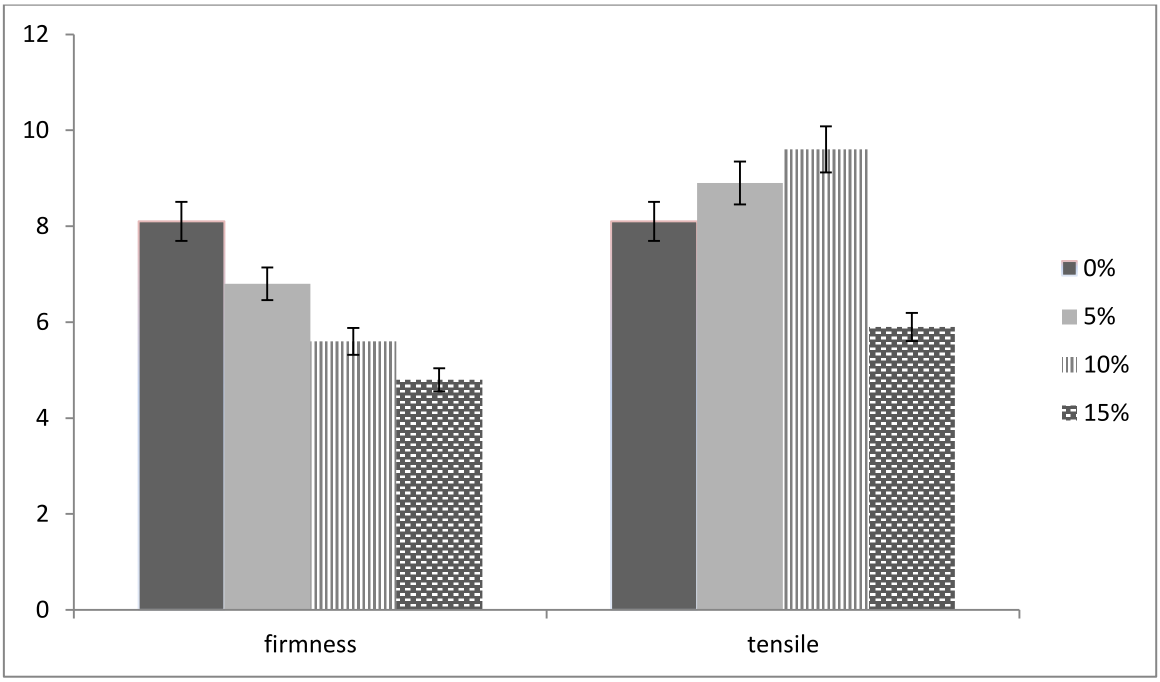

Fig. 3. Texture characteristics of SS yellow alkaline noodle

Conclusion

This study offers an opportunity to the efficient application of SSP in yellow alkaline noodles manufacture. The results indicated that the additional Spirulina seaweed powder could significantly affect the quality of yellow alkaline noodles. Crude fiber content increased significantly with the addition of SSP. Cooking yields increased but textural properties of cooked noodles reduced significantly with the increased levels of SSP. According to the results, the addition of 5 to 10% replacement of wheat flour by SSP would be considered as the optimum concentration.

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