Journal of Food and Nutrition Research, 2021, Vol. 9, No. 4, 187-192
Available online at http://pubs.sciepub.com/jfnr/9/4/3
Published by Science and Education Publishing
DOI:10.12691/jfnr-9-4-3

Physicochemical, Sensory, and Cooking Qualities of Gluten-free Pasta Enriched with Indonesian Edible Red Seaweed (*Kappaphycus Alvarezii*)

Enny Sholichah[1,#], Rima Kumalasari[1,#,*], Novita Indrianti[1,#], Lia Ratnawati[1,#], Ari Restuti[2,#], Aris Munandar[2,#]

[1]Research Center for Appropriate Technology, Indonesian Institute of Sciences, Subang, Indonesia
[2]Fisheries Study Program, Faculty of Agriculture, University of Sultan Ageng Tirtayasa, Serang, Indonesia
[#]These authors contributed equally to this work.
*Corresponding author: rima.kumalasari@gmail.com

Received February 19, 2021; Revised March 26, 2021; Accepted April 06, 2021

Abstract Nowadays, gluten-free (GF) products have become a trend as a healthy food. Making GF pasta has its challenges because there is no gluten content in GF flour. Application of red seaweed (*Kappaphycus alvarezii*) as hydrocolloid to enhance the quality of GF pasta has been conducted. The effects of the addition of *K. alvarezii* puree (0, 10, 20, 30, and 40% of the total flour) on chemical characteristics (moisture content, ash, fat, protein, carbohydrates, total dietary fiber, and calcium content), physical characteristics (elongation, adhesiveness, cohesiveness, springiness, and color), cooking properties (cooking time and cooking loss) and sensory evaluation (color, taste, aroma, firmness and overall acceptability) were investigated. *K. alvarezii* was able to increase viscous-elasticity, calcium, dietary fiber, cooking properties, and panelists' preference of GF pasta. *K. alvarezii* can be used as an additive to improve physicochemical properties, cooking quality, and acceptance of GF pasta.

Keywords: *gluten-free pasta, Kappaphycus alvarezii, seaweed puree, hydrocolloid*

Cite This Article: Enny Sholichah, Rima Kumalasari, Novita Indrianti, Lia Ratnawati, Ari Restuti, and Aris Munandar, "Physicochemical, Sensory, and Cooking Qualities of Gluten-free Pasta Enriched with Indonesian Edible Red Seaweed (*Kappaphycus Alvarezii*)." *Journal of Food and Nutrition Research*, vol. 9, no. 4 (2021): 187-192. doi: 10.12691/jfnr-9-4-3.

1. Introduction

Pasta products, including dry macaroni, noodles, and spaghetti, are the most popular foods globally and have become an international food. The International Pasta Organization (IPO) reports that pasta's world consumption increased during a lockdown and the export of pasta increased by 25% in 6 months [1]. Dried pasta is simple to cook, easy to store, and paired with any sauce and flavorings, making it a good, healthy, and "favorite" food in this challenging period. Usually, the best quality pasta products are made from durum wheat flour (semolina) even though many pasta kinds are made from common wheat or other flour enriched with some functional components. Nowadays, gluten-free (GF) pasta is being consumed by people with celiac and those who wish to exclude gluten-based products from their diet for health reasons [2]. GF products are mostly inferior in nutritional and low cooking quality to wheat products [2].

The process of making GF pasta has its challenges. There is no gluten content in GF flour (e.g., rice, tubers, maize, millet, sorghum, etc.), a protein found in wheat, causing the cooking quality and texture of GF pasta to be unsatisfactory. Gluten is an essential ingredient to build protein structure, which holds the starch in place and forms a protein network [3,4]. Gluten is a fundamental property to build dough's viscoelastic characteristics [4]. GF flours' viscoelastic characteristics depend on the starch component properties [5]. Some GF flours that have been reported to be successful in making pasta are amaranth flour, rice flour, millet flour, maize flour, modified cassava flour, quinoa flour, buckwheat flour, or a mixture thereof [6,7,8]. An additive may be selected to increase a cohesive mass in GF pasta. The alternative ingredients observed to emulate gluten's functionality are enzymes, proteins, and hydrocolloids [5]. Previous research used guar gum in noodles made from a mixture of modified cassava flour, rice flour, and maize flour. The results show that guar gum's addition provides positive effects on viscosity peak, breakdown viscosity, cooking time, and cooking loss of non-wheat noodles [9].

Seaweed is a unique source of valuable hydrocolloids that have significant importance in the food, medicinal, and biotechnological industries due to their functional properties. The addition of seaweed in the dough to produce noodles and pasta has been reported by some researchers. Seaweed can improve nutrition, dietary fiber, product quality, microstructure, biofunctional properties, and sensory acceptability [10,11]. Indonesia is the world's leading source of tropical seaweeds. The essential products processed from seaweeds are the hydrocolloids agar and carrageenan. The utilization of tropical seaweed originating from Indonesia for pasta products has not been explored optimally. Therefore, research is needed to explore the usefulness of tropical seaweed, especially to improve GF pasta's function value and cooking qualities. *K. alvarezii* is one type of superior local seaweeds from Indonesia. *K. alvarezii* is a species of red algae. It is one of the most important commercial sources of carrageenans, a family of gel-forming and polysaccharides. This study uses composite flour from corn, modified cassava flour, and rice. Based on our previous research results, gluten-free pasta can be made from a mixture of rice flour, maize flour, and modified cassava flour [7,8,12]. Our previous research still had weaknesses, the texture was not accepted by the panelists. In this study, the addition of seaweed to the pasta dough is expected to increase panelist acceptance.

Also, rice, cassava, and corn are local products available throughout the year in Indonesia at affordable prices. This study aims to explore the benefits and effects of the addition of *K. alvarezii* on the physical properties, sensory properties, and cooking qualities of gluten-free pasta.

2. Materials and Methods

2.1. Materials

Modified cassava flour was purchased in Bandung, West Java, Indonesia. The rice flour (Rose Brand, Indonesia), corn seed (Pioneer 21), and salt (Cap Kapal, Indonesia) were purchased from a local market in Subang, West Java, Indonesia. The seaweed (*Kappaphycus alvarezii)* was purchased from Serang-Banten, Indonesia. Chemicals used for analysis (n-hexane, hydrochloric acid, and nitric acid) were purchased from Merck (Germany).

2.2. Pasta Preparation

The GF pasta preparation used the method described in our previous research with modification [7]. Modified cassava flour, rice flour, and maize flour were mixed gently, *K. alvarezii* puree and salt solution were added and mixed for almost 15 min. The dough was steamed for 45 min and extruded at a temperature of 50°C. The extruder was with a single type screw (screw diameter, 60 mm, locally manufactured by the Research Center for Appropriate Technology, Subang, West Java, Indonesia). The barrel length was 45 mm. The extruder was operated at a screw speed of 50 rpm, and the setting temperature of the barrel was 50°C. The drying process was terminated when the product had a moisture content of approximately 10-12%, indicated by the pasta's breakability and transparency in the pasta's core. The experiment was carried out in triplicate. Before analysis, all samples were kept in a closed plastic box at ambient temperature.

2.3. Chemicals Analysis of GF Pasta

Moisture, ash, fat, and the GF pasta's carbohydrate contents were determined using the AOAC method [13]. Protein content was measured using DuMaster Protein Analyzer (Buchi D-480, Switzerland). Total dietary fiber (TDF) was determined using a combination of enzymatic and gravimetric methods [13].

Calcium content was measured using Atomic Absorption Spectroscopy AAS (GBC 933AA, Australia). The sample was bashed in a muffle furnace (Neytech Vulcan D 130, USA) at 450°C for 12 h. The ash was solubilized in a mixture of nitric acid and distilled water. The solution was filtered and injected into the instrument. All chemical analyses were repeated in duplicate.

2.4. Physical Analysis of GF Pasta

The physical analysis of GF pasta was expressed as elongation, adhesiveness, cohesiveness, and springiness. The physical analysis using a texture analyzer (TAXT-Plus, Stable Micro Systems, Surrey, UK). The sample was cooked in boiling water (based on each sample's cooking time) and drained for about 2 min at room temperature. Elongation of the cooked pasta was measured using spaghetti tensile grips (A/SPR) rig at pre-test speed of 1 mm/s, test speed of 3 mm/s, and post-test speed of 10 mm/s and initial distance between clamps of 80 mm. Adhesiveness, cohesiveness, and springiness of the cooked pasta were obtained using a P/36-cylinder probe. The test was done at mode; trigger type, auto 0.5 g; pre-test speed of 2 mm/s, test speed of 2 mm/s; the post-test speed of 10 mm/s, and strain of 75%. All measurements were carried out in five replicates [7].

The color measurements of raw GF pasta were performed instrumentally using a chroma meter (NH3, China) [12]. The color parameters including lightness (L; 0 = black, 100 = white), redness/greeness (a; + = red, - = green), and yellowness/blueness (b; + = yellow, - = blue) were reported. The measurement was done in duplicate.

2.5. Cooking Properties of GF Pasta

The samples (5 g) were cut into 4-5 cm in length and cooked in 100 ml boiling distilled water. The cooking time was evaluated according to the time taken for the complete gelatinization (disappearance of white core of the pasta when squeezed the cooked pasta between two transparent glass slides). The cooking loss was carried out in the following stages: the samples (1 g) were cut into small pieces with 3-5 cm in length and boiled in 50 ml boiling distilled water (according to cooking time test). The cooked pasta was then placed on a nylon screen, rinsed with distilled water, and drained for 1 min. The cooking water and flush water in a pre-weighed glass were evaporated and dried in a hot-air oven at 105°C until constant weight. Cooking loss was expressed as the percentage of dry matter loss during cooking to dry the sample weight [12]. All measurements were performed in duplicate.

2.6. Sensory Evaluation

Sensory testing was performed with the obtained GF pasta samples. It was conducted to an acceptability test using a 6-point hedonic scale where "1" is equal to "strongly dislike," and "6" is equivalent to "strongly like." The evaluated attributes were aroma, color, firmness, taste, and overall acceptability. The tests were carried out in a laboratory by thirty non-trained judges. The samples were served in 25g portions accompanied by a tomato-based sauce in individual booths. The pasta products were prepared using no salt or oil added to the cooking water. The mean value was taken for each characteristic of the samples, representing the panelists' judgment on the sensory quality of the GF pasta.

2.7. Research Design

A completely randomized design (CRD) single factor (formulation of GF pasta) was considered for preparing different samples (Table 1). The addition of *K. alvarezii* puree (0, 10, 20, 30, and 40% of the total flour). One-way analysis of variance (ANOVA) was used to analyze the data. EXCEL software was used to perform data analysis. Duncan's Multiple Range Test was applied to find the significant ($p < 0.05$) difference among samples.

Table 1. GF Pasta Formulation

No	Formula	F1	F2	F3	F4	F5
1	Modified cassava flour (g)	600	600	600	600	600
2	Rice flour (g)	525	525	525	525	525
3	Corn flour (g)	375	375	375	375	375
4	*K. alvarezii* puree (g)	-	150	300	450	600
5	Water (g)	430	430	430	430	430
6	Salt (g)	15	15	15	15	15

3. Result and Discussion

3.1. Chemical Properties of GF Pasta

The chemical properties of GF pasta with a variety of *K. alvarezii* puree addition are tabulated in Table 2. The ash content, the total dietary fiber, and calcium contents significantly increased ($p<0.05$) with the increasing *K. alvarezii* puree. The ash content showed values between 1.40-1.82%, which was lower than the maximum range of dried noodles according to the Indonesian National Standards (SNI 8217:2015), which is 3% [14]. Moisture and protein contents of samples were not significantly affected by *K. alvarezii* puree ($p>0.05$). The moisture content of samples ranged from 10.75 to 11.62%. This value was lower than the maximum moisture content of dried noodles according to the Indonesian National Standards (SNI 8217:2015), which is 13% [14]. The protein content of pasta in this study ranged between 5.30-5.45%.

The F5 sample with the highest of *K. alvarezii* puree addition had the highest ash content. This study's result is in line with the previous studies conducted by Dewi [15], who reports that the *K. alvarezii* substitution increases ash content by almost 70%. TDF of *K. alvarezii* is 12 g/100 g [16]. The control sample (F1) showed the lowest TDF value by 2.13%, while the F5 had the highest TDF value by 7.54%. The previous study by Keyimu [17] reports that the TDF content of noodles without seaweed addition is 1.40%, whereas, with 7% seaweed addition, the TDF content increased to 1.76%.

The calcium content in the GF pasta increased with the addition of *K. alvarezii* puree. Due to the high calcium content of the seaweed puree (red strains of *K. alvarezii*), 467.65 mg/100g [18]. Fradinho *et al*. [19] also report that the addition of brown seaweed increases the calcium content of cooked pasta from 3.4 mg/100g to 5.6mg/100g (liquid extract) and 15.3 mg/100g (seaweed puree). *K.alvarezii* puree substitution significantly increased the carbohydrate content. Still it decreased the fat content in gluten-free pasta. The previous study has shown that the addition of brown seaweed (liquid extract and puree) reduces the fat content of pasta from 2.2% (without the addition of brown seaweed) to 0.7% (liquid extract) and 1.7% (seaweed puree) [19].

3.2. Physical Properties of GF Pasta

Elongation is one of the parameters to determine the quality of noodles. Good quality noodles have a high elongation value, and people prefer noodles with elasticity when served [20]. *Table 3* shows that the addition of *K. alvarezii* causes a significant increase in GF pasta elongation. *K. alvarezii* seaweed is a kappa carrageenan source, a phyllocoloid that generally uses a gel former [21]. Carrageenan content of seaweed produces firm dough during the gelatinization process and elastic noodles texture [22].

Texture properties are the most critical parameters to define the quality and consumers' acceptance of cooked noodles [23]. The addition of *K. alvarezii* significantly increases the adhesiveness of GF pasta (Table 3), but there are no significant differences in the cohesiveness and springiness. Adhesiveness increase in GF pasta with *K. alvarezii* can be related to the increase in dietary fiber content. Dietary fiber in seaweed can absorb more water into the gelatinized matrix structures of noodles during cooking, resulting in higher noodle adhesiveness [19]. This result is similar to Mohammad *et al*. [21], who state that the addition of 30% seaweed puree increases yellow alkaline noodles' adhesiveness.

Table 2. Chemical Properties of GF Pasta

Chemical Properties	Formula				
	F1	F2	F3	F4	F5
Moisture content (%)	11.25±0.53^{a}	10.75±0.45^{a}	10.92±0.61^{a}	11.21±0.46^{a}	11.62±0.55^{a}
Ash content (%)	1.40±0.04^{ab}	1.30±0.94^{a}	1.63±0.10^{abc}	1.73±0.10^{bc}	1.82±0.09^{c}
Fat content (%)	4.86±0.37^{b}	4.88±0.05^{b}	4.67±0.24^{b}	1.35±0.24^{a}	1.22±0.13^{a}
Protein (%)	5.30±0.04^{a}	5.30±0.11^{a}	5.31±0.24^{a}	5.42±0.23^{a}	5.45±0.22^{a}
Carbohydrate (%)	77.18±0.72^{a}	77.77±0.14^{a}	77.48±0.65^{a}	80.29±0.54^{b}	79.89±0.38^{b}
Total Dietary Fiber (%)	2.13±0.11^{a}	5.89±0.04^{b}	6.54±1.30^{bc}	6.74±0.03^{bc}	7.54±0.53^{c}
Calcium (mg/100g)	33.86±0.49^{a}	46.96±6.47^{ab}	212.82±106.99^{abc}	237.77±161.17^{bc}	274.72±126.91^{c}

Mean values with a different alphabet in the same row were significantly different (Duncan $P<0.05$).

Table 3. Physical and Color Properties of GF Pasta

Physical and Color Properties	Formula				
	F1	F2	F3	F4	F5
Elongation (%)	168.48±4.76[a]	172.32±4.34[a]	182.06±3.47[b]	183.6±2.47	190.87±1.86[c]
Adhesiveness (g.s)	-35.54±2.02[a]	-36.21±2.17[a]	-40.55±5.49[ab]	-49.52±8.28[bc]	-56.41±8.88[c]
Cohesiveness	0.77±0.05[a]	0.79±0.06[a]	0.83±0.07[a]	0.86±0.07[a]	0.89±0.08[a]
Springiness	0.30±0.05[a]	0.36±0.14[a]	0.39±0.11[a]	0.44±0.16[a]	0.59±0.34[a]
L (brightness)	69.70±0.50[b]	69.03±0.80[b]	68.56±0.50[b]	66.57±0.68[a]	66.32±1.52[a]
a (redness)	3.94±0.17[ab]	3.87±0.24[ab]	3.71±0.12[a]	4.45±0.37[ab]	4.56±0.72[b]
b (yellowness)	18.87±0.63[a]	18.82±0.67[a]	17.88±0.45[a]	18.48±0.70[a]	18.42±1.05[a]

Mean values with a different alphabet in the same row were significantly different (Duncan *P<0.05*).

The color of GF pasta is one of the vital quality parameters that determine consumer acceptance of products in the market [19]. The brightness (L) of GF pasta significantly decreases along with the increasing amount of *K. alvarezii* puree but significantly increases in redness (a) (Table 3). It is probably due to the addition of *K. alvarezii*, which can change the molecular structure of the matrix of samples and show different responses to the light [10]. The hygroscopic properties of seaweed might absorb some water and moisture, resulting in a darker color in the gluten-free pasta [17]. The higher intensity of redness (a) by increasing seaweed puree might be caused by the presence phycoerythrin pigment content of *K. alvarezii* seaweed that induces red color [21].

3.3. Cooking Properties of GF Pasta

Table 4 shows that the cooking time of GF pasta increases significantly in the addition of *K. alvarezii* ($p<0.05$). Cooking time was determined based on the complete pasta gelatinization. Seaweed mostly consists of carrageenan, agar, and alginates [24]. A hydrocolloid can form good gel properties due to polysaccharide chains and water [25]. The hydrophilicity of incorporated seaweed in pasta matrix due to the absorb water is more straightforward than starch and inhibits water absorption of starch granules. The more seaweed is added, the more water will be absorbed [26].

Cooking loss is the amount of solid component leach into the cooking water, indicating the quality of noodle or pasta product, which is considered less than 10% [27]. The addition of *K. alvarezii* increases the cooking loss (Table 4). This result is similar to Ahmed *et al.* [28], who states that the supplementation of high fiber materials in pasta products increases the cooking loss. It is reported that gluten pasta has low cooking loss because of the homogeneity of gluten matrix formation. Gluten-free flour or starch noodles have a higher cooking loss due to starch solubility during the process of boiling noodles [28].

3.4. Sensory Evaluation of GF Pasta

The addition of *K. alvarezii* has significant effects on increasing the panelists' preference for the color, firmness, taste, and overall acceptance of GF pasta (Table 5). The addition of seaweed can cause the color of GF pasta to darken [30], but panelists like it more. In contrast to Santoso et al.'s [31] research results, panelists increasingly dislike seaweed noodles because of their darker color. Widyaningtyas and Susanto [32] stated that seaweed as a stabilizer for food products has odorless and tasteless characteristics so that it does not affect when added to food ingredients. These hydrocolloids will interact with proteins and influence each other to form a gel, thereby increasing the noodles' elasticity and making the texture better [32].

Table 4. Cooking Properties of GF Pasta

Cooking Properties	Formula				
	F1	F2	F3	F4	F5
Cooking time (s)	460±17.32[a]	500±17.32[b]	520±17.32[b]	580±17.32[c]	680±17.32[d]
Cooking loss (%)	8.89±1.42[ab]	7.59±1.03[a]	9.84±1.06[ab]	10.33±2.30[ab]	12.17±3.36[b]

Mean values with a different alphabet in the same row were significantly different (Duncan *P<0.05*).

Table 5. Sensory Evaluation of Gluten-Free Pasta

Sensory Properties	Formula				
	F1	F2	F3	F4	F5
Color	4.43±0.86[ab]	4.00±0.69[a]	4.03±0.93[a]	4.50±0.68[b]	4.66±1.02[b]
Aroma	4.40±0.89[a]	4.03±0.89[a]	4.16±0.91[a]	4.20±0.85[a]	4.23±0.73[a]
Taste	4.06±1.08[a]	3.83±1.15[a]	3.80±1.16[a]	4.00±1.02[a]	4.27±0.83[a]
Firmness	3.60±0.89[a]	3.63±1.10[a]	3.67±1.21[a]	4.27±0.91[b]	4.43±0.73[b]
Over all	3.83±0.83[a]	3.90±1.02[a]	3.97±1.03[a]	4.23±0.77[ab]	4.63±0.61[b]

Mean values with a different alphabet in the same row were significantly different (Duncan *P<0.05*).

4. Conclusion

The addition of *K. alvarezii* significantly increases the dietary fiber, calcium, adhesiveness, and the panelists' preference for GF pasta. The addition of 40% *K. alvarezii* seaweed is the best treatment, which produces GF pasta with chemical characteristics (moisture content 11.62%, ash 1.82%, fat 1.22%, protein 5.45%, carbohydrates 79.89%, dietary fiber 7.54%, and calcium 274.72 mg/100g), physical characteristics (elongation 47.71%, adhesiveness -56.41 g.s, cohesiveness 0.89, springiness 0.59, L 66.32, a 4.56, b 18.42), cooking properties (cooking time 680 s, cooking loss 12.17%), and receives "moderate like" scores from the panelists.

Acknowledgements

The authors would like to thank LPDP-the Ministry of Finance and the Ministry of Research of Indonesia that has funded this project through the PRN-Stunting project. The authors would also like to appreciate the PRN coordinating team from the Research Center for Appropriate Technology - Indonesian Institute of Sciences.

References

[1] IPO International Pasta Organization, "Pasta, world consumption boom since the lockdown started 1 consumer out of 4 ate more, 25% export increase in 6 months. Available: https://internationalpasta.org/news/pasta-world-consumption-boom-since-the-lockdown-started-1-consumer-out-of-4-ate-more-25-export-increase-in-6-months/#:~:text=16.10.2020-. [Accessed January 8, 2021].

[2] Marti, A. and M.A Pagani, "What can play the role of gluten in gluten free pasta?" *Trends in Food Science & Technology* 31 (1). 63-71. May.2013.

[3] Murray, J.A. Watson, T. Clearman, B. Mitros, F, "Effect of a gluten-free diet on gastrointestinal symptoms in celiac disease". *Am. J. Clin. Nutr.* 79. 669-673. 2004.

[4] Mariotti, M. Iametti, S. Cappa, C. Rasmussen, P. Lucisano, M, "Characterisation of gluten-free pasta through conventional and innovative methods: Evaluation of the uncooked products" *Journal of Cereal Science* 53 (2). 319-327. May.2011.

[5] Padalino, L. Conte, A. Nobile, M.A.D, "Overview on the general approaches to improve gluten-free pasta and bread". *Foods* 5 (87). 1-18. Dec. 2016.

[6] Schoenlechner, R. Drausinger, J. Ottenschlaeger, V. Jurackova, K. Berghofer, E, "Functional properties of gluten-free pasta produced from amaranth, quinoa and buckwheat". *Plant Foods for Human Nutrition* 65 (4). 339-349. Oct. 2010.

[7] Sholichah, E. Indrianti, N. Yulianti, L.E. Sarifudin, A. and Kiatponglarp, W, "Impact of tempeh flour supplementation on the properties of non-gluten pasta product". *African Journal of Food Agriculture, Nutrition and Development* 20 (7). 16905-16921. Dec. 2020.

[8] Yulianti, L.E. Sholichah, E. Indrianti, N, "Addition of tempeh flour as a protein source in mixed flour (mocaf, rice, and corn) for pasta product". *IOP Conf. Series: Earth and Environmental Science.* 251. 1-6. 2019.

[9] Ratnawati, L. and Afifah, N, "The effects of using guar gum, CMC and carrageenan on the quality of noodles made from blend of mocaf, rice flour and corn flour". *Jurnal Pangan* 27 (1). 43-54. Oct. 2018.

[10] Shahsavani, L. Mostaghim, T, "The effect of seaweed powder on physicochemical properties of yellow alkaline noodles". Journal of Food Biosciences and Technology 7 (2). 27-34. 2017.

[11] Raman, M. and Doble, M, "Physicochemical and structural characterisation of marine algae *Kappaphycus alvarezii* and the ability of its dietary fibres to bind mutagenic amines". *Journal of Applied Phycology* 26. 2183-2191. Feb. 2014.

[12] Afifah, N. and Ratnawati, L, "Quality assessment of dry noodles made from blend of mocaf flour, rice flour and corn flour". *IOP Conf. Series: Earth and Environmental Science* 10. 1-9. 2017.

[13] AOAC. *Official Methods of Analysis 15th Edition*. Washington: Association of Official Analysis Chemists (1990).

[14] National Standarization Agency (BSN). SNI 8217-2015: Dried Noodles.

[15] Dewi, E.C, "Quality evaluation of dried noodle with seaweeds puree subsitution". *Journal of Coastal Development*, 14 (2). 151-158. Feb. 2011.

[16] Kumar, K.S. Ganesan, K. and Rao, P.V.S, "Seasonal variation in nutritional composition of Kappaphycus alvarezii (Doty) Doty-an edible seaweed". *Journal of Food Science and Technology* 52 (5). 2751-2760. May. 2015.

[17] Keyimu, X.G, "The effects of using seaweed on the quality of asian noodles". *Journal of Food Processing and Technology* 4 (3). 1-4. 2013.

[18] Adharini, R.A. Setyawan, A.R. Suadi, Jayanti, A.D, "Comparison of nutritional composition in red and green strains of *Kappaphycus alvarezii* cultivated in Gorontalo Province, Indonesia". E3S Web of Conferences 147, 03029. Jan. 2020.

[19] Fradinho, P. Raymundo, A. Sousa, I. Dominguez, H. Torres, M.D, "Edible brown seaweed in gluten-free pasta:Technological and nutritional evaluation". *Foods* 8. 1-17. 2020.

[20] Astuti, R.D. David, W. Ardiansyah, "Sensory evaluation of noodles substituted by sweet potato flour and rice bran". *Curr. Res. Nutr. Food Sci.* (8). 144-154. 2020.

[21] Mohammad, S.M. Razali, S.F.M. Rozaiman, N.H.N.M. Laizani, A.N. Zawawi, N, "Application of seaweed (*Kappaphycus alvarezii*) in Malaysian food products". *International Food Research Journal* 26 (6). 1677-1687. Dec. 2019.

[22] Halimah, S.N. Suryani, R.A. Wijayanti, S.W. Pangestu, R.A. Deni, G.D. Romadhon, "Fortification seaweed noodles [*Euchema cottonii* (Weber-van Bosse, 1913)] with nano-calcium from Bone Catfish [*Clarias batrachus* (Linnaeus, 1758)]", *Aquatic Procedia*. 221-225. Aug. 2016.

[23] Agusman, Murdinah, and Wahyuni, T, "The nutritional quality and preference of wheat noodles incorporated with *Caulerpa* sp. Seaweed". *International Food Research Journal* 27 (3). 445-453. June. 2020.

[24] Roohinejad, S. Koubaa, M. Barba, F.J. Saljoughian, S. Amid, M. and Greiner, R, "Application of seaweeds to develop new food products with enhanced shelf-life, quality and health-related beneficial properties". *Food Research International* 99. 1066-1083. 2017.

[25] Belitz, H.D. Grosch, W. Schieberle, P, *Food chemistry*. Springer, Berlin, 2009.

[26] Billina, A. Waluyo, S, "Study of the physical properties of wet noodles with addition of sea weed". *Jurnal Teknologi Pertanian Lampung* 4 (2). 109-116. Jan. 2014.

[27] Malcolmsom, L. Matsuo, R, "Effects of cooking water composition on stickiness and cooking loss of spaghetti". *Cereal Chemistry* 70. 272-275. 1993.

[28] Ahmed, I. Qazi, I.M. Jamal, S, "Quality evaluation of noodles prepared from blending of broken rice and wheat flour". *Starch/Staerke* 67 (11). 905-912. May. 2015.

[29] Fu, B.X. "Asian noodles: History, classification, raw materials, and processing". *Food Research International* 41 (9). 888-902. Nov. 2008.

[30] Jaziri, A.A. Sari, D.S. Yahya, Prihanto, A.A. and Firdaus, M, "Fortification of *Eucheuma cottonii* flour on dried noodle. *Indonesian Jurnal of Halal* 1 (2). 266-347. 2018.

[31] Santoso, J. Lestari, O.A. Anugrahati, N.A, "Peningkatan kandungan serat makanan dan iodium pada mie kering melalui subtitusi tepung terigu dengan tepung rumput laut". *Jurnal Ilmu Teknologi Pangan* 4 (2). 131-145. 2006.

[32] Widyaningtyas, M. and Susanto, W.H, “Effect of type and concentration of hydrocolloids (carboxy methyl celullose, xanthan gum, and carrageenan) on characteristic dried noodle based sweet potato variety yellow ase paste”. *Jurnal Pangan dan Agroindustri* 3 (2). 417-423. Apr. 2015.