Systematic Literature Review on The Short Pasta Noodles Reinforced with Seaweed

Angelo Jean Pierr Janampa-Salvatierra,
Faculty of Engineering and Architecture, University of Lima, Perú
20172249@aloe.ulima.edu.pe

Alejandro Rodolfo Lamas-Vidalon,
Faculty of Engineering and Architecture, University of Lima, Perú
20170797@aloe.ulima.edu.pe

Martín Fidel Collao-Diaz
Faculty of Engineering and Architecture, University of Lima, Perú
mcollao@ulima.edu.pe

Abstract

In the present research, through a systematic literature review, we seek to describe the application of seaweed in the production of noodles, as an alternative to traditional preparation and to improve the nutritional content of noodles. For this, in the first place, papers were extracted from different databases such as Scopus and Google Scholar. Then, the most relevant information was analyzed and extracted from each scientific article. With this information, the objectives were answered. Finally, the results were analyzed in detail and the doors were opened for new research on noodles reinforced with seaweed, but centralized in Peru. Thanks to this research, it can be said that the application of seaweed in small proportions (<= 5%) is beneficial at the nutritional level, since it increases the amount of proteins, fiber and minerals, as well as decreases the amount of carbohydrates and fats.

Keywords
Noodle, Seaweed, Nutritional characteristics, Healthy and Benefits.

1. Introduction
According to Su a rez et al. (2018), the demands in the food sector together with the new orientations in nutrition have generated a new avenue towards the elaboration of alternative foods, that is, consumers are looking for foods that are healthy, nutritious and, in addition, that taste good and require a low cost. Wheat-derived foods are in high demand in much of the world, so most countries need to import wheat to meet the demand of their population (Munandar et al. 2019). On the other hand, Al Barr et al. (2021) found that recent research shows that a substitute for wheat is being sought for both noodle production and other foods. As well as, due to the large quantities of imported wheat, in countries such as Indonesia, the main objective is to reduce high costs and improve the nutritional content of products.

Afterwards, Varela et al. (2019) discovered that dry pasta is a common food in several countries due to its high consumption, for example, Latin America is in fourth place in the world with respect to per capita consumption of wheat and has a value of 64 kilograms per year per person, in addition Peru is the second country in Latin America that consumes more noodles (Castillo and Olivos 2018). This is mainly because wheat flour noodles are a low-cost food with a high level of ease in their preparation, in addition to having a long shelf life and pleasant sensory characteristics. However, according to Pongpichaiudom et al. (2018), wheat flour-based noodles have high levels of fat and carbohydrates, as well as low levels of protein which makes it a product with certain characteristics deficient in its nutritional level.

With these conditions, various substitutes for wheat flour have been sought, such as those explained below. For example, Pongpichaiudom and Songsermpong (2018) established that noodles enriched with chicken, egg and seaweed would have a higher amount of protein and, in addition, a lower amount of fat, even have a lower number of

unwanted oils. Then, Falade and Badanga (2021) found that the enrichment of noodles by soybean meal generates benefits for both the health and costs of producing companies.

Seaweed can be a great substitute because is rich in vitamins and minerals such as iodine, calcium, magnesium, and iron. As reported by Tung Chi (2023), iodine is especially important for thyroid health, and calcium and magnesium are essential for bone health. Seaweed also contains antioxidants such as carotenoids and flavonoids, which can help protect against oxidative stress and inflammation in the body.

According to Takebayashi et al. (2020), seaweed possesses numerous nutritional and antioxidant properties, bringing benefits to people by helping them maintain a healthy lifestyle. On the other hand, Nagai (2018), mentions that algae are renewable natural resources not yet used on a large scale and is applicable in different sectors such as cosmetics, fertilizers and food. The latter, algae can provide benefits such as sodium reduction in meat products, in addition to being a supply of minerals to meet the daily requirement and, finally, adjust the values of fatty acids and thus guide it to healthy consumption.

Additionaly, seaweed cultivation and processing can have significant economic and environmental benefits, particularly in coastal communities where it can provide an alternative source of income and promote sustainable agriculture. According to Rajeshkumar et al. (2021), in addition to its nutritional benefits, seaweed has also been found to have antimicrobial and antioxidant properties, which can help to extend the shelf life of food products and prevent the growth of harmful bacteria. Incorporating seaweed into food products can therefore improve their safety and reduce the risk of foodborne illnesses and has the potential to improve the nutritional content and safety of this widely consumed food product.

With this information, it would seek to incorporate seaweed in the production of noodles, as an alternative to traditional processing and, in this way, improve the nutritional content of noodles, as well as their flavor and texture. Finally, that is why, to carry out this elaboration, it is important to know the product that has an adequate nutritional composition.

1.1 Objectives

The present research is carried out in order to analyze the characteristics of short pasta noodles reinforced with seaweed. Based on a bibliographic study in which various scientific articles are compared to determine if this product is healthy for human consumption. The main motivation is to discover new alternatives in relation to traditional foods that have better nutritional characteristics and also have a good taste and texture.

2. Literature Review

Studies on the application of seaweed to noodles date back many years. First, Prabhasankar et al. (2009) determined in 2009 that noodles could be produced based on brown seaweed flour with a proportion of 2.5% of the total, improving the nutritional content and giving a useful value to algae as an ingredient for other products. Then, in 2017, El-Baz et al. (2017) pointed out that the incorporation of Dunaliella salina seaweed in pasta production produces an improvement effect on cooking and sensory properties, in addition to the nutritional quality of pasta-type products. In the same year, Debbarma et al. (2017) incorporated green algae up to 20% of the percentage of the composition of the noodles, obtaining noodles with more fiber and healthier.

Later in 2018, Suárez et al. (2018) obtained both the nutritional label and the costs of applying seaweed to noodles in the Patagonia region, and a positive application of it was obtained. On the other hand, Pongpichaiudom and Songsermpong (2018) observed that in the application of algae and other food supplements (egg yolk and chicken meat) an improvement in nutritional characteristics such as increased fiber and protein, and reduction of unwanted carbohydrates and oils was obtained. Finally, this product was acceptable in terms of taste, according to the sensory evaluation made to the 70 panelists.

In 2019, the investigation continued. San Juan Bosco (2019) made the substitution of wheat flour candeal by Porphyra columbina flour, which is an alga native to the region of Argentina, allowed to make noodles with 12% more protein, 65% more in the value of minerals and 158% more in dietary fiber. Then, Mohammad et al. (2019) incorporated the seaweed K. alvarezii in the different meals has a growth potential in the marketing of the industry itself, in addition to improving nutritional contents such as fiber and phenolic content. In addition, according to Varela et al. (2019), noodles based on red seaweed flour can be made to take advantage of this natural maritime resource and not depend

so much on wheat imports, this application allows to improve in addition to costs the nutritional composition of noodles.

The following year, Agusman and Wahyuni (2020) demonstrate that the addition of the seaweed Caulerpa sp. In the preparation of noodles modifies the appearance and elasticity of noodles, as well as this addition does not affect the acceptance of the product and that this type of pasta can bring nutritional advantages in daily style diets. Finally, at present, Al-Baarr et al. (2021) determined that the addition of spirulina, which is a well-recognized type of algae, combined with basil leaf makes the noodles have a solid and chewy texture. Therefore, this would make it an optimal substitute for wheat flour.

3. Methods

The current research work is a systematic review, it is a work based on the synthesis of research articles on the topic explained in the previous chapter. This investigation is qualitative type, since it is based on the use of papers from the selected databases. It is also a descriptive and exploratory research, because the data obtained from the articles studied will be simplified, at the same time study designs will be included with the aim of producing results of this work, even generating ideas for future investigations.

For the present research, the following databases were used as search tools: Scopus and Google Scholar. The first allows us to obtain various scientific articles through keywords and connectors that limit the search. The second is considered an easily accessible tool that also contains a variety of scientific articles and theses by different authors. On the other hand, the search for information was delimited in the range of 2017-2021, in order to obtain recent and updated research.

Then it is necessary to determine the String, which is the set of keywords in both English and Spanish that delimit our search in the databases giving us more specific and updated articles for the present research work. The string used is:

TITLE-ABS-KEY ((fideo OR pasta OR noodle) AND (alga OR seaweed))

With the string already delimited, we proceed to determine the selection and exclusion criteria of the search, which are exposed in Table 1.

Table 1. Selection and exclusion criteria

Selection criteria	Exclusion criteria
Period: From January 2017 to June 2021 **Type of publication:** Scientific articles and/or theses. **Language:** English and Spanish **Subject area: Agriculture and life sciences,** biochemistry, genetics, engineering, environmental sciences, chemical engineering, economics and finance, nutrition	**Context:** Nutritional aspects in countries around the world. **Aspects of seaweed-reinforced noodles :** physical and sensory characteristics Nutritional content. Production system.

Through these selection and exclusion criteria, we proceed to represent this process in Figure 1, which resulted in a total of 26 articles that we used for this research work. In resume, for the process described in Figure 1, articles were obtained in the two main data bases: Google Scholar and Scopus. Then, we reduce the number of the articles by using the main keywords, period, language, type of publication, area of knowledge and main aspects to obtain the theme of interest.

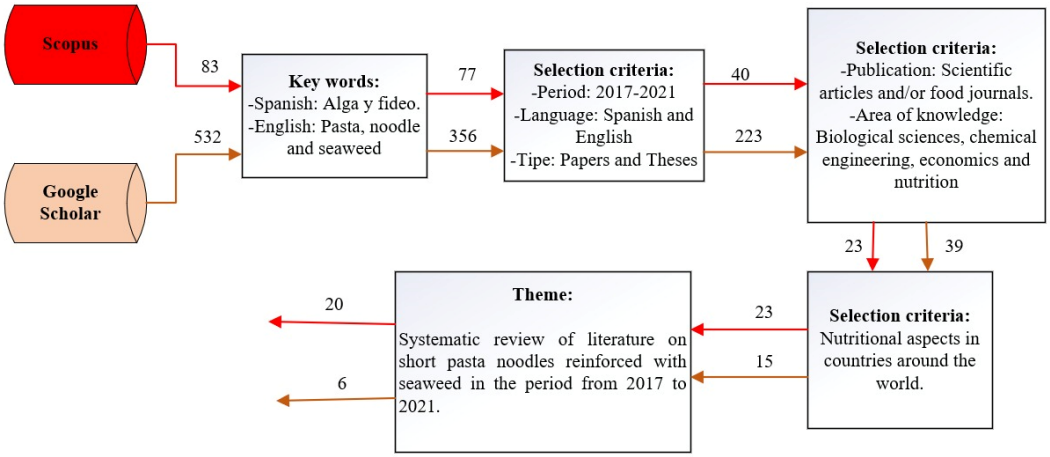

Figure 1. Diagram of the article selection process

With the sources collected, we will seek to interrelate the information in order to obtain similarities and differences that allow to satisfy the questions raised in the objectives.

4. Data Collection

For the development of this investigation, 12 scientific articles dealing with the incorporation of seaweed as an additive in the preparation of noodles were considered. These articles, exposed in Table 2, explain from the development of the idea of noodles to the presentation of the results of these noodles reinforced with seaweed.

Table 2. Selected articles

Paper number	Title
1	Application of seaweed (Kappaphycus alvarezii) in Malaysian food products
2	Characterization of frying, microwave-drying, infrared-drying, and hot-air drying on protein-enriched, instant noodle microstructure, and qualities
3	Chemical composition and protein quality of noodles supplemented with Porphyra columbina flour.
4	Evaluation of microstructure and quality characteristics of microwave-dried instant noodles enriched with chicken meat, egg yolk, and seaweed
5	Improvement of microwave-dried, protein-enriched, instant noodles by using hydrocolloids
6	Influence of Indian brown seaweed (Sargassum marginatum) as an ingredient on quality, biofunctional, and microstructure characteristics of pasta.
7	Microalgae Dunaliella salina for use as Food Supplement to Improve Pasta Quality
8	Nutritional and physical characteristics of noodles incorporated with green seaweed (Ulva reticulata) and fish mince
9	Pasta complemented with Porphyra, seaweed from Argentine Patagonia Nutritional value, culinary behavior and sensory evaluation
10	Nutritional label and calculation of the cost of Patagonian dry noodles
11	The hardness analysis of noodles made from modified cassava flour, spirulina (Spirulina platensis) and basil leaves extract (Ocimum sanctum L.)
12	The nutritional quality and preference of wheat noodles incorporated

5. Results and Discussion

5.1 Characteristics of short pasta noodles reinforced with seaweed

To determine the characteristics of short pasta noodles reinforced with seaweed, the nutritional characteristics (amount of protein, amount of fiber, amount of fat, antioxidants, amount of protein, amount of carbohydrates, etc.) and the physical characteristics of noodles such as their color and flavor will be described. In case some kind of feature is not mentioned in the article it will be put "Does not mention" instead. These characteristics will be listed by item according to Table 3.

Table 3. Nutritional and physical characteristics of noodles

Paper number	Nutritional characteristics	Physical characteristics
1	Noodles with K. alvarezii seaweed are rich in fiber and antioxidants, as well as being low in carbohydrates.	Reddish yellowish color with a pleasant taste verified by 50 panelists.
2	Instant noodles made with Undaria pinnatifida, egg and chicken algae low in oil and fat.	Yellow color a little darker than traditional pasta and with a pleasant taste tested by 25 panelists.
3	Noodles with seaweed (Porphyra columbina) rich in protein and dietary fiber and low in carbohydrates and fats.	Does not mention
4	Instant noodles made with Undaria pinnatifida seaweed, egg and chicken, rich in protein and low in oil and fat.	Light green color, with a pleasant taste.
5	Instant noodles made with Undaria pinnatifida seaweed, egg, chicken and hydrocolloids, rich in protein and low in oil and fat.	Light green color, with a pleasant taste and a good texture of noodles.
6	With an incorporation of 2.5% of the Sargassum marginatum algae content, a 4-fold increase in the amount of fiber was detected.	Creamy white to light brown
7	Thanks to the incorporation of algae (1-3%), there is a slight increase in the amount of protein and fat, as well as a slight reduction in carbohydrate content	A darker color of green hue is shown by the number of algae to be incorporated. In addition, 1 and 2% of the seaweed content does not affect the acceptance of the noodle.
8	Noodles with the incorporation of algae (ulva reticulata) in 10-20% of the solid composition had improvements in the amount of carbohydrates and dietary fiber making them more nutritious and healthier.	Green color, with a pleasant taste and without affecting the texture of the noodle.
9	Noodles reinforced with Porphyra columbina seaweed at 20 and 30% of the solid composition increases the amount of protein, fiber and minerals and decreases the amount of lipids	Dark green color and sweet marine flavor.
10	Noodles supplemented by Porphyra columbina flour at 30% of the solid phase, with fewer calories and carbohydrates, and more protein and dietary fiber	Dark green noodles
11	Noodles with seaweed (Spirulina platensis) and basil.	More chewy, solid noodles that cannot be easily broken were obtained.
12	By incorporating the seaweed Caulerpa sp. In 0-20% of the solid composition, an increase in the amount of minerals, β-carotene and phenolic content was obtained	It shows a greenish and dark hue proportional to the addition of algae. For taste, neither liking nor disliking was obtained.

According to the information below, it can be determined that, thanks to the incorporation of seaweed in the preparation of noodles, positive changes are obtained in their nutritional qualities such as the increase in fiber,

protein and minerals; As well as it is observed that the amount of carbohydrates is reduced. On the other hand, due to the characteristic color of seaweed, a product with a color similar to the algae used in its elaboration is developed, taking into account the proportion used, in addition, it does not negatively affect the acceptance of noodles according to sensory evaluations in the various articles.

5.2 Composition of seaweed in the finished product

For the next point, the percentage of seaweed implemented in the noodles by the present articles is demonstrated. Additionally, the impact it has on the finished product is shown in Table 4.

Table 4. Percentage of the seaweed and how it affects the finished product

Paper number	Percentage of algae	How does it affect the finished product
1	2.50% Kappaphycus alvarezii seaweed in noodles	The fiber and ash content were significantly increased to 2.00% and 1.46%, respectively. In addition to reducing carbohydrates by 30%.
2	1.5% Undaria pinnatifida seaweed in noodles	Unwanted oils were significantly reduced and the fats of the product were reduced by 80%.
3	3.5% Porphyra Columbina seaweed in noodles	Noodles were obtained with 12% more protein, 65% more minerals, 158% more dietary fiber, 20% less carbohydrates and 16% less lipids.
4	2% Undaria pinnatifida algae in noodles.	Noodle protein was increased by 25% and carbohydrates were reduced by 12%.
5	2% Undaria pinnatifida seaweed in noodles	The protein in the noodles was increased by 25% and carbohydrates were reduced by 12% without greatly harming the texture of the noodles.
6	2.50% Sargassum marginatum seaweed in noodles	The amount of protein was increased by 10.88%, the amount of carbohydrates was reduced by 1.35% and the amount of fats by 18.52%
7	3% Dunaliella salina seaweed in noodles	Reduced moisture by 14%, increased protein by 3%, reduced carbohydrates by 2%
8	2% Ulva reticulata seaweed in noodles	Carbohydrates were reduced by 10%, dietary fiber was increased by 80% and the fats in the product were greatly reduced.
9	3.5% Porphyra columbina seaweed in noodles	Increase of 158% in the amount of dietary fiber, 12% in protein and 65% in minerals. Instead, a decrease of 23% in carbohydrates, 16% in lipids was obtained.
10	3.5% Porphyra columbina seaweed in noodles	It decreased the amount of calories and carbohydrates by 23%, as well as 16% less total fat and 157% more dietary fiber.
11	2% Spirulina platensis seaweed in noodles	The incorporation of spirulina algae produces a variation in the texture of the wet noodles becoming softer and softer. In addition, there is an increase in the amount of protein
12	5 % Caulerpa sp seaweed in noodles	An increase of 85.2/100 g of phenolic content, 0.29% in the amount of protein and 3.68 mg/kg of β-carotene content was obtained.

According to the table, it can be noted that the percentage of seaweed used in the preparation of noodles are relatively small indeed, since their values range from 1.5% of algae incorporated to 5% of this in relation to the amount of the total finished product. This is because it seeks to maintain the texture of the noodle and improve its nutritional qualities. The incorporation of the algae in the noodles produces certain changes. For example, in the case of the addition of Porphyra Columbina in noodles, a 150% increase in dietary fiber, a 23% reduction in carbohydrates and a 12% increase in the amount of protein are generated. In contrast, the seaweed Caulerpa sp only produced a 0.29% increase in the amount of protein.

5.3 Benefits of short pasta noodles reinforced with seaweed

This section of the results seeks to identify, in Table 5, the benefits that this finished product would have in the various articles mentioned. This in order to establish the main benefits that consuming these noodles with seaweed would bring.

Table 5. Benefits of seaweed noodles

Paper number	Benefits
1	Food rich in fiber, antimicrobial properties and high phenolic content.
2	More nutritious protein-rich, low-fat instant noodles.
3	Nutritious food rich in protein and fiber taking advantage of this abundant and economical resource that is algae.
4	Rich in protein, fiber and minerals, such as sodium, potassium, calcium and magnesium.
5	Noodles rich in protein, fiber and antioxidants but with better viscosity and acceptance by hydrocolloids.
6	Noodles with benefits in antioxidant activity.
7	Noodles with more minerals and more protein.
8	Nutritious and healthy noodles rich in fiber and with fewer carbohydrates.
9	Benefits at the metabolic level: decrease in sugar and cholesterol levels, in addition to the improvement at the physiological level: intestinal tract.
10	Due to the reduction of fats and calories, it would seek to reduce the risk of overweight and obesity, and the increase in fiber would benefit at the metabolic and physiological level.
11	Noodles with a higher amount of protein and soft, soft texture
12	Food rich in minerals, phenolic content. Beta carotene. Due to the properties of the algae itself.

Due to the incorporation of seaweed in the preparation of noodles, benefits are obtained from the algae itself such as the increase of proteins, minerals as well as benefits at the physiological level such as the reduction of cholesterol and at the metabolic level through the increase of fiber which allows to improve the intestinal tract.

5.4 Validation

With the information presented, the incorporation of algae in noodles as a reinforcement input generates an improvement in its main nutritional characteristics such as proteins, minerals, fiber, etc. Despite this, various types of algae have been used that provide similar characteristics to the final product**.** The average content of noodles reinforced with seaweed are shown in Figure 2.

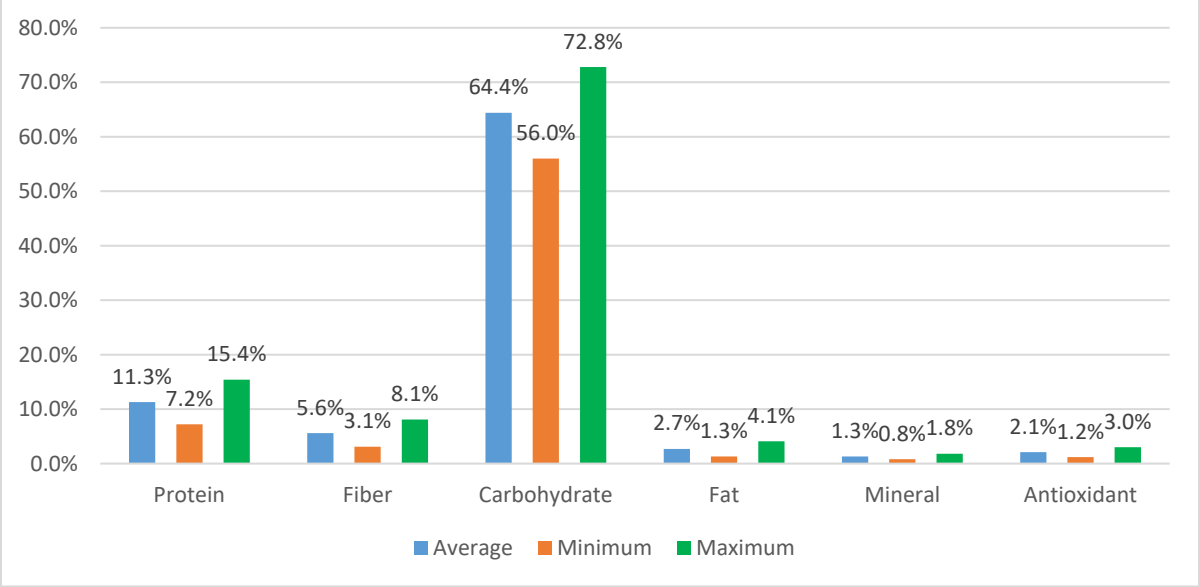

Figure 2. Content in noodles reinforced with seaweed

The algae have been used in small proportions, less than 5% to not affect the texture and taste of the noodles. In all cases there was an improvement in the final product so when applying any type of algae in the noodles, improvements in its nutritional content would be generated. These algae come from various parts of the world, so you can also see the application of seaweed-reinforced noodles in the future in Peru.

6. Conclusion

It is concluded that noodles reinforced with seaweed present an improvement in their nutritional characteristics, since there is an increase in the amount of protein and dietary fiber, as well as a reduction in the amounts of fats and carbohydrates. Then, the color of the noodles occurs according to the color of the seaweed and without negatively affecting the taste of the noodles. With respect to how the proportion of algae affects the finished product, it is concluded that these have to be used in a proportion less than 5% so as not to affect the texture of the noodles.

The composition of the algae in all cases have a large amount of fiber and are rich in proteins in most cases. The main additives in addition to the algae are salt, water, wheat flour and egg with this it can be obtained the noodles reinforced with seaweed.

Finally, the benefits of incorporating the algae into the finished product are that it generates at a physiological level such as the reduction of cholesterol and at the metabolic level through the increase of fiber which improves the intestinal tract.

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Biographies

Angelo Jean Pierr Janampa Salvatierra is a Bachelor's degree in industrial engineering from University of Lima with experience in human resources and supply chain management, currently working at JJC.

Alejandro Rodolfo Lamas Vidalon is a Bachelor's degree in Industrial Engineering from University of Lima with experience in project management and process design.

Martín Fidel Collao-Diaz at ESAN University and Industrial Engineer from the University of Lima specialized in supply chain management and operations. A leader with more than 25 years of local and international experience in national and multinational companies in the industrial, hydrocarbon, and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport, distribution, and warehouse management), operations (planning and control of production and maintenance), and integrated system management (ISO 9001, ISO 14001, and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Besides, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology, among others, focused on being a High-performance Organization (HPO). Development of a high-performance team. Member of IEEE and CIP (College of Engineers of Peru).