PAPER • **OPEN ACCESS**

A study of the influence of the method of pretreating Japanese kelp on its quality

To cite this article: N V Dementieva *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1052** 012017

IOP Conf. Series: Earth and Environmental Science 1052 (2022) 012017 doi:10.1088/1755-1315/1052/1/012017

A study of the influence of the method of pretreating Japanese kelp on its quality

N V Dementieva[1], T M Boytsova[1], O V Sakharova[1], E V Shemetova[2]

[1]Far Eastern State Technical Fisheries University, 52B Lugovaya St., Vladivostok, 690087, Russian Federation
[2]Vladivostok State University of Economics and Service, 41 Gogol St., Vladivostok, 690014, Russian Federation

E-mail: dnvdd@mail.ru

Abstract. One of the ways to create functional foods is to fortify them with dietary fiber. Dietary fiber includes a large group of compounds that must be an integral part of the daily diet of people. Raw materials of marine origin containing dietary fiber are brown algae. For example, Japanese kelp, along with important biologically active substances, contains soluble and insoluble dietary fibers. Soluble fibers include alginates, insoluble – cellulose (alguleza). A common disadvantage of different methods of processing the kelp is the loss of important functional nutrients: organic and mineral substances. The choice of the correct modes of primary processing the algae will contribute to obtaining a high quality semi-finished product and the production of a wide range of food products based on it. A method has been developed for the primary processing of the kelp, which contributes to the improvement of organoleptic characteristics and ensures the preservation of physiologically important components of algae. The organoleptic and chemical characteristics of kelp after primary processing have been studied.

1. Introduction

Proper nutrition, namely the composition of food and its digestibility, is important for the normal functioning the human body. For normal life, it is necessary to observe the correct ratio of individual components in food products on which metabolism and, ultimately, human life expectancy depend [1].

The development of such food products with pronounced immunoprotective properties at this stage of technology development is a priority if we want to significantly improve the health of the nation as a whole and of each subsequent generation – in particular.

Today, one of the most popular ways to create functional food products is their production from raw materials, which are rich in minor substances with pronounced therapeutic and prophylactic properties. One way to create functional foods is to fortify them with dietary fiber.

Dietary fibers include a large group of compounds that must be an integral part of the daily diet of people. Some are soluble in water (pectin), while others are not soluble in water (cellulose) [2, 3].

It was found that soluble dietary fiber reduced the level of cholesterol in the blood. With a sufficient amount of their effect, they can be compared with drugs. They are able to absorb cholesterol from food. In addition, soluble dietary fiber is capable of binding the bile acids in the intestinal tract, which are involved in the formation of endogenous cholesterol in the liver [3].

Insoluble fiber has much less binding capacity than soluble fiber does. However, they have a beneficial effect on the process of food digestion. They are natural stimulants of intestinal peristalsis. With the consumption of food that does not contain fiber, it can remain in the intestinal tract for several days, and with the consumption of insoluble dietary fiber, the process is shortened to 24 hours. Regular consumption of food rich in fiber promotes easy bowel movement. At the same time, there is no development of dysbiosis and stagnation of feces, which can lead to colon cancer [4, 5, 6]. Dietary fiber provides quick satiety, which prevents and stops overeating and promotes weight loss.

Scientists from different countries have developed special norms for the consumption of dietary fiber for the prophylaxis and prevention of various diseases. They recommend consuming 35 - 40 g of dietary fiber per day to prevent the development of cancer, cardiovascular diseases, and diabetes mellitus. For an urban citizen, such a high consumption rate is almost impossible. Therefore, in different countries, various biologically active food additives based on dietary fiber are being developed and produced [3].

In our country in recent years, two main areas of application and production of dietary fiber have been developed: in the form of food additives to prebiotics and in the form of biologically active additives (BAA).

However, at present, the third promising direction has begun to gain potential, namely the production of food products from raw materials, which are rich in dietary fiber. This direction is new, which means that the share of food products from raw materials rich in dietary fiber in comparison with the share of dietary supplements based on them being still extremely small.

Land-based plant materials are the important sources of dietary fibers [3, 7]. Plant foods that are high in fiber are low in calories. Once in the stomach, the fiber absorbs water. It swells; its volume increases 4-6 times. When the fiber swells, the stomach expands, a feeling of fullness is created, appetite decreases, and less food is consumed.

In turn, vegetable raw materials of marine origin, for example, seaweed, like all brown algae, are also rich in dietary fiber [8].

Japanese kelp (*Laminaria japonica*), along with important biologically active substances, contains soluble and insoluble dietary fiber. Soluble include alginates, insoluble cellulose (alguleza) [9, 10, 11]. Today, Japanese kelp is a priority among the raw materials for the production of functional and therapeutic and prophylactic food products in view of the unique combination of soluble and insoluble dietary fiber, as well as the mass of phytoparapharmaceuticals [12, 13, 14].

There are various ways of processing the kelp, which have their own advantages and disadvantages. A common disadvantage of kelp processing methods is the loss of important functional nutrients: organic and mineral substances. While the organoleptic characteristics of the algae do not change. The presence of a specific smell and taste significantly reduces the range of food products produced on its basis.

Based on the above, we can conclude that algae are an ideal raw material for creating the functional food products [15, 16, 17]. The choice of the correct modes of primary processing the algae, in which minimal losses of physiologically valuable substances occur and high organoleptic characteristics are provided, will contribute to the production of a wide range of food products based on them.

2. The purpose of the study

An important task is to choose the correct method of primary processing the algae, which will maximally preserve physiologically valuable substances and improve organoleptic characteristics. Japanese kelp (*Laminaria japonica*) is used as a raw material. A distinctive feature of algae processing is the use of "sparing" temperature regimes, which allows one to preserve a significant part of biologically active substances and microelements. The purpose of the research was to study the influence of the method of pretreatment of Japanese kelp on the chemical and organoleptic characteristics of the alga.

3. The object of the study

The object of the study was Japanese kelp (*Laminaria japonica*), collected in the Far Eastern seas of Primorsky Krai.

4. Materials and methods

Food organic acids were used as auxiliary materials: acetic and citric acids.

Frozen kelp was used for the study. The algae were thawed at a temperature of 15-20°C for 0.5 hour. Then they were washed with cold water (water temperature of 10-15°C) to remove mucus. Then the algae was poured with water in the ratio of algae: water – 1:2. Then the mixture was heated to a temperature of 85-95°C. After that, the broth was poured out, the kelp was again poured with water, and cooking was carried out twice under the above modes. The broth was drained after each cooking. At the second stage of cooking algae, organic acids were added to the water in an amount from 1 to 3% by volume of water. We determined the influence of the concentration of organic acids on the organoleptic characteristics of the alga. Algae treated in the same way, but without the addition of organic acids, was used as a control.

The moisture content was determined on an AND ML 50 moisture analyzer (VesExpert Ltd, Russia, Moscow) in accordance with the instructions for this type of product.

The amount of mineral substances was determined by removing the organic substances from the product by burning in a muffle furnace at a temperature of 500°C and determining the ash by weighing.

Organoleptic assessment of the method of pretreatment of kelp was carried out by the profile method [18]. To construct profilograms, the developed five-point scale was used (Table 1).

Table 1. Scale of the organoleptic assessment of the quality of kelp

Quality indicators	Verbal characteristics of points	Points
Colour	Bright green	5
	Green	4
	Green with a brown tint	3
	Light brown with a yellow tint	2
	Dark brown	1
Smell	Neutral	5
	Subtle algae smell with a slight hint of organic acid	4
	Light aroma of organic acid	3
	Algae smell with aroma of organic acid	2
	Strong smell of algae (organic acid)	1
Taste	Neutral	5
	Subtle algae flavor with a slight organic acid flavor	4
	Slight organic acid flavor	3
	Algae taste with organic acid flavor	2
	Pronounced taste of algae (organic acid)	1
Consistency	Dense, elastic, crunchy	5
	Dense, crunchy	4
	Dense	3
	Dense, tough	2
	Very dense, tough	1

To determine mannitol, an average algae sample was crushed (raw algae are cut, and dry brittle ones are crushed in a mortar or mill). A weighed portion of about 1 g of algae was placed in a measuring cylinder with a ground-in lid, 50 ml of warm water was poured in, and infused for 1 hour. Then 25 ml of 4N NaOH and 25 ml of a solution of copper sulfate (125 g of $CuSO_4 \times 5\ H_2O$ in 1 l of water) were added, thoroughly shaken and infused for 1 hour. After that, the solution was shaken vigorously, part of the solution was poured into a 40-50 ml test tube and centrifuged. We took 25 ml of a clear solution into a conical flask (100-150 ml) with a wide neck, added 10 ml of 30% KJ solution, 25% H_2SO_4, and immediately titrated rapidly with 0.1 N hyposulfite solution. A starch solution was used as an indicator. The consumption of 0.1 N hyposulfite was used to determine the mannitol content in algae. The mass of the extract is 50 g. The mannitol content was calculated by the formula (1):

$$\mathrm{Mv} = \frac{\mathrm{Mt \cdot Ve}}{5\mathrm{N}\,(100-\mathrm{Vv})}, \qquad (1)$$

where Mv - the amount of mannitol in algae, %; Mt - the amount of mannitol found in the table (reference data) based on the titration results, mg; Ve - mass (weight) of the extract; N - algae sample, g; Vv - algae moisture, %.

The quantitative determination of alginic acid was carried out as follows: the material was dried in air or slightly heated to a state of fragility (raw algae were preliminarily cut with scissors). The algae were crushed to particles with a size of 4-5 mm (mesh size – 0.5 mm) and stored in a hermetically sealed jar. To determine moisture, two weighed portions were taken into weighing bottles, and three weighed portions into flasks with a capacity of 250 ml were taken to determine the content of alginic acid. Each weighed portion of approximately 0.5 g of algae or 0.25 g of alginate and algine; weighing accuracy was 0.0002 g.

To determine alginic acid, weighed portions in cones were extracted three times with 20 ml of a 0.5% HCl solution (for alginate – 5% solution), each time infusing for 1 h at a temperature of 50°C. The precipitate was separated from the solution on a glass filter so that the precipitate did not fall on the filter, extracted three times with 25 ml of cold water and then with ten milliliters of alcohol until a negative reaction for chlorine or acid (according to methyl orange). The washed precipitate was carefully transferred to a filter and separated from the solution. The filter with the precipitate was placed in a glass, filled with water so that the filter was covered with it, and an excess of a titrated 0.1N solution of alkali and phenolphthalein was added thereto. The amount (ml) of alkali should be 150-300 times greater than the weighed portion of dry alginate, or 80-200 times – the weighed portion of alginate, or 20-50 times – the weighed portion of algae, since alginic anhydrins fully react with alkali only in a strong alkaline environment. The vessel was protected from the action of carbon dioxide and insisted with stirring for about 1 hour. Then the excess of alkali was titrated with 0.1 N acid with finolphthalein. The amount of alginic acid was calculated using the formula (2):

$$\mathrm{A} = \frac{(\mathrm{Vsh}-\mathrm{Vk})180.5}{\mathrm{N}(100-\mathrm{V})}, \qquad (2)$$

where, A - amount of alginic acid, %; V_{sh} - amount of 0.1N alkali, added to the sample, mg; V_k – amount of 0.1 N acid consumed for alkali titration, ml; N – sample, g; V – sample moisture, %; 180.5 – titer of 0.1N alginic acid multiplied by 10000. The duration of the determination is about 7 hours.

5. Discussion of the results

The organoleptic characteristics of Japanese kelp, depending on the concentration of acetic and citric acids added at the second stage of cooking algae, are in Tables 2 and 3.

Table 2. Organoleptic indicators of Japanese kelp depending on the concentration of acetic acid

Acetic acid concentration	Organoleptic indicators			
	Colour	Smell	Taste	Consistency
Control	Bright green	Pronounced algae smell	Pronounced taste of algae	Dense, slightly tough
1 %	Green	Algae smell	Neutral	Dense
2 %	Green with a slight brown tint	Algae smell with subtle acetic acid aroma	Subtle aftertaste of acetic acid	Dense
3 %	Green with a brown tint	Light acetic acid aroma	Strong aftertaste of acetic acid	Dense

Table 3. Organoleptic indicators of Japanese kelp depending on the concentration of citric acid

Concentration of citric acid	Organoleptic indicators			
	Colour	Smell	Taste	Consistency
Control	Bright green	Pronounced algae smell	Pronounced algae taste	Dense, slightly tough
1 %	Green	Light algae smell with a hint of citric acid	Subtle taste of algae with a light, pleasant aftertaste of citric acid	Dense, elastic, crunchy
2 %	Green	Light algae smell with a hint of citric acid	Subtle taste of algae with a light, pleasant aftertaste of citric acid	Dense, elastic, crunchy
3 %	Green	Light algae smell with a hint of citric acid	Moderate citric acid aftertaste	Dense, elastic, crunchy

The profilogram of the general organoleptic assessment of Japanese kelp, processed by the second method, taking into account the influence of introduced organic acids, is shown in Fig. 1.

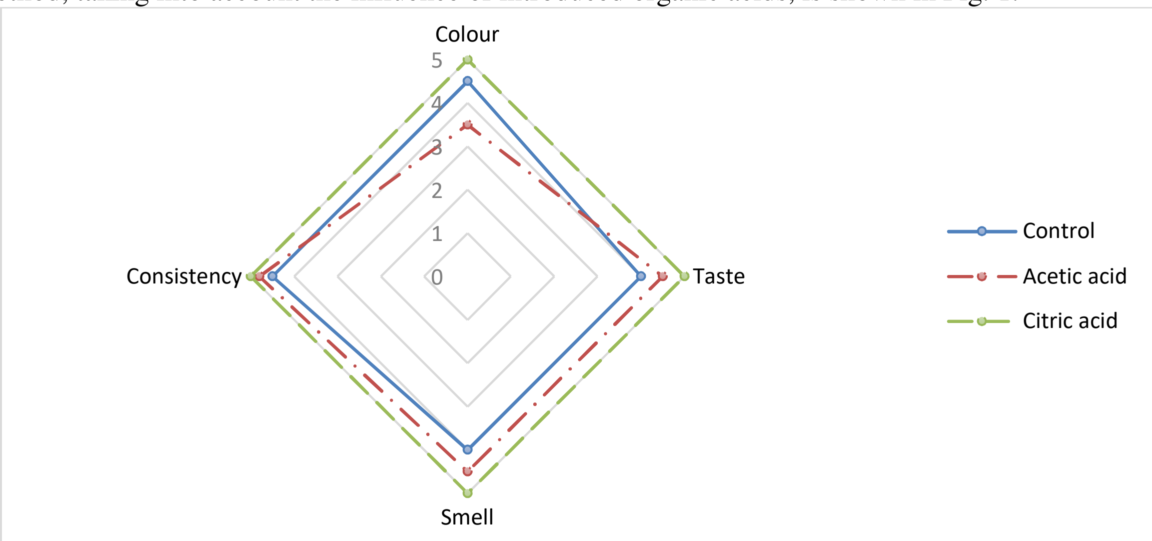

Figure 1. Profilogram of the general organoleptic assessment of Japanese kelp, taking into account the influence of introduced organic acids

When the algae is boiled three times at a temperature of 85-95°C, the consistency remains dense, but at the same time it becomes less rigid. Organic acids improve organoleptic characteristics. An increase in the concentration of acids by more than 3% is not required, since the resulting semi-finished product acquires a pronounced taste and aroma of the acids introduced. Rational concentrations of organic acids in the composition of cooking water during heat treatment have been defined: acetic acid – 1-3%; citric acid – 1-2%. The proposed method of processing helps to soften the consistency of algae. It also removes the pronounced taste and smell of kelp.

When choosing a method of processing the kelp, it is important to ensure not only obtaining the necessary consistency and high organoleptic characteristics of the algae, but also to maximize the preservation of physiologically important nutrients that will directly affect the nutritional value of products derived from it.

We studied the influence of the proposed method of preliminary technological processing the Japanese kelp without adding organic acids and with their use on the change in the chemical composition of the alga. The results of studies of changes in the content of organic and mineral compounds in Japanese kelp, depending on the processing method, are in Table 4.

Table 4. The content of organic and mineral compounds depending on the method of processing the kelp

Sample name	Studied indicators			
	Water, %	Minerals, %	Mannitol, %	Alginic acids, %
Kelp without treatment	94.50	1.90	16.80	27.44
Kelp after boiling three times at a temperature of 85-95°C	91.30	1.37	8.37	25.44
Kelp after boiling three times at a temperature of 85-95°C with the addition of organic acid	90.60	0.59	7.74	33.87

The study has shown that during the processing the algae, it slightly lost moisture. It was found that the fresh algae before processing contained 94.5% of water, after processing the amount of water in the algae slightly decreased.

During heat treatment of algae, there is a loss of minerals. The maximum loss of minerals is observed when processing with the addition of organic acid (minerals – 0.59%).

Processing reduces the amount of mannitol in the algae. So in fresh seaweed before processing it contained 16.8% of mannitol, and after processing, its content was 7.74 – 8.37%.

It has been experimentally determined that the addition of organic acids to cooking waters during the processing the algae contributed to an increase in alginic acids in them. In fresh algae, the content of alginic acids was 27.44%, and after treatment with organic acids, their content was 25.44 – 33.87%, depending on the method.

6. Conclusion

Thus, the study have shown that the developed method of processing the kelp helped to improve the organoleptic characteristics of algae and provided small losses of physiologically important components. Therefore it can be recommended for obtaining a semi-finished product that can be used in the production of various types of food products (dried, culinary, preserves, etc.). And after processing kelp can be used for the production of confectionery (phytocandy, pastilles, jams, etc.).

References

[1] Voskoboinikov V A, Tipiseva I A 2004 On the classification of dietary fiber *Food ingredients: raw materials and additives* **1** 17-19

[2] Drozdova L I 2003 Prophylactic healthy food products *Federal and Regional Aspects of Healthy Nutrition Policy: Proceedings of the International Symposium* 138-144
[3] Jan W, Julie M, Jones A 2004 A focus on dietary fiber and whole grains *Cereal food world* **3** 41
[4] Ottaway B P 2009 *Food fortification and biologically active additives* (St. Petersburg: Profession) 312 p
[5] Krichman E S 2004 New Generation of Dietary Fiber *Food Ingredients* **1** 28
[6] Pogozheva A B, Vysotsky V G 2008 *The role of dietary fiber in human nutrition* (Moscow: Foundation "New Millennium") 326 p
[7] Novikova Z V, Sergeeva S M, Mukhanov E V 2020 Design of bakery products for healthy nutrition using plant raw materials *Proceedings of Voronezh State University of Engineering Technologies* **82(4)** 188-195. DOI: https://doi.org/10.20914/2310-1202-2020-4-188-195
[8] Semenova E V, Bilimenko A S, Chebotok V V 2019 The use of seaweed in medicine and pharmacy *Modern problems of science and education* **5** 118
[9] Odinets A G, Orlov O I, Ilyin V K, Revina A A, Antropova I G, Fenin A A, Tatarinova L V, Prokofiev A S 2015 Radioprotective and antioxidant properties of brown seaweed gel *Bulletin of regenerative medicine* **5** 161-174
[10] Sokolan N I, Kuranova L K, Voron N G, Grokhovskii V A 2018 Investigation of the possibility of producing sodium alginate from the product of processing fucus algae *Proceedings of Voronezh State University of Engineering Technologies* **80(1)** 161-167. DOI: https://doi.org/10.20914/2310-1202-2018-1-161-167
[11] Demidova M A, Volkova O V, Savchuk I A 2011 Influence of Japanese kelp extract on the lipid spectrum of rabbit blood with dyslipoproteinemia *Traditional medicine* **5** 338-343
[12] Kim Y S, Kang C O, Kim M H, Cha W, Shin H J 2011 Contents of water extract for Laminaria japonica and its antioxidant activity *KSBB J.* **26** 112-118. DOI: https:// doi: 10.7841/ksbbj.2011.26.2.112
[13] Shirosaki M, Koyama T 2011 Laminaria japonica as a food for the prevention of obesity and diabetes *Advances in Food and Nutrition Research* **64** 199-212
[14] Kang K S, Nam C S, Park E K, Ha B J 2006 The Enzymatic Regulatory Effects of Laninaria japonica Fucoidan Extract in Hepatotoxicity *J. Life Sci.* **16** 1104–1108. DOI: https:// doi: 10.5352/JLS.2006.16.7.1104
[15] Araújo R M, Assis J, Aguillar R, Airoldi L, Bárbara I, Bartsch I et al 2016 Status, trends and drivers of kelp forests in Europe: an expert assessment *Biod. Conserv.* **25** 1319–1348. DOI: https://doi: 10.1007/s10531-016-1141-7
[16] Kang Y M, Lee B J, Kim J I, Nam B H, Cha J Y, Kim Y M, Ahn C B, Choi J S, Choi I S, Je J Y 2012 Antioxidant effects of fermented sea tangle (*Laminaria japonica*) by Lactobacillus brevis BJ20 in individuals with high level of gamma-GT: A randomized, double-blind, and placebo-controlled clinical study *Food Chem. Toxicol.* **50** 1166–1169. DOI: https://doi: 10.1016/j.fct.2011.11.026
[17] Lin H T V, Lu W J, Tsai G J, Chou C T, Hsiao H I, Hwang P A 2016 Enhanced anti-inflammatory activity of brown seaweed Laminaria japonica by fermentation using Bacillus subtilis *Process. Biochem.* **51** 1945-1953. DOI: https://doi: 10.1016/j.procbio.2016.08.024.
[18] Berketova L V, Perov V I 2018 Application of sensory analysis in the enterprise of production of food *Proceedings of Voronezh State University of Engineering Technologies* **80(1)** 146-150. DOI: https://doi.org/10.20914/2310-1202-2018-1-146-150