Seaweed Processing Project Report

Report prepared by Allison Byrne, North Island College, for Cascadia Seaweed Corp.

April 2021

Project funded by an NSERC Engage grant

Cascadia Seaweed
for a healthy planet

NORTH ISLAND COLLEGE
NIC

1 Executive summary

This collaborative research project between North Island College (NIC) and Cascadia Seaweed Corp. (CSC) was funded by an Engage grant from the Natural Sciences and Engineering Research Council of Canada (NSERC) and took place at NIC's Campbell River campus from October 2020 to February 2021. The goal of the project was to develop a value stream map for two seaweed processing streams – dried and frozen. Two species of kelp (provided in frozen blocks by CSC) were tested: *Alaria marginata* and *Saccharina latissima*.

To begin the dried kelp stream, samples of each species were dried on either air-drying racks or in a dehydrator at 52°C to determine the dehydrator capacity, unblanched/unsorted dry weight yield for each species, and minimum drying times. Dehydrator capacity was approximately 20 kg fresh kelp. Dried *Alaria marginata* weighed 11% or 12% of its original wet biomass for air-dried and dehydrator-dried samples, respectively. Dried *Saccharina latissima* weighed 7% or 8% of its original wet biomass for air-dried and dehydrator-dried samples, respectively. Both Alaria and Saccharina reached a constant dry weight after 2 hours in the dehydrator at 52°C. Air-dried Alaria and Saccharina samples took 48 hours to reach constant dry weight.

The dried kelp stream was then expanded to include an optional blanching step before sorting and drying. Kelp was either blanched for 60 s or unblanched, sorted to remove biofouling/decaying kelp, and then either air dried or dehydrator dried at 52°C. Three samples per species, per treatment were analyzed. These dried kelp samples are currently stored at NIC. Yield after blanching was 78% and 59% of the original wet biomass for Alaria and Saccharina, respectively. Yield after sorting was 39% and 40% of the original wet biomass for Alaria and Saccharina, respectively. On average, 49% of Alaria and 66% of Saccharina was classified as "good". Finally, yield after drying was 5% and 4% of the original wet biomass for Alaria and Saccharina, respectively. Processing time was 26 min/kg (13 min/kg/person) and sorting was the limiting step (we were not limited by room in the dehydrator at this scale).

Kelp in the frozen stream was blanched for 0, 5, 30, 60, 120 or 240 seconds, before being vacuum sealed and frozen at -20°C. Three samples per species, per treatment were analyzed. These samples were submitted for iodine and moisture analysis at SGS Labs in Burnaby. Saccharina contained substantially more iodine (4- to 7-times more) than Alaria across all blanching treatments. For both species, mean iodine content decreased as blanching time increased. The most dramatic decrease was observed after 5 seconds of blanching for Alaria (just over 70% decrease) and after the first 30 seconds of blanching for Saccharina (nearly 80% decrease). Maximum iodine reduction was observed in the longest blanching treatment for both species (92% total reduction for both species).

Yield after blanching was 82% and 54% of the original wet biomass for Alaria and Saccharina, respectively. Yield after sorting was 48% and 40% of the original wet biomass for Alaria and Saccharina, respectively. On average, 58% of Alaria and 73% of Saccharina was classified as "good". Processing time was 38 min/kg (15 min/kg/person) and sorting was the limiting step.

Opportunities for further research include examining moisture absorption in dried kelp in different types of packaging over time (relevant for food preservation/spoilage); measuring iodine content in Alaria from BC, processed in the same way as the Alaskan Alaria in the present study, to gain knowledge on the regional impacts of iodine absorption; and measuring protein, sugars, arsenic species, fatty acids, or other more detailed nutritional parameters in kelp products (relevant for micronutrient marketing). NSERC Applied Research and Development grants (ARD) provide $75,000 to $150,000 per year, for 1- to 3-year projects. There is currently no deadline for applications, and the turnaround time (from time of submission) is 4 to 6 months. The cash contribution requirement is 25% for up to $75,000 per year, and 40% for up to $150,000 per year.

Contents

2 Methods

2.1 Project initiation

The goals of this project were to transform raw, frozen kelp from Cascadia Seaweed Corp. (CSC) into dried or frozen shelf-stable products. The project ran from October 2020 through February 2021 and created the following products using frozen *Alaria marginata* and *Saccharina latissima* from CSC (Figure 1).

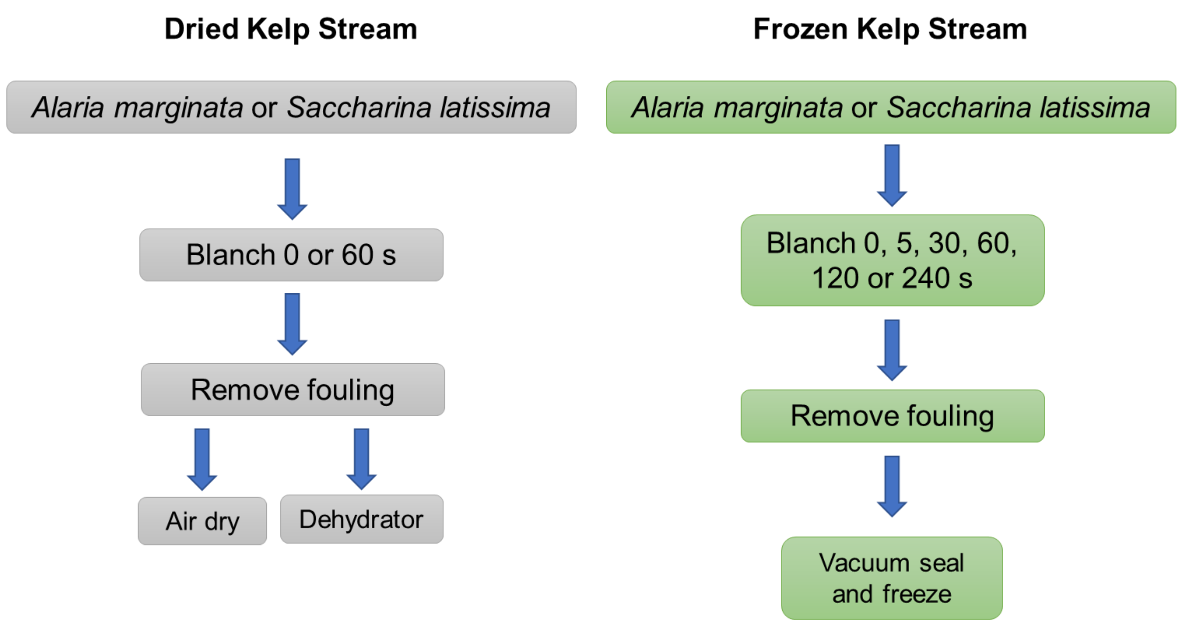

Figure 1. Dried and kelp processing streams for the research project.

2.2 Kelp processing equipment

Food processing equipment was purchased through a previous Applied Research Tools and Instruments Grant from the Natural Sciences and Engineering Research Council (NSERC ARTI grant) as well as the present NSERC Engage grant. The following major pieces of food processing equipment were used in this project. Prices do not include tax or installation costs (e.g. installing electrical cord), however some of the installation costs are described in the Comment section.

Dehydrator

- **Make and model**: Excalibur COMM2
- **Supplier**: Russel Hendrix
- **Lead time**: 2 weeks
- **Cost**: CAD $22,650
- **Capacity**: 12.7 sq m; room for 42 trays that are 18” x 26”
- **Outer dimensions (HDW)**: 71” x 35” x 30”; 180 x 89 x 76 cm
- **Electrical requirements**: 220-240V, 50Hz/60Hz Single Phase 3 Wire, 30 Amp dedicated branch circuit
- **Comment**: Comes with 42 drying trays and optional plastic mesh covers for smaller items. This machine does not come with a power cord. From the manual: “You can have the electrician wire the unit to 30-amp 4 prong drier pigtail plug or the unit may be hard wired.” This cost us approximately $400.

Steam kettle

- **Make and model**: Cleveland Range Ltd. KET-3-T
- **Supplier**: Millstream Appliance and Refrigeration (used kitchen equipment in Campbell River)
- **Lead time**: N/A
- **Cost**: CAD $900 used; estimated $7,000 new
- **Capacity:** 3 gallons; 11.4 liters
- **Outer dimensions (WDH including handle):** 20 1/4", 13 1/4", 28 7/8";
- **Electrical requirements:** This unit requires a 208V 3 phase, 3 wire electrical connection. 208V will put out 4.1 kW while 240V offers 5.4 kW. The plug was the same as our kitchen stove in the aquaculture lab.
- **Comment**: This is a tilting, tabletop steam kettle. We had an existing power outlet that was compatible but in the wrong location. It costed us approximately $400 for an electrician to run a 20 ft extension cord to where we used the machine.

Vacuum sealer

- **Make and model**: VacMaster VP320
- **Supplier**: Russel Hendrix
- **Lead time**: N/A
- **Cost**: CAD $2,795
- **Capacity**: 16” x 18” maximum bag size
- **Outer dimensions (WDH)**: 22.25” x 20” x 20”; 57 x 51 x 51 cm
- **Electrical requirements**: 110V, 60Hz, 13 Amps
- **Comment**: Includes 100 assorted bags 3-mil (0.0762 mm): 25 (8" X 12"), 25 (6" X 10"), 25 (12" X 16") and 25 (14" X 16") and 2 filler plates.

In addition to the major equipment listed above, we used supporting equipment including two rack-and-roll shelving units that each fit 20 18” x 26” trays, a 9-cu-ft chest freezer for storing the frozen kelp, a 15-kg capacity benchtop scale (Kilo Tech KPC2000-15 from Russel Hendrix), a Rubbermaid Heavy Duty Utility Cart, a fish tote (219 Gal, 48" x 43" x 38") and 18” x 26” aluminum sheet pans. All equipment was set up in the aquaculture wet laboratory at NIC’s Campbell River campus. A seaweed washer, seaweed cutter, and blast chiller were present in the laboratory but were not operational in time for the project (Appendix 1).

2.3 *Processing steps*

2.3.1 Thawing

The frozen blocks of kelp were thawed in a freshwater bath, either using a bucket or a fish tote depending how much kelp was thawed.

2.3.2 Drying

Kelp in the dried stream was either dried in an Excalibur COMM2 dehydrator at 52°C or air-dried at room temperature (20-22°C) on rack-and-roll shelves. The dehydrator holds 42 trays that are 18” x 26”. The rack-and-roll shelves hold 20 trays of the same size. We lined the trays with a plastic sheet mesh that came with the dehydrator (Figure 2). The maximum capacity of the dehydrator was approximately 20 kg fresh kelp (475 g per tray).

Figure 2. Left: air-dried kelp on a rack-and-roll shelf. Middle top: a plastic tray liner. Middle bottom: Upper and lower chambers of the dehydrator are open (only the lower chamber is loaded with trays). Right: Excalibur COMM2 commercial dehydrator.

2.3.3 Blanching

Kelp was blanched in a 3-gallon Cleveland Range Ltd. KET-3-T steam kettle. The kettle was filled with tap water and brought to a boil before adding the kelp. Kelp was removed after 5, 30, 60, 120 or 240 seconds. The maximum capacity of the steam kettle was approximately 1.2 kg kelp.

2.3.4 Sorting

In most of the processing trials, biofouled and decaying pieces of kelp were removed from the raw or blanched kelp before further processing. Biofouling included bryozoans, fish eggs, small snails, amphipods, and (surprisingly) barnacles. The biofouling organisms were much easier to spot after the kelp had been blanched due to a higher colour contrast – fish eggs and bryozoans turned white or light grey, and amphipods turned a bright pink.

2.3.5 Packaging

Kelp was packaged in plastic vacuum seal bags and sealed using the VacMaster VP320 vacuum sealer. The machine was set for 25 second vacuum, 1 second seal, and 2 second cool. For blanched samples, it was easier to partially freeze the samples before sealing them to minimize moisture in the seal. The maximum capacity of the largest 14" x 16" bags was approximately 2.5 kg wet kelp biomass.

2.3.6 Freezing

Both raw kelp and processed kelp was frozen in a standard chest freezer at -20°C.

2.4 Data collection

The data collected is summarized in Table 1. Observations included both kelp observations (e.g. colour, texture) and any challenges that arose during the processing step.

Table 1. Data collection sheet used during the seaweed processing trials.

Processing Step	Data
☐ Thaw, room temperature ☐ Thaw, water bath ☐ Rinse by hand ☐ Rinse air bubbler ☐ Cut by machine ☐ Blanch in steam kettle ☐ Remove fouling ☐ Dry on rack (air dry) ☐ Dry in dehydrator ☐ Package ☐ Vacuum seal **Kelp Species** ☐ *Saccharina latissima* ☐ *Alaria marginata*	Date: Personnel: Start time (handling): Start time (operation): Start biomass: End time: End biomass: Room temperature: Water temperature (if applicable): Machine parameters (if applicable): Observations:

2.5 Iodine testing

Blanched and frozen Alaria and Saccharina samples were submitted for iodine and moisture analysis at SGS Canada Inc. in Burnaby. Triplicate samples were submitted for 0, 5, 30, 60, 120, and 240-second blanching for each species (36 samples total). The cost per sample was around $75 for iodine and around $25 for moisture content. The project paid for 24 of the iodine samples; CSC paid for the remaining 12 iodine samples and all 36 moisture samples as an in-kind donation. Iodine results are presented as milligrams per kilogram kelp dry weight to account for the variable moisture content in each sample. For example, 10 mg iodine/kg wet weight, in a sample that is 90% moisture, would be converted to 1 mg iodine/kg dry weight.

2.6 Cascadia sample preparation

On January 12-14, 2021, three types of CSC kelp samples were prepared for demonstration purposes to a potential buyer. Samples were processed by Liam Collins and Mairi Edgar from Cascadia and Allison Byrne and Avalon Kline-Smith (student researcher) from NIC. The following three types of samples were prepared using frozen *Alaria marginata*.

1) Frozen: Alaria was thawed, fouling removed, vacuum sealed in 2.5 kg bags, and frozen.
2) Blanched and frozen: Alaria was thawed, blanched for 2 minutes, fouling removed, vacuum sealed in 2 or 2.5 kg bags, and frozen.
3) Blanched, salted and frozen: Alaria was thawed, blanched for 2 minutes, fouling removed, sprinkled with coarse kosher salt, frozen, and vacuum sealed in 2 kg bags.

3 Results and Discussion

3.1 Frozen seaweed value stream

Yields and processing time for the frozen seaweed stream are presented in Figure 3. Most of the Alaria and Saccharina would change colour from brown to green immediately after entering the boiling water (this colour change was more dramatic for Saccharina than Alaria). There was no obvious colour difference between samples dried for 5 s versus 240 s (Figures 4 and 5). Because of the colour change, blanching made it easier to remove biofouling and decaying bits of kelp. Bryozoans became a bright white or grey that stood out against the green kelp; small “shrimp” turned a bright pink; and decaying bits of kelp remained a faded brown colour. When sorting, on average 58% of Alaria and 73% of Saccharina was classified as “good” and went onto the packaging step. Figures 4 and 5 show an example of Saccharina and Alaria after blanching and sorting.

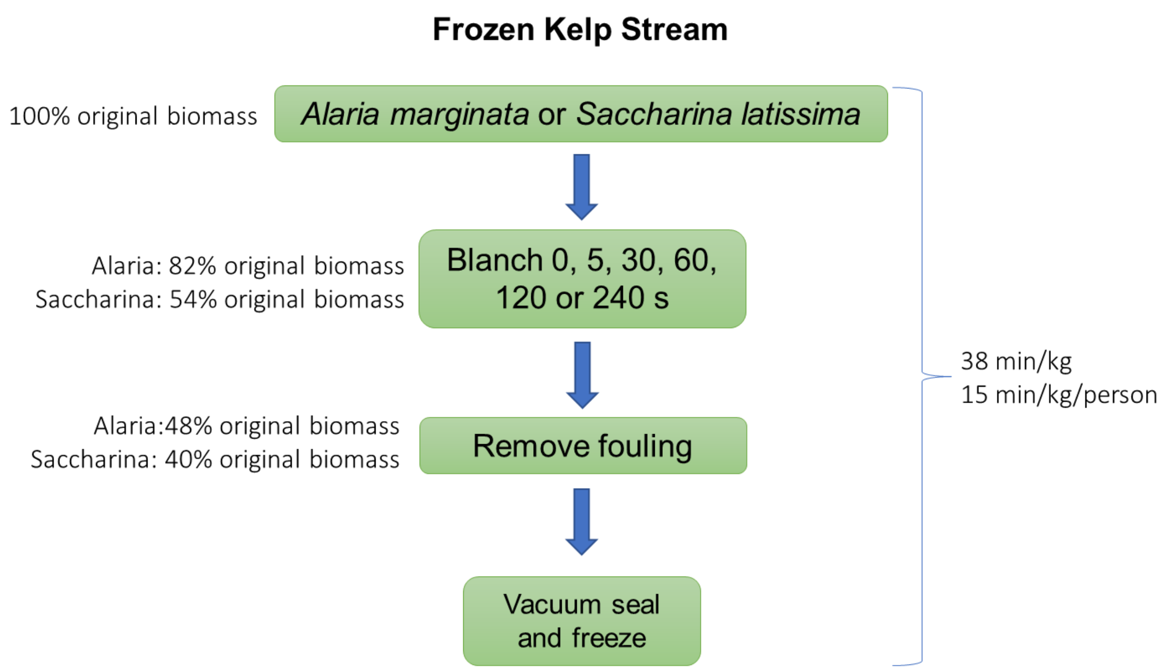

Figure 3. Value stream map for frozen seaweed. Processing times are averaged across both species.

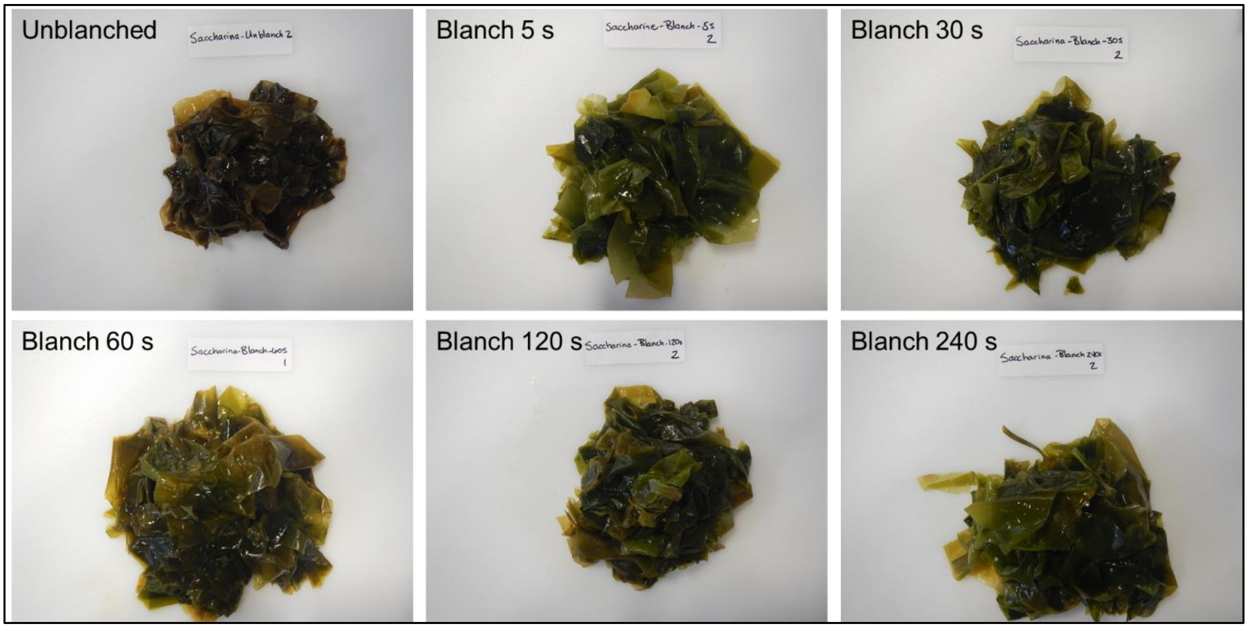

Figure 4. *Saccharina latissima* thawed and then blanched in boiling water for 0, 5, 30, 60, 120 or 240 seconds. Photos were taken after removing biofouled kelp biomass.

Figure 5. *Alaria marginata* thawed and then blanched in boiling water for 0, 5, 30, 60, 120 or 240 seconds. Photos were taken after removing biofouled kelp biomass.

Blanching was a 1-person job; sorting the blanched kelp required 2 people to keep up with the blanching batches. With a larger steam kettle, sorting the kelp would become even more of a limiting step. For large-scale processing we recommend only sending highest-grade kelp through the blanching process that requires minimal sorting. It would also be worthwhile to cut off the distal tips of the kelp during the harvest, which were usually the most decayed and fouled portions of the blades, to reduce handling time in the processing facility. The distal tip biomass could of course be used for another (lesser grade) product stream, or it could be quantified and perhaps left on-site as food/habitat provisions for surrounding species.

3.1.1 Steam kettle details

The steam kettle used in the project took 10 minutes to boil from room temperature and 8 minutes if the machine was already hot. In this project, two batches of kelp were blanched before changing the water (approximately 2.5 kg thawed kelp total). There was no apparent decrease in quality between the first and second batch. Each round of kelp blanching was completed as follows (for a 1.5-2-minute blanching):

- 0-1.5 minutes – blanch first batch of kelp
- 1.5-2.5 minutes – remove kelp and add second batch of kelp
- 2.5-4 minutes – blanch second batch of kelp
- 4-5 minutes – remove kelp, dump water
- 5-13 minutes – re-heat new batch of water

We opted to purchase a small tipping steam kettle that was a self-contained unit – i.e. steam source built into the vat – which fit into our limited Engage operating budget. We did have leads on two used, larger vessels – a 100-L vat from Natural Pastures Cheese Co. Ltd. (price unknown, contact Doug Smith, Operations Manager doug@naturalpastures.com to inquire) and a 200-L vat from E-Fish-Ent Fish Co. Ltd. for $1000 (Bryan Mooney 250-642-4007). Neither of these vats came with a built-in steam source and we did not have a steam source in the aquaculture lab to connect to. Therefore, the options were to purchase and hook up a separate boiler or steam generator. Apex Steel and Gas Ltd. in Victoria is able to do this (cost unknown) but they need to know how much steam is required, at what pressure, and whether it is gas or electric. Contact Eric Zakreski eric@apexsteel.ca for more information. Larger steam kettles should have a hose nearby for filling and should be positioned near a floor drain for easy cleaning.

3.1.2 Iodine testing

Summarized iodine results are presented in Figure 6; raw data are presented in Appendix 2. Saccharina contained substantially more iodine (4- to 7-times more) than Alaria across all blanching treatments. For both species, mean iodine content decreased as blanching time increased. The most dramatic decrease was observed after 5 seconds of blanching for Alaria (just over 70% decrease) and after the first 30 seconds of blanching for Saccharina (nearly 80% decrease). Maximum iodine reduction was observed in the longest blanching treatment for both species (92% total reduction for both species).

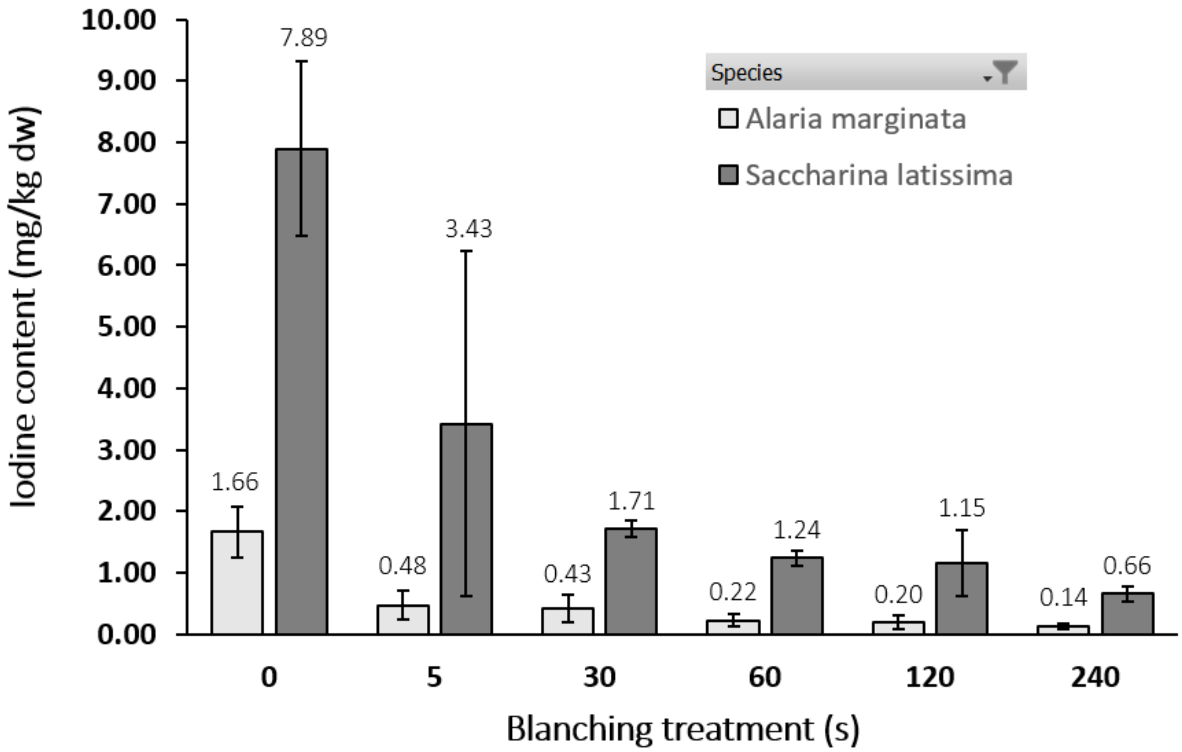

Figure 6. Iodine results (mean ± standard deviation). Sample size = 3 for each treatment. Results are standardized for kelp dry weight (dw) to account for moisture variation between samples.

3.2 Dried seaweed value stream

To begin the dried kelp stream, samples of each species were dried on either air-drying racks or in a dehydrator at 52°C to determine the dehydrator capacity, unblanched/unsorted dry weight yield for each species, and minimum drying times. Dehydrator capacity was approximately 20 kg fresh kelp. Dried *Alaria marginata* weighed 11% or 12% of its original wet biomass for air-dried and dehydrator-dried samples, respectively. Dried *Saccharina latissima* weighed 7% or 8% of its original wet biomass for air-dried and dehydrator-dried samples, respectively. The lower percentage for Saccharina can be attributed to the significant amount of "slime" expelled during the freeze/thaw cycle; frozen Alaria blocks did not contain this wet slime and thus almost all the Alaria biomass was the kelp itself. Both Alaria and Saccharina reached a constant dry weight after 2 hours in the dehydrator at 52°C. Air-dried Alaria and Saccharina samples took 48 hours to reach constant dry weight. For this unblanched and unsorted kelp, loading time was the limiting step which took about 2 minutes per tray for Alaria and 3- 4 minutes per tray for Saccharina due to the "slime" present on the kelp. Loading time would be significantly reduced with larger blades of kelp, and if kelp was loaded onto trays as a batch was already drying in the dehydrator.

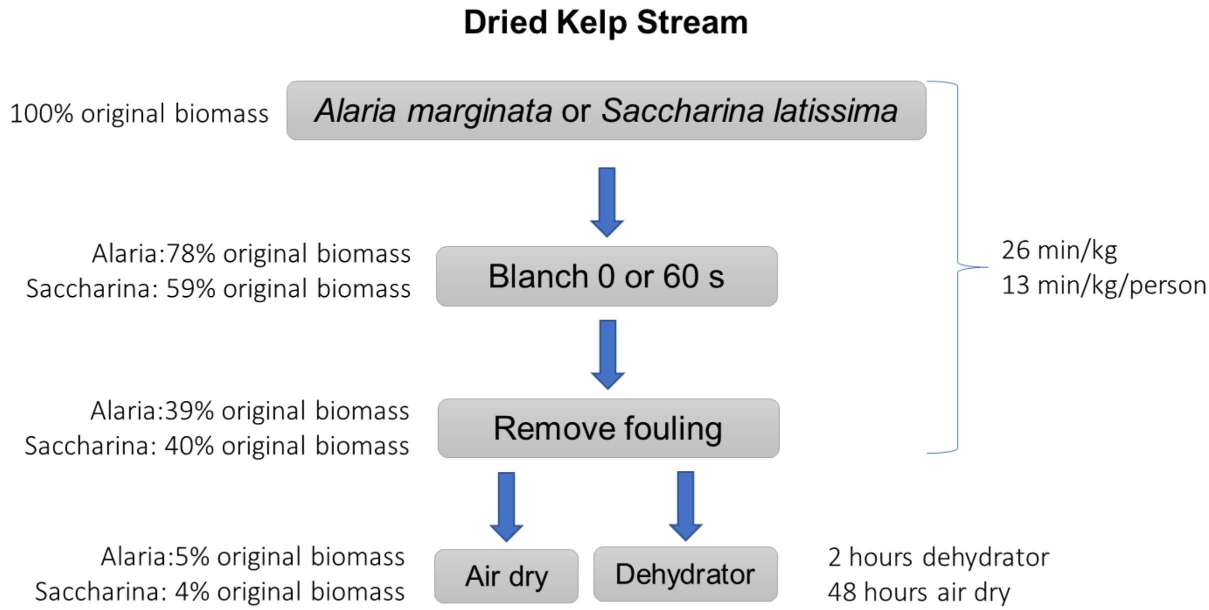

Figure 7. Value stream map for dried seaweed stream. Dried biomass percentages are averaged across both drying treatments (air dry and dehydrator dry). Processing times are averaged across both species.

The dried kelp stream was then expanded to include an optional blanching step before drying. Kelp was either blanched for 60 s or unblanched, sorted to remove biofouling/decaying kelp, and then either air dried or dehydrator dried at 52°C. Three samples per species, per treatment were analyzed. These dried kelp samples are currently stored at NIC. Yields and processing time for the dried seaweed stream are presented in Figure 7. When sorting, on average 49% of Alaria and 66% of Saccharina was classified as "good" and went onto the drying step. Figures 8 and 9 show an example of Saccharina and Alaria after each treatment (blanched or unblanched, sorted, and then air dried or dehydrator dried).

Figure 8. Dried *Saccharina latissima* in different drying treatments; clockwise from top left: air dried, blanched and air dried, blanched and dehydrator dried, dehydrator dried.

Figure 9. Dried *Alaria marginata* in different drying treatments; clockwise from top left: air dried, blanched and air dried, blanched and dehydrator dried, dehydrator dried.

3.2.1 Dehydrator and packaging details

The dehydrator worked well, and we experienced no operational issues. For large-scale processing using the same or a similar machine, it would be faster to have trays with a built-in liner (see Figure 2) to reduce the handling and cleaning time. Dried kelp, especially Alaria, regularly pierced the vacuum sealer bags (3-mil, or 0.0762 mm, thickness). Therefore, we do not recommend this type of packaging for dried kelp.

3.3 Cascadia sample preparation

Frozen, blanched/frozen, and blanched/salted/frozen Alaria samples were prepared over 2.5 days (Figure 10). The unblanched, frozen Alaria samples took 2 hours to process (thaw, remove biofouling, and package/vacuum seal) 35 kg with 3 personnel. Blanched Alaria samples took 13 hours to process (thaw, blanch, remove fouling, and package/vacuum seal) 30 kg with 3 personnel. Lastly, the blanched and salted samples took only a few hours to process because we were limited on usable kelp biomass. A significant amount of kelp was deemed unusable after spending the night in the freshwater bath; the texture became thick and slimy especially after blanching.

Figure 10. Preparing Alaria samples. Top left: Mairi Edgar removes thawed Alaria from the fish tote freshwater bath. Top right: steam kettle used to blanch batches of kelp. Bottom left: Liam Collins and Mairi Edgar sort the blanched Alaria to remove any fouled pieces. Bottom right: blanched and sorted kelp, before being packaged and frozen.

4 Next steps

4.1 Ideas for further research

- Examine moisture absorption in dried kelp in different types of packaging over time (relevant for food preservation/spoilage)
- Measure the iodine content in Alaria from BC, processed in the same way as the Alaskan Alaria in the present study, to gain knowledge on the regional impacts of iodine absorption
- Measure iodine, protein, sugars, arsenic species, fatty acids, or other more detailed nutritional parameters in kelp products; relevant for micronutrient marketing
- Scale up the washing, blanching, and drying steps at Dock Plus
- Expand the research to include production experiments such as multiple harvesting, staggered out-planting of seed, or 'green' alternatives for production infrastructure (e.g. explore biodegradable materials for seed twine)
- Host a seaweed-based cooking competition at NIC in collaboration with NIC chefs and culinary students; invite guest judges

4.2 Additional project funding

In March 2021, CSC and NIC plan to submit an NSERC Engage Plus grant application to extend the research. The additional funds would support a $6,000 project ($3,000 from CSC and $3,000 from NSERC) that would include transporting the seaweed washer to CSC's Dock Plus facility, and engaging NIC researchers in commercial kelp harvesting and processing.

One funding option for further, more long-term research is an **Applied Research and Development grant (ARD)** from NSERC. ARD grants provide $75,000 to $150,000 per year, for 1- to 3-year projects. There is currently no deadline for applications, and the turnaround time (from time of submission) is 4 to 6 months.

- **Cash contribution**: 25% of the grant value for up to 75k per year, or 40% of grant value for 75-150k per year. For example, a request of $75,000 per year from NSERC will require a cash contribution of $18,750 per year from industry giving a total project budget of $93,750 per year. *Note that NSERC is changing its contribution requirements for ARD grants; in fiscal year 2021-22 all requests up to 150k per year may only require 25% cash from industry.*
- **What projects are eligible?** ARD Grants support well-defined applied research and development projects undertaken by college researchers with their private-sector partners. ARD projects can be at any point in the research and development spectrum. The mutually beneficial collaborations are expected to result in economic benefits to the company and/or Canada.

5 References

Nielsen, C.W., Holdt, S.L., Sloth, J.J., Marinho, G.S., Sæther, M., Funderud, J., Rustad, T., 2020. Reducing the high iodine content of *Saccharina latissima* and improving the profile of other valuable compounds by water blanching. Foods 9. https://doi.org/10.3390/foods9050569

Roleda, M.Y., Skjermo, J., Marfaing, H., Jónsdóttir, R., Rebours, C., Gietl, A., Stengel, D.B., Nitschke, U., 2018. Iodine content in bulk biomass of wild-harvested and cultivated edible seaweeds: inherent variations determine species-specific daily allowable consumption. Food Chem. https://doi.org/10.1016/j.foodchem.2018.02.024

6 Appendix 1 – Unused equipment

The following three pieces of equipment were present in the laboratory but were not used for the project. The seaweed washer and cutter, which came from China, were not approved for use in Canada in time for the project; the blast chiller did not function upon arrival and required servicing which was not completed in time for the project.

Seaweed washer

- **Make and model**: Air Bubble Washing Machine GG-3000
- **Supplier**: Henan Gelgoog Machinery Co. Ltd.
- **Lead time**: 5 weeks to manufacture plus 6 weeks for shipment, plus 3 weeks if the shipment is flagged for Canada Customs inspection
- **Cost**: USD $5,900 including CSA motor
- **Capacity**: 1000 kg/h
- **Outer dimensions (LWH)**: 10 ft x 4.5 ft x 5 ft; 323 x 150 x 133 cm
- **Electrical requirements**: 208v, 60hz, three phase; 0.75kw+0.75kw+2.2kw
- **Comments**: Load about 848L water per time; no special drainage requirement. You should request a CSA standard motor from Gelgoog, and will need to have the machine CSA approved in Canada before plugging it in. This was completed through Intertek in Nanaimo. The total cost of CSA inspection and the electrical modifications required was approximately $13,000 for both the washer and cutter.
- Shipping from China to Vancouver and then to Campbell River, plus warehouse and customs charges, was approximately $4500 for the washer and cutter.

Seaweed cutter

- **Make and model**: Cutting Machine GG-1000
- **Supplier**: Henan Gelgoog Machinery Co. Ltd.
- **Lead time**: 5 weeks to manufacture plus 6 weeks for shipment to Vancouver
- **Cost**: USD $1,450 including CSA motor
- **Capacity**: 1000 kg/h
- **Outer dimensions (LWH)**: 4.3 ft x 1.7 ft x 3.5 ft; 130 x 51 x 105 cm

- **Electrical requirements**: 208v, 60hz, three phase; 1.5kw
- **Comment**: You should request a CSA-approved motor from Gelgoog, and will need to have the machine CSA approved in Canada before plugging it in. This can be done through Intertek in Nanaimo. The total cost of CSA inspection and the electrical modifications required was approximately $13,000 for both the washer and cutter.
- Shipping from China to Vancouver and then to Campbell River, plus warehouse and customs charges, was approximately $4500 for the washer and cutter.

<u>Blast chiller</u>

- **Make and model**: Omcan BC-IT-0906
- **Supplier**: iFoodEquipment
- **Lead time**: N/A
- **Cost**: CAD $6,400
- **Capacity**: 6 trays (18” x 26”); 18 kg at 3°C; 12 kg at -18°C
- **Outer dimensions (DWH)**: 32.5” x 32.3” x 55.5”; 83 x 82 x 141 cm
- **Electrical requirements**: 220V / 60Hz / 1Ph; 5.5 amps
- **Comment**: Unit comes with hook up wire but no plug – you supply and install your own plug; this costed us approximately $400. Unit does not come with trays; these are $10 each.

7 Appendix 2

Table 2. Iodine results.

Sample ID	Species	Blanching treatment (s)	Iodine (ppm or mg/kg wet weight)	Moisture (%)	Dry kelp fraction	Iodine content (mg/kg dw)
1	Alaria marginata	0	13.4	87.5	0.125	1.675
2	Alaria marginata	0	9.0	86.3	0.137	1.233
3	Alaria marginata	0	13.0	84.0	0.160	2.08
4	Alaria marginata	5	5.5	92.4	0.076	0.418
5	Alaria marginata	5	4.4	93.8	0.062	0.2728
6	Alaria marginata	5	7.5	90.2	0.098	0.735
7	Alaria marginata	30	7.1	90.7	0.093	0.6603
8	Alaria marginata	30	2.7	92.5	0.075	0.2025
9	Alaria marginata	30	4.8	91.4	0.086	0.4128
10	Alaria marginata	60	2.0	94.3	0.057	0.114
11	Alaria marginata	60	3.8	91.9	0.081	0.3078
12	Alaria marginata	60	3.1	92.1	0.079	0.2449
13	Alaria marginata	120	1.4	94.3	0.057	0.0798
14	Alaria marginata	120	3.5	92.4	0.076	0.266
15	Alaria marginata	120	3.1	92.0	0.080	0.248
16	Alaria marginata	240	1.5	93.8	0.062	0.093
17	Alaria marginata	240	2.4	92.5	0.075	0.18
18	Alaria marginata	240	1.8	92.5	0.075	0.135
19	Saccharina latissima	0	95.9	91.6	0.084	8.0556
20	Saccharina latissima	0	83.2	92.3	0.077	6.4064
21	Saccharina latissima	0	106.0	91.3	0.087	9.222
22	Saccharina latissima	5	100.9	93.4	0.066	6.6594

23	Saccharina latissima	5	29.7	94.9	0.051	1.5147
24	Saccharina latissima	5	42.2	95.0	0.050	2.11
25	Saccharina latissima	30	39.4	95.5	0.045	1.773
26	Saccharina latissima	30	32.6	95.2	0.048	1.5648
27	Saccharina latissima	30	35.4	94.9	0.051	1.8054
28	Saccharina latissima	60	30.7	96.2	0.038	1.1666
29	Saccharina latissima	60	30.9	95.5	0.045	1.3905
30	Saccharina latissima	60	26.5	95.6	0.044	1.166
31	Saccharina latissima	120	13.6	95.6	0.044	0.5984
32	Saccharina latissima	120	25.8	95.4	0.046	1.1868
33	Saccharina latissima	120	31.6	94.7	0.053	1.6748
34	Saccharina latissima	240	11.7	95.5	0.045	0.5265
35	Saccharina latissima	240	15.5	95.5	0.045	0.6975
36	Saccharina latissima	240	15.4	95.0	0.050	0.77