VALUE ADDING AND SUPPLY CHAIN DEVELOPMENT FOR FISHERIES AND AQUACULTURE PRODUCTS IN FIJI, SAMOA AND TONGA

Seagrapes Post-harvest and Value Addition in Fiji: Progress Report

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Supporting Pacific Island Countries in the sustainable development of their marine resources

Value adding and supply chain development for fisheries and aquaculture products in Fiji, Samoa and Tonga:
Seagrapes post harvest and value addition in Fiji: Progress Report

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EXECUTIVE SUMMARY

Caulerpa racemosa or *nama* is the most common *Caulerpa* species harvested in Fiji. However, throughout the Pacific Islands and South East Asia, several other species and varieties of seaweed are utilized as fresh food. In Fiji and Samoa, edible seaweeds form an important part of the diet and it appears that, prior to commercialization, Fijians and Samoans have had a long tradition in its collection and consumption. The commercialization of seaweed however, appears to be a relatively recent phenomenon that coincides with the expansion of the cash economy.

The major problem with *nama* is its perishable nature and hence, its utilisation within the Pacific Island countries has been restricted to domestic trade and consumption. This project aims to explore ideal techniques of extending the shelf-life of seagrapes for marketing and therefore, as a potential export commodity.

Different preservation techniques were investigated to determine an appropriate method for preserving and extending the shelf life of seagrapes bought from the Suva market. Interviews were conducted with seagrape vendors to find out the history, supply chain and post-harvest treatments of their seagrapes. Identification of seagrape varieties was conducted to ensure that the commonly consumed variety was selected for further studies. Seagrapes were trialed using different treatments to assess impacts on the weight, size, sensory preferences and acceptability, especially fibrosity and crispiness.

Results of different treatments revealed that fresh brining treatments with high brine concentrations stored at refrigerated temperature (1^0C) were the most preferred and acceptable, in terms of fibrosity and crispiness. These samples also had longer shelf life as evident in the low levels of total microbial count. For the heat-treated samples, the 5% brine treatment, stored at refrigerated temperature, ranked second and also had low total microbial count. This project found the storage medium most appropriate for fresh seagrapes is 35% brine.

The two major treatments that were explored in this experiment and that could be employed to extend the shelf life of seagrapes is: (i) heat treated samples need to be washed, rinsed, blanched and stored in 5% brine solution and (ii) fresh samples are to be washed in 5% brine solution only prior to packaged in 35% brine. Both samples; (i) and (ii) are to be stored at refrigerated 1^0C.

1. INTRODUCTION

In Fiji, edible seaweeds are an important part of the diet of coastal people. Native Fijians have a long tradition of collecting and consuming different species and varieties of seaweeds. However, *Caulerpa racemosa* or seagrapes is one of the most common species that is regularly harvested for consumption and sale in Fiji (Morris and Bala, 2011; Richards. *et al.*, 1993). *Nama* is a highly nutritious sea vegetable rich in iodine, vitamin A and carotenoids and is therefore an important part of the diet for coastal people. According to South (1993a), commercialization of edible seaweeds is a relatively recent phenomenon that coincides with the expansion of the cash economy in the Pacific. A major problem with *C. racemosa* however, is its perishable nature which prevents it from being stored long after harvest. Its utilisation within the Pacific has thus been restricted to domestic trade and consumption (Chamberlain, 1997).

The aim of this project is to explore and develop an ideal preservation method for seagrapes that would be acceptable to consumers and make it possible for exporting.

2. BACKGROUND

Nama, the indigenous Fijian name for seagrapes, is a subsistence food in Fiji, traditionally eaten fresh as a salad, to accompany other food. It is often prepared by marinating in lemon juice, adding grated coconut juice (*lolo*), finely chopped chili and canned fish or fermented coconut (*kora*) (Morris and Bala, 2011; Richards *et al.*, 1993). Collecting, marketing and preparing edible seaweeds in Fiji is largely an activity of Fijian women and girls. It is community-based, with the work being shared amongst family and village groups. Seaweeds is usually harvested on a weekly basis from the lagoon and reef and is stored for eventual sale at the end of the week (Richards *et al*, 1993). Experienced Fijian *nama* harvesters normally collect only the upright shoots, leaving the stolons to regenerate more shoots (Morris and Bala, 2011; Richards *et al*, 1993). Harvesting strategy includes rotation of collecting areas over at least a 3-4 week cycle, to promote regeneration (Richards *et al*, 1993). Good harvesting sites are protected by the villagers and appear to have been harvested over many generations (Richards *et al*, 1993).

Nama shoots are sold in heaps, at prices ranging from FJD1.00-2.00 per heap in Fiji. Some vendors may exclusively collect and sell *nama* but normally, *nama* sales are combined with those of other seaweeds and non-fish products such as shellfish (Morris and Bala, 2011; Richards *et al*, 1993). A single vendor may sell between 10 and 20 heaps on a market day, earning up to FJD80.00 per week (Richards *et al*, 1993). The greatest sales usually take place on Fridays and Saturdays at Suva, Nausori, Nadi and Lautoka markets (Morris and Bala, 2011; Richards *et al*, 1993).

Seagrapes is well-known for its rapid spoilage and short shelf life and the quality of seagrapes is often determined by its size with turgor pressure and bright green color. This means that picking methods and post harvest handling and storage conditions may also contribute to the shelf-life. Transporting *C. racemosa* in seawater has been trialled to prevent loss of turgor pressure and physical damage caused by abrasion (Chamberlain, 1998). It has been found that

C. racemosa spoils very rapidly at temperatures <I5˚C and >30˚C and a constant temperature of 20°C is optimum for good handling of *C. racemosa* (South, 1997).

Bacterial counts, especially coliforms, have been found to be high in C. racemosa. Sources of coliforms are typically from contaminated water and unwashed hands and could be largely improved by adopting more hygienic handling practices (South, 1997). Earlier trials conducted by FAO to reduce bacterial loads involved dipping the product into a detergent (Chamberlain & Pickering, 1998). The dip did reduce bacterial counts successfully and was acceptable to Japanese markets as a safe chemical treatment; however the dip caused unacceptable shrinkage and loss of turgor caused by osmotic pressure differences (South, 1997). Few studies have been conducted on post harvest handling of *Caulerpa racemosa* for artisanal and export fisheries in Fiji. This project thus explores various preservation techniques that would enable it to retain turgor, a translucent green color and having low coliform counts. This would extend its shelf life and would be acceptable by its consumers.

3. RESEARCH METHODOLOGY

The major aim of the project was to explore appropriate preservation techniques of extending the shelf-life of *C. racemosa* for marketing purposes both within Fiji and for exporting abroad. The aim was achieved by preserving *C. racemosa* using the following treatments: washed and blanched in tap water prior to brine storage; washed and blanched in brine solution prior to brine storage; and fresh brining (without heat treatment) prior to brine storage. Through physical measurements and sensory evaluation, the effects of the three treatments on its texture, especially crispiness and fibrosity, were examined.

3.1 Harvest site

The seagrape samples used in this project were harvested from Gunu village, Naviti Island. This is located in the Yasawa group, on the Western part of Fiji. Usually the harvesters of Gunu village harvest seagrapes on Tuesdays and Wednesdays and store it in potato or flour sacks and submerged in seawater. This is then transported to major municipal markets like Suva, on Thursdays and sold to middlemen who then sell it on Fridays or Saturdays.

Gunu village is about 130 km away from Suva and it takes about 4-5 hours to travel by fibre-glass boat and van/trucks to reach Suva. The route travelled by seagrapes from Naviti, Yasawa to Suva is shown in Figure 1 below.

Figure 1: Map showing the route from Yasawa to Suva

At the municipal market, seagrapes is usually displayed on top of giant green taro leaves. A number of heaps (10 - 15 heaps) of seagrapes were purchased from the Suva municipal market on the Friday of the week of the experiments. The samples were bought in the morning and wrapped in polythene bags and then, processed immediately on arrival at the University of the South Pacific's Post-harvest Fisheries laboratory.

3.3 Pre-treatment

All seagrapes that were brought into the post-harvest laboratory were first weighed on a digital scale. They were then sorted, washed and cleaned (Figures 2 and 3) in either tap water or 5% brine solution depending on the type of treatment that would be tested. The washing was done using transparent glass bowls to ensure that all debris and sand were completely removed. A second weight was taken after thorough cleaning and removal of excess water. This was done to estimate the percentage recovery of the current handling practices and to assess good quality seagrapes suitable for further processing and preservation.

3.4 Treatment and preservation

Washed seagrapes were divided into three different treatments: Treatments 1, 2 and 3.

3.4.1 *Treatment 1***:** Seagrapes were washed and rinsed in 5% brine solution, blanched for 5 minutes in 5% brine and stored in sterilized plastic containers containing three different brine solutions, i.e. 0%, 1% and 5% and refrigerated at 1^0C until the sensory evaluation and microbial test period.

Figure 2: Sorting seagrapes manually

Figure 3: Washing in transparent glass bowls

3.4.2 *Treatment 2:* Seagrapes were washed and rinsed in tap water, blanched for 5 minutes in tap water and stored in sterilized plastic containers containing three different brine solutions i.e. 0%, 1% and 5% brine and refrigerated at 1^0C until the sensory evaluation and microbial tests period.

3.4.3 *Treatment 3:* Fresh seagrapes were washed in 5% brine solution and stored in sterilized plastic containers containing 8 different brine concentrations i.e. 10%, 15%, 20%, 25%, 30%, 35%, 40%, and 45% and refrigerated at 1^0C until the sensory evaluation and microbial tests period. These samples were not heat treated but freshly preserved in brine solutions.

3.5 Weight Loss Determination of Wawa and Matai-lelevu

Each fresh variety was divided into two equal portions and weighed on a digital scale before and after Treatments 1 and 2, as discussed above. After heat treatments, samples were left to cool in dinner plates and dried on tissue papers before each treated sample was weighed on a top-pan balance to determine the extent of weight loss.

3.6 Size and Shrinkage Determination

After weighing, seagrape sizes were measured using a micrometer (Figure 4) to determine the diameter of each vesiculate ramuli. At least 20 measurements were carried out randomly on each fresh variety, from which the average diameters were recorded.

Figure 4: Measuring seagrapes using micrometer

3.7 Sensory Evaluation

To determine preference and acceptability of the various types of treatment, sensory evaluations were carried out and this was based on important quality attributes applicable for seagrapes. The evaluations were conducted on different days depending on the preparations and treatment types. Panelists were recruited each day of the sensory evaluation and all panelists had previous experience eating seagrapes or are regular seagrape consumers. Depending on the types of sensory evaluation, untrained or trained panelists were recruited. All sensory evaluations were conducted either at the Food Science or the Post-harvest Fisheries laboratory at the University of the South Pacific.

3.7.1 Fresh varieties of Wawa and Matai-lelevu

A preference test was carried out on 54 untrained panelists to select which of the two varieties was the most preferred. Both the seagrape varieties were coded prior to panelists' involvement. The panelists were asked to also select characteristics and attributes of the preferred sample.

3.7.2 Treatments with Added Preservatives stored at different temperatures

A total of 7 trained panelists were recruited for descriptive and hedonic tests to evaluate the acceptability levels of seagrapes that were preserved in $NaHCO_3$ and $CaCl_3$ and that were stored at 1^0C and ambient temperature (28^0C).

3.7.3 Treatments with additional Ingredients

The same 7 trained panelists that were recruited above also took part in descriptive and hedonic tests in the addition of other ingredients to seagrapes preserved in $NaHCO_3$ and $CaCl_3$ and that were stored at 1^0C and ambient temperature (28^0C). The ingredients tested included canned tuna meat and fermented coconuts (*kora*). These are normal ingredients added to seagrapes in Fijian dishes, along with the standard onions and chillies.

3.7.4 Three different treatments

A descriptive sensory analysis was carried out on three separate treatments after 3 weeks of cool storage (1^0C) where sensory attributes like crispiness, fibrosity, saltiness, color and flavor were evaluated using the hedonic scale. The three treatments that were tested are discussed under 'Treatment and Preservation.'

3.8 Physiological Assessment

3.8.1 Diameter Measurements and Physical Observations

3.8.1.1 Fresh Wawa and Matai-lelevu seagrapes

After sorting out the fresh *nama* samples into their two common varieties, *Wawa* and *Matai-lelevu,* randomly selected grapes of each variety were measured by a micrometer to determine the diameter of each vesiculate ramuli. At least 20 measurements were carried out on grapes of each fresh variety and their distinct diameters were recorded. The average diameters of each variety were calculated.

Physical observation was also carried out to determine any physical or physiological difference between the two fresh varieties.

3.8.1.2 Treated seagrapes

At weeks 1 and 3 of preservation and storage at cool temperature, of the three different treatments discussed in sections 3.4.1, 3.4.2 and 3.4.3 respectively, randomly selected grapes from these three treatments were measured by a micrometer to determine the shrinkage level. This was done by measuring the diameter of each vesiculate ramuli. At least 15 measurements were carried out randomly on each treatment and the average diameters of each were used.

Physical observation was also carried out to determine any physical or physiological difference between the three different treatments.

3.9 Microbiological Test

A total of 20 preserved seagrapes were tested for microbial contamination to ensure that the treatments employed were safe for human consumption and could contribute to its shelf life.

Total microbial count using the FDA method (http://www.fda.gov/Food/ScienceResearch/LaboratoryMethods/BacteriologicalAnalyticalManualBAM/ucm063346.htm) was used with some modification.

Briefly, 10g sample was put into the stomacher bag with 90mL of sterilized brine. 10^{-1} dilution was stomached at 230rpm for 60sec. 0.5mL of 10^{-2} to 10^{-6} were added into a 4.5mL of 0.85% brine (w/v). 1 mL of each dilution was inoculated in duplicates into a 15-20mL of PCA (45 ± 1^0C)

and mixed well prior to incubation for 48h at 35 ± 1^{0}C. Calculation and counting of microbes was based on the FDA method.

4. RESULTS & DISCUSSION

4.1 Sources and Post-Harvest Handling

The major source of seagrapes sold in the Suva municipal markets came from the Yasawa islands in the Western division. Usually the harvesters harvest seagrapes on Tuesdays and Wednesdays and store them in sacks (Figure 5) that are submerged in seawater before they are transported to Suva on Thursdays, first by boat to Lautoka and then, by van or truck to Suva. These are received by the middleman on the evenings of Thursdays for sale on Fridays and Saturdays. The seagrapes travel about 130kms for 4-5 hours to reach the Suva market.

Figure 5: Seagrapes stored in sacks at the Suva Municipal Market

Figure 6: Displaying ready-to-sell seagrapes at Suva municipal market

Given the storage and transportation conditions and the distance travelled before it reaches Suva, the seagrapes damaged condition and the rate of spoilage is expected to be aggravated and high. Further spoilage aggravation occurs while displaying for sale, exposing them to flies, heat and other environmental conditions. It is thus recommended that seagrapes be stored in good, clean and thin horizontal containers that allow good air circulation and to avoid abrasion, by spreading the seagrapes thinly across the containers. This may help retain the freshness of *nama* during the 3-4 days of post harvest handling and 4-5 hrs of travel. Another way to retain freshness is to seal the wounds (Nick Paul (JCU), pers. comm. 2012) resulting from harvesting. Sealing appears to be a vital process and the best way to do this is to place the shoots in seawater, in a revolving drum, for about 24 hours. Once the wounds are sealed, there will be more seagrapes viable for sale.

4.2 Weight Recovery after Sorting and Washing

Table 1 below shows the recovery weight of seagrapes after sorting, cleaning and thorough washing off of debris and sand. Results revealed that seagrapes sold at the Suva market have high average weight loss up of to 55%. This high level of debris and sand may be accumulative and due to reasons like poor storage conditions from the point of harvest through to the point of sale. It is therefore recommended that sorting, cleaning, washing and regeneration be carried out by the harvesters in clean salt water prior to storage and transportation. This may increase the recovery rates of fresh *nama,* if preservation is to be carried out successfully.

Table 1: Seagrapes recovery after sorting, cleaning and washing

	Initial weight (kg)	**Weight after sorting and cleaning (kg)**	**Weight after washing (kg)**	**Total loss (kg)**	**% loss**
Basin 1	1.520	1.305	0.955	0.565	62.8
Basin 2	1.185	0.710	0.570	0.615	48.1
Total (Av)	2.705 (1.353)	2.015 (1.008)	1.525 (0.763)	1.180 (0.590)	(55.5)

4.3 Physiological Differences between Fresh Wawa and Matai-lelevu

Table 2 shows the differences in size between *Wawa* and *Matai-lelevu* varieties; *Matai-lelevu* is bigger in grape size as shown with its greater diameter compared to *Wawa*.

Table 2: Diameter of fresh varieties of C. racemosa - grapes (µm) (n=20)

Diameter of fresh *C. racemosa* - grapes (µm)		
Variety	*Wawa*	*Matai-lelevu*
Average Diameter	3.417 µm	3.9155 µm

Furthermore, closer observations revealed that the *Matai-lelevu* variety have longer necks (Figure 7a) while *Wawa* have shorter necks (7b). Detailed differences are shown in Figures 7a and 7b below which revealed that within the *Matai-lelevu* variety, differences were also observed in the shape of the head of the grapes in which (a) had a mushroom head-like shape while (b) and (c) both had smooth enlarged head shape (Figure 7a). On the other hand *Wawa* (Figure 7b) has a short neck with (a) having a round head and (b) has a smooth enlarged head shape and (c) a mushroom head-like shape.

Figure 7: Physical differences between fresh varieties of C. racemosa

(a) (b) (c)

Figure 7a: *Matai-lelevu:* these are the common *matai-lelevu* forms sold at the Suva Municipal market harvested from Gunu village in Naviti, Yasawa; (a) has a long neck with a very distinct head with sharp edges, (b) long neck with smooth enlarged head similar to (c).

(a) (b) (c)

Figure7b: *Wawa:* these are the common *wawa* forms sold at the Suva municipal market harvested from Gunu village in Naviti, Yasawa. The samples have different physical characteristics in terms of head shapes; (a) has short neck and a round distinct head, (b) short neck with a smooth enlarged head and (c) has a longer neck and a sharp enlarged head that is distinct from the other two.

4.4 Effects of Different Treatments

4.4.1 Effects of heat on weight of Wawa and Matai-lelevu

Table 3 shows the effect of heat treatment on the weights of *Wawa* and *Matai-lelevu.* The application of heat to seagrapes contributed to weight losses. However, no difference in the weight loss was observed between *Wawa* and *Matai-lelevu* when the two different preservation media, tap water and 5% brine, were used respectively. Weight loss appeared to be within 62 – 66% when blanched in tap water and 64 – 66% when blanched in 5% brine. This study reveals that heat treatment *per se,* irrespective of the preservation media used causes weight loss which may have resulted in the shrinkage and reduction in the seagrape’s size.

Table 3: Effect of heat treatments on weight of *Wawa* and *Matai-lelevu* (n=20)

Heat Treatment medium	Variety	Mass before (g)	Mass after (g)	% weight loss
Tap water	*Matai-lelevu*	102.8	67.7	65.9
	Wawa	108.2	67.0	61.9
5% brine	*Matai-lelevu*	113.6	73.1	64.4
	Wawa	98.2	64.5	65.7

4.4.2 Effect of heat on size and shrinkage of Wawa and Matai-lelevu

Table 4 shows the effect of different heat-treated preservation media on the size of seagrapes, which reveals that each variety of grapes shrunk in size in both tap water and 5% brine heat treated preservation media.

Table 4: Effect of heat treatments on size of *Wawa* and *Matai-lelevu*

Diameter of different treatment of grapes (µm)						
	Fresh sample (no heat treatment)		**Tap water heat treatment**		**5% Brine heat treatment**	
	matai-lelevu	*wawa*	*matai-lelevu*	*wawa*	*matai-lelevu*	*wawa*
***Ave. Diameter* (µm)**	**3.916**	**3.417**	**2.848**	**2.885**	**2.852**	**2.605**

(n=20)

The ANOVA test revealed no significant difference in the shrinkage between each variety and between the two treatments, however significant differences were observed between the untreated (without heat treatment) and treated samples.

4.4.3 Effects of different treatments on size and shrinkage of Wawa

Table 5 shows the effects of two treatments; Treatment 1 (washed, rinsed and blanched in 5% brine) and Treatment 2 (washed, rinsed and blanched in tap water). Results revealed that 5% brine washed, rinsed and blanched (treatment 1) appear to have lesser impacts on size and shrinkage level compared to tap water washed, rinsed and blanched (treatment 2) samples.

Table 5: Effects of treatments 1 and 2 on size and shrinkage of *Wawa* (n=15)

Treatment 1 – Brine washed and brine blanched							
		0% Brine (tap water)		**1% Brine Solution**		**5% Brine Solution**	
	Fresh samples	**Wk 1**	**Wk 3**	**Wk 1**	**Wk 3**	**Wk 1**	**Wk 3**
Av. Diameter (µm)	3.697	2.76	2.716	3.293	3.257	3.508	3.477
% Shrinkage	0	25.3%	26.5%	10.9%	11.9%	5.1%	6.0%
Treatment 2 – Tap water washed and blanched							
		0% Brine (tap water)		**1% Brine Solution**		**5% Brine Solution**	
	Fresh samples	**Wk 1**	**Wk 3**	**Wk 1**	**Wk 3**	**Wk 1**	**Wk 3**
Av. Diameter (µm)	3.697	2.906	2.893	2.891	2.855	2.951	2.911
Shrinkage Level	0	21.4%	21.7%	21.8%	22.8%	20.2%	21.3%

It is important to note that the *Wawa* variety had been selected for this study due to the outcome of the sensory evaluation preference (Section 4.5.1 below) which revealed that *Wawa* is preferred over *Matai-lelevu*. Results also exhibited that storage in 5% brine has lesser shrinkage compared to 1% brine, while tap water storage may be inappropriate. There seemed to be no significant difference between week 1 and week 3 storage periods. Therefore an appropriate preservation technique to be recommended at this stage would be 5% brine washed, rinsed, blanched and stored in 5% brine. This result is not surprising because 5% brine is equivalent to 35% brine of sea water in which seagrapes grow best. At this concentration, osmotic pressure within and outside the grapes may be at equilibrium, resulting in the little impact on the shrinkage.

4.5 Sensory Evaluation

Sensory evaluations were carried out to determine the preference and acceptability of the different treatments that were preserved for a certain period of time. Figure 8 below shows one such sensory evaluation session conducted at the University of the South Pacific.

4.5.1 Fresh varieties of *Wawa* and *Matai-lelevu*

Out of the 54 untrained panelists who participated in this sensory evaluation session, the majority (39 or 72.2%) were females while only 15 (or 27.8%) were males. Overall, results showed the *Wawa* was preferred over *Matai-lelevu* where 57.4% of the participants preferred the *Wawa* variety while 42.6% preferred *Matai lelevu (Figure 9a)*.

Figure 8: One of the sensory evaluation sessions held at USP’s Post-harvest Fisheries lab

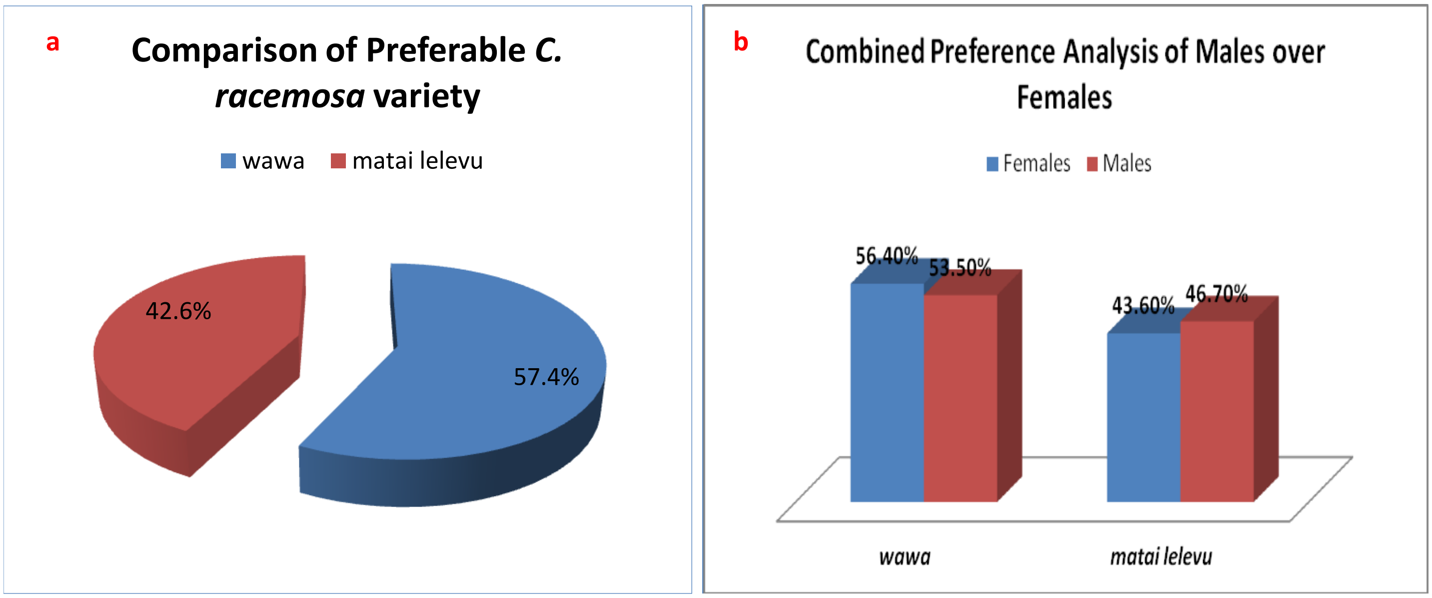
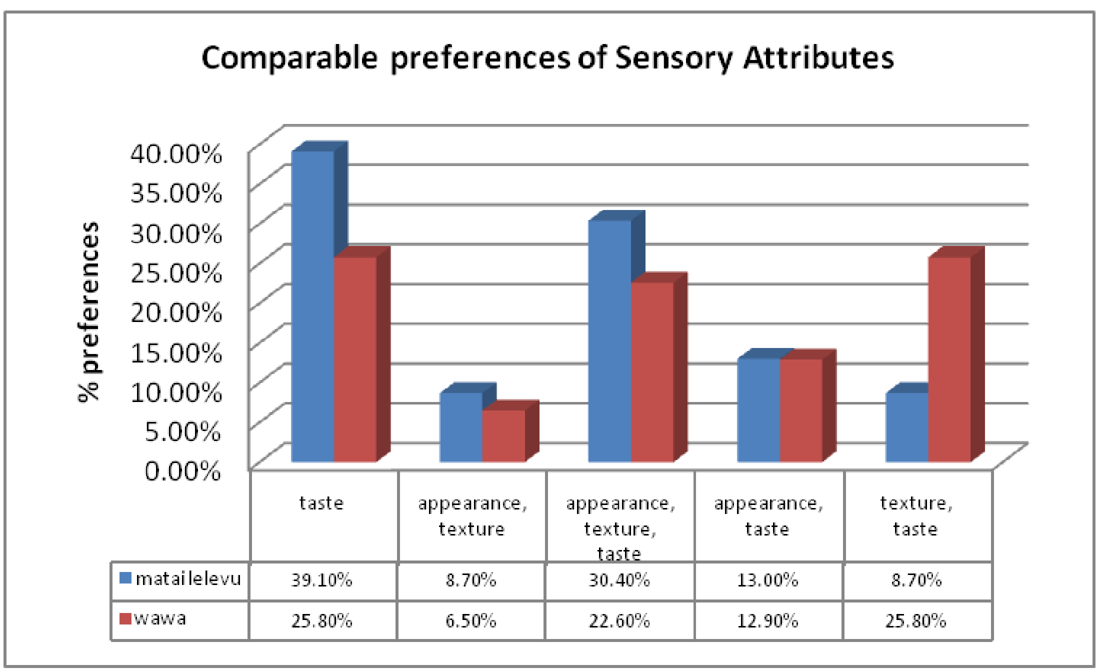


Figure 9 & 10: Preference test between the *Wawa* and *Matai-lelevu*

In terms of preference differences between genders, out of the 39 female participants, 56.4% preferred *Wawa* while 43.6% preferred *Matai lelevu*. For the 15 male participants, 53.5% preferred *Wawa* and 46.7% preferred *Matai lelevu*. However, when asked about the specific sensory attributes that contributed to their overall choice of preference, 25.8% indicated that *Wawa* has the combined effect of two attributes: texture and taste. For the overall combination of three attributes: appearance, texture and taste, 30.4% identified *Matai-lelevu* have them all while 22.6% chose *Wawa*. Figure 11 below reveals the details of the sensory attributes preferences which demonstrated an inconsistent result with the overall preference result.



	taste	appearance, texture	appearance, texture, taste	appearance, taste	texture, taste
matai lelevu	39.10%	8.70%	30.40%	13.00%	8.70%
wawa	25.80%	6.50%	22.60%	12.90%	25.80%

Figure 11: Preference of sensory attributes between *Wawa* and *Matai-lelevu*

4.5.2 Treatments with Added Preservatives

Results from the physical observations of the 7 trained panelists on the storage life of seagrapes preserved in $NaHCO_3$ and $CaCl_3$, and stored at refrigerated temperature (1^0C) against those stored at ambient temperature (28^0C) respectively, showed that refrigerated storage samples retained their green color. Refrigerated samples retained their green color from day 1 to 12 months of storage, without any change (Figure 12). This demonstrated that the ideal storage condition for blanched seagrapes is 1^0C and that this could reach up to 12 months of shelf life (Figure 12c).

Figure 12: Preserved seagrapes stored at 5^0C on different days

Sensory evaluation on the descriptive and hedonic tests revealed that samples containing both $NaHCO_3$ and $CaCl_3$ were most preferred, compared to $NaHCO_3$ alone or $CaCl_3$ alone.

4.5.3 Treatments with Additional Ingredients

The addition of either tuna or fermented coconuts (*kora*) revealed that after 30 minutes of exposure to these ingredients, seagrapes started to shrink further and liquid from the seagrapes filled up their respective plates. However the samples with $CaCl_3$ had some prolonged shrinkage compared to samples without $CaCl_3$. Figure 13 shows the effect of additional ingredients on seagrapes.

Sensory evaluation on the descriptive and hedonic tests revealed that the addition of tuna appears to mask the loss in fibrosity and crispness of heat-treated samples, especially for the $CaCl_3$ treated sample. Fermented coconut (*kora)* was the least preferred samples, which may in part be due to the unfamiliarity of the taste and flavor of *kora* to some panelists.

4.5.4 Crispness and Fibrosity of the three different treatments

Figure 14 showed the crispiness and fibrosity hedonic ranking of three different treatments: Treatment 1 (washed, rinsed and blanched in 5% brine), Treatment 2 (washed, rinsed and blanched in tap water) and Treatment 3 (without heat treatment) of *Wawa* stored in different brine concentrations.

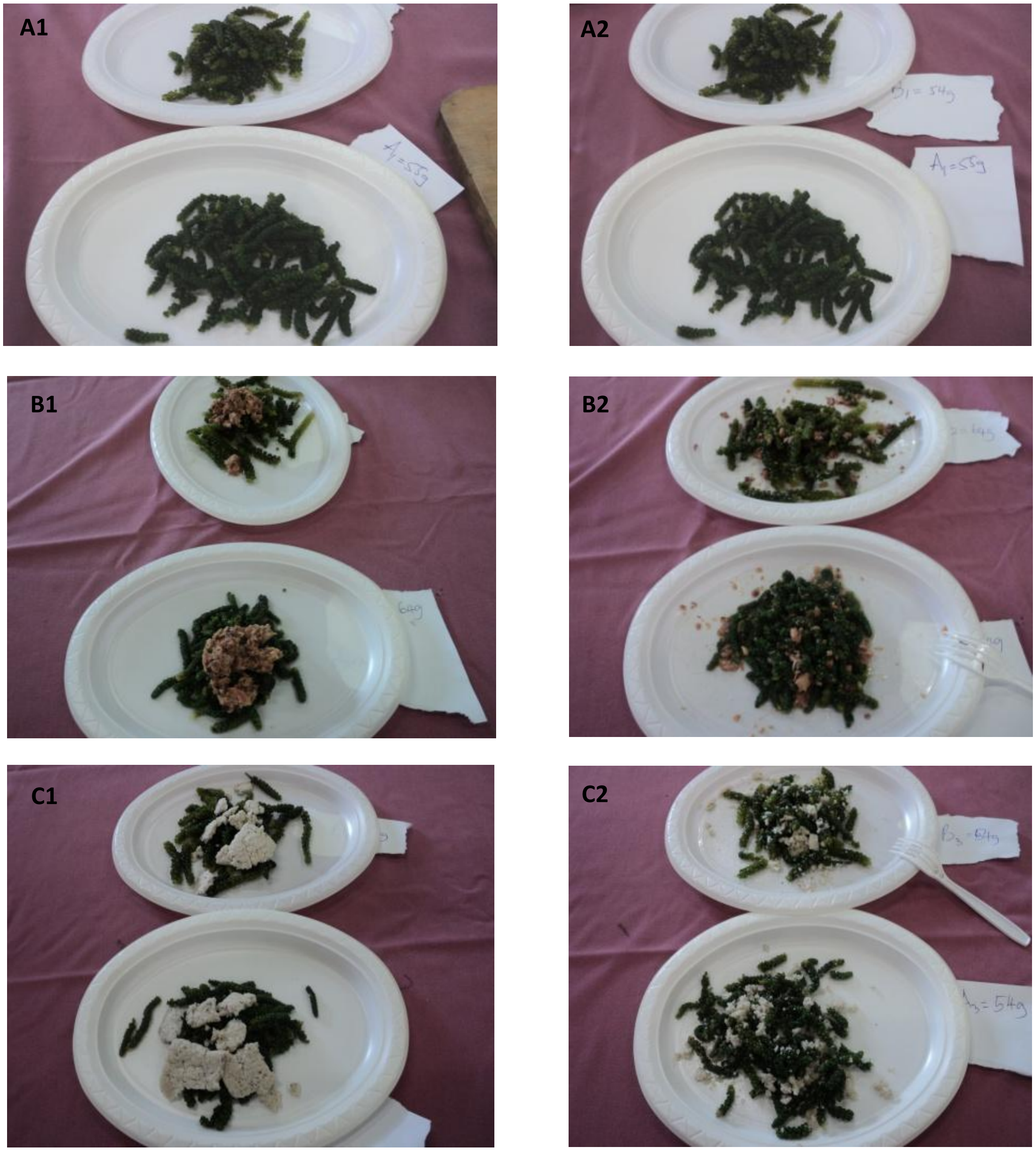
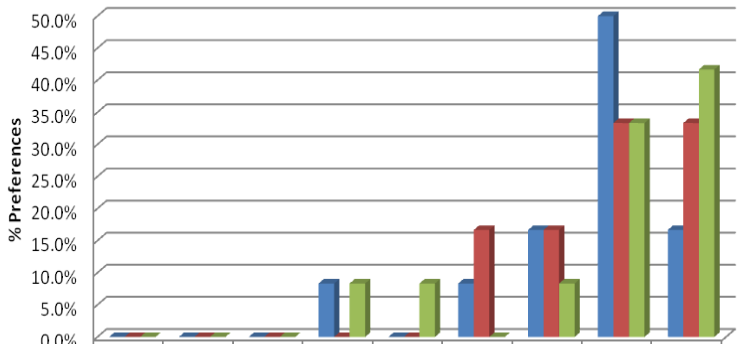


Figure 13: Preserved seagrapes with added Tuna and or Fermented coconut (*kora*)

Results showed that the highest ranking samples for crispiness were those under “like extremely” for treatment 3 stored in 35% brine (50.3%) and “like very much” for treatment 1 stored in 0% brine. This was followed by “like extremely” for treatment 1 stored in 5% brine and treatment 3 stored in 45% brine. With regards to fibrosity, highest ranking was observed as “like moderately” for treatment 1 stored in 0% brine (58.3%), followed by “like extremely” for treatment 3 stored in 35% brine, “like moderately” for treatment 3 stored in 15% brine and 40% brine, and “like moderately” for treatment 2 stored in 0% brine. In terms of fibrosity and crispness, the sensory evaluation showed that fresh treatments are the most preferred followed by 5% brine heat treated.

A1

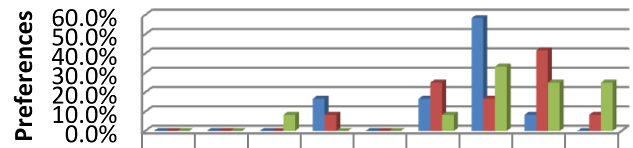
Crispiness analysis for Treatment 1 *wawa*



	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
T100	0.0%	0.0%	0.0%	8.3%	0.0%	8.3%	16.7%	50.0%	16.7%
T101	0.0%	0.0%	0.0%	0.0%	0.0%	16.7%	16.7%	33.3%	33.3%
T105	0.0%	0.0%	0.0%	8.3%	8.3%	0.0%	8.3%	33.3%	41.7%

A2

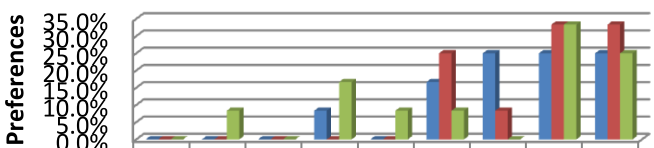
Fibrosity analysis of Treatment 1 wawa



	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
T100	0.0%	0.0%	0.0%	16.7	0.0%	17%	58.3	8.3%	0.0%
T101	0.0%	0.0%	0.0%	8.3%	0.0%	25.0	16.7	41.7	8.3%
T105	0.0%	0.0%	8.3%	0.0%	0.0%	8.3%	33.3	25.0	25.0

B1

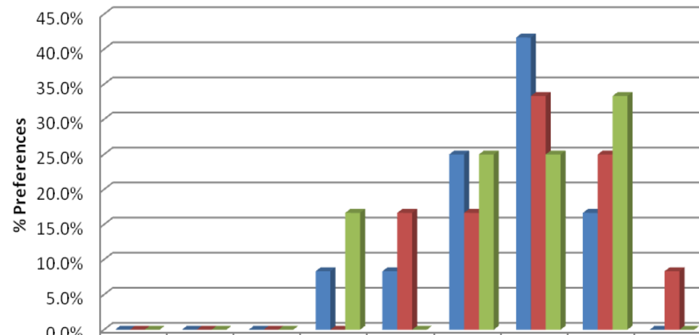
Crispiness analysis for Treatment 2 wawa



	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor di...	Like slightly	Like moderately	Like very much	Like extremely
T200	0.0%	0.0%	0.0%	8.3%	0.0%	16.7	25.0	25.0	25.0
T201	0.0%	0.0%	0.0%	0.0%	0.0%	25.0	8.3%	33.3	33.3
T205	0.0%	8.3%	0.0%	16.7	8.3%	8.3%	0.0%	33.3	25.0

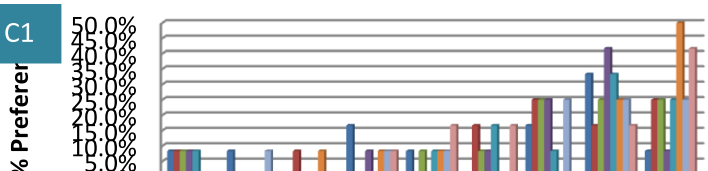
B2

Fibrosity analysis for Treatment 2 *wawa*



	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
T200	0.0%	0.0%	0.0%	8.3%	8.3%	25.0%	41.7%	16.7%	0.0%
T201	0.0%	0.0%	0.0%	0.0%	16.7%	16.7%	33.3%	25.0%	8.3%
T205	0.0%	0.0%	0.0%	16.7%	0.0%	25.0%	25.0%	33.3%	0.0%

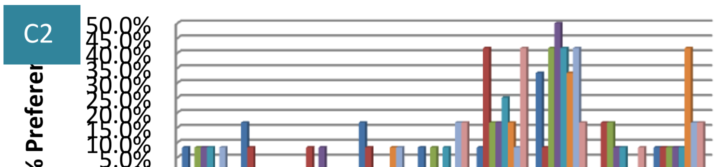
C1



Crispiness analysis for Treatment 3 wawa

	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
T310	8.3%	8.3%	0.0%	16.7	8.3%	0.0%	16.7	33.3	8.3%
T315	8.3%	0.0%	8.3%	0.0%	0.0%	16.7	25.0	16.7	25.0
T320	8.3%	0.0%	0.0%	0.0%	8.3%	8.3%	25.0	25.0	25.0
T325	8.3%	0.0%	0.0%	8.3%	0.0%	8.3%	25.0	41.7	8.3%
T330	8.3%	0.0%	0.0%	0.0%	8.3%	16.7	8.3%	33.3	25.0
T335	0.0%	0.0%	8.3%	8.3%	8.3%	0.0%	0.0%	25.0	50.0
T340	0.0%	8.3%	0.0%	8.3%	8.3%	0.0%	25.0	25.0	25.0
T345	0.0%	0.0%	0.0%	8.3%	16.7	16.7	0.0%	16.7	41.7

C2



Fibrosity analysis for Treatment 3 wawa

	Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
T310	8.3%	16.7	0.0%	16.7	8.3%	8.3%	33.3	0.0%	8.3%
T315	0.0%	8.3%	8.3%	8.3%	0.0%	41.7	8.3%	16.7	8.3%
T320	8.3%	0.0%	0.0%	0.0%	8.3%	16.7	41.7	16.7	8.3%
T325	8.3%	0.0%	8.3%	0.0%	0.0%	16.7	50.0	8.3%	8.3%
T330	8.3%	0.0%	0.0%	0.0%	8.3%	25.0	41.7	8.3%	8.3%
T335	0.0%	0.0%	0.0%	8.3%	0.0%	16.7	33.3	0.0%	41.7
T340	8.3%	0.0%	0.0%	8.3%	16.7	8.3%	41.7	0.0%	16.7
T345	0.0%	0.0%	0.0%	0.0%	16.7	41.7	16.7	8.3%	16.7

Figure 14: Crispiness and fibrosity preference of three different treatments of *Wawa* stored in different brine concentrations

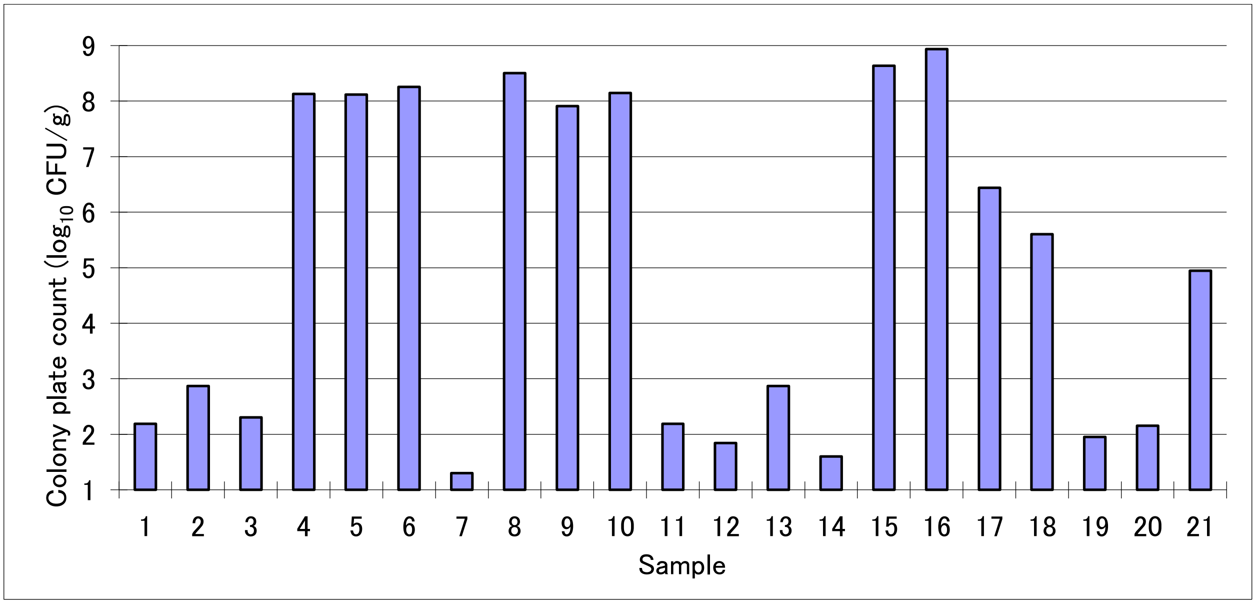


Figure 15: Total Microbial Count of stored samples

Fresh seagrapes (treatment 3): 1 (10% brine), 2 (15% brine), 3 (20% brine), 20 (25% brine), 11 (30% brine, 12 (35% brine), 13 (40% brine) and 14 (45% brine.

Treatment 1: 4 and 8 (0% brine), 5 and 10 (1% brine) and 7 (5% brine).
Treatment 2: 6 and 16 (1% brine), 9 and 15 (0% brine) and 17 and 18 (5% brine)
Sample 19 was treatment using additional preservatives discussed in section 4.5.2.

4.6 Microbiological test

After 4 months of storage at the refrigerated temperature of samples 1-18, 20 and 21, and after 12 months of sample 19, they were tested for total microbial count to determine shelf life and suitability for human consumption. Results revealed that samples stored in high concentrations of brine, compared to low brine concentrations, appear to have reduced microbial growth (Figure 15). This is especially evident in untreated-fresh samples stored at 10-45% brine. This means that the preservation medium should be at least 10% brine concentration for fresh seagrapes and 5% brine concentration for heat treated seagrapes.

Further tests were carried out on samples 7 (5% brine), 12 (35% brine) and 19 (5% brine and other preservatives) to test for the presence of coliforms and *E. coli* using Most Probable Number (MPN). Results revealed that all the three samples had either low levels or absence of both coliform and *E. coli* as shown in Figure 16. This confirms the quality and safety of these three treatments. The use of salt and the concentration used reduced the growth of microbes.

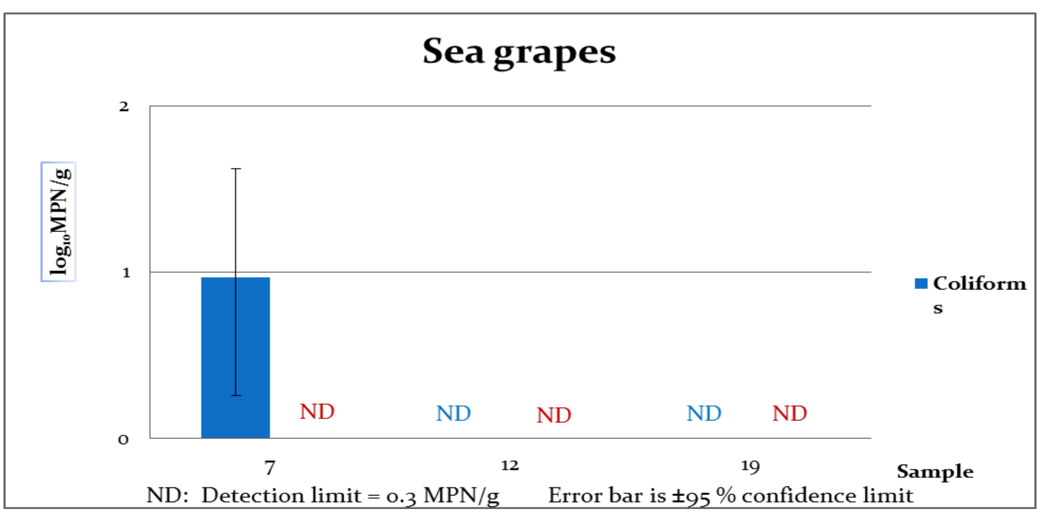


Figure 16: Coliforms and *E. coli* level

5. CONCLUSION

The current research confirms *C. racemosa* can be preserved fresh with high brine concentration or heat-treated and stored in high salt concentration with additional preservatives added and stored at refrigerated temperature. However, it is important to note that good post-harvest handling and pre-preparation activities are crucial in maintaining high quality and longer shelf-life of the preserved seagrapes. Further work is yet to confirm the loss in fibrosity of the heat-treated seagrapes.

REFERENCES

Chamberlain, A. (1997). *Export potential of the edible seaweed Caulerpa racemosa from the Pacific*. Suva: The University of the South Pacific. Project 6607-6301-70766-00

Chamberlain, A. & Pickering, T. (1998). *Post-harvest handling of Caulerpa racemosa for artisanal and export fisheries in Fiji*. In: 'Fisheries and Marine Resources' Marine Studies Programme Technical Report 3: 90-102. Papers presented at symposium 8, VIIIth Pacific Science Inter-Congress, the University of the South Pacific, Fiji, 13-19 July, 1997

Chamberlain, T. (1998). Culture and shelf-life extension of Caulerpa racemosa. *South Pacific Journal of Natural Science 16*: 11-19

Morris, C. & Bala, S. (2011) *Supply chain of Seagrapes (Caulerpa racemosa) in Fiji*. Unpublished report. Institute of Marine Resources, the University of the South Pacific

Richards, A. (1993). *Cook Islands Fisheries Resources Profiles*. Pacific Islands Forum Fisheries Agency: Research and Information Division and Cook Islands Ministry of Marine Resources. FFA Report 93/25: 63-65

Richards, A. *et al*. (1993). *Fiji Fisheries Resources Profiles.* FFA Report No. 94/4: 97-100

South, G.R. (1993). Edible seaweeds of Fiji: and ethnobotanical study. *Botanica Marina* 36: 335-349

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