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Assess the Social-Economic Dimensions of Carrageenan *(Kappaphycus alverezii)* Value Chain in Sri Lanka

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ABSTRACT

Carrageenan is an excellent emulsifier; stabilizer, suspension and binder which extracted 100% naturally from red edible seaweed (*Kappaphycus alveresii*) and spend thousands of dollars annually to import it, even though country has ability to produce it. Production of Carrageenan will initiate countless opportunities to the small and medium entrepreneurs and bring economic prosperity to the coastal inhabitants in Sri Lanka, due to boosting domestic and international demand for Carrageenan continuously. This paper has examined the structure, and performance of the value chain in Carrageenan production in Sri Lanka and assess the potential of expand through exploring and analyzing each stakeholder who represents the stages of value chain. Value chain analysis of the sector has proved country has great potential of production of Carrageenan even to export level and already promote new livelihood option in fisheries sector in north and north western provinces. Study was revealed farmers were play vital role for escalate the productivity of the Carrageenan. Also study was stated lack of reliable information, technological innovations, and market accessibility is the major constraints faced by all stakeholders. According to the current conditions, ability of Carrageenan production is basically determined by scaling up the seaweed production in the country. So Carrageenan production have capable to arise economic conditions of the country by itself and with regards to that seaweed farming, opportunity arise with the Carrageenan production; has potential to rise low income levels in Sri Lankan coastal areas.

KEYWORDS: Carrageenan, Coastal inhabitants, *Kappahycus alverazii*, Seaweed farming, Value chain

INTRODUCTION

Trade, export and import play a vital role in the Sri Lankan economy. Sri Lanka imports approximately ten thousands of commodities (personal communication) with respect to fulfill domestic demand.

Carrageenan is belongs to the family of linear sulphated polysaccharides. It's special curl forming helical molecular structure give its ability to form variety of gel types under various conditions.it can be used in a remarkably wide range of products in the food processing, cosmetic and pharmaceutical industries as an excellent emulsifier, stabilizer, suspension and binder. Carrageenan is the one and only chemical substance used in those industries which is extracted 100% natural source (Neish, 2013).

Demand for the carrageenan boosted annually, accordingly with the rising demand for processed foods and various cosmetic items. According to the statistics of custom in 2015, Sri Lanka spends Rs. 82,135,069 to imported different processed forms of Carrageenan.

Many red algal species produce different types of carrageenan during their developmental history, especially by the class of *Rhodophyceae* (Neish, 2013). *Kappaphycus* species belong to the class of *Rhodophyceae* is recommended to grow in Sri Lanka for better harvest.

There is a great potential for Sri Lanka to produce Carrageenan domestically, because main row material to produce Carrageenan is obtaining from sea. The maritime area of 230,000 km^2 belonging to Sri Lanka which is about three times larger than the land area and its Exclusive economic Zone is about 517,000 km^2 which is approximately eight times larger than the island (Singappuli, 2012).

At present, Indonesia and Philippines came to the first place in Carrageenan production in the world rank (FAO Fishstat, 2014). Therefore, Indonesia is called from the common names of *Kappaphycus*, which is land of *cottonii*. These countries provide evidence that mariculture is one of the better solutions to bring prosperity to the economy. Due to several favorable attributes like simple farming techniques, low requirements of capital and material inputs, and short production cycles, carrageenan seaweed farming has become a worthy livelihood source for smallholder farmers and generated substantial socio-economic benefits to marginalized coastal communities in developing countries.

In Sri Lanka Carrageenan seaweeds farming is commercially pioneered by Hayleys Agriculture Holdings Ltd. In 2014, Hayleys initiated a pilot project of Carrageenan seaweed *(Kappaphycus alverezii)* farming as a demonstration project in the North Western

coastal area of Sri Lanka (in Mannar Sea Basin) to fulfill objective of assess the potential of seaweed cultivation in Sri Lanka. As a secondary objective Hayleys concerned to help fishing communities in above areas to rebuild their lives standard who were suffering from conflicts. This pilot project proved Sri Lanka has high potential for production Carrageenan domestically. Success of the project can be proven by the subsidiary received by Hayleys from UNDP in Jun 19, 2015 as nominated by the government.

Carrageenan was selected for this study especially because this industry is not well developed in Sri Lanka to cater the total demand. Although Carrageenan is an import product and by initiating production within the country it can be prevent money float to overseas. Also it can influence small and medium entrepreneurs. The aim of this study was to analyze the value chain of this product and trace out the barriers and opportunities to develop the industry suggesting the intervention and solutions.

METHODOLOGY

Theoretical Framework

Theoretical framework consists of three steps. In first step simple flow chart value chain was prepared by using information gathered from Focus Group Discussions (FGD). Identification of the key stakeholders in value chain and figure out major constraints and opportunities with respect to each of them were done in second step. During the final step interventions were suggested for constraints to improve the present situation of the production.

Data Collection

Data were collected from farmers, collectors, processers and marketers. Eighty farmers and 30 collectors were selected from the District Secretarial Divisions in Jaffna district which has prodigious potential to cultivate Carrageenan (*i.e.* Mannar, Kilinochchi and Nandikadal). Twenty marketers were selected from Colombo district and interviews were conducted during the period of January to May, 2016.

Desk research was conducted to get basic idea about the product and based on the information obtained; the flow chart of value chain was developed. Focus group discussions were implemented with the different stakeholders and information was gathered. Different questionnaires were prepared for different stakeholders and data were collected by using pre-tested questionnaires.

Questionnaires consist with both open-end and close-end questions. Open-end questions used for qualitative analysis and based on the qualitative information, grid chart value chain was prepared. Potential of the production was measured as responses of each stakeholder using five point Likert scale statements ranging from Strongly agree (5) to strongly disagree (1) and from very important (5) to very unimportant (1).

Data Analysis

Data were analyzed both qualitatively and quantitatively. Descriptive analysis was performed in order to analyze the data descriptively. Kruskal-Wallis and Binary Logistic Regression analysis used to analyze data quantitatively.

Binary Logistic Regression was used to figure out the impact of different factors to increase or decrease the potential of carrageenan seaweed production. Dependent variable is the categorical response variable and five predictor variables were included in the Regression model.

$$Y = a + \beta x$$

$$ln\{P/(1-P)\} = a + \beta x$$

$$\frac{P}{(1-P)} = r^{a+\beta x}$$

$$P = \frac{e^{a+\beta x}}{1+e^{a+\beta x}}$$

Where,

P = Increase the perception or ability

1-P = Decrease the perception or ability

RESULTS AND DISCUSSION

Descriptive Statistics of Sample

Five major stake holders were identified (farmer, collector, primary processor, secondary processor, and marketer) and flow chart value chain was developed for Carrageenan industry (Figure 1).

Secondary Processor was not identified in Sri Lankan Carrageenan value chain while others were identified.

In the study, marketers were identified as food and cosmetic manufacturing companies who use blends of Carrageenan as a row material of the product. They are using Carrageenan not in the form of raw but in the form of blend. But around 90% of these blends were consisted with row Carrageenan. Seventy percent of the marketers were willing to buy local form of Carrageenan blends if it is available and 30% of them (especially cosmetic manufactures) were not willing to use local blends as they maintain their reputation using world branded products. But 75% of the marketers stated that they are not willing to produce Carrageenan blends by own even though processed form of Carrageenan is available in Sri Lanka. Hundred percent of the

processors were stated that, they can produce refined and semi refined Carrageenan domestically if raw material *(Kappaphycus alverezii)* is available in required amount. Eighty percent of the seaweed collectors were willing to expand the amount of collection if it is available in excess amount. Eighty five percent of the farmers were willing to expand the cultivation of *Kappaphycus alverezii*, if farmers were facilitated by necessary factors.

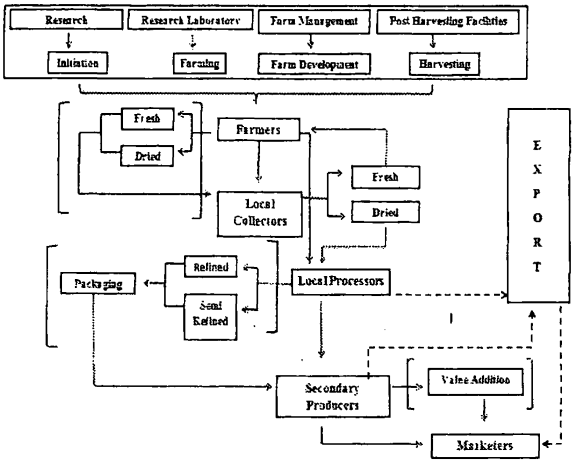

Figure 1: Complete flow chart value chain of Carrageenan

Constrain Analysis of Collectors and Marketers

Four major constrains related to the Carrageenan production was identified with help of literature and they were ranked by the collectors to identify factors influencing the collectors' ability to expand the quantity of collection. Same procedure was continued for marketers too to evaluate ten influential factors (Table1 and Table 2). Ranked data were analyzed using Kruskal-Wallis test.

The test statistic had a p-value of 0.001, both unadjusted and adjusted for ties, indicating that at least one factor is highly influence for production expansion of Carrageenan.

By observing the median values and the average ranks, it is evident that availability of reliable information and market opportunities were more impactful over the influence collector's perception towards increase the quantity of collection (Table 1).

Table 2 represents the median values and the average ranks obtained for ten factors related to the marketer perception towards selecting processed carrageenan blend as row material.

The results revealed that quality of the processed carrageenan blend was more impactful on marketer's decision when selecting a carrageenan blend compared to other factors (Table 2).

Other than that brand name, availability advanced processing techniques and easy access, were the secondary influential factors.

Table 1. Results of Kruskal-Wallis analysis for collectors

Factors	Median	Average value	Z value
1	2.25	16.4	-8.01
2	3.50	65.1	0.84
3	4.00*	89.8	5.32
4	3.75*	70.7	1.85

*Note: * Represent highest median value; Adjusted P value 0.001; Z-Corresponding standardized Z values; 1-access to finance, 2-new technological innovations, 3-reliable information, 4-market opportunities*

Table 2. Results of Kruskal-Wallis analysis for marketers

Factors	Median	Average value	Z value
1	4.00*	115.3	1.20
2	5.00*	178.9	6.39
3	3.00	83.7	-1.37
4	4.00*	146.1	3.72
5	4.00*	127.7	2.21
6	2.00	41.2	-4.83
7	1.50	46.0	-4.44
8	4.00*	122.7	1.81
9	3.00	90.6	-0.81
10	2.00	52.8	-3.88

Note: Represent highest median value; Adjusted P value 0.000; Z-Corresponding standardized Z values; 1-brand name, 2-quality, 3-price, 4-availability, 5-advanced processing techniques, 6-advertising, 7-government support, 8-easy access, 9-easy supervision, 10-local product*

Outcome of the Binary Logistic Regression Analysis

Potential to expand the production were tested with five major selected factors (access to finance, new technological innovations, reliable information, market opportunities, and favorable environment conditions) using Binary Logistic Regression. Of them, reliable information on raw materials, fertile seedlings, government support, and training like supportive services was found negatively related to the farmer perception about their ability to increase quantity of production. But factors of new technological innovations and market opportunities were found positively related to the farmer perception about their ability to increase quantity of production. However there were no evidence on relationship between access to finance and favorable environment factors for farmer perception.

Table 3. Relationship between five factors and farmer perception about their ability to increase quantity of production

Predictor	Coef	P value	Odd ratio
Constant	-5.72632	0.502	
X_1	1.15458	0.274	3.17
X_2	1.94492	0.034*	6.99
X_3	-2.94736	0.034*	0.05
X_4	4.02884	0.010*	5.62
X_5	-2.01074	0.346	0.13

*Note: * Significance level at 0.05; Probability value for the regression model 0.001; X_1-Access to finance, X_2-new technological innovations, X_3-reliable information, X_4-market opportunities, X_5-favorable environment factors*

The probability value for the new technological innovations is 0.034 with the positive coefficient value and 6.99 odd ratio value, which is indicating odds of farmer perception towards increasing in using of new technological innovations *cetris paribus,* will increase the farmers ability to increase the Carrageenan seaweed production by 6 times. It indicated that, farmers were provided new technology; they would be able to increase the harvest of Carrageenan seaweed.

Similarly increasing of the market opportunities will lead to increase farmer ability of boosting Carrageenan production

The probability value for the reliable information is 0.034 with the negative coefficient value and it was had 0.05 odd ratio value, which is indicating odds of farmer perception towards decreasing of the availability of reliable information *cetris paribus,* will decrease the farmer ability to increase carrageenan seaweed production by one time. It indicates that, if farmers do not get correct information about cultivation and other supportive services in correct time it will leads to decrease the harvest of seaweed cultivation. It implies that providing correct information to the farmers on possible cultivation systems, cost effective row materials, good quality plant materials, government services, legal services, trainings, etc. would help to increase the yield than present (Table 3). Potential grid chart value chain of carrageenan in Sri Lanka and relevant opportunities, constrains and possible interventions were also developed (Table 4 and Table 5).

Table 4. Potential grid chart value chain of the carrageenan in Sri Lanka

Stakeholder	Product	Actions		Market	Price in Rs.*	
Small, medium and large scale farmers	Fresh carrageenan seaweed Dry carrageenan seaweed	***Fresh Form*** Preparation floating rafts. Cultivate the *Kappaphycu alverezii.* Maintenance of the raft. Harvesting. transportation	***Dry Form*** Preparation floating rafts. Cultivate the *Kappaphycu alverezii.* Maintenance of the raft. Harvesting. Preparing Drying Racks. Drying. transportation	Local market only	***Fresh*** 5-15	***Dry*** 75-90
Collector	Fresh carrageenan seaweed Dry carrageenan seaweed	***Fresh Form*** Collect the seaweed from farmers. Clean them Storage in safe place	***Dry Form*** Collect the seaweed from farmers. Clean them Preparing drying racks. Drying. Store in hydrated place	Local market only.	***Fresh*** 10-15	***Dry*** 75-90
Primary Processor	Alkali Treated Chips (1) Technical Grade Semi Refined Carrageenan (2) Gel press Refined Carrageenan (3) RC-Alcohol precipitated refined Carrageenan (4)	***Without advance processing techniques*** Buy the seaweed from the seller Prepare the seaweed bales Take them to the collection centers for consolidation Load the containers and transport Deal with overseas buyer	***With advanced processing techniques*** Buy seaweed from the seller Clean and wash the seaweed Extraction Corse filtration Fine filtration Gel pressing or Alcohol recovery of fine filtrated sample Drying Milling Blending	International market and Local market	(1) 250-350 (2) 400-500 (3) 1000- 1500 (4) 1000-1500	
Secondary Processor	Food Grade Semi Refined Carrageenan (1) Advanced Blends of Carrageenan (2)	Potassium Hydrocside extraction Fresh water washing and chopping Color removal Fresh water washing Close drying Sterilizing Milling Add requires food additives		International and Local market	(1) 600-800 (2) >2000	
Marketer	Dairy products Water based products Meat products Pet products Air freshener gels Tooth paste			International and Local market		

Table 5. Opportunities and constraints of the carrageenan value chain and proposed interventions

Opportunities/Constraints	Proposed Interventions/Suggestions
A) Institutional	
Constraints	
Less no of researches conduct relevant to the subject matter and less interest over it.	Ask for government support and permission to conduct research about relevant subject
Lack of technical approaches, or new technological innovations	Seeking the opportunities to get international grants
Opportunities	
Availability of the institute who can get responsibility about the subject (NARA, COSTI, NEDA)	Explore the research on potential of the better use of marine resources and economic impact of it.
B) Farming	Motivate the farmers to maintain own seaweed nurseries
Constrains	Or motivate some selected farmers to cultivate seaweed with high quality to sell as seedlings only
Lack of supply high quality seedlings	Establish commercial level seaweed nurseries in provincial vise and establish seaweed gene bank to develop seedlings with better quality characteristics
Lack of knowledge and scientific studies about methods of increase the harvest	Trained the agricultural officers to help farmers
Lack of knowledge about good management practices	Design and develop new financing and crop insurance programs to give more confidant for farmers
Limited availability of supportive services	Find low cost alternatives for existing row materials or develop method to access row materials in cost effective
Lack of access to the financial resources and unavailability of special financial plan.	Conduct scientific investigations to check environmental effects
Difficulty of finding row materials (Bamboo)	Give initial support by government to establish required post-harvest facilities (drying pens) or guide farmers to build them in cost effective way.
Lack of knowledge to reduce seasonal or monsoon effect for quantity of harvest	
Lack of post-harvest facilities	
Opportunities	
Guidance of buying agents	
Ability to increase the farming scale and reduce per unit cost of production	
Favorable environment conditions for growth and dry the seaweeds	
Farmers awareness about the difference between the income gain through fresh and dry seaweed forms	
C) Marketing	
Constraints	Motivate the production of row material (*Kappaphycus alverezii*)
Less availability of carrageenan seaweed than required quantity	Informed and motivate several selected firms by government to engage with the value chain as primary and secondary processors
Lack of interest of the marketers	Give chance to the processors to have the knowledge and practice they required from international under government support
Unawareness of the potential Lack of knowledge and technology	
Opportunities	
Continuously grown international and local demand for the carrageenan	
Processors ability to engage with the advanced processing techniques	
Marketers willingness to buy local product than exported one	

CONCLUSIONS

Production of Carrageenan is highly profitable and viable business opportunity but still not develop in satisfactory level in Sri Lanka. Carrageenan production has higher potential to improve with favorable condition prevailing in the country.

Study revealed five major stakeholders (farmer, collector, primary processor, secondary processor, and marketer) who represent the linkages in Carrageenan value chain and secondary processor is not existing linkage in domestic value chain. Carrageenan production is not mature in Sri Lanka due to several difficulties face by stakeholders. The study revealed that farmer is a key stakeholder in domestic Carrageenan value chain, which plays vital role to escalate Carrageenan production. Study stated farmers required technological innovations, reliable information, and market opportunities in order to boost the productivity.

Study addressed opportunities, constraints, and proposed interventions for stakeholders and it stated further in discussion section.

In farmers point of view this is stress-free cultivation system than any other crop and farmers like to expand the cultivation further. Capital investment of the industry is less while materials cost is comparatively significant. Carrageenan seaweed farming is labor intensive activity. But in small scale farmers it is becoming a family operation and cost can be reduce.

Women engagement in the seaweed cultivation is also critical. Women who directly involve to the farming system play vital role in household and under correct supervision they can earn considerable income annually. In present condition the level of collectors arise with the increase of women farmers who only maintain few floating rafts.

Carrageenan production can conserve millions of dollars annually in domestically and if more improvised level it can earn foreign exchange via export the processed blends.

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