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Efficacy Of Traditional Methods of Harvesting and Drying Seaweed in Reducing Loss of Seaweed Quantity and Quality Experiences from South District Unguja-Zanzibar

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Abstract
Efficiency in seaweed harvesting and drying methods is essential for preventing substantial loss and degradation of the quality of seaweed products. This study investigated if the current practices of harvesting and drying seaweed applied by seaweed farmers negatively affect the optimum yield and quality the seaweed products. Thus, the study examined the efficacy of the existing practices and technologies that are employed by farmers in harvesting and drying seaweed on their efficiency in preserving the yields and the quality of seaweed products. Specifically, the study assessed the influence of the farmers existing practices during harvest and drying processes on the (a) seaweed quantity (yield loss), and (b) quality change (degradation). The study applied quasi-experimental design insights, where the influence of farmer's method (intervention 1) and the controlled method (intervention 2) in affecting the weight of seaweed harvested, weight of the dried seaweed, and change physical and chemical quality through contamination in impurities, sand, and microbial content (the outcomes of the interventions) were examined and compared. Drawing from the data obtained in three seaweed producing villages of Jambiani, Michamvi and Uzi in Southern Coast of Unguja Island, the study combined quantitative techniques and field-based observations to determine how farmers applied method (traditional method) compared in their performance against a procedure utilized by the researcher (controlled method) during harvesting and drying. Field observations allowed for direct measurements and record of physical quality variables, while the laboratory analysis enabled determining chemical change and microbial content against established standard. Survey method; further incorporate data on the conditions of loss and common practices applied by farmers in traditional farming of seaweed. Data analyses were based on the a priori determined calculations which considered all observed variables, and the descriptive statistics were applied to present the data as per the variables investigated.

The results indicated that, controlled method performed better than traditional method in all performance variables of harvesting and drying that were measured. On physical impurities traditional based samples recorded 0.3kg against 0.056kg for controlled method with loss of and 0.073kg and 0.051kg for traditional and controlled methods respectively. More importantly, the efficiency of drying technique (EDT) for traditional method 16% of the total weight against 25% for controlled method with equivalent to reduction (loss) in 84% of the fresh weight for traditional method against 75% for controlled method. With this rate, the controlled method had potential of resulting in 951.25kg of total dry weight if applied on the farmers harvested and dried seaweed compared to only 622.5kg of the actual weight by the current traditional method – a difference of 328.75kg that could be added by controlled method. The estimated potential loss of the value market according to the current price of 1,200TSZ was 747,000 TZS (farmer's method), compared to 1,1415,00 TZS for controlled method, which gives a difference of 394,500.00 TSZ. This means that, there as increase of 34.5% value of seaweed dried based on controlled method compared to the original farmers' method. Overall, this study provided simple and easily method that could improve the quality of seaweed harvest against the common applied practices by farmers. It pointed to the deficiencies that contribute weight and quality loss, and hence the market value of seaweed based on farmers' method. Hence, the study implies on the importance of the technical support to

seaweed farmers to understand this deficiency in their practices and support to an enhanced by changing the current practices with simple technology for drying and following guidelines that can yield in high quality seaweed harvest and products.

Keywords: Seaweed, Traditional method, Harvesting, Drying.

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1. Introduction

Farming aquatic plants is a large industry worldwide, accounted for about 7 million tons in 2014 alone (FAO, 2016). While in Europe, the seaweed industry is still beginning, it is the main part of manufacture in Asian countries, where China and Indonesia producing about 91% of the aquatic plant to the world market supply (Hasselström et al., 2018). Tanzania and particularly Zanzibar is the one among producer in East Africa, exporting more than 30,000 tons of dry weight seaweed annually (Anderson 2005).

Seaweed farming is one among Zanzibar largest practiced economically activity contributing for about 40% of the rural poor livelihoods income and poverty reduction (Lange and Jiddawi, 2009) It employs more women than men, who's empowering most of these rural women economically. There are different species of seaweed, and most of them are red, green and brown. Most of common species cultivated in Zanzibar is Eucheuma Cottonii species and Eucheuma Spinosum. The red seaweed known as Eucheuma cottonii, it has no root but some branches attach to corals and grow. The cottonii seaweed is used for production of carrageenan, an ingredient for cosmetics, food processing and industrial manufacturing. Fresh seaweed contains moisture, pigments, fatty acids, lipids, carrageenan, and some minerals (Vairappan et al., 2014). The post-harvest loss, here is define as any loss that occurs after separation of the product from the site of immediate growth to the moment reaches to consumer (Suleiman, R., & Rosentrater, K., 2015).The post-harvest loss limit good quality and enough quantity out of the harvesting to reach to the end consumers mostly due to the process involved in harvesting, off farm preparation and drying of seaweed. There are many challenges that hinder post-harvest efficiency and leading to the loss in quality and quantity of seaweed product. The poor postharvest handling and management practices reduces seaweed accessibility and hence market opportunities and causes a decline in income opportunities due to high physical loss (Yeshiwas, Y. 2021).

2. Objective

To assess the efficacy of the current farmers applied practices of harvesting and drying process on seaweed quality and quantity in among the seaweeds farmers in selected villages in South Region Zanzibar.

3.Literature Review

3.1 Source of seaweed

Seaweeds are important marine plants that grow in the water, along with sea grasses and mangroves (Oliveira, et all, (2003). They are essential for producing food in the ocean (Crawford, 2002). Seaweeds can come in different shapes, but they typically have four main parts: holdfast, stalk, leaf-like structure, and reproductive parts. The main groups of seaweeds are categorized by their main colours that help them make food. The different types of algae include green (chlorophyta), brown (phaeophyta), and red algae (rhodophyta). Green algae have chlorophyll, brown algae have carotenoids, and red algae have phycoerythrin. They use light as energy and are found in coastal areas from the intertidal zone to shallow sub tidal zones (Crawford, 2002). Seaweeds are plant-like organisms that typically live near rocks or other hard surfaces in coastal regions (Edwards, 2015).

3.2 Importance of seaweed

Seaweed is a natural resource that can be used for human consumption and processed into food supplements, animal feed, fertilizers, biofuel, beauty products, and pharmaceuticals. (Msuya, 2012). The use of seaweed extracts such as carrageenan, agar, and alginates as gelling substances, stabilizers and emulsifiers in industrial products like perfumes, shampoos, toothpaste, medicines, ice cream, milk shakes, and yoghurt (Msuya, 2012). Edible seaweed contains entirely varieties of nutrients like antioxidants, proteins, minerals, vitamins, and fatty acids. The red, brown and green seaweeds can help to reduce blood pressure, prevent cancers, obesity and diabetes. Seaweed is a good organic fertilizer or animal feed for farmers. As the fertilizer, it helps plants absorb nutrients and protects them from soil-related diseases (Le Gouvello et all, 2022). Additionally, when animals eat it, there is a reduction in methane gas, a major component of greenhouse gas emissions from the agriculture

sector that is produced by cows. By adding a small amount of dehydrated seaweed to the diets of cows, it can help decrease up to 99% of the methane gas produced by the cows. (Morais et al., 2020)

4. Methodology

This study mainly followed on the quantitative approach to the research design whereas field based comparison on the efficacy of the two methods (traditional and controlled) of harvesting and drying seaweed farming was investigated. The study research questions were measured based on three levels. The first level, through direct observation, that is based field work at Jambiani, Michamvi and Uzi. The second level was through collection of data from the seaweed farmers on current practices and experiences of the seaweed farming methods, here termed traditional methods, where structured survey was employed. Finally, the third level was based on chemical and nutrient analysis that was carried through laboratory analysis of the collected samples for variables on microbial content and chemical of dry seaweed specification harvest to determine the efficiency of these two methods in influencing the cottonii quality of seaweed. Overall, the comparison was made based on the observed data and experience collected on data on traditional methods with the controlled method, to assess the efficacy these two methods in influence in quantity and quality of cottonii seaweed. This employed observation and quantitative survey design to achieve intended goal. Sampling of field units.

Samples for comparing efficacy in reduced seaweed quantity loss were determined based on the lost seaweed cottonii after each of the 85 farmers from each village has harvested and moved their seaweed into drying place. Here, the loss was determined based on each of these harvested seaweed. On contrary, under controlled method, the plastic bags were used to collect cottonii and were measured for comparison in quantities. Also during drying process was determined the lost that obtained in three village areas and in controlled method was used floor areas and special trays.

4.1 Sampling of samples of laboratory

In collected sample were needed gloves for handling seaweed and inserted to sealed plastic bag in each village. The laboratory samples were needed 3kg for each village of dry cottonii seaweed for physical/dry cottonii specification such as moisture content, impurity salt and sand, hence the same kilograms were needed for controlled method. Also in microbial analysis one kilograms of seaweed were needed in each village to maintain the total plate count, E. coli, yeast and mould. The same amounts in microbial analysis were needed in controlled method.

4.2. Data Collection Methods

This is empirical study that relied on the primary data collection method to achieve its objectives. The study applied three types of data collection: a)The observational methods, where data on efficacy of the two methods influencing physical properties of seaweed were collected in the field .b)Also questionnaire which addresses variables such as method that used for cultivation involved shallow or deep water farming, the skilled and tools that involved in seaweed faming, challenges that obtained in harvesting and drying activities and so on and c) laboratory analysis of sampling, for determination of microbial and dry specification of seaweed cottonii. To obtain the information of quality, it was needed to have data on standard drying procedure, in order to have the data of dry specification and microbial, this information would do comparison between the traditional method and controlled method that would able to show the quality and quantity of cottonii seaweed. The quantitative data was able to collect by the measurement of cotton seaweed from harvesting which allow to knowing the amount of debris and loss that obtain within, and through drying process, it would allow knowing the amount of loss and impurities that contaminant.

4.3. Data Analysis

On the harvesting and drying techniques were able to analyze through questionnaire and observation that can able to know the methods that involving in activities. Quantitative data was collected through experimental that were able to analyses using the Microsoft excels. Quantitative data collected through experimental observation on seaweed resources was able to get data, that was be analyses using content analytical procedures in order to extract relevant information. Using this technique, data was being classified into meaningful units and themes in line with the specific objectives. These data were able to compared to the standard value between the traditional farmers and controlled farming procedure that was be used in the study. The qualified data was being analyses through microbial and proximate analyses in order to know the market value of seaweed.

Calculations that involved in post-harvest losses of seaweed

% Loss due to harvesting %=x/Ht…….…. (1)

% Loss due to improper collection of seaweed after and during drying
%=y/Dt…….. (2)
FDW1 = WW1 – DW1…… (3)
Where FDW1 is the final dry weight of the cottonii seaweed based on farmers' method; WW1 is the original fresh wet weight of seaweed form the farmer and DW1 is the dry measured dry weight of the farmers'
FDW2 = WW2 – DW2…….. (4)
Where FDW2 is the final dry weight of the cottonii seaweed based on controlled method; WW2 is the original fresh wet weight of seaweed form the controlled method and DW2 is the dry measured dry weight of the researcher's sample.
To obtain the efficiency of drying each drying technique (EDT) i.e. between traditional method (FM) and controlled method (CM), the percentage of preserved weight was calculating for each method and compared. This was achieved as follows: -
EDT = DWx/WWx…….... (5)
Where DWx represent the final dry weigh of a method x i.e. traditional or controlled method, and WWx is the wet weight of a method x (i.e. FM, or CM)

4.3.1. The physical and dry specification of cottonii in quality loss (change
According to (TBS, 2020), there are difference methods of drying seaweed specification which can enable to determine the quality of seaweed; these methods were able to use in this study are as follow.
Percent Moisture= ((wo-wf)/wo) x100
%Impurities or debris=WD/WO x100
%salt=VAgNO3xNAgNO3 (74.50/1000) X100/250x (50%
Sand=Wd/250 x100/1000) x (10/250)

4.3.2.Determination of microbial
In determination of microbial was need half kilograms of dry cottonii seaweed in each village areas. According to (TBS, 2020) the code of microbial analysis was TZS 109, which were allowed to measure the constituent such as total plate count, Escherichia coli, Yeast and Mould.

5. Research Findings

Four specific research questions were investigated to achieve these main objectives, these were: i) assessing the impact of the traditional of harvesting and drying on the quantity loss of seaweed .ii) quantifying the physical and dry specification of post-harvest quality loss(change)of cottonii seaweed farming based traditional and control of harvesting and drying methods and iii) determining the difference between traditional and control methods of drying seaweed influencing the levels of microbial cottonii content and finally: iv) Estimate potential difference in market value of cottonii seaweed based on traditional and controlled method. : – First level was on the seaweed farmers based experience Here 135 numbers of farmers were recruited from villages that were 85, 34 and 16 farmers from Uzi, Michamvi and Jambiani Kichaka Nyuki respectively. At the second level, samples of seaweed cottonii from freshly harvested 3805kg and 622.5kg after drying seaweed were collected and measured based on seaweed farms in Uzi, Michamvi and Jambiani Kichaka Nyuki while in 25kg of freshly seaweed cottonii seaweed sample were measured and 6.3kg were collected after drying in controlled method. In situ measured samples were measured for quantifying loss in harvesting and drying of cotton seaweed.

Additionally, 9kgs of the dried numbers of samples were further randomly collected and were subject to laboratory analysis to examine moisture content, impurities, salt as KCL and sand variables and to the microbial it was needed 3kgs for obtaining total plate count, for Escherichia coli and yeast and moulds. For comparison of the loss the variables were measured as controlled vs. uncontrolled for in situ based measurements and laboratory analyses. This chapter reports the results of these key variables with the main themes organized to their research objectives.

5.1) Efficiency of drying techniques (EDT) between traditional and controlled method
This study also investigated how efficient are the two methods (traditional method i.e. FM and controlled method CM) can result in more of dry weight, which is final raw product of seaweed cottonii that is mostly sold in the market (See Section 3.8 for method description). The results indicated that EDT for traditional method was 16% against 25% for controlled method. This is equivalent to reduction (loss) in 84% of the fresh weight for traditional method against 75% for controlled method (Table 1).

Table 1: Comparison weight loss due to Farmers vs. Controlled Drying Method

	Wet Weight (Kg	Dry Weight (Kg)	Difference (WW-. DW)	Percentage of Dry Weight (DW/WW)	Percept of the lost seaweed
Samples from farmers method	3805	622.5	3182.5	16%	84%
Samples from controlled (researcher) method	25	6.3	18.7	25%	75%

5.2) Dried seaweed specific requirement

Based on the dried seaweed specific requirement, there were different criteria that were investigated to determine the quality of cottonii seaweed. Direct samples from each village farmers were analysed and determined with some criteria of dried seaweed specific requirements to the cottonii seaweed. These criteria were analysed under the observation of standard of analytical result of sample that obtained in Table 2. According to (TBS, 2020) in dry seaweed specification, the quality of seaweed would obtain into standard value.

Analytical results (standard values) of samples on dried seaweed specification requirement.

Criteria	K.alvarezii(cotton)
Moisture content ,% max	40
Impurities ,%max	3
Salt as KCL,max	25
Sand,% max	1

On the basis of traditional and control methods of harvesting and drying process was analysed and determine the dry specifications in post-harvest loss of quality of dry cottonii seaweed. Direct samples from each village farmers were analysed and the average of loss was determining accordingly. The results were determined based on the samples collected from farmers' direct dry procedures and recorded the by four criteria that obtained in dry quality. One the variable of moisture content of value 36%, 30.24% and 25.23% were measured. The second change was also determined by the level of impurities of the seaweed and the result revealed that farmers samples had value 9.99%, 2.25%, and 2.56%, the third variable was salt content the results showed that the samples from farmers had the value of 15.34%, 9.06% and 7.81%, and the fourth variable was analysed under criteria level of sand of value of 1.59%, 4.12% and 1.84%,that were measured for samples from Uzi, Michamvi and Jambiani respectively that seen on Table 2. In contrast, samples analysed under controlled category by the researcher to determine the quality of dry specification , the first variable of moisture content recorded value of 21.97%, 31.47%and 16.93%, while that of impurity of value of 1.10%, 3.8% and 0.62%, both observation for Uzi, Michamvi Jambiani respectively as shown in Table 4.5.2.2.Morever, salt contents was measure of value of 21.06%, 19.16% and15.22%, while variable of sand content had value of 1.54%, 2.85% and 1.14% for samples taken from Uzi, Michamvi Jambiani respectively as shown in Table .2.

Table 2:Average Results of criteria on sample of cottonii seaweed from the sites.

Source of seaweed samples	Site	Moisture contents (%)	Impurity(%)	Salt(%)	Sand (%)
Farmers direct seaweed	Uzi	36.00	9.99	15.34	1.59
	Michamvi	30.24	2.25	9.06	4.12
	Jambiani	25.23	2.56	7.81	1.84
Samples of seaweed from researcher's	Uzi	21.97	1.10	21.06	1.54
	Michamvi	31.47	3.81	19.16	2.85
	Jambiani	16.93	0.62	15.22	1.14

5.3) Microbiological limit for dried seaweed.

In traditional and controlled methods were also indicate the variables which influence the quality of cottonii seaweed, its analyzed and determine the variables in microbial contents of drying seaweed. The quality of microbial contents was determined through standard values that were compared between farmers and researcher data. According to (TBS, 2020) in a sample results of standard of cottonii seaweed were obtained in TZS109 Code of hygiene for processing unit.

Standard values of microbial contents.

Parameters	TZS 109
Total Plate Count(TPC) cfu/g	10^5
Escherichia coli(E.Coli),perMPN/100Ml,max	Absent
Yeast and Molds(YM) cfu/g	10^3

Examined and ascertained the effect of the drying procedure on the quality of seaweed in three communities. The average microbiological contents were calculated based on the analysis of direct samples taken from each farmer in the village. The findings indicate that samples were taken directly from farmers and recorded using three parameters related to the microbiological quality. Table 3 displays the values of three variables: Total Plate Count (7.4cfu/g, 5.2cfu/g, and 4.15cfu/g), Ecoli (0, 0, and 0), and Yeast (2.1cfu/g, 3.1cfu/g, and 1.8cfu/g in Uzi, Michamvi, and Jambiani, respectively). As demonstrated in Table 4.6.2, samples analysed under the controlled category, on the other hand, had three variables: TPC values of 0.275cfu/g, 3.075cfu/g, and 0.24cfu/g; E. coli values of 0, 0, and 0; and yeast and mold values of 0.1225cfu/g, 0.036cfu/g, and 0.051cfu/g in Uzi, Michamvi, and Jambiani, respectively.

Table 3: Average results of microbial contents of cottonii seaweed in the sites.

Source of seaweed sample	Sites	TPC *10^3	E. E.Coli *10^3	YM *10^3
Farmers direct seaweed	Uzi	7.4	0	2.1
	Michamvi	5.2	0	3.1
	Jambiani	4.15	0	1.8
Controlled by researcher	Uzi	0.275	0	0.1225
	Michamvi	3.075	0	0.036
	Jambiani	0.24	0	0.051

The farmers' and controlled samples' results complied with the TZS109 Code of Hygiene for Processing Unit

5.4.) Potential change in estimated value market price of cottonii seaweed based on traditional and controlled method.

The study also investigated the potential influence of the loss in seaweed (reduction in weight of seaweed from drying method) in market value given the current market price. The current market price was determined based on the preliminary inquiry to farmers and vendors of seaweed, which was in 2023 1200/= TZS. To obtain a meaningful estimate of this potential loss, the reduction in weight of the dry seaweed from the wet weight seaweed was determined in objective 1 (See Section 3.8 for detailed description), was used to calculate the difference between the farmers' method and the researcher's method in preserving the weight, hence, increased in market value. To determine the efficiency of the two methods in preserving the wet weight to dry weight, the percent of the method efficiency was calculated for both as a percentage of weight loss (then converted into lost seaweed in kg) and the percent of final weight dried (preserved weight). The results indicated that the controlled method could result in 951.25kg of total dry weight compared to the current 622.5kg of the traditional method (Table 4).

Table.4. The Potential Market Value Implication

	CM	FM	Potential difference between FM and CM	Percent increase base on CM
Dry weight (kg)	951.25	622.5	328.75	34.5%
Market Value (@1200TSH/kg)	1,141,500	747,000	394,500	34.5%

This gives a difference of 328.75kg that could be added by controlled method. The results in potential loss of the value market according to the current price of 1,200TSZ were then determined as 747,000 TZS (farmer's method), compared to 1,1415,00 TZS for controlled method, which gives a difference of 394,500.00 TSZ. In other words, there as increase of 34.5% value of seaweed dried based on controlled method compared to the original farmers' method.

6. Discussion of The Results

The effectiveness of the current farmers' utilized methods of harvesting and drying process on seaweed quality and quantity were necessary in order to enhance the seaweed market value. The use of conventional practices contributes to the depletion of cottonii seaweed during the harvesting and drying processes, leading to a reduction in the overall quality and quantity of cottonii. This ultimately results in a decline in the seaweed market, as also noted by (de Jong Cleyndert et al., 2021). The findings showed that there is an average percentage decrease of 0.0040 and 0.0355 in quantity during the harvesting and drying processes, respectively, when using traditional methods. While the waste of cottonii in the controlled process was negligible in both harvesting and drying phases, this is because of the techniques that were employed, such as a bulk that was not filled with seaweed, removed the impurities from harvesting seaweed, to use tools like trays and special places on the floor. So the current practices lead the demerit over controlled method, hence efficiency that obtained on controlled method result the increasing in quantity and quality of cottonii seaweed, so sustainable development were needed.

The dry specifications components were analyses in the quality of cottonii seaweed. Through the use of standard criteria, sand variables do not meet the required standards in both rural locations using traditional and controlled methods, while impurity variables did not meet the standard criteria in Uzi and Michamvi using traditional and controlled methods, respectively. The dry constituents of seaweed were very importance so it increased industrial grade as a seen in (Norman et all, 2019)

The microorganism contents were assessed using both traditional and controlled methods that conformed to standard specifications. This means that there were good qualities in microbial contents of cottonii seaweed. Microbial contents also emphasized good standard of seaweed, hence it increasing good market price of the products as noted by (de Jong Cleyndert et al., 2021).

The efficiency of controlled methods was more compared the traditional methods; this was leaded the increasing in amount of cottonii seaweed which result in increased in market value. So as we increased in market price, it increases the economy especially Blue economy in Zanzibar.

7. Conclusion

This study embarked on the key question of the efficacy of harvesting and drying techniques applied by seaweed farmers on their contribution to the loss in terms of reducing weight (mass) and quality change (degradation) of seaweed, which in turn could affect the market value.

The results overall suggested a negative impact of the current farmers applied methods on quantity. The study found 84% loss of the wet weight by the current method compared to 75% of the simple method applied by the farmer. This in turn resulted in more than 30% market value decrease.

Hence, the main conclusion from the results is that efficacy of the current seaweed farming process in terms of the harvesting and drying is low compared to alternative method applied by farmer. These indicate on the ability

by farmer to improve their yields with better practices than what they are applying. This study contributed to the assessment of the impact of the traditional of harvesting and drying methods on quantity loss of seaweed cottonii with respect to loss of mass and quality change. The study complemented to the wide studied area of seaweed, by many scholars, but using a new area echoed for the improvement, which is a need to invest in appropriate method of drying and harvesting seaweed to enhance profitability of the seaeweed to local farmers, who are mostly women to large percent. The proposed improvement in harvesting and drying technique was target the improved post-harvest handling on the chemical constituents and quality of carrageenan in the harvested seaweed, hence, improving the efficacy of traditional methods of harvesting and drying seaweed in reducing loss of seaweed quantity and quality among the farmers of Zanzibar.

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