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Effects of Drying Methods on the Quality of Dried Sea Cucumbers from Sabah – A Review

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Abstract: **Sea cucumbers are one of the highly appreciated commodities amongst traditional health practitioner for its retrospective health properties. Societies with knowledge of sea cucumbers usually demand for good processed dried sea cucumber. There are several options of post-processing of fresh, live sea cucumbers; freeze drying, cabinet drying, sun drying, smoke drying and much more. Sun drying procedures easy to be initiated and is a free source of energy. However, it is hard to control the hygienic capacity of sun drying process as to ensure optimum conditions during drying process where drying temperature will affects the drying rate and end products. Not only the value of dried sea cucumber depends on its own species, but, the size of the product and the quality of the post-processing in term of sensory attributes (colour, smell, appearance, texture and overall acceptance). Freeze drying process maintained better quality yields from the physicochemical properties and rate of drying aspects if compared to sun drying, hot air drying and air drying through moisture removal. Freeze drying ensured good appearance if compared to air drying, but requires greater energy and longer drying. The natural therapeutic properties of sea cucumbers should be investigated more, while its development and establishment of sea cucumber SOP could strengthened the post-harvest standard quality, economical values and sustainability.**

Keywords: **Sea cucumber, Post-harvest processing, drying methods, therapeautic properties, economical values and sustainability.**

1. INTRODUCTION

Sabah is densely accommodated with medicinal and pharmaceutical marine composites. In Malaysia, it is estimated to have ever increasing fish landings at the sea port since 1995, approximately 155 tonnes (Baine & Poh Sze, 1999; Bahrami *et al.*, 2014). Local claims of its healing properties over wound, gastric ulcer, arthritis, gout, asthma, eczema, and hypertension have ignited retrospective research perspective (Ridzwan *et al.*, 2014; Fredalina *et al.*, 1999). The increasing demand of the sea cucumbers are observable throughout the whole wide world, as it deems to be one recognised marine tonic in China, Japan and Korea. Generally, sea cucumbers are marketed in dried form as to prolong its shelf life and reduce transportation constraints on it. Drying technology is part of the essential process to remove moisture through evaporation (Barbosa-Canavos & Vega-Mercado, 1996). Ancient drying technology is sun drying where it is freely available source of energy, but it's prone to contamination risk from pest invasion and uncontrollable climate change. There are other drying technologies been implemented on the drying of sea cucumbers such as freeze drying, vacuum drying and cabinet drying The after effects of dried sea cucumbers utilizing different drying methods are susceptible to physical quality, chemical quality, microbiological quality and sensorial change. Not only that, the natural bio-therapeutic agents and nutritional quality of the sea cucumbers should be studied (Honey-Escandon *et al.*, 2015)

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1.1 Categories of Sea Cucumber:

According to Baine (1999), Malaysia holothurians is one of the UK Darwin Initiative funded research project for fishery development and future management. In Malaysia, three most promising fishery activities situated in Pulau Langkawi, Pulau Pangkor and Sabah. Sabah has been the main hub for sea cucumber fisheries, where it will be estimated landings of 155 tonnes in year 1995 (Baine & Poh Sze, 1999). The most abundant sea cucumber found in Malaysia are *Holothuria scabra*(sandfish), *Stichopus herrmanni* (curryfish), *Holothuria coluber* (snakefish), *Actinopyga lecanora* (stonefish) *Actinopyga echinites* (deep-water redfish), *Holothuria whitmaei* (black teatfish) and, *Bohadschia vitiensis* (brown sandfish), *Bohadschia sp.*, and *Bohadschia, argus* (tigerfish) (Choo, 2012; Annual Fisheries Statistics, Sabah, 2000 - 2005).

2. BACKGROUND STUDY OF SEA CUCUMBER

Since the industrial revolution, where human forces are aided by steel and coal, fisherman gained direct potent to capture sea cucumbers in the late 1980s (Conand, 1981). Massive expansion of the fisheries ideology contributed to prolong capturing of marine-protein sources (Ferdouse, 2014). Sea cucumbers fisheries profile of multinational companies expected to be vastly differentiated, where the supply and demand of beche-de-mer, tre-pang or gamat oil, for biomedical functions and aquacultures, are still unpredictable. Therefore, it is only true that government shall seek answers in controlling their sea cucumber resources, as in preventing over-exploitation of the sea creatures (Toral-Granda et al., 2008). Fishing scenario, dramatized with either traditional or non-traditional fishing arenas. For instances, Galapagos, Mexico and North America served to have non-traditional fishing. Modern countries have their own fishing technologies and research hubs (aquaculture or fisheries department) which could yield premium quality of sea cucumbers, for local and export or import reasons. Efficiency in handling and managing sea cucumbers leads to better understanding of the quality management, financial supports and sustainability of the sea cucumber resources (Carleton *et al*., 2013). Sea cucumbers are gaining its own unique reputation steadily, globally, where demand of sea cucumbers for bio-nutritional research, medical purposes are increasing.

Gigantic collection of sea cucumbers could be differentiated from the view of its quality; premium quality sea cucumbers or lower quality sea cucumbers. Sea cucumbers harvested at bigger scale across the world, where the species collected varies considerably. The most commercially valued sea cucumber species are *Holothuria scabra* (Sandfish), *Holothuria nobilis* (black teatfish) and *Holothuria fuscogilva* (white teatfish) which found to be distributed in the tropical waters of the Western Pacific and Indian Oceans (Conand, 1981; Carleton et al., 2013; Bordbar et al., 2011). Whilst, other averaged valued sea cucumbers involved are *Actinopyga echinites* (brownfish), *Actinopyga miliaris* (blackfish), *Thelonota ananas* (prickly redfish). The rest of the sea cucumbers which have least commercial value are *Holothuria fuscpunctata*, *Holothuria atra*, *Stichopus chloromonotus* and *Stichopus variegates*, refer to TABLE I. Thus, the market and trade potential of sea cucumbers diminished from the aspects of its characteristics and bio-nutrition availability.

A considerable amount of research shown that species of sea cucumbers are widely distributed under the sea-bed. There have been traces indicate that sea cucumber species of *Istichopus fuscus* emerging to be in the fishery hub in the eastern pacific region, *Parastichopus californicus* and *P. parvimensis* in the Pacific coasts of North America, whereas Stichopus japonicas in the western Pacific of United States of America. The catches of sea cucumbers are lesser objectify in the sea-bed of Indian Pacific regions, while the lowest are in Caribbean and Latin American regions (approximately 800 tonnes estimated annually). The increasing of sea cucumber catching activities presumed not quite sustainable, in Asia and Pacific region, where this arises question on the capability of the government sector in controlling their own natural resources.

2.1 Global Trend of Sea Cucumber:

Globally, the highest valued sea cucumbers derived from Holothuria Scabra (Sandfish), Holothuria nobilis (Blackteatfish), Holothuria fuscogilva (White teatfish) are well accepted by sea cucumber lover. It is commercialized to serve as bio-remedy for many types of health problems, as traditional cuisine in certain cultures and traded widely from country to countries via export and import (Carleton *et al.*, 2013). The biggest source of sea cucumber have been investigated to be in South East Asian, Pacific regions, and India Oceans. According to a statistical research found, the total of world sea cucumbers catches from year 1988 to 2005, estimated 411,878 tonnage (Bordbar et al., 2011). The

highest number of sea cucumber worldwide harvest was in the year 2003 (28,085 tonnes), while the least harvest was in year 1989 (17,467 tonnes). However, there are certain countries that banned the harvest activities on sea cucumber such as in Panama and Costa Rica due to their responsibilities to prevent the extinction of these echninoderms (Toral-Granda et al., 2008).

Due to lacking in management routine in sea cucumber fisheries in Philippines, the government initiate a strict guidelines for the fishermen to follow. Philippine and Indonesia are both major sea cucumber supplier, which produced for both importation and exportation (Brown et al., 2010). Trade market of Philippine is so fast (Brown et al., 2010), that improper management of their resources, caused negative implication on the sustainability of the sea cucumbers. Threats of sea cucumbers emerge as a consequences of over-harvesting and uncontrollable sea cucumber fisheries resources (Perez & Brown, 2011). Indonesia became the largest producer of sea cucumber or commonly known as tre-pang. There are statistics record showed that Indonesia exported large sum of sea cucumber to China, Japan, Republic of Korea, Taiwan Province of China, Singapore, Hong Kong and Malaysia. Processed Tre-pang also sold to the open market by Indonesian traders.

Almost 90% of the trading business of tre-pang or sea cucumbers worldwide generated from fisheries of China Hong Kong SAR, China, Singapore, Malaysia, and Taiwan Province of China. Sea cucumbers are common ingredients used in Chinese cuisine, belief contains natural bio-remedy ingredients. The functions of sea cucumber have not been discovered entirely, but, China people has strong traditional belief adapt from their ancestors on the application and benefits of sea cucumber. It has been long traded in China. Conservation management strategies on the sea cucumber fisheries resources need to be adjust with the market potential and its usage (Goldman, 2014). China has the capability of controlling their global import-export business trade so well, that they successfully transported sea cucumber to the interior regions of China mainland. An increase in the consumption of sea cucumber in China indicates how popular sea cucumber by means of application among Chinese, in year 1991 (4456 tonnes).

Vietnamese also has their own collections of sea cucumbers for trade, Phu Quoc Islands is one of the source of sea cucumbers ever since especially high valued Holothuria Scabra were commonly collected from around archipelago in the shallow reefs. However, there have been significant reports of the reduction in sea cucumber stock species. Vietnam is one of the traders or importers for the selling of dried sea cucumbers, mainly to Ho Chi Minh City (Otero-Villanueva & Ngoc Ut, 2007). 25 species found around the Archipelago of Vietnam and Cambodia, which serve as essential ecological transition area between the South China Sea and the Gulf of Thailand. For some countries like Venezuela and Panama, sea cucumber harvest is being banned for some security reasons, while there's no fishery activities in El Salvador, Honduras, Jamaica and Argentina.

2.2 Market Venture of Sea Cucumber:

Different type of sea cucumber commercially available and rate based on its nutritional quality, sensorial taste, or sometimes how rare is the sea cucumber can be found. Table 4.1 shows the list of t common sea cucumber in Malaysia with its value in the market. As we can see that high value sea cucumber are sandfish and white teatfish, price ranged RM 270- RM 300, seen in TABLE I. While other genera of sea cucumber are either of medium quality, low quality or very low quality. Usually, very low quality will be further processed to other pharmaceutical products or beauty products such as lotion, oil-based foundation and so on.

Table I: List of Sea Cucumber with its value in the market.

Code	Common Name	Scientific Name	Purchase Price RM per kg (dried)	Value Group	Av. Weight
SF	Sand Fish	*Holothuria Scabra*	295	H	70
WTF	White Teatfish	*Holothuria fuscogilva*	273	H	159
GSF	Golden Sandfish	*Holothuria lesson*	196	M	-
BTF	Black Teatfish	*Holothuria whitmaei*	173	M	29
GF	Green Fish	*Stochopus chloronatus*	163	M	19
PRF	Prickly Redfish/Pineapple Fish	*Thelenota ananas*	147	M	30

BF	Deepwater Blackfish/Panning's blackfish	*Actinopyga palauensis*	147	M	1
DRF	Deep Water Redfish	*Actinopyga echinites*	147	M	8
SRF	Surf Redfish	*Actinopyga mauritiana*	128	M	45
BF	Blackfish/Hairyfish	*Actinopyga miliaris*	66	L	26
CF	Curryfish	*Stichopus hermanni*	66	L	53
STF	Stonefish	*Actinopyga lecanora*	66	L	18
TF	Tigerfish/Leopardfish	*Bohadschia argus*	66	L	74
SNF	Snakefish	*Holothuria coluber*	53	L	86
PNF	Peanutfish/Dragonfish/Warty	*Stichopus horrens*	47	L	7
CHF	Chalkfish/Brownspotted sandfish	*Bohadschia similis**	47	L	48
BSF	Brown sandfish	*Bohadshia vitiensis**	47	L	3
FF	Flowerfish/Orangefish/Ripple fish	*Pearsonothuria graeffei*	47	L	97
AMF	Amberfish	*Thelenota anax*	47	L	48
LF	Lollyfish/Reef lollyfish	*Holothuria atra*	37	VL	182
ETF	Elephant trunkfish	*Holothuria fuscopunctata*	37	VL	42
PKF	Pinkfish	*Holothuria edulis*	21	VL	18

- Indication of Value Group; H = High, M = Medium, L = Low, and VL = Very Low.

Source: Carleton et al. (2013)

3. PROCESSING OF DRIED SEA CUCUMBER

In Malaysia, majority of fishers will processed sea cucumbers themselves, fresh from sea. Sun drying and air drying are simplest and repeatable methods used by fishermen in coastal regions. Decades ago, people in Sabah has already capture sea cucumbers and processed them in their own home. As for fishermen in Pulau Limau-Limauan, they rear various types of sea cucumber species in their sea-cage such as *Holothuria scabra*, *Holothuria fuscopunctata*, *Holothuria edulis*, *Holothuria atra* and so on. The word processing defined as a series of actions or steps taken in order to achieve a particular end. There are plenty of processing methods practiced by communities in coastal region of Malaysia. Commonly, the utensils needed are sharp knife, cooking pot, wooden paddle, mesh net, sufficient salts, drying racks, large plastics and sticks. Sea cucumbers are very heat sensitive creature as the heat from sunlight could damage the quality of sea cucumber. Salts are usually added to give sensorial and preservatives advantages prior to cooking or drying process (Purcell & Southern Cross University, 2014).

3.1 Pre-Handling Of Sea Cucumber:

Sea cucumbers are harvested from sea cucumbers where fishers usually collect it during low tide or dive into the sea. For sea cucumbers that is not directly processed will need to be kept shaded and cool in the boat or bags. The sea cucumbers are cook right away from the sea to ensure its freshness. For gutting and evisceration process, the techniques varies with the species attended (Purcell & Southern Cross University, 2014).

3.2 Salting Of Sea Cucumber:

Salting is also an effort to preserve foods like sea cucumber. It is concerned with food preservation uses salt water, ie salt water. It is the oldest method in the era of natural food preservation (Ang *et al.*, 1999). Marinating is used in food as most bacteria, fungi and other pathogenic organisms unable to survive in a highly saline environment, because of the nature of hypertonic saline (Khan, 2012). Any live cell in such a dry environment through a process of osmosis and die or become inactive. The estimated ratio salt to sea cucumber is often 1 to 3 ratio, where 1 kg of salt is fully covered the sea cucumber for several days (Purcell & Southern Cross University, 2014). This is also part of dehydrating the sea cucumbers prior to drying process. Salting of the sea cucumbers mean to remove water by osmotic dehydration (Khan, 2012). Besides, it will also give better appearance of dried sea cucumbers, where it will be heavier and denser if it is cooked and dried, means more profit index. Coarse or medium-grade salt only used due to its porosity in providing slow penetration of salts into

the flesh of sea cucumbers. The fine particle of salts may damage the skin of the sea cucumbers. Moreover, salt has been reported to ease the rehydration of meat (Laopoolkit & Suwannaporn, 2011).

FIGURE I : Sabahan local showing the modified sea cucumber cooking pot, with adhered coconut shell, on top

3.3 Cooking/ Boiling Method Of Sea Cucumber:

Cooking of sea cucumbers is the preliminary stages of post-harvest treatment on sea cucumbers. It is carried out in the presence of water and salts (Wen *et al.*, 2010). Seawater used years ago to cook the sea cucumber, where it is freely available and easily to obtain. Sea cucumber cooked prior to drying. Cooking at extreme condition is avoided where it can damage the skin and reduce the appearance quality(Duan *et al.*, 2010). Saltwater for cooking is preferable rather than freshwater, cooking dependent with the sizes and types of sea cucumber, where larger expected to be cook for longer time (Purcell & Southern Cross University, 2014). Cooking time will effects the muscle fibre to soften and disintegrate, where its cooking time correlates with the cooking pressure and drying temperature, so, the rehydration ratio much higher (Laopoolkit & Suwannaporn, 2011; Duan *et al.* , 2010).

3.4 Drying is a mass transfer Potential Drying Method Of Sea Cucumber:

Process consisting of removal of water or other solvent by evaporation of solid, semi- solid or liquid. This process is often used as the final production step before selling or product packaging. To be considered a "dry ", the final product must be solid, in the form of a continuous sheet (eg, paper), long pieces (eg, wood), particles (eg, cereal or corn flakes) or powder (eg, sand, salt, washing powder, milk powder). A heat source from steam that is produced by drying process often involves water removal. In bio-products such as food, grains, and pharmaceuticals such as vaccines, solvent removed is almost always water. In the most common case, the flow of gas, eg, air, apply heat by convection and carry itself as a moisture vapour. Another possibility is vacuum drying, in which heat is supplied by conduction or radiation (or microwave), while the vapour generated was removed by a vacuum system.

3.4.1 Cabinet Drying:

Cabinet dryer is used in combination with other drying technologies. This type of drying is more flexible than its use for drying without focusing on the problem of weather, season or animals. One typical unit is shielded cabinet is equipped with a shallow tray with each holder of 1-3 inch products. Hot air flow generated across the region in the cabinet to achieve optimum drying (Greensmith, 1998). Cabinet dryer module operates in groups and tend to be found in smaller ease boarding because it is capital simpler and more flexible (Barbosa-Canovas and Vega-Mercado, 1996).

In general, the qualities of the product are affected by the drying temperature and flow of the heat transfer. Cabinet dryer is a method ensuring safe storage of food products where the moisture content of the food should be less than 20% for fruits and meat, less than 10% for vegetables and 10-15% for grains. The stability of a dried food during storage depends on its moisture content and the ease with which the food can pick up moisture from air. The risk of moisture pick up is greater in regions of high humidity. However, different foods pick up moisture to different extends (Barbosa-Canavos & Vega-Mercado, 1996; Aguilera *et al.*, 2003). The low water activity (aw) aids in retarding the growth of microorganisms, reduce the bio-chemical enzymes and non-enzyme reactions of food. Better consistency of heat transfer inside cabinet dryer can be easily regulated by the controller (Greensmith, 1998). By that means, the air movement inside the cabinet dryer rather speeds up the evaporation process of moisture content. The combination of higher temperature, air movement and lower humidity increases the drying rate. The faster drying the higher temperature deters insects and rate reduces the risk of spoilage microorganisms if compared to the traditional sun-drying process.

Weather conditions does not seems one of the problem in cabinet drying mechanisms since it is protected from rainy or stormy days. Cabinet dryer is designed similar to the solar type but in this case the heat is supplied by burning fuel or electricity. If electricity is available, a fan can be used to increase the speed of an air moving over the food and therefore increase the rate of drying. Drying of food using cabinet dryer has better outcome of its quality, where food are less prone to the detrimental effect of on-going oxidation, pollution and so on. Drying of food with nutrient content such as protein, lipid and carbohydrate causes it to have relative high percentage of these nutrients. However, the correlation of known nutrient with drying process is still varies according to the food products. Proteins, fat and carbohydrates in food products will not have excessive loss if compared to vitamins. Protein and carbohydrates are nutrients that contributed to the Maillard reactions (Duan *et al.*, 2010; Barbosa-Canavos & Vega-Mercado, 1996). The desirable brownish colour of food products may be permitted in certain products as it served to their uniqueness and characterization.

3.42 Freeze Drying:

Freeze drying or known as lyophilisation promotes the drying process where the solvent (water) and/or the suspension medium is crystallised at a low temperature after sublimated from the solid state direct to vapour state. It is one of the most expensive drying methods and slowly gaining its attention for its diversified application ranges, from simple daily livestock, complex biotechnological towards pharmaceutical products, to more Nano-sized products. Operationally, the freeze drying process initiated when food is frozen below eutectic temperature and exhibits crystalline structure. During primary drying (sublimation) process, the partial pressure of surrounding vapour lowers than the ice's vapour pressure. The energy supplied in the form of heat shall remain lower than the products' eutectic temperature. Then the second drying process shall be carried out where the partial pressure rising from the product will be at its lowest (Ciurzyńska & Lenart, 2011). Thus, it can achieve chemical balance, that it retains heat sensitive components in the sea cucumbers and creates value for the dried sea cucumber in term of quality, but require higher cost (Duan, *et al.*, 2010).

Freeze drying provides key benefit over conventional drying methods and food preservations where it can increase percentage yield, retention of morphological, biochemical, and immunological properties, lower microbial growth, recovery ability on volatile substance, longer shelf life and weight reduction for transportation mode. Lyophilisation developed for preservation of most food commodities and other bioactive molecules (DNA, enzyme and protein), pharmaceuticals products (antibiotics) and other delicate, solvent-impregnated materials(Duan et al., 2010; Li *et al.*, 2011). Despite of its high energy consumption, high maintenance and operation costs, it offers rehydration capacity as freeze drying did not objectify to cellular rupture. Overall, freeze drying can produce food products with quality similar to the fresh product where the heat sensitive biomolecules can be sustained.

3.4.3 Vacuum Drying:

Vacuum drying applicable to the principle of dehydrating moisture from food components, under reduced pressure. Various aspects of food processing could take advantage of the drying processes, that it can gently dry high quality products containing water or solvents without altering the actual product's properties. At low pressure, the food components dried where the solvents changed from liquid to vapour phase at low temperature. The principle of the vacuum dryer consisted of the complete heating systems, a vacuum pump assembly designed specifically for the drying process and a heat regulator temperature knob. Vacuum drying generally used in the preservation of fruits and vegetables

which resulting in the microstructure variations. The porous structure of food products with high water holding capacity promotes better rehydration ratio after vacuum dried (Laopoolkit & Suwannaporn, 2011).

4. TRADITIONAL BELIEFS AND USAGE OF DRIED SEA CUCUMBERS

Sea cucumber is captured by fishermen or the local people by hand, deep water dive-in or from trawling activities. Lately, hatchery rearing of sea cucumber is a promising activities to meet the supply and demand of it, where Juveniles grown in tanks and elongates to two centimetres in three months. Sea cucumber delicacies famous among Chinese, Malaysia, Japanese, Singaporean, Taiwan and others. Chinese people typically will utilise this commodity in their traditional cuisines; mainly as ingredients in soups or stew, in the banquet dishes called *The Eight Immortals Crossing the Sea*, *Hoi sam*. In Japan, sea cucumber often eaten raw, as *Sashimi* or *Sunomono*, and its intestinal part eaten raw, salted and/or fermented, named as *konowata*. Dried ovary of sea cucumber eaten raw by the Japan community and called as *konoko* or *kuchiko*.

4.1 Post-Harvest Handling of Sea Cucumber:

Sea cucumbers collected from sea are prone toward quality damage. It is thermally sensitive that, prolong exposure to sunlight caused biochemical reactions and radical activation, so, the sea cucumber should be handle carefully to maintain its freshness and prevent subsequent bioactive components from leaching out. To ensure longer shelf life of sea cucumbers, the sea cucumbers are usually dried through a series of process. Generally, the steps involved are first boiling, cutting and gutting, salting, second boiling, smoke drying, third boiling and finally sun drying (Purcell & Southern Cross University, 2014). The fishers have a tendency to use short-cut methods or alternative methods to produce the dried sea cucumbers. Corresponding to the alternate method used, it may contains quality defects due to inappropriate post-harvest handling techniques. There are certain sea cucumber species has harder processing techniques (Purcell & Southern Cross University, 2014). Synonymously, the white teatfish is hard to maintain its end products, while curry fish and green fish have fragile body. The most prominent quality defects cases are undersized dried sea cucumber, improper gutted sea cucumbers, contaminated with sands and dusts. and misshaped sea cucumbers where cylindrical shaped is major grade determiner (Purcell & Southern Cross University, 2014).

4.2 Sun-Drying Of Sea Cucumber (Traditional Drying):

The quality of the produce fresh ocean quickly deteriorate unless some way can be found to maintain it. Drying is a method of food preservation that works by removing water from the food, which inhibit the growth of microorganisms. This method reveals the sea cucumber under the sun, is the technology that's in terms of capital and operating costs (Janjai & Bala, 2012.). The method does not require energy costs, labour expenses or machine costs which are expensive because the sun's energy is free and does not require trained labour. However, commodity sea cucumber using this equipment are more likely to become pests' invasion such as rats, dogs, birds and so on (Butterfly, 1995). Drying using sun and under presence of wind has been practiced since ancient times to preserve food. Water is usually removed by evaporation (air drying, sun drying, or hot air drying), but, in the case of dried- freezing, frozen food is dried first before removal of water through sublimation (Bhuiyan *et al.*, 2011). Bacteria, yeast and moulds need food or nutrient availability in water to grow, and drying effectively prevents it from living in food procuts (Canovas and Vega - Mercado, 1996). Quality sea cucumber preserved through traditional methods such as drying and salting. The traditional way is the oldest breed fish drying in the presence of wind and sun, dried. Drying food is the oldest known preservation method in the world, and dried fish has a shelf life of several years (Janjai & Bala, 2012.). This method is cheap and effective in suitable climates; work can be done by fishermen and their families, and the resulting product is easily transported to market. Sun dried sea cucumber products have sensory aspects of higher quality taste, appearance and exotic smell.

5. SOCIAL ECONOMIC CONTRIBUTIONS OF DRIED SEA CUCUMBERS

The commercial venture of sea cucumbers in Sabah monopolized by local people. Fishers collect sea cucumbers during low tide as they will avoid the monsoon season or sea rainy-storm in the middle of the year and end of the year. Sandfish collectors collect it just by strolling near the beach or by diving (Lavitra *et al.*, 2008). From collections to exportations process, the commercial chains are fully covered by the fishers, the middlemen, the collector, the operator and the exporter in TABLE II.

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TABLE II: Commercial chain of stakeholders in sea cucumber business

Stakeholders	Function
The fishers	Performed by villager, man or woman; age ranged 7 to 60 years old; collects around holothurian natural habitat
The middleman	Performed by villager, man or women from 25 to 60 years old; buy sea cucumbers from fisher and resell to collectors. Sometimes fisher or collector also serve this function
The collector	Performed by villager, man or woman between ages of 25 to 60 years, who buys goods from fishers or middleman; processes holothurians and sells the processed product to operator
The operator	Performed by man from the city or town who buys the product from several collectors, completes the processing (if necessary), and resells to exporter
The exporter	Performed by man from the city or town who delivers the product to the international market; buy semi-dried products from collectors and must complete the processing

Source: Lavitra et al. (2008)

6. THERAPEUTICS PROPERTIES OF SEA CUCUMBER

Sea cucumbers are reservoir for many pharmaceuticals and therapeutics possibilities, which derived from marine sources. Sea cucumbers have been speculated before as being useful to treat various diseases or wound infections. Malaysian people has long recognised sea cucumbers as functional foods, even before the existence of high technological laboratory. The usage of sea cucumbers are not limited to consumption only, but have been diversified into many commercialized products such as lotions, beauty products, sub-ingredients in biomedical fields and so much more. Moreover, sea cucumbers are one of the marine resources that instigate novel bioactive compounds. This marine tonic reserves many potential bio-remedies and functional properties such as anti-fungal properties, anti-bacterial, cytotoxic effects, anti-hypertensive and so much more.

From the point of its nutritional profile, it is high in proteins, vitamins such as vitamin A, B1 (thiamine), B2 (riboflavin) and B3 (niacin), minerals and fatty acids. Subsequently, the most promising therapeutic properties confound in the biomolecule of sea cucumbers body, such as triterpene glycosides (saponins), chondroitin sulfates, glycosaminoglycan, sulphated polysachharides, sterols, phenolics, essential fatty acids, peptides, glycoprotein, glycospingolipids, phenolics and cerberosides (Bordbar *et al*, 2011). Artificial anti-cancer drug on the pharmacist counters are not shelf-friendly as it tends to deteriorates in function and effectiveness. Long term side effects of it still unknown, where the potential of sea cucumber's anticancer derivatives probably can benefits patient with buildings of cancerous cells. Revelation of the new findings of anti-cancer potential in *Holothuria edulis* uphold the strength for continual studies of sea cucumber anti-cancer properties, in other sea cucumber species (Wijesinghe *et al*, 2013). High components of lysine (LYS) and arginine (ARG) reduce significantly the concentrations of cholesterol in the blood system. Sea cucumber showed lower values of LYS: ARG; 1.20:0.34 (g/100g d. w) if compared to other fisheries product (Lee *et al*., 2012). Thus, sea cucumbers can be major substitute for synthetic drugs to treat diseases.

Sea cucumbers also has remarkable cytotoxic effects. A study showed that *H. scabra* were not effective against bacterial species even at concentration of 18 µg/ml. But, its negative results upon *S. aureus* and *E. coli* indicated that it is not effective to be antibacterial agents (Mohammadizadeh, et al., 2013). However, sea cucumber (*cucumaria frondosa)* did have anti-microbial nature. As an addition, methanol extracted from sea cucumber (*Actinopyga lecanora*) signified anti-fungal properties in the nature of sea cucumbers, in-vitro (Mohammadizadeh, et al., 2013). Bit of isolated bacterial strains in *H. atra* pre-tain an incredible anti-bacterial defense. High antifungal activity had been reported, and its defense mechanism against *Aspergillus niger* strains was high. This has been reported to be novel sources of anti-mycotics medicines to treat pulmonary tuberculosis.

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TABLE III: Different species of sea cucumber with the extracted components and its bioactive properties

Sea cucumber	Extracts/Compound Identified	Bioactive Properties	Reference
Holothuria Scabra	Methanolic Extracts, xanthophyll, β-crptoxanthin, β-carotene, saponins, Triterpene gycosides	Anti-fungal, Anti-bacterial, Cytotoxic effects	(Mohammadizadeh *et al*., 2013; Hassan Abdallah Hassan Ibrahim, 2012)
Holothuria fuscogilva	Saponins, Sulfacated, tritepene glycosides	Anti-bacterial, Anti-fungal, Immono-defence	(Honey-Escandon, *et al*., 2015)
Holothuria lesson	Saponins	Cytotoxic Effects, Immunomodulatory effects, Anti-cancer	(Honey-Escandon, *et al*., 2015)
Holothuria whitmaei	Saponins	Antifungal, Bactericidal, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Stochopus chloronatus	Saponins	Bactericidal, Immunomodulatory effects, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Thoelenota ananas	Saponins	Cytotoxic Effects	(Honey-Escandon, *et al*., 2015) (Myron, *et al*., 2014)
Actinopyga palauensis	Saponins	Hemolytic, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Actinopyga echinites	Triterpene glycosides, Sulfated - saponins	Anti-bacteria, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Actinopyga mauritiana	Triterpene glycosides, Sulfated - saponins	Cytotoxic Effects, Anti-fungal,	(Honey-Escandon, *et al*., 2015)
Actinopyga miliaris	Triterpene glycosides, Sulfated-saponins	Anti-fungal, Apoptosis, Anti-cancerous, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Stichopus hermanni	Saponins	Cytotoxic Effects, Anti-bacterial,	(Honey-Escandon, *et al*., 2015)
Actinopyga lecanora	Saponins	Anti-bacterial, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Bohadschia argus	Non-sulfated saponins	Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Holothuria coluber	Saponins	Cytotoxic Effects, Anti-bacterial, Anti-fungal,	(Honey-Escandon, *et al*., 2015)
Stichopus horrens	Saponins	Anti-cancer, Cytotoxic Effects, Anti-bacterial	(Honey-Escandon, *et al*., 2015)
Bohadschia similis*	Saponins	Antibacterial, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Bohadshia vitiensis*	Saponins	Anti-gungal, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Pearsonothuria graeffei	Saponins, Glycosaminoglycan	Cytotoxic Effects, bacteriacidal,	(Honey-Escandon, *et al*., 2015)
Thelenota anax	Tritepene glycosides, Saponins	Anti-parasitic, Anti-cancer, Cytotoxic Effects	(Honey-Escandon, *et al*., 2015)
Holothuria atra	Phosphate-buffered saline (PBS) Extracts	Anti-bacterial	(Ridzwan *et al*, 1995)
Holothuria nobilis	Sulfacated Polysachharides	Anti-coagulant	(Dong, et al., 2014)
Holothuria fuscopunctata			(Honey-Escandon, *et al*., 2015)
Holothuria edulis	Fucosylated chondroitin sulphate,	Anti-thrombotic, Anti-tumor, Anti-cancer, Immunostimulato	(Honey-Escandon, *et al*., 2015)
Isostichopus badionotus	Sulfacated fucan-Ib	Anti-thrombotic and anti-coagulant	(Chen, et al., 2012)
Acaudina molpadioidea	Gelatin hydrolysate (GH-III), fucosylated polysachharide sulfates (ACP and HOP), Fucosylated chondroitin Sulphate, Fucoidan	Anti-hypertensive, Anti-coagulant, Mitigate hyperglycaemia, Anti-oxidant, Anti-inflammation, Gastric Matrix Hydrolysis Suppresion	(Zhao, *et al*., 2007; Dong, *et al*., 2014; Hu, *et al*., 2014; Wang, *et al*., 2012)
Stichopus variegatus	Water Extracts of *Stichopus*	Growth-promoting-Agent,	(Patar, *et al*., 2012)

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7. CONCLUSION

Sea cucumber is authentically accepted as therapeutic or pharmaceutical marine sources of foods, due to its remarkable healing properties associated with its daily application by local people in Sabah, mainly in Malaysia and other countries like China, Hong Kong, United States of America, European country, Egypt and much more. Sea cucumbers are exported around the globe either fresh or in dried form and transported cool in plastics. Fresh sea cucumbers are less marketed as compared to dried sea cucumbers, for its physical quality, nutritional availability and sensorial profile. Sun drying is typical drying methods for sea cucumbers since ancient times that it is free-renewable energy, but, prone to pest invasions. There are other methods of drying as well, like smoking, as it is not highly appreciated and producing lower grade of dried sea cucumbers. Quality of dried sea cucumbers are major determiner in setting-up a good pricing rate of the sea cucumbers. There are other type of drying methods such as expensive freeze drying and simplified cabinet drying, where both could provide a high grade quality of dried sea cucumbers. Researchers from every corners of the map have discovered the potential applications from pro-founding bio-active components such as triterpene glyceride, saponins, gelatin hydrolysate, fucosylated polysaccharides, fucosylated chondroitin sulphate, Methanolic extracts and others in sea cucumber's gonad, cuverian tubules, or body. The significant presents of these biomolecules ignited futuristic point of views in the development of health capacity to treat patients with chronic diseases, for instance diabetic patients, tuberculosis, wound healing. The highlighted bioactive components like anti-tumor, anti-cancer, anti-fungal, bactericidal, apoptosis and others have substantially become more controversial as researchers aware of this unique creature's miraculous silent glory. Besides that, its nutritional availability also elevates idea to preserve and sustain the sea cucumbers population from extinction, includes aqua-culturing high value sea cucumbers, provides funds and subsidies to fisher in supporting cage-rearing sea cucumbers along the coastal regions, or resort strategic locations to promote growth of sea cucumbers, especially high valued sea cucumbers such as *Holothuria scabara*, *Holothuria fuscogilva* and *Holothuria lesson.* This marine herbs provide excellent source of protein value, vitamins, amino peptides and fatty acids for the rebuilding of body tissues and promoting cells growth or against pathogenic and for infections control.

8. CHALLENGES AND FUTURE CONSIDERATION

The identification of vast sea cucumber's taxonomic characteristics are not straightforward tasks, as there are more than 1,500 type of species and are more to come (Kamarudin *et al.*, 2010). Taxonomists have greater burden to classify the sea cucumbers into their own. Successiveness in classification of the sea cucumbers links to better and prominent results of each sea cucumber's species based on their own genera (Baine & Forbes, 1998; Liu, *et al*., 2012). Food researchers, food technologists and other food departments can provide more meaningful research scheme as to provide public with guaranteed nutritional and eating values. The miss-conception of the sea cucumber's identity could lead to false manifestation of the functional properties, reduction of product satiety and arisen safety issues, or questionable remarks. Due to the capability of sea cucumbers to serve for health and human developments, the experimental workload to ensure the sustainability of the sea cucumbers supply also quite challenging, as to find aqua-culturing conditions that meets the surviving parameters of sea cucumbers. Water quality index of the sea water is an issue to suspect for increase in sea cucumber's motility rate where water salinity, acidity, pH, temperature, oxygen availability and so on may affect the growth of sea cucumbers (Bai *et al*., 2015; An *et al.*, 2007; Kamler *et al.*, 2012). The recent explosive news on the occurrence of red tide can cause the reduction of water quality, decrease in oxygen level and contamination from the hazardous substances produced by red algae (Staugler, 2013; Zhang *et al.*, 2014). Research on the water quality of surroundings habitant of sea cucumbers could provide intelligent support on the aquaculture activities of sustaining the sea cucumber's statistical population.

Sea cucumbers are notable bio-active components, where the challenges pinpoint researcher's credibility to obtain more data and accurate interpretations of each sea cucumber's functional biomolecules. It is undeniably truth that the corresponding research by previous researchers on the identification of essential bio-active molecules such as saponins, triterpene glyceride, gelatin hydrolysate and much more provide opportunity on new updates of the sea cucumbers health and medicinal benefits (Honey-Escandon, *et al.*, 2015). The findings of bactericidal, anti-fungal, anti-hyperactivity, anti-hypertension, anti-cancerous cells are probing towards improvement of human's living in the future. However, the casualties on the long term effects of the suspected bio-active components are still debatable. Therefore, there are still loop-hole in the research aspects of sea cucumber's health benefits that the side effects of prolong usage, over-dosage or

over-consumption of the sea cucumbers and other racemic reactions with other biological components in human bodies such as the allergen.

The sea cucumber is capable of generating sufficient nutrients supply for human's salvation, while there is still perfect chances for the technological advancement and modulation of the potential post-harvest processing. The government shall provide more research grants and supports to re-structure modest processing methods of sea cucumber which are beneficial to the development of fisheries industry, commercialization and upgrading of fisher's living trends. By conducting more experimental assays, the knowledge of sea cucumbers could be generated in enhanced scientific demonstrations and reliable for future references. Sea cucumber is humbly presence centuries before where its benefits discovered. Collaboration between nations wide research centre, information transfer, funding, human resources, management devotions and scientific advocacy are platforms for successful research counter-act of this unique marine creatures. Short term findings might not be the best marker for the research path of sea cucumbers, as the potential of sea cucumbers could not be measure directly from just several findings. The study on sea cucumbers can be further differentiated, focussing greatly on the impact of sea cucumbers toward human consumption, the sustainability of these resources, and involvement of diversified player in the industry could be the ultimate goal in the regeneration the fishery industry, mainly sea cucumbers.

Apart from that, the government is fully responsible of controlling the nation's marine resources from being bully by external sources, such as over-exploitations of fisheries, neighbouring fish hunter, fish's feed terrorism, water quality contamination and severe water pollution from oil-spillage or improper chemical drainage system. Armouring fishery industry with extensive laboratory work scheme, strict governmental policy and advancement technology of the post-harvest processing could generate brighter future for the sustainability of the sea cucumber species, more-environmental friendly post-harvest processing, diversified marketing plan and strategic management of sea cucumbers resources are possible criteria, but requires full commitment by both government and private sectors to be successfully accomplished(Perez & Brown, 2011). However, this intelligent control over sea cucumbers recognised as ways to upgrade the economic status of sea cucumber's fishers and along the way, it could increase our nation's economic, social and political status. Let the establishment of sea cucumbers hub be prominent and significant in Malaysia, for the betterment, from establishment of modern facilities, infrastructure and law and regulations.

Last but not least, the most crucial aspects of sustaining sea cucumbers are to have standard operating procedure (SOP). The establishment of SOP beneficial to ensure the development of sea cucumber industry developed in a green and health way (Perez & Brown, 2011). By strengthening the work force training process, the sea cucumber technicians and workers in sea cucumber hatcheries could gained insights on the fundamental knowledge and techniques of sea cucumber biology, ecology and breeding. Clear enforcement in a way aid in building up the industry practice standard, as to improve the technology and production level in sea cucumber hatcheries and farms (Perez & Brown, 2011). Moreover, the impact of post-harvest processing are of often precursor for the quality determiner on setting up a good pricing of dried sea cucumbers (Özer *et al.*2005; Purcell & Southern University, 2014) . As for that, its physical quality is best represented by its exterior appearance, moisture content, sizes; chemical quality is on its nutritional value; and eating quality that satisfied consumer's unique pallet; or microbiological quality that could potentially reduce the spoilage and increase shelf life storage of dried sea cucumbers (Lo, 2004).

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