Processing and quality characteristics sea cucumber *Bohadschia vitiensis* at Kambuno Island in Sembilan Islands, Bone Gulf, South Sulawesi, Indonesia

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**Abstract.** Sea cucumber is an Echinoderm which has high economic value due to their high nutritional value and medicinal properties. More than 80% of Indonesia’s sea cucumber productions were exported as dried products. Therefore, before being exported, sea cucumbers go through processing, which was almost carried out on a household scale whose processing and quality were very diverse. This study aims to evaluate the processing and quality characteristics of sea cucumber *Bohadschia vitiensis* at Kambuno Island in Sembilan Islands, Bone Gulf, South Sulawesi, Indonesia. Sembilan Island is a household scale sea cucumber processing area. This study uses the method of observation, evaluation, and laboratory analyses. *B. vitiensis* processing method at Kambuno Island uses four stages, namely weeding, salting, boiling, and drying. Quality characteristics observations of *B. vitiensis* indicated that several parameters did not meet the Indonesian National Standards (INS). The quality parameters that did not meet INS standards were organoleptic and chemical parameters. Organoleptic parameters that less than seven were appearance, odor, and texture. Whereas chemical parameters that did not reach INS were water levels that exceed the maximum limit.

1. Introduction

Sea cucumber is an Echinoderm that contains active ingredients that are beneficial to health because they can be used as a protein source, wound medicine, and anti-inflammatory [1, 2]. Generally, dried sea cucumbers have a water content of 8.9%, protein 82.0%, fat 1.7%, ash 8.0%, carbohydrate 4.8% [3]. Sea cucumbers also contain calcium, phosphorus, substances, sodium, potassium, vitamin A, vitamin B, thiamine, riboflavin, peptides, collagen, gelatin, polysaccharides, and saponins, which function as anti-cancer, anti-coagulation, anti-oxidants, and anti-osteoclastogenesis [4]. The diverse benefits of making sea cucumbers become a product of high economic value and are one of the world’s export products [5-11].

Sea cucumbers market demand shows a significant increase, especially from China [12]. Indonesia is the number five of sea cucumber exporting country with a volume of around 6.87% of the total supply of Hong Kong sea cucumbers in 2015 [13]. Sea cucumber population in Indonesia shows a decline [14, 15]. However, Indonesia’s export trends show an increase. This was due to new species
being exploited [16]. The potential of sea cucumbers in Indonesia has not significantly contributed to the improvement of local community welfare; this was caused by the low quality of dried sea cucumbers, which reduce the price of dried sea cucumbers [12, 13, 17, 18].

Sea cucumber processing in different countries has different processing stages such as Malaysia, the Philippines, China, Madagascar, and some regions in the Pacific, but in general only includes four stages, such as weeding, boiling, salting, and drying [19-21]. The processing stage can be different from one processor to another [22]. Sea cucumber processing greatly affects the quality produced [23]. In general, processing was still done traditionally, which was less concerned with quality aspects [20, 23], where the quality greatly affects the selling price of sea cucumbers both in local and international markets [21]. The quality of dried sea cucumbers can be known through visual observation such as appearance, texture, odor, and fungus or a proximate examination such as protein, water and ash content [24]. According to the Indonesian National Standards (INS) the quality of sea cucumbers can be known through the parameters of sensory, chemical, microbial contamination, metal contamination, and chemical residues [25].

One famous area for sea cucumber production in Indonesia is Sulawesi [26, 27]. Most of the sea cucumbers were still caught from the wild [16, 28], and a small portion comes from the cultivation [2, 18]; many efforts have been made to increase the production of sea cucumber cultivation [2, 29-41], but there were still many problems encountered [2, 42]. Therefore, the only effort that can be done to increase the contribution of sea cucumbers to the local economy is to increase the dry sea cucumbers’ price through improving the quality [19, 22, 25, 34].

In Sulawesi, sea cucumbers were produced by two regions, namely South Sulawesi and Southeast Sulawesi. In South Sulawesi, there are two regions that produce quite large dried sea cucumber, namely Pangkep Regency and Sinjai Regency [43], where long ago the sea cucumbers have been processed traditionally [9, 25]. The process and quality of dry sea cucumber processing at Kambuno Island in Sembilan Islands, Sinjai Regency has never been analyzed using the INS, and so it is necessary to study the processing process and it is quality characteristics. This study aims to analyze the processing and quality characteristics of sea cucumber B. vitiensis at Kambuno Island in Sembilan Islands, Sinjai Regency, South Sulawesi.

2. Materials and methods
The study was conducted in 2019 in Pulau Sembilan District, Sinjai Regency (Figure 1). Proximate, chemical, microbial contamination, Salmonella, and metal contamination analyzes were conducted at the ISO standard laboratory. The study was conducted using the case study method through observation and evaluation. Direct observation and interview techniques were used to collect data and information about the processing of B. vitiensis. An evaluation was carried out to determine the quality characteristics of dried B. vitiensis. The B. vitiensis quality characteristics evaluated were: (1) organoleptic parameters, namely appearance, texture, odor, and fungus; (2) chemical parameters, namely water content, protein, ash, total plate count (TPC), salmonella, and metal contamination.

Sampling was done using a stratified random sampling method, where the dried B. vitiensis were made strata referring to body size, namely small, medium, and large. The samples were collected, referring to the number of dried B. vitiensis in each body size strata. Samples for laboratory analyses were taken 10%. B. vitiensis processing obtained was presented as a flowchart. The quality parameters of dried sea cucumbers were tested and calculated, referring to INS.

Organoleptic evaluation of dried B. vitiensis was done by using a score sheet referring to INS 8442: 2017, which includes appearance, odour, texture, and fungus. Then the test results were calculated using the formula referring to INS (2346: 2015). Organoleptic testing was carried out by semi-trained panelists with a total of 15 persons. The sensory assessment sheet is referring to INS 01-2346-2006. Water molecules are removed by heating with an oven at 105°C for 16-24 hours. Determination of water content was calculated gravimetrically based on the difference in weight of the sample before and after the sample is dried, referring to INS-01-2354.2-2006. The water content of B. vitiensis was calculated using the formula referring to INS 01-2354.2-2006.
Nitrogen compounds were released from the meat tissue through destruction using concentrated sulfuric acid and heat at 41ºC for ± 2 hours (until a clear solution was obtained) in which nitrogen compounds were bound by sulfa to form ammonium sulfate. Furthermore, ammonium sulfate was converted into NH₄OH base salt by the addition of NaOH. NaOH was distilled using steam heat to separate ammonic compounds; ammonia was bound by boric acid to form ammonium borate and then titrated with hydrochloric acid. The amount of nitrogen was calculated by stoichiometry, and protein content was obtained by transferring the amount of nitrogen by a conversion factor (INS-01-2354.4-2006). The protein content of dried sea cucumber was calculated using the formula according to INS-01-2354.4-2006.

Protein content testing was done by oxidizing the sample at 550ºC in a furnace for 8 hours to get white ash. Determination of ash weight calculated gravimetrically. Dry sea cucumber ash content was calculated using the formula referring to INS 01-2354.1-2006.

Microorganisms were grown by pouring methods, incubated in aerobic or anaerobic conditions at the appropriate temperature and time to grow and multiply by forming countable colonies. In the pour cup method, to avoid the reduction of bacterial populations due to excessive heat, the agar media to be poured was first put on a waterbath having a temperature of 45.0ºC ± 1.0ºC before use (INS 2332.3: 2015). The procedure for testing TPC levels was carried out by referring to INS 2332.3: 2015.

Salmonella testing was done by first growing on enrichment media and then detected by growing it on selective agar. Colonies suspected of being Salmonella on selective media were isolated and continued with confirmation through serological tests to ensure the presence or absence of Salmonella bacteria. Salmonella testing procedures were carried out by referring to INS 01-2332.2-2006 for determining Salmonella in fishery products. The content of lead (Pb) and cadmium (Cd) dried sea cucumbers were calculated by referring to INS 2354.5: 2011.
3. Results
3.1. Processing

*B. vitiensis* processing at Kambuno Island was still done traditionally. Processing was carried out through four stages, such as weeding, salting, boiling, and drying (Figure 2). *B. vitiensis* processing using once boiling process, twice the salting process, namely wet salting and dry salting (Figure 2a).

![Figure 2. *Bohadschia vitiensis* processing flowchart at Kambuno Island in Sembilan Islands, Sinjai Regency, South Sulawesi (a), weeding (b-c), wet salting (d), dry salting (e-f), examples of bad (g) and good (h) salting process, boiling (i), and sun drying (j).](image)

*B. vitiensis* processing begins with weeding to remove the intestine. Weeding was done by cutting the sea cucumber’s body in the middle of the abdomen using a knife (Figure 2b). After that, the wet salting process was carried out by placing *B. vitiensis* in a Styrofoam box filled with liquid salt (Figure 2d). Wet salting aims to preserve *B. vitiensis* during storage, which usually lasts three to seven days. Wet salting was done until the *B. vitiensis* volume was enough for one processing. The ratio of water and salt used for wet salting was one liter of water and 0.5 kg of salt. During storage, there was no water replacement and salt addition. When the volume of *B. vitiensis* was sufficient for one processing, the processing stage was continued to dry salting. Dry salting was done by inserting *B. vitiensis* into styrofoam box (Figure 2e-f). The dry salting process was done by putting salt into the *B. vitiensis* stomach through an incision. Then the *B. vitiensis* were covered with salt in a styrofoam box with the stomach positioned on top. Dry salting lasts for three days in a closed condition. The indication that *B. vitiensis* were ready to be boiled was when the *B. vitiensis* meat has become springy like the texture of squid meat. The bottom side of the styrofoam box for dry salting was perforated so that water coming out of the *B. vitiensis* meat flow out of the styrofoam box. The salting process was the key point to produce a good quality of *B. vitiensis*, because if the salting was unsuccessful, during the boiling process, the *B. vitiensis* meat would be damaged (Figure 2g); whereas if salting was successful, after the boiling, *B. vitiensis* meat did not break when folded and have a rubbery texture (Figure 2h).

After salting, *B. vitiensis* were boiled (Figure 2i). The boiling process was done to make the *B. vitiensis* body shape becomes round again. Boiling was only done once; boiling was done for 5 to 10 minutes at a low temperature of 50ºC to 90ºC. *B. vitiensis* was sea cucumber species that has a thickness meat of 0.7 cm and soft meat so that the boiling process was carried out in a short time. The boiling process was stopped when the *B. vitiensis* body has a round shape, and the meat texture become harder like rubber. The last step was drying, the drying process was carried out in the traditional way by drying directly in the sun (Figure 2j), and the drying time was four days. The
purpose of drying was to reduce the water content of *B. vitiensis* so that the dry product can be stored longer.

### 3.2. Quality

Quality parameters of dried *B. vitiensis* indicated that some parameters did not comply with the INS for sea cucumbers dry product. The parameters that did not comply with INS were organoleptic parameters and chemical parameters. Organoleptic evaluation on the appearance of dry *B. vitiensis* indicated poor quality because it did not meet the INS standard (Table 1). This poor quality could be caused by the weeding process, which was not done properly, so that the incision was still open after the *B. vitiensis* was dried.

#### Table 1. Organoleptic test results for *Bohadschia vitiensis*.

| Parameters | Means value | Coefficient | s/√n | 1.96.s/√n | P≤ | ≤P | Results |
|------------|-------------|-------------|------|-----------|----|----|---------|
| Appearance | 5.1         | 1.96        | 0.193798 | 0.379845 | 4.7 | 5.5 | 5.1     |
| Odour      | 5.5         | 1.96        | 0.224806 | 0.44062  | 5.1 | 5.9 | 5.5     |
| Texture    | 5.5         | 1.96        | 0.289406 | 0.567235 | 4.9 | 6.1 | 5.5     |
| Fungus     | 9           | 1.96        | 0       | 0         | 9  | 9  | 9       |

The microbial contamination parameters (TPC and Salmonella) and metal contamination (Pb and Cd) were not exceeding the specified INS standards (Table 2).

#### Table 2. The quality parameters of dried *Bohadschia vitiensis*.

| Replication | Water content (%) | Ash (%) | Protein | TPC Content (CFU/g) | Salmonella (each 25 g) | Lead (µg/g) | (Pb)Cd (µg/g) |
|-------------|------------------|---------|---------|--------------------|------------------------|-------------|---------------|
| 1           | 40.97            | 30.45   | 17.62   | 6.2x10^2           | Negative               | 0.04        | 0.01          |
| 2           | 43.19            | 31.06   | 17.78   | 3.6x10^2           | Negative               | 0.05        | 0.01          |
| 3           | 41.62            | 30.83   | 17.69   | <0.25x10^3         | Negative               | 0.09        | 0.01          |
| Mean        | 41.92            | 30.78   | 17.69   | ± 3.35x10^2        |                        | 0.06        | 0.01          |

### 4. Discussion

#### 4.1. Processing

Generally, sea cucumber processing in various countries only involves four stages, namely weeding, repeated boiling, salting, and drying [19, 20, 23, 24, 44]. Weeding *B. vitiensis* at Pulau Sembilan did not have a standard cut and was not uniform in cut size so that there was a still open incision at the dry product. The incision on the sea cucumber should not be too long so that during boiling and drying, the incision can be reclosed again. An incision that was too wide large can reduce the quality and selling price of sea cucumbers [20], and make the appearance of dried sea cucumbers less good [24].

Salting aims to preserve before processing and to remove water in sea cucumber meat [20, 44]. The salting method can be done in two methods, namely wet salting and dry salting [20, 21]. Sea cucumbers have soft and easily broken meat when boiled. Therefore, sea cucumbers need to be salted to reduce the water content in the meat, and make the meat texture harden and not be destroyed when boiled [20, 21].

Salting process in *B. vitiensis* was the key to the processing success; a good salting process will produce a good quality of the dry product. This study indicates the salting process carried out was not good enough because the appearance of *B. vitiensis* indicated the low quality. This was caused by the
wet salting process, which was too short, only three days, even though it should be a minimum of four days [21].

Boiling was a traditional way to maintain the quality of dried products, boiling was expected to reduce microorganisms [24]. At the certain species of sea cucumber, boiling was usually done two to three times [12, 20, 24] or even up to four times [44]. The sea cucumbers boiling that have thin meat should be done with a low temperature of 50 - 90°C, so that the meat is not destroyed, as well as to make the appearance cylinder and the texture become elastic [44].

Drying was done to reduce the water content to the lowest level [24]. The drying process was carried out to reduce the water content of the dried product. The drying process was carried out to reduce the water content of the dried products so that they can be stored longer. Drying can be done in several ways, both traditional and modern ways [45].

The drying method of B. vitiensis used in Pulau Sembilan was still classified as traditional, namely by drying in the direct sun for four days. Drying time was still too short, it should be done for a minimum of seven days to get a good quality of dried sea cucumbers [21]. This drying method in direct sunlight was often used because it was quite efficient, although it was not very effective at reducing water content in the sea cucumbers meat [45].

4.2. Quality

Sea cucumber processing methods vary depending on the sea cucumber species that will be processed [25, 46]. In the sea cucumbers processing, the processing stages can be done repeatedly. Repetition or modification of the processing stages will have an impact on the quality or nutrient content of processed dried sea cucumbers [44]. Duration and temperature during the boiling process also need to be considered because sea cucumber skin contains high collagen. The composition and structure of sea cucumber collagen are strongly influenced by water temperature [47, 48] and boiling time [49].

Organoleptic testing of B. vitiensis indicated that the appearance, odor, and texture parameters only reached 5 of minimum 7 points, this can be caused by the process of weeding, salting, or drying that were not good enough. There were still meat that was destroyed during the boiling, and the incision was still open at the dried B. vitiensis. This can be caused by suboptimal salting. Sea cucumber species that have soft, thin, and easily broken skin such as B. vitiensis need to be wet salted for at least four days before boiling [20, 21]. B. vitiensis texture that did not reach INS standard could also be caused by suboptimal drying, that making the dried product texture less harsh due to high water content.

B. vitiensis water content was an average of 41.92%; this water content exceeds the INS standard threshold of a maximum of 20%. Water content in the meat of B. vitiensis that is too high can be caused by suboptimal salting and drying processes. The salting process carried out for B. vitiensis in the Sembilan Islands was only three days; to get a good quality, salting should be done at least four days [21]. Besides salting, drying process could also affect the moisture level of dried sea cucumber. Water content could affect the texture of dried sea cucumber. The B. vitiensis ash level reached an average of 30.78%, far higher than the water content in the previous research results, which was 9.8% [24]. The mineral content of dried sea cucumbers is at least 7%. Protein levels of B. vitiensis were, on average 17.69%. This can be caused by water levels in the meat that are too high.

5. Conclusion

B. vitiensis processing method at Kambuno Island uses four stages, namely weeding, salting, boiling, and drying. Quality characteristics observations of B. vitiensis indicated that several parameters did not meet the INS. The quality parameters that did not meet INS standards were organoleptic and chemical parameters. Organoleptic parameters that less than seven were appearance, odor, and texture. Whereas chemical parameters that did not reach INS were water levels that exceed the maximum limit.
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