Ranking of Seaweed Agro-Industry in Indonesia Using Fuzzy OWA Method

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Abstract. Seaweed has an important role in efforts to increase Indonesia's fisheries production capacity because seaweed is one of the three main commodities of the fisheries revitalization program which is expected to improve community welfare. At 2016, Indonesian seaweed production had reached 11 million tons and has to increase in the coming year.Indonesia is one of the largest producers of Euchema and Gracilaria, and dominate 50% of market share in the world.Nowadays, 80% of the exported products are still in the form of raw material (dried seaweed). Therefore, the government plans to reduce the export of seaweed in the form of raw materials and process it into several potential commodities. To rank the most potential commodities, this study uses the Non-Numeric Fuzzy method and the OWA Method. The results indicate that there is a lack of development from the seaweed agro-industry in Indonesia, while the demand for processed products is high. From the three alternatives of the processed products, SRC was the first product to develop with a weight of 0.5436 and the lowest value.

1. Introduction

Seaweed, known in science as algae. Seaweed was first known in China around the year 2,700 BC. At that time, seaweed was used for medicines and self-consumed. In 65 BC, the Romans used seaweed as a cosmetic ingredient. At present, seaweed especially its processed products, is widely used as additional ingredients for the food industry, cosmetics industry, and other industries. The growth and distribution of seaweed are depended on oceanographic factors (physics, chemistry, and dynamics of sea water), as well as the type of substrate. Seaweed often found in shallow waters with sandy waters, a little mud, or a mixture of both [1].

Seaweed has an important role in efforts to increase Indonesia's fisheries production capacity because seaweed is one of the three main commodities of a fisheries revitalization program that plays an important role in improving the welfare of the community [2]. Van Bosse through the Siboga Sea expedition in 1899-1900 reported that Indonesia had approximately 555 types of 8,642 seaweed species found in the world [3]. Seaweed from the class of red algae (Rhodophyceae) is the highest in Indonesian marine waters, after those green algae (Chlorophyceae) and brown algae (Phaeophyceae) [3]. Behind its ecological and biological role in maintaining the stability of marine ecosystems and as a place to live as well as protection for other biotas, this macroalgae group has economic potential, namely as raw materials in industry and health [3]. Seaweed is a good source of nutrition because it contains carbohydrates, protein, a little fat, and ash which is mostly sodium and potassium salt compounds. Seaweed also contains vitamins, such as vitamins A, B1, B2, B6, B12, and C; Beta-carotene; and minerals, such as potassium, calcium, phosphorus, sodium, substances, and iodine.

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of market share in the world. Nowadays, 80% of the exported products are still raw material (dried seaweed) [4]. Indonesian seaweed is dominated by two types of seaweed; Eucheuma Cottonii and Gracilaria [5]. Both types of seaweed if processed will produce carrageenan and gelatin. There are two types of carrageenan; refined carrageenan and semi refined carragenan. Based on the information above, this research was conducted to find out which of the three existing commodities are potential commodities.

2. Literatur

2.1. Fuzzy

Many problems cannot be encoded in two values (existing and non-existent), but are more likely to be mapped by a logic that requires incomplete, inaccurate, fuzzy and uncertain processing of information. Therefore, a Fuzzy system and fuzzy groups can be modeled. With fuzzy logic, the input is characterized by linguistic terms, not by numbers [6].

There are several fuzzy group decision-making methods that have been developed to solve the multi-hierarchy problem, among others [7]:

- Semi non-numeric method
- Non-numeric method

Non-numerical methods are used to analyze the four commodities of seaweed. The characteristics of the non-numerical method, are followed:

- A Simple model and flexible.
- Consider the criteria explicitly.
- Can be used to manipulate satisfaction levels.

Factors that can use non-numeric fuzzy applications are [8]:

- The level of requirements for quality, quantity, and continuity of raw materials.
- Availability of human resources.
- Availability of processing technology.
- Market absorption of the products.
- Fulfillment of business capital.
- Professional of management.
- Etc

2.2. Ordered Weigth Average (OWA)

In a fuzzy environment, ranking fuzzy numbers is very important in decision making procedure. There are several methods that can be used to rank a number, OWA method is one of them [9]. OWA is a multicriteria procedure which depends on some parameters and can be specified by fuzzy [10]. OWA operators provide parameters from the aggregation that has been used in several applications. The OWA concept was introduced by Yager in 1985. This concept provides a unified framework for making uncertain decisions, where aggregation methods are different from decision criteria such as optimistic (maximization), pessimistic (maximal), most likely (Laplace) and Hurwicz criteria [11]. The application of OWA to decision makers is the determination of weight.

3. Methodology

The methodology is a systematic thinking in solving problems. The Methodology in this research are:

- Find out the product conditions and identify criteria based on literature. The criteria of this research are demanding (C1), return on investment (C2), market absorption (internal (C3) and external (C4)) and raw material (C5). The alternative commodities are; refined carrageenan (RC), semi-refined carrageenan (SRC) and gelatin.
- The frequency distribution approach has used to find the standard values, see table 1. The weight for standard value is based on 0 - 1, using the frequency distribution approach that number is divided into 7 classes.

Table 1. Standard Value.

No	Weight	Value	Score
1	0,0313 – 0,1603	Lowest (Lst)	1
2	0,1604 – 0,2894	Very low (VL)	2
3	0,2895 – 0,4185	Low (L)	3
4	0,4186 – 0,5476	Medium (M)	4
5	0,5477 – 0,6767	High (H)	5
6	0,6768 – 0,8058	Very high (VH)	6
7	0,8059 – 0,9349	Perfect (P)	7

- Determine the weights for each criterion. The weight of criteria based on the commodity probability of each criterion on literature data[5,12]. For example, the demand for refined carrageenan is 42,070 kg from 117,565 kg. The probability of refined carrageenan for demand criteria is 0.3578. The probabilities will be the weight of criteria, so the value of refined carrageenan of demand criteria is low. The value of other alternatives in each criterion can be seen in table 2.

Table 2. Value of Alternative in Criteria.

Alternative	C1		C2		C3		C4		C5	
	1	2	1	2	1	2	1	2	1	2
RC	L	L	M	VL	Lst	Lst	Lst	Lst	P	P
SRC	H	H	M	L	VL	L	VH	VH	P	P
Gelatin	Lst	Lst	VH	L	H	H	Lst	L	Lst	Lst

- The weight of each alternative can be known by using the geometric mean, see equation 1.

$$G = (X_1 x X_2 x X_3 x \dots x X_n)^{1/n} \quad (1)$$

- The values for each alternative (i) from each decision maker (j) can be known by using equation 2.

$$V_{ij} = \text{Min } [Neg\ (W_{ak}) \text{ v } V_{ij}(ak)] \quad (2)$$

The negation of value for each alternative as is follow [9]

Neg (P) = Lst Neg (M) = M Neg (Lst) = P
Neg (VH) = VL Neg (L) = H
Neg (H) = L Neg (VL) = VH

- The value of each alternative can be known by using the OWA method, see equation 3.

$$V_i = f(V_i) = \max [W_j \wedge b_j] \quad (3)$$

4. Result and Discussion

Before carrying out further analysis, the weight of each alternative is calculated using equation 1. All data related to each commodity (alternatives) are averaged using geometric mean, the result of the weight calculation, then adjusted to the standard values in table 1. Weight and Value for each alternative can be seen in table 3.

Table 3. Weight and Value of Alternatives.

Alternatives	Weight	Value

RC	0,2694	Very Low
SRC	0,5436	Medium
Gelatin	0,2064	Very Low

Based on data analysis in table 2 and by using equations 2, the aggregation results for each alternative shown in table 4.

Table 4. The Aggregation result.

DM	Alternatives		
	RC	SRC	Gelatin
1	Min[H,M,P,P,Lst] = Lst	Min[L,M,VH,VL,Lst] = Lst	Min[P,VL,L,P,P] =VL
2	Min[H,VH,P,P,Lst] = Lst	Min[L,H,H,VL,Lst]= Lst	Min[P,H,L,H,P]= L

The weight of each decision maker is considered the same. This decision is based on their expertise related to seaweed commodity. The weight of each decision maker, then adjusted to the standard value in table 1. Weight and value of decision maker can be seen in table 5.

Table 5. Weigth and Value of Decision Maker

DM	Weight	Value
1	0,5000	Medium
2	0,5000	Medium

After obtaining the value of decision makers in table 5 and aggregation results in table 4. An alternative value can be known using the OWA method. Equation 3 is used to find the value of each alternative. The value of each alternative is:

- RC : Max[M^Lst, M^Lst]
  Max[Lst,Lst] =Lst
- SRC : Max[M^Lst, M^Lst]
  Max[Lst,Lst] = Lst
- Gelatin : Max[M^VL, M^L]
  Max[VL,L] = L

The results of the calculation for the three commodities indicate that the three commodities (alternatives) have a low value, especially for RC and SRC. The output obtained from the five input parameters (criteria) that used in this study. These results indicate a lack of seaweed agro-industry in Indonesia that is not comparable with the amount of seaweed produced. The high market demand both domestically and abroad has not been able to be met by seaweed agro-industry in Indonesia. Of the three alternatives (commodities), SRC was the first product to develop. This is based on the weight of SRC higher than the other two commodities (see table 3) and the value of SRC is lowest (Lst). This result also shows that the SRC was ranked first in the seaweed agro-industry in Indonesia, followed by RC and Gelatin.

5. Conclusion

Based on the results and discussion above, the conclusions from this research are:

- All alternatives have low values.
- From the five existing criteria, SRC has the highest weight if we compared to RC and gelatin

From the result above, carrageenan especially SRC needs to be developed in the future time. The aggregation results show that SRC has the lowest Value. The lowest value of SRC is caused by an imbalance between the amount of seaweed production and the number of SRC production in Indonesia, while the demand for this product is high.

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