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Differences in Appearance of Saltwater, Freshwater and Imitation Pearls with Microscopic Electron Spectrum

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Abstract: This study aims to identify the differences between saltwater, freshwater, and imitation pearls based on their morphology and topography. Samples were collected from the pearl trading center in Sekarbela, Mataram, Lombok, Nusa Tenggara Barat. The methods employed included physical analysis focusing on origin, formation process, shape, weight, color and light reflection, as well as price. Additionally, morphological and topographical scanning was conducted using Scanning Electron Microscopy (SEM)-EDS to obtain more detailed data. The research findings revealed significant differences among the three types of pearls, particularly in color reflection and luster. Saltwater pearls exhibited the strongest and most radiant color reflection compared to freshwater and imitation. Morphological examination showed pearl grains were irregular in shape and varied in size. Bright colors were predominantly associated with elements having high atomic numbers, whereas dark colors were linked to elements with low atomic numbers. The EDS analysis indicated distinct differences in the chemical composition of each pearl type. Calcium was found to dominate in saltwater pearls, carbon in freshwater pearls, and silicon in imitation. These findings provide deeper insights into the morphological characteristics and chemical compositions of each type of pearl, enhancing the identification of quality differences and the unique traits of each variety.

Keywords: Element; Lombok; Scanning electron microscopis (SEM); South pearls

Introduction

Pearls are organic materials that can be used as jewelry. Jewelry made of pearls includes crowns, necklaces, bracelets, rings, brooches, and tie clips that have a high selling value. Pearl jewelry, which was only used by the nobility, has now penetrated the general public (Hamzah et al., 2009). This is due to the pearl cultivation technique that was originally developed in Japan since the 20th century by Nishikawa, Mise, and Nikimoto until now which has been developed in various countries. This cultivation technique has helped in the process of breeding pearl oysters (Bone et al., 2018; Yasmin et al., 2012). However, due to its shortcomings the technology of developing pearl quality, entrepreneurs often experience difficulties because the quality of pearls produced during the harvest season is very low, which is characterized by inconsistency in shape and size, which leads to a decline in the development of the pearl market. Based on these problems, one of the solutions offered is to harvest the pearls needed, by developing a pearl monitoring system that can see the shape and size of pearls without having to open the shell.

The shell is made up of calcified substances secreted by the outer epithelium. This outer epithelium also produces calcium carbonate (CaCO3) crystals in the form of argonite crystals better known as nacre and

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hexagonal calcite crystals that form a prism-like layer on the shell (Widyasanti et al., 2013). A standard is a technical document or regulation that contains requirements, specifications, instructions, or characteristics that can be used to ensure materials, products, processes and services are up to their intended purpose (Naik et al., 2015). In international trade, standards are used to regulate the quality of goods entering or exiting a particular country. Standards can be used as a technical barrier, preventing low-quality goods from entering Indonesia, including imitation jewelry that is suspected of containing materials that are harmful to the human body (Ilhamuddin et al., 2021).

This research is important because it raises fundamental problems in the pearl industry, namely the low quality of pearl harvest which causes uneven shapes and sizes, as well as declining market competitiveness. In addition, challenges related to the increasing circulation of imitation pearls and the lack of public education about the difference in pearl quality have a direct impact on consumer preferences for real pearls, especially saltwater pearls which have higher economic value.

The novelty of this research lies in its innovative approach, namely the development of a pearl quality monitoring system using cutting-edge characterization technology such as Scanning Electron Microscopy (SEM). This technology allows for detailed analysis of the structure of pearls without damaging the shell, thus providing concrete solutions for assessing the quality of pearls with precision, while supporting the sustainability of the aquaculture ecosystem.

Jewelry is very close to our lives as a means of supporting appearance. Different types of jewelry that women love such as necklaces, bracelets, rings, brooches, and other accessories. The raw material for jewelry is generally precious metals such as gold because it has economic value and is a symbol of eternity and beauty for women. Not only jewelry designs are considered by users, but also gold has an increasing economic value (M. Krzemnicki, 2013).

Pearls produced in Indonesia are known as South Sea Pearls, which are the best quality types of pearls in the world (Zhou et al., 2017). Understanding of quality determination systems requires more concrete application with regard to consumers, and to be successful in maintaining the market requires a pearl, namely pearl quality. Pearl quality is an important thing in determining the choice of a pearl by consumers. The pearl offered must be a pearl that is truly well tested regarding its quality. Because the priority for consumers is the quality of the pearl itself. Consumers will prefer and choose pearls that have better quality when compared to other similar pearls that can meet the needs and desires of consumers in order to maintain the market and increase sales the pearl (M. S. Krzemnicki et al., 2017).

The system for determining the quality of pearls to be marketed in order to increase the sales level of pearl shells and how to deal with increasingly fierce competition in the pearl shell industry (Lufiani, 2018). In this case, the Pearl Quality determination system includes efforts to achieve an increase in the company's sales with its environment in order to maintain its market share on the issue of how the selected business can be run successfully in a competitive environment to serve the target market.

In determining the quality and value of domestic pearls, the same method is used as applied to natural pearls. The price of pet pearls is generally lower than natural pearls. In addition, large quantities of imitation pearls can be produced, where the core of these artificial pearls is made of glass or plastic coated with pearl essence made from layur fish scales (Trachiurus spp) (Rahman et al., 2020). According to Tung (2012) types of Pearl Shells are divided into two, namely: a. Genuine pearls consisting of natural pearls and cultured pearls. b. Artificial pearls/imitation (imitation pearl). The circulation of fresh water pearls and imitations causes a decrease in consumer interest in saltwater pearls. Lack of education to the public about the differences between pearls has an effect on the quality of pearls in circulation. This problem is discussed in this research, how to distinguish saltwater, fresh water and imitation pearls from several elements and further studies with characterization using SEM.

This research is also very relevant because; (1) Increasing the competitiveness of Indonesia's pearl industry, especially for South Sea Pearl (SSP) which is known as one of the best quality pearls in the world. Responding to the challenges of trade globalization, where international quality standards are a technical barrier that must be met by manufacturers to maintain market share. (2) Providing public education, by providing practical guidance in distinguishing between real, cultivated, and imitation pearls, thus helping to prevent the circulation of low-grade or dangerous products. (3) Supporting technological innovation in the pearl industry, which can be a competitive advantage for Indonesian pearl producers in the international market.

By combining a scientific approach, education, and technology development, this research is expected to be able to have a significant impact, both economically and socially, on the pearl industry in Indonesia.

Method

Study Area and Sampling

Sampling was carried out at several producers of saltwater pearls, fresh water and imitation pearls

according to the research procedures in Figure 1. Precisely in Sekarbela sub-district, West Lombok, NTB. The samples obtained were 3 with A: Saltwater Pearls, B: Freshwater Pearls and C: Imitation Pearls. Sampling and physical analysis were carried out in January – May, 2023.

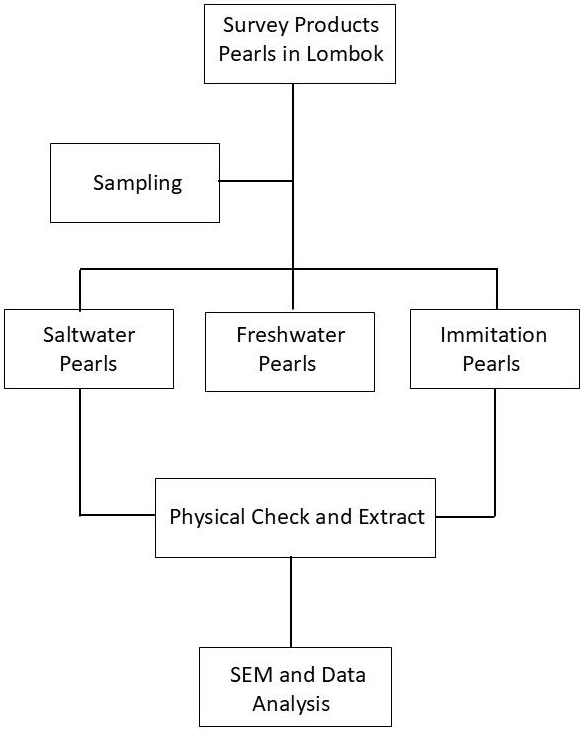


Figure 1. Research procedures

Physical Check

This research method uses a mixed method with qualitative and quantitative methods. Mixed research methods are research methods that combine two qualitative and quantitative research methods in a research activity so that more comprehensive, valid, reliable, and objective data will be obtained (Ningsih et al., 2016). This research qualitative method is used in the data collection process by conducting literature studies, documentation. While the quantitative method is carried out in the physical determination of pearls which includes physical differences from pearls, origin, process of occurrence, shape and weight, color and reflection of light and selling price of pearls.

Scanning electron microscopy (SEM)

Preparations were made by the modification method (Adam et al., 2019). After dissection, the paraffin was removed from sections and they were thinly cut to 2–3 mm thick and immediately immersed with 2% glutaraldehyde in 0.05 M osmium tetraoxide (pH: 7.4; fixative osmotic pressure: 310 mosmol l-1) for 90 min . Then they were set at room temperature for 4 × 10 min each in 0.15 M osmium tetraoxide buffer. Afterwards, they were left to dry for 5 min then put in acetone solution (30, 50, 70, 90 and 100%) respectively for 5 min and dried at critical point (critical point dryer, Balzers CPD 030). The sample was mounted on a silver paint stub by maintaining the primary lamella parallel to the stub, and then gold was coated by the sputtering method (Balzers). Scanning electron microscopy with Philips XL 20. For each experimental condition, five fish were examined. Chloride cells were found on the trailing edges of the first filaments in the interlamellar area and photographed at 8000 magnification. At least four non-contiguous areas were randomly selected from each fish for morphometric analysis.

Spectrum Determination

Determination of the mineral spectrum in the Pearl content was carried out by electron interactions in SEM. The results of electron-sample interactions (there are two types of interactions, namely elastic and non-elastic collisions produce several electron and photon spectra. Electron-matter interactions will produce several signal spectra, including Cathodoluminescence (Photons), X-Rays, Backscattered Electrons (BSE), Auger electrons , and Secondary electrons (SE), as well as transmission electrons.In general, SEM uses SE and BSE to scan the sample, so that SEM is not only used to observe the topography and morphology of the sample surface, but can also analyze the atoms that make up the sample.The determination of the spectrum in this study uses standards Table 1.

Data Analysis

The results of the analysis were analyzed descriptively by analysis of variance (ANOVA). Furthermore, the LSD test was carried out to determine the differences between each treatment based on a 95% confidence interval.

Table 1. Standards Determination of the Spectrum

Standards	Atom Composition Type
C	CaCO3
O	SiO2
Na	Albite
Mg	MgO
Si	SiO2
S	FeS2
Cl	KCl
K	MAD-10 Feldspar
Ca	Wollastonite

Result and Discussion

Many people do not know the difference between saltwater pearls, fresh water and fake (imitation) pearls. This knowledge is necessary for every potential buyer, because the types of pearls are very different.

Information regarding genuine sea and freshwater pearls and fake (imitation) pearls is described in Table 2 below NPK fertilizer (P1) treatment gave an average final length of 9.56 cm, and the palm sap fertilizer (P2) gave an average final length of 4.66 cm (Figure 2).

Table 2. Differences between Saltwater Pearls, Fresh Water and Fake Pearls (Imitation)

Different Type	Sea Pearl	Freshwater Pearl	Imitation Pearl
Origin	Sea pearls come from shells that live in sea water (sea waters)	Fresh pearl granules come from clams that live in fresh water	Fake (imitation) pearl granules come from factories, use sophisticated machines, the manufacturing elements are made of plastic
The Process Occurs	To produce sea pearl granules takes about 18 -24 s/d months	To produce fresh pearls takes about 6 to 8 months.	To produce fake pearls (imitation) takes less than 24 hours with sophisticated machine technology
Physique; Shape and Weight	Sea pearls are relatively large and round in shape. There are also oval, half round (Mabe) and Baroq (irregular shapes). The weight of a saltwater pearl is very appropriate for its size, the pearl's grain element is very dense.	Fresh pearls are relatively medium and small in shape, rarely found in round and large shapes. Freshwater pearl shapes: Round, imperfectly round, oval, half round (Mabe), and Baroq (irregular. Freshwater pearls are lighter in weight than sea pearls of the same size.	Imitation pearls (fake) are very perfect in shape, perfectly round, The size is not limited from the smallest to the largest, because these imitation pearls are made by factory machines, which means they don't occur naturally. Usually, imitation pearls are basically made of plastic or glass, which are coated with a solution of layur fish scales.
Color and Reflection of Light	Sea pearls have natural color characteristics, namely Gold, White, Black and silver, while other colors are not far from that color. The light reflection of the pearl layer reflects light more strongly, then the nacre layer (the outermost layer of pearls) is thicker when compared to freshwater pearls.	Fresh water pearls have colors: white, pink, black, orange, yellow and silver, while other colors are not far from that color. The light reflection of freshwater pearls is less strong when compared to sea pearls.	Imitation pearls or pearls made of plastic have various colors without exception. Because they are made by factory machines, plastic pearl designers are free to make fake pearls of any color at will. The sheen and reflection of fake pearls is perfect, has a striking sheen, perfectly brilliant.
Selling Price	The price of sea pearls depends on the quality (grade), the price classification is determined by the grade of the pearl. And the bigger and rounder the more expensive. The price of sea pearls is calculated per gram. The price range for sea pearls ranges from IDR 100,000/gram to IDR 1,000,000/gram. Depending on the shape, luster and weight / size.	The price of freshwater pearls depends on their quality and shape, round, oval and baroque shapes differ in price. Usually the calculation of the selling price of freshwater pearls is per item. But for super quality pearls, the price is calculated per gram. The price per item of bargain pearl ranges from IDR 10,000 to IDR 100,0000 per item.	The price of plastic pearls or fake pearls is very cheap on the market, because factories produce on a large scale, the presence of fake pearls on the market is abundant, usually imitation pearls are sold in the form of jewelry that has been bound with stainless material. The existence of fake pearls (plastic) at very low prices can damage the market price of genuine pearls.

Some fake pearl names do sound interesting, such as Angel, Sheba, Mikomo, Kobe, Nikko, Sumo, Fijii, Aloha. This is intentional, considering that these pearls also come with a certificate and a special box (Ayesha et al., 2020). While fake pearls may look like expensive pearls, they are actually made of glass, ceramic, shell or plastic. The beads are coated with refining oil or some other substance that creates a luster that can deceive the eye (Ahmad et al., 2020). On the other hand, real pearls are valuable commodities made from mollusks, whether oysters, clams, or other types that have two valves. For the rare, usually formed spontaneously in the wild and found by chance. Pearls like these are the most expensive. Sometimes, old fashioned jewelery falls into this category (Ahmad et al., 2020). Most real pearls today come from cultivation and farming, by placing the material inside a mollusk, after which nacre (crushed shell powder) is coated in concentric layers over a long period of time to produce colorful pearls (Ernawati et al., 2021).

For more details, the differences in the physical form of sea, fresh and imitation pearls are shown in Figure 2.

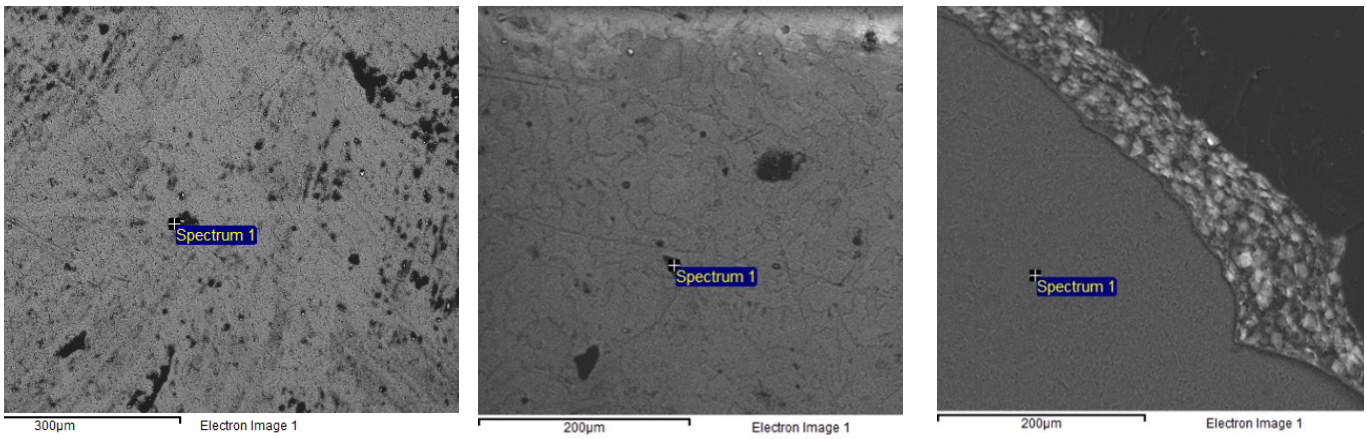
(a) (b) (c)

Figure 2. Appearance of the physical form of the differences in saltwater pearls (a), freshwater pearls (b) and imitation pearl (c). The most prominent difference of the three types of pearls is the reflection of the sparkling color. Saltwater pearls have the strongest and most sparkling hue reflections than other pearls

Shape Characteristics Using SEM

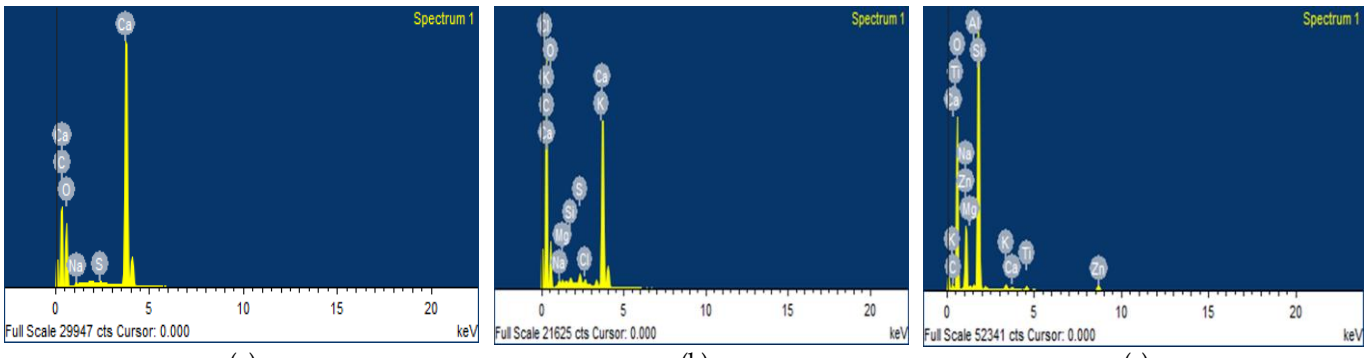
Observations with Sem were carried out to investigate the surface microstructure (geopolymer including porosity and crack formation as well as the morphology of the seams of the Pearls. The results of the neutralized SEM characterization are shown in Figure 3. Analysis using SEM was carried out to determine the morphological and topographical structures of Pearls.

SEM image measurements of the Mutiara sample were carried out at an accelerating potential (HV) of 20.0 kV with a secondary detector (SE) even with a different view field. It can be seen that the morphology of the sample shows irregular grains with varying sizes. Bright colors that appear more dominant in samples with constituent elements that have a high atomic number, while dark colors that appear on the surface of the sample are constituent elements with a low atomic number.



(a) (b) (c)

Figure 3. The morphological and topographical structure of Mutiara on a 200 um scale bar



(a) (b) (c)

Figure 4. Spectrum of pearl sample EDS test results

The spectrum of the EDS test results for the pearl samples is shown in Figure 4. Based on the picture, it appears that elements that have a high atomic value of calcium are in saltwater pearls, the carbon atom value is in saltwater pearls and the silicon atom value is in imitation pearls.

Element Spectrum Structure

Counterfeit products often match the appearance of genuine products. This is what makes consumers make alternative products than original products that have high prices. Counterfeit brands bear the brand name of the original branded product (Tayfur et al., 2018). Aesthetic pleasure is a direct response that precedes the assessment of its utilitarian qualities or the needs it can satisfy (Kristyaningrum, 2018). Thus, interest in buying counterfeit products can process favorable personalities towards counterfeit products. Consumers buy counterfeit products to get aesthetic pleasure. Appearance is the main reason to buy counterfeit products (Ong, 2013).

Table 3. The Constituent Elements of the Pearl Samples

Element	A		B		C	
	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%
C–K	24.51	36.58	56.37	69.28	5.07	8.15
O–K	43.85	49.14	25.98	23.97	54.10	65.22
Na–K	0.35	0.28	0.36	0.23	6.71	5.63
Mg–K	-	-	0.16	0.10	0.32	0.26
Si – K	-	-	0.25	0.13	26.49	18.20
S – K	0.15	0.09	0.65	0.30	-	-
Ca–K	31.14	13.93	15.48	5.70	0.39	0.19
Cl– K	-	-	0.30	0.12	-	-
K – K	-	-	0.45	0.17	0.75	0.37
Al - K	-	-	-	-	0.19	0.14
Ti – K	-	-	-	-	0.82	0.33
Zn–K	-	-	-	-	5.14	1.52
Total	100.00		100.00		100.00	

According to research conducted by Sholeh (2014) revealed that product knowledge has a positive effect on utilitarian attitudes. Similar results were found by Setiawan et al. (2019) that product appearance has a positive effect on hedonic attitudes. Seeking new things is the internal motivation of individuals to explore new information (Street et al., 2016). Counterfeit products have a lower price than the original branded version of the product. Because consumers buy them to satisfy their need for experimentation and curiosity. Consumers who are looking for novelty are more likely to buy counterfeit products because they are a cheap way to satisfy their curiosity and need for experimentation (Sethi et al., 2006).

Conclusion

Based on the results of the research conducted, it can be concluded that there are fundamental differences from sea pearls, freshwater pearls and imitation pearls. These differences provide a deeper understanding of the morphological characteristics and chemical composition of each type of pearl, strengthening the identification of quality differences as well as the unique properties of each type.

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Author Contributions

Conceptualization, M.A.A. and R.K.; methodology, M.A.A, R.K, I.F., I.D. and T.B. ; software, R.K, and M.A.A.; validation, I.F, I.D. and T.B.; formal analysis, R.K and M.A.A.; investigation, I.F and I.D.; resources, R.K.; data curation, M.A.A and R.K, I.F and I.D.; writing—original draft preparation, M.A.A, and R.K.; writing—review and editing, I.F, I.D. and T.B.; visualization, I.D and T.B.; supervision, I.F.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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