

## Comparative evaluation of paraffin wax, shell powder, acrylic and calcium powder as nucleus materials for image pearl preparation

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ARTICLE INFO	ABSTRACT
<p><b>Article history</b></p> <p>Received: 21 November 2025 Accepted: 29 December 2025 Published: 31 December 2025</p> <p><b>Keywords</b></p> <p>Paraffin, shell, acrylics and calcium image, physical properties, Image pearl, Nacre</p> <p><b>*Corresponding Author</b></p> <p>Sonia Sku ✉ sku.soniya@gmail.com</p>	<p>Image pearls are a type of freshwater cultured pearl resembling blister pearls and can be produced in customized shapes such as flowers, leaves, and logos. These images are prepared using different materials and implanted between the mantle tissue and shell of freshwater mussels, where nacre is secreted to form pearls. This study compared the effects of four nucleus materials: paraffin wax (T<sub>1</sub>), shell (T<sub>2</sub>), acrylic (T<sub>3</sub>), and calcium powder (T<sub>4</sub>) on pearl quality. A total of 2,400 mussels (600 per treatment) were operated and cultured at the Bangladesh Fisheries Research Institute (BFRI), Mymensingh, using the net bag hanging method. After 11 months, the highest pearl production rate was recorded in paraffin (42%), followed by acrylic (38%), shell (35%), and calcium (29%). However, luster and nacre thickness were comparatively higher in paraffin (49.85 lux; 0.83 ± 0.17 mm) and calcium treatments (47.82 lux; 0.79 ± 0.15 mm). Despite higher biological performance in paraffin, calcium-based pearls showed better durability and market acceptance, whereas paraffin and acrylic pearls were more prone to breakage and heat damage during processing. Overall, calcium powder is recommended as the most suitable nucleus material considering quality, durability, and market demand.</p>

### 1. Introduction

Natural pearls form when foreign particles enter the body of a mussel and become coated with nacre as a defense mechanism. This process results in irregularly shaped pearls. In contrast, cultured pearls are produced by surgically implanting a nucleus of desired shape and size into the mussel. As a defense device, the animal secretes a calcium carbonate material known as nacre to coat the foreign body. Layer upon layer is secreted on external particle and this deposition of nacre leads to the pearl formation. Nacre is also called mother of pearl. Natural pearl formed in this fashion are usually irregular in shape. Cultured pearls are formed essentially by the same process, except that the natural external particle is nucleus of desired shape and size is surgically implanted into the body of bivalve molluscs where it is difficult to be expelled. Image pearls are a specialized form of

cultured freshwater pearls, where designed shapes (e.g., flowers, symbols, logos) are implanted between the mantle and shell. The mussel then secretes nacre over the image, forming a pearl. Image made up of with different elements were transplanted between the mantle tissue and the shell of mussel and the mussel secretes nacre to cover the image and then the image or design turns into image pearl. (Tanu et al., 2022). Pearls are measured as an fashionable recognition of royalty and this is only for the wealthy powerful people (Pandey and Singh 2015, Dirlam et al., 1985). Freshwater pearl is that kind of pearl which is produced in freshwater mollusk, mainly from freshwater pearl mussel. As the name suggests, they are grown in fresh water usually in mussels that live in pond, lakes and rivers. The most popular wealth of mussels in Bangladesh is *Lamellidens marginalis*, *L. corrianus* *L. phenchooganjensis*. *L. jenkinsianus* (Barman et al., 2018). These species of bivalves, which have

the pearly nacre on the interior of the shell surface, can produce freshwater pearl. Different elements of image can be transplanted between the mantle tissue and the shell of mussel body and the mussel secretes nacre to wrap the image and then the image or design turns into image pearl. Image pearl has accordant uniqueness to the unique sculpture covered by the shiny pearl layer which is one of the most beautiful craft of adoration (Dan et al., 2001). Image can be produced with different materials where paraffin wax, dead shell of mussels, acrylic powder and calcium powder. In 12<sup>th</sup> Century, first records of image pearls established by produced Buddha figures in freshwater mussels by Buddhist monks (George 1966). After then in 13<sup>th</sup> century the similar Buddha image pearl produced on the inner shell surfaces of the freshwater mussels (*Cristaria plicata*) (Abbott 1972; Alagarswami 1987; Akamatsu et al. 2001). Different elements of image have different impact on mussel body and these elements may influence the mussel to secretes the nacre. Therefore, a study was conducted to compare the quality of pearl among paraffin, dead shell, acrylic and calcium made image.

## 2. Materials and Methods

### 2.1. Image preparation procedure

In this experiment we used 4 different ingredients to observe the image pearl quality. Every ingredient has different preparation procedure. Preparation procedure is given below:

**Paraffin image preparation:** Mussels dead shell, soybean oil, paraffin, heather, and needle were used to prepare image. Soybean oil was applied on the concave side of the dead shell to pick up the paraffin image from the shell easily. Then the liquid wax was poured on the oil layer of the concave side of the shell and shakes one side to another for making a thin layer (1.5-3.5mm) of wax. After that, an image or sculpture was designed with a needle (Tanu et al., 2022).

**Shell image preparation:** First the desired design was drawn on the shell with a pencil. Then image was created by cutting with grinding machine according to the design. The finishing image was prepared by smoothing the edges of the image (Tanu et al., 2021)

**Acrylic image preparation:** When creating an image with acrylic, the inside of the desired design was lubricated with oil. Then an average of 1 g of acrylic powder and acrylic liquid 11.08 ml. pour in design and allow solidifying, which was then take the shape of the desired image. After that gently lift the image from the design dice.

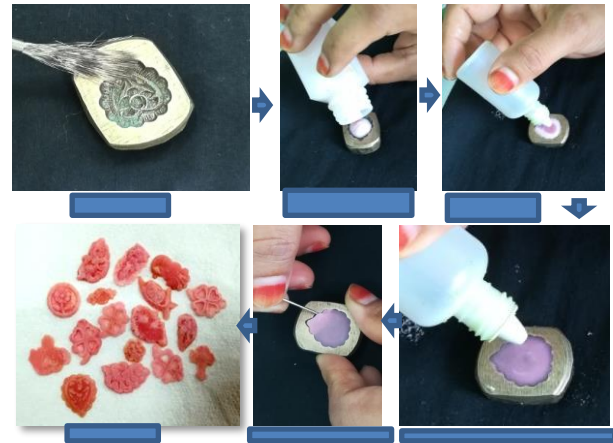


Figure 1: Acrylic image preparation

**Calcium image preparation:** Mussel shell powder, marble, powder, grout powder, sun stone powder and glue were mixed to create a dough. Then according to desire design image was made by dough on dice. In order to set the images properly inside the mussel, the images were kept on dead shell of mussel for 3-4 hours while dough soft. Prepared image was soaked overnight in water to remove glues odor.



Figure 2: Calcium image preparation

**Cistern Preparation:** A disinfected cistern with a dimension of 2.42 m × 1.88m × 1m, having a water

exchange facility was used for the post and pre-operative treatment of the mussels.

## 2.2. Pond preparation

Ponds were prepared following standard pond preparation procedure. Four different ponds were selected to culture the operated mussels and the area of each pond was 7.5 decimal and it was separated in three parts by bamboo fence (*bana*) to make it 2.5 decimal. Another pond also selected for stocking collected mussels. The ponds having sandy soil, clean water, pollution free bottom were selected. At first ponds were totally drained out and dried, then lime and salt were applied at the rate of 1kg/decimal to remove the insect and earthworm. Organic and inorganic fertilizers were applied to produce plankton naturally in pond viz. organic manure applied at the rate of 1kg/decimal, T.S.P. 0.125kg/decimal and Urea 0.1kg/decimal. Lime was applied at 0.5kg/decimal. After 6-7 days of liming freshwater was supplied to the ponds.

## 2.3. Mussel collection and selection

Mussels were collected from various places of freshwater region. *Lamellidens marginalis* was sorted out for image operation due to its suitability to operate (Hossain et al., 2023). The average size of selected mussel for operation was 10 cm length and 5 cm width. Selected mussels were stocked in prepared stocking pond, where they nourished for further image operation. For image operation, a healthy, disease-free mussel having a yellow edge is best.

## 2.4. Pre-condition

Mussels were preconditioned in a disinfected cistern for 7 days. Water was changed regularly. Mussels were brought to the laboratory and kept them downward position on a porous basket before two hours to reduce the water from the internal organ of the mussel.

## 2.5. Equipment needed for operation

**Wooden stand:** This stand was used to keep the mussel in a fixed position so that the operator can handle the mussel easily.

**Gill adjusting oar:** Gill adjusting oar used as tongue depressor, which can adjust the gill and visceral mass at proper place.

**Mussel opener:** Mussel opener was used for opening the mussel in proper distance to prepare for operation.

**Stopple:** Stopple used to keep two valves of the mussel open, material of which can be wood or steel.

**Image materials:** Mussel shell, paraffin wax, acrylic powder, calcium powder

**Obtuse headed forceps:** Obtuse-headed forceps were used for transferring image of paraffin wax into the mussel.

**Prepared image:** Paraffin-made image, shell-made image, acrylic made image and calcium powder made image

## 2.6. Image operation method

Image operation followed the process of Tanu et al. (2022), where mussels were washed by distilled water to eliminate dirt. The nominated live mussel was opened approximately 8 mm with the help of a mussel opener. A little area of the attached mantle was detached from the shell by a spatula cautiously to make a space as the size of inserting the image. Then the image was inserted into the cavity between the shell and mantle of the mussel. After insertion, the image was adjusted in the cavity and gently removed the air from the cavity area. Finally, the operated mussels were kept at an upward position on the tray till transfer to the cistern so that the image cannot come out.

## 2.7. Post-conditioning

After image operation, mussels were conditioned in a cistern for 7 days without feeding. Water was changed regularly in the cistern. The next 21 days, mussels were fed plankton ( $60 \times 10^3$  cell/l) collected from the pond and thereafter transferred to the pond.

## 2.8. Culture method

Culture method was followed by Tanu et al., (2022). Operated mussels were kept in cistern for one week without food and then kept in another cistern for three weeks with food. Operated mussels were cultured in pond by using net bag hanging

method. Six operated mussels were stocked in six pockets of a rectangular shaped net bag and hanged by rope till 30-35 cm depth with a float. The rope stretched across the pond on the surface of the water. The distance between two bags was 25-30 cm and rope to rope distance was 1.5m. Finally, after 11 month culture, the image pearls were harvested. The survival rate and mussels having image were recorded. Stocking density of mussels was 80/decimal and fish 30/decimal. The fish were stocked with mussels to ensure the maximum use of pond.

**2.9. Water quality parameter measurement**

Temperature was recorded from Celsius thermometer. Dissolved oxygen from DO meter (YSI, model 58), pH from pH meter (Jenway, model 3020), ammonia from ammonia test kit (HACH test kit; FF-3 model) and calcium ion were measured by using Spectrophotometer (HACH-DR1900). Plankton were observed by a light microscope (NOVEX Holland, Lens no.: 10/0.25) on SR cell by using the following formula (Rahman 1992 and Stirling 1985).

$$N = \frac{A \times 1000 \times C}{V \times F \times L}$$

**2.10. Experimental design**

A total of 2400 mussels were operated with image. Four treatments were set for same culture periods viz. Paraffin image (T<sub>1</sub>), Shell image (T<sub>2</sub>) Acrylic image (T<sub>3</sub>) and Calcium image (T<sub>4</sub>). In each treatment, 600 mussels were operated with 3 replications (Table 1). Finally, after the culture period, the image pearls were harvested and data were recorded.

**Table 1:** Design of the experiment

Treatment	Name of image	Culture method	Mussel used for pearl production
T <sub>1</sub>	Paraffin	Net bag hanging method	<i>Lamellidens marginalis</i>
T <sub>2</sub>	Shell		
T <sub>3</sub>	Acrylic		
T <sub>4</sub>	Calcium		

**2.11. Luster and nacre layer assessment**

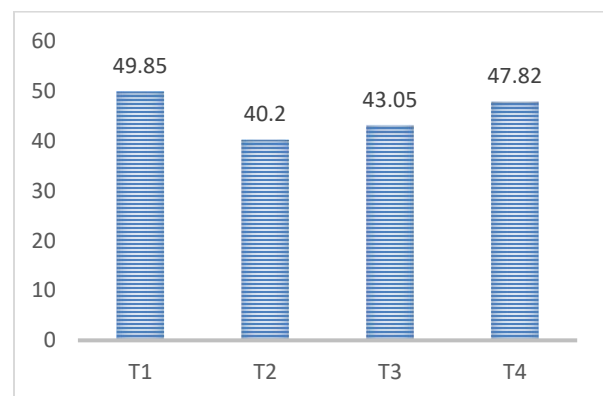
Luster was measured by the Light meter (Model: Lutron LX-101AS) and eye observation. Distance between image pearl and sensor of light meter was 1 inch during luster measurement. Nacre layer was recorded by Gauge calipers.

**3. Results**

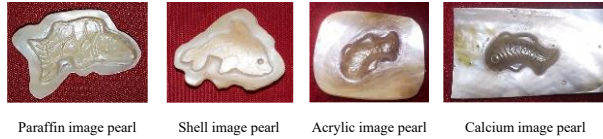
A total of 2400 mussels were operated, for each treatment 600 mussels operated by keeping three replicas and reared at BFRI pond complex at Mymensingh, Bangladesh. Among the operated mussels 600 mussels were operated with paraffin made image (T<sub>1</sub>), 600 mussels with shell image (T<sub>2</sub>), 600 mussels with acrylics made image (T<sub>3</sub>) and rest 600 mussels operated with calcium powder made image (T<sub>4</sub>). These ingredients are very much important for image pearl production. By using these ingredients, the experiment was set to identify which ingredient is more suitable for image pearl production. After image operation and 11 months of culture period pearl were harvested.

**3.1. Survival and pearl production rate**

After the 11 months of experiment, we got different survival rates of mussel and pearl production rate for four different treatments, 42%, 35%, 38% and 29% in T<sub>1</sub>, T<sub>2</sub> T<sub>3</sub> and T<sub>4</sub>, respectively. The final results are founds after 11 months of culture showing the T<sub>1</sub> is better in perspective of survival and pearl production rate (Figure 1).



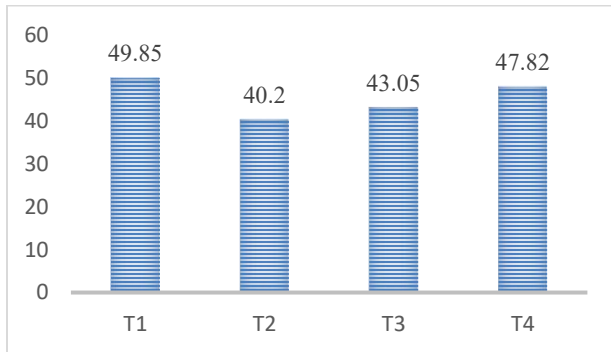
**Figure 3:** Survival and pearl production rate of produced image pearl



**Figure. 4:** Pearls produced from different ingredient image

**3.2. Nacre layer thickness**

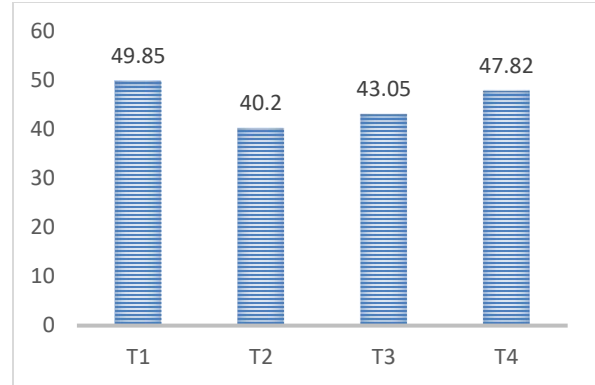
Following the post harvest techniques, we got different nacre layer from three different treatments. Nacre layer of T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> found 0.83±0.17mm, 0.62±0.15mm, 0.76±0.11mm and 0.79±0.15mm, respectively. That’s to say, luster is an important quality for making a pearl to gem. The final results are founds after 11 months of culture showing the T<sub>1</sub> and T<sub>4</sub> is better in perspective of nacre layer thickness followed by the T<sub>1</sub> and T<sub>3</sub> (Figure 3).



**Figure 5:** Nacre Layer of produced pearl

**3.3. Luster (lux) of the pearls**

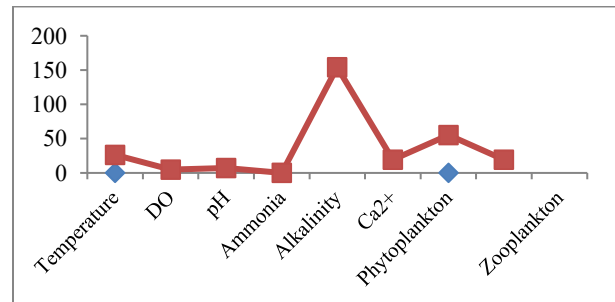
Different luster of pearls from three different treatments. The average value of luster found 49.85±0.13 lux in T<sub>1</sub>, 40.2±0.12 lux in T<sub>2</sub>, 43.05±0.15 lux in T<sub>3</sub> and 47.82±0.11 lux in T<sub>4</sub>. All kind of image pearls produced with medium to high shiny luster. Based on luster shining, all image produced medium to good quality image pearl. The final results were founds after 11 months of culture showing the T<sub>1</sub> and T<sub>4</sub> is better.



**Figure 6:** Luster of image pearl produced from four treatments

**3.3. Water quality parameter**

Water quality parameter of the cultured pond was monitored fortnightly and measured data were recorded (Figure 3). The water quality parameter observed more or less similar for all the treatment so the data showed altogether. Temperature was found 26.14±0.94°C, DO 5.07±0.33 mg/l, alkalinity 154.16±13.95 mg/l, pH found 7.10±0.31, Ammonia 0.024±0.02, Ca<sup>+2</sup> 19.2±3.2, phytoplankton 55.18±1.3×10<sup>3</sup> cell/l and zooplankton 9.14±0.23×10<sup>3</sup> cell/l which are suitable for mussel culture. During monitoring the water quality parameters, plankton population was also monitored under microscope and different groups of phytoplankton and zooplankton were identified. Among them *Cyanophyceae*, *Bacillariophyceae*, *Euglenophyceae*, *Chlorophyceae*, *Chrysophyceae* were identified from the phytoplankton group and *Moina*, *Daphnia*, *Nauplius*, *Brachionus* from zooplankton group during the culture period.



**Figure 7:** Water quality parameters of experimental pond

#### 4. Discussion

After the culture period, the operated mussels were harvested from the experimental ponds and all surviving mussels containing image pearls were sorted according to treatments. The present study clearly demonstrates that nucleus material significantly influences both biological performance (survival and pearl yield) and physicochemical quality (nacre thickness and luster) of image pearls.

Survival and pearl production rates were found to be highest in T<sub>1</sub> (paraffin: 42%) and lowest in T<sub>4</sub> (calcium: 29%) (Figure 3). The higher survival in paraffin-treated mussels may be attributed to the soft, smooth, and biocompatible nature of paraffin, which reduces mantle tissue injury and stress during implantation (Tanu et al., 2021; Siddique et al., 2020). This finding is consistent with previous studies where paraffin images resulted in relatively higher survival rates (Tanu et al., 2021).

In contrast, the lower survival observed in calcium-based treatments may be associated with the hard and relatively abrasive structure of calcium composite nuclei, which can induce mechanical irritation and immune stress responses in mussels (Hossain et al., 2023). Additionally, the use of binding materials (e.g., glue and grout) in calcium images might contribute to localized stress or toxicity immediately after implantation.

When compared with other studies, the survival rates observed in this experiment are moderate but acceptable under pond culture conditions. Siddique et al. (2020) reported lower survival rates (18.5–20%) under similar conditions, whereas higher survival (55–95%) has been documented in other species such as *Margaritifera falcata* (Fernandez MK, 2013) and *Parreysia corrugata* (Suryawanshi AV and Kulkarni AN, 2015). These variations indicate that survival is influenced by multiple factors including species, environmental conditions, and implantation materials.

Nacre deposition is a critical determinant of pearl quality. In the present study, nacre thickness was highest in T<sub>1</sub> ( $0.83 \pm 0.17$  mm) followed by T<sub>4</sub> ( $0.79 \pm 0.15$  mm), while the lowest thickness was observed in T<sub>2</sub> ( $0.62 \pm 0.15$  mm) (Figure 5). The

higher nacre deposition in paraffin and calcium treatments suggests that these materials provide a favorable surface for mantle epithelial cells to secrete nacre layers (Pandey A and Singh A, 2015; Misra et al., 2009).

Interestingly, despite lower survival, calcium-based nuclei produced comparatively thicker nacre layers, indicating a trade-off between survival and pearl quality. This may be explained by the chemical similarity between calcium-based nuclei and natural shell composition (calcium carbonate), which enhances biomineralization efficiency and nacre crystallization (Dan et al., 2001).

Compared to earlier studies, the nacre thickness recorded in this study is significantly higher. Previous reports indicated nacre thickness ranging from 0.21 to 0.48 mm after 8 months of culture (Tanu et al., 2021; Siddique et al., 2020), whereas the current study achieved up to 0.83 mm after 11 months. This suggests that extended culture duration positively influences nacre deposition and pearl quality.

Luster is another important quality parameter. The highest luster was observed in T<sub>1</sub> (49.85 lux), followed by T<sub>4</sub> (47.82 lux), while T<sub>2</sub> showed the lowest (40.2 lux) (Figure 6). Higher luster in paraffin and calcium treatments may be attributed to better arrangement and uniform deposition of nacre layers, which enhances light reflection and surface smoothness (Dirlam et al., 1985; George, 1966).

Luster is directly dependent on the arrangement and thickness of aragonite platelets within nacre; therefore, improved nacre structure results in higher brightness and better gem quality pearls (Misra, 2005).

Water quality parameters recorded during the study (Figure 7) were within optimal ranges, including temperature ( $\sim 26^\circ\text{C}$ ), dissolved oxygen ( $\sim 5$  mg/L), pH ( $\sim 7.1$ ), and calcium concentration ( $\sim 19$  mg/L). These values fall within the recommended ranges for freshwater mussel culture (Rahman, 1992; Stirling, 1985; Dan et al., 2001). Therefore, environmental conditions were not a limiting factor, and differences in results are primarily attributed to nucleus material.

From a practical and commercial perspective, a clear trade-off exists between biological performance and pearl durability:

- Paraffin provides higher survival and production efficiency
- Calcium ensures better structural integrity and market acceptance

Although paraffin nuclei enhance survival, the resulting pearls are relatively soft and susceptible to deformation and heat damage during processing. In contrast, calcium-based pearls exhibit higher strength, durability, and resistance to handling stress, making them more suitable for commercial applications.

Shell and acrylic materials showed moderate performance, but their inconsistency in both survival and pearl quality limits their commercial viability.

## 5. Conclusion

Freshwater pearl culture, particularly the production of image pearls, represents a unique intersection of biology, craftsmanship, and sustainable aquaculture. This study was undertaken to explore how different image substrates: paraffin, shell, acrylic, and calcium image affect the quality of pearls produced by the freshwater mussel *Lamellidens marginalis*. The research was motivated by the growing interest in eco-friendly pearl farming in Bangladesh and the need to identify cost-effective, biologically compatible materials that can enhance pearl quality while supporting rural livelihoods.

A total of 2400 mussels were used across four treatments, each representing a different image substrate. The mussels were cultured in pond environments for eleven months, during which survival rates, pearl production, nacre thickness, luster and water quality parameters were meticulously monitored. The study also considered the broader biological responses of the mussels to each substrate, including their tolerance, post-operative survival, and ability to deposit nacre over time.

Overall, these outcomes highlight that while paraffin supported higher survival, calcium powder

remains the most suitable substrate for image pearl farming in Bangladesh due to its superior nacre deposition, luster. Shell and Acrylic image offers an intermediate option but with less consistency in pearl quality.

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