

CMFRI  
bulletin 39



JANUARY 1987

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**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE**  
(Indian Council of Agricultural Research)  
P.B. No. 2704, Cochin 682 031, India

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# **PEARL CULTURE**

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## CULTURED PEARLS-PRODUCTION AND QUALITY

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## INTRODUCTION

Pearls have a premium on quality. The quality differences are so subtle and discrete that even professionals in the pearl trade can make wrong judgements. The value of pearls, on the one hand, is decided on bulk by weight and, on the other, by the quality of individual pearls. Being a biological product, not coming from the assembly line of a factory, individual variations are infinitely large. The secretion of the mantle or the pearl-sac which leads to the formation of the pearl may be organic or inorganic or their combination with unpredictable variations in structure and composition and the product may range from the finest to the trash, even under the highest possible human control. Therefore, it is apt in this paper to consider the factors that contribute to successful production and to the quality of cultured pearls.

## PRODUCTION

The average pearl production rate in the Indian pearl oyster *Pinctada fucata* is about the same as in the Japanese pearl oyster *P. fucata martensi* because the techniques employed are almost identical. However, from batch to batch some differences are common. These are due to various factors such as the health and physiological condition of the oyster, gonad condition, treatment and care at surgery and the seasonal changes in the environmental conditions. Differences in production rates are illustrated in Table 1 which gives the data from the Veppalodai laboratory. These differences can be narrowed down through careful selection of oysters for seeding with nuclei and by controlling the human factors at the surgery.

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TABLE 1. Some examples of gross pearl production rates to show differences as observed at Veppalodai during 1974-1977

Examined on	No. of oysters	Gross production of pearls (No.)
22.1.'74	17	10
23.2.'74	9	9
23.7.'74	6	1
23.5.'75	38	25
10.12.'75	16	11
3.5.'76	22	17
24.9.'76	22	10
22.9.'77	12	10
Total	142	93 (65.5%)

The factors which are required to be controlled for achieving enhanced production rates are as follows :

**Selection of oysters :** Size and weight ; fouling load, boring by sponges and polychaetes and blisters ; gonad condition ; and general health as can be judged from the colour of visceral mass and gills.

**Conditioning process :** amount of menthol used for volume of water and number of oysters ; and duration of narcotisation.

**Graft tissue preparation :** One of the critical factors controlling the rate of production ; size and quality of donor oyster ; condition of mantle ; region from which mantle is drawn ; process of stretching, cleaning, trimming and piece-cutting ; care of orientation ; water quality and chemical agents used in maintaining the tissue pieces and duration of stay on the blocks ; orientation of epithelial sides and standard for nucleus-graft tissue size relationship.

**Implantation :** The most important factor in cultured pearl production ; selection of site ; deft handling of needles to reach site ; positioning and orientation of graft tissue in contact with nucleus ; general skill in surgery and patience ; extra care on multiple implantation.

**Convalescence :** removal of effect of narcotisation by periodic change of water or gentle flowthrough of water ; time for healing of incision ; and subdued metabolism.

**Maintenance of tools :** sharpness of tools ; sterilisation or good cleaning and sun-drying ; prevention of rusting.

Alagarswami (1974 a) reported 55.8% pearl production in the initial six batches of seeded oysters. He (1974 b) obtained 62.8% success in single implantation and 68.3% in multiple implantation with reference to the number of nuclei used and 62.8% and 180.6% respectively with reference to number of oysters used. It is possible to improve these rates further by careful control of the factors mentioned above. Shirai (1970) suggested 70% gross yield rate with 6-mm nuclei and 40% yield with 7-mm nuclei and stated that in the Japanese pearl oyster large nuclei involve a greater financial risk.

Gross production of pearls obtained during harvest is comprised of from the finest pearl to trash. Some of the pearls may be of outstanding colour and perfectly round shape ; many are inferior ; some are totally valueless as gems or jewels ; in some cases the oyster would have only the nucleus in round or eroded form ; and in others even the nuclei would not be present (Shirai, 1970). Such composition is common to pearl culture anywhere in the world. The economic success of pearl culture depends on the percentage composition of the various categories. The examples of results obtained at Veppalodai are given in Table 2. The categorisation has been simplified to denote only the following three grades of pearls to include those of the best quality or with one minor flaw in grade A, those with minor flaws which can be corrected through processing in grade B and those which cannot be considered to have any economic value except for retrieval of nuclei in grade C.

It may be useful to note the finer categorisation of cultured pearls of the Japanese beaching as given by Shirai (1970) as it is generally common for the pearls harvested from the Indian pearl oyster. Shirai's (1970) categorisation can be represented as follows :

**Class A :** flawless, one flaw, small flaws, small stain, pink, silver or light cream. Further

TABLE 2. Examples of composition of grades of pearls obtained in experimental work at Veppalodai in some batches during 1974-1976.

Examined on	Gross production (No.)	Grades (No.)		
		A	B	C
22. 1.'74	10	7	2	1
24. 1.'74	8	3	5	..
23. 2.'74	9	6	2	1
6. 9.'74	13	5	3	5
23. 5.'75	25	10	8	7
10.12.'75	11	2	6	3
3. 5.'76	17	2	9	6
Total	93	35 (37.6%)	35 (37.6%)	23 (24.8%)

categorised into : (A-1) top pearls—perfectly round, pink, flawless and lustrous ; but may include those with small blemishes about the size of a pin-point. (A-2) first class pearls with slightly larger pits and protuberances ; once treated, will become indistinguishable from top pearls.

**Class B :** fairly large flaws, stains, cream colour, irregularities of shape.

**Class C :** trash pearls ; wild shaped, badly coated, heavily pock-marked, clayey lumps, half good and half bad.

According to Shirai (1970), Class A and B pearls together usually account for about 60% of a beaching and class B pearls the rest 40%.

#### STRUCTURE AND COMPOSITION OF PEARL

According to Dubois (1909), as cited by Bolman (1941), the *Pteria* (= *Pinctada*) pearl has the following chemical composition :

Water	..	3.97%
Organic matter	..	3.83%
Calcite and aragonite	..	91.59%
Loss	..	0.61%
		100.00%

It is evident from the above that the pearl is essentially composed of calcium carbonate, which occurs in the two forms of calcite and aragonite, in a sparse organic matrix,

Wada (1970) describes the process of mineralisation of *Pinctada martensii* pearl as follows: A part of the organic substances in the specific solution secreted by the pearl sac epithelium is denatured to form conchiolin. The latter forming the organic matrix over the surface of an inserted nucleus provides the active surface for the initiation of crystal nucleation of calcium carbonate. For the first one or two weeks small crystals of calcium carbonate precipitate here and there on the matrix. These crystals grow larger and larger, join each other and develop into the first mineral lamella. Intercrystalline matrix is sandwiched between them. The second, third and subsequent lamellae are formed and crystals precipitate alternatively with conchiolin layer which is termed the interlamellar matrix. Consequently, the nacre of *Pinctada* pearl consists of the typical laminar structure just like a brick wall.

Wada (1970) further states that the particle size, shape and aggregation of crystals are influenced by the secreting activity of the pearl sac which in turn varies according to the physiological condition of the oyster and environmental factors. Regular laminar structure of nacre gives pearls the iridescence and good lustre, while pearls with an irregular laminar structure are poor in transparency and lustre.

Given the structure and composition of cultured pearl as above, it can be classified into three kinds, namely the nacreous layer pearl, prismatic layer pearl and organic layer pearl. In the nacreous pearl, which alone is valued as jewel, the mineral component is calcium carbonate in aragonite form and the organic matrix is composed of a protein having large amounts of aspartic acid, serine, glycine and alanine residues. The aragonite in the nacre is in a tabular form. The thickness of the lamella is in the range of 0.29  $\mu\text{m}$  to 0.6  $\mu\text{m}$  (Wada, 1970).

Bolman (1941), in his classification of pearls, refers to the following six categories: (1) conchiolin pearls entirely composed of organic matter or mixed with a certain percentage of calcium carbonate; (2) nacre pearls or aragonite pearls whose outermost layers consist of mother-of-pearl having the same relief drawing as on the internal surface of the shell of the pearl-producing mollusc exhibiting the terrace-shaped structure of the elemental lamellae of mother-of-pearl; (3) calcite-prism pearls consisting of some prism layers of calcite with or without a covering of nacre layers; (4) aragonite-prism pearls in which the prism layers are composed of aragonite (typical of freshwater mussel pearls); (5) pearls of translucent layers with columnar aragonite crystals situated perpendicular to the terrace-shaped mother-of-pearl laminae; and (6) pearls of

composite structure in which the above different substances appear in variable quantities.

It is evident from the structure and composition of the pearl that several formations are possible during the development of cultured pearls. Only those pearls formed by aragonite crystals in tabular (not prismatic) form, presenting a regular laminar brickwall like structure with microlayers of elemental mineral lamellae alternating with homogeneously deposited organic matrix in concentric layers around the inserted nucleus would qualify as gems. The rest of the formations would not and, therefore, will have less or no commercial value. It is important to realise that the present level of technology is not adequate to ensure bulk production of such quality and, hence the scientific pursuit is on towards achieving such a goal in future.

#### LUSTRE AND COLOUR OF PEARL

The lustre and colour of pearls are mainly due to the reflection and interference of light, and to some extent the colour of the component substance. There is a close correlation between colour and lustre and these are derived from the concentric and external structure of nacreous layers. The colours produced by the Indian pearl oyster are predominantly golden yellow and ivory white and some are grey (Alagarwami and Qasim, 1973). Other pearl colours are pinkish white, silver, cream, yellow, yellowish pink, gold, green, green pink, blue, steel black and black (Matsui, 1960).

Basically the colour of pearl follows the colour of nacre of the shell of the mollusc which produces the pearl which is genetically determined. Thus the pearls produced by *Pinctada maxima* are silver white, *P. margaritifera* black or steel grey, abalone green, freshwater mussels pink. The site at which the nucleus has been implanted also determines the colour. In *P. fucata* while the pearls produced in the ventral region of the gonad are white or golden, those produced in the dorsal region of the gonad in proximity to the hepatopancreas are grey or white. The physiological condition of the oyster again determines the colour of pearl. The environmental factors of the culture grounds play a role in colour formation. The important factors are depth and light penetration. The quality of phytoplankton forming the food of pearl oyster is another factor which is considered important.

Uchida and Ueda (1947) (*vide* Matsui, 1960) found that the golden and cream coloured pearls contain more copper and silver, skin coloured and pink pearls contain more sodium and zinc and that the gold pearl

contains more metal elements than the green ones; the colour varies according to the amount of porphyrins and metalloporphyrins present in the pearls. Sawada (1961) (*vide* Wada, 1970) observed that the iron-bound peptide in the nacre favours the formation of yellow pearls. The organic substances deposited at the beginning of pearl formation also would decide the colour. The good quality blue pearls are of this origin. Above all the granular and laminar structure of nacre produces the iridescence of pearls.

#### FACTORS DETERMINING QUALITY OF PEARLS

Although several species of pearl oysters occur in the sea, only a few have been found to produce pearls of gem quality. As already mentioned *P. maxima*, *P. fucata* and *P. margaritifera* stand out distinct from other species in this respect. Efforts to produce pearls in *P. sugillata*, *P. anomioides* and *P. atropurpurea* at Veppalodai with graft tissue either from the same species or from *P. fucata* did not yield satisfactory results. The pearls were translucent and dull in lustre and the rate of rejection of nuclei was higher. It shows that quality pearls can be produced only by certain species which are genetically capable of producing nacre of high quality.

The culture grounds play a significant role in determining the quality. According to Matsui (1960), some culture grounds yield pearls of good quality, whereas others do not. Some yield pink or white pearls while others produce only yellow and gold pearls. He opined that repeated culture on the same ground often affect the quality of pearl. The Japanese pearl culturists shift their rafts to different locations to take advantage of their potential for yielding good quality pearls. 'Make-up' culture during the final phase of farming has been a common practice (Alagarwami, 1970). There have been real difficulties in maintaining the quality of pearls in Japan since the late 1960s partly because of pollution problems affecting the quality of seawater (Simkiss and Wada, 1980).

Short-culture practice has been another reason for deterioration in the quality of pearls. Pearls should be allowed to reach maturity in proper time. As quoted by Ward (1985), the Japanese farmers kept the oysters in the water for two and a half years before 1960, but subsequently dropped the duration to one and a half years by 1979 and presently to six to eight months. This short-culture practice results in reduced thickness of nacre on the nucleus and affects the quality of the pearl. Pearls with 0.5 mm nacre in 18 months

is acceptable, but those with 0.2 mm nacre achieved in about 6 months are rushed into the market (Ward, 1985).

The rate of growth of nacre is dependent on the size of nucleus. Alagarwami (1975) observed growth of nacre in *P. fucata* pearls at Veppalodai as follows:

Nucleus diameter mm	Thickness of nacre mm	Duration of culture
3.00	0.32	191 days
4.00	0.31	161 days
5.81	0.26	159 days

The above data would show that in the Indian waters the rate of deposition of nacre is much faster than in the Japanese waters and hence pearls of acceptable nacre thickness can be produced at much shorter time.

The time of beaching of oysters for pearl harvest is considered important in getting the best quality. Winter has been found the ideal time in Japan. When the temperature falls down to about 10°C the oyster's metabolism is at the minimum and the nacreous layers deposited are thinner than at higher temperatures. The thinner mineral lamellae on top of the pearl enhances the lustre of the pearl. Also the pH of the body of the oyster is in the range of 7.3-7.5 in winter and the pearl at this time has a good iridescence (Alagarwami, 1970). Thus the time of harvest has to be decided in accordance with the rate of deposition of nacre and the thickness of the mineral lamellae laid down in different seasons, keeping the above factors in view.

Besides the factors of management of pearl culture for improving the quality of pearls as stated above, the current thrust is on application of modern tools such as genetic improvement and tissue culture. These technologies are in early stages of development. The future for improving the quality of cultured pearls appears to be in the advancement in these two areas, besides improving the practices of pearl culture.

The technology of processing of cultured pearls through bleaching and dyeing is a highly specialised area for value addition which is managed by the pearl processing technicians according to the market needs of various trading centres (Shirai, 1970). It is believed that most of the cultured pearls in the market go through some kind of processing for removal of minor defects and improvement of colour.

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