MAKAPUNO-A Gelatinous Mutant Coconut Variety

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ABSTRACT
Makapuno is a mutant type of coconut, the endosperm of Makapunois thicker and softer instead of crispy (Ohler, 1999). It is used for making ice cream, confectioneries, candies, sweetmeats and other food products. The embryo of makapuno cannot germinate in situ. It is either seed propagated from the normal nut of makapuno bearing palms or through embryo culture technique. The Makapuno is highly valued coconut varieties in the South East Asia particularly in Philippines and Thailand because of its rare occurrence. There is a huge commercial potential for Makapuno nuts for new and diversified food and specialty items.

INTRODUCTION

The Makapuno fruit consists of very thick and fluffy solid endosperm almost filling up the whole cavity and has little or no water in its central space. The normal coconut has a hard, compact, and crisp solid endosperm with lots of coconut water, or liquid endosperm, in contrast, the Makapunonuts filled with a viscous, white, translucent jelly like endosperm. With the exception of the endosperm, Makapuno and normal coconut trees are similar in all morphological aspects. The naturally thick endosperm of Makapuno is four to five times more expensive than the normal coconut, it is utilized for dessert preparation, delicacies, and has other industrial and food applications, hence it has economic benefit. Macapuno was first described scientifically from wild specimens in 1931 by Edwin Copeland. The word “Makapuno” is derived from
a Filipino term meaning ‘tends to fullness’. They were cultivated commercially in the Philippines after the development of the "embryo rescue" in vitro culture technology in the 1960s by Emerita V. De Guzman. It has become an important crop in coconut-producing countries and is now widely used in the cuisines of Southeast Asia and the Pacific Islands. There are similar varieties found in other countries with different local names: Dua Sap (Vietnam), Dikiri Pol (Sri Lanka), Kopyor (Indonesia), Maphrao Kathi (Thailand), DahiNariyal (Myanmar), ThairuThengai (India), Dong Kathy (Cambodia) and NiuGaruk (Papua New Guinea).

How it is formed?

The makapuno embryo contains diploid chromosome number (2n = 32), and 78.4% of the endosperm cells showed nuclei with the expected triploid chromosome number (3n = 48). These cells were of regular size during the early stages of development (Abraham and Mathew, 1963), however towards endosperm maturity, there was a prominent increase in the frequency of abnormalities (e.g. cells of 6n, 9n, 12n, 24n, and 48n) (Abraham et al., 1966). The production of numerous polyploid cells, and the increasing incidence of abnormalities in the older makapuno endosperm, prevented further cell division, but promoted an altered mechanism of cell division called ‘amitosis’ (Abraham et al., 1965, Abraham et al., 1966).

Significant differences between makapuno and normal coconut have been observed in the make-up of the endosperm fractions (Del Rosario and Gabuya, 1980).

de la Cruz and Ramirez (1968) found two major cell types in the makapuno endosperm. There were microcells which were smaller and had a highly disorganized shape was discovered in the study other than the normal cells, with a regular shape. These microcells may originated from the irregular cell division of normal cells, or through amitosis. Sebastian et al., 1987 observed that the makapuno microcells had a loose cell wall structure, indistinguishable cell borders, irregular size and were often elongated which distinctly reduced their intercellular adhesion, leading to the unique texture of the endosperm. The viscous part of the endosperm contains high level of polysaccharides (14.4%) and mostly galactomannans compared to normal fruit (7.5%). Mujer et al. (1983) reported that, there is higher activity of peroxidase in makapuno fruits in early developmental stages and lower nearing maturity. The changes in peroxidase activity increased the biosynthesis of indole-3-acetic acid which may triggered the over-proliferation of microcells in the makapuno endosperm. Additionally, in makapuno endosperm, there is an acute deficiency of a-D-galactosidase (8300-fold lower as compared with normal fruit endosperm) and the decreased activity of β-mannosidase. These might inhibit the degradation and mobilisation of certain reserve polysaccharides. Loss of this energy source would then lead to the failure of embryo germination (Samonte et al., 1989).

Torres, (1937) reported that, Makapunois due to a triploid, homozygous single recessive gene (mmm) trait, with the makapuno-bearing palm being heterozygous (Mm) with respect to this trait. These observations, however, differed from the expected outcome from a single recessive gene. In contrast, Ramirez (1991) postulated that alterations in the transcription of genes encoding for the
enzymes involved in galactomannan metabolism might create the makapuno endosperm trait. The issue of gene control of makapuno endosperm production has yet to be resolved.

**Makapuno Varieties and Hybrids**

In Makapuno trees, when the recessive pollen self-fertilized with a recessive ovary, the resulting homozygous recessive genotype yields a Makapuno nut. This is the reason for lower frequency of Makapuno coconuts in a single bunch. The breeding of pure Makapunoyielding palms was carried out in Visayas College, Bay Philippines by hybridization of embryo rescued recessive tall Makapuno palms and the selfpollinating dwarf coconut palms with the objective of combining the high degree of selfpollination with the Makapunobearing character. The F1 nuts were selfed and the F2 generation nuts was embryo rescued and examined the morphological traits. In this breeding process, two types of Makapuno bearing trees were noticed. One was a dwarf type with 90% intraspadix overlapping (possibility for self pollination) while the other was similar to DXT hybrid. However both types gave more than 90% Makapuno nuts and were named VM1 and VM2 (Visayas Makapuno 1 and 2), respectively (Nunez et al., 1996). Further, four dwarf x Makapuno crosses were developed namely CNO x MAC, Malayan Red dwarf (MRD) x MAC, Malayan Yellow Dwarf (MYD) x MAC and TAC x MAC. Homozygous Makapuno (mm) palms of the F2 and F3 have been derived from those hybrids. The homozygous palms proved to be precocious, flowering at 26 months from field planting (Nunez, 2003).

Five Makapuno coconut varieties viz., VMAC-1, VMAC-2, VMAC-3, VMAC-4 and VMAC-5 were released by the National Coconut Research Centre, Leyte State University, Baybay, Philippines. These five varieties showed significant differences in the physical attributes such as thickness of endosperm (2.2-3.5 cm) and weight of the solid endosperm (232 g kg-1). DXT Makapuno hybrids were noteworthy for high intraspadix overlapping that may lead to 100% Makapuno nuts. Selfing was observed to be little higher in the hybrids than in normal Makapuno palms (Nunez et al., 1990).

**Nutritional composition of Makapuno nuts**

Nutritive value of makapuno/kopyar nuts was studied by Santosoy et al (1996). The chief constituent of Makapuno meat was carbohydrate, followed by lipid, in contrast to that of the normal mature meat which is an oil source. McAllan (1985) estimated the dietary fibre of Makapuno meat and it was hemicellulose while in the young meat it was cellulose. The dietary fibre of the normal mature meat was found to be composed of cellulose, hemicellulose and lignin in proportional amounts. Rosario & Gabuya (1980) reported that the main cell wall material of the normal mature coconut meat was hemicellulose and that of makapuno was pectin. The polysaccharides in meat of coconut have been reported to be mainly cellulose. Balasubramaniam (1976) reported that coconut meat contained high amounts of galactomannan and mannan. The mineral composition of Makapuno meat was comparable with that of the young or normalmature meat and this shows a good source of dietary minerals with potassium as the chief mineral. The vitamin content of Makapuno meat was also comparable with that of the normal-mature meat but with markedly higher content of vitamin C and a-tocopherol. The sweet taste of normal coconut is largely due to sucrose (Caray, 1921; Jayalekshmy & Mathew, 1990), and the contents of sucrose, glucose and fructose in Makapuno meat are higher than those in the normal-mature meat. The relatively higher contents of these sugars in combination with higher contents of citric and malic acids might contributed the deliciousness of Makapuno endosperm. In general, the composition of coconut water or meat varies with different factors such as palm variety, degree of maturity and the nature of
the soil on which the coconut is grown (Rosario et al., 1989, Adrian & Manahan, 1932, Kumar et al., 1975). The fatty acid composition of lipids from Makapunomeat is similar to that of lipid from the normal-mature coconut meat, with lauric acid as the chief fatty acid. Lipids from the young meat were found to contain oleic and linoleic acid in high proportions. The amino acid profile of proteins from Makapuno meat is dominated by glutamic acid, followed by arginine and aspartic acid. Compared to the proteins of normal-mature meat, lysine was very low in Makapuno meat. Proteins from normal coconut were reported to have a relatively favourable amino acid profile and a fairly high nutritive value (Molina & Lanchance, 1973; Hagenmaier et al., 1975). Gunathilake et al., (2009) studied the nutritional composition of Makapuno coconut and reported that it contains 38.91±0.9%, 2.95 ± 0.2%, 58.21± 3.6%, 17.62 ± 0.2%, 6.63 ± 0.3% and 14.59% of dry matter, ash, crude fat, crude fibre and carbohydrate respectively. The main dietary fiber components were pectin and hemicellulose while that of normal coconut was cellulose. Lignin content was significantly lower in the kernel of Makapuno coconut (3.98 ±0.9) than normal coconut kernel (6.14 ± 0.7%). Equivalent weight, methoxyl value, moisture, ash and acetyl value of Makapuno meat pectin were 1052.7 ± 11.08, 8.72 ±0.25, 85.8±1.65, 0.8 ± 0.04 and 0.09 ± 0.01 respectively. The main mineral found in Makapuno meat was potassium and vitamin C content was 2.32 mg/100g. The fatty acids composition of Makapuno meat was similar to normal coconut and saturated fatty acids constituted nearly 90% of total fatty acids and lauric acid is the main fatty acid followed by myristic acid.

**Value addition in Makapuno coconuts**

Food products developed from Makapunoincludes **makapuno** candy, balls, strings, tart, pie, muffin and macaroons. In The Phillipines, it is eaten raw or used as a ingredient in desserts like traditional food items viz., halo-halo and Pastillas. It is also used in pastries, cakes, ice creams, candies and beverages. Arancon (1996) reported Makapuno ice cream in Philippines is considered as one of the best flavoured ice-creams in the world. In Indonesian, Macapuno coconut (*kelapa puan/kopyor*) is considered a delicacy. *Es kelapapuan/ kopyor* is a dessert drink which is made using this Makapuno coconut. In Vietnam, macapuno is mixed with milk and crushed ice to make a smoothie and served with crushed toasted peanuts. Gunathilake (2010) standardized protocol for preparing value added products from makapuno at Sri Lanka viz., Dikiri spread, Dikiri Toffe and Dikiri added ice cream.

**CONCLUSION**

Makapuno is a specialty coconut of exceptional sensory quality and are used mainly for food processing. The high price of makapuno nuts showed that the demand is higher than the supply. So, the demand of seedlings is also to increase yearly. Based on the demand of makapuno for food processing, the demand of seedlings for growing, there is potential for development of makapuno plantation. The embryo culture technique successfully used for the production of makapuno coconuts. Apart from increasing the production of such quality seedlings, rigorous quality maintenance of products should also be considered. Shelf life at the market of these fruit types controls their viable shipping time, limitation of their market reach remains an issue which hampers prediction of their full market potential. Improvements in shelf life enable reduction in loss of quality during shipping/ transportation and further expand the opportunity for these uniquely interesting specialty coconuts to reach worldwidemarkets.

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