The influence of maturity of VMAC5 (*cocos nucifera* L. ‘makapuno’) on its physicochemical, proximate composition and fatty acid profile

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**Abstract.** “Makapuno” is one of the promising commodities of the Philippines with good nutritional quality. VMAC5 is the most recent “makapuno” variety developed by the Visayas State University, Baybay City, Leyte, Philippines. Maximum utilization of this commodity is dependent on its thorough characterization. This study aimed to determine the influence of nut maturity on its physicochemical, proximate composition and fatty acid profile. Results revealed that VMAC5 nuts were affected by maturity. An 8-month old nuts exhibited heavier weight compared to mature nuts. The total sugar decreased with maturity. TSS and pH were not affected by maturity. Proximate composition were affected by maturity with moisture content of 59.17-86.88%, crude protein of 1.58-2.62%, crude fiber of 2.24-5.43% and crude fat of 3.06-12.14% of which >50% were medium chain fatty acids (MCFA).

**Keywords:** coconut, makapuno, physicochemical, proximate composition, fatty acid profile

1. **Introduction**

Coconut is a nutritious food source being classified as a "functional food" because it provides many health benefits beyond its nutritional content [1]. Equally interesting is the coconut mutant, the “makapuno”, which is reported from the Philippines as early as 1931 by [2]. The term “makapuno” comes from the Filipino word *puno* which means “full” and so “makapuno” means “almost full” [3]. The “makapuno” coconut is by far more important to food processors because of its protein content which is higher than the normal coconut [2]. Further, the crude fat fraction is more than 90% saturated fatty acids [4][5]. Most of the saturated fat in coconut oil is easily digestible and converted quickly into energy and not stored in the body as fat [6].

The National Coconut Research Center-Visayas (NCRC-V) of Visayas State University (VSU) in Baybay City, Leyte has developed 5 “makapuno” varieties (VMAC1, VMAC2, VMAC3, VMAC4, VMAC5). The physical and proximate composition of the first 4 of these VSU-developed “makapuno” varieties excluding VMAC5 which is the most recent variety, a hybrid from Tacunan x tall “makapuno”
were reported by [7]. The fatty acid profile of the 5 VSU-developed “makapuno” varieties were reported by [8] and [9]. Aside from these, there is no other published work on the characteristics of VSU-developed “makapuno” varieties especially the VMAC5. This characterization of VMAC5 will provide insights in determining the nutritional content on its nut endosperm as well as the possible product formulations that can be derived from it. In addition, these profiles may also serve as guides in developing better varieties and hybrids. Moreover, this characterization is expected to help the farmers, entrepreneurs, and researchers determine the fruit maturity which is best in preparing novel products that can be derived from its endosperm.

2. Materials and Methods

2.1. Sample collection and preparation

“Makapuno” (VMAC5) nuts were procured from the experimental field of the NCRC-V, VSU, Baybay City, Leyte, Philippines. Seven (7) nuts from each of the different maturity (8, 9 and 10 months old) of VMAC5 were harvested and subjected to physical profiling. Chemical characterization followed the quartering method in preparing the sample. Three (3) replications were analyzed per parameter.

2.2. Physical properties

The weight of whole nut, dehusked nut, solid and liquid endosperm were determined using triple beam balance. The ratio of liquid and solid endosperm weight to their whole nut and dehusked nut weight was computed. Meat thickness and firmness were measured using a vernier caliper and penetrometer, respectively.

2.3. Chemical characteristics

The solid endosperm or “meat” was analyzed on its color (L*), total and reducing sugar, TSS, pH, proximate composition and fatty acid profile. The TSS, viscosity and pH were analyzed using Atago hand-held refractometer, NDJ-SS Digital LCD viscometer, and handheld pH meter, respectively. The total sugar, reducing sugar and starch content were analyzed using Phenol-sulfuric method, dinitrosalicylic assay and Anthrone method by [10][11][12], respectively. The color was determined using Lovibond LC 100. The proximate composition (moisture, crude fat, crude fiber, crude protein, and ash) was determined following the procedure of [13]. The fatty acid profile was analyzed by determining quantitatively the methyl esters of fatty acids using AOAC-IUPAC gas chromatographic method [13]. A spectrophotometric method of [14] was used to determine the lipid peroxidation.

3. Results and Discussion

The study focused on the basic characterization of the VSU-developed “makapuno” variety, VMAC5 nut. Determining the characteristics of this “makapuno” variety, helps establish its industrial matchbox significance or readiness for industrial applications and pave a way for its optimum utilization.

3.1. Physical characteristics of VMAC5 nut

Nut maturity of VMAC5 affected most of its physical characteristics. The whole nut of an 8 and 9-month old nuts were heavier (2610-3010g and 2182-2900g, respectively) compared to a 10-month old nut (1920-2300g) as shown in Figure 1. It was also observed that from 8 to 10 months old, the weight of the husk constituted around 50% of the nut total weight. The other 50% was composed of solid and liquid endosperm and shell.
Result also showed that the weight of solid endosperm or “meat” increased as the nut became mature and the meat became thicker (from 6.20 mm of an 8-month old to 13.75 and 14.00 mm of a 9 and 10-month old nut, respectively as shown in Figure 2a. This is due to the higher respiratory activity of “makapuno” endosperm compared to normal coconut that resulted to tumorous nature because of the disturbance of auxin-kinin balance [15]. The quantity of the liquid endosperm decreased as it matures with the corresponding increase in weight of the solid endosperm or “meat” (Figure 2a). The percent meat based from the weight of the whole nut and dehusked nut increased with nut maturity (Figure 2b). However, the percent weight of liquid endosperm to its whole nut and dehusked nut decreased with maturity. This data is useful if there is a plan to transport the nuts to urban areas.

**Physicochemical Characteristics of VMAC5 Solid Endosperm or “Meat”**

**Figure 2.** a) Percent weight composition and meat thickness and b) percent weight of the liquid endosperm and meat of VMAC5 to its weight of whole nut and dehusked nut at different stages of maturity

### 3.1.1. Meat firmness

The firmness of the “makapuno” solid endosperm or “meat” is one of the very important attributes to consider for its potential application. Figure 3 shows that firmness of VMAC5 meat increased from 8 to 10 months in three different locations of the nut meat (eye, middle and bottom portion) where measurements were taken. A significant increase in the firmness of meat was observed from 8 months old nut (3.94 kg/cm² to 6.90 kg/cm²) to 9 (7.21 -10.57 kg/cm²) with a very minimal increased in 10 months old (7.13 to 12.17 kg/cm²) regardless of nut locations and either front and back side of the meat. Generally, the middle (4.74 to 12.10 kg/cm²) and bottom portion (5.31 to 12.12 kg/cm²) of the nut meat were more firm than the eye portion (3.94 to 11.21 kg/cm²) regardless of maturity and on either side of the

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![Figure 1](image1.png)

**Figure 1.** Composition (weight percentage) of an (a) 8-month, (b) 9-month and (c) 10-month old VMAC5 nut
meat. The very soft meat was not yet manifested up to 10 months old because according to [16] and [17], budding and fragmentation of endosperm cells were observed beyond ten months of endosperm development. The ploidy level of the cells of the “makapuno” endosperm increases with the increase in the age of the nuts. After 10 months, amitotic division supersedes the normal mitosis due to high ploidy resulting into a round and loosely packed cells.

**Figure 3.** Firmness of VMAC5 solid endosperm or “meat” at different stages of maturity

3.1.2. Color, total and reducing sugar, TSS and pH. The front side color of the VMAC5 solid endosperm or “meat” was affected by maturity of the nut in which the younger the nut (8-month old), the higher the color value (near 100 as standard white color) compared to a more mature nuts (10-month old) as shown in Table 1. However, color was not affected by nut maturity at the back side of the meat. Color ranged from 60.05 to 89.02 (Table 1) which are all above 50 which mean that they are above grey or neutral color. The total sugar of VMAC5 meat ranged from 2.33 to 4.22% which was slightly affected by nut maturity. It decreased as the nut became mature (Table 1). Reducing sugar ranged from 1.23 to 1.43%, highest value was observed in an 8 and 10-month old nuts and lowest in a 9-month old. The TSS and pH values of VMAC5 meat were not significantly affected by nut maturity and the values ranged from 4.14 to 4.88°Brix and 6.86 to 7.06, respectively (Table 1). These results may be due to the slow respiratory activity exhibited by “makapuno” nuts towards maturity [15].

| Maturity (Mos) | Meat color ($L^*$) | Total sugar (%) | Reducing sugar (%) | TSS (°Brix) | pH |
|---------------|--------------------|-----------------|-------------------|-------------|----|
| 8             | 70.99a             | 88.40a          | 4.22a             | 1.43a       | 4.88a | 6.86a |
| 9             | 64.89b             | 89.02a          | 2.84b             | 1.23b       | 4.14a | 6.98a |
| 10            | 60.05c             | 88.23a          | 2.33b             | 1.41a       | 4.68a | 7.06a |

Means with the same letter are not significantly different at 5% using Tukey HSD.

3.1.3. Proximate composition. The proximate composition of the VMAC5 meat was generally affected by nut maturity as presented in Table 2. The meat of an 8-month old “makapuno” contained the highest moisture (86.88%) and decreased significantly as it reached 9 months old (59.17%) but increased slightly as it reached 10 months old (66.02%). This means that the dry matter composition was highest in a 9-
month old nut (38.83%) compared to 10-month (30.98%) and 8-month old nut (13.12%). These figures for moisture content were very close to the figure reported by [2] as cited by [18] which are 71.59% and 66.28%, respectively. From the dry matter component of the meat, specific components were analyzed such as crude protein, crude fat, crude fiber, ash and NFE was calculated. However, the report of these components in Table 2 was presented based on meat sample not based from dry matter composition. The crude protein content in an 8-month old nut meat was 1.58% of its meat (Table 2). This component increased significantly as the nut became mature accounting 2.62% and 2.11% in 9 and 10-month old nut, respectively. This quantity was lower compared to the values reported by [7] for the previous 4 VSU “makapuno” varieties but quite similar to the figure previously reported by [19] which is 2.4%. The report of [20] stated that mature “makapuno” endosperm has low glutamic acid and valine content. The crude fat component was also affected by nut maturity (Table 2). The meat from an 8-month old nut was lower in crude fat content (3.06%) compared with the meat from both 9 and 10-month old “makapuno” nut which contained 12.14% and 11.40%, respectively. A close figure of 17.60% was reported by [19]. The report of [7] stated that oil (crude fat) is the chief constituent of the 4 previously LSU-developed (now VSU) “makapuno” varieties (VMAC1, VMAC2, VMAC3 and VMAC4). However, it was also reported by [9] that more than 60% of the total fatty acid component of VSU-developed “makapuno” varieties are medium chain fatty acid (MCFA; chain lengths of 6 to 12 carbon atoms) [9]. It was pointed out by [21] that MCFA are more effectively absorbed and metabolized in the body as compared to saturated long-chain fatty acids (LCFA). The crude fiber content of VMAC5 meat was also affected by its maturity (Table 2). Higher crude fiber was observed at 9 (5.43%) and 10 (5.11%) months old nuts than 8 months old nuts (2.24%). This result was very close to the result of [19] which is 5.00% or 6.52 (cited by [18]) but higher compared to the result of [7] for the four (4) previous varieties evaluated that ranged only from 0.17 to 0.32%. The ash content of VMAC5 meat ranged from 0.14-0.36% and this component of the meat was not affected by its maturity. So, the NFE was higher in mature nuts (20.40% and 15.00% in 9 and 10 months old, respectively) than in younger nuts (6.10% in 8 months old). The result was close to the figure reported by [19] at 17.6% and within the values reported by [7] for the four (4) previous varieties which ranged from 4.36 to 25.34%.

Table 2. Proximate composition of VMAC5 solid endosperm or “meat” at different stages of maturity

| Maturity (months) | MC   | Dry matter | Crude Protein | Crude Fat | Crude Fiber | Ash | NFE     |
|-------------------|------|------------|---------------|-----------|-------------|-----|---------|
| 8                 | 86.88a | 13.12c     | 1.58b         | 3.06b     | 2.24b       | 0.14a | 6.10b   |
| 9                 | 59.17c | 40.83a     | 2.62a         | 12.14a    | 5.43a       | 0.24a | 20.40a  |
| 10                | 66.02b | 33.98b     | 2.11a         | 11.40a    | 5.11a       | 0.36a | 15.00a  |

Means with the same letter are not significantly different at 5% using Tukey HSD.

3.1.4. Fatty acid profile and lipid peroxidation. The fatty acid profile of VMAC5 meat presented in Table 3 shows that saturated fat was high in mature nuts (84.66% in 10-month and 83.97% in 9-month old nut) compared to younger nut (80.57% in 8-month old nut). However, majority of the saturated fat component were MCFA that constituted more than 50% of the total fat specifically lauric acid, a predominant fatty acid in “makapuno” which accounted more than 40% of the total fat. These results were generally lower as compared to the one reported by [9] and [22] but higher in terms of oleic acid in an 8-month old “makapuno” meat. A small amount of linolenic acid was found in the previous four (4) VSU-developed “makapuno” varieties as reported by [9] but was not detected in VMAC5. On the other hand, linoleic acid
component was detected and quite high in an 8-month old nut but not reflected in the previous report. The VMAC5 meat exhibited higher lipid peroxidation for a more mature nuts (44.59% and 44.85% for a 9 and 10-month old) compared to a younger nuts (38.34% for an 8-month old).

Table 3. Fatty acid profile and lipid peroxidation of VMAC5 solid endosperm or “meat” at different stages of maturity

| FATTY ACID      | CONCENTRATION, % | 8 months | 9 months | 10 months |
|-----------------|------------------|----------|----------|-----------|
| Caproic (C₆)    | 0.20             | 0.32     | 0.28     |
| Caprylic (C₈)   | 4.46             | 5.65     | 5.66     |
| Capric (C₁₀)    | 4.31             | 5.21     | 5.13     |
| Lauric (C₁₂)    | 43.41            | 46.91    | 45.85    |
| **MCFA**        | **52.38b**       | **58.97a** | **56.92a** |
| Myristic (C₁₄)  | 17.29            | 16.37    | 17.38    |
| Palmitic (C₁₆)  | 8.49             | 6.40     | 6.99     |
| Stearic (C₁₈)   | 2.33             | 3.04     | 3.30     |
| **Saturated Fat** | **80.59b**   | **83.97a** | **84.66a** |
| Oleic (C₁₈:₁)   | 7.14             | 3.26     | 3.19     |
| Linoleic (C₁₈:₂)| 1.13             | 0.28     | 0.47     |
| Linolenic (C₁₈:₃)| ND               | ND       | ND       |
| Arachidonic (C₂₀)| 0.07             | 0.06     | 0.06     |
| Behenic (C₂₂)   | ND               | ND       | ND       |
| Lignoceric (C₂₄)| 0.02             | ND       | ND       |
| **Unsaturated Fat** | **8.27a** | **3.55b** | **3.66b** |
| Lipid peroxidation | 38.3b      | 44.59a   | 44.85a   |

*ND = not detectable*

3. Conclusion
Maturity of VMAC5 nut affected its characteristics. A thicker and more firm meat from mature nuts is ideal for processing. The superior quality of makapuno meat from a more mature nuts in terms of proximate composition and fatty acid profile also a good mark as a potential condition for food product development.

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