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Comparative analysis of coconut water in four different maturity stages

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Abstract
The objective of the present study was to investigate the variation of physicochemical properties of coconut water taken from coconuts obtained at different maturity stages. The four maturity staged considered in this study were maturity stage 1 of the developmental stage of 7 months, maturity stage 2 of the development stage of 9 months, maturity stage 3 of the development stage of 11 months and maturity stage 4 of the development stage of 13 months. Coconut water samples of each maturity stage were analysed to determine the Total soluble solids (TSS), pH, Electrical conductivity, Titratable acidity and the electrolyte concentration. It could be concluded that Total soluble solids (TSS), pH, Electrical conductivity, and the electrolyte concentration were increased with maturation of coconuts but Titratable acidity was reduced. The data were analysed by Minitab 17 statistical package.

Keywords: Coconut Water, *Electrolyte concentration, Electrical conductivity, maturity stages*

1. Introduction
The coconut fruit of the coconut palm (*Cocos nucifera* L.) has been a great source of versatility and has probably been used by humans for centuries. Coconut water is considered as a refreshing and rehydrating drink as it contains sugars, vitamins, minerals, growth promoting factors, proteins and amino acids. It is reported that coconut water is the most sterile liquid and can be administered intravenously in small doses to the patients. Specially used as diluted solution with water for patients suffering diarrhea. The edible part of the coconut fruit (coconut meat and coconut water) is the endosperm tissue. Endosperm tissues undergo one of three main modes of development, which are the nuclear, cellular and helobial modes and the development of coconut endosperm belongs to the nuclear mode [1]. Nutrients from coconut water are obtained from the seed apoplasm (surrounding cell wall) and are transported symplasmically (through plasmodemata, which is the connection between cytoplasms of adjacent cells) into the endosperm [2]. Apart from its consumption as a natural drink, one of the most important uses of coconut water is medicinal [3]. In the Indian ayurvedic medicine, it is described as "unctuous, sweet, increasing semen, promoting digestion and clearing the urinary path" [4]. Coconut water is significantly sweeter, caused less nausea, fullness and no stomach upset. It was also easier to drink in large quantities than the carbohydrate-electrolyte beverage and plain water. Concerning blood pressure, a mixture of coconut water and Mauby bark syrup (*Colubrina arborescens*) from Trinidad and Tobago could have a beneficial effect on human hypertension [5].
Minerals such as potassium, sodium, calcium, phosphorous, iron, copper, sulfur and chloride are present in coconut water. Potassium rich, tender coconut water increases the urinary output [6].

2. Materials and Methodology
2.1 Sample Collection
Tender coconuts and king coconuts used for the research study were obtained from a coconut plantation at Polgahawela, Sri Lanka.

2.2 Sample Preparation
Harvesting of Coconut
Coconuts of four different maturity stages were obtained. Maturity stage 1of the developmental stage of 7 months, maturity stage 2 of the development stage of 9 months, maturity stage 3 of the development stage of 11 months and maturity stage 4 of the development stage of 13 months that are in sound condition were used as the source of coconut water which were harvested during the cooler part of the day.

Washing the coconut fruits
First the coconut fruits were washed with potable water for the removal of extraneous matter. Then washed coconut fruits were soaked in a dilute bleach solution (1 tablespoon bleach per 4.5 liters of water) for 15 minutes. Then the sanitized coconut fruits were transferred to a clean surface off the ground to air dry.

Sanitization of tools and implements for processing
All tools and implements were washed with a cleaning agent and potable water and transferred to sanitizer (1 tablespoon bleach per 4.5 liters of water) for 15 minutes.

Sanitization of PET bottles and caps
All bottles and caps were washed with potable water and sanitized by soaking in a dilute bleach solution (1 tablespoon bleach per 4.5 liters of water) for 15 minutes and allowed to air dry in the inverted position.
The water was obtained within 48 hours of harvest. Filtration using a sanitized stainless steel strainer to remove fibers and endosperm (meat) particles. Coconut water was separately filled into the sterilized PET bottles.

2.3 Physicochemical Analysis of coconut water at different maturity stages.
Total Soluble Solids (TSS) - The brix values (TSS) of samples were measured using a portable hand held refractometer at room temperature.

pH Value - The digital pH meter (Hanna Instruments HI84435-01 Mini Titrator and pH Meter) was calibrated against standard buffer solutions. The samples were mixed well to homogenize and the pH values were measured using the calibrated pH meter.

Electrical Conductivity - The conductivity meter was calibrated against standard buffer solutions. The samples were mixed well to homogenize and the conductivity was measured using the calibrated conductivity meter.

Titratable Acidity (TA) - Titratable acidity was determined according to the AOAC method [7].

Determinations of minerals by atomic absorption spectrophotometer - Dry ashing and the metals were quantified by Atomic Absorption Spectrometer (Buck Scientific model 210 VGP)

3. Results and Discussion
The resulting data were statistically analyzed using Minitab 17 statistical software and can be interpreted as follow.

3.1 Variation of Total soluble solids (TSS).

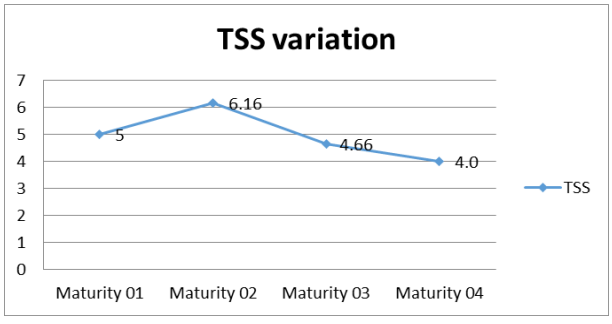

Fig 1: Changes of TSS of coconut fruits with maturity

According to the figure 1, the initial Brix values of samples, maturity 01 and maturity 02 appear gradual increasing and brix value between samples, maturity 03 and maturity 04 gradually decreasing. The maturity stage number 02 appears the highest value of the TSS value. The reason behind this is when coconut fruits becomes to the maturity stage 02, they start the development of the kernel, and therefore at this stage it starts the reduction of TSS value. When developing kernel it absorb the soluble materials existing in the coconut water. Therefore, TSS value of the coconut water decreased with maturity.

3.2 Variation of pH
The pH of the coconut fruits was measured at room temperature. Results pertaining to changes occurrence on pH of the coconut fruit against the maturity of the coconut fruits are given in figure 2.

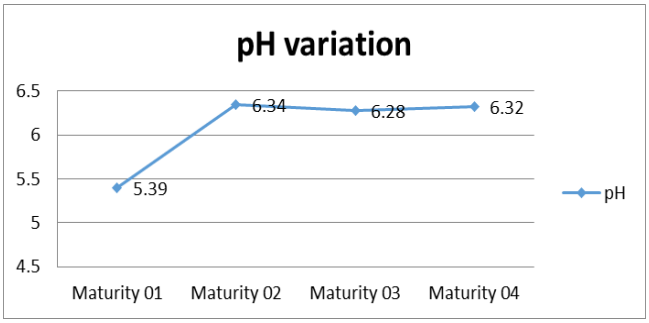

Fig 2: Changes of pH of coconut fruits with maturity

According to the figure 2, the initial pH values of sample maturity 01 increases up to maturity 02 and pH value of samples maturity 02, 03 and 04 appear the same pH values.
The pH of the samples varied slightly with maturation; overall, the pH of coconut water increased as the coconuts matured from 7 to 9 months and thereafter pH level fluctuate with slight values. In this case, pH increased steadily throughout maturity stage 1 and 2, and then slightly decreased in maturity stage 03 and again pH slightly increased in maturity stage 4.
The findings on the increase of pH with maturity supported those of [8] who found that pH increased from 4.7 to 6.3 with a maturity in their samples.

3.3 Variation of conductivity
Changes occurring in electrical conductivity of coconut water during the maturation was measured using a conductivity meter. The figure 3 shows the change in electrical conductivity of coconut water with different maturity stages.

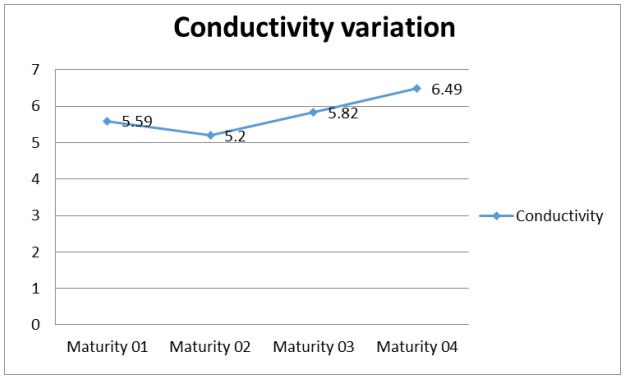

Fig 3: Variation of electrical conductivity of coconut water with maturity

Conductivity is a measure of the concentration of ions in solution. The units are given in micro Siemens/cm (mS/cm) and milliSiemens/cm (mS/cm). Highest mean value appear in maturity stage four and lowest mean appear in maturity stage 02. The electrical conductivity of natural cococnut water is 5.9±0.3 mS/cm [9] and the conductivity of the study samples maturity stage 01 and maturity stage 3 are observed within that range and maturity stage 02 and maturity stage 04 slightly deviate from the range. Variety difference or the maturity stage difference can caused to the above deviation.

3.4 Variation of Titrable acidity.

The degree of TA was measured at ambient temperature. Results pertaining to changes occurrence on TA against maturity level are given in figure 4.

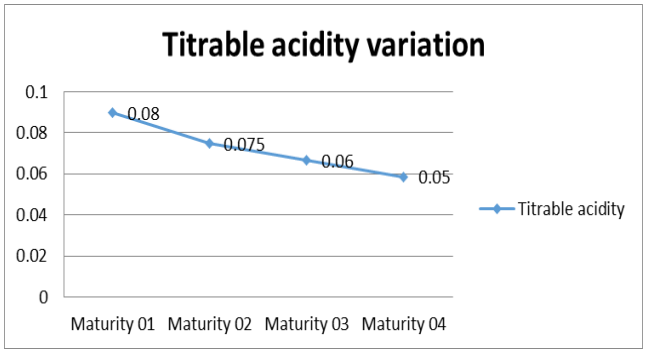

Fig 4: Changes of Titrable acidity of coconut fruits with maturity

The titratable acidity of the samples were expressed as malic acid %. Acidity affects the flavour of coconut water. According to the all these fig 4 highest value appear in maturity stage 01 and lowest value appear in maturity stage 04.

3.5 Variation of Electrolyte content

Sodium

Sodium concentration measured by atomic absorption spectroscopy. Limits of the measurement is mg/100ml.

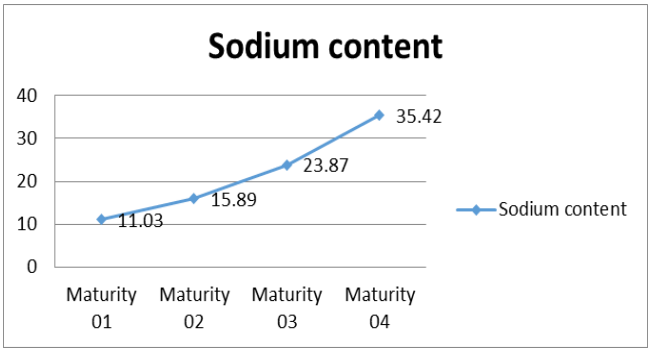

Fig 5: Changes of Sodium content of coconut water with maturity

Sodium is one of the important mineral for humans. Sodium concentration of the coconut water increase with maturity. Because coconut water volume reduce with maturity.

Potassium

Potassium concentration measured by atomic absorption spectroscopy. Limits of the measurement is mg/100ml. potassium is the major electrolyte in coconut water.

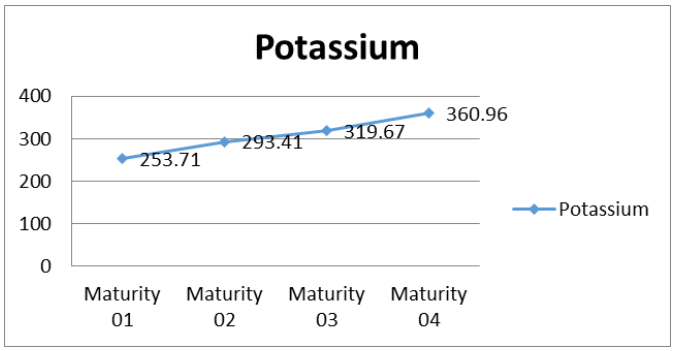

Fig 6: Changes of potassium content of coconut water with maturity

Potassium concentration of the coconut water increase with maturity. Because coconut water volume reduce with maturity. Potassium concentration gradually increase with the maturity of coconut water. As findings of the limits of Potassium level 299.06± 14.32 mg/100ml. readings are above these limits, maturity difference and variety changes can cause to that deference [10].

Magnesium

Magnesium concentration measured by atomic absorption spectroscopy. Limits of the measurement is mg/100ml.

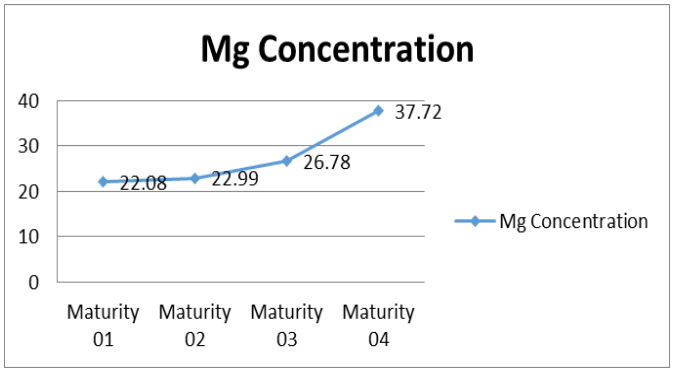

Fig 7: Changes of Mg content of coconut water with maturity

Magnesium concentration of the coconut water increase with maturity. Because coconut water volume reduce with maturity. Magnesium concentration gradually increase with the maturity of coconut water. As findings of [10] limits of Magnesium level 22.49 ± 4.52 mg/100ml.

Calcium

Calcium concentration measured by atomic absorption spectroscopy. Limits of the measurement is mg/100ml.

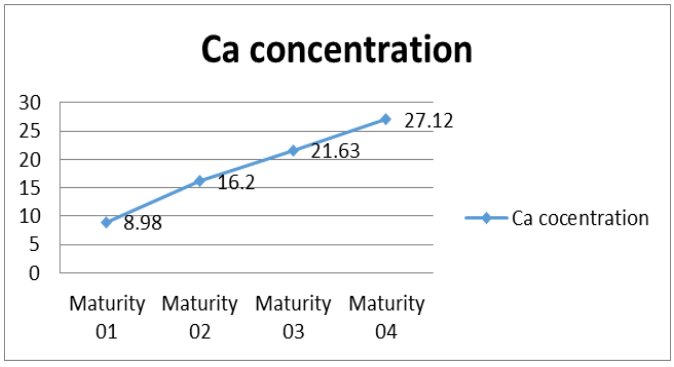

Fig 8: Changes of Calcium content of coconut water with maturity

Calcium concentration of the coconut water increase with maturity. Because coconut water volume reduce with maturity. Calcium concentration gradually increase with the maturity of coconut water. As findings of the [10] limits of calcium level 33.69 ± 2.52 mg/100ml.

Zink

As a results of ANOVA test P value is lower than 0.05. Therefore we can conclude that there is a significance difference between the Zink concentration of coconut water at different maturity stages under 95% level confidence level. Zink concentration of the coconut water increase with maturity. Because coconut water volume reduce with maturity.

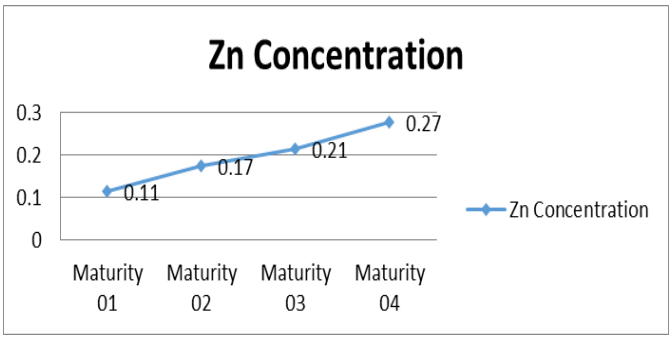

Fig 9: Changes of Zink content of coconut water with maturity

Zink concentration gradually increase with the maturity of coconut water. As findings of the [10] limits of calcium level in matured coconut water is 0.28 ± 0.02 mg/100ml.

4. Conclusion

A significant difference ($p<0.05$) was observed in TSS, pH, electrical conductivity, electrolyte concentration, Titratable acidity among the four maturity stages of coconut water. The total soluble solids were reduced during maturation. The pH was increased with maturation. The electrical conductivity was increased with maturation. The electrolyte concentration of all the considered minerals were increased with the maturity stage. The titratable acidity was reduced with maturation.

5. References

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