A Unique Coconut Water?

By: Reza Kamarei, Ph.D.

Coconut (Cocos nucifera L.) water is one of the world's most versatile natural products. It is the liquid tissue inside a young coconut that serves as a natural reservoir of nutrients and bioactive compounds to promote growth and produce "coconut meat."

The Reference Flavor of Coconut Water

In April 2012 I visited India for the first time. While the driver was taking me to different places in Kerala South India, we could see piles of fresh, green coconuts under the coconut trees offered to us by the roadside sellers. When the driver asked me if I would like to taste a fresh green coconut, my answer was an emphatic "yes." A roadside seller took a fresh green coconut in his left hand and, with a sharp machete in his right hand, cut the top off so that I could drink the fresh coconut water with a straw. The flavor (taste, aroma, and mouthfeel) of *fresh,* tender coconut water under the coconut tree is still vividly with me and I consider it the "reference flavor" of coconut water.

Scientific and Technological Challenges

A few years later, an Indian-American friend told me of his dream to bring the coconut water from Indian farms to American consumers without any organoleptic or nutritional degradation. This would require that the tender coconut water be directly transferred from a coconut into a bottle! I immediately considered the scientific and technological challenges that realizing his dream would have to overcome because fruits go through physical, chemical (including enzymatic), and microbiological changes upon harvesting – especially if there are bruised. The only way that these challenges could be overcome was to arrest all of these physiological changes and deliver coconut water that was sterile and intact both physically and chemically.

Nutritional and Bioactive Values of Coconut Water

The nutritional value of coconut water is shown in table 1, which outlines that one cup (240 ml) of coconut water is a "good source" of magnesium, potassium, and sodium (electrolytes), as well as vitamin B2. Consequently, coconut water is a naturally nutritious refreshment.

Table 1) Nutritional value of coconut water per 100 grams and per one cup (240 grams)
(Source: USDA Food Composition Database)

Nutrient	Unit	Value per 100 g	Value per Cup 240 g
Water	g	94.99	227.98
Energy	kcal	19	46
Protein	g	0.72	1.73
Total lipid (fat)	g	0.20	0.48
Carbohydrate, by difference	g	3.71	8.90
Fiber, total dietary	g	1.1	2.6
Sugars, total	g	2.61	6.26
Magnesium, Mg	mg	25	60 (16.8%)
Potassium, K	mg	250	600 (12%)
Sodium, Na	mg	105	252 (11%)
Riboflavin (B2)	mg	0.057	0.137 (10%)

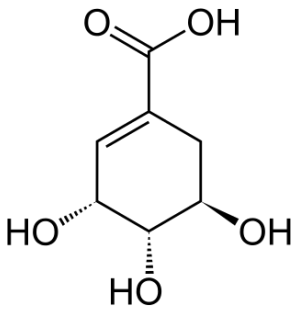
Some variations in nutritional composition of coconut water is expected due to natural and environmental factors such as variety, geographical location, stage of maturity, soil, water, sunshine, etc. Therefore, it is conceivable that one cup (240 ml) of coconut water can be a “good source” or even an “excellent source” of some other nutrients.

Saat *et al* (2002) conducted a cross-over study to assess the effectiveness of fresh young coconut water (CW) and a carbohydrate-electrolyte beverage (CEB) compared with plain water (PW) for whole body rehydration and blood volume restoration following exercise-induced dehydration. These researchers found that CW was significantly sweeter, caused less nausea, and was easier to consume in a larger amount compared with a CEB and PW. They concluded that ingestion of fresh, young coconut water, a natural refreshing beverage, can be used for whole body rehydration after exercise.

Interestingly, the classic nutritional value tables do not mention or refer to any bio-active compound in a product. Bioactive compounds (also known as phytonutrients or nutraceuticals) provide health benefits beyond basic nutrition upon ingestion.

Alleyne et al (2005) investigated the effect of regular consumption of two tropical food drinks, coconut water and mauby, on the control of hypertension using twenty-eight hypertensive subjects. These researchers found the largest decreases in mean systolic and mean diastolic pressure (24 mmHg and 15 mmHg respectively) in the group that received the mixture of both drinks.

The bioactive shikimic acid is found in coconut water. The shikimic acid pathway is related to the metabolism of carbohydrates and aromatic amino acids (Kugan and Verpoorte, 2013) and has a significant role in the growth and development of the coconut.

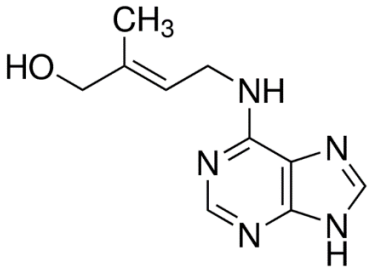


Shikimic Acid

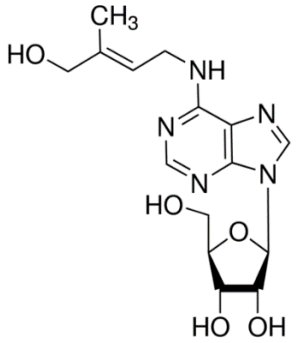
Shikimic acid has three hydroxyl groups (similar to gallic acid) and is therefore expected to have an antioxidant property. Manna et al (2014) investigated whether and how the coconut water concentrate (CWC) and its major active phytoconstituent shikimic acid (SA) can effectively protect murine hepatocytes from the deleterious effect of hydroperoxide-mediated oxidative stress. They found that CWC and its active component SA reversed the hydrogen peroxide induced oxidative damage in liver cells.

The chemical composition and biological properties of coconut water are thoroughly reviewed by Yong et al (2009). These researchers concluded that cytokinins (a class of plant substances that are involved in cell growth and differentiation) are the most important components in coconut water.

Lazim et al (2015) quantified cytokinins in coconut water from different maturation stages of two of Malaysia's coconut varieties. All native cytokinins are derivatives of the Adenine. The amount of cytokinins in coconut water was found to be maturation-level dependent. Trans-Zeatin riboside was noted to be the major cytokinin compound present in coconut water for both varieties.



trans-Zeatin



Riboside

Kim et al (2008) found that a Zeatin supplement improves scopolamine-induced memory impairment in mice, which suggest that Zeatin might be useful in protecting cognitive dysfunction and in reducing the activation of Acetylcholinesterase in dementia.

It has also been reported that trans-zeatin prevents amyloid beta-induced neurotoxicity and scopolamine-induced cognitive deficits in mice which suggest a possible chemo-preventive role of zeatin in Alzheimer's disease (Choi et al, 2009).

Effects of cytokinins, cytokinin ribosides and their analogs on the viability of normal and neoplastic human cells was examined by Casati et al (2011). While cytokinins trans-Zeatin does not show any effect, cytokinin ribosides, such as trans-Zeatin riboside impair the viability of normal and neoplastic cells.

Meeting the Challenges

Coconut waters available in the market are mostly from concentrate. This mean that coconut water is obtained by breaking the green (and sometimes mature brown) coconut open in the air, extracting the coconut water, thermally concentrating the recovered coconut water to a syrup (to facilitate overseas transportation), re-constituting the syrup with water back to single strength, pasteurizing, and packaging the coconut water to a finished product. The not-from-concentrate coconut waters in the market skip the thermal concentration and, therefore, the reconstitution steps.

Several factors can impact the nutritional and sensory properties of coconut water from the time the coconut is broken open in the air until it is in the hands of the consumer. The longer and more intense the exposure to such factors, the more severe the adverse impact on the sensory and nutritional quality of the recovered coconut water.

Physical presence of bits and pieces of coconut hard shell can cause the leaching of extraneous compounds including pigments into coconut water.
When coconut water is exposed to air, oxygen, as an oxidizing agent, can affect sensitive nutrients and bioactive compounds. Oxidation is a major cause of sensory and nutritional deterioration. In the absence of oxygen, lipid oxidation will not occur and enzymes polyphenol oxidase (which catalyzes enzymatic browning when tissue is damaged from bruising and exposure to air) will not have a chance to function.
Temperature accelerates chemical reactions. The concept of Q10 temperature coefficient (rate change of a biological or chemical system as a consequence of increasing the temperature by 10°C) is a reasonable guideline. This means that if extraction, storage, transportation, processing and distribution steps of coconut water can be done at refrigerator temperature (5°C instead of 15°C or 25°C), the organoleptic and nutritional quality of coconut water is better preserved.

Considering these factors, how can these challenges be met?

1) Extraction Stage
These challenges can be met at the extraction stage through technology explained in US patent 8,679,562. This technology is related to penetrating the shell of a green coconut within 48 hours from harvesting via a probe (the probe having a gas inlet and an egress port) and injecting nitrogen gas under pressure into the coconut through the gas inlet, thus enabling the gas under pressure to push the coconut water to an oxygen-free collection vessel.

2) Distribution Stage
These challenges are met at the distribution stage through technology explained in US patent 8,586,119. This technology is related to a method of distributing coconut water that has been extracted from a coconut in a manner that prevents oxygen from contacting the coconut water during extraction, manufacturing a product that includes coconut water, and distributing the product in oxygen-barrier packages to consumers through a refrigerated supply chain.

3) Microbial Reduction Stage
According to FDA's Juice HACCP regulation, juices must be treated for 5-log pathogen reduction of the most resistant microorganism of public health significance that is likely to occur in the juice (e.g., *E. coli* O157:H7). The 5-log pathogen reduction may be achieved using different methods:

a) Thermal pasteurization and ultra-pasteurization (UHT) are the most common methods for juices, but, parallel to the destruction of pathogens and spoilage bacteria, heat can also affect the nutrients and bioactive compounds in the juice and can change the flavor profile of the coconut water. Pasteurization offers a limited shelf life.

b) A better method in terms of safety and shelf life is the cold pasteurization High Pressure Processing (HPP), in which the juice, already sealed in its final package, is subjected to high pressure (transmitted by water) in the range of 100 to 800 Megapascal (MPa), for up to 30 minutes (1MPa = 10 Bar or approximately 10 atmospheres). However, while the high-pressure damages and destroys DNA of bacteria, it may also affect the nutrients and bioactive

compounds in the juice. The resultant juice, will have a shelf life of 45 to 90 days if stored and distributed through a refrigerated supply chain.

c) The best method possible is cold filter-sterilization of clarified juices in absence of oxygen. In this method, instead of leaving the killed bacteria (vegetative and spores), yeasts and molds in the product, they are *physically* removed without any nutritional damage to the juice. This exceeds the legally required 5-log microbial reduction of juices. Using an inert gas like nitrogen to eliminate oxygen from the head space of filter-sterilized juice during distribution and storage makes this the desirable 5-log pathogen reduction method, because, in such juices, no microbial or chemical oxidation is expected. Filter-sterilized juices packed under nitrogen in oxygen barrier PET bottles, and stored and distributed through a refrigerated supply chain should have 5 to 6 months shelf life. This method has not been used for microbial reduction of "coconut water" before. However, this method is now used for the first time on coconut water to meet the challenges explained above.

Conclusion

We can now see how to meet the scientific and technological challenges of bringing fresh coconut water from Indian farms to American consumers without any organoleptic or nutritional degradation. I tried bottled TAJA coconut water that had been prepared to meet the challenges described above and found its flavor (taste, aroma, and mouthfeel) to be exactly the same as the "reference flavor" under the coconut tree. Considering the novel technologies used at the extraction, distribution, and microbial reduction stages, and since (to my knowledge) no other coconut water in the world is processed from A to Z like this one, it is reasonable to conclude that TAJA coconut water is unique.

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