Production of Energy Drink from Coconut Water

R. S. S. Pathiranage[#1], M. A. M. Jinasena[*2], T. R. Jayawickrama[#3]
Student, Chemical and Process Engineering Department, University of Moratuwa, Katubedda, Sri Lanka

Abstract

Tender coconut water is one of the popular sport drinks. In this paper, flash pasteurization of tender coconut water was undertaken using lab-scale autoclave. Experiments were conducted at different temperatures in the range of 60-90 ^0C and cross flow rate 30mg/l to optimize the operating conditions. A simple laboratory process arrangement was used to flash pasteurization and cool down to room temperature within 2 minutes to avoid destroy nutritional value in natural coconut water. Various parameters of the feed and treated coconut water were carried out such as total soluble solids, pH, clarity, concentration of sodium, potassium, and total solids. A subsequent storage study was undertaken and it was observed that the filtered juice was successfully stored for 50 weeks in refrigerator and 30 days in normal environment. This study was adequately backed up by conducting a taste analysis.

I. INTRODUCTION

The mature coconut is a useful source of iron and potassium. Approximately 86% of the calories in coconuts is from the white meat inside the shell and are from fat calories, most of which is saturated fat. But the water of the coconut contains less than 1 %. So, the pure coconut water is Cholesterol Free and 99% fat free [1].

Coconut water, the liquid endosperm inside young coconuts, has long been a popular drink in the tropics. It is naturally fat-free and low in food energy (16.7 calories or 70 kJ per 100 g), and has potential as a sports drink because of its high potassium and mineral content [2].

Coconut water is extracted from young coconuts, and is an opaque, almost clear juice or water that has a slight almond flavor. Naturally low in fat and calories, with no cholesterol, and a balance of sodium, potassium, calcium and magnesium, it makes a healthy electrolyte drink. Usually consumed fresh from the coconut wherever it grows, the water has been used for rehydration and as a health and beauty aids in tropical regions around the world for centuries. Recent studies have confirmed its medicinal and therapeutic uses, and it is poised to enter the international sports drink market [3].

The major drawback of coconut processing has always been the speed of deterioration once the products are exposed to air; the water rapidly loses most of its organoleptic and nutritional characteristics and begins to ferment.

Domestic consumption of coconut water has shown an interesting shift towards increasing sales of water bottled on the spot, as an alternative to drinking from the nut itself. All would welcome a properly canned or bottled product that is tasty. Once the product can be assured of a reasonable shelf life of at least a few days to a week, there is every likelihood that sales will take off. A marketing effort to educate and confirm people's assumptions about the product would increase consumption markedly. Tender coconut water has already been accepted on the local market, though primarily a foreign product but the ability to compete on price and other product characteristics, will allow for successful entry into the foreign markets.Though capacities vary widely, an average water nut could contain approx. 260ml to 300ml.

The water of tender young coconut, technically is the liquid endosperm. It is one of the purest, most nutritious wholesome waters and beverages with which nature has provided us. The people in tropical regions and countries have been enjoying this drink for centuries. They have used the all-natural coconut water to refresh, refuel, re-hydrate, feed and maintain the proper nourishment and fluid levels in their bodies. The natural water has a caloric value of 17.4 per 100 gm [4].

It is naturally sweet, ingratiating, promoting proper digestion, and naturally helps clearing our urinary paths, and lubricating our body systems. These are some of the many numerous medicinal properties of young tender coconut water low in carbohydrates, low in fat 99% fat free, low in natural occurring sugar, keeps the body cool and at the proper temperature, contains organic compounds possessing growth promoting properties, cures malnourishment, effective in the treatment of kidney and urethral stones, natural drink for feeding infants suffering from intestinal disturbances, excellent oral re-hydration medium, an all-natural isotonic for all ages, natural diuretic, presence of saline and albumen makes it an excellent drink in cholera cases[5]. And more maintains the human body's natural fluid levels, aids in the quick absorption of drugs and

makes their peak concentration into the blood stream easier because of its electrolytic effect. Like the theory of fructose compounding with faster absorption into the cells and body it can be injected intravenously in emergency cases. Found as a blood plasma substitute because it is sterile, does not produce heat, and does not destroy red blood cells and is readily accepted by the body. It kills intestinal worms and aids in keeping the skin from itching, application on the body also helps prevent prickly heat, and summer boils, and helps subside the effects of rashes caused by chicken pox, hives, measles, small pox, mosquito and insect bites [6]. Further, helps control body's natural fluid levels to help maintain proper blood pressure, circulation, kidney functions, digestion, and liver functions. And more helps maintain our mental concentration and aids in the prevention of headaches by keeping the body's natural fluid levels maintained and the body properly hydrated. This natural isotonic beverage comes with the same electrolytic balance as we have in our bodies which is helps in carrying nutrients and oxygen to cells. Excellent all-natural water to anyone [7].

Nutrients in mature coconut water is shown in Table 1. Which has Vitamins, Sugar, Minerals, Protein and Amino Acids mainly [8,9].

A. Vitamins:

Young tender coconut water contains ascorbic acid. The concentration of ascorbic acid ranges between 2.2 to 3.7 mg per ml. This ascorbic acid content gradually diminishes as the kernel surrounding the water begins to harden up. The coconut water also contains vitamins of the B group.

B. Sugars:

The natural sugars in the forms of fructose and glucose form a crucial element of the young tender coconut water. The concentration of natural sugars in the water of the coconut steadily increases from about 1.5 % percent to about 5.0 to 5.5 % percent in the early months of maturation. This process slowly begins to fall back to around 2 % percent at the stage of full maturity of the coconut. It is in the preliminary stages of maturity when the sugars that are in the form of fructose and glucose (reducing sugar) and sucrose (non-reducing sugar) appear. Sucrose appears only in the later stages and increases with the maturity of the coconut, while the reducing sugars fall of. In the fully mature coconut approximately (90%) percent of the total sugars is in sucrose form.

C. Minerals:

Young tender coconut water contains many valuable minerals for our bodies such as calcium, sodium, potassium, copper, iron, phosphorous, Sulphur, and chlorides. Among the minerals that accounts for more than half the concentration of the coconut water is potassium. The environment in which the coconut trees are grown markedly influences the concentration of which. Young tender coconut water with its high concentration of potassium is the perfect electrolytic balance for our body. This help in the elimination of toxic waste from the body by increasing the urinary output.

Table 1: Nutrients in Mature Coconut Water

Nutrient	**Units**	**Value per 100 grams of edible portion**
Proximates		
Water	g	94.99
Energy	kcal	19
Energy	kj	79
Protein	g	0.72
Total lipid (fat)	g	0.20
Ash	g	0.39
Carbohydrate, by difference	g	3.71
Fiber, total dietary	g	1.1
Sugars, total	g	2.61
Minerals		
Calcium, Ca	mg	24
Iron, Fe	mg	0.29
Magnesium Mg	mg	25
Phosphorus, P	mg	20
Potassium, K	mg	250
Sodium, Na	mg	105
Zinc, Zn	mg	0.10
Copper, Cu	mg	0.040
Manganese, Mn	mg	0.142
Selenium, Se	mg	1.0
Vitamins		
Vitamin C, total ascorbic acid	mg	2.4
Thiamin	mg	0.030
Riboflavin	mg	0.057
Niacin	mg	0.080
Pantothenic acid	mg	0.043
Vitamin B-6	mg	0.032
Folate, total	mcg	3

D. Protein:

Coconut water contains insignificant amounts of protein. The percentage of alanine, arginine, cystine and serene in the protein of young coconut water is higher than cow milk. Soymilk is another major source of good protein. Since young coconut water does not contain any complex proteins the danger of producing shock to the patients is minimized.

E. Amino Acid Composition of Coconut Water:

The following Table 2 shows the percentage of each amino acid of the total protein content

Table 2: Percentage of Each Amino Acid of the Total Protein Content

Amino Acid	% of total Protein
Alanine	2.41
Arginine	10.75
Aspartic acid	3.60
Cystine	0.97 - 1.17
Glutamic acid	9.76 - 14.5
Histidine	1.95 - 2.05
Leucine	1.95 - 4.18
Lysine	1.95 - 4.57
Proline	1.21 - 4.12
Phenylalanine	1.23
Serine	0.59 - 0.91
Tyrosine	2.83 - 3.00

There are several advantages of investing in this industry such as good average returns on investment over the life of the project, year-round availability of cheap raw materials, with the use of appropriate machinery, the labor involved is not expensive, as it is mostly unskilled and widely available. There are additional government incentives for agro-processing operations [10]. Either of these operations is a viable project on their own, but will benefit from synergies of production if the investment is made for all operations.

Energy drink can be prepared using tender coco water as well as mature coconut water. Considering the available processes, economics of the byproducts it was decided that normal coco water is the most suitable for such a beverage production. Although the tender coconut water is high in nutritional characteristics, normal coco water contains almost all essential nutrients which should be available in a sports drink [11]. However, the amount of lipid available in mature coco water is higher than tender coco water and a normal sport drink. To reduce lipids to necessary level centrifugation technique was utilized which is not necessary if the beverage was prepared from tender coco water.

On the other hand, if tender coconut was used for the beverage production the economic benefits gained from the project is far less than using the mature coconut water. Because the commercial value of he by products will be far less.

Most commercial production today utilizes a high-temperature short-time pasteurization (the same technology used in UHT long-life milk). This is a thermal processing technique which eliminates not only the risk of bacteria, but also some of coconut water's nutrients and almost all its delicate flavors. This severely limits the product's marketability. In addition, during canning also most of nutrients & delicate flavors get lost.

The cold preservation process recommended by FAO instead protects the natural flavor of coconut water. The process involves filtration, bottling and rigorous temperature control.

The cold preservation process requires little investment and skills, and it offers small entrepreneurs a chance to enter the market of bottling coconut water of excellent quality. By this method bottled coconut water that stays fresh from 10 days to three weeks can be produced. The simple cold preservation process will provide the consumer the convenience of purchasing a bottle of refreshing coconut water which contains almost all vital nutrients of fresh coco water and it opens new pathways for small farmers and entrepreneurs in coconut producing countries. This cold preservation technology is not protected by a patent and can be used by anybody.

Essentially, the cold preservation process involves filtration to remove particulates that might affect the coconut water's appearance, bottling under hygienic conditions and rigorous temperature control. Good practices need to be applied at every step, from harvesting, loading and transporting to cutting, bottling and sale.

Extracting the precious liquid is done by first trimming the husk with a sanitized stainless-steel cutlass, then opening the shell. The water inside is decanted into a sanitized container equipped with a strainer lined with a sanitized silk screen or cotton cloth. The filtered water should be promptly transferred to a cooling tank and cooled to 4°C, or placed in a freezer for three to four hours. Where large volumes of coconut water are to be bottled, the use of a refrigerated cooling tank for rapid cooling is highly recommended. Waste material - mainly husks - must be removed from the processing environment and promptly disposed of.

The water must be quickly bottled and sealed - in bottles that have been rinsed in potable water and sanitized for 15 minutes - then stored in a chiller at 4°C. The bottling facility needs to be clean and free of animals, insects, dust or garbage, and physically separate from area where the coconuts are cut open.

Bacteria and yeasts are the main micro-organisms that threaten freshly bottled coconut water. It is critical, therefore, that the temperature of the bottled water be kept at between 0 and 4°C during transportation to preserve quality and to prolong shelf-life. Finally, the manual advisers, processors need to make sure that their product is handled with care after delivery. Continuous Monitoring of retail outlets will ensure that the bottled coconut water is stored at the correct temperature and away from direct light.

Most commercial production today is carried out in Indonesia, the Philippines and Thailand, using high- temperature/short-time. But thermal processing has a drawback - it eliminates not only the risk of bacteria, but some of coconut water's nutrients and almost all its delicate flavor. This severely limits the product's marketability.

The answer is micro filtration technology. Micro filtration process for the sterilization of coconut water is straightforward. Coconuts are harvested by lowering to ground, at the age of maturity. The harvested coconuts are thoroughly water washed, then sanitized by transferring to a 1% bleach solution for at least 15 minutes. The nuts are cut, and the coconut water is immediately filtered through a coarse filter to remove solids and particulates. The water is then transferred to a sterile refrigerated tank and cooled to 4-6 degrees C to avoid fermentation and enzymatic deterioration during further processing [12, 13].

Though microfiltration can guarantee a commercially sterile product, it requires skills and investments that are often beyond the capacity of small and medium-scale processors.

II. MATERIALS AND METHOD

A. *Raw Material*

For the final process, matured coconut water was selected, although the canning procedure is complicated than the young coconut water canning process, it's more usable when considering the by-products.

Natural coconut water contains almost all the requirements of a sports drink so the canning procedure is simple. Only a few is to be added. After the coconut water is separated from the shell it was kept at a temperature of 10^0C. Then lime is added as preservatives. Lime was chosen because it is not only a preservative but also a natural food additive.

Sports drinks do not contain proteins and fat. Therefore, to remove it, a centrifuge is used. After removing the fat, protein and suspended solids the clear coconut water is sent to the mixing tank. The required amount of sugar, sodium chloride and other ingredients were added in the mixing tank. Then it is filtered. The purified coconut water is then pasteurized. For all the above samples were added the following amounts of salt, glucose and lime juice to reach the requirements of an energy drink and to obtain a good taste to 300ml of coconut water (Table 3).

Table 3: Additions to the Coconut Water Sample

Ingredient	Amount
Salt (g)	2.156
Glucose (g)	39.226
Lime Juice (ml)	10

B. *Method*

1) *Heat Treatment*

The prepared apparatus which can be sterilized in auto clave. Using this apparatus, coconut juice could have injected to a holding tube which is heated to 80 ^{0}C by circulating hot water around it. This heated product was collected to a container which was soaked in an ice bath, so that we could guarantee an immediate cooling down from 80 ^{0}C to 30 ^{0}C.

This whole experiment was carried out inside the laminar flow equipment to minimize contamination. All the equipment including the glass ware, cotton wool, injection syringe, steel ware used for mixing were sterilized prior to the experiment by keeping inside the autoclave. The pure product obtained from the experiment was kept in a refrigerator for one month. Glucose was added to another sample, and it was also refrigerated. A blank sample from the unprocessed coconut water was also kept in refrigerator.

2) *Microbial Analysis*

The microbial analyses were performed using the plate count method. The sample was serially diluted in a phosphate buffer solution and plated in duplicate onto selective media. Mesophilic microorganisms, total coliforms, yeasts and molds and lactic acid bacteria were plated onto plate count agar and malt extract agar. The incubation temperatures and times were: 30 C for 48 h for mesophilic microorganisms; 30 C for 24 h for total coliforms; 25 C for 4 d for yeasts and molds; and 35 C for 48 h for lactic acid bacteria. At the end of the incubation periods, the number of colonies was counted and the inactivation level was determined by evaluating the Log (CFU/ml) of the microorganisms before and after the treatments. The results were means based on data from at least three experimental runs. All the samples were checked for their bacterial count weekly.

*3) **Quality Control***

The physical chemical was performed on coconut water samples stored at -20 ^{0}C. The day of the analysis, the samples were thawed at 4 C (overnight) and processed without incubation. Microbiological analyses were performed to verify the inactivation of the natural microbial flora to undetectable levels.

*4) **Physical Chemical Analysis***

The pH of the samples was measured with a digital pH meter. Water content was determined by weight loss during heating at 80 ^{0}C for 2 h and dry matter by the resulting weight difference.

The color of the coconut water was determined using a portable colorimeter.

*5) **Centrifugation***

As proteins and fats are not easily digesting it is not suitable for an energy drink to obtain instant energy. To, remove it; some laboratory experiments were carried out to compare the separation efficiency of fats and proteins by centrifugation and extraction. Finally, that centrifugation is better in terms of efficiency and in terms of cost effectiveness.

III. RESULTS AND DISCUSSION

Unprocessed sample underwent rapid deterioration. Taste of the sample changed during few days. Cloudiness developed in the product and was not suitable for consumption after a week. Processed coconut water sample showed a significant less bacterial count than the unprocessed one. In first few weeks the bacterial count in the processed beverage was zero.

As Flash pasteurization was decided for the method of preservation of coconut water, samples of coconut water were tested to observe the microbial growth. The test results are as follows.

Table 4: Microbial Growth In Coconut Water Samples

Dilution factor (10^{-x})	Number of microorganisms		
	Raw sample	Pasteurized with glucose	Pasteurized without glucose
0	182	1	2
1	13	8	0
2	2	1	0
3	3	0	0
4	2	1	0
5	2	0	0
6	1	0	0

The test result could be observed as follow. The appearance of the above samples by keeping them at room temperature.

The observations are as follows.

- Blank sample-Cloudy
- Pasteurized with glucose-Clear
- Pasteurized without glucose-Clear

Microbial analysis performed on heat treated coconut water demonstrated that 80 ^{0}C for 1 min was sufficient to inactivate the natural microbial to undetectable levels.

Color indication of heat treated sample and bank samples were shown clearly different. In other words, treated products were less bright than blank coconut water. Treated coconut water pH was lower than normal coconut water as it was added lime.

Both samples had no significant effect on dry matter and soluble solid content of coconut water. However, minerals were (Mg, K, Ca and Fe) were lower in heat treated coconut water.

IV. CONCLUSION

This study indicated the feasibility of heat treatment as low temperature pasteurization of fresh coconut water. The ideal process conditions were determined to be 80 ^{0}C 2 minutes and cool down to 30 ^{0}C rapidly induced about reduction of mesophilic microorganisms, lactic acid bacteria, yeasts and molds. Few difference in the physical chemical and nutritional attributes were indicated. No difference was observed in dry matter, soluble solids, sugars and vitamins content although a reduction of its volatile fraction was detected.

Overall, the study demonstrated that pasteurized coconut water can be used as an energy drink while it can be stored in normal room temperature than one moth. Refrigerated sample could keep nearly one year.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Dr. Maralia who always guide and support to carried out this project successfully. And need to thank full laboratory staff who support to done all lab works in Chemical Engineering Department, Universality of Moratuwa.

REFERENCES

[1] Preetha P., Devi V., G., Rajamohan T., "Comparative effects of mature coconut water and glibenclamide in some biochemical parameters in alloxan induced diabetic rats", Revista Brasileira de Farmacognosia 2013; 23(3):481-487.

[2] Tamara T., Tory M., F., Narco T., Kathleen C., "The intravenous use of coconut water", The American Journal of Emergency Medicine 2000;18(1):108-111.

[3] Reddy K., V., Madhusweta D., Das S., K., "Filtration resistances in non-thermal sterilization of green coconut water", Journal of Food Engineering.2005;69(3):381-385.

[4] Salgueiro C.,C.,M., Nunes J.,F., "Powder coconut water on biotechnological processes", Journal of Biotechnology. 2008;136:101-102.

[5] William M. Cutting., "Coconut water and Home Rehydration": University of Edinburgh, United Kingdom; 2001.
[6] Venkatraman A., Khawaja A., Shapshak A.,H., "Homorrhagic stroke after consumption of an energy drink", The American journal of emergency medicine. 2017;35(3):522-527.
[7] Ressig C., Eric C.,S., Roland R., G., "Caffeinated energy drinks- A growing Problem", Drug and Alcohol Dependence.2009;99(1):1-10.
[8] 1984 - Coconut today vol 2 No(1)
[9] The Philippine journal of coconut studies vol 4 No 2
[10] Sharma J., Vinod L., "Indian Coconut Journal"; 1986 Vol 17(2)
[11] Thampan G.,M., "Hand book on Coconut Palm"; Third Edition
[12] Coulson J.,M.,Richardson J.,F.,"Chemical Engineering Volume 2- New York;2001
[13] Coulson & Richardson "Chemical Engineering Volume 6- New York;2005