Automation In Coconut Water Extraction and Breaking Machine – A Review

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Abstract—

Mature Coconut water is rich in carbohydrates and electrolytes such as potassium, sodium, and magnesium, but lot of coconut processing industries are wasting tons of coconut water because they did not have proper way of water collection system. And also, lots of copra industries are using manpower to break the coconut it is unhygienic and time-consuming process. To overcome such problems facing in copra industries we developing a coconut cutting cum water collection machine with cooling system. The main aim of this machine is to minimize the coconut water wastage , hygienic way of water collection, and cooling system maintains the coconut water in certain temperature to avoid fermentation. By collecting coconut water, we can produce lots of byproducts like ready to drink coconut water, coconut water vinegar etc... Which is completely natural product containing lot of micro and macro nutrients.

Keywords*— Mature Coconut Water, Coconut Water, Existing Machines, Coconut Water Collector, Cooling System, Waste Utilization.*

1. INTRODUCTION

Cocos nucifera (L.) is a critical family member Aceraceae (palm family) popularly referred as coconut. The plant is originally from Southeast Asia (Malaysia, Indonesia and the Philippines) and the island between the Indian and Pacific Oceans. The coconut are the fruits of the cocos tree, which is part

of family of palm trees. The term “coconut” may refer to the entire coconut palm, its seed or its fruit, which is botanically a drupe rather than a nut.

The aqueous portion of coconut endocarp is known as coconut water (CW). Coconut water is used as a tropical beverage, an environment for growth for microbes, a medication and a ceremonial gift. About 25% of the overall weight of the nut is made up of coconut water. Its contents are translucent and colorless, with a flavor that is pleasantly sweet and tart. In its natural state, the liquid endosperm is sterile and housed in a hermetic container.

There are two primary types of coconut water: Mature Coconut Water (MCW) and Tender Coconut Water (TCW), each having unique flavors, appearance and nutritional profile. TCW is the liquid that can be found inside a young, green coconut. It has a translucent appearance, taste sweeter and is transparent. Mature Coconut water, on the other hand, is the liquid that may be found inside a fully matured, brown coconut. It has moderately nutty flavor and hazy, opaque appearance.

It is naturally isotonic beverage made primarily of components that are similar to those present in blood plasma and is considered nutritional and healthful when derived from palm trees. Coconut water is packed with nutrients, vitamins, minerals, ammino acids, antioxidant, growth hormones and enzyme.

Coconut water is seen as a natural functional drink because of its distinct qualities. It’s a great refreshing and rehydrating beverage to have after physical activity because of its sugar content and mineral composition.

Total phenolic and sugar content is greater in TCW compared to MCW. serine, cysteine, arginine, and alanine are among the ammino acids that are more abundant in TCW. Rich in arginine, coconut water supports the body’s stress-response mechanisms.

Most of the soluble solids in coconut water are composed of sugars. Sucrose, Fructose, glucose and sorbitol are main sugars in MCW. The smaller sugar galactose, mannose and xylose come next. The predominant sugars present in coconut water are glucose, fructose and sucrose which also comprise the majority of the soluble solids.

Mature coconut water has historically been seen as waste products, particularly in plants that process coconuts (such as the ones that produce coconut milk and desiccated coconuts).

A desiccated coconut plant that breaks down roughly 300,000 coconuts a day produces 50 m^3 of effluent per day, consisting of 44m^3 of wash water and about 5.3 m^3 of pure coconut water. The biological oxygen demand (BOD) of wash water and pure coconut water combined is approximately 3000 and 29000 mgL^{-1} respectively. As a result, the factory’s overall liquid waste contains 5800 mgL^{-1} of BOD, which needs to be lowered to the recommended amount of 50 mgL^{-1} .

Due to technological issues in gathering coconut water and separating the oil from the coconut water, the initial attempts to use the liquid waste by food industry were unsuccessful. Therefore, we are building a machine that will mechanically breaking the coconut and collect the water by filtering through the filters.

2. REVIEW OF LITERATURE

A. . Nutritional Characteristics of Coconut water

Coconut water is a nutritious clear liquid inside coconut fruit, which is rich in vitamins and minerals. The soft coconut water, technically liquid endosperm is the most nutritious health drink than nature provided the inhabitants of the tropics with fighting strains heat with a calorific value of 17.4 per 100$gm^{3.}$

Coconut water contains plant hormones namely auxins, cytokinin’s, gibberellins and abscises acid (ABA), which act as plant growth regulators addition, it is rich in minerals such as potassium, calcium, magnesium, iron, sodium, phosphorus, zinc, manganese, copper, Sulphur, aluminum, boron, selenium and chlorine. Among these minerals, potassium is dominant, followed by sodium as the next visible element. Coconut water contains several B vitamins, especially thiamine(B1), riboflavin(B2), niacin(B3), pantothenic acid (B5), pyridoxine (B6), biotin (B7) and folate(B9).

Coconut is known as a functional food which gives health benefits other than basic nutrients. Lauric acid is a main ingredient of coconut product; about 50% The fatty acids in coconut oil are lauric acid. (Percent arginine, alanine, cystine and Sestos sensitivity protein coconut water is higher. The green dwarf variety contains the highest in total phenols and vitamin C24. Amino acid important not only as a building material for the body, but it is another important characteristic, as an energy source (the body transforms amino acids to glucose), helps produce lymphocytes that there are cells in the human lymph nodes and bloodstream that are vital immune system It can help regulate blood sugar; help reduce symptoms of prostate enlargement in men, helps the adrenal gland function.

a. Nutritional Chart

- Calories: 22 Kcal
- Carbs: 3.7 grams
- Protein: 0.7 grams
- Fat: 0.2 grams
- Fiber: 1.1 grams
- Iron: 1% of the Reference DailyIntake (RDI)
- Calcium: 2% of RDI
- Magnesium: 6% of RDI
- Vitamin C: 4% of RDI

B. Composition of Coconut Water

The majority of the soluble solids in coconut water are sugars. The main sugar in mature coconut water includes glucose, fructose, sucrose and sorbitol. Lesser sugar like mannose, galactose and xylose comes next. The primary sugars in coconut water are glucose, fructose and sucrose which also makes up majority of the soluble solids. But as a plant reaches maturity, its non-reducing sugar content increases while its reducing sugar content increases while its reducing sugar content decreases with fructose and glucose. The synthesis of sucrose at the expense of the glucose-fructose bond is responsible for these changes. Among the components of coconut water, minerals come in second terms of quantity.

Based on available data, their composition ranges from 0.4 % to 1% of the constituents in coconut water, which is adequate to provide isotonicity. The six main minerals that were discovered were magnesium, potassium, sodium, calcium, zinc and iron. In coconut water, potassium is followed in abundance by sodium, calcium, magnesium and calcium. Zinc and iron, however, are only present in extremely minute levels.

Table 1 : Mineral Composition of Coconut Water

Vitamins	Tender Coconut Water	Mature Coconut Water
Calcium	0.47	0.57
Magnesium	0.11	0.11
Potassium	3.50	4.64
Sodium	0.03	0.29
Phosphorous	0.08	0.23
Sulphur	0.01	0.07
Manganese	20.3	14.4
Iron	4.06	2.94
Zinc	11.3	3.51
Copper	0.96	5.32
Boron	12.8	14.3

A single cup of coconut water contains 600-700 mg of potassium, 60mg of magnesium, 40 mg of calcium. When added to a balanced diet, coconut water can be great method to increases mineral composition and improve overall health and wellbeing

C. Physiochemical Properties

a) Volume of Coconut Water

A tender coconut typically has 200 to 300 ml of water; however, a mature coconut may only have 100 to 200ml. The reason for the decreases in water content is that as the coconut ages, more of the water is absorbed by the developing coconut meat. The water content might vary depending on its growing environment. The chemical composition of coconut water from several Indian states, including Kerela, Tamilnadu, Andhra Pradesh and Goa were reviewed. It was found that the quantity of coconut water varied significantly by location. Coconuts from Kerala had the highest average water content, at 271.3 mL per coconuts. The lowest water content was found in Tamilnadu coconuts, which had an average of 159.7mL per coconut. The average amount of water in the coconut from Andhra Pradesh and Goa was 201.6 mL and 220.2 mL respectively.

b) Total Soluble Sugar (TSS)

MCW was shown to have more total soluble solids than TCW which is a measure of sweetness. As the kernel develops, it takes up the soluble substances found in the coconut water. As a result, the TSS value of coconut decreased with age. From the review article by using the freeze concentrations method, the initial TSS values of the mature coconut and tender coconut could be enhanced by two-fold from 3.9 to 7.9^{o} Brix and from 6.0 to 12.1 ^{o} brix respectively.

c) Titrable Acidity (TA)

Due to its impact on food flavor and aroma, acidity is an important parameter that is used as a sensory indicator. Tender coconut water coming in second and third.

d) Preservation and Processing of Coconut Water

CW is safe and sterile as long as it remains inside the inner chamber of the coconut. After being extracted from the internal chamber of the nuts, it must first go through a complex and time-consuming procedure in order to preserve its quality before being taken from the nut for additional processing. After the coconut water is removed from the nuts, it is exposed to the external air. As a result of faster biochemical and enzymatic activities, CW changes in colour, turbidity, appearance, and numerous biological components.

In this field, several non-thermal, thermal, and Hurdle technologies with additional additives are employed. Among these techniques are infrared heating, ultrasonication, pulsed electric fields, plasma processing, microwaves, and dense phase carbon dioxide processing.

D. Value Added Products

Zero waste ideas provide the foundation of the mass production of value-added coconut goods. In the coconut plantation, the husk that is collected during dehusking is used for burial. Cashew nut processing uses the coconut shells that are removed during deshelling as a fuel source. The Testa extracted in order to produce virgin coconut water is dried, combined with cow feed and fed to farm's diary animals. The defatted, desiccated coconut is marketed after being added value to other goods. As previously mentioned, coconut water collected during processing is used enhance the value of a variety of variety of goods. Nursery plants and vegetable are grown using the concentrated, nutrient-enriched coconut water and leftover kernel wash water, which have undergone microbiological processing. It is therefore kept as zero polluting unit.

a) Coconut water vinegar

A naturally occurring product made from coconut water and sugar, which is fermented by adding yeast or Acetobacter and the allowed to oxidize and become acidic and they are filtered out as vinegar.

The drawbacks of synthetic vinegar made from industrial acetic acid, which is bad for your health are absent from natural vinegar.

b) Coconut water syrup

Delicious beverage created by persevering the freshness of the mature nuts used to make the coconut water while making virgin coconut oil. Coconut water, ginger, sugar, natural coloring and citric acid as a preservative are combined in equal measure to produce it. After diluting four to five times with water, it can ingest.

c) Xanthum Gum

Xanthum gum forms a flocculent complex with coconut protein under acidic condition. Soy polysaccharides specifically binds to coconut protein. Under acidic conditions, this complex is stabilized through the steric hindrance of soy polysaccharides. Due to gelatine coconut protein interaction, the isoelectric point of this complex changes.

d) Nata-de-Coco

The cellulose white to creamy yellow substance known as “nata-de-coco” is produced on the surface of sugar enriched coconut water, coconut milk, plant extract and other sugar-rich waste product by acetobacter aceti subspecies Xylinium. It is frequently served as dessert. Additionally, it’s a component of food items like fruit cocktails, ice cream and more. The Spanish term “Nata” comes from Latin word “nature” which means to “to float”. Because there is increasing interest in producing in nata from coconut water, a plentiful byproduct of coconut processing facilities, Nata making from coconut water, a plentiful byproduct of coconut processing facilities, Nata making is critical to the growth of our coconut sector.

e) Coconut Squash

It is hydrating and revitalizing healthy soft drink concentrate made by combining the sugar, coconut water and organic preservatives like ginger and lemon.it has few calories and is high in vitamins and minerals. Three months is product’s shelf life in normal conditions.

f) Frozen Coconut Water

The spray evaporation method can be used to create coconut water concentrate. Fresh coconut water is used to create frozen coconut water. Fresh coconut water collected in a hygienic manner from recently opened shell. Prior to concentration, the suspended particles and oils were eliminated by centrifugation and the minerals were extracted from the coconut water by passing it through an ionic resin -packed column to give it as sweet flavor. the flavor. The concentrated ‘s shelf life ranged six to twenty-four months, depending on how concentrated it was. Approximately 800g of concentrate might be produced from ten liters of coconut water. After diluting the concentrate to the appropriate concentration, it can

Figure 1 : Coconut Vinegar

be refrigerated or kept in cans and used as a base to make both carbonated and non-carbonated coconut drinks.

E. Existing Machines

a) Conventional method for coconut breaking

Since past few years, a sharp knife has been used to cut the dry coconut completely in manual method. The tools are unsteady, risky and need training and experience. In addition to the significant danger of damage and there will be risk of injury.

Figure 2 : Manual Breaking of Coconut

b) Coconut Water Extraction System

Coconut Water is derived from dry coconut can be used to produce high quality ready to drink coconut water. Coconut Water can be extracted by drilling the hole close to one of the three eyes on the coconut, where the meat and shell are thinnest. Its purpose is to reduce contamination and simplify handling.

c) Coconut Water Collection System

Breaking half of a fresh coconut and collecting the coconut water in a tank is one method of collecting coconut water. Coconut elevator, Equipment for holding and cutting coconuts and a tank for collecting coconut water make up system. The fresh coconut is transported by elevator to a coconut holding and cutting apparatus that has sharp blades fitted. The apparatus identifies the coconut and cut them in half, collecting the coconut water that remains after the coconut are cracked and chopped. Although there is less labour intensity with this procedure than the first, the hygiene condition is still lower.

Figure 3 : Existing Machine for Coconut Cutting

d) Hydraulic Coconut Splitter

A Hydraulic coconut splitter is a specialized machine designed to crack open coconuts efficiently. The working mechanism of a hydraulic splitter typically involves a hydraulic cylinder or press. When a coconut is placed in the splitter, hydraulic pressure is applied to the shell. The force exerted by the hydraulic system causes the coconut shell to crack open revealing inner contents. When compared to

traditional hand cracking, hydraulic splitters perform favorably, with an average cracking efficiency of 94.17%.

e) Coconut Water Pre-Pasteurization

The coconut water must be quickly chilled or pasteurized after filtering. The processing capacity determines whether the coconut water needs to be pasteurized or chilled. In the event that the coconut water has a modest capacity and can be sterilized and packaged in 5-8 hours, it can be stored in batch tanks after being chilled to 4°C. Either the jacketed tank feeding chill water or the plate cooler can be used to rapidly cool the water and coconut water in the tanks. Pre-Pasteurization is the preferable method if the coconut water must be kept in tanks for more than 12 hours or a day in order to be processed and packed later. The major goal of this process is to render the enzymes in the coconut water inactive and prevent oxidation. The purpose of the plate pasteurizer is to heat treat coconut water. Following pasteurization, the water is cooled to 4–10°C and stored in insulated tanks.

f) Coconut Water Cooling System

The coconut water must be quickly chilled or pasteurized after filtering. Depending on the processing capacity, the coconut water may need to be pasteurized or chilled. In the event that the coconut water has a modest capacity and can be sterilized and packaged in 5-8 hours, it can be stored in batch tanks after chilled 4^{o} C. The coconut water in the tanks can be rapidly cooled using the jacketed tank providing chill water or by using the plate cooler. Pre-pasteurization is the preferable method if coconut water must be kept in tanks for longer than 12 hours or a day in order to be processed and packed later. The main goal is to render the enzyme in the water inactive and prevent oxidation. After the coconut water is pasteurized, it is chilled to 4 - 10^{o} C and stored in insulated tanks.

F. Benefits of Machine

- In order to effiency to cut the coconut in half and collects its fluids, a machine for cutting coconuts is designed.
- It helps to save time, labor and resources when compared to cutting a coconut by hand, however the physical handling and process of slicing a coconut causes several risks and inefficient.
- Sanitary hazards can exist since the seller may not have provided enough hygiene materials, which could lead to microbial growth.
- Freshly extracted coconut water is unstable they start to ferment within a hour, so our machine helps to stabilize the coconut water by cooling the water where stability can be extended to four hours.

3. DESIGN METHODOLOGY

A. Design Of Machine

From a machine design perspective, the mature coconut's proportion are very important. In order to understand the range of dimension involved in the mature coconut, several farms and location were visited. When compared to region of India like Tamil Nadu and Kerala where coconuts are abundant, certain coconuts from Andaman and Nicobar Islands are quite large.

This study 's primary goal is to develop a coconut cutting machine that incorporates with rotatory motion of cutting. This design will serve as the foundation for prototype creation and a source for commercial manufacture. The research will specifically look into following:

- Outline the disadvantages faced by the farmers while collecting coconut water and splitting of coconuts.
- List the data elements that call for the automation of the cutting of coconuts.
- Using the principles of rotatory motion as basics, create a three-dimensional design for an automated coconut cutting machine.
- Using machine shop technique, create a prototype for the machine design.
- Compare the data collected from manual operation with motorized coconut cutting machine's effectiveness.

4. CONCLUSION

The current paper summarises the substantial research efforts and findings on the usage of mature coconut water and collection machines in order to make the material useful. Future scholars as well as those who build alternative machines will find value in the information gained in this work. We can comprehend the market opportunities such as coconut squash, frozen coconut water, nata de coco, coconut water syrup, coconut water vinegar, Xanthum gum, and also other existing machines. A greater percentage of the mature, healthy coconut's water content is wasted. According to the assessment, there is an opportunity to gather coconut water in a hygienic way for the creation of different items. By considering contemporary technologies like automation, data analytics, and sensors, smart machines provide higher productivity, consistency, and efficiency than manual techniques. In addition to enhancing the output and quality of coconut water and associated goods, automation's continuous monitoring and control features also save labour costs and increase worker safety. The use of automated systems in the coconut sector is positioned to play a vital role in satisfying market needs while fostering innovation and sustainability in production processes, particularly as the demand for healthy beverages like coconut water continues to rise internationally.

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