PROCESSING AND PRESERVATION OF GREEN COCONUT WATER

A THESIS

BY

TAPON RAY
Student No. : 1105042
Session : 2011-2012
Semester : January- June, 2012

MASTER OF SCIENCE (MS)
IN
FOOD ENGINEERING AND TECHNOLOGY

DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY, DINAJPUR

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DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
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JUNE, 2012


DEDICATED TO
MY BELOVED PARENTS

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JUNE, 2012 ***THE AUTHOR***

ABSTRACT

Green coconut water is an inevitable source of nutrient which is rich in some important minerals such as Ca, Mg, K, Na etc in small amount and ascorbic acid, fat, protein etc. The research on processing and preservation of green coconut water was conducted in the Laboratory of the Faculty of Agro-Industrial and Food Process Engineering, Laboratory of Chemistry, Pathology lab, Hajee Mohammad Danesh Science &Technology University Dinajpur and in BCSIR during the month from May 2012 to September 2012. The clean and sound green water was filtered through a filtering machine. The coconut water was then analyzed for total solid, total soluble solids (TSS), moisture content, sugar, acidity, pH, ascorbic acid, ash content and carotene. The proximate composition of coconut water showed moisture 95.03%,TS 4.5%, TSS 4%, acidity 0.08%, reducing sugar 3.2%, non-reducing sugar 0.6%, ascorbic acid 1.5mg/100gm, carotene 0% and minor quantity of protein and fat. The water was heated at 80- 85 ^{0}C for 10 minutes, cooled and strained through a fine strainer. The water was heated at 80- 85 ^{0}C for 10 minutes, cooled and strained through a fine strainer. Nine samples were prepared with original (TS). The (TS) of green coconut water were found 4.5%. The acidity of two samples was maintained at 0.95% and 1% by adding citric acid. The preservatives $K_2S_2O_5$, sodium benzoate, sugar, green colour were used in samples. The water was filled into bottles keeping 0.25 inch head space, exhausted, sealed, heated for 15 minutes, cooled immediately to 40 ^{0}C, labeled and stored. The change in colour, flavour, turbidity, TSS, acidity, microbial load and gas formation were observed during the bottles were stored at 4 ^{0}C temperature. Observation was made at an interval of one month up to 4 months. The colour and flavour of processed green coconut water remained unchanged in some samples throughout storage period. The preservatives and acidity improved transparency. No gas formation was observed in bottle water while stored. The microbial load was observed very low. The acceptability considering colour, flavour and overall acceptability but Sample B (treated as heat at 80-85^{0}C, acidity 0.8% and 0.6g/1000ml KMS) was highly acceptable considering 4 month storage. The bottle green coconut were found shelf stable up to 4 month of storage in refrigerator at 4 ^{0}C temperature. The results of sensory evaluation and the shelf stable of the processed green coconut water indicated that the fresh green coconut water could be bottled successfully for consumption as storage experiment was conducted only four month.

LIST OF ABREVIATION

CMC	:	Carboxyl methyl cellulose
KMS	:	Potassium-meta- bisulphite($K_2S_2O_5$)
CFTRI	:	Central Food Technology Research Institute
TS	:	Total solid
TSS	:	Total soluble solid
$NHSO_4$	:	Sodium meta- bisulphate
AOAC	:	Association of Official Analytical Chemistry
BBS	:	Bangladesh Bureau of Statistics
ANOVA	:	Analysis of variance
DMRT	:	Duncan's Multiple Range Test
pH	:	Hydrogen ion concentration
SS	:	Sum of square
MS	:	Mean square
df	:	Degree of freedom
GS	:	Gas chromatography
SPME	:	Solid phase micro-extraction
PEF	:	Pulsed electric fields
et al.	:	and others

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CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Coconut (*Cocos nucifera*) is one of the oldest fruits in the world and is confined to sea coast in the humid tropics. It is an important plant crop of Bangladesh and called nurse of India. The coconut crop of the world is estimated at 16914 million nuts and comes out from India, Indonesia, the Philippines, Sri Lanka, Malaysia and South pacific Island (*wood roof, 1979).* With a total production of 9200 million nuts during 1989-90, India is the third largest producer of coconut in the world (*George et al. 1991).* Coconut is also cultivated in large quantities in Philippines, Ceylon and Kerala state of India. Coconut is used mainly for the production of oil.

Coconut is one of the important nut crops in Bangladesh. Its production in Bangladesh is 402391 nuts from 6071 acres of land in 2009-2010 (BBS, 2011). It is mostly grown in the southern part of the country. The climatic condition of Bangladesh is suitable for the cultivation of coconut. Huge quantity of coconut is grown in the southern part of the country specially in the greater Chittagong region (65772 coconuts), Faridpur region (29105 coconuts), Jessore region (34921 coconuts) and Khulna region (61498 coconuts), (BBS, 2011). It is an important food item in Bangladesh. The fresh kernel is consumed all over Bangladesh and the water from green coconut is a refreshing drink during hot days.

Bangladesh does not produce sufficient fruits and vegetables to fulfill her requirements. But some of these are available as seasonal surpluses during certain period of the year. So, effort should be made by the consumers and producers to process at least a part of these surpluses for their own home consumption. If such efforts are increased in production, bring better returns to the agriculturists and improve status of the people at large (Uddin, 1991).

Bangladesh is one of the developing countries of the world which suffer from severe malnutrition problems. The vast majority of its population, especially the vulnerable groups suffer from acute malnutrition. The production of milk is inadequate and there is a general shortage of milk. The shortage is becoming more acute due to rapid increase in the population. Thus, the average diet of the people is generally deficient in milk and milk products.

Coconut water is the liquid endosperm that fills the central cavity enclosed by a solid endosperm protected by the hard cell and husk. Tender coconut water is a delicious and

nutritious drink. In natural state, it is sterile and is used as an oral rehydration medium for gastroenteritis. Coconut water is also reported to contain substances capable of inducing rapid proliferation of plant tissues culture medium.Vinegar, Nata decoco, a fermented drink popular in the Philippines, are prepared using coconut water as base. It presents ant carcinogenic properties (Sylianco *et al., 1992*) and can be used as dehydrating solution administrated in oral and intravenous form, the later in case of severe dehydration (Magat and Agustin 1997; Falck et al., *2000).* It has a great demand especially during the hot season. It is very effective especially for diarrhoea attacked people and excellent tonic for old and sick person.

Coconut water plays an important role in the ripening of the fruit and in germination. At its tender stage, a large nut may contain about 500-800 ml water with 30 g sugar and 2 g potassium. Towards the end of maturation, the volume of water decreases considerably accompanied by, changes in the chemical composition and palatability. Water from ripe nut is bland in taste and flavor and therefore, is a waste product in desiccated coconut and coconut industries. Studies on the chemical changes of coconut water related to maturity are limited and are confined to certain constituents. Coconut water from tender coconut is a poor source of protein and calorie. It has a high osmolarity because of the sugars present, which are primarily glucose and fructose in the immature coconut, and sucrose in the more mature fruits. Coconut water is also rich in many essential amino acids including lysine, leucine, cystine, phenylalanine, histidine, and tryptophan. Cholesterol and triglycerides are absent or present in very small concentrations, and it is not a good source of vitamins or protein.

Coconut water is an important additive in the tissue culture media of several plants, including orchids and traditional Chinese medicinal herbs. The cytokines found in coconut water support cell division, and thus promote rapid growth. They are mostly used to propagate protocorm-like bodies of orchids in plant industries. However, it should be noted that cytokines cannot completely substitute coconut water's effects. This is due to the presence of other phytohormones (such as auxin and gibberellins or even undefined chemical components which may exert synergistic effects with cytokinins. One advantage of coconut water is that it results in considerable plant cell proliferation without increasing the number of undesirable mutations. Coconut water contains various cytokinins. For this review, only kinetin, transzeatin and their derivatives are known to possess medicinal values. The liquid endosperm inside a young coconut is known as

coconut water. It is fat free and low in calories. Sodium, potassium, phosphorus, chloride and magnesium are the main minerals found in coconut water, besides vitamin C and sugars (Magda, 1992; Campos *et al.*,1996; Nadanasabapathy and Kumar, 1999).

Coconut water with its high concentrations of sugar and potassium, has been studied extensively for its use as a potential oral rehydration solution. Although some feel that it is an ideal oral rehydration and the Oral Rehydration Salts promoted by the World Health Organization and UNICEF should be used exclusively. Despite numerous studies and reports, a final consensus has yet to be reached on its use as an oral rehydration solution. The low pH may theoretically worsen an already present acidosis, common in many diseases. However, studies have shown no change in pH measured within 24 hours after infusion of as much as 3,000 ml of coconut fluid. It appears that the body's buffering system effectively neutralizes the acidity of the coconut water.

In our country huge quantity of coconut are grown in the southern part but the utility of green coconut and coconut based products is limited. Green coconut water and coconut product has received much attention throughout the world specially due to physiochemical properties. The demand of green coconut water has increased in a large scale in our country. Now, green coconut water is a desirable drink for children and people of all ages. Because of containing different types of important constituent ill person can easily take it as diet therapy. If it is processed and preserved, besides its production area it will be possible to get reached it at cheap price everywhere. By exporting it to different countries, foreign currency earnings will be possible. Various type of new product will be produced through different technologies. As a result, the farmers of coconut will be benefited economically as well as it will be possible to spread the processed coconut product worldwide.

The processed green coconut water increase the availability of coconut water and the producers sell it at reasonable price. So, the present investigation was undertaken with a view to preserve green coconut water which will be easily transported, and increase availability all over the country.

Objectives:

1. To analyze the proximate composition of the green coconut water.
2. To explore process for preservation of coconut water.
3. Sensory evaluation of the processed coconut water.
4. To find out the storage stability and shelf life of the processed coconut water.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Coconut water is very nutritious drink and so different research work has been done from the ancient time. Some of the research works are given as following:

Coconut water is widely used in the plant tissue culture industry. The extensive use of coconut water as a growth promoting component in tissue culture medium formulation can be traced back to more than half a century ago when Overbeek *et al.* first introduced coconut water as a new component of the nutrient medium for callus cultures in 1941. From a scientific viewpoint, the addition of coconut water to the medium is rather unsatisfactory, as it precludes the possibility for investigating the effects of individual components of the medium with any degree of accuracy. The question of which components cause the growth stimulation arose immediately. Besides its nutritional role, coconut water also appears to have growth regulatory properties, e.g. cytokinin type activity.

Total world coconut cultivation area in 1996 was estimated at 11 million hectares (ha), and around 93% is found in Asian and Pacific regions (*Reynolds, 1988*). The two biggest producers, Indonesia and the Philippines, have about 3.7 million (ha) and 3.1 million (ha) respectively. India is the third largest producer. In the South Pacific countries, Papua New Guinea is the leading producer. In Africa, Tanzania is the largest producer while in Latin America Brazil accounts for more than one half of the total coconut area for that region (Punchihewa and Arancon, 2005).

Coconut water has been called the "fluid of life" in many parts of the world due to its medicinal benefits. It has been reported as a natural isotonic beverage due to electrolytes like sodium and potassium, and its isotonic properties are demonstrated by its osmol (the number of moles of osmotically active particles; 1 mole of glucose, which is not ionizable, forms 1 osmol, 1 mole of sodium chloride forms 2 osmols) concentration, which lies in the range of 300-330 osmol/kg (Gomes and Coelho ,2005). With its high electrolyte content, it has been studied for its potential use as an oral rehydration solution. Comparison of coconut water with a "carbohydrate electrolyte beverage" resulted in similar rehydration indices. There are

many reports of its successful use in gastroenteritis or diarrhea (Kuberski ,1980). It is suggested as a readily available source of potassium for cholera patients (Carpenter *et al.*).

Coconut water resembles blood plasma in its contents. Its successful intravenous use has been documented (Falck *et al.).* During the Pacific War of 1941-45, coconut water was siphoned directly from the nut to wounded soldiers for emergency plasma transfusions (FAO, 2005). Although its glucose, potassium, magnesium and calcium levels are higher and sodium content is lower than blood plasma, studies on its intravenous infusion show no allergenic or sensitivity reactions (Fries and Fries, 1983). A summary of the contents of coconut water and normal blood plasma is given in Table 2.1.

Table 2.1: A summary of contents for coconut water and human blood plasma.

Study	Specific gravity	pH	Na^+ meq/L	K^+ meq/L	Cl^- meq/L	Glucose g/L	Ca+ meq/L	PO_4- meq/L	Mg^{2+} meq/ L
Pradara *et al.*	1.018	----	5.0	64	45.5	1.2	17	2.8	------
Eiseman	---------	5.6	4.2	53.7	57.6	1.8	9	2.4	17
Rajasurya	1.02	4.8	-------	38.2	21.3	--------	14.5	4.4	-------
Olurin	1.02	5.6	0.7	81.8	38.6	---------	3.6	3.2	25
Iqbal	1.019	5.6	5.0	49	63	2.1	12	8	4.7
Kuberski	--------	----	4.0	35.1	41	2.8	13.1	4	5.2
Mscngi 1985	1.023	6.0	2.9	49.9	-------	---------	5.3	-------	13.4
Attoiffi 1997	---------	4.2	9.7	43.1	39.8	1.73	-------	--------	------
Normal plasma	1.027	7.4	140	4.5	105	0.1	5.0	2.0	1.8

Source : Flack *et al.*

Campos *et al.* determined the chemical and physio-chemical composition of a pool of coconut water from 30 green coconuts. They measured water content, total solids, total soluble solids, total sugars, reducing sugars, ash, protein, lipids, total phenolics, total titratable acidity and turbidity (Table 2.2). Carbohydrates are the main constituents of coconut water and glucose and fructose are the most abundant soluble solids in green coconuts, while sucrose is the main one in ripe coconuts (Oliveira *et al.).*

Table 2.2: Chemical and physicochemical composition of green coconuts

Water (g/100 ml.)	94.2±1.90
Total solids (g/100 ml)	5.80±0.12
Soluble solids (Brix, 20 ^{0}C)	5.27±0.11
Total sugars (g/100 ml)	5.30±0.21
Reducing sugars (g/100 ml)	4.90±0.20
Non-reducing sugars (g/100 ml)	0.40±0.04
Ash (g/100 ml)	0.50+0.01
Protein (mg/100 ml,)	19.50±0.50
Lipids (mg/l00 ml)	ll.00±1.60
Total phenolics (mg catechin/100 ml)	6.86±0.55
Total titratable acidity (mg citric acid/ 100 ml)	131.20±2,80
pH	5.20±0.10

Source : Campos *et al.*

Coconut water is rich in mineral composition (Table 2.3). It is high in potassium, calcium, magnesium, and manganese, and low in sodium. Coconut water is low in fat and proteins. It is rich in many essential amino acids such as lysine, leucine, cystine, phenylalanine, histidine and tryptophan (Pradera *et al.*). Its arginine, alanine, cysteine and serine percentage is higher than those of cow's milk (Maciel *et al.*). It contains ascorbic acid and B complex vitamins. Ascorbic acid content of coconut water from a 7-9 month coconut has been reported to be 2.2 to 3.7 mg/100 ml (Mantena *et al.*). Coconut water is low in calories with a caloric value of 17.4 kcal/100 g (Wood roof, 1979).

Table 2.3: Mineral composition of tender coconut water

Minerals	(mg/100ml)
Copper	26
Potassium	290
Sodium	42
Calcium	44
Magnesium	10
Phosphorous	9.2
Iron	106

Source : Krishnankutty, 2005

The high potassium, calcium, and magnesium content are a concern in the intravenous use of coconut water particularly when given in fluid boluses.

Olurin *et al.* showed rises in serum potassium levels by 1.5 to 2.8 meq/L, calcium levels by 0.6 to 2.0 meq/L, and magnesium levels by less than 1.0 meq/L after infusion of 2,000 to 3,000 ml of coconut fluid over 6 to 12 hours. Additionally, he measured urine electrolytes and noted that the amount of excreted potassium, calcium, and magnesium increased as the amount of infused coconut water increased.

In 1954, Eiseman conducted a prospective study in both Thailand and St. Louis in which 21 patients successfully received filtered IV coconut water without serious reactions. He infused approximately 200 to 500 ml per patient over a period of 25 to 180 minutes. Patients experienced local infusion site discomfort at higher rates of infusion only.

Rajasuriya *et al.* also reported successful infusion of filtered coconut water in 26 Ceylonese patients. Between 1965 and 1976, other investigators reported their use of intravenous coconut fluid in patients as well.

Iqbal (1976) reported successful direct infusion of water in Malaysia without any preliminary preparation or filtration system. Since that time, coconut water has been studied only for oral rehydration use with no subsequent reports of intravenous use. The authors brought representative coconut water to the States for analysis. Electrolyte analysis was performed on the coconut water at a university medical center clinical laboratory. The coconut water was analyzed at three early development stages leuleu, bulo and zokelebulo and the results were consistent with those reported previously. The electrolyte composition of coconut water resembles intracellular fluid more closely than extracellular plasma. The predominant cations are potassium, calcium, and magnesium. Sodium, chloride and phosphate are found in much lower concentrations. It is a hypotonic solution that is more acidic than plasma and has a specific gravity of approximately 1.020, comparable with blood plasma. Coconut water's hypotonicity does not make it the ideal resuscitation fluid.

Flavor is a combination of the perceived aroma, taste and trigeminal sensations (Fisher and Scott, 1997). Taste sensation has four major categories; sweet, sour, bitter and salty.

The desirable flavor of coconut water is sweet and slightly astringent with a pH around 5.6 (Maciel *et al.)*. There are a limited number of studies on the analysis of coconut flavor compounds.

Lin and Wilkens (1970) identified 15 aroma compounds in coconut meat by gas chromatography (GC) analysis. Among these, δ-C8 and δ –C10 lactones were the major volatile components and were described as buttery, tropical-fruity and coconut-like.

The other aroma compounds were octanal, 2-heptanol, 2-octanol, 2-nonanol, 2-undecanol, hexanol, octanol, 2-phenylethanol, benzothiazole, ethyl decanoate and dodecanoic acid, that were described mostly as fruity and also as nutty, rancid, green, lemon and rose aromas.

Jayalekshmy *et al.* determined aroma compounds of roasted coconut meat by GC. They suggested that roasting of coconut meat led to the formation of heterocyclic aroma compounds, especially pyrazines. The lactones, alcohols, esters and fatty acids also contributed to the overall roasted coconut flavor. They isolated acid, neutral and basic fractions from roasted coconut by selective solvent extraction and pH adjustment. They identified pyrazines and other heterocyclic compounds, which gave the roasted aroma, in the basic fraction. There were twenty different types of pyrazines identified and their amount increased with time of roasting. The GC profile of neutral fraction was dominated by lactones and their amount decreased from 80% to 60% during roasting. The basic and acid fractions were dominated by pyrazines and short chain fatty acids respectively.

Jirovetz *et al.* identified aroma compounds in the coconut milk and meat of ripe coconuts from Cameroon. They extracted headspace volatiles by SPME, an identified more than thirty compounds using GC. The main components of coconut aroma were nonanal, nonanol, heptanal, ethyl octanoate, heptanol and 2-nonanol, while coconut meat was rich in-octalactone, ethyl octanoate, nonanal, nonanoic acid, decanol decanal and nonanol. Other short chain alcohols, aldehydes, ketones, lactones, acids and esters were present in lower concentrations. They did not detect any-lactones or δ -C14 lactone that were reported in coconut meat by previous researchers. Although there are a few studies regarding the flavor compounds in coconut meat or milk, there is no flavor study with coconut water from immature fruit.

Pasteurization is a mild heat treatment for high acid foods such as juices and beverages, and low acid refrigerated foods such as milk and dairy products. It is used in order to inactivate vegetative cells of pathogenic microorganisms.

Usually foods are pasteurized by a low temperature long time (LTLT) process at about 145 ^{0}F (63 ^{0}C) for 30 min or a high temperature short time (HTST) process at about 162 ^{0}F (72 ^{0}C) for 15s (David *et al.*). The resulting shelf life of the product is about 2 to 3 weeks under refrigerated (lower than 7^{0}C) conditions. The pasteurization process does not intend to inactivate all spoilage bacteria or any heat resistant spores, thus the product is not commercially sterile after pasteurization (David *et al.).*

Common thermal processes used for juices and soft drinks are flash pasteurization, hot filling, in-pack pasteurization and aseptic filling (Tompsett, 1998 and Lea, 1998). Usually flash pasteurization is done by passing juice rapidly through heated plates by HTST treatment at 96 ^{0}C for 4 s, or by standard process at 80 ^{0}C for 20 s. In hot filling, the product is heated in a heat exchanger above 80 ^{0}C (typically 87 ^{0}C), sent to the filler while hot, filled into containers and held for about 2 min. Hot fill process is adequate for acidic beverages to obtain a shelf stable product with a shelf-life of 6 to 12 months. In-pack pasteurization is achieved by passing completely filled closed packs through a heating and a superheated zone and then through a pasteurizing zone for the desired period of time and finally through a cooling zone. Typical in-pack processing is done at 74 ^{0}C for 17 min. A special in-pack process is possible by heating the product above 100 ^{0}C in a retort and then cooling (Lea, 1998 and Tompsett, 1998). Aseptic filling may involve HTST pasteurization or UHT sterilization, depending on the high acid or low acid character of the juice, which is then filled into sterile containers in a sterile environment (David *et al.*).

The choice of pasteurization method depends on the level of microbial contamination of the raw materials and packaging, the ability of the product to withstand heat, growth potential of microorganisms and the pH of the product. In orange and tangerine juice processing, pasteurization does not only kill microorganisms but also inactivates pectin esterase. Normally, temperatures above 71 ^{0}C are enough to kill pathogens and spoilage bacteria in orange juice. However, temperatures between 86 and 99 ^{0}C are required to inactivate pectin

esterase. In commercial practice, orange and tangerine juices are flash pasteurized by heating the juice rapidly to about 92 ^{0}C for 1 to 40 s (Nordby and Nagy 1980).

Thermal processing methods have been shown to change the flavor of foods. For example, the delicate flavor of fresh orange juice is easily changed by heat treatment. Citrus processors and favorites search for methods to make processed orange juice and orange-flavored beverages taste more like fresh orange juice (Shaw, 1982).

Shreirer *et al.* reported that some volatile compounds such as α-terpineol and carveol, which are formed by the oxidation of δ-limonene, increased and the amount of terpene hydrocarbons decreased in heat pasteurized orange juice.

Non-thermal processing methods have gained increasing interest in recent years and several emerging technologies are under intense research to evaluate their potential as alternatives to traditional thermal methods. Traditionally, most foods are preserved by subjecting to temperatures between 60 to 100^{0}C for a certain period of time (Barbosa and Cánovas, 1998).

Several studies evaluated the quality of fruit juices processed by non-thermal technologies. Pulsed electric fields (PEF) treated orange juice had significantly higher ($P<0.05$) ascorbic acid, flavor compounds and color than thermally processed orange juice (Hye *et al.* and Min *et al.).*

Jia *et al.* showed that there was 10 to 40% loss in the major orange juice flavor compounds after heat pasteurization while 0 to 5% losses occurred for the same compound with PEF processing.

Ayhan *et al.* reported that PEF processing did not alter sensory evaluation of flavor and color of fresh orange juice. Similarly, Min et al reported higher sensory scores for flavor and overall acceptability of PEF treated tomato juice compared to heat pasteurization. Apple juice retained fresh like ascorbic acid levels and color after PEF processing (Akdemir *et al.* and Liang *et al.*).

UHP processing at pressures between 100 to 800 MPa has been reported to be effective in inactivation of pathogens without affecting taste or nutritional value of fresh juices (Morris 2000). UHP treated citrus juices retained a fresh-like flavor with no loss of vitamin C and a shelf-life of approximately 17 months (Farr, 1990).

Maciel *et al.* (1992) reported that the effect of storage temp. (4, 22 or 28 ^{0}C) duration of storage (0- 5 week) and polyethylene packaging on preservation of green coconut (*cocos nucifera*) water from 134 dwarf fruits was determined. RH ranged from 80-85%, except for samples stored at 22 ^{0}C when RH was maintained at 60-65%, physiochemical (Brix, Total Acidity, pH and wt.) microbiological and sensory properties of the coconut water samples were determined. Results suggest that optimum storage conditions occurred when coconut water was packaged in polyethylene and maintained at l2 ^{0}C for 4 wk.

Arumugham *et al.* (1993) conducted on experiment on the microbiological quality of coconut cream at various stages of processing and investigated together with contents of total solid (TS), fat, protein, and sugars, minerals and gums. Samples studied were coconut water, water after blanching, crushed grating, milk extract, additives, milk plus additives, milk after stirring and homogenization, milk during pasteurization and pasteurized milk in a bottle collected on days of preparation; total counts/ml were respectively, 10^2-10^3, 10^3-10^4, 10^4-10^5, 0-10, 10^5-10^6, 10^2-10^3 and 10^3 percentages of TS, SNS, fat, protein, sugars, minerals and added gums were 37, 12,25,4.5,5.5 1.8 and 0.4 respectively.

Rajasekharan *et al.* (1961) indicated that good quality copra could be obtained when drying at 70^{0}C for the first eight hour, 60 ^{0}C for remaining period.

Sierra and Balleza (1972) studied the proximate analysis of fresh coconut meat at different ages of the nuts.

Jayalekshmy *et al.* (l986) found that coconut water collected from the nuts at 8 progressive stages of maturity were analyzed for titratable acidity, pH, T.S.S and reducing sugars, total and non-protein N, fat and fatty acid composition, ash and mineral constituents. A marked reduction in the vol. of water accompanied by significant changes in the chemical composition was observed during maturation. On a per nut basis, a drastic reduction in contents of T.S. sugars and ash and mineral constituents were noticed whereas fat and protein contents were found to increase on maturation. Changes in the chemical composition of coconut water during maturation are indicative of quality changes.

Tulecke *et al.* (1961) compared free amino acids and organic acid contents of mature and tender coconut water. He reported on the major and minor constituents of coconut water and their changes at different stages of maturity of the coconut fruit.

Nathanael *et al. (*1966) reported the changes in the sugar content. At its tender stage, a large nut may contain about 600m1water with 30g sugar and 2g potassium. Towards the end of maturation, the volume of water decreases considerably, accompanied by, charges in the chemical composition and palatability, water from ripe nut is bland in taste and flavor and therefore, it is a waste product in the desiccated coconut and coconut oil industries. Studies on the chemical changes of coconut water related to maturity are very limited and are confined to certain constituents.

Chitara and Campos (1995) studied the use of the protein fraction from albumen (the edible part), copra and cake of coconut (*cocos nucifera)* to prepare milk substitutes. Extraction of protein was tested with water, NaCl solutions in different concentrations and HCI and NaOH solutions at different pH values. Best results were with a solution of NaCl 1mol/litre at a ratio of coconut. Solution of 100:75.2 successive treatment with this solution extracted 80% of total N_2. After separation of the proteins by precipitation with a 40% solution of trichloroacetic acid and drying, they were in the form of a white powder without taste or smell and had a solubility index in water of about 31.5%. When shaken with water, the insoluble part gave a milk suspension with agreeable organoleptic properties.

Magda (1988) suggested that the use of a new stimulated milk from coconuts as a cheap alternative to cow's milk in developing countries is to be discussed. The use and applications of coconut milk are described and discussed and include a fermented beverage prepared using coconut skimmilk as a substrate for lactobacillus bulgaricus' coconut milk as a substitute for sweetened and evaporated milks and for white soft cheese and yogurt manufacture' Production of toned milk and coco-cheese production.

Mathew (1991) reported that the chemical composition of coconut and the use of coconut oil and coconut water. It is a tuber that coconut drying, copra milling and the production of desiccated coconut are important.

Christensen and Olsen (1990) showed that the production of high grade coconut production, particularly coconut oil and coconut milk, involves enzymatic treatment of an aqueous suspension of particles (<1mm) of coconut meat with a cell wall degrading enzyme and all essentially free from lipase's and separating out sludge phase.

Hocharomatish (1979) found that the creamed coconut is a new standardized product made from pure coconut without additives. It is made by a special process, after disruption of the tissue, all coconut flesh, constituents are emulsified. The product which is aromatic and guaranteed to be free from salmonellae is supplied in solid blocks and has a longs storage life under good conditions. Composition resembles that of desiccated coconut 6% protein, 62% fat l0% carbohydrates, 21%, crude fiber plus ash and l.l% moisture. Applications include use in filled sweets and chocolate cream fillings for ten and various kinds of cakes yeast raised products and short bread type products.

Rosario (1982) reported that coconut water and coconut meat fibrous residue or sepal one by products that can be converted into sugar and alcohol. Coconut water mainly composed of simple sugars and sugar alcohol's is a promising substrate for feast production. Reverse osmotic concentration gives sugar which may be used as food or fermentation substrate. Sepal is made up of semi cellulose and cellulose, which can be converted into ethyl alcohol. Procedures of such conversion have been worked out as well as estimated for product yield and major costs. Large scale aqueous processing is proposed to allow the recovery of food water and fibrous residue.

Jindal (1984) stated that the thermal properties of shredded coconut were determined experimentally in the moisture content and temperature range of 2- 50% wet basis and 25-50 ^{0}C respectively. Specific heat and thermal conductivity of coconut increased linearly with increasing moisture content at any given temperature. Considerable variation was noticed in thermal diffusivity determination apparently due to expertness entail errors and material characteristics.

Satyanarayana and Kaserappa (1991) investigated that the method of preparation, dehydration, preservation and constitution of dehydrated coconut chutney and its storage behavior at different temp. was investigated. Dehydrated coconut chutney was made from

fresh coconut, green chilies, salt, tamarind pulp, fresh ginger, coriander leaves, curry leaves, hydrogenated oil and mustard seeds using a simple hot air drying technique. Dehydrated chutney reconstituted well in cold water and had all the characteristics of fresh chutney. The product had a shelf life of 3 months at 37 ^{0}C and 6 months at ambient temp. when packed in flexible pouches.

Fernando and Than gavel (1987) reported that shredded coconut is usually dried commercially to facilitate storage over reasonable periods of time and to reduce weight and vol. in transport and packaging. Fluidized bed drying is generally accepted as efficient. Experiments were carried out to investigate the fluidization behavior of shredded coconut at various moisture contents.

Moorjant and Subrahmanyam (1955) standardized a method for the preparation of coconut milk substitute. The milk they prepared had the following average composition: total solid 10.20%, protein 0.80%, fat 7.10%, carbohydrate 1.75% (sucrose 1.40% reducing sugars 0.35%), minerals 0.55%, calcium 3.20% and phosphorus 33.00%. They also reported that coconut milk has an attractive white color and a pleasing characteristic coconut flavor. The milk was found to be quite acceptable. Fairly good milk and curd were obtained by blending milk powder, or soybean with coconut milk to the extent of 25 to 50%. The addition of skim milk improved the flavor of coconut milk.

According to Biancardini and Tastal di (1965) coconut endosperm contained 23.8-63.5% mg vitamin C and coconut water contained 13.5-17.5% mg vitamin C. In coconut the endosperm increases and water decreases in vitamin C content during ripening.

Pillar (1997) analyzed the ash of kernels and coconut water separately for silica content of ranged from 158.3 to 455.5 gm and that of coconut water was 2.0 to 128.0 mg.

Lin And Wolkens (1970) reported that the pleasant characteristic aroma of coconut which appears to be an acceptable flavor to most people is due to the presence of methyl ketones (C_7,C_9,C_{11},C_{13},C_{15}) and delta lactones (C_6, C_8, C_{10}, C_{12}, C_{14}) in volatile flavor constituents.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The research was conducted in the Laboratory of the Faculty of Agro-Industrial and Food process Engineering, Laboratory of Chemistry, Pathology lab, Hajee Mohammad Danesh Science & Technology University, Dinajpur and in BCSIR during the month from May 2012 to September 2012 collecting green and fully matured coconuts for experimental purposes.

3.1 MATERIALS

3.1.1. Green and tender coconuts

Green, sound and tender coconuts were collected from campus of Hajee Mohammad Danesh Science & Technology University, Dinajpur.

3.1.2 Chemical, solvents and ingredients

Chemical and solvents used in the experiment were:

1. Analytical grade and water
2. Sugar
3. Potassium-Meta- bisulphate
4. Sodium benzoate ingredients were procured from the local market.
5. Bottles jar was used for storage of sample
6. Color etc.

3.2 METHODS

3.2.1 Processing and treatment of green coconut water

Fresh green coconut water was collected from freshly harvested coconut and filtered. Filtered water was prepared by heat at predetermined temperature 80-85 ^{0}C for a definite period of time. Then the potassium metabisulfite ($K_2S_2O_5$), sodium benzoate, citric acid were used as preservative in concentrations. Then the color, sugar, was fortified as per requirement of human body. Later, samples was mixed properly and cooled at room temperature. Two types of samples were prepared and tested. From sample B to sample H

were prepared as shown in Fig. 3.1. Sample A was prepared as shown in Fig. 3.2. In sample A, heat was not applied. Only citric acid and KMS as preservative were added. Heat was applied to sample B to Sample H and KMS, sugar, citric acid (to increase acidity, transparency, stability), sodium benzoate and colour were added to these samples as prescribed amount as shown in Table 3.1. KMS, sugar, citric acid (to increase acidity, transparency, stability), sodium benzoate was added as preservatives and the amount of these parameters was varied and colour was added to sample H to increase appearance..

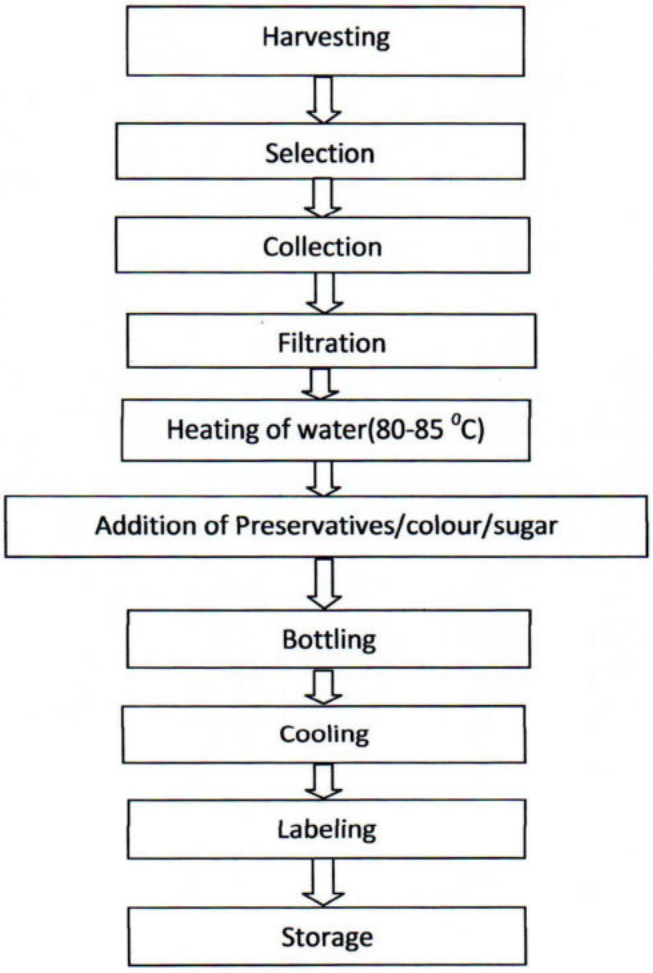

Fig. 3.1 : Flow sheet diagram for coconut water processing

Table 3.1 : Treatments of processed green coconut water

Sample code	Sample specification					
	Treatment	Acidity(%)	Potassium metabisulphate(KMS)	Sodium benzoate	Sugar	Colour
A	Without heat	0.8	0.5g/1000ml	-	-	-
B	Heat at 80-85^{0}C	0.8	0.6g/1000ml	-	-	-
C	Heat at 80-85^{0}C	0.95	0.5g/1000ml	-	-	-
D	Heat at 80-85^{0}C	0.8	-	0.5g/1000ml	-	-
E	Heat at 80-85^{0}C	0.8	-	-		-
F	Heat at 80-85^{0}C	0.8	-	-	10g/1000ml	-
G	Heat at 80-85^{0}C	1	0.5g/1000ml	-	-	-
H	Heat at 80-85^{0}C	0.8	0.5g/1000ml	-	-	1mg/1000ml
M	Without heat	0.08	-	-	-	

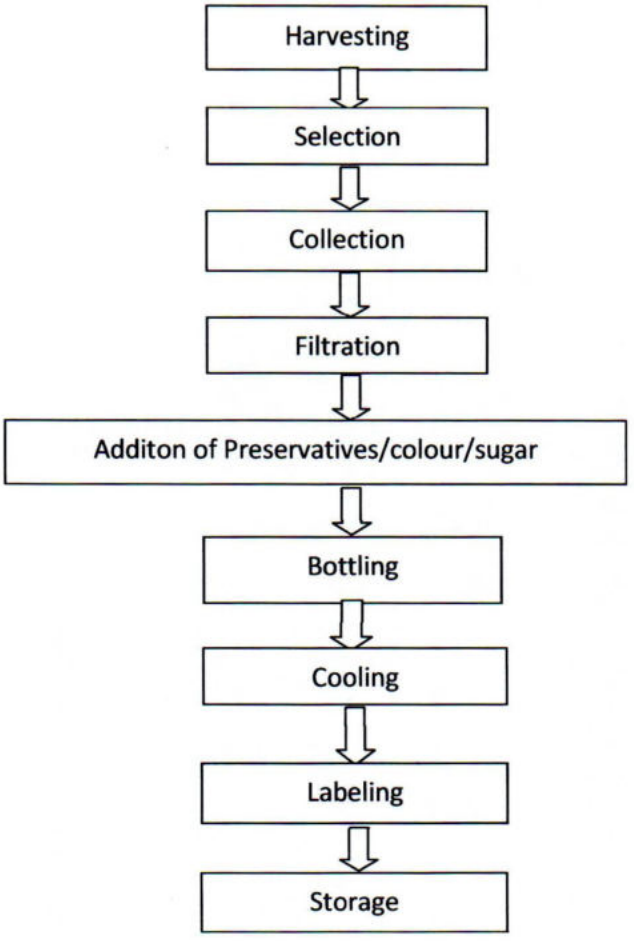

Fig. 3.2 : Flow sheet diagram for coconut water processing without heat

3.2.2 Bottling of green coconut water

The processed water was filled into clean glass bottle keeping about 6mm head space (0.25 inch). The bottles was exhausted in boiling water for 20 minutes and immediately closed with pp caps and/or crown caps. The bottles were then sterilized at 121 ^{0}C for 15 minute. The heat processed bottles were immediately cooled under running water to 40 ^{0}C. The bottle was then labeled and stored at ambient temperature and refrigerated temperature (4 to l0 ^{0}C)

3.3 Proximate analysis of green coconut water and process water

The heated and strained green coconut water was analyzed for moisture, ash, vitamin-C, carotene, total soluble solid, pH, terrible acidity, reducing sugar, non reducing sugar and total sugar content, protein, fat.

3.3.1 Moisture

The waters was taken in porcelain crucibles in triplicate and in an oven dried at 80 ^{0}C until the weight became constant. Percent of moisture content was calculated according to the following formula:

$$\%\text{Moisture} = \frac{(1-F)\times 100}{I}$$

Where,

I = Initial weight, and

F= Final weight of sample

3.3.2 Determination of acidity

Reagents

- 0.1N NaOH Solution
- 1% Phenolphthalein indicator

Procedure

Five gram sample was taken in 250 ml beaker added 30-40ml distilled water and was dissolved by stirring with a glass rod boiled and cooled. Then volume made up 100ml in volumetric flask. 10ml solution was taken in a conical flask added 2-3 drops phenolphthalein indicator and titrated against 0.1N NaOH solution. At the end point pink color was observed and the following data was obtained.

Calculation

The acidity of the pulp was estimated by the following formula:

Equivalent weight of citric acid = 64

$$\%\ acid = \frac{\boldsymbol{Titre\times Normality\ of\ alkali\times volume\ made\ up\times Equivalent\ wt.of\ acid\times 100}}{\textbf{wt.of sample taken}\times\textbf{volume of sample taken for estimation}\times 1000}$$

3.3.3 Fat determination

Coconut water sample remaining after moisture determination was transferred to a thimble and plugged the top of the thimble with a wad of fat free cotton. The thimble was dropped into the fat extraction tube of a Soxhlet apparatus. The bottom of the aspiration tube was attached to a Soxhlet flask. Approximately 75 ml or more of anhydrous ether was poured through the sample in the tube in to the flask. The top of the fat extraction tube was attached to the condenser. The sample was extracted for 16 hrs or longer on a water bath at 70-80 ^{0}C. At the end of the extraction , the thimble from the apparatus was removed and distilled off most of the petroleum ether by allowing it and was collected in Soxhlet tube.

The petroleum ether was poured off when the tube was nearly full. When the petroleum ether had reached small volume, it was poured into a small, dry (previously weighed) beaker through a small funnel containing plug cotton. The flask was raised and filtered thoroughly using ether. The ether was evaporated on steam bath at low temperature and was then dried at 100 ^{0}C for 1 hour then cooled and weighted. The difference in the weights gave the ether soluble material present in the sample.

The percent of crude fat was expressed as follows:

$$\% \text{ Crude fat} = \frac{Weight\ of\ ether\ soluble\ material \times 100}{Weight\ of\ sample}$$

3.3.4 Protein content determination

Digestion

About 2 ml sample was weighed and was transferred in to the Kjeldahl flask. About 25 ml of concentrated H_2SO_4 and digestion mixture were added to the flask. Then the contents of the Kjeldahl flask was heated over a low flame in a digestion chamber until the solution becomes clear (bluish colour). After digestion, the flask was cooled carefully and made the volume 100 ml with distilled water.

Distillation

An aliquot (5 ml) was taken for distillation in a distillation flask 10 ml boric acid solution, 10-15 ml of ammonia free water and 2 drops of mixed indicator were taken in a 100 ml

conical flask. The distillation apparatus was connected up with the delivery tube dipping below the boric acid solution in the conical flask. To the distillation flask, about 40 ml of 40% NaOH solution was added and the ammonia was distilled off into the boric acid solution. When the distillation was over, the burner was removed, the condenser and the delivery tube was washed down into the receiver.

Titration

The ammonia collected was titrated with 0.1 N HCI solutions and the volume was recorded. The percentage of nitrogen in each of the sample was multiplied by a factor of 6.25 (protein conversion factor) and then the average value was considered to be the crude protein.

$$\%\text{Nitrogen}=\frac{(Sample\ titre-Bland\ titre)\times Normality of\ HCl\times 14\times Volume\ made\ of\ the\ digestion\times 100}{Aliquot\ of\ digestion\ taken\times weight\ of\ the\ sample\ taken\times 1000}$$

$$\%\ \text{protein} = \%\ \text{Nitrogen} \times 6.25$$

3.3.5 Total Soluble Solids

A Refractrometer was used for determination of total soluble solid content of the water. A drop of green coconut water sample was placed on the prism of the Refractrometer and percent of total soluble solid was obtained from direct reading. Temperature Correction was made as described by Rangana (1992).

3.3.6 Total sugar

Fifty milliliters of the filtrated water obtained for determination of reducing sugar was taken in a 250 ml volumetric flask and 10 nil conc. HCL was added to it. The mixture was allowed to stand at room temperature for 24 hrs, neutralized with NaOH, made to volume and then titrated against measured volume of Fehling's solution. Percent of total sugar was calculated as in % reducing sugar making uses of titrate value obtained in determination of total sugar after inversion.

3.3.7 Reducing sugar

Ten milliliters water was homogenized with water and transferred to 500-ml beaker. It was neutralized with 0.1 N NaOH and boiled gently for one hour adding water to keep the volume nearly constant. The content of the beaker was cooled and transferred to a 500-ml volumetric flask. Two milliliters lead acetate followed by 1.1 ml of Potassium Oxalate was added to clear the mixture and then the volume was made to 500 m1. The mixture was filtrate and used to titrate against a measured amount of Fehling's solution. The Fehling's solution had earlier been titrated with standard invert solution.

$$\% \text{ total Sugar} = \frac{I \times D \times 100}{T \times W}$$

Where,

I = mg of invert sugar required to reduce known volume of Fehling Solution

D = Dilution

T = Titration

W = Weight sample.

3.3.8 Non-reducing sugar (sucrose)

Non-reducing sugar content was calculated as follows:

% Non-Reducing sugar = %Total sugar - %Reducing sugar

3.3.9 Ascorbic acid

Ten milliliters water was homogenized in a blender with meta-phosphoric acid solution. The homogenized liquid was transferred to a 100 ml volumetric flask and made to volume with meta-phosphoric acid solution. Contents of the flask was then thoroughly mixed and filtered. Ten milliliters of the aliquot was taken in an Erlenmeyer flask and titrated with 2-6 dichlorophenol indophenols dye.

The dye had earlier been standardized with vitamin C solution of find an equivalence factor for the dye. The ascorbic acid content of the sample was calculated from the following formula:

$$\textbf{Mg of ascorbic acid per 100ml of water} = \frac{T \times D \times V1 \times 100}{V \times W}$$

3.3.10 Ash

The oven-dried sample used for determination of moisture was burnt in a muffle furnace at 550 ^{0}C for 4 hours after initial churning at 100 ^{0}C and percent % ash was calculated as follows: (A.O.A.C. method.)

$$\%\text{Ash} = \frac{A \times 100}{I}$$

Where, A = Weight of ash and

I = Initial weight of water

3.3.11 Standard plate count

Preparation of dilution:

Weighed 10.0 grams of green coconut water and transferred into a conical flask containing 90 ml of sterile physiochemical solution (0.85 % NaCl). After adequate shaking further dilutions was made.

Plating and incubation:

Transferred 0.1/ml from each dilution in sterile solidified agar plate and spread uniformly with a sterile triangular shaped glass rod. The inoculated plates (petridishes) were incubated (inverted position) at 30 ^{0}C for 72hrs. A blank was also run simultaneously to assess the contamination from environment and other sources

Counting plates: Colonies were counted on duplicate plates with 30-300 colonies per plate.

3.3.12 Sensory evaluation

Water was tasted by a panel of 10 judges according to ISI specification (1970) and BSTI standard methods. All the judges consisting the panel were conversant with the factors governing the quality of the products. The products was served to each judge who independently examined the characteristic (a) colour and texture (b) taste and flavor and (c) The relative importance of each factor was expressed numerically described in appendix 1 and recorded his/her observation in the score sheet as shown in appendix 2.

The average score of each factor with overall average for each product was then calculated. To ascertain uniformity of judgment among the judges, the total score assigned by each of them for the same product was calculated by adding up the scores for the various individual

CHAPTER IV

RESULTS AND DISCUSSIONS

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Chemical composition of green coconut water

Freshly green coconut water (photo.4.1) collected from Hajee Mohammad Danesh Science and Technology University, Dinajpur campus were analyzed for various chemical compositions. The moisture, ash, acidity, pH, total sugar and ascorbic acid were found 95.03, 0.6, 0.08, 4.95, 3.8 percent and 1.5 mg per 100 ml water respectively and shown in Table 4.1. From table it was observed that fresh coconut water is carotene free and also acidity percentage is very low (i.e 0.08%). Bian Cardini and Tasta Di (1965) reported that the percentage of the moisture content, ash, total sugar, pH and ascorbic acid content of fresh coconut water were 95.5, 0.5, 3.2, 5.1 percent and 1mg per 100 g coconut water respectively. The percentage of moisture, ash and pH were observed very closed to Bain Cardin and Tasta Di (1965)

Photo 4.1 : Tender green coconut

4.2 Proximate Composition of processed green coconut water

Samples that were processed were analyzed for chemical composition.In chemical analysis moisture ,TS, TSS, reducing sugar , non reducing sugar,acidity ascorbic acid were found.It was observed that moisture,TS,TSS,acidity and ascorbic acid were changed and reducing sugar , non reducing sugar were unchanged as shown inTable 4.2.

Table 4.1: Composition analysis of green coconut water

Sample	Moisture (%)	Ash (%)	Acidity (%)	pH	Total solid (TS) %	Total soluble solid(T.S.S) %	Reducing sugar (%)	Total sugar (%)	Ascorbic acid mg/100ml	Carotene	Protein mg/1000g	Fat mg/1000g
Green coconut water	95.03	0.6	0.08	4.95	4.5	4.0	3.2	3.8	1.5	0	0.1	0.1

Table 4.2 : Proximate Composition of processed green coconut water

Sample Code	Moisture (%)	TS (%)	TSS (%)	Reducing Sugar (%)	Non Reducing sugar (%)	Total sugar (%)	Acidity (%)	Preservatives (KMS)	Ascorbic acid mg/100ml
A	93.05	6.95	5	3.2	0.6	3.8	0.149	0.5g/1000ml (KMS)	1.5mg
B	94.03	5.97	4.5	3.2	0.6	3.8	0.155	0.6g/1000ml (KMS)	0.55mg
C	93. 20	6.8	5	3.2	0.6	3.8	0.259	0.5g/1000ml (KMS)	1.0mg
D	94. 03	5.97	5.1	3.2	0.6	3.8	0.145	0.5g/1000ml (Sodium benzoate)	0.99mg
E	95.3	4.97	4	3.2	0.6	3.8	1.00	-	1.00mg
F	91. 53	8.47	7.5	3.2	0.6	3.8	0.149	Sugar	1.10mg
G	94. 06	5.94	4.6	3.2	0.6	3.8	0.499	0.5g/1000ml Kms	1.25mg
H	93. 33	6.67	5.3	3.2	0.6	3.8	0.149	0.5g/1000 ml	0.55mg

4.3 Sensory evaluation of green and processed coconut water

The green coconut water was treated with different amount of citric acid, preservatives and other condiments requirement and permissible limit of human body (Table 3.1, Table 4.2 and Photo 4.2). A panel of ten judges evaluated the samples. The mean scores for colour, flavor and overall acceptability of the samples are presented in appendix 3, 4, 5, 6, 8 and 9. A two ways analysis of variance indicated that all these sensory attributes of different samples were significantly ($p<0.01$) different and thus the sensory attributes of the samples showed various degrees of acceptability. As shown Table 4.3 the DMRT test revealed that the samples E, D, B, and H scored significantly better colour of green coconut water and equally acceptable. But there was no significant difference in colour preference among the samples F and G. There was also no significant different in color among samples A and C. Sample A had shown least colour acceptability than other samples of coconut water. Sample E secured the highest score for colour (24.10) whereas sample A secured the lowest score (21.10).

Sample (Table 4.4) E, B, C and F scored significantly better flavour and acceptability than other samples. There was no significant difference in flavour acceptability among the samples H, D and G. Sample (without pasteurization) showed least acceptability in flavour preference. Sample B scored (7.90) significantly better consistency

Photo 4.2 : Samples

Table 4.3 : Duncan's Multiple Range Test (DMRT) Value for colour of green water

Sample type	Original order	Sample type	Ranked order
A	21.20^{b}	E	24.10^{a}
B	23.90^{a}	D	24.00^{a}
C	21.90^{b}	B	23.90^{a}
D	24.00^{a}	H	23.80^{a}
E	24.10^{a}	F	23.70^{ab}
F	22.70^{ab}	G	22.40^{ab}
G	22.40^{ab}	C	21.90^{b}
H	23.80^{a}	A	21.10^{b}

Mean with same superscript within a column are not significantly different at $p<0.01$

Sample A : Without heat + acidity 0.8% + 0.5 g/kg KMS

Sample B : Heat + acidity 0.8% + 0. 6g/kg KMS

Sample C : Heat + acidity 0.95% + 0.5g/kg KMS

Sample D : Heat + acidity 0.8% + 0.5g/kg Sodium benzoate

Sample E: Heat + acidity 0.8%

Sample F : Heat + acidity 0.8% + 10g/kg Sugar

Sample G : Heat + acidity 1% + 0.5g/kg KMS

Sample H: Heat + acidity 0.8% + Colour 1mg/kg + 0.5g/kg KMS

Table 4.4 : Duncan's Multiple Range Test (DMRT) Value for flavour of green water

Sample type	Original order	Sample type	Ranked order
A	21.20^{c}	E	23.80^{a}
B	23.70^{a}	B	23.70^{a}
C	23.50^{ab}	C	23.50^{ab}
D	21.70^{bc}	F	23.20^{ab}
E	23.80^{a}	H	22.70^{abc}
F	23.20^{ab}	D	21.70^{bc}
G	21.60^{bc}	G	21.60^{bc}
H	22.70^{abc}	A	21.20^{c}

Mean with same superscript within a column are not significantly different at $p<0.01$

Sample A : Without heat + acidity 0.8% + 0.5 g/kg KMS

Sample B : Heat + acidity 0.8% + 0. 6g/kg KMS

Sample C : Heat + acidity 0.95% + 0.5g/kg KMS

Sample D : Heat + acidity 0.8% + 0.5g/kg Sodium benzoate

Sample E: Heat + acidity 0.8%

Sample F : Heat + acidity 0.8% + 10g/kg Sugar

Sample G : Heat + acidity 1% + 0.5g/kg KMS

Sample H : Heat + acidity 0.8% + Colour 1mg/kg + 0.5g/kg KMS

Table 4.5: Duncan's Multiple Range Test (DMRT) Value for Overall acceptability of green coconut water

Sample type	Original order	Sample type	Ranked order
A	5.60^{c}	B	7.90^{a}
B	7.90^{a}	E	7.80^{a}
C	6.70^{abc}	D	7.70^{ab}
D	7.70^{ab}	F	7.20^{abc}
E	7.80^{a}	C	6.70^{abc}
F	7.20^{abc}	H	5.80^{bc}
G	5.80^{bc}	G	5.80^{bc}
H	5.80^{bc}	A	5.60^{c}

Mean with same superscript within a column are not significantly different at $p<0.01$

Sample A : Without heat + acidity 0.8% + 0.5 g/kg KMS

Sample B : Heat + acidity 0.8% + 0. 6g/kg KMS

Sample C : Heat + acidity 0.95% + 0.5g/kg KMS

Sample D : Heat + acidity 0.8% + 0.5g/kg Sodium benzoate

Sample E: Heat + acidity 0.8%

Sample F : Heat + acidity 0.8% + 10g/kg Sugar

Sample G : Heat + acidity 1% + 0.5g/kg KMS

Sample H : Heat + acidity 0.8% + Colour 1mg/kg + 0.5g/kg KMS

than samples (Table 4.5). Sample A scored least (5.60) acceptability in terms of consistency. There was no significant difference in consistency among the samples of B, E, D, C and F. These samples were equally acceptable and did not show significance in consistency. There was no significant difference in overall acceptability among the samples H and G and those samples were statistically equally acceptable. Sample A had the least overall acceptability when compared with other. The overall acceptability of green coconut water, the samples, E, D and F were the most preferred and significantly better when compared with other samples.

4.4 Storage studies of green and processed coconut water

Nine samples (with mother sample) of processed green coconut water were stored at room temperature (25 to 35 ^{0}C) and refrigerated temperature (4 to 10 ^{0}C). The effect of storage time (l, 2, 3 and 4 months) on physical properties such as colour, flavour, turbidity and on chemical properties such as total soluble solid (TSS), acidity, microbial load were studied. In observation it was shown that Sample M (only filtered water without any treatment) was spoiled after 10 days. From Table 4.6 and Photo.4.3,photo 4.4 and photo 4.5 showed that the color of all the samples was in good condition up to 4 months of storage in both temperatures.

The flavour of all samples except E, D, H and G were in good condition up to 4 months of storage but after that time fermentation began in sample A. Cloudy turbidity was observed in sample E and F after one months of storage and sedimentation was observed in sample H after 1 months of storage, Acidity ash, total soluble solid (TSS) and gas formation remain almost unchanged during the full period of storage. A noticeable fluctuation was recorded in the microbial load and the highest microbial load was observed in the sample F (828) which was finally spoiled as shown in Table 4.6 and 4.7.

Table 4.6: Storage studies of processed green coconut water

Period of storage (month)	Sample Code	Colour	Flavour	Turbidity	T.S.S (%)	Acidity (%)	Gas formation	Microbial Load	Remarks
1	A	Colour less	Good	Transparent	4	0.149	Nil	300	Good
	B	Colour less	Good	Transparent	4	0.160	Nil	215	Good
	C	Colour less	Good	Transparent	4	0.250	Nil	220	Good
	D	Reddish	Good	Transparent	4	0.145	Nil	300	Good
	E	Reddish	Not Good	Cloudy	4	0.90	Nil	450	Spoiled
	F	Yellow	Good	Cloudy	4.25	1.05	Nil	425	Spoiled
	G	Colour less	Not Good	Transparent	4	0.499	Nil	225	Good
	H	Greenish	Good	Transparent	4	0.149	Nil	250	Good
2	A	Colour less	Good	Transparent	4	0.149	Nil	330	Good
	B	Colour less	Good	Transparent	4	0.160	Nil	320	Good
	C	Colour less	Good	Transparent	4	0.258	Nil	340	Good
	D	Reddish	Not Good	Transparent	4	0.148	Nil	520	Spoiled
	E	Reddish	Not Good	Cloudy	4	0.95	Nil	500	Spoiled
	F	Yellow	Not Good	Cloudy	4.25	1.14	Nil	525	Spoiled
	G	Colour less	Good	Transparent	4	0.499	Nil	345	Good
	H	Greenish	Not Good	Transparent	4	0.150	Nil	360	Good

Table 4.7: Storage studies of processed green coconut water

Period of storage (month)	Sample Code	Colour	Flavour	Turbidity	T.S.S (%)	Acidity (%)	Gas formation	Microbial Load	Remarks
3	A	Colour less	Good	Transparent	0.398	0.151	Nil	380	Good
	B	Colour less	Good	Transparent	4	0.161	Nil	320	Good
	C	Colour less	Good	Transparent	4	0.259	Nil	340	Good
	D	Reddish	Not Good	Transparent	4	0.151	Nil	710	Spoiled
	E	Reddish	Not Good	Cloudy	4	0.153	Nil	600	Spoiled
	F	Yellow	Good	Cloudy	4.25	0.98	Nil	645	Spoiled
	G	Colour less	Not Good	Transparent	4	0.500	Nil	355	Good
	H	Greenish	Not Good	Transparent	4	0.149	Nil	380	Good
4	A	Colour less	Good	Transparent	0.398	0.152	Nil	400	Good
	B	Colour less	Good	Transparent	4	0.149	Nil	427	Good
	C	Colour less	Good	Transparent	4	0.399	Nil	480	Good
	D	Reddish	Not Good	Cloudy	4	0.157	Nil	820	Spoiled
	E	Reddish	Not Good	Cloudy	4	0.156	Nil	780	Spoiled
	F	Yellow	Good	Cloudy	4.25	0.160	Nil	828	Spoiled
	G	Colour less	Good	Transparent	4	0.501	Nil	435	Good
	H	Greenish	Good	Transparent	4	0.151	Nil	491	Good

Photo 4.3 : Samples after 1st month

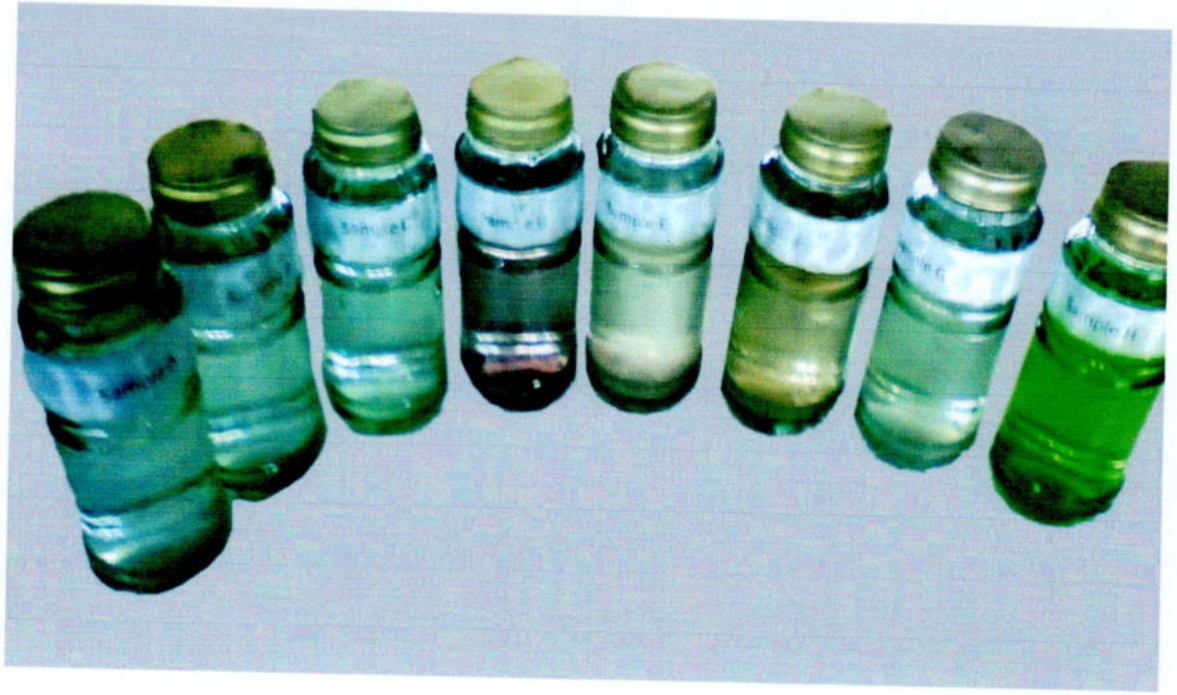

Photo 4.4: Samples after 2nd month

Photo 4.5: Samples after 4th month

CHAPTER V

SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSION

The research was conducted in the Laboratory of the Faculty of Agro-Industrial and Food process Engineering, Laboratory of Chemistry, Pathology lab, Hajee Mohammad Danesh Science & Technology University, Dinajpur and in BCSIR during the month from May 2012 to September 2012 collecting green coconut from the HSTU campus.

The clean, tender and sound green water was filtered through a filtering machine.The coconut water was then analyzed for total soluble solids, moisture content, sugar, acidity, pH, ascorbic acid, ash content and carotene. The proximate composition of coconut water showed moisture 95.03%, TSS 4%, acidity 0.08%, reducing sugar 3.2%, non-reducing sugar 0.6%, ascorbic acid 1.5mg/100gm, carotene 0% and minor quantity of protein and fat. The water was heated at 80- 85 ^{0}C for 10 minutes, cooled and strained through a fine strainer. Nine sample samples were prepared with original total solid (TS). The total solid (TS) of green coconut water were found 4.5%. The acidity of two samples were maintained at 0.95% and 1% adding citric acid. The preservatives $K_2S_2O_5$, Sodium benzoate, Sugar, green colour were used in samples. The water was filled into bottles keeping 0.25 inch head space, exhausted, sealed, heated for 15 minutes, cooled immediately to 40 ^{0}C, labeled and stored.

The change in colour, flavour, turbidity, TSS, acidity, microbial load and gas formation were observed during the bottles were stored at in refrigerator temperature. Observation was made at an interval of one month up to 4 months. The colour and flavour of processed green coconut water remained unchanged in some samples throughout the storage period. The preservatives and acidity improved transparency. No gas formation was observed in bottle water while stored. The microbial load was observed very low.

From this research it can be concluded that sample B was the best of all samples considering color, flavor, overall acceptability and storage period. Sample B was treated as heat at 80-85^{0}C, acidity 0.8% and 0.6g/1000ml KMS.

Tender coconut water preserved in a large scale in commercial basis can be supplied to the weak patients, old aged people and tender aged children creating some scope of employment in the coconut, coconut water based industries to earn or save a large amount of money.

This study will open up possibilities for further work on the processing and preservation of green coconut water and as it is rich in nutrient specially rich in mineral contents, all should drink it daily specially in hot days.

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APPENDICES

APPENDICES

Appendix 1 : Methods for indicating score for coconut water

CHARACTERSTICS	DESCRIPTION	MAXIMUM NUMBER OF POINTS
Colour	Good, bright, practically uniform, free from discolouration due to oxidation or other causes, changes normally associated with processing as defects	25
	Good, bright, reasonably uniform colour	20
Taste and flavour	Pleasant taste and flavor characteristics of the product ; free from any taste or odour of scorching, caramelization, oxidation and terpency flavor; free from any objectionable smell or off-odour	25
	Pleasant taste; slight flavor indicating scorching or burning but such as not to render the product unacceptable	20
Absent of defects	Practically free from defects such as presence of particles of membrane, peel, skin, seed, rag and foreign materials like grit, dirt, fibrous tissues and coarse particles of juice. No oily ring at the surface.	25
	Reasonably free from defects; a few coarse particles of juice may be present. No oily ring at the surface.	20

Appendix 2 : Score sheet for individual judge

Details of sample:

Sample no. .....

Date of sampling:

a) Product:.....

b).....

b) Batch no. ..... d).....

Factors	Scores point	Sample containers							
		A	B	C	D	E	F	G	H
Colour and texture	20 - 25								
Flavour	20 - 25								
Overall acceptability	20 - 25								

Appendix 3: Rating score for colour of green coconut water

Judge	Samples(treatment)							
	A	B	C	D	E	F	G	H
1	23	24	23	24	25	21	23	25
2	20	25	21	24	23	22	22	23
3	21	23	22	23	24	24	22	24
4	22	23	23	25	25	23	23	23
5	21	25	20	25	24	24	24	25
6	20	25	23	24	24	25	23	24
7	21	23	21	23	23	21	23	24
8	21	24	22	24	24	22	22	23
9	20	24	23	25	25	23	21	25
10	23	23	21	23	24	22	21	22
Total	212	239	219	240	241	227	224	238
Mean	21.2	23.9	21.9	24	24.1	22.7	22.4	23.8

Appendix 4 : Analysis of variance (ANOVA) for color of green coconut water

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit* (At 1% level)
Rows	16.27778	9	1.808642	0.926043	0.508025	2.012705
Columns	2807.822	8	350.9778	179.7042	2.11E-44	2.069832
Error	140.6222	72	1.953086			
Total	2964.722	89				

Appendix 5: Rating score for flavour of green coconut water

Judge	Samples(treatment)							
	A	B	C	D	E	F	G	H
1	20	25	23	21	25	23	21	22
2	23	25	24	21	23	23	21	23
3	20	24	23	22	24	24	23	22
4	21	23	25	23	24	22	22	24
5	22	22	23	21	23	21	21	23
6	22	21	25	23	25	23	23	25
7	21	25	24	21	24	24	21	21
8	20	23	21	22	23	23	22	23
9	21	24	23	22	22	25	21	21
10	22	25	24	21	25	24	21	23
Total	212	237	235	217	238	232	216	227
Mean	21.2	23.7	23.5	21.7	23.8	23.2	21.6	22.7

Appendix 6 : Analysis of variance (ANOVA) for flavour of green coconut water

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit* (At 1% level)
Rows	20.76667	9	2.307407	1.109528	0.367297	2.012705
Columns	2697.6	8	337.2	162.1443	6.98E-43	2.069832
Error	149.7333	72	2.07963			
Total	2868.1	89				

Appendix-7 : Single stimulus method of consumers taste panel

Name of judge:

Product :

Date :

Like extremely(9)	A	B	C	D	E	F	G	H
Like very much(8)								
Like moderately(7)								
Like slightly(6)								
Neither like nor dislike(5)								
Dislike slightly(4)								
Dislike moderately (3)								
Dislike very much(2)								
Dislike extremely(1)								

Appendix 8: Rating score for overall acceptability of green coconut water

Judge	Samples(treatment)							
	A	B	C	D	E	F	G	H
1	6	7	5	7	7	6	4	7
2	5	7	6	8	8	7	7	7
3	5	8	8	8	7	7	5	8
4	6	9	9	7	9	6	7	5
5	7	8	7	9	7	8	7	4
6	7	8	8	8	7	8	6	4
7	5	7	6	8	8	7	5	3
8	6	8	5	7	8	7	6	5
9	3	8	6	7	8	8	6	7
10	6	9	7	8	9	8	5	8
Total	56	79	67	77	78	72	58	58
Mean	5.6	7.9	6.7	7.7	7.8	7.2	5.8	5.8

Appendix 9 : Analysis of variance (ANOVA) for overall acceptability of green coconut water

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit* (At 1% level)
Rows	26.88889	9	2.987654	1.498916	0.164874	2.012705
Columns	81.6	8	10.2	5.117374	4.61E-05	2.069832
Error	143.5111	72	1.99321			
Total	252	89				