STORAGE STABILITY AND QUALITY EVALUATION OF COCONUT WATER–FRUIT JUICE BLENDS

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Abstract. The development of an acceptable juice blend with mature coconut water as a full water substitute into a ready-to-drink beverage was investigated in this study. Mature coconut water was mixed with fruit juices of pineapple, orange and soursop (*guyabano*), separately and at varying ratios, to come up with a juice blend.

Acceptability was determined through sensory evaluation. The best formulation of each juice blend were found to be as follows: Coconut water-Orange Blend 30:70 ratio; Coconut water-Pineapple Blend 40:60 ratio; and Coconut water-Soursop Blend 60:40 ratio.

Storage stability was conducted on the most acceptable formulation from each fruit juice blend. Stored for 7 weeks at 4-5ºC, the product samples yielded a decrease in Vitamin C content, more prominently in soursop blend. Physicochemical changes during storage did not affect product acceptance; the samples were still acceptable after the storage period. Microbial activity remained below limits hence thermal processing and level of acidity were found adequate. The proximate composition was comparative with recent studies.

Keywords: *mature coconut water, fruit juice blends, Vitamin C, storage stability, physicochemical analysis, microbial analysis*

1. INTRODUCTION

Fruit juices of all types and in all forms have a significant role in both food nourishment and satisfaction. This trend has certainly increased over the last half decade. Juice products manufactured at small-scale level have become available in international trade and could be scaled up upon demand (Bates *et al*., 2001).

According to Ringblom (2007), the European market shows a steady increase in sales volume of fruit juices, which are now at some 11 billion liters per year. Similarly, the retail commercial value of the almost 20 billion liters of juice and juice products in the USA exceeded US$18 billion, which is roughly 3% of the total food sales expenditure amounting to US$630 billion. World trade has also accelerated over the last decade with developing countries achieving over 60% of fruit juice exports. Brazil, the largest citrus producer, provides 25% of world production (Bates *et al*., 2001).

The global demand for processed Philippine fruits accounted for an average yearly growth of approximately 7% from 2006 to 2010. Major processed fruits exported include prepared or preserved fruits which account for 53% of total exports; while juices or concentrates and purees cover 24%. Furthermore, the 2010 export proceeds amounted to US$386.76 million or an increase of 2.44% from 2009 and exported to 108 countries (Board of Investments Report, 2011).

As the market for fruit juices experiences significant growth, so are the need for higher nutritional value and more innovative products. Some known flavorful juices, that may not be balanced nutritionally or which lack particular nutrients can be blended with other natural juices to bring about completeness (Bates *et al*., 2001). De Carvalho *et a*l. (2007) worked on coconut water-cashew-apple beverage, where two or more kinds of fruit juices are blended to obtain a product that combines the nutritional value of both fruits. This kind of new product development presents a different but pleasant taste. This is now ongoing in the food industry and has been well accepted by consumers.

Coconut water is the liquid endosperm that fills the central cavity enclosed by a solid endosperm protected by the hard cell and husk (Chowdhury and Aziz, 2005). According to Chauhan *et al*. (2012), the wide applications of coconut water is due to its unique chemical composition; it contains reducing sugars, vitamins, minerals, amino acids and phyto-hormones. The total reducing sugar and protein content increase as the coconut matures.

The present study focuses on the development of three separate fruit juice blends wherein mature coconut water is combined with fresh orange juice, fresh pineapple juice and fresh soursop (*guyabano)* juice. This study is divided into two phases: (1) Evaluation of the acceptability of the processed fruit juice blends through sensory evaluation; and (2) Storage stability of the best formulation of each fruit juice blend.

2. METHODOLOGY

The Philippine Coconut Authority (PCA) supplied the mature coconut water for this study. On the other hand, three selected fruits namely: orange, pineapple, and soursop (*guyabano*) were obtained from Anonas Extension Market, Quezon City.

Fresh orange, pineapple, and soursop fruits at firm ripe stage were visually examined for no defects, no deformities, no dark spots and no microbial contamination after which they were selected, and thoroughly washed with tap water. The fruits were then peeled assuring that unnecessary parts were removed. Next, the peeled oranges were cut into quarters and then squeezed using the manual squeezing device; while the pineapple fruit was squeezed using an electric juicer. The soursop juice was extracted by first removing the seeds then squeezing the pulp manually through sterilized cheesecloth then filtering further through the use of plastic sieve.

Each fruit juice was mixed with mature coconut water in varying ratios. The 2005 Codex General Standard for Fruit Juices and Nectars has standards for Total Soluble Solids (TSS) and pH. The required TSS, measured in deg Brix, was attained by adding refined sugar to the mixture; whereas the required pH 4 was attained by adding food grade phosphoric acid to the mixture. The juice blends were then pasteurized using HTST at 96°C for 20 sec after which they were filled into 250-ml glass bottles. After pasteurization, the juices were cooled to room temperature. Samples were finally stored at refrigerated temperature of 4-5°C.

2.1 Acceptability

Each fruit juice blend, in three different ratios, was subjected to sensory evaluation separately to determine the best formulation. Twenty-five panelists evaluated the product samples in terms of color, flavor, aroma, aftertaste and overall acceptability. The collected data was analyzed using Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) for multiple comparisons, at 5% level of significance.

2.2 Storage Stability

The best formulation from each fruit juice blend was stored at refrigerated temperature of 4-5^{o}C for seven weeks and evaluated periodically for organoleptic changes. Samples were assessed on the 1st week, 3rd week and 7th week and subjected to physicochemical analysis, proximate analysis, microbial assessment and sensory evaluation.

Physicochemical analysis consisted of pH, total soluble solids (TSS) and titratable acidity (TA) and ascorbic acid (Vitamin C) determination; while Proximate analysis included moisture content, crude protein, crude fat and ash content. These were done by a third party Lab Testing service, using standard analytical methods. Microbiological assessment consisted of total plate count (TPC) and yeast and mold count (YMC) also performed by the same 3rd party Lab Testing service, using AOAC methods.

For sensory evaluation, the triangle test was utilized to determine if a critical product attribute such as its original flavor was retained during storage. This approach consists of presenting three coded samples at one time with two of the samples being identical and the third different. The latter is generally referred to as the odd sample. The panelist tastes each sample then she marks on the score sheet the odd sample, the sample that is different from the other two. If a certain number of the panelists correctly chooses the odd sample, then significant difference is established. At that point, deterioration has taken place and the samples are no longer safe for human consumption. For this test, 20 panelists tasted each coded sample and then marked on the score sheet the odd sample. The identical samples consisted of the latest production samples while the odd sample was the sample under storage.

3. RESULTS AND DISCUSSION

Mature coconut water was combined with fresh juice of orange, pineapple and soursop (*guyabano*) independently to form three separate juice blends. This juice blend is a ready-to-drink beverage. According to Haynes et al. (2010), blended juice beverages include coconut water, instead of regular water, to provide natural isotonic properties to the beverage.

3.1 Acceptability

Three ratios of each fruit juice blend underwent sensory evaluation to determine the acceptable formulation. The proportions were added with sugar to meet the standard total soluble solids, measured in ºBrix, as stated in the 2005 Codex General Standard for Fruit Juices and Nectars. Food grade phosphoric acid was used to adjust the pH to 4.0 which is also a requirement in Codex.

The 2013 Code of Federal Regulations Title 21 which is administered by the USFDA emphasizes the limitation of this phosphoric acid not to exceed 0.5% by weight. As illustrated in the method for production of blended juice beverages using coconut water, phosphoric acid is added in an amount of less than 1% by weight (Haynes *et al*., 2010). While other acids can be used, phosphoric acid is preferred because of its cost efficiency and the desirable sensory properties of coconut water beverage when added with this acid. The juice blends were processed using HTST (high temp short time) to minimize the undesirable quality changes that occur (Rupasanta and Yu, 2012). Haynes *et al*. (2010) points out that if the pH of the beverage can be lowered to pH below 4.5 then it can be pasteurized to meet wholesomeness and microbial control requirements. The HTST at 96°C for 20 seconds. will not destroy the natural pleasing taste and aroma of the juice blend, as do higher temperature which is done in low-acid foods and beverages.

3.2 Coconut Water-Orange Blend

Mature coconut water was mixed with fresh orange juice to form a ready-to-drink beverage. Table 1 shows the proportions for this blend and the corresponding mean scores from sensory evaluation

In terms of color, flavor and aroma, no significant difference was detected among the three mixtures. J^3 was rated highest, as follows: 2.8 for color (*orange color*), 3.72 for flavor (*moderately orange flavor*) and 3.40 for aroma (*no distinctive orange aroma*).

Table 1. Mean scores of the different formulations of coconut water-orange blend (N=25)

Formulations (Coconut Water: Orange Extract)	Color	Flavor	Aroma	After-taste	Overall Acceptability
J^1 50:50	2.60^a	3.68^a	3.20^a	3.80^b	3.44^b
J^2 40:60	2.04^a	3.40^a	3.12^a	4.12^{ab}	3.96^a
J^3 30:70	2.80^a	3.72^a	3.40^a	4.24^a	4.08^a

Superscripts of the same letter within each column are not significantly different from each other at $P \leq 0.05$.

Mean score legend:

- Color: 1-light orange; 5- dark orange [Color chart provided]
- Aroma: 1-no odor; 5-extremely sweet and has a distinctive citrus aroma
- Flavor: 1-imperceptible; 5-strong orange flavor
- Aftertaste: 1-extreme coconut water after-taste; 5-no coconut water after-taste
- Overall Acceptability: 1-not acceptable; 5- most acceptable

On the other hand, with aftertaste and overall acceptability J^3 was not significantly different from J^2 but was significantly different from J^1 due to the high amount of juice extract in J^3. For aftertaste, J^3 posted the highest mean score at 4.24 (*little after-taste)*. With overall acceptability, results showed that J^3 had the highest mean score at 4.08 (*acceptable*). The mean ratings of each attribute were directly influenced by the 10% increase of fruit juice extract present in J^1 to J^3.

3.3 Coconut Water-Pineapple Blend

Mature coconut water was likewise blended with pineapple juice extract to produce a ready-to-drink beverage. Data collected from sensory evaluation of the juice blend ratios are tallied in Table 2. In terms of color, J^3 acquired the highest mean rating of 2.96 (*yellow* color*)*; it had highest proportion of juice hence the more yellow.

In terms of flavor, J^3 posted the highest mean score of 3.68 (*moderate pineapple flavor)* but was not significant with J^2. For aroma and overall acceptability, J^3 got the highest rating of 3.67 and 3.72, respectively but was not significantly different from J^2 and J^1. The juice blend ratios may have been close to each other to exhibit significant difference. For aftertaste, no significant difference was likewise detected but J^1 got the highest rating of 4.08 (*little aftertaste*).

Table 2. Mean scores of the different formulations of coconut water-pineapple blend (N=25)

Formulations (Coconut Water: Pineapple Extract)	Color	Flavor	Aroma	After-taste	Overall Acceptability
J^1 (60:40)	2.12^{ab}	3.36^{b}	3.48^{a}	4.08^{a}	3.56^{a}
J^2 (50:50)	1.96^{b}	3.52^{a}	3.60^{a}	3.92^{a}	3.68^{a}
J^3 (40:60)	2.96^{a}	3.68^{a}	3.67^{a}	3.96^{a}	3.72^{a}

Superscripts of the same letter within each column are not significantly different from each other at $P \leq 0.05$.

Mean score legend:

- Color: 1-light orange; 5- dark orange [Color chart provided]
- Aroma: 1-no odor; 5-extremely sweet and has a distinctive citrus aroma
- Flavor: 1-imperceptible; 5-strong orange flavor
- Aftertaste: 1-extreme coconut water after-taste; 5-no coconut water after-taste
- Overall Acceptability: 1-not acceptable; 5- most acceptable

3.4 Coconut Water-Soursop Blend

Mature coconut water was also blended with soursop (*guyabano*) juice extract. Sensory evaluation was conducted on the three varying ratios of the juice blend. From Table 3, the mean scores exhibited no significant difference in all attributes although F3 got highest rating in color (*less off-white color*) and flavor (*moderate soursop flavor*), while J^1 got highest rating in aroma (together with J^2), aftertaste (*little aftertaste*) and overall acceptability (*moderately acceptable*). This could be due to the close intervals between proportions.

Table 3. Mean scores of the different formulations of coconut water-soursop blend (N=25)

Formulations (Coconut Water: Soursop Extract)	Color	Flavor	Aroma	After-taste	Overall Acceptability
J[1] (75:25)	3.28[a]	3.64[a]	3.68[a]	4.12[a]	3.76[a]
J[2] (60:40)	3.68[a]	4.08[a]	3.68[a]	3.92[a]	4.08[a]
J[3] (50:50)	3.84[a]	4.08[a]	3.64[a]	4.04[a]	3.72[a]

Superscripts of the same letter within each column are not significantly different from each other at $P \leq 0.05$.

Mean score legend:

- Color: 1-light orange; 5- dark orange [Color chart provided]
- Aroma: 1-no odor; 5-extremely sweet and has a distinctive citrus aroma
- Flavor: 1-imperceptible; 5-strong orange flavor
- Aftertaste: 1-extreme coconut water aftertaste; 5-no coconut water aftertaste
- Overall Acceptability: 1-not acceptable; 5- most acceptable

3.5 Storage Stability

Shelf-stable foods are foods that can retain its original attributes during a period of storage. Hence, the best formulation of each fruit juice blend was stored at refrigerated temperature of 4-5ºC for 7 weeks.

According to shelf life studies of foods and beverages (De Souza *et al*., 2004), natural juices have a short shelf life even if they are kept under refrigeration. Factors that affect juice stability such as raw material, processing conditions, packaging material, and storage conditions are the chief causes of microbiological, enzymatic, chemical, and physical alterations that damage sensorial and nutritional characteristics).

Costa *et al*. (2003) noted in his research on storage stability of pasteurized cashew apple juice that in a 12-month storage period at room temperature, physicochemical changes did not change significantly; the sensorial analysis showed that juice acceptance remained high throughout the storage period.

Similarly, Raj *et al*. (2011) reported that blending of sand pear juice with apple juice at definite proportions was found shelf stable during the 6-month storage period.

All the juice blends exhibited minimal changes in TA, TSS and pH in seven weeks of storage, as shown in Tables 4, 5 and 6. Vitamin C content, however, showed a marked decrease especially in soursop blend. Vitamin C (ascorbic acid) is sensitive to light, heat and pH. But since pH was fairly constant and the samples were not subjected to heat during storage, then the samples may have been affected by light during storage.

Table 4. Physicochemical changes in coconut water-orange blend during storage

Physicochemical Analysis	Range (1-7 Weeks)
Titratable Acidity	0.28-0.57 % (wt/vol)
TSS	19.1-19.6 °Bx
pH	3.58-3.68
Vitamin C	37-34 g/ml

Table 5. Physicochemical changes in coconut water-pineapple blend during storage

Physicochemical Analysis	Range (1-7 Weeks)
Titratable Acidity	0.20-0.40 % (wt/vol)
TSS	17.5-17.9 °Bx
pH	3.7-3.9
Vitamin C	23-20 mg/ml

Table 6. Physicochemical changes in coconut water-soursop blend during storage

Physicochemical Analysis	Range (1-7 Weeks)
Titratable Acidity	0.25-0.30 % (wt/vol)
TSS	20.3-20.8 °Bx
pH	4.0-4.3
Vitamin C	22.6-15.3 mg/ml

Table 7. Results of triangle test after seven weeks of storage

Mature Coconut Water-Fruit Juice Blend	Computed Value	Tabulated Value
Orange	8	11
Pineapple	10	11
Soursop	16	11

Note: If computed values are less than tabulated values, then there is no significant difference at 5% level of significance.

Triangle test results (Table 7) show no significant difference was detected after the 7th week of storage as compared to the 1st week for orange and pineapple blends. To the panelists, the samples were still acceptable. The results indicated that the physicochemical changes did not affect the acceptability of the stored samples. The soursop blend however showed significant difference, which meant that the sample was no longer acceptable to the panelists. In effect, sensory evaluation is crucial to the acceptability of the stored samples.

All juice blends had a fairly constant microbial count of <10 cfu/mL which is below the limit of 1000 cfu/mL for TPC and 50 cfu/mL for YMC as established by Philippine National Standards (2007), indicating that thermal treatment and level of acidity were adequate, and sanitary processing conditions were applied during beverage production.

Table 8. Proximate composition of mature coconut water-orange blend.

Component	Calculated	Standard	
		Mature Coconut Water	Orange Juice
Moisture (g/100 g)	79.9	79	88.10
Ash (g/100 g)	0.4	0.04	0.39
Protein (Nx6.25) (g/100 g)	0.3	0.26	0.68
Total Fat (g/100 g)	0.1	0.33	0.06
Carbohydrates (g/100 g)	19.3	8.9	10.78

Table 9. Proximate composition of mature coconut water-pineapple blend.

Component	Calculated	Standard	
		Mature Coconut Water	Pineapple Juice
Moisture (G/100 G)	81.6	79	83.99
Ash (G/100 G)	0.4	0.04	-
Protein (Nx6.25) (G/100 G)	0.3	0.26	0.62
Total Fat (G/100 G)	0.1	0.33	0.12
Carbohydrates (G/100 G)	17.7	8.9	12.67

Table 10. Proximate composition of mature coconut water-soursop blend.

Component	Calculated	Standard	
		Mature Coconut Water	Soursop Juice
Moisture (g/100 g)	78.2	79	75.80
Ash (g/100 g)	0.5	0.04	8.9
Protein (Nx6.25) (g/100 g)	0.3	0.26	0.26
Total Fat (g/100 g)	0.1	0.33	0.85
Carbohydrates (g/100 g)	20.9	8.9	13.83

Tables 8, 9 and 10 show proximate composition of the juice blends to be comparative with results from previous studies on coconut water (Prades *et al*., 2012), on orange juice (Deiky and Weirauch, 1988), on pineapple juice (Ogbonna *et al*., 2013) and on soursop juice (Vwioko *et al*., 2013).

4. CONCLUSIONS AND RECOMMENDATIONS

Three (3) sets of juice blends were investigated in this study. Coconut water-Orange Blend was most acceptable at 30:70 ratio; while Coconut water-Pineapple Blend was most acceptable at 40:60 ratio; whereas Coconut water-Soursop Blend was most acceptable at 60:40 ratio. Storage study of these formulations in a span of 7 weeks at 4-5ºC yielded a decrease in Vitamin C content, more prominently in soursop blend. Minimal changes in the physicochemical during storage did not affect product

acceptance; the samples were still acceptable after the storage period. Microbial activity remained below limits. The proximate composition was comparative with recent studies.

It is highly recommended that storage stability at ambient or room temperature be undertaken using PET bottle or laminated foil pouch as packaging. In addition, different kinds of stabilizer can be studied for the effect on the quality of the end product.

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