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Ready-to-Drink Beverage: A Science and Technology Formulation for Non-Alcoholic Food Processing

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ABSTRACT

Food processing is a scientific and technological action that transforms agricultural products into a viable food. This involves one or more combination of processes to develop consumer-ready food items making seasonal produce readily available all-year round. Ponkan, watermelon and dragonfruit are seasonal and highly perishable fruits which are locally grown by local farmers as another cash crop. Such fruits have unique characteristics that is viable for ready-to-drink beverage. Ready-to-drink beverage on the other hand, is a formula from a pre-mixed ingredients that require no extra preparation other than thermal application. The study aimed to formulate a ready-to-drink (RTD) beverage from ponkan, watermelon and dragonfruit; analyze its physicochemical and sensory properties; and determine the return on investment. The study was conducted following the Completely Randomized Design (CRD) and statistically analyzed using the One-way Analysis of Variance (One-way ANOVA). Total soluble solids of the RTD ranged from 8-11 degrees Brix with ponkan-dragonfruit RTD as the highest. pH level of the RTD ranged from 3.44-5.22, displaying a varied pH level of the samples. Specific gravity of the dragonfruit RTD recorded the highest value (1.20); watermelon recorded the lowest (1.03); and ponkan – dragonfruit and watermelon-dragonfruit blend recorded same specific gravity of 1.12. In terms of sensory acceptability, all of the characteristics were organoleptically acceptable which differed significantly at 0.05 level of significance. The Return on Investment (ROI) of 56.18-87.45 shows that the RTD are feasible for production. The processing of ponkan, watermelon and dragonfruit into a ready-to-drink beverages presents a sustainable solution to mitigate post-harvest losses and add value to these fruits. By analyzing the physicochemical properties and sensory acceptability of the RTD, the study has highlighted the potentiality as valuable ingredients in producing consumer-ready beverages in the market. By developing value-added products from highly perishable fruits, it contributes to the efforts of the agriculture sector to promote food security through innovative food processing technologies.

Keywords: Ready-To-Drink Beverage, Non-Alcoholic, Food Processing

INTRODUCTION

Food processing plays an important role in mitigating post-harvest losses and adding value to agricultural produce. As an observation, highly perishable fruits go to waste whenever it is not sold in the market, posing a significant loss of income by farmers. As a result, farmers dump their produce due to lack of storage facility and food processing technologies.

The province of Nueva Vizcaya, Philippines is rich in fruits like ponkan, white and purple-fleshed dragonfruit and watermelon. Farmers grow these fruits as additional cash crop on top of rice and corn farming. The province is known for “Citrus Capital of the North” particularly the municipality of Kasibu. Citrus fruits are seasonal and harvesting season starts on May and ends up to September. Dragon fruit, on the other hand, is also a thriving livelihood of the province. Baseline studies showed that there are two (2) popular type of dragon fruit cultivated in the province, the white and purple flesh. This fruit is harvested during summer season. Likewise, watermelon is a popular fruit that provides a significant income of the farmers. The fruit is usually harvested in months like March to June. Probably because these are the months which fall under summer and watermelon usually thrives during summer season.

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Ponkan (*Citrus reticulata*) is a well-known fruit from the citrus family. It contains phytochemicals, antioxidant and flavonoids (Chang, Y. W. et. al 2024) which is good for the human body. This fruit is claimed to be natural remedies for people who are suffering oral ulcers (Liu, L. 2024). These aforementioned benefits of the fruit make it even more important in the human diet. Likewise, watermelon (*Citrullus lanatus*) is from the family Cucurbitaceae and is a popular fruit eaten as raw because of its sweetness and its quenching water content. It is known for its richness in bioactive and nutrient substances which contributes to health improvement. Dragon fruit (*Hylocereus polyrhizus)* belongs to the family *Cactaceae* that is widely cultivated in Asia. It is known for its richness in glucose, fructose and oligosaccharides (Wichienchot, S. Jatupornpipat M. and Rastall, R.A., 2010) which is an important compound used for juice formulation.

These aforementioned fruits are classified as highly perishable given their chemical structure, presence of considerable moisture content (MC). Due to their chemical structure, their shelf-life is unstable causing these fruits to go to waste whenever they are unsold. As a result, farmers suffer significant loss of income. Mitigating efforts such as introducing food processing technologies lessens the post-harvest losses as well as add value to these highly perishable fruits. Food processing technologies include developing shelf-life stable food products which includes non-alcoholic beverages.

Non-alcoholic beverage is prepared from simple processing procedures which includes thermal treatment. Beverages are one of the preferred refreshments alongside its functional properties. Beverages constitute one of the most important needs for living. During summer, almost all individuals are looking for hydration that will quench their thirst. Likewise, occasions are not complete without refreshments in the menu. Fresh beverages are common nowadays because of the growing health issues. Formulation of ready-to-drink beverage with less addition of sugar promotes well-being without compromising the quality of the product. Commonly, packed ready-to-drink uses a significant amount of sugar as preservative agent. This usually is claimed as risky to our health. Using different locally available fruits in the formulation of ready-to-drink beverage will not only help local farmers sell their crops with value-addition but will provide the general public with healthy drinks.

Objectives of the Study

This study aimed to formulate a scince and technology based ready-to-drink beverage using different ponkan, watermelon and dragonfruit. Specifically, it aimed to:

1. Analyze the physicochemical properties of the ready-to-drink beverages.
2. Determine the optimal fruit blends for desirable sensory characteristics of the ready-to-drink beverage.
3. Determine the Cost of Production of the ready-to-drink beverages.

METHODOLOGY

Materials

Materials. The raw materials used in the study includes ripe ponkan, red pulp watermelon, and ripe purple dragon fruit. These were bought from the market and was brought to the Processing Center of the Nueva Vizcaya State University for pre-processing before their utilization. Table 1 shows the different RTD beverages that has undergone physicochemical testing. Samples A, B and C were not blended to other fruit samples while sample D, E and F were blended with the other fruit samples. This is done to create another flavor of the ready-to-drink beverage.

Table 1. Samples for characterization

Samples	RTD beverages
A	Ponkan
B	Watermelon (red pulp)
C	Dragonfruit (purple pulp)

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D	Ponkan-Watermelon
E	Ponkan-Dragon fruit
F	Watermelon-Dragonfruit

METHODS

Preparation of ready-to-drink beverage. The fruits were washed with 1% potassium metabisulfite and was rinsed under flowing water, peeled then sliced to facilitate juice extraction. Solid contents were sieved. The extracts were measured in a pre-determined units then homogenized using a blender. The mixture was filtered using a clean muslin cloth to further remove solids such. Bottles were sterilized before bottling. The half sealed ready-to-drink beverage was pasteurized at 92 degrees Celcius using hot water bath method, then fully sealed ready for physicochemical and sensory testing. The preparation of the ready-to-drink beverage were done in a controlled condition following safety procedures in the food processing facility. Microbial load testing was not performed right after the pasteurization.

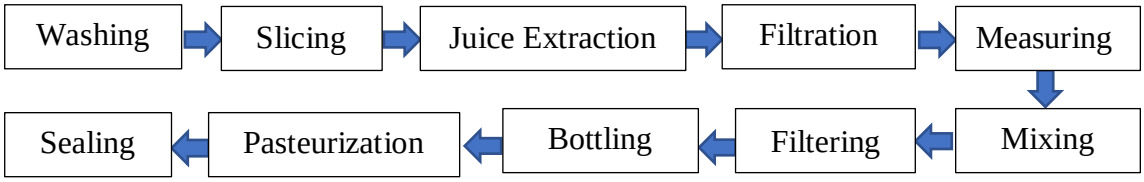


Figure 1. Process flow in the preparation of ready-to-drink beverage

Physicochemical Analysis. The study is limited to analyzing its total soluble solids (TSS), pH level and specific gravity.

Total soluble solids (Brix). The total soluble solids (TSS) content of the samples was determined following the refractometric method. Each RTD sample was measured by dropping a sample on the prism of the refractometer. The reading was recorded based on the line between the light and the dark.

pH level. The pH of the RTD was determined using a digital pH meter. A 100 ml of the juice was transferred into a beaker and pH was determined after the meter was calibrated using standard buffer solutions. The pH was then recorded after reading.

Specific gravity. The specific gravity of the samples was measured using a handheld refractometer calibrated at 20 degrees Celsius temperature. A small amount of the sample was dropped on the prism of the handheld refractometer intended for measuring the specific gravity. The values displayed on the scale were recorded.

Sensory Evaluation Method. Before the administration of the sensory evaluation of the product, consent form was signed by the students involved. Administration of sensory evaluation was carried with 20 panelists evaluating the color, aroma, taste, mouthfeel and over all acceptability of the RTD samples using the 9-point Hedonic scale. Each RTD sample was served with clean glasses to individual panelist, bottled water was provided to rinse the mouth between evaluations. The order of presentation of samples to the panelist was randomized,

Determine the Cost of Production. The determination of ROI was done using the following formula.

$$ROI = \frac{Net\ Income}{Total\ Cost\ of\ Production} x\ 100$$

Statistical Analysis

Statistical analysis was performed to compare the mean values from the different treatments. Data gathered was analyzed using One-way Analysis of Variance (ANOVA). The LSD was used to compare significance between treatment groups at 5% level of significance.

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RESULTS AND DISCUSSION

Physicochemical Values of the RTD

Table 2. Physicochemical analysis of the RTD

Samples	Total Soluble Solid (degrees Brix)	pH level	Specific gravity
Ponkan	10.2	3.44	1.05
Watermelon (red pulp)	8	5.22	1.03
Dragonfruit (purple pulp)	10.3	5.1	1.20
Ponkan-Watermelon	9	4.27	1.04
Ponkan-Dragonfruit	11	4.24	1.12
Watermelon-Dragonfruit	9.20	5.17	1.12

Total soluble solid. Total soluble solid is an estimate of sugar content present in fruits and their by-products. As shown in table 2, TSS values ranged from 8 - 11 degrees Brix. The result showed that watermelon RTD has the lowest TSS which could be influenced by the dilution process. Naturally, watermelon is sweet in nature, however, the dilution of the extract to an amount of water may have affected the TSS of the formula. In contrast,

Sample ponkan-dragonfruit displayed the highest TSS (11 degrees Brix) among the samples being characterized, reflecting higher sugar substance which is one of the factors that influence consumer acceptance. Ponkan and dragonfruit displayed almost the same value. The presence of a significant TSS values is an indication of sweet taste of the different RTDs. However, the presence of higher TSS may improve palatability but may also increase caloric intake.

pH level. The pH is a significant factor that influences the acidity and alkalinity of ready-to-drink beverage. It is also one of the factors that influences microbial growth. The result showed a varied values in a reference pH scale from 0-14 where 7 is neutral. Ponkan has the lowest pH level (3.44). This fruit naturally contains citric acid, an organic acid which influenced the pH level of the ponkan RTD. Organic acids such as citric acid plays an important role in processed product. The natural presence of citric acid in the ponkan creates conditions that slows down microbial growth and spoilage delay as well as shelf-life stability. Watermelon recorded the highest value of 5.22, similar to the findings of Ishita and Athmaselvi (2017) showing significant difference at 5% level of significance. Dragonfruit and blend of watermelon-dragonfruit has 5.1 and 5.17 pH level respectively displaying a non-acid nature of the RTDs. However, as ponkan extract is blended with watermelon and dragon fruit extracts, it's pH varies in values, 4.27 and 4.24 respectively. This means that the acid content of ponkan is being neutralized by the addition of watermelon and dragonfruit. Drinks with pH < 4.5 reduce the risk of growth of pathogenic bacteria as emphasized by Daramola and Osanyinlusi (2022).

Specific gravity. Specific gravity is a ratio that compares the weight of a substance to the density of a reference material, usually water. It is described as the solutes present in the different samples. All values are higher than the specific gravity of water (1.00 at 20 degrees Celcius). Dragonfruit RTD exhibited the highest specific gravity (1.20), followed by ponkan-dragonfruit and watermelon-dragonfruit blend (1.12). Watermelon, ponkan-watermelon blend, and ponkan exhibited a slightly increasing specific gravity (1.03, 1.04, and 1.05). This mean that these samples exhibited lesser solutes while the RTD with 1.12 and 1.20 specific gravity indicated a denser formula. This trend aligns with the soluble solid observation among the RTD samples. Dragonfruit RTD's higher specific gravity may be due to presence of soluble solids and fibers, which contributes to denser consistency.

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Sensory Characteristics

Table 3. Mean difference of Ready-to-Drink Beverages

Sample	Color	Aroma	Taste	Mouthfeel	Overall Acceptability
Ponkan	8.35[b]	8.46[c]	7.43[a]	7.50[a]	7.53[a]
Watermelon	8.46[c]	7. 43[a]	7.94[b]	7.71[b]	7.53[a]
Dragonfruit	7.75[a]	7.30[a]	7.88[b]	7.60[a]	7.70[b]
Ponkan-Watermelon	8.30[b]	8.06[b]	7.80[b]	7.82[b]	8.11[b]
Ponkan-Dragonfruit	8.30[b]	7.92	7.88[b]	8.35[c]	8.04[b]
Dragonfruit-Watermelon	7.75[a]	7.75[b]	7.94[b]	8.35[c]	8.11[b]

Color. The color of the different samples were characterized as very dark in color. This could be associated in the nature of the fruits utilized and the minimal addition of water. All RTDs with dragonfruit ingredient showed lower means and significantly differed from the other samples at 0.05 level of significance.

Aroma. Aroma sensation is noticeable smell of the sample being evaluated. The aroma of the ready-to-drink formulated beverage was characterized to have a very natural aroma and statistically different among the samples. The high acceptance of the aroma is an indication of possible consumer acceptance of the RTD product. Naturally, ponkan has an aromatic smell while the watermelon and dragonfruit do not have. The aromatic smell influences the other samples when blended with it hence, the significant effect of ponkan with the other fruits.

Taste. The taste characteristics of the samples evaluated ranged from moderately sweet to very sweet. All other RTD formulated product was characterized as very sweet except ponkan which was adjudged to be is moderately sweet. Looking at the values obtained from pH and TSS, ponkan has a pH of 3.44 making it slightly acidic which lowers the sensation of taste. However, as it is blended to the other fruits, its taste increases to very sweet. This observation is related to the presence of a significant amount of TSS which balances the acidity of ponkan RTD.

These findings have practical implications for juice formulation and production. The results suggest that blending of ponkan to watermelon and dragonfruit formulations to enhance taste sensation without compromising overall quality. The moderate sweetness of ponkan provides a baseline for future experiments, allowing researchers to explore ways to improve the taste of RTD formulations while maintaining desirable characteristic. The experiment formulation of the optimal sweetness level of juice ponkan-watermelon, ponkan- dragon fruit that balances consumer preferences and nutritional value. It means that this formulation demonstrates versatility across various juice type. These observations are a critical component of juice formulation, influencing consumer acceptance and loyalty.

Mouthfeel. The mouthfeel is the sensation pertaining to a physical-textural in the mouth during and after consumption of food or a beverage. Mouthfeel of the different samples significantly differ with each other at 0.05 level of significance. RTD samples were adjudged to be highly smooth. Ponkan-dragonfruit and dragonfruit-watermelon RTDs revealed a higher smoothness over the other samples. This could be associated in the natural smooth characteristics of dragonfruit. This could also be connected with the presence of physico-chemical particularly the specific gravity of the samples.

Overall Acceptability. The overall acceptability of the different ready-to-drink beverage significantly differs among the samples. This indicates that the panelist viewed the combination of ponkan with dragonfruit and water melon to be more acceptable than that of the pure formula. The experiment on the formulation of the

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different flavored juice such as ponkan-watermelon and ponkan-dragon fruit is as important as the other fruit juices. It means, the formulation is as acceptable as the other fruit juices in terms of overall acceptability.

Cost and Return Analysis

Table 4. ROI results of the different Ready-to-Drink Beverages

Sample	Ponkan	Watermelon	Dragonfruit	Ponkan-Watermelon	Ponkan-Dragonfruit	Dragonfruit-Watermelon
Total Cost	154.37	149.37	159.37	151	156.87	154.37
Yield per cycle (in bottle)	7	7	7	7	7	7
Gross Income	245.00	245.00	245	245	245	245
Net Income	90.63	130.63	85.62	93.125	88.13	90.63
ROI	**58.71**	**87.45**	**53.72**	**61.32**	**56.18**	**58.71**

Return on Investment. The ROI result of the different RTD is shown in table 4. The RTD displayed a varying ROI result. Watermelon showed the highest ROI (87.45) followed by ponkan-watermelon (61.32). Same ROI results was observed from ponkan and dragonfruit-watermelon RTD (58.71). Dragonfruit and Ponkan-dragonfruit RTD had an ROI of 53.72 and 56.18 respectively. The result showed its feasibility for a small-scale production by community and the farmers who are cultivating these fruits.

CONCLUSION AND RECOMMENDATION

The processing of ponkan, watermelon and dragonfruit into ready-to-drink non-alcoholic beverage presents a scientific, technological and sustainable solution to mitigate losses, improve economic value of the said fruits and food security promotion. By scientifically analyzing the physicochemical, sensory and cost and return analysis of the ready-to-drink beverages, it highlighted the viability of these highly perishable fruits as valuable by-products. The presence of important physicochemical properties of the ready-to-drink beverages provides significant information for maximizing their integration into food systems. Consumer acceptability and high returns shows feasibility of the formulated ready-to-drink beverages from the different aforementioned fruits. To fully utilize the ready-to-drink beverages, it is highly recommended that it undergoes microbial and shelf-life testing.

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