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Development and Acceptability of Ready-To-Drink (RTD) Mixed Vegetable Juice

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ABSTRACT

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This study, conducted at Sustainable Agriculture and Fishery Enterprise (SAFE) in Southern Philippines Agri-Business and Marine and Aquatic School of Technology (SPAMAST) Buhangin campus, Buhangin, Malita, Davao Occidental, explored the development and acceptability of a ready-to-drink (RTD) vegetable juice using varying combinations of carrot, chayote, and bottle gourd. A Completely Randomized Design (CRD) was utilized, with seven treatments replicated three times. Sensory attributes—appearance, odor, color, taste, and general acceptability—were evaluated by 30 randomly selected panelists composed of students, faculty, and staff of SPAMAST Buhangin Campus. Physico-chemical properties, including pH, titratable acidity (TTA), and total soluble solids (TSS), were also analyzed. Statistical analyses were performed using ANOVA and the Least Significant Difference (LSD) test. Findings showed that Treatment 1 (100% carrot juice) consistently achieved the highest sensory ratings for appearance, color, taste, and overall acceptability, with statistically significant differences across treatments for these parameters ($p < 0.05$). Odor, however,

showed no significant variation. Physicochemical analysis revealed that Treatment 1 had a relatively low pH (3.70), the highest TTA (0.570%), and the highest TSS (12), which contributed to its more favorable flavor profile. These findings indicate the potential for further product optimization and marketability, sparking optimism for the future of RTD vegetable juice.

INTRODUCTION

Vegetable juice, a healthy drink made by juicing a variety of vegetables, is often combined to create a refreshing and nutrient-packed beverage. It is rich in vitamins, minerals, antioxidants, and fiber, offering numerous health benefits, including improved digestion, better hydration, and a strengthened immune system. Typical ingredients for vegetable juice include carrots, spinach, kale, celery, cucumbers, and beets. This drink is a great way to incorporate more vegetables into your diet, providing a wealth of health benefits (Henning, 2017).

Vegetable juices can act as a prebiotic in maintaining the gut flora or microbiome. They are a rich source of polyphenols, oligosaccharides, polysaccharides, fibers, and nitrates, which makes juice-based diets popular. Juice blending is also one of the most effective methods for improving the nutritional quality of the juice (Rathod et al., 2014). Despite its numerous health benefits, it is becoming increasingly difficult for a wide range of the population to incorporate this into their regular diet (Henning, 2017).

Carrots (Daucus carota) are known to promote eye and skin health. They are rich in antioxidants, protect against oxidative stress, and support digestive health by promoting bowel regularity and lowering cholesterol levels. Chayote (Sechium edule) is known for its mild flavor and crisp texture. It is rich in fiber, vitamins (especially vitamin C and B vitamins), minerals such as potassium and folate, and antioxidants. Chayote supports digestive health by regulating bowel movements due to its high fiber content (Deng, 2019). Bottle gourd (Lagenaria siceraria) is rich in fiber, vitamin C, potassium, magnesium, and iron. It promotes cardiovascular health, digestion, and immune function (Yadav, 2019). These vegetables are used in the preparation of soups, stews, juices, curries, and cookies, among other dishes.

Although various studies have explored the health benefits of individual vegetables, such as carrots, chayote, and bottle gourd, there is a gap in research on the development and consumer acceptability of ready-to-drink (RTD) vegetable juices made from these combinations. Most research focuses on the nutritional properties and processing of each vegetable separately, with limited attention to how their blend affects nutrition and flavor in RTD form. Additionally, there is a lack of studies on optimizing these vegetables into a single beverage that retains bioactive compounds while ensuring good taste, texture, and appearance. The synergistic effects of these vegetables in juice form remain underexplored (Henning, 2017).

Objectives of the Study

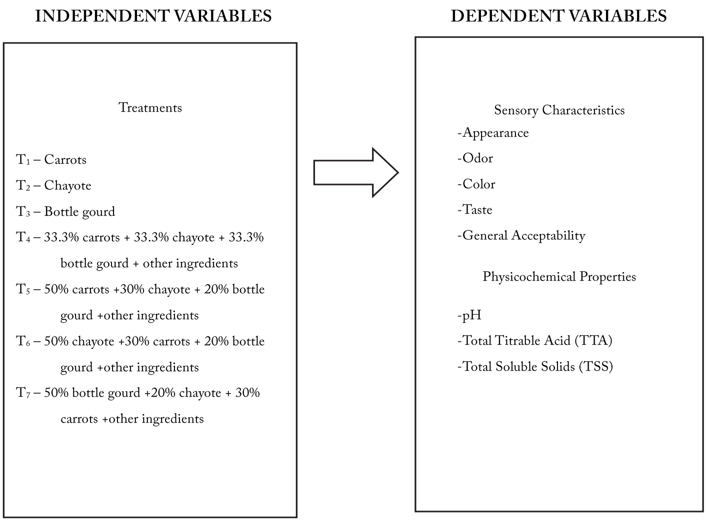
Evaluate the sensory characteristics of ready-to-drink (RTD) vegetable juice in terms of appearance, odor, color, and taste.

- Determine the most preferred formulation based on general acceptability.
- Determine the physico-chemical properties (pH, TTA, TSS) of a ready-to-drink (RTD) vegetable juice.

CONCEPTUAL FRAMEWORK

Figure 1

The conceptual framework showing the independent and dependent variables of the study



In this study, the different treatments served as the independent variables, representing the various conditions or interventions applied to the samples. At the same time, the sensory characteristics and physico-chemical properties functioned as the dependent variables, reflecting the responses and outcomes influenced by these treatments. The relationship among these variables is inherently causal, as the treatments are expected to induce measurable changes in sensory attributes—such as appearance, odor, color, taste, and general acceptability—as well as physicochemical parameters like pH and TTA. And TSS. By systematically varying the treatments, the study aimed to elucidate how specific interventions affect these dependent variables, thus providing insights into the mechanisms underlying sensory perception and physico-chemical stability. Understanding these relationships is crucial for optimizing treatment conditions to achieve the desired product qualities, as the dependent variables not only respond to the treatments but also help assess the efficacy and impact of each intervention within the broader context of product development or quality control.

Significance of the Study

This research is significant to consumers, researchers, food manufacturers, and students. It ensures the development of nutritious, marketable vegetable juice formulations. Findings inform innovation in product formulation, manufacturing practices, and academic research.

Scope and Limitation

The study was conducted at SPAMAST, Buhangin Campus, Malita, Davao Occidental. The study is limited to the sensory evaluation and physicochemical analysis of RTD vegetable juice using carrots, chayotes, and bottle gourds, as evaluated by 30 randomly selected respondents.

MATERIALS AND METHODS

Research Design

The study employed a Completely Randomized Design (CRD) to assess the sensory quality of a ready-to-drink (RTD) vegetable juice.

Treatments and Replications

There were seven (7) treatments employed in the study, which were replicated three (3) times. The treatments were as follows:

T_1: 100% Carrots
T_2: 100% Chayote
T_3: 100% Bottle Gourd
T_4: 33.3% carrots + 33.3% chayote + 33.3% bottle gourd + other ingredients
T_5: 50% carrots + 30% chayote + 20% bottle gourd + other ingredients
T_6: 50% carrots + 30% chayote + 20% bottle gourd + other ingredients
T_7: 50% bottle gourd + 30% carrots + 20% chayote + other ingredients

Procedure for Preparing Vegetable Juice Extract

Fresh and high-quality raw materials, such as carrots, chayote, and bottle gourd, were used. The vegetables had a smooth texture and exhibited their natural, appropriate color. Vegetables free from blemishes, cracks, and that do not have a flabby or rubbery texture were selected. The vegetables were weighed according to their desired sizes, then thoroughly washed to remove any surface contaminants. Vegetables were then peeled and cut into small pieces to facilitate easier extraction of juice. Finally, the vegetables were filtered to separate the juice from the remaining solids, ensuring a smooth and clear juice.

Procedure in Preparing the Ready-To-Drink (RTD) Vegetable Juice

Figure 2 illustrates the process flow for the preparation of ready-to-drink (RTD) vegetable juices. The process started with four vegetable ingredients: carrots, chayote, and bottle gourd. These vegetables were mixed in specific proportions. The mixed vegetable juice was pasteurized. This process involved heating the juice to a specific temperature for a set time to kill harmful bacteria and extend shelf life. The pasteurized juice is then hot-filled into glass bottles. This ensures that the juice remains sterile and prevents recontamination. The filled glass bottles were cooled to room temperature. This helps to maintain the quality and stability of the juice. The cooled glass bottles were then labeled and packaged, ready for sensory evaluation.

Figure 2

Process flow for vegetable extraction

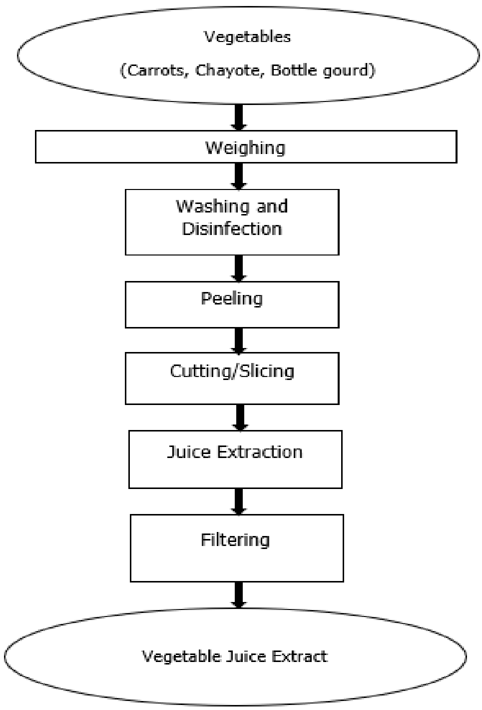


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Figure 3

Process flow for the preparation of ready-to-drink (RTD) vegetable juices

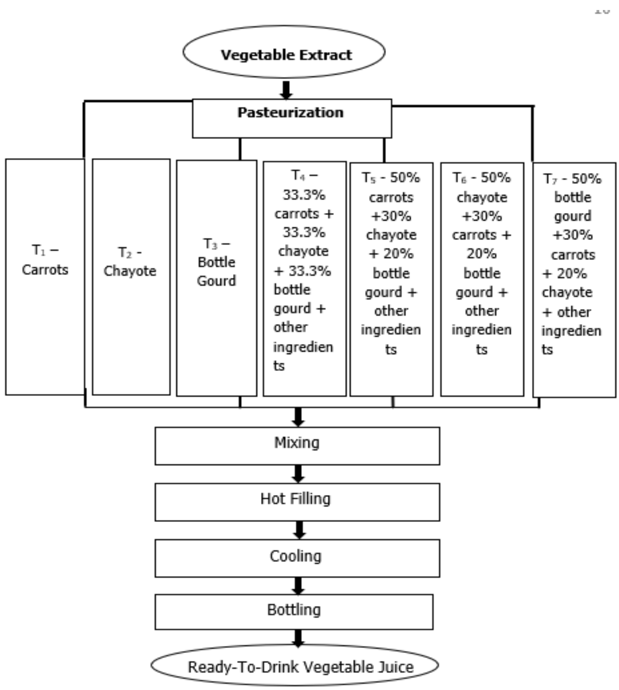

Figure 3 illustrates the step-by-step process for producing ready-to-drink (RTD) vegetable juices from carrots, chayote, and bottle gourds. Each step is designed to ensure product quality, safety, and consistency.

First, vegetable extracts are prepared and then pasteurized to eliminate microorganisms and enhance shelf stability. After pasteurization, various formulations are created by blending different ratios of carrot, chayote, and bottle gourd, following specific recipes for each treatment.

The blended juices undergo mixing to ensure even distribution of components, followed by hot filling, where the juice is placed into bottles while still hot to prevent contamination. The bottles are then cooled and sealed, resulting in the final RTD vegetable juice.

To assess the sensory quality of these RTD vegetable juices, the method of Gatchalian (2016) was used. Thirty respondents evaluated the samples 1–2 days after production using a 5-point hedonic scale for specific sensory attributes (appearance, odor, color, and taste), while general acceptability was assessed with a 9-point hedonic scale. All samples were presented in uniform glasses with controlled volume and temperature, and the evaluation was conducted in a quiet, odor-free, well-lit environment. This careful setup minimized external influences, ensuring that panelists could assess each juice formulation's sensory properties comfortably and consistently.

Physico-Chemical Analysis

To assess the physicochemical analysis of the ready-to-drink (RTD) vegetable juice, specific procedures were followed for each parameter.

pH Level

In pH measurement, samples of ready-to-drink (RTD) vegetable juices were prepared. A pen-type pH meter was calibrated using standard buffer solutions (usually pH 4, 7, and 10). The pH electrode was immersed in the juice sample, ensuring that the probe did not come into contact with the container walls. The pH values were recorded once the reading stabilized. The pH value indicates the acidity or alkalinity of the juice. A pH value in the range of 4.5-5.5 is typical for ready-to-drink (RTD) vegetable juices, indicating mild acidity. The pH results were used to determine the potential shelf-life of the juice, as more acidic juices tend to have better preservation.

Total Titrable Acidity (TTA) Level

In the Total Titrable Acidity (TTA) measurement, a 25 mL vegetable juice sample was used. Add a few drops of phenolphthalein indicator to the juice. Add the juice to a standard sodium hydroxide (NaOH) solution (0.1 N) until the juice turns pink, which indicates the endpoint. TTA measures the total amount of acid present in the juice. A higher TTA indicates a more acidic juice, which is typical for vegetable juices. The TTA value helps determine the sourness or sharpness of the juice, which is important for flavor profile and shelf life.

Total Soluble Solid (TSS) Level

A small sample of the ready-to-drink (RTD) vegetable juice (about 2-3 drops) was used for TSS measurement using a refractometer by placing the juice on the prism. The refractometer was calibrated before taking the reading. The Brix value was recorded as a percentage, corresponding to the TSS of the juice. TSS refers to the total concentration of dissolved solids, primarily sugars, in the juice.

Statistical Tools

Mean and Analysis of Variance (ANOVA) were used in data analysis. The statistical results were calculated with a significance level of α = 0.05, using SPSS version 20. The Least Significant Difference (LSD) test was used to further analyze parameters with significant results.

RESULT AND DISCUSSION

Table 1 presents the sensory evaluation results of ready-to-drink vegetable juices in terms of appearance. The table displays two primary classifications of acceptability based on mean scores: "very appealing" (VA) and "appealing" (A). Treatment 1, which consists of carrot juice, achieved the highest mean score of 4.36, and Treatment 5 (50% carrots + 30% chayote + 20% bottle gourd) with a mean score of 4.24, classified as "very appealing" (VA). In contrast, Treatment 4 (33% carrot + 33% chayote + 33% bottle gourd), Treatment 6 (50% chayote + 30% carrot + 20% bottle gourd) Treatment 7 (50% bottle gourd + 20% chayote + 30% carrot), Treatment 3 (bottle gourd), and Treatment 2 (chayote) were classified as "appealing" (A). Furthermore, a significant difference in the sensory evaluations of the various treatments of ready-to-drink (RTD) vegetable juice in terms of appearance, with a computed value of 14.569 and a p-value of 0.000 at 5% level of significance.

Table 1. *Sensory evaluation of ready-to-drink (RTD) vegetable juice in terms of appearance*

TREATMENTS	MEAN	DES.	Fc	p-value	Decision
T_1 - carrot (Ca)	4.36[a]	VA	14.169**	.000	Reject Ho_1
T_2 - chayote (Cha)	3.47[c]	A			
T_3 – bottle gourd (Bg)	3.57[c]	A			
T_4 – 33%Ca+33%Ch+33%Bg	4.17[ab]	A			
T_5 - 50%Ca+30%Ch+20%Bg	4.24[ab]	VA			
T_6 - 50%Ch+30%Ca+20%Bg	4.07[b]	A			
T_7 - 50%Bg+20%Ch+30%Ca	3.98[b]	A			

** = highly significant at 5% VA –very appealing A -appealing

Odor

Results presented in Table 2 show that all treatments obtained a descriptive rating of "strong odor", suggesting that the overall quality of odor across the evaluated juices was perceived as strongly corresponding to the odor of the respective vegetables used. Specifically, the mean ratings for odor ranged from a low of 3.57 (Treatment 3 - bottle gourd) to a high of 3.91 (Treatment 5 - 50% carrot, 30% chayote, 20% bottle gourd), numerically indicating a general preference for ready-to-drink (RTD) vegetable juices with higher carrot content. Furthermore, no significant difference in sensory evaluations of the various treatments of ready-to-drink (RTD) vegetable juice in terms of odor was noted, with a computed value of 1.42 and a p-value of 0.273 at a 5% level of significance.

Table 2. *Sensory evaluation of ready-to-drink (RTD) vegetable juice in terms of odor*

TREATMENTS	MEAN	DES.	Fc	p-value	Decision
T_1 - carrot (Ca)	3.89	SO	1.42[ns]	0.273	Accept Ho
T_2 - chayote (Cha)	3.71	SO			
T_3 – bottle gourd (Bg)	3.57	SO			
T_4 – 33%Ca+33%Ch+33%Bg	3.81	SO			
T_5 - 50%Ca+30%Ch+20%Bg	3.91	SO			
T_6 - 50%Ch+30%Ca+20%Bg	3.76	SO			
T_7 - 50%Bg+20%Ch+30%Ca	3.81	SO			

ns = not significant SO – strong odor

Color

The sensory evaluation of the color of RTD vegetable juices showed a clear consumer preference for the vibrant orange color of carrot juice, which received the highest rating of 4.26, indicating an "extremely like" response. Treatments with mixed vegetables—Treatments 4, 5, 6, and 7—received moderate ratings between 3.51 and 3.74 ("like moderately"), suggesting they are somewhat acceptable but less preferred than pure carrot juice. In contrast, Treatments 2 (chayote) and 3 (bottle gourd) scored significantly lower at 2.44 and 2.48, respectively, both categorized as "dislike," reflecting less appealing colors compared to carrot juice. This preference for the bright orange color of carrot juice was a significant factor in the overall acceptability of the product.

Table 3. *Sensory evaluation of ready-to-drink (RTD) vegetable juices in terms of color*

TREATMENTS	MEAN	DES.	Fc	p-value	Decision
T_1 - carrot (Ca)	4.26^{a}	LE	11.288**	0.000	Reject Ho
T_2 - chayote (Cha)	2.44^{b}	D			
T_3 – bottle gourd (Bg)	2.48^{b}	D			
T_4 – 33%Ca+33%Ch+33%Bg	3.74^{ab}	LM			
T_5 - 50%Ca+30%Ch+20%Bg	3.62^{ab}	LM			
T_6 - 50%Ch+30%Ca+20%Bg	3.51^{ab}	LM			
T_7 - 50%Bg+20%Ch+30%Ca	3.60^{ab}	LM			

** = highly significant LE -like extremely LM -like moderately D - dislike

Figure 4
Different treatments of the product, highlighting its color

Taste

Table 4 summarizes the sensory evaluation of ready-to-drink (RTD) vegetable juices in terms of taste. The mean ratings for taste show that all treatments received favorable impressions, with all scores indicating a "sweet" (S) descriptor. The Treatment 4, which consists of equal parts of carrot, chayote, and bottle gourd, obtained the highest mean score of 4.13, closely followed by Treatment 1 (pure carrot) and Treatment 7 (50% bottle gourd, 20% chayote, 30% carrot) with same mean score of 4.11, Treatment 6 (50% chayote, 30% carrot, 20% bottle gourd) at 4.10, and Treatment 5 (50% carrot, 30% chayote, 20% bottle gourd) at 4.06. Moreover, Treatment 2 (chayote) and Treatment 3 (bottle gourd) scored slightly lower at 3.92 and 3.68, respectively; however, these ratings still reflect a generally sweet taste. The statistical analysis indicates that the differences among the treatments are highly significant (p-value = 0.025), with an F-value of 3.749, leading to the rejection of the null hypothesis (H0).

Table 4. *Sensory evaluation of ready-to-drink (RTD) vegetable juice in terms of taste*

TREATMENTS	MEAN	DES.	Fc	p-value	Decision
T_1 - carrot (Ca)	4.11^a	S	3.749**	0.025	Reject Ho
T_2 - chayote (Cha)	3.92^a	S			
T_3 – bottle gourd (Bg)	3.68^b	S			
T_4 – 33%Ca+33%Ch+33%Bg	4.13^a	S			
T_5 - 50%Ca+30%Ch+20%Bg	4.06^a	S			
T_6 - 50%Ch+30%Ca+20%Bg	4.10^a	S			
T_7 - 50%Bg+20%Ch+30%Ca	4.11^a	S			

** = highly significant S -sweet

General Acceptability

Table 5 presents the general acceptability of various ready-to-drink (RTD) vegetable juices with different formulations of carrot, chayote, and bottle gourd. Results showed that Treatment 1, which contains pure carrot, received the highest mean score of 8.01, categorized as "like very much" (LVM), demonstrating a strong consumer preference for this formulation. Other combinations, such as Treatment 5 (50% carrot, 30% chayote, 20% bottle gourd), Treatment 7 (50% bottle gourd, 20% chayote, 30% carrot), Treatment 4 (33% carrots + 33% chayote + 33% bottle gourd), Treatment 6 (50% chayote, 30% carrots, 20% bottle gourd), and Treatment 2 (chayote), also scored within the "like very much" (LVM) range. In contrast, juice primarily with bottle gourd (Treatment 3) yielded the lowest score of 6.97, falling into the "like moderately" (LM) category. The statistical analysis indicates that the differences among the treatments are highly significant (p-value = 0.006), with an F-value of 4.970, leading to the rejection of the null hypothesis (H0).

Table 5. *General acceptability of ready-to-drink (RTD) vegetable juices*

TREATMENTS	MEAN	DES.	Fc	p-value	Decision
T_1 - carrot (Ca)	8.01^{a}	LVM	4.970^{**}	0.006	Reject Ho
T_2 - chayote (Cha)	7.11^{b}	LVM			
T_3 – bottle gourd (Bg)	6.97^{c}	LM			
T_4 – 33%Ca+33%Ch+33%Bg	7.53^{ab}	LVM			
T_5 - 50%Ca+30%Ch+20%Bg	7.62^{ab}	LVM			
T_6 - 50%Ch+30%Ca+20%Bg	7.50^{ab}	LVM			
T_7 - 50%Bg+20%Ch+30%Ca	7.62^{ab}	LVM			

** = highly significant LVM -like very much LM -like moderately

pH Level

The results shown in Table 6 indicate that all juice treatments are acidic, with pH values below 7. Treatment 1 (carrot) has the lowest pH, at 3.70, which classifies it as strongly acidic, likely due to the presence of natural sugars and organic acids. Treatments 2 (chayote) and 3 (bottle gourd) have slightly higher pH values of 3.90, still strongly acidic. The mixed treatments (4 to 7) have higher pH values ranging from 4.20 to 4.40, indicating moderate acidity. This increase in pH suggests that blending reduces overall acidity, potentially improving palatability and making the juices more suitable for regular consumption.

Table 6. *pH level of ready-to-drink vegetable juices*

TREATMENTS	MEAN	DES.	IMPLICATION
T_1 - carrot (Ca)	3.70	SA	May cause discomfort to the stomach; can enhance flavor in small amounts, but should be consumed with caution to avoid irritation or acid reflux.
T_2 - chayote (Cha)	3.90	SA	
T_3 – bottle gourd (Bg)	3.90	SA	
T_4 – 33%Ca+33%Ch+33%Bg	4.40	MA	Provide a tangy flavor and are safe for most people, but excessive consumption may still cause discomfort for some.
T_5 - 50%Ca+30%Ch+20%Bg	4.40	MA	
T_6 - 50%Ch+30%Ca+20%Bg	4.20	MA	
T_7 - 50%Bg+20%Ch+30%Ca	4.30	MA	

Legend: SA – strongly acidic, MA -moderately acidic

Total Titrable Acidity (TTA)

The results presented in Table 7 reveal notable differences in total titrable acidity (TTA) among the tested vegetable juices. Pure carrot juice (Treatment 1) exhibits the highest TTA at 0.570, indicating a moderate level of acidity that contributes to a balanced and appealing tartness, likely enhancing consumer palatability. Moreover, chayote (Treatment 2) and bottle gourd juices (Treatment 3) have very low TTA values of 0.113 and 0.222, respectively, producing milder, less tart flavors that may be perceived as bland or overly sweet. The mixed formulations (Treatments 4 to 7) show that increasing the carrot content slightly increases TTA, but not enough to produce a noticeable increase in acidity. All these blends maintain low TTA levels, suggesting they would have mild flavors that might require flavor enhancement to meet consumer preferences.

Table 7. *Total Titrable Acidity (TTA) level of ready-to-drink vegetable juices*

TREATMENTS	MEAN	DES.	IMPLICATION
T_1 - carrot	0.570	MA	This level often contributes to a balanced flavor in many beverages, providing an enjoyable tartness that enhances the taste while remaining palatable for most consumers.
T_2 - chayote	0.113	VLA	The ready-to-drink juices at this level may have mild flavor and can taste somewhat bland or sweet. It often lacks the tartness that can enhance the flavor of the juices.
T_3 – bottle gourd	0.222	VLA	
T_4 – 33%Ca+33%Ch+33%Bg	0.147	VLA	
T_5 - 50%Ca+30%Ch+20%Bg	0.207	VLA	
T_6 - 50%Ch+30%Ca+20%Bg	0.225	VLA	
T_7 - 50%Bg+20%Ch+30%Ca	0.251	VLA	

MA – moderately acidic VLA – very low acidic

Total Soluble Solid (TSS)

Table 8 reveals that carrot juice (T1) has the highest TSS at 12° Bx, classifying it as "moderately sweet" and highly palatable. Bottle gourd (Treatment 3) and chayote (Treatment 2) juices also fall into the "moderately sweet" category with TSS levels of 10° Bx and 9° Bx, respectively. Among the blended treatments, Treatment 4 (33% carrot, chayote, and bottle gourd) maintains a TSS of 10° Bx, which is similar to that of bottle gourd alone. In comparison, Treatment 5 (50% carrot, 30% chayote, 20% bottle gourd) has a TSS of 9° Bx, indicating slightly reduced sweetness. The other blends, Treatment 6 (50% chayote, 30% carrot, 20% bottle gourd) and Treatment 7 (50% bottle gourd, 20% chayote, 30% carrot), show lower TSS levels of 8° Bx and 6° Bx, respectively, categorizing them as "low sweetness" and suggesting a less sugary flavor profile.

Table 8. *Total Soluble Solid (TSS) level of ready-to-drink (RTD) vegetable juices*

TREATMENTS	MEAN	DES.	IMPLICATION
T_1 - carrot (Ca)	12° Bx	MS	Pleasantly sweet and palatable
T_2 - chayote (Cha)	9° Bx	MS	Pleasantly sweet and palatable
T_3 – bottle gourd (Bg)	10° Bx	MS	Pleasantly sweet and palatable
T_4 – 33%Ca+33%Ch+33%Bg	10° Bx	MS	Pleasantly sweet and palatable
T_5 - 50%Ca+30%Ch+20%Bg	9° Bx	MS	Pleasantly sweet and palatable
T_6 - 50%Ch+30%Ca+20%Bg	8° Bx	LS	It has a hint of sweetness but is predominantly less sugary
T_7 - 50%Bg+20%Ch+30%Ca	6° Bx	LS	It has a hint of sweetness but is predominantly less sugary

MS -moderately sweet LS – low sweetness

The results presented in Table 1 reveal notable differences in the appearance acceptability of the various ready-to-drink vegetable juice treatments. Treatment 1 (carrot juice) and Treatment 5 (a blend of 50% carrots, 30% chayote, and 20% bottle gourd) received the highest mean scores of 4.36 and 4.24, respectively, categorizing them as "very appealing." This suggests a clear preference for carrot-based formulations in terms of appearance. On the other hand, treatments with higher proportions of chayote and bottle gourd, such as Treatments 2, 3, 4, 6, and 7, were rated as only "appealing," indicating a relative decline in visual appeal with increased inclusion of these ingredients. The one-way ANOVA results, with a significant F-value of 14.569 and a p-value of 0.000, confirm that these differences are statistically significant, allowing us to reject the null hypothesis that all treatments have equal appearance ratings. A discernible trend emerges where formulations containing a higher proportion of carrots tend to be more visually appealing, possibly due to their color and texture. In contrast, increased inclusion of chayote and bottle gourd may negatively influence appearance. This insight can guide formulation adjustments to optimize visual appeal and consumer acceptance.

Furthermore, the LSD analysis indicates that Treatment 1 (carrot) significantly differs in appearance from Treatments 2 (chayote), 3 (bottle gourd), 6, and 7, but not from Treatments 4 and 5. Treatments 2 and 3 consistently score lower and differ significantly from most other treatments, highlighting their less favorable appearance. Meanwhile, Treatments 4, 5, 6, and 7 show no significant differences among themselves, suggesting similar visual characteristics. Overall, Treatment 1, along with Treatments 2 and 3, has more distinct effects on appearance. In contrast, Treatments 4 and 5 tend to be more similar, indicating that the formulation composition influences the visual appeal of the vegetable juices. According to a study conducted by Ray (2021), the use of carrots in juice can also contribute to the color of the juice. Carrots' natural pigments, such as carotenoids, give their juice and other baked goods a vibrant orange color, making them visually appealing.

Odor

The results indicate that all the tested vegetable juice formulations were perceived to have a "strong odor," closely reflecting the characteristic smell of the respective vegetables used. The mean odor ratings ranged from 3.57 for Treatment 3 (bottle gourd) to 3.91 for Treatment 5 (50% carrot, 30% chayote, 20% bottle gourd), suggesting a slight preference for formulations with higher carrot content, which may have contributed to a more favorable or potent odor perception.

Moreover, further analysis revealed no statistically significant differences among the treatments in terms of odor perception (F-value of 1.42, p-value of 0.273). This indicates that, despite some variations in mean scores, the overall odor profiles are perceived quite similarly across all formulations. The consistent perception of "strong odor" suggests that the odor attribute is relatively stable regardless of the specific vegetable combinations. This consistency could be advantageous for product development, as it suggests that changing the vegetable ratios may not significantly affect odor perception.

Color

The sensory evaluation results for the color of ready-to-drink vegetable juices reveal clear trends and preferences among the different formulations. Notably, there is a strong consumer preference for pure carrot juice (Treatment 1), which received the highest rating of 4.26 ("like extremely"), likely due to its vibrant orange color that is visually appealing. In contrast, formulations containing chayote and bottle gourd (Treatments 2 and 3) received significantly lower scores (around 2.44–2.48, "dislike"), reflecting less attractive coloration. Treatments with mixed ingredients, including carrot, chayote, and bottle gourd, generally fell into the "like moderately" category (3.51–3.74), indicating moderate acceptance but not surpassing that of pure carrot juice. This suggests that adding other vegetables tends to dilute the visual appeal associated with the bright orange of the carrot.

Statistically, the significant differences (F = 11.288, p = 0.000) confirm that ingredient composition has a meaningful impact on color perception. This indicates a strong consumer preference for the vibrant color of pure carrot juice, while combinations involving less colorful vegetables are less favored visually. This insight can guide formulation adjustments to improve the visual appeal of vegetable juice products containing chayote and bottle gourd.

Furthermore, the LSD test results indicate that Treatment 1 (carrot) had the highest and most preferred color scores, significantly outperforming T2 (chayote), T3 (bottle gourd), and the combined treatments T5, T6, and T7. The pure chayote and bottle gourd juices received the lowest scores, showing they were less visually appealing. The mixed formulations (T4, T5, T6, T7) had similar color acceptability, with some blending treatments comparable to pure carrot juice, suggesting blending can enhance visual appeal.

Taste

The taste ratings for all treatments were generally favorable, with all scoring in the "sweet" category. The highest-rated treatment was the equal-part blend of carrot, chayote, and bottle gourd (Treatment 4), closely followed by pure carrot juice (Treatment 1) and other blended formulations containing carrot, indicating that these combinations maintained a sweet flavor profile. Treatments made solely from chayote and bottle gourd scored slightly lower but still reflected a sweet taste. The statistical analysis reveals significant differences among the formulations (p = 0.025), indicating that ingredient composition affects perceived taste. This suggests that blending vegetables, especially with carrots, tends to preserve or enhance sweetness, and formulations are generally well-received in terms of taste.

Taste plays a pivotal role in the sensory evaluation and consumer acceptance of vegetable-based beverages. According to Lawless and Heymann (2010), taste is one of the most influential attributes in determining consumer preference, especially in products that include ingredients with naturally bitter or bland profiles, such as bottle gourd and chayote. Studies have shown that blending vegetables with naturally sweet ingredients, like carrots, can enhance the overall flavor profile and mask undesirable taste notes (Bhardwaj, 2011). Carrots are known for their natural sweetness, which is attributed to their high sugar content, particularly sucrose and glucose, making them an ideal base for improving the palatability of vegetable juices (Manju, 2017). This aligns with the results of the current study, where carrot-based treatments, especially when blended with other vegetables, received higher taste scores. In contrast, bottle gourd (*Lagenaria siceraria*), while rich in nutrients, is generally characterized by a neutral to slightly bitter taste, which may negatively affect taste acceptability when used alone (Ray *et al.*, 2012). This explains the significantly lower mean sensory scores observed in Treatment 3 (100% bottle gourd) in the current study.

The LSD analysis showed that Treatment 3 (100% bottle gourd) had significantly lower taste scores compared to several other treatments, making it the least preferred in taste. In contrast, other treatments, including pure carrot, chayote, and various blends, received similar and more acceptable taste ratings. The results suggest that blending vegetables, especially with carrots, improves taste perception compared to bottle gourd alone, which was less favored.

General Acceptability

The results indicate that pure carrot juice (Treatment 1) was most preferred, receiving the highest acceptability score and falling into the "like very much" category. Other formulations with a mix of vegetables also scored well, suggesting that blending chayote and bottle gourd with carrot maintains high consumer acceptance. In contrast, juice primarily made from bottle gourd alone scored lower, in the "like moderately" range. The significant statistical differences ($p = 0.006$) demonstrate that formulation impacts consumer preferences, with carrots playing a key role in overall acceptability. This indicates that incorporating carrot enhances the appeal of vegetable juices, while high proportions of bottle gourd alone are less favored.

Furthermore, the LSD analysis revealed that Treatment 1 (carrot) had the highest acceptability score and was not significantly different from several other vegetable blends, including Treatments 4, 5, 6, and 7, indicating comparable acceptability. Treatment 2 (chayote) was significantly different only from carrot and bottle gourd, but was similar to the blended treatments. Treatment 3 (bottle gourd) had the lowest acceptability, significantly different from all other treatments, making it the least preferred. Overall, blending vegetables, especially with carrots, maintains an acceptable taste, while a high content of bottle gourd reduces acceptability.

pH Level

The findings clearly illustrate a significant relationship between the composition of the juices and their pH levels, reflecting their acidity profiles. All treatments exhibited pH values below 7, confirming their acidic nature, which aligns with the typical organic acid content in these vegetables. Notably, Treatment 1 (carrot) recorded the lowest pH at 3.70, categorizing it as strongly acidic. This high acidity can be primarily attributed to the presence of organic acids, such as ascorbic acid, citric acid, and malic acid, which are naturally found in carrots. Carrots are known for their sweet flavor, but their acidity also plays a crucial role in flavor profile and potential physiological effects. In contrast, Treatments 2 (chayote) and 3 (bottle gourd) exhibited slightly higher pH values of 3.90; however, they are still classified as strongly acidic. Although these vegetables are characterized by their mild flavor and high-water content, they contain organic acids that contribute to their acidity. The subtle difference in pH suggests that while both are acidic, chayote and bottle gourd are marginally less so than carrots, possibly due to their high water content diluting the acid concentration.

The result contradicts Bhardwaj's (2011) statement that most vegetables used for juice production, such as carrots, chayote, and bottle gourd, are considered mildly acidic to near-neutral under fresh, raw conditions. Leahu *et al*. (2013) found that fresh carrot juice typically has a pH of around 5.98, indicating mild acidity. Similarly, Flores *et al*. (2018) observed a pH of 6.0 in chayote juice, and Monika *et al*. (2023) reported a pH of 5.87 for bottle gourd pulp. However, the actual pH value can vary depending on processing methods, storage conditions, and ingredient combinations. Factors such as enzymatic activity, microbial fermentation, and storage temperature can significantly influence the pH of vegetable juices. Pathania *et al*. (2018) noted that processing methods, such as pasteurization, acidification, and the addition of ascorbic acid, can lower the pH of fresh juices. Furthermore, microbial activity during or after juicing can also contribute to a decrease in pH due to the production of lactic and acetic acids (Amit *et al*., 2017).

The most notable observation is that as the proportion of strongly acidic carrot juice decreases in the formulations, the overall pH increases. This is evident in the mixed treatments (Treatments 4 through 7), which exhibit pH values ranging from 4.20 to 4.40, classified as moderately acidic. For example, Treatment 4 (33% carrot, 33% chayote, 33% bottle gourd) and Treatment 5 (50% carrot, 30% chayote, 20% bottle gourd) display higher pH values compared to pure carrot juice, indicating a dilution effect where the less acidic vegetables mitigate the overall acidity. This result underscores that the mixture's composition directly influences acidity levels. Increasing the proportion of chayote and bottle gourd, which are mildly acidic or near-neutral in taste, results in a more neutralized, less aggressive pH. This is consistent across all mixed formulations, highlighting the potential for tailoring juice formulations to achieve the desired acidity level.

Blending different vegetable juices can moderate the pH, improving both taste and shelf stability. Verma (2018) demonstrated that mixed vegetable juices showed more balanced pH values compared to single-ingredient juices, which helped enhance consumer acceptability. This supports the findings in the current study, where the combination of carrot, chayote, and bottle gourd increased the pH from strong to moderate acidity, making the drinks potentially more palatable and safer for sensitive consumers. Additionally, high acidity can affect consumer experience, especially for individuals prone to acid reflux or stomach sensitivity. According to Choi *et al*. (2015), beverages with a pH below 4.0 can irritate the gastric lining when consumed frequently, particularly if the acidity is not balanced with sweetness or a buffering compound.

Total Titratable Acidity (TTA)

The findings indicate apparent differences in TTA levels among the tested juices, with pure carrot juice (Treatment 1) showing the highest acidity at 0.570, contributing to a balanced, tart flavor profile that is likely more appealing to consumers. In contrast, chayote (Treatment 2) and bottle gourd juices (Treatment 3) have much lower TTA values (0.113 and 0.222), resulting in milder, less tart flavors that may be perceived as bland. The blended treatments generally maintain low TTA levels, with only slight increases in acidity corresponding to higher carrot content. Moreover, it was observed that increasing carrot proportion slightly raises acidity, but not enough to produce a significantly more tart flavor, suggesting that most formulations remain mild and may require flavor adjustments to meet consumer preferences.

Total Titrable Acidity (TTA) and pH are related but inversely correlated measures of acidity in fruit and vegetable juices. Generally, as TTA increases, indicating higher acidity, the pH value decreases, reflecting a more acidic environment. Regarding the study's results, carrot juice (Treatment 1), with the highest TTA (0.570), is expected to have the lowest pH among the treatments, indicating higher acidity. Chayote (Treatment 2) and bottle gourd juices (Treatment 3), with low TTA values (0.113 and 0.222), would likely have higher pH values, indicating milder acidity. Blended treatments with slight increases in TTA (like Treatments 4 to 7) would correspond to marginal decreases in pH, maintaining a generally mild acidity profile. Thus, the higher the TTA, the lower the pH, and vice versa. Therefore, the differences observed in TTA levels across treatments would be reflected in inverse differences in their pH levels, which would affect flavor perception and stability.

The findings of the current study align with existing literature, which indicates that carrot juice, containing citric, malic, and ascorbic acids, typically exhibits moderate TTA levels (0.5–0.7%), contributing to its balanced sweet-sour flavor and enhanced sensory appeal (Sethi, 2015; Patil et al., 2020). In contrast, chayote and bottle gourd juices are characterized by low organic acid content, resulting in mild, neutral, or bland flavors, with TTA values often below 0.3% (Méndez et al., 2019; Singh & Kumar, 2018). Blending these low-acid vegetables with moderately acidic carrots enhances the overall flavor balance and sensory acceptance, as noted by Deora et al. (2014). Moreover, moderate acidity not only enhances taste but also promotes microbiological safety by inhibiting the growth of spoilage microorganisms, an important consideration for ready-to-drink formulations that lack preservatives or refrigeration (Verma, 2018). For this current study, it is noted that increasing carrot content in vegetable juice blends yields higher TTA and improved flavor profiles, supporting the benefits of strategic blending for enhancing consumer preference and product stability.

Total Soluble Solid (TSS)

The Total Soluble Solids (TSS) levels across all treatments, ranging from 6° Bx to 12° Bx, demonstrate a spectrum of sweetness profiles, with carrot juice (T1) exhibiting the highest TSS at 12°, categorizing it as "moderately sweet," while treatments with higher proportions of chayote and bottle gourd—such as Treatment 7 (50% bottle gourd)—show the lowest TSS at 6°, falling into the "low sweetness" category. Intermediate formulations, including Treatment 4 (33% carrot, chayote, and bottle gourd) at 10° Bx and Treatment 5 (50% carrot) at 9° Bx, maintain moderate sweetness levels. These variations indicate that increasing the ratio of non-carrot vegetables tends to decrease the TSS and, consequently, the perceived sweetness of the juice. This result suggests that formulations with higher carrot content are naturally sweeter and more appealing to consumers seeking a moderate sweetness. In contrast, those with a greater proportion of chayote and bottle gourd offer a milder, less sugary flavor profile, suitable for health-conscious or low-sugar preferences. This further implies tailoring product profiles to target specific consumer preferences—ranging from moderately sweet to low-sugar options. From a product development perspective, balancing TSS is crucial. At the same time, higher TSS enhances palatability and perceived sweetness; however, it must be managed to avoid excessive sugar content, especially for health-conscious markets. On the other hand, lower TSS formulations may benefit from flavor masking or the addition of natural sweeteners to improve sensory appeal. Thus, understanding and controlling TSS allows manufacturers to optimize juice formulations for desired flavor profiles, consumer acceptance, and nutritional considerations.

Deora et al. (2014) emphasized that optimizing vegetable juice blends by adjusting proportions based on TSS and sensory evaluation can enhance consumer acceptance, particularly when catering to diverse sweetness preferences. Similarly, Verma (2018) noted that low-TSS juices (below 8° Bx) often require flavor enhancement for commercial viability, as reduced sweetness can lead to a bland or less satisfying taste; however, such juices may still attract health-conscious consumers seeking lower sugar options.

CONCLUSION

Based on the findings of the study, the following conclusions are drawn:

In sensory evaluations, Treatment 1 (carrot juice) consistently achieved the highest scores in appearance, color, taste, and overall acceptability, indicating a strong preference for this formulation among consumers. These sensory attributes—appearance, color, taste, and overall acceptability—showed statistically significant differences across treatments, highlighting their influential role in determining the sensory quality of ready-to-drink vegetable juices. On the other hand, odor scores did not differ significantly among the formulations, suggesting that odor was less influential or that the formulations produced similar aromatic profiles. Physico-chemical analysis revealed that Treatment 1 possessed a relatively acidic pH (3.70), high titratable acidity (0.570%), and the highest total soluble solids (12° Bx), all of which likely contributed to its superior flavor profile and consumer preference. In contrast, other formulations exhibited milder acidity, lower titratable acidity, and lower TSS, which may have resulted in less intense sensory experiences. Finally, the results suggest that formulations with higher carrot content not only enhance chemical qualities but also significantly improve sensory appeal, making them more suitable for consumer acceptance. This implies prioritizing formulations with higher carrot content to enhance flavor acceptance and nutritional value. Optimize acidity and TSS levels in the formulations. Adjustments, such as natural sweeteners or flavor enhancers, can be employed to achieve a harmonious taste while preserving the beneficial physicochemical characteristics. It is advisable to conduct shelf-life studies to ensure product stability and sustained quality over time. This will help in developing commercially viable, ready-to-drink vegetable juices that meet consumer preferences and safety standards.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest in this study. They affirm that there are no personal, financial, or professional interests that could have influenced the research outcomes.

DECLARATION OF REGENERATIVE AI

Regenerative AI is primarily used for tasks like grammar checking, identifying misspelled words, and proofreading. Its capabilities are limited to these specific functions.

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