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RSM-based optimization of a celery–pomegranate–carrot–lemon juice blend

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ABSTRACT

This study aimed to develop and optimize a multi-component vegetable–fruit juice blend using response surface methodology (RSM) to achieve desirable physicochemical and sensory properties. The formulation included pomegranate, carrot, celery, and lemon juices, selected for their complementary nutritional and sensory attributes. A mixture design was employed to assess the effects of varying proportions on pH, total soluble solids (TSS), and color parameters (L*, a*, b*). Significant regression models with high R^2 values were obtained, confirming the adequacy of the fitted models. The optimal blend was determined as 40.18% pomegranate, 32.19% carrot, 12.63% celery, and 15% lemon juices. Predicted physicochemical values under these conditions were pH 3.93, TSS 8.62 °Brix, L* 55.1, a* 21.1, and b* 8.3. Component contributions were also examined: lemon and celery decreased pH, pomegranate increased TSS and redness, while carrot enhanced lightness and yellowness due to its β-carotene content. Sensory evaluation with ten semi-trained panelists using a nine-point hedonic scale indicated moderate acceptability, with mean scores between 6.78 and 7.08 for taste, flavor, color, and overall preference. These findings highlight the effectiveness of RSM for optimizing complex beverage formulations and demonstrate the potential of this juice blend as a natural, clean-label functional drink. This study represents the first reported optimization of a celery, pomegranate, carrot, and lemon juice blend, highlighting both its novelty and industrial relevance.

Contribution/Originality: This study contributes to the existing literature by optimizing a unique blend of celery, pomegranate, carrot, and lemon juices. It employs response surface methodology as a novel estimation tool for the development of multi-component beverages. The primary contribution of the paper is demonstrating that balanced sensory and physicochemical properties can be achieved, highlighting its potential for industrial application.

1. INTRODUCTION

In recent years, there has been increasing consumer demand for natural, clean-label, and minimally processed food and beverage products. Among these, vegetable-fruit juice blends have attracted attention due to their refreshing taste, appealing color, and potential nutritional benefits. These beverages are typically formulated without synthetic additives or preservatives, relying instead on the intrinsic properties of the raw juices to achieve desirable quality attributes (Islam & Kabir, 2019). From a product development standpoint, such blends offer significant flexibility in terms of flavor profiles, natural coloring, acidity, and sweetness.

The use of celery juice (*Apium graveolens*) in juice formulations has gained popularity due to its light green hue, characteristic herbaceous flavor, and relatively high levels of sodium and potassium, which can contribute to taste and electrolyte balance in beverages (Szarek, Jaworska, & Hanus, 2024). Although its slightly bitter and salty notes

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may limit its use as a standalone beverage, it can be effectively incorporated into multicomponent blends to enhance complexity.

Pomegranate juice (*Punica granatum L.*) is well-known for its vivid red color, contributed by anthocyanins and other polyphenols, and for its acidic character, which helps balance the sweetness of other ingredients and stabilize product pH (Moradnia et al., 2024). It is frequently used to enhance the color and freshness perception of juice formulations. Carrot juice (*Daucus carota*), on the other hand, is appreciated for its naturally sweet flavor, smooth texture, and high β-carotene content, which imparts a bright orange color and body to the final product (Dallagi et al., 2023). Lemon juice (*Citrus limon*) is a widely used acidulant in juice processing due to its high citric acid content. It plays an important role in pH reduction, flavor enhancement, and microbiological safety (Sato, Ichinose, Takeuchi, & Koikeda, 2024).

Despite the advantages of each juice component, formulating a stable, appealing, and well-balanced juice blend requires careful optimization. This is particularly important when combining ingredients with diverse sensory profiles and physicochemical properties, such as pH, total soluble solids (TSS), color intensity, and viscosity. The proportion of each juice significantly affects the overall sensory perception and shelf stability of the beverage.

To address this challenge, Response Surface Methodology (RSM), a statistical tool for modeling and optimizing multivariable systems, is frequently employed in beverage formulation studies. RSM helps to identify optimal mixing ratios by evaluating the effects of individual components and their interactions on key response variables. Previous studies have shown that RSM is a reliable and cost-effective approach to optimize sensory attributes, color parameters, acidity, and °Brix in multi-juice beverages (Nayi & Kumar, 2021).

However, many previous juice blend optimization studies have relied on simple trial-and-error formulations or one-factor-at-a-time approaches, which cannot capture the complex interactions among ingredients. Compared to these traditional methods, Response Surface Methodology (RSM) offers a more systematic and statistically reliable framework, enabling multi-response optimization while reducing experimental workload. For these reasons, RSM was selected as the methodological basis of the present study.

The goal was to produce a vegetable–fruit juice blend with a balanced composition and desirable quality traits using only natural juice components. Despite the increasing interest in vegetable–fruit juice blends, limited studies have focused on the systematic optimization of multi-component formulations using response surface methodology. In particular, no previous study has investigated the combined use of celery, pomegranate, carrot, and lemon in a single beverage. This research fills this gap by providing the first comprehensive optimization of such a blend, emphasizing both its scientific novelty and its potential for functional beverage development.

2. MATERIALS AND METHODS

2.1. Materials

Fresh pomegranate (*Punica granatum L.*), carrot (*Daucus carota*), celery (*Apium graveolens*), and lemon (*Citrus limon*) were purchased from a local market in Şanlıurfa, Türkiye. All fruits and vegetables were selected for uniformity in ripeness, size, and appearance. The raw materials were processed on the same day to preserve their freshness and minimize variability in composition.

2.2. Experimental Design

The beverages formulated with celery, pomegranate, carrot, and lemon juices were blended in varying proportions and optimized using Response Surface Methodology (RSM), following the approach outlined by Nayi and Kumar (2021). The juice proportions were treated as equidistant factors, as described by Montgomery (2017). Specifically, celery (10–30 mL), pomegranate (30–50 mL), carrot (20–40 mL), and lemon (5–15 mL) were defined as independent variables. These factor levels were determined based on preliminary experiments that evaluated pH, total soluble solids (TSS), and color parameters L* and b* as dependent response variables.

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2.3. Preparation of the Vegetable–Fruit Juice Blend Containing Celery, Pomegranate, Carrot, and Lemon

The preparation and processing steps of the fresh fruit-vegetable juice are illustrated in Figure 1. The process consists of several unit operations, including washing, peeling, cutting, juice extraction, filtration, and filling into PET bottles or pre-sterilized glass containers.

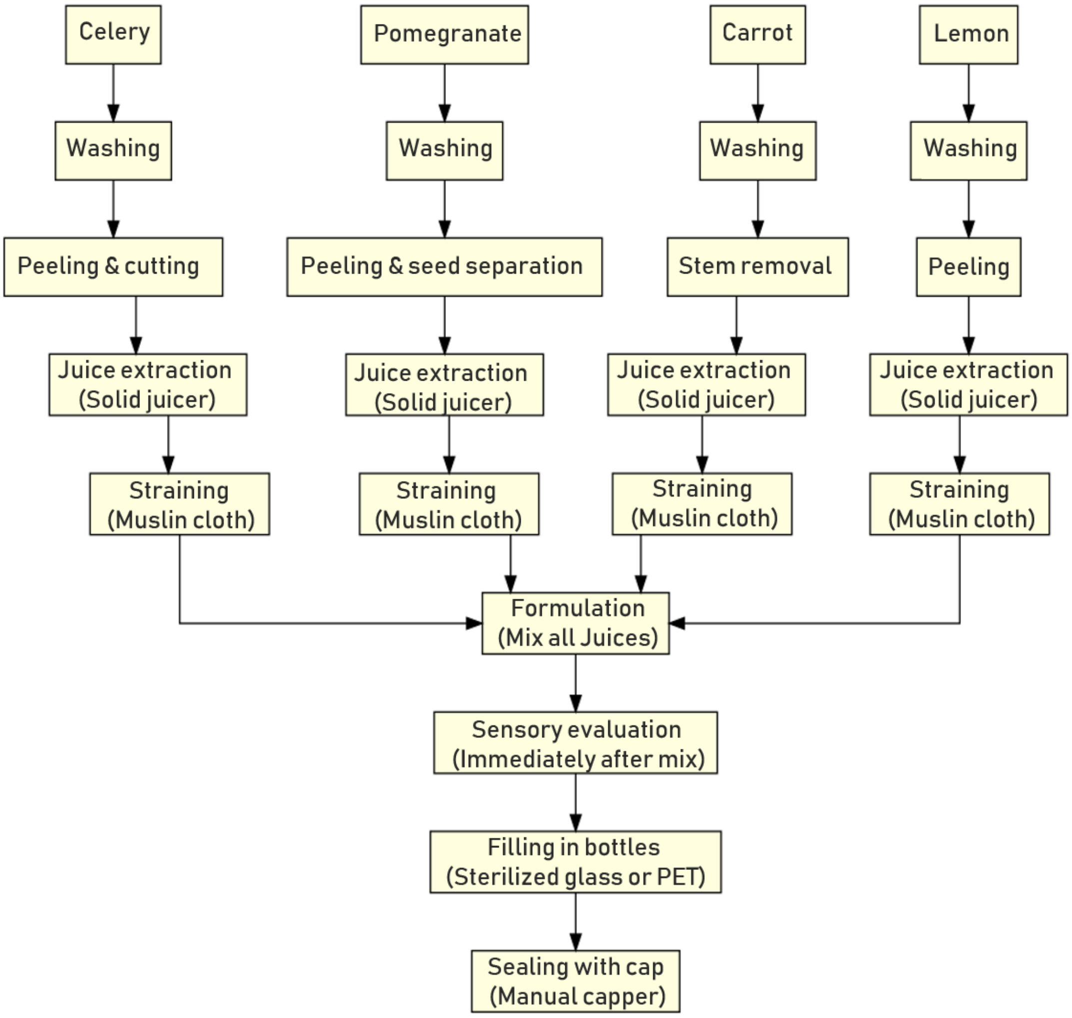

Figure 1. Process flow diagram illustrating the preparation steps of the vegetable–fruit juice blend formulated with pomegranate, carrot, celery, and lemon juices.

The newly obtained fruits and vegetables were carefully rinsed with flowing tap water to remove possible residues on their surfaces. The celery was peeled and cut into smaller pieces before being processed using a juice extractor (Philips HR1832/00) to obtain the juice. Pomegranate juice was extracted by first peeling the fruits and separating the arils from the membranes, after which the arils were processed using a solid juice extractor. Similarly, carrot juice was obtained by removing the stems and juicing the carrots using the same type of extractor. Lemon juice was prepared by peeling the lemons and extracting the juice with the same equipment. The obtained juices were then passed through a muslin cloth to separate solid particles and achieve a clear liquid.

Subsequently, the four different freshly extracted fruit and vegetable juices were blended in appropriate proportions according to the formulations presented in Table 2. Sensory evaluation of the blended juice samples was carried out immediately after their preparation to ensure optimal sensory attributes. As a final step, the freshly formulated celery-based juice blends were transferred into sterilized glass or PET bottles and securely closed with crown caps using a manual capping device before subsequent analyses.

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2.4. Physicochemical Properties of Celery, Pomegranate, Carrot, and Lemon Juices

2.4.1. Proximate Composition

Moisture, fat, protein, and ash contents of the fruit and vegetable juices were analyzed according to the standard procedures outlined by AOAC (2006).

2.5. pH and Total Soluble Solids (TSS)

Sample pH was determined with a digital pH meter (LABMAN LMPH-12, India) following the approach described by Rather et al. (2022). The total soluble solids (TSS) of all juice samples were assessed using a handheld refractometer (ATAGO-0258999, Japan), as outlined by Punoo, Rather, and Muzaffar (2023).

2.6. Instrumental Color Measurement

Sample color characteristics were determined using a Hunter Color Lab system (Flex EZ Model No. 45/0). Lightness (L), redness (a*), and yellowness (b*) values were recorded in triplicate, following the standardized procedure described by Rather et al. (2022).

2.7. Sensory Evaluation

The sensory properties of the optimized beverage formulation were evaluated following the methodology outlined by Rather, Akhter, Rather, Masoodi, and Dar (2024). Evaluations were performed under controlled conditions at room temperature (25 ± 2 °C) at 12:00 PM by a semi-trained panel consisting of senior faculty members and research assistants from the Department of Food Science and Technology, Harran University, with equal representation of male and female participants. Each assessor was provided with 50 mL of the sample for evaluation. Sensory attributes, including color, taste, texture, and overall acceptability, were assessed using a nine-point hedonic scale, where 1 denoted "disliked extremely" and 9 denoted "liked extremely."

3. RESULTS AND DISCUSSION

3.1. Physicochemical Composition of Raw Fruit and Vegetable Juices

Prior to the blending process, the physicochemical properties of celery (Apium graveolens), pomegranate (Punica granatum), carrot (Daucus carota), and lemon (Citrus limon) juices were analyzed. The average physicochemical composition of the raw juices, calculated based on triplicate measurements, is presented in Table 1.

Table 1. Physicochemical composition of raw fruit and vegetable juices.

Constituents (%)	Celery juice (mL)	Pomegranate juice (mL)	Carrot juice (mL)	Lemon juice (mL)
Moisture	94.52±0.03	85.74±0.04	88.14±0.08	92.32±0.04
Protein	0.78±0.01	0.43±0.05	0.93±0.01	0.47±0.02
Fat	0.12±0.04	0.35±0.01	0.27±0.02	0.25±0.03
Ash	0.84±0.05	0.32±0.03	0.65±0.01	0.43±0.05
pH	5.63±0.02	3.54±0.05	6.22±0.05	2.54±0.08
TSS	6.18±0.06	15.42±0.08	9.12±0.03	8.18±0.06

The findings of this study are largely consistent with previously reported data regarding the physicochemical properties of celery, pomegranate, carrot, and lemon juices. In particular, the general trend indicating that vegetable juices possess a higher moisture content compared to fruit juices has been confirmed. For instance, Moţ, Gurbină, Stoin, and Cozma (2020) demonstrated that vegetable-derived juices such as celery and carrot exhibit higher moisture content and distinct physicochemical characteristics, including pH and electrical conductivity, compared to fruit juices (Moţ et al., 2020). These findings align with the current study's results, in which celery juice exhibited a moisture content of 94.52%, while pomegranate juice displayed the lowest moisture level at 85.74%. This supports the general

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understanding that vegetable juices typically have higher water content and lower soluble solid concentrations relative to fruit juices, thereby highlighting the fundamental physicochemical differences between these two categories of beverages. Carrot juice exhibited the highest protein content at 0.93%, whereas lower protein levels were observed in pomegranate and lemon juices. This finding is consistent with the literature, which suggests that fruit and vegetable juices generally possess low protein content (Aderinola & Abaire, 2019). All samples were found to have low fat content, which can be attributed to the naturally low lipid levels typically observed in fruit and vegetable juices. The highest ash content, representing mineral matter, was recorded in celery juice at 0.84%, corroborating previous findings that highlight celery's richness in essential minerals (Yan et al., 2022). Regarding pH values, pomegranate (3.54) and lemon (2.54) juices exhibited distinctly acidic characteristics, whereas carrot (6.52) and celery (5.63) juices were closer to neutral pH. These observations are consistent with previous studies reporting the inherent acidity of pomegranate and citrus juices, where pomegranate juice was found to have pH values ranging from 2.87 to 3.77 (Rababah et al., 2023). In terms of total soluble solids (TSS), pomegranate juice displayed the highest value at 15.42 °Brix, which is consistent with previous findings reporting the high sugar and soluble solids content in pomegranates (Mashavhathakha, Soundy, Ngezimana, Nkomo, & Mudau, 2016).

3.2. Physicochemical Properties of the Vegetable–Fruit Juice Blend

A response surface methodology (RSM) was applied to optimize the formulation of mixed juice. The experimental data were collected accordingly, and the mean values of triplicate measurements for the evaluated responses are summarized in Table 2.

Table 2. Independent variables and response parameters used in the optimization of the vegetable–fruit juice blend formulated with pomegranate, carrot, celery, and lemon juices.

Variables					Responses				
Run	Juice (mL)				pH	TSS	L	a	b
	Pomegranate	Carrot	Celery	Lemon					
1	50	30	10	10	3.88	7.92	53.214	22.556	6.94
2	50	20	15	15	3.65	8.22	52.014	21.856	6.86
3	30	35	30	5	4.056	7.34	56.705	16.581	9.68
4	30	40	20	10	3.93	8.03	54.885	17.714	10.38
5	30	35	30	5	4.056	7.32	56.705	16.581	9.68
6	35	40	10	15	3.71	7.75	56.998	20.103	9.72
7	45	40	10	5	3.92	9.15	53.933	20.392	8.27
8	50	20	25	5	4.11	9.22	51.236	22.756	6.46
9	37.5	40	17.5	5	3.91	8.91	58.405	21.845	10.14
10	32.5	22.5	30	15	3.87	8.32	58.974	17.381	7.56
11	50	20	15	15	3.65	8.35	52.014	20.856	6.78
12	50	20	25	5	4.11	9.22	51.236	22.756	6.46
13	40	30	20	10	4.25	9.18	54.725	21.351	8.27
14	41.6	31.6	21.6	5	4.17	9.31	53.235	22.012	7.87
15	42.5	32.5	10	15	3.74	9.05	53.132	20.566	8.12
16	35	40	10	15	3.71	7.75	56.998	20.103	9.72
17	37.5	27.5	30	5	3.95	7.44	54.113	17.452	7.75
18	50	30	10	10	3.88	7.92	53.214	22.556	6.94
19	40	20	30	10	4.15	7.35	55.732	17.463	7.73
20	30	32.5	22.5	15	3.98	8.18	56.332	16.221	9.41

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Table 3. ANOVA for the effects of different fruit and vegetable juice combinations on the chemical properties of the blended juice.

Source	pH				Source	TSS				
Model	**Sum of squares**	**df**	**Mean square**	**F-value**	**p-value**	**Model**	**Sum of squares**	**df**	**Mean square**	**F-value**	**p-value**
	0.6062	12	0.0505	2775.60	< 0.0001		7.92	9	0.8799	4.77	0.0113
[(1)]Linear Mixture	0.3621	3	0.1207	6632.27	< 0.0001	[(1)]Linear Mixture	2.42	3	0.8056	4.37	0.0329
AB	0.0663	1	0.0663	3641.32	< 0.0001	AB	0.7737	1	0.7737	4.19	0.0677
AC	0.0288	1	0.0288	1584.23	< 0.0001	AC	2.32	1	2.32	12.59	0.0053
AD	0.0001	1	0.0001	7.02	0.0330	AD	0.8632	1	0.8632	4.68	0.0558
BC	0.0802	1	0.0802	4408.95	< 0.0001	BC	1.74	1	1.74	9.43	0.0118
BD	0.0672	1	0.0672	3694.19	< 0.0001	BD	0.7340	1	0.7340	3.98	0.0740
CD	0.0217	1	0.0217	1191.05	< 0.0001	CD	0.1351	1	0.1351	0.7323	0.4122
ABC	0.0329	1	0.0329	1805.54	< 0.0001	Residual	1.84	10	0.1845		
ACD	0.0243	1	0.0243	1335.95	< 0.0001	Lack of Fit	1.83	5	0.3667	162.96	< 0.0001
BCD	0.0181	1	0.0181	996.71	< 0.0001	Pure Error	0.0113	5	0.0023		
Residual	0.0001	7	0.0000			Cor Total	9.76	19			
Lack of Fit	0.0001	2	0.0001			Std. Dev.	0.4295				
Pure Error	0.0000	5	0.0000			Mean	8.29				
Cor Total	0.6063	19				C.V.%	5.18				
Std. Dev.	0.0043					R^2	0.8111				
Mean	3.93					Adjusted R^2	0.6410				
C.V.%	0.1084					Predicted R^2	0.1828				
R^2	0.9998					Adeq Precision	7.6221				
Adjusted R^2	0.9994										
Predicted R^2	0.9812										
Adeq Precision	174.5365										

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Table 4. ANOVA for the effects of different fruit and vegetable juice combinations on the color properties of the blended juice.

Source	L					Source	a					Source	b				
	Sum of Squares	df	Mean Square	F-value	p-value		Sum of Squares	df	Mean Square	F-value	p-value		Sum of Squares	df	Mean Square	F-value	p-value
Model	72.01	3	24	12.5	0.0002	Model	8.8	5	1.76	53.92	< 0.0001	Model	32.38	9	3.6	62.25	< 0.0001
Linear Mixture	72.01	3	24	12.5	0.0002	Linear Mixture	0.726	1	0.726	22.23	0.0006	[1]Linear Mixture	30.44	3	10.15	175.58	< 0.0001
Residual	30.73	16	1.92			AB	0.7036	1	0.7036	8.17	0.0289	AB	0.373	1	0.373	6.45	0.0293
Lack of Fit	30.73	11	2.79			AC	0.0676	1	0.0676	0.7845	0.4099	AC	0.3002	1	0.3002	5.19	0.0459
Pure Error	0	5	0			AD	0.6592	1	0.6592	7.65	0.0326	AD	0.2171	1	0.2171	3.76	0.0813
Cor Total	102.74	19				BC	0.016	1	0.016	0.1858	0.6815	BC	0.0148	1	0.0148	0.2564	0.6235
Std. Dev.	1.39					BD	0.2808	1	0.2808	3.26	0.1211	BD	0.0077	1	0.0077	0.1336	0.7223
Mean	54.69					CD	0.0184	1	0.0184	0.2141	0.6599	CD	0.1146	1	0.1146	1.98	0.1893
C.V.%	2.53					ABC	0.6578	1	0.6578	7.63	0.0327	Residual	0.5779	10	0.0578		
R^2	0.7009					ABD	0.9241	1	0.9241	10.72	0.0169	Lack of Fit	0.5747	5	0.1149	179.59	< 0.0001
Adjusted R^2	0.6448					ACD	0.3704	1	0.3704	4.3	0.0835	Pure Error	0.0032	5	0.0006		
Predicted R^2	0.5105					BCD	0.0655	1	0.0655	0.7596	0.417	Cor Total	32.95	19			
Adeq Precision	8.9691					Residual	0.517	6	0.0862			Std. Dev.	0.2404				
						Lack of Fit	0.017	1	0.017	0.1703	0.697	Mean	8.24				
						Pure Error	0.5	5	0.1			C.V.%	2.92				
						Cor Total	104.84	19				R^2	0.9825				
						Std. Dev.	0.2935					Adjusted R^2	0.9667				
						Mean	19.96					Predicted R^2	0.8902				
						C.V.%	1.47					Adeq Precision	25.0473				
						R^2	0.9951										
						Adjusted R^2	0.9844										
						Predicted R^2	0.8704										
						Adeq Precision	26.3689										

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The pH, TSS, L, a, and b values of the blended fruit juice ranged from 3.65 to 4.25, 7.34 to 9.31, 51.236 to 56.998, 16.221 to 22.756, and 6.46 to 10.38, respectively (Table 2). Four-dimensional surface plots were constructed for each fitted model to demonstrate the combined influence of the three independent variables on the responses, while the fourth factor was maintained at its central level. The experimental results were analyzed using linear, quadratic, and interaction models, and statistical evaluations were performed for each response (Table 3, Table 4).

3.3. Model Equations

The regression equations for the measured parameters (pH, TSS, L*, a*, and b*) of the vegetable–fruit juice blend were derived using Response Surface Methodology. These equations represent the relationship between the independent variables (A: Pomegranate juice, B: Carrot juice, C: Celery juice, D: Lemon juice) and the response parameters.

pH (Equation 1): $pH = 3.93 + 0.1179AB - 0.2215AC + 0.1191AD + 0.1332BC + 0.2029BD + 0.2442CD + 0.4740ABC - 0.1626ACD + 0.1260BCD$

Total Soluble Solids (TSS) (Equation 2): $TSS: 7.69 \cdot A + 6.72 \cdot B + 1.84 \cdot C + 17.83 \cdot D + 7.58 \cdot AB + (-17.73) \cdot AC + (-8.13) \cdot AD + 4.13 \cdot BC + (-14.16) \cdot BD$

*Lightness (L) (*Equation 3*):* * $L = 48.46 \cdot A + 57.57 \cdot B + 56.40 \cdot C + 58.51 \cdot D$

*Redness (a) (*Equation 4*):* * $a = 42.65 \cdot A + 26.21 \cdot B + 6.15 \cdot C + 51.10 \cdot D + 7.41 \cdot AB - 17.38 \cdot AC - 68.33 \cdot AD - 21.42 \cdot BC + 18.47 \cdot BD + 24.01 \cdot CD - 44.26 \cdot ABC + 31.65 \cdot ABD$

*Yellowness (b) (*Equation 5*):* * $b = 5.95 \cdot A + 12.71 \cdot B + 7.52 \cdot C + 7.14 \cdot D - 6.20 \cdot AB$

These regression equations provide a mathematical description of the effects and interactions among juice components on each measured parameter. The high coefficients of determination (R^2 values) confirm the adequacy of the models for predicting the physicochemical and color properties of the blended beverage.

3.4. Impact of Blended Fruit Juice Composition on pH

During the experiments, the pH values of the blended fruit and vegetable juices ranged from 3.65 to 4.25 (Table 2). The effect of the vegetable-based blended juice formulation on pH is illustrated in Figure 2A. An increase in lemon content was associated with a decrease in pH due to its high acidity, while higher carrot and celery levels slightly increased pH. These trends are consistent with previous findings (Nayi & Kumar, 2021) and highlight the importance of juice composition for product stability. According to the results, an increase in the proportion of lemon juice significantly reduced the pH of the beverage, thereby increasing its acidity. This effect is consistent with previous studies attributing the high acidity of lemon juice to its substantial citric acid content (Pham et al., 2020). Celery juice also exhibited a pH-lowering effect, which aligns with observations reported in the literature. Although pomegranate juice is often characterized as contributing to increased acidity, it demonstrated a pH-elevating effect in the present study. This discrepancy may be explained by variations in pomegranate cultivar, ripeness stage, and juice composition ratios (Rababah et al., 2023). Carrot juice, being generally more neutral in nature, exhibited a slight tendency to increase pH. In conclusion, lemon and celery juices lowered the pH, rendering the beverage more acidic, while the effects of pomegranate and carrot juices varied depending on their compositional characteristics. These findings highlight the necessity of carefully optimizing component ratios in the formulation of beverages.

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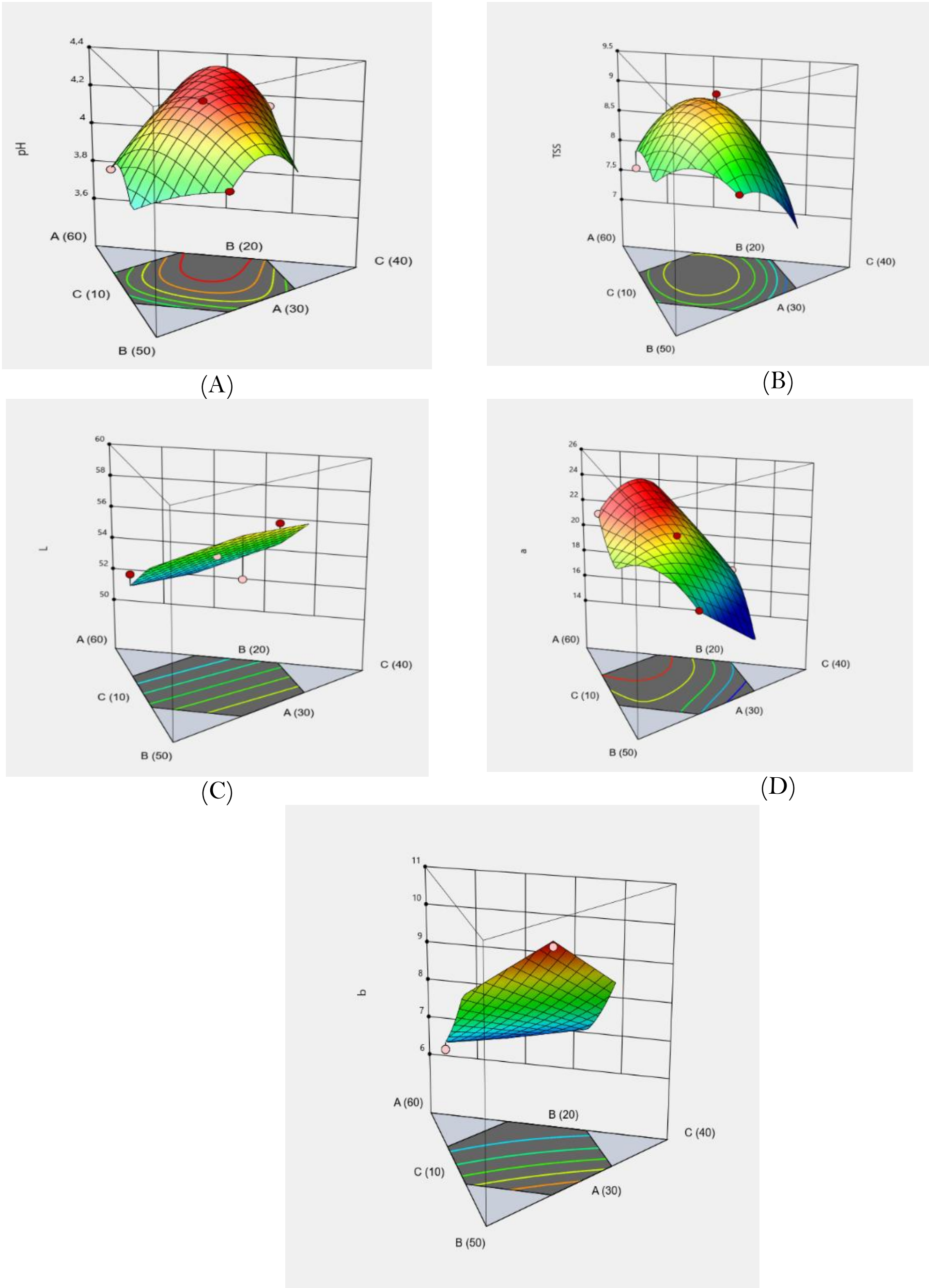

Figure 2. Response surface plots showing the effects of pomegranate juice (A), carrot juice (B), celery juice (C), and lemon juice (D) on: (A) pH, (B) total soluble solids (TSS), (C) L* (lightness), (D) a* (redness), and (E) b* (yellowness) of the vegetable–fruit juice blend.

According to Table 3, the analysis of variance (ANOVA) indicated that the linear mixture of celery, pomegranate, carrot, and lemon juices had a statistically significant effect ($p < 0.05$) on the pH values of the blended juice. Among the interaction and quadratic terms, the AD interaction (pomegranate juice-lemon juice) was found to have a significant influence on pH. The R^2 and adjusted R^2 values were 0.9998 and 0.9994, respectively, indicating a very good fit of the model. Based on the actual values of the variables, the regression equation representing the effect of the processing factors on the pH of the blended juice is provided in Equation 1.

$$pH = 3.93 + 0.1179AB - 0.2215AC + 0.1191AD + 0.1332BC + 0.2029BD + 0.2442CD + 0.4740ABC - 0.1626ACD + 0.1260BCD \quad (1)$$

A: Pomegranate juice, B: Carrot juice, C: Celery juice, D: Lemon juice.

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3.5. Impact of Blended Fruit Juice Composition on Total Soluble Solids (TSS)

During the experiments, the total soluble solids (TSS) values of the blended fruit and vegetable juices ranged from 7.32 to 9.31 °Brix (Table 2). The effect of the vegetable-based mixed juice formulation on TSS is illustrated in Figure 2B. According to Figure 2B, increasing pomegranate and carrot content elevated TSS values due to their higher natural sugar concentrations, while celery contributed to lower TSS. These findings align with earlier studies reporting that fruit-based components enhance °Brix levels and consumer-perceived sweetness, an important attribute for beverage acceptability. The highest TSS values were observed in formulations with a high proportion of pomegranate juice. This result is in direct agreement with the findings reported by Mashavhathakha et al. (2016), where pure pomegranate juice was shown to contain approximately 15.3 °Brix and significantly increase TSS levels in mixtures. In terms of total soluble solids (TSS), pomegranate juice displayed the highest value at 15.42 °Brix, consistent with findings reporting the high sugar and soluble solids content in pomegranates (Mohan, Komathkandy, & Faheema, 2024). In the present study, carrot juice also contributed to a moderate increase in TSS, consistent with reports indicating that carrot juice typically exhibits a °Brix value in the range of 7–9 (Aderinola & Abaire, 2019). In contrast, lemon and celery juices exerted a reducing effect on TSS due to their low sugar and soluble solids content, as confirmed by studies indicating a °Brix value around 4–5 for lemon juice (Pham et al., 2020). In this context, our findings indicate that pomegranate had the strongest positive effect on TSS, whereas lemon contributed the least.

According to Table 3, the analysis of variance (ANOVA) demonstrated that the linear mixture of celery, pomegranate, carrot, and lemon juices had a statistically significant effect ($p < 0.05$) on the total soluble solids (TSS) values of the blended juice. While the AB interaction (pomegranate juice – carrot juice) had no significant effect on TSS, the AC (pomegranate juice – celery juice), AD (pomegranate juice – lemon juice), BC (carrot juice – celery juice), and BD (carrot juice – lemon juice) interactions showed statistically significant effects. The coefficient of determination (R^2) and the adjusted R^2 values were 0.8111 and 0.6410, respectively, indicating a moderate fit of the model. Based on the actual proportions of the variables, the regression equation representing the effects of the processing factors on the TSS value of the blended juice is given in Equation 2.

$$TSS = 7.69 \cdot A + 6.72 \cdot B + 1.84 \cdot C + 17.83 \cdot D + 7.58 \cdot AB + (-17.73) \cdot AC + (-8.13) \cdot AD + 4.13 \cdot BC + (-14.16) \cdot BD \qquad (2)$$

3.6. Impact of Blended Fruit Juice Composition on Color Characteristics (L)*

During the experiments, the L* values of the blended fruit and vegetable juices ranged from 51.236 to 58.974, with the highest L* values observed in formulations containing higher proportions of celery and carrot juices (Table 2). The effect of the vegetable-based blended juice formulation on the L* value is illustrated in Figure 2C. Figure 2C shows that higher carrot and lemon proportions increased lightness (L*), while pomegranate reduced L* due to its darker pigments. This trend is consistent with reports that anthocyanin-rich fruits decrease brightness, whereas carrot and citrus juices contribute to a lighter visual appearance, enhancing consumer appeal. Among the color parameters, the L* value represents the lightness of the beverage. This finding is consistent with results indicating that celery juice is low in color pigments and provides a light-colored matrix. Previous studies also reported that increasing the proportion of pomegranate juice in mixtures leads to a darker color (lower L* value), which is consistent with the current study's observation that higher pomegranate content results in reduced L* values (Dimitreli, Petridis, Kapageridis, & Mixiou, 2019). Similarly, Türkyılmaz and Özkan (2014) demonstrated that condensed tannins and anthocyanins in pomegranate juice contribute to opacity and darkness, thereby decreasing L* values (Türkyılmaz & Özkan, 2014).

As shown in Table 4, the analysis of variance (ANOVA) revealed that the linear mixture of celery, pomegranate, carrot, and lemon juices had a statistically significant effect ($p < 0.05$) on the L* values of the blended juice. The remaining interaction and quadratic terms did not exhibit a significant influence on the L* value. The coefficient of determination (R^2) and adjusted R^2 were 0.7009 and 0.6448, respectively, indicating a moderate model fit. Based on

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the actual proportions of the variables, the regression equation representing the influence of the processing factors on the L* value of the blended juice is provided in Equation 3.

$$L = 48.46 \cdot A + 57.57 \cdot B + 56.40 \cdot C + 58.51 \cdot D \quad (3)$$

3.7. Impact of Blended Fruit Juice Composition on Color Characteristics (a)*

During the experiments, the *a* values of the blended fruit and vegetable juices ranged from 16.221 to 22.756 (Table 2). The effect of the vegetable-based mixed juice formulation on the *a* value is illustrated in Figure 2D. *As shown in* Figure 2D, increasing pomegranate proportion enhanced redness (a*) due to its high anthocyanin content, while carrot also contributed positively. In contrast, lemon and celery reduced a* values, consistent with their lower pigment concentrations. These results confirm that pigment-rich fruits are the main drivers of red coloration in juice blends. The a values of the beverages increased proportionally with the pomegranate juice content. This increase can be attributed to the high anthocyanin content in pomegranate, particularly given that its red pigments are known to be stabilized in acidic environments (pH 3–4) (Kumar et al., 2020). The present study confirms that these pigments contribute a dominant red hue within the mixture. Sharma et al. (2021) similarly reported increased A values in mixtures of pomegranate and black carrot as the proportion of pomegranate increased (Sharma et al., 2021). Carrot juice contributed a moderate degree of redness due to its inherent pigment, beta-carotene, which aligns with the color index analyses of carrots reported by Arscott, Simon, and Tanumihardjo (2010). In contrast, celery and lemon juices exhibited a diluting effect on redness, reducing the a value, which is consistent with pigment density analyses reported in the existing literature.

The data in Table 4 demonstrate that the analysis of variance (ANOVA) revealed a statistically significant effect ($p < 0.05$) of the linear mixture of celery, pomegranate, carrot, and lemon juices on the a* values of the blended juice. Among the interaction and higher-order terms, AC (pomegranate juice–celery juice), BC (carrot juice–celery juice), BD (carrot juice–lemon juice), CD (celery juice–lemon juice), ACD (pomegranate juice–celery juice–lemon juice), and BCD (carrot juice–celery juice–lemon juice) did not exhibit significant effects on the a* values. However, AB (pomegranate juice–carrot juice), AD (pomegranate juice–lemon juice), and ABC (pomegranate juice–carrot juice–celery juice) showed statistically significant influences. The coefficient of determination (R^2) and adjusted R^2 values were 0.9951 and 0.9844, respectively, indicating an excellent model fit. Based on the actual proportions of the variables, the regression equation representing the influence of processing factors on the a* value of the blended juice is presented in Equation 4.

$$a = 42.65 \cdot A + 26.21 \cdot B + 6.15 \cdot C + 51.10 \cdot D + 7.41 \cdot AB - 17.38 \cdot AC - 68.33 \cdot AD - 21.42 \cdot BC + 18.47 \cdot BD + 24.01 \cdot CD - 44.26 \cdot ABC + 31.65 \cdot ABD \quad (4)$$

3.8. Impact of Blended Fruit Juice Composition on Color Characteristics (b)*

During the experiments, the *b* values of the blended fruit and vegetable juices ranged from 6.46 to 10.38 (Table 2). The effect of the vegetable-based blended juice formulation on the *b* value is illustrated in Figure 2E. Figure 2E *indicates that higher carrot levels increased yellowness (b) because of* its carotenoid pigments, whereas pomegranate reduced b* values due to the masking effect of anthocyanins. Lemon and celery had moderate effects. These findings are consistent with previous reports linking carrot juice to increased yellowness in mixed beverages. Among the components, carrot juice contributed the most to the increase in *b* values. This is attributed to the presence of beta-carotene in carrots, which imparts yellow-orange hues and leads to elevated *b* values. This finding is in strong agreement with the study by Senarathne and Wickramasinghe (2019), which comprehensively demonstrated the contribution of beta-carotene to b-value enhancement (Senarathne & Wickramasinghe, 2019). Lemon juice also showed a limited positive effect on b values due to its yellow pigment content. In contrast, increasing the proportion of pomegranate juice led to a decrease in b values, likely due to the dominance of its red-purple pigments that suppress yellow tones. Similarly, Türkyılmaz and Özkan (2014) reported that higher pomegranate content reduces the b value

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by overshadowing yellowness with redness (Türkyılmaz & Özkan, 2014). Celery juice, due to its neutral greenish tones, had a moderate influence on the b value, without causing any significant increase or decrease.

As presented in Table 4, the analysis of variance (ANOVA) revealed that the linear mixture of celery, pomegranate, carrot, and lemon juices had a statistically significant effect ($p < 0.05$) on the b* values of the blended juice. Among the interaction and quadratic terms, only the AB interaction (pomegranate juice – carrot juice) exhibited a significant effect, while the remaining terms were not statistically significant. The coefficient of determination (R^2) and the adjusted R^2 were 0.9825 and 0.9667, respectively, indicating a strong model fit. Based on the actual proportions of the variables, the regression equation representing the effect of processing factors on the b* value of the blended juice is provided in Equation 5.

$$b = 5.95 \cdot A + 12.71 \cdot B + 7.52 \cdot C + 7.14 \cdot D - 6.20 \cdot AB \qquad (5)$$

3.9. RSM-Based Optimization of a Multi-Component Juice Blend Containing Pomegranate, Carrot, Celery, and Lemon

In this study, Response Surface Methodology (RSM) was employed to optimize the effects of pomegranate juice, carrot juice, celery juice, and lemon juice on pH, total soluble solids (TSS), and color parameters (L*, a*, and b*) of the blended beverage. The F-values obtained for all models were statistically significant at the 5% confidence level, indicating that the selected juice components had a meaningful and measurable influence on the physicochemical and color attributes of the formulation.

The coefficient of determination (R^2) values for pH, TSS, L*, a*, and b* were 0.9988, 0.8111, 0.7009, 0.9951, and 0.9825, respectively, indicating that the models accounted for more than 70% of the variability in the experimental data. The close agreement between the predicted and observed values further confirmed the robustness and reliability of the developed regression models.

The adequacy of the models was validated through a lack-of-fit test, which was found to be non-significant, thereby confirming that the models provide accurate and reliable predictions within the specified range of ingredient levels. Based on these results, an optimal formulation comprising appropriate proportions of pomegranate juice, carrot juice, celery juice, and lemon juice was identified to achieve the most desirable physicochemical and color properties in the blended beverage.

Based on response surface optimization, the optimal ingredient ratios were determined to achieve a target pH of 3.8, maximize total soluble solids (TSS) and a* value, target an L* value of 55.105, and maintain the b* value within an acceptable range. The optimized formulation is presented in Table 5. Furthermore, the industrial applicability of this formulation was assessed. These findings highlight that mixture design-based modeling is a reliable and effective approach for optimizing both color and physicochemical attributes in the development of beverages.

Table 5. Experimental design ranges of juice components used for the optimization of the vegetable–fruit beverage using response surface methodology.

Constraints	Goals	Optimization	
		Lower limit	Upper limit
Factor			
A- Pomegranate Juice	In range	30	50
B- Carrot Juice	In range	20	40
C- Celery Juice	In range	10	30
D- Lemon Juice	In range	5	15
Response			
pH	Is target = 3.8	3.65	4.25
Total Soluble Solids (TSS)	Maximize	7.3	9.3
L	Is target = 55.105	55	60
a	Maximize	16.221	22.756
b	In range	7.5	8.5

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For the simultaneous optimization of multiple responses, numerical optimization techniques were employed using Design-Expert software (Design-Expert® version 10.0.6, Stat-Ease Inc., Minneapolis, USA, http://www.statease.com). Specific constraints were applied to the variables according to the predefined targets for each ingredient and response parameter. Based on these criteria, the optimal formulation was successfully identified.

The proportions of pomegranate juice, carrot juice, celery juice, and lemon juice were evaluated within predefined limits. The optimal formulation was determined to comprise 40.178% pomegranate juice, 32.193% carrot juice, 12.629% celery juice, and 15% lemon juice. Under these optimized conditions, the predicted physicochemical and color properties of the beverage were as follows: pH 3.93, total soluble solids (TSS) 8.62 °Brix, L* value 55.1, a* value 21.1, and b* value 8.3.

The optimized formulation was validated through confirmation experiments, further confirming the reliability and predictive accuracy of the model. The results demonstrate that the optimal combination of ingredients effectively enhances both the color attributes and physicochemical properties of the beverage, thereby contributing to improved consumer acceptability. The formulation recommended by the Design-Expert software provides a robust foundation for the development of fruit-vegetable beverages with high sensory appeal and enhanced stability, supporting its applicability within the fruit-vegetable beverage industry.

3.10. Sensory Evaluation of the Optimized Beverage Sample

Sensory analysis constitutes an essential component of novel food product development, as it provides critical information on product quality and consumer acceptance. Various sensory methodologies can be systematically integrated at distinct stages of the product development process to ensure compliance with consumer expectations and industry standards (Świąder & Marczewska, 2021). The increasing reliance on sensory evaluation services, together with the demand for innovative analytical approaches that yield industry-relevant data, has markedly intensified research efforts in this domain, particularly within the beverage sector (Vázquez-Araújo, 2022). The sensory evaluation findings obtained for the optimized beverage formulation are presented in Figure 3.

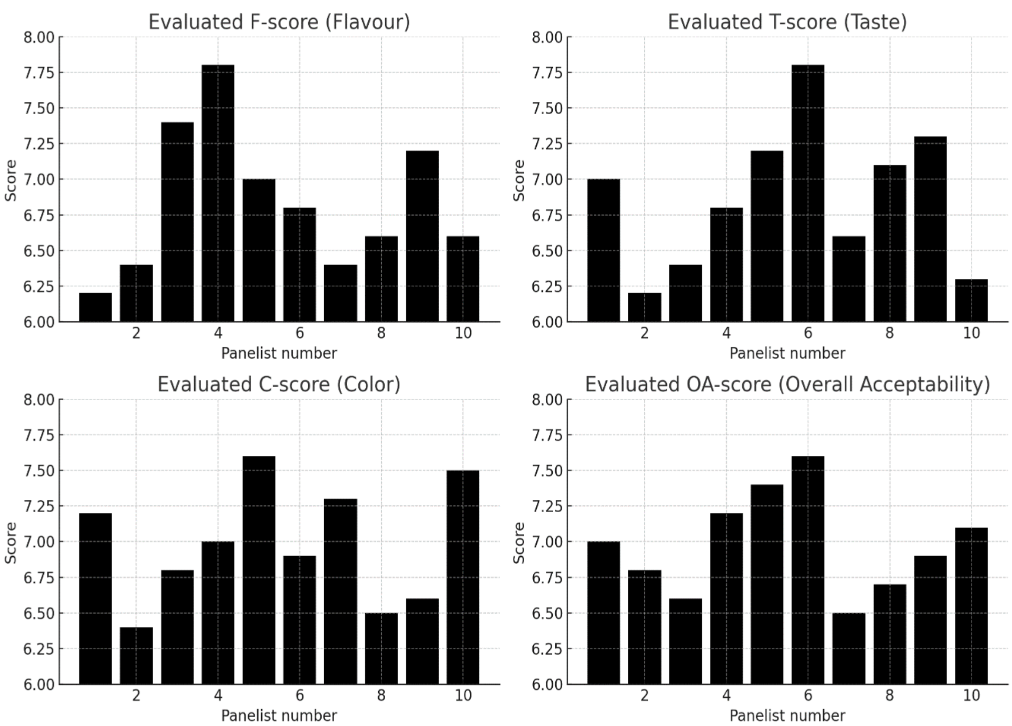

Figure 3. Sensory evaluation of the optimized beverage sample, where F = Flavor, T = Taste, C = Color, and OA = Overall Acceptability.

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4. EVALUATION OF SENSORY ANALYSIS RESULTS

4.1. Flavor

Flavor is one of the most critical sensory quality attributes determining consumer acceptance. The flavor (F-score) of the optimized beverage sample containing celery juice was evaluated by a panel of ten sensory panelists, as illustrated in Figure 3. According to the panelists' assessments, flavor scores ranged from 6.2 to 7.8, with a calculated mean score of 6.78 ± 0.49. This score corresponds to the "moderately liked" level on the nine-point hedonic scale. When compared to the flavor scores reported by Mane, Zinjarde, Bhosale, Raskar, and Tambe (2019), which ranged between 6.9 and 8.6, the results obtained in this study are within an acceptable range but remain below the threshold for "extremely liked" from a consumer perspective.

4.2. Taste

Taste is another key sensory attribute that directly influences the intrinsic quality of a beverage and overall consumer satisfaction. The taste (T-score) of the evaluated beverage sample ranged from 6.2 to 7.8, with a mean score of 6.86 ± 0.49. This score indicates that the optimized product was "moderately liked" by the sensory panelists. When compared to the higher taste scores reported by Ranga et al. (2023), which ranged between 7.80 and 7.84, the result of this study is slightly lower but still considered acceptable for similar types of beverages.

4.3. Color

The visual appearance of food is one of the primary parameters that influence consumer perception. The color (C-score) of the optimized beverage sample ranged from 6.4 to 7.6, with a mean score of 6.88 ± 0.38. This score corresponds to the "moderately liked" level on the nine-point hedonic scale. Although the color score was lower than the value of 7.8 reported by Kardas, Rakuła, Kołodziejczyk, and Staśkiewicz-Bartecka (2024), it still falls within an acceptable range in terms of visual appeal.

4.4. Overall Acceptability

Overall acceptability provides an integrated assessment of all sensory attributes. In this study, the OA-score of the optimized beverage ranged from 6.5 to 7.6, with a mean score of 7.08 ± 0.35. This result indicates that the beverage was "moderately liked" by the panelists overall. The findings are consistent with the overall acceptability range of 5.40 to 8.11 reported by Sahrawat and Chaturvedi (2023) supporting the sensory acceptability of the formulated product.

5. CONCLUSION

In this study, the formulation of a vegetable–fruit juice blend produced by combining pomegranate, carrot, celery, and lemon juices in specific proportions was successfully optimized. Using a Response Surface Methodology (RSM)-based experimental design, statistically significant models were developed for pH, total soluble solids (TSS), and color parameters (L*, a*, and b*). The optimal formulation was determined to consist of 40.178% pomegranate juice, 32.193% carrot juice, 12.629% celery juice, and 15% lemon juice. Under these conditions, the predicted physicochemical values were pH 3.93, TSS 8.62 °Brix, L* 55.1, a* 21.1, and b* 8.3.

Sensory evaluation results indicated that the optimized juice blend was moderately liked in terms of taste, flavor, color, and overall acceptability. These findings demonstrate that the developed formulation provides a balanced combination of physicochemical and sensory characteristics. Moreover, the results highlight the usefulness of mixture design as an effective tool in the formulation of multi-component beverages with desirable quality attributes. However, the study was limited by a small sensory panel and the absence of bioactive compound analysis and shelf-life evaluation. Future research should address these aspects to support the product's industrial applicability and consumer acceptance. From an industrial perspective, the optimized formulation demonstrates strong potential as a

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natural, clean-label functional beverage, and future studies should focus on bioactive compound profiling and shelf-life evaluation to enhance its commercial relevance.

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REFERENCES

Aderinola, T. A., & Abaire, K. E. (2019). Quality acceptability, nutritional composition and antioxidant properties of carrot-cucumber juice. *Beverages*, *5*(1), 15. https://doi.org/10.3390/beverages5010015

AOAC. (2006). *Official methods of analysis of AOAC International* (18th ed.). United States: AOAC International.

Arscott, S. A., Simon, P. W., & Tanumihardjo, S. A. (2010). Anthocyanins in purple-orange carrots (Daucus carota L.) do not influence the bioavailability of beta-carotene in young women. *Journal of Agricultural and Food Chemistry*, *58*(5), 2877-2881.

Dallagi, W., Rguez, S., Hammami, M., Rebey, I. B., Bourgou, S., & Sellami, I. H. (2023). Optimization of processing conditions to enhance antioxidant and carotenoid contents of carrot juice. *Journal of Food Measurement and Characterization*, *17*(5), 4384-4393. https://doi.org/10.1007/s11694-023-01950-4

Dimitreli, G., Petridis, D., Kapageridis, N., & Mixiou, M. (2019). Effect of pomegranate juice and fir honey addition on the rheological and sensory properties of kefir-type products differing in their fat content. *LWT*, *111*, 799-808. https://doi.org/10.1016/j.lwt.2019.05.071

Islam, J., & Kabir, Y. (2019). Effects and mechanisms of antioxidant-rich functional beverages on disease prevention. In Functional and Medicinal Beverages. In (pp. 157–198). Cambridge, United Kingdom: Academic Press

Kardas, M., Rakuła, M., Kołodziejczyk, A., & Staśkiewicz-Bartecka, W. (2024). Consumer preferences, sensory evaluation, and color analysis of beetroot and tomato juices: Implications for product development and marketing in health-Promoting beverages. *Foods*, *13*(24), 4059. https://doi.org/10.3390/foods13244059

Kumar, M., Dahuja, A., Sachdev, A., Kaur, C., Varghese, E., Saha, S., & Sairam, K. V. S. S. (2020). Black carrot (Daucus carota ssp.) and black soybean (Glycine max (L.) Merr.) anthocyanin extract: A remedy to enhance stability and functionality of fruit juices by copigmentation. *Waste and Biomass Valorization*, *11*(1), 99-108. https://doi.org/10.1007/s12649-018-0450-3

Mane, R. L., Zinjarde, R., Bhosale, S. S., Raskar, Y., & Tambe, N. (2019). Effect of carrot juice on sensory quality and chemical composition of flavoured milk by using double tonned milk. *International Journal of Chemical Studies*, *7*(5), 2850-2854.

Mashavhathakha, K., Soundy, P., Ngezimana, W., Nkomo, M., & Mudau, F. (2016). Chemical properties, bioactive compounds, organic sugars and acids of harvested pomegranate cv wonderful in the Western Cape Province, South Africa. *Tropical Agriculture*, *92*, 129–138.

Mohan, A., Komathkandy, F., & Faheema, K. K. (2024). Formulation and physical, chemical, and sensorial characterization of pomegranate and beetroot juice. *European Journal of Nutrition and Food Safety*, *16*(9), 221–231.

Montgomery, D. C. (2017). *Design and analysis of experiments*. United States: John Wiley & Sons.

Moradnia, M., Mohammadkhani, N., Azizi, B., Mohammadi, M., Ebrahimpour, S., Tabatabaei-Malazy, O., . . . Ale-Ebrahim, M. (2024). The power of Punica granatum: A natural remedy for oxidative stress and inflammation; A narrative review. *Journal of Ethnopharmacology*, *330*, 118243. https://doi.org/10.1016/j.jep.2024.118243

Moţ, P.-R., Gurbină, D., Stoin, D., & Cozma, A. (2020). Biophysical and nutritional characterization of some natural fruit and vegetable juices. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series*, *50*(2), 321–326.

© 2025 Conscientia Beam. All Rights Reserved.

Nayi, P., & Kumar, N. (2021). Development of ready to reconstitute dehydrated traditional sweet corn halwa. *Journal of Food Science and Technology, 58*(12), 4486-4494. https://doi.org/10.1007/s13197-020-04930-4

Pham, T., Nguyen, N., Dinh, D., Kieu, N. T., Bach, L., Phong, H., . . . Truc, T. (2020). Evaluate the chemical composition of peels and juice of seedless lemon (Citrus latifolia) grown in hau giang province, Vietnam. *IOP Conference Series: Materials Science and Engineering, 991*(1), 012127. https://doi.org/10.1088/1757-899X/991/1/012127

Punoo, H. A., Rather, J. A., & Muzaffar, A. (2023). Development of soy whey fortified orange juice beverages: Their physicochemical, rheological, antioxidant, and sensory properties. *Exploration of Foods and Foodomics, 1*(4), 206-220.

Rababah, T., Al-U'datt, M., Gammoh, S., Khatatbeh, T. a., Magableh, G., Almajwal, A., . . . Al-Rayyan, N. (2023). Study of the physiochemical and nutraceutical properties of sour and sweet pomegranate Juice in Northern Jordan. *Journal of Food Quality, 2023*(1), 5426321. https://doi.org/10.1155/2023/5426321

Ranga, A. N. G., Harika, A., Lakshmi, K., Devi, G. N., Beera, V., Bora, R., . . . Kalita, B. B. (2023). Organoleptic characteristics and nutritional composition of whey-grape juice blended beverage. *The Journal of Research ANGRAU, 51*(1), 52–57.

Rather, J. A., Akhter, N., Rather, S. A., Masoodi, F., & Dar, B.N. (2024). Effect of xanthan gum treatment on the shelf-life enhancement of retorted meatballs (Goshtaba): A traditional meat product of India. *Measurement: Food, 13*, 100127. https://doi.org/10.1016/j.meafoo.2023.100127

Rather, J. A., Majid, S. D., Dar, A. H., Amin, T., Makroo, H., Mir, S. A., . . . Dar, B. N. (2022). Extraction of gelatin from poultry byproduct: Influence of drying method on structural, thermal, functional, and rheological characteristics of the dried gelatin powder. *Frontiers in Nutrition, 9*, 895197. https://doi.org/10.3389/fnut.2022.895197

Sahrawat, N., & Chaturvedi, N. (2023). Quality evaluation and consumer acceptance test of functional fruit-herb beverages. *Asian Journal of Dairy and Food Research, 42*(2), 110–116. . https://doi.org/10.18805/ajdfr.DR-2022

Sato, K., Ichinose, K., Takeuchi, A., & Koikeda, T. (2024). Lemon-derived flavonoids and their health-promoting properties: A comprehensive review. *Journal of Functional Foods, 110*, 105571.

Senarathne, Y., & Wickramasinghe, I. (2019). Development of beta (β) carotene enriched drinking yoghurt by incorporating carrot (Daucus carota) pulp and orange (Citrus sinensis) juice. *Vidyodaya Journal of Science, 22*(1), 40-49. https://doi.org/10.4038/vjs.v22i1.6063

Sharma, S., Dionisio, G., Holme, I. B., Dzhanfezova, T., Joernsgaard, B., & Brinch-Pedersen, H. (2021). Anthocyanin synthesis in orange carrot cv. Danvers is activated by transgene expression of the transcription factors DcMYB113_NB and DcEGL1_NB from black carrot cv. Nightbird. *Plant Molecular Biology, 106*(3), 259-270. https://doi.org/10.1007/s11103-021-01141-z

Świąder, K., & Marczewska, M. (2021). Trends of using sensory evaluation in new product development in the food industry in countries that belong to the EIT regional innovation scheme. *Foods, 10*(2), 446. https://doi.org/10.3390/foods10020446

Szarek, N., Jaworska, G., & Hanus, P. (2024). Profile of phenolic compounds and antioxidant activity of celery (Apium graveolens) juices obtained from pulp after α-amylase treatment from Aspergillus oryzae. *Molecules, 29*(7), 1438. https://doi.org/10.3390/molecules29071438

Türkyılmaz, M., & Özkan, M. (2014). Effects of condensed tannins on anthocyanins and colour of authentic pomegranate (Punica granatum L.) juices. *Food Chemistry, 164*, 324-331. https://doi.org/10.1016/j.foodchem.2014.05.048

Vázquez-Araújo, L. (2022). Feature papers in sensory analysis of beverages. *Beverages, 8*(3), 37. https://doi.org/10.3390/beverages8030037

Yan, J., Yang, X., He, L., Huang, Z., Zhu, M., Fan, L., . . . Zhu, W. (2022). Comprehensive quality and bioactive constituent analysis of celery juice made from different cultivars. *Foods, 11*(18), 2719. https://doi.org/10.3390/foods11182719

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