Consumer acceptability and sensory profiling of Rhododendron cider vinegar

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ABSTRACT

Rhododendron arboreum (Burans) was used to develop a value-added cider vinegar infused with mint and basil to enhance flavour and health benefits. Sensory evaluation and consumer acceptability were assessed through hedonic, JAR, and CATA tests with 400 respondents. Results revealed significant differences among samples ($F = 91.15$, $p < 0.001$). The 12% basil-infused vinegar (B3) achieved the highest overall liking (5.56 ± 1.25), while the 12% mint–basil blend (C3) was least accepted (3.58 ± 1.01). Consumers associated positive attributes such as good aroma, taste, and appearance, while negative feedback included offensive odour and dull colour. Overall, basil-infused rhododendron vinegar demonstrated high acceptance, with aroma and colour being key drivers of preference. According to these findings, rhododendron cider vinegar has a great chance of becoming a commercial product and being well-liked by consumers in a variety of market niches, especially when it is infused with basil at the right amounts.

***Keywords**: CATA, JAR, consumers, sensory evaluation vinegar,*

INTRODUCTION

Vinegar, derived from the French word *vinaigre* (sour wine), is a non-alcoholic beverage valued for its therapeutic properties. It is produced through double fermentation of starch- or sugar-rich agricultural resources, yielding acetic acid, which is linked to health benefits such as lowering blood pressure, aiding weight management, reducing inflammation, and providing antibacterial effects (Shah and Banerjee, 2013). Fermentation also enhances the nutritional value and bioavailability of phenolic antioxidants. Globally, various vinegars, *viz*., apple cider, fruit, wine, balsamic, and malt are produced, with processing methods significantly affecting quality. In India, where 80% of the population relies on plant-based remedies, fermenting fruits, flowers, and herbs into functional vinegars is gaining popularity. *Rhododendron arboreum*, the state flower of Uttarakhand and national flower of Nepal, grows at elevations of 1500–3300 m and is known for its medicinal properties (Bisht *et al*., 2023). Medicinal plants are defined as having active ingredients used in herbalism or used in drug development and synthesis (Ariyawansha *et al*., 2024). Medicinal plants, widely used in traditional and modern healthcare, contain bioactive compounds that can treat ailments ranging from digestive disorders to metabolic and osteoarticular problems (Maryama *et al.,* 2025).

Consumer acceptance is the crucial for the success of any value added products. Sensory analysis provides insights into consumer preferences, guiding product development and positioning (Ruiz-Capillas *et al*., 2021). Rapid sensory profiling methods, such as Check-All-That-Apply (CATA), Just-About-Right (JAR) scales, and hedonic testing, are increasingly used due to their efficiency and reliability. CATA, in particular, has been applied successfully across diverse food products, offering a simple yet powerful tool to capture consumer perceptions (Lee, 2021). JAR scales

complement hedonic ratings by identifying product attributes that are "too much" or "too little," enabling targeted improvements (Gera, 2017). Penalty analysis further quantifies how these attributes influence overall liking.

MATERIALS AND METHODS

An interviewer-administered questionnaire was used to collect information on food quality characteristics of Vinegar sample. A well-structured questionnaire comprising of 9 points hedonic test, Just About Right test (JAR) and Check-All That-Apply test (CATA) was administered to 400 consumers**.**

Product development

Indigenous variety of Rhododendron *arboreum* flowers was procured from the Rudrprayag district, Uttarakhand (Garhwal) while mint and basil were collected from the local market of Jaipur, Rajasthan. All the collected materials were thoroughly cleaned and washed with the help of distilled water, to remove dirt and pests. Extraction of *Rhododendron arboreum* flower juice was done by cold-pressing technique that is used by the processor to overcome the problem of thermo-sensitive phytochemical properties that get affected and to provide a wholesome product to the consumers.

After that, the juice's sugar content was brought down to 10 °Brix before adding of *Saccharomyces cerevisiae* yeast. The most common and practical method used is controlled dilution with water or low-sugar juice. First, the initial sugar level of the juice is accurately measured using a calibrated refractometer. Based on this value, the amount of water required for dilution is calculated using the dilution formula $C_1V_1 = C_2V_2$, where $C_1$and $C_2$are the initial and desired °Brix values, and $V_1$and $V_2$are the initial and final volumes, respectively. Theen, filtered water is then added gradually to the juice under hygienic conditions while stirring continuously to ensure uniform mixing. The °Brix is rechecked after mixing, and adjustments are made if necessary to achieve the target 10 °Brix. Alcoholic fermentation was then conducted for five to ten days at 26 ± 2 °C. Following this phase, acetic acid fermentation was carried out by inoculating the fermenting medium with *Acetobacter aceti*, a bacterium that produces acetic acid, and keeping it at 26–29 °C for three to four weeks. The vinegar was fermented, clarified, bottled, and pasteurized for 30 to 40 minutes at 75 to 80 °C. The finished product had a six-month shelf life and was kept in glass bottles at ambient temperature (15–25 °C) or in a refrigerator (4–7 °C) for preservation.

During the study, three different variants of value-added vinegar were prepared using Rhododendron as the base ingredient, with the incorporation of mint and basil in varying proportions. **Variant 1** was developed by adding mint at three different concentrations (8%, 10%, and 12%) to Rhododendron. **Variant 2** involved the addition of basil at similar concentrations (8%, 10%, and 12%) to Rhododendron. **Variant 3** was formulated by combining both mint and basil, each added at 8%, 10%, and 12% levels, to the Rhododendron base.

Consumers Acceptability Tests (CAT)

Rhododendron cider vinegar made from rhododendron flower pulp. Extraction of Rhododendron juice was done by cold-pressing technique that is used by the processor to overcome the problem of thermo-sensitive phytochemical properties and was tested for consumer acceptance with 400 informed participants. Using a convenience selection technique with purposive criteria, respondents were chosen to ensure that only Dehradun-based adults (18-50 years) who were acquainted with *Rhododendron arboreum* flowers, food and beverage items, and potential users of functional drinks were included. Nine coded samples were evaluated using three successive tests, firstly a 9-point hedonic scale (1 = extremely dislike, 9 = extremely like) was used for overall liking. Before the 9-point hedonic sensory exam, each participant received comprehensive information on the study's goals, methods, and possible risks. Participants were made aware that participation was completely optional and that there would be no repercussions if they decided to stop at any

moment. Before the sensory test began, each participant provided written informed consent. To preserve participant anonymity, data were evaluated collectively and individual responses were guaranteed confidentiality. Panel members were screened for absence of allergies or aversions to vinegar and for their willingness to participate in sensory evaluations. Nine coded samples were served in identical cups at room temperature with water available to wash the palate in between samples, and they were evaluated under carefully monitored serving settings. To prevent positional bias, samples were served in a randomized order. After giving informed consent, received a brief explanation of methods and then completed a two-step questionnaire i.e. a 5-point JAR scale (1 = much too little, 3 = just right, 5 = much too much) to assess attribute intensity, and a CATA test with 11 sensory descriptors (Meyners *et al.,* 2016). First, they rated overall liking; second, they identified characteristics using CATA and judged their appropriateness with JAR. A descriptor list was provided for clarity, and finally, panelists compiled essential traits of an "ideal" Rhododendron Vinegar. Further, The Just-About-Right (JAR) evaluation was followed by a penalty analysis to ascertain how variations in sensory qualities affected consumers' overall satisfaction with the product. The JAR scale determines whether an attribute is viewed as too low, just right, or too high, but it doesn't show how much these differences affect customer approval. When an attribute is assessed as "too low" or "too high" in comparison to the "just right" category, the mean decrease in overall liking is calculated. This is how penalty analysis tackles this issue.

Data analysis

In order to generate frequencies and to analysed the data using descriptive statistics including percentages, frequencies, charts and Correlation analysis to better understand the interrelationships among sensory attributes, a correlation analysis was conducted between overall liking (9-point hedonic scale) and the key attributes evaluated in the JAR test (aroma, colour, taste, sourness, and after-mouth taste) from the Statistical Package for Social Sciences (SPSS version 16.0) and Excel statistical package (XLSTAT).

RESULTS AND DISCUSSION

Consumer's Acceptability Test Using 9-point Hedonic Test,

Overall liking was significantly impacted by sample type, according to the analysis of variance ($F = 91.15$, $p<0.001$). The results of the post hoc Tukey's HSD test showed that sample B3 (5.56 ± 1.25^{e}) outperformed all other treatments and had the highest customer acceptability. Although sample AX (5.05 ± 1.11^{d}) had a good score as well, it was still much lower than B3. Samples C1 (3.70 ± 1.14^{a}) and C3 (3.58 ± 1.01^{b}), however, obtained the lowest scores, suggesting a decrease in customer preference. The majority of A-series and B-series samples (A1, A2, A3, B1, B2, C2, and C3) clustered within an intermediate acceptance group, showing no significant differences among them. These findings suggest that formulation B3 was the most preferred by the panel, while C-series samples tended to be less favoured as shown in (Table 1).

Check-All-That-Apply (CATA) test

The Check-All-That-Apply (CATA) test identified both positive and negative attributes of the preferred sample (B3). Favourable qualities included good aroma (100%), neatness (84%), good taste (83.5%), good appearance (81%), slightly sour (62.5%), and fermented odour (60%). Negative descriptors were offensive odour (74.75%), dark/dull colour (71.75%), no taste (69%), sour (56.25%), and turbid appearance (53.75%) represented in (Table 2, 3) Overall, B3 vinegar showed desirable sensory traits such as a pleasant aroma, neat appearance, balanced sourness, and mild fermented smell, highlighting its potential as a refreshing and functional beverage (Osunbade *et al*., 2021).

Just About Right (JAR) test

Just-About-Right (JAR) test further confirmed B3 variant as the most preferred

sample by (77.00 %) consumers in terms of aroma and colour (77.00%), (75.0 %) in terms of taste, (70.5%) in terms of after mouth taste and (60.25%) in terms of sourness (Figure 1, 2, 3, 4). JAR test showed that B3 sample was most preferred variant in terms of aroma, colour, taste. It was in accordance with the 9-point hedonic results that scored B3 variant highest.

Penalty analysis

Penalty analysis was performed to identify how deviations from the "Just-About-Right" (JAR) level of sensory attributes affected overall liking of the Rhododendron cider vinegar. The analysis revealed that for aroma, 77% of panelists perceived it as "too little," resulting in a mean drop in liking from 5.597 to 5.467, with a significant penalty effect ($p<0.001$), indicating that insufficient aroma negatively impacted overall acceptance (Table 4). Similarly, for colour, 77% of respondents rated it as "too little," leading to a comparable decrease in mean liking from 5.467 to 5.597 ($p<0.001$), suggesting colored samples were less preferred. Regarding taste, 16.75% of panelists found it "too much" and 6.25% "too little," producing minor mean drops (5.578–5.448) and non-significant penalties ($p< 0.05$), indicating taste deviations had less impact on overall liking. For sourness, 57.5% of participants rated it as "too little," leading to a reduction in mean liking from 5.617 to 5.500 ($p <0.001$), highlighting that insufficient sourness reduced consumer preference. Finally, after-mouth taste showed mixed responses, with 70.5% perceiving it as "too little" and 12.25% as "too much," generating a mean drop from 5.610 to 5.306 ($p = 0.030$), indicating that an inadequate lingering taste negatively affected acceptance as mentioned in Table 4. Overall, penalty analysis identified aroma, colour, sourness, and after-mouth taste as key attributes where deviation from the ideal JAR level significantly decreased consumer liking. Properly stored vinegar can maintain its physicochemical properties and antioxidant activity for 12–24 months, although minor changes in color, aroma, and flavor may occur during prolonged storage. To maximize shelf life, vinegar should be stored in airtight, dark containers at ambient or slightly cool temperatures, avoiding direct sunlight and contamination. Regular monitoring of pH, acidity and sensory attributes can help ensure product quality and consumer acceptability throughout its shelf life.

Correlation analysis

The relationships between the sensory elements were further examined by comparing overall liking with the sensory qualities evaluated by the JAR test (aroma, color, taste, sourness, and after-mouth taste). High positive correlations were found between all sensory attributes and overall liking as mentioned in Table 5, with coefficients ranging from $r = 0.950$ to $r = 0.959$ ($p \leq 0.01$). Among these, sourness ($r = 0.959$) and aroma ($r = 0.955$) were most highly linked to overall-liking, suggesting that a balance between sourness and pleasant aroma significantly influenced consumer acceptance. Additionally, the sensory qualities themselves had a good association ($r > 0.99$ in most cases), indicating that consumers evaluated aroma, color, taste, sourness, and after-mouth taste holistically rather than separately. According to this study, enhancing one attribute, such as scent, is likely to simultaneously improve aftertaste and flavor perceptions, which will raise total consumer satisfaction. There are strong correlations between sensory attributes and overall preference, which is consistent with earlier studies on functional beverages that found aroma and flavor balance to be significant acceptability determinants. Studies on vinegars made from fruits and flowers, where acidity is a determining factor in customer preference, are consistent with the prevalence of sourness as a primary determinant. The strong connections between aroma, color, taste, and after-mouth taste further demonstrate that consumers evaluate product quality holistically rather than attribute-by-attribute. This highlights how important it is to simultaneously improve multiple sensory components while creating new products to boost customer satisfaction.

Consistent with findings from earlier research, the current study showed that rhododendron-based functional meals had a strong taste appeal and possible health advantages because of its bioactive ingredients. Similar studies on *Rhododendron arboreum* flower extracts added to yogurt and drinks, for example, demonstrated increased antioxidant activity and improved sensory qualities, which are consistent with the increases in overall liking as seen in the investigation made by Postolache *et al*. (2023). Previous studies showing that vinegars derived from flowers or fruits maintain a considerable phenolic content and the ability to scavenge free radicals throughout storage are consistent with the reported antioxidant activity in the generated vinegar products (Antoniewicz *et al.,* 2021).

CONCLUSION

Collectively, the findings suggest that optimizing basil infusion levels can support the development of Rhododendron vinegar as a novel, functional, and commercially viable product with strong consumer appeal. Further research on nutritional profiling, long-term stability, and market feasibility is recommended to facilitate product scaling and commercialization.

CONFLICT OF INTEREST STATEMENT

The author declare that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Mean Overall liking based on 9-point hedonic scale

Sample code	AX	A1	A2	A3	B1	B2	B3	C1	C2	C3	F-value
Overall Liking	5.05 ±1.11^{d}	4.27± 1.60^{bc}	4.53±1 .26^{c}	4.08± 1.00^{b}	4.24± 1.09^{b}	4.24±1. 27^{b}	5.56±1 .25^{e}	3.70± 1.14^{a}	4.19±1 .45^{b}	3.58±1. 01^{b}	91.15

Results are expressed as mean ± S.D. F- Values are significant at P ≤ 0.001. Values with the same letters are not significantly different from each other, while different letters indicate a significantly different. AX- Standard *Rhododendron* vinegar, A1- 8% mint infused+ *Rhododendron* vinegar, A2- 10% mint infused+ *Rhododendron* vinegar, A3- 12% mint infused+ *Rhododendron* vinegar, B1- 8% basil infused+ *Rhododendron* vinegar, B2- 10% basil infused+ *Rhododendron* vinegar, B3- 12% basil infused+ *Rhododendron* vinegar, C1- 8% basil + 8% mint each+ *Rhododendron* vinegar, C2- 10% mint + 10% basil+ *Rhododendron* vinegar and C3- 12% mint+ 12% basil+ *Rhododendron* vinegar

Table 2: Good descriptors of vinegar sample using CATA test for the most preferred variety *i.e.,* B3= 12% basil infused R. arboreum vinegar

Attributes	Respondents	Rank
Good aroma	100%	1
Neat	84%	2
Good taste	83.5%	3
Good appearance	81%	4
Slightly sour	62.5%	5
Fermented odour	60%	6

Table 3: Bad descriptors of vinegar sample using CATA test for the most preferred variety i.e. B3= 12% basil infused R. arboreum vinegar

Attribute	Respondent	Rank
Offensive odour	74.75%	1
Dark/dull colour	71.75%	2
No taste	69%	3
Sour	56.25%	4
Turbid appearance	53.75%	5

Table 4: Penalty analysis (product B3)

Variables	Level	%	Sum (Overall-liking)	Mean liking	Mean drop	Penalties	p-value
Aroma	Too much aroma JAR Too little aroma	0.00% 77.0% 23.00%	 1724.00 503	 5.597 5.467	 0.130	-	0.000
Colour	Too much colour JAR Too little colour	23.00% 77.00% 0.00%	 503.00 1724.00	 5.467 5.597	 0.130	-	0.000
Taste	Too much taste JAR Too little taste	16.75% 77.0% 6.25%	365.00 1718.00 144.00	5.448 5.578 5.760	0.130	-	0.762
Sourness	Too much sour JAR Too little sour	0.00% 42.50% 57.50%	 935.00 1292.00	 5.500 5.617	 0.117	-	0.000
After-mouth taste	Too much after-mouth taste JAR Too little after-mouth taste	12.25% 70.50% 17.25%	260 1582 385	5.306 5.610 5.580	0.304 0.030	0.144	0.296

Table 5: Correlation coefficients between overall liking and sensory attributes of basil infused Rhododendron vinegar (B3)

Attribute	Overall Liking	Aroma	Colour	Taste	Sourness	After taste
Overall Liking	**1.000**	0.955	0.951	0.950	0.959	0.947
Aroma	0.955	**1.000**	0.998	0.992	0.992	0.994
Colour	0.951	0.998	**1.000**	0.995	0.997	0.997
Taste	0.950	0.992	0.995	**1.000**	0.994	0.999
Sourness	0.959	0.992	0.997	0.994	**1.000**	0.996
Aftertaste	0.947	0.994	0.997	0.999	0.996	**1.000**

Results are expressed as Pearson's correlation coefficients (r). All correlations are significant at $p \leq 0.01$. Values close to 1.0 indicate strong positive correlations between attributes

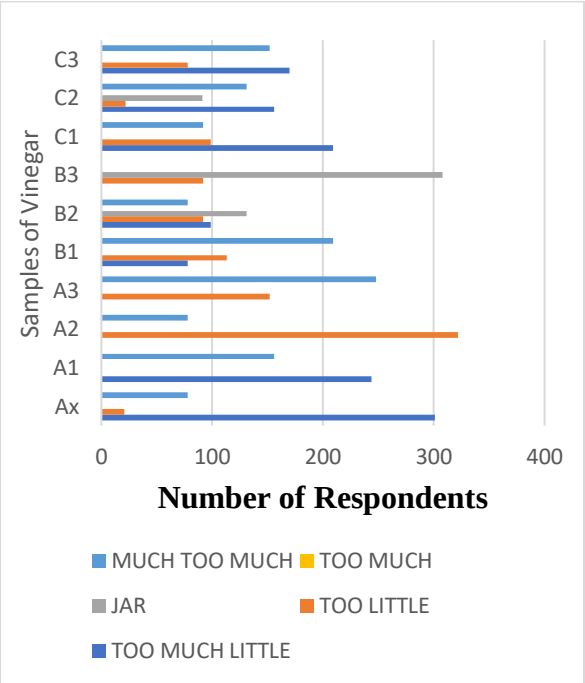

Figure 1: JAR scale for Aroma

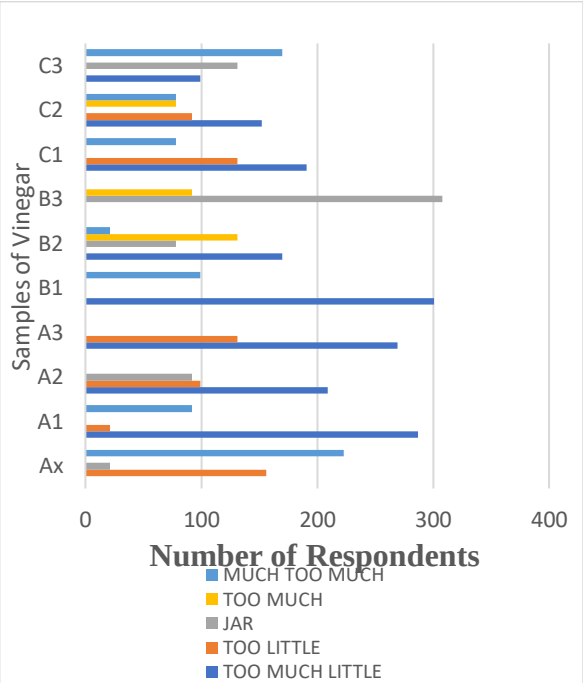

Figure 2: JAR scale for Colour

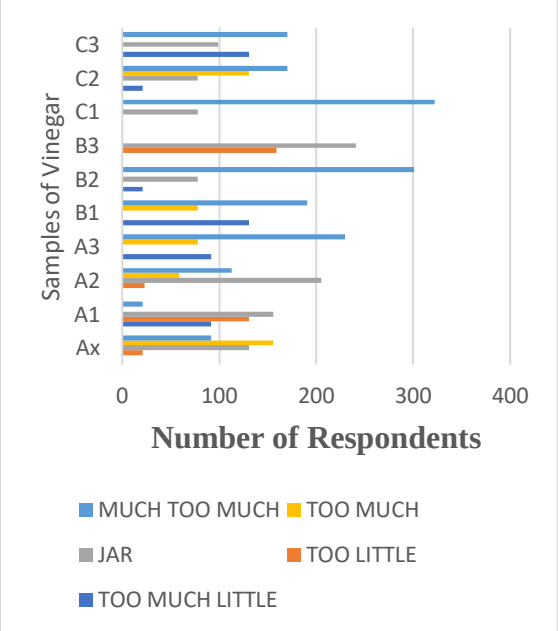

Figure 3: JAR scale for taste

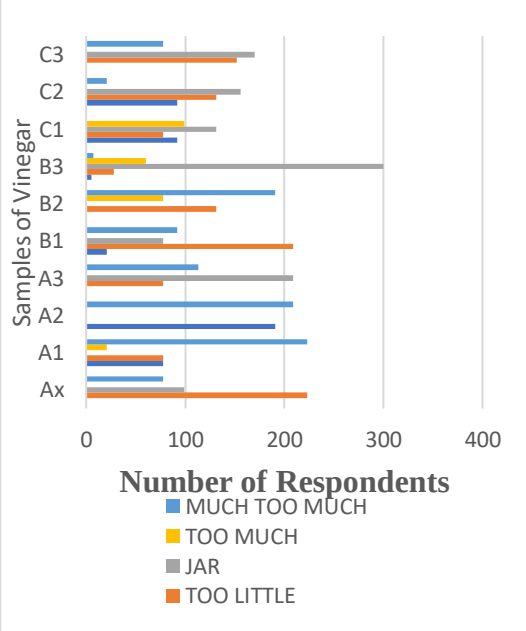

Figure 4: JAR scale for Sourness