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STATISTICS

Understanding the perception of consumers through different affective scales and their interactions: A case study with strawberries

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ABSTRACT. Affective scales play a crucial role in determining product quality by accurately measuring consumers' sensory and attitudinal responses. This study aimed to assess consumer behavior towards strawberries using various affective scales and measures. A total of 715 consumers evaluated 30 strawberry samples using different affective measures. Linear 9 cm scales gauged fondness and expectations, while ideal scales determined sweetness, juiciness, and acidity preferences. Results showed these attributes directly influenced consumer acceptance, satisfaction, and purchase intent. Optimal indices for sweetness, juiciness, and acidity were 5.08, 5.58, and 4.90, respectively. These findings allow for a comprehensive understanding of consumer perceptions and strawberry quality. Moreover, the study highlights the importance of utilizing diverse affective scales in product evaluation, offering insights for potential product development.

Keywords: Hedonic scale; scale of the ideal; acceptance; expectation; satisfaction; sensory analysis.

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Introduction

In the commercialization of in natura foods or even during their development and improvement, the industry and researchers must strive to understand the desires and needs of consumers. In addition, understanding customers' perceptions of a final product can ensure consumer satisfaction (Varela et al., 2010; Cruz et al., 2013). Thus, one must understand how consumers perceive food, how they make their choices, and what affects their decision-making (Cruz et al., 2013). Consumer studies can be used to characterize the sensory profiles of foods, determining characteristics such as sweetness, acidity, and chewiness. In addition, they can quantify consumer acceptance or preference via affective tests (Yu et al., 2018).

Different scales can be used to quantify the affective responses of consumers (Yeung et al., 2021). Among them, the 9-point hedonic scale (Lawless et al., 2010a) stands out as one of the most commonly used methods for accurately measuring consumer acceptance or fondness (Kim et al., 2018). Another option is the Just-About-Right (JAR) scale, which aims to define when the intensity of a particular attribute, such as sweetness, is considered ideal by consumers (Ribeiro et al., 2020). There is also the attitude scale, which quantifies the degree of acceptance of products based on the attitude of consumers, i.e., how much they would be willing to consume or pay more for a product (Drake, 2007).

Other adaptations of affective scales have been presented in several studies. Global hedonic intensity scales (Kalva et al., 2014), for example, include the Labeled Hedonic Scale (LHS) (Lim, 2011) and the Labeled Magnitude Scale (LAM)—an effective alternative to the 9-point scale because it performs well in the discrimination of products (Lawless et al., 2010b). Finally, there are also the simplified labeled affective magnitude scales (Lahne & Zellner, 2015), which are often called visual analog scales (VAS). Each VAS is a continuous line, anchored at each end by a minimum and a maximum value of a given attribute, considered a practical and reliable tool for measuring and comparing human experiences across different populations (Kershaw & Running, 2019).

Accordingly, various affective scales can be used to understand consumer behavior. However, each of them measures the sensory responses of consumers in a different way, which can lead to mixed results. Choosing among these various affective scales can be a challenge for researchers. Therefore, the selection and application of affective scales of consumer response is an active area of investigation and discussion within the sensory science community (Yeung et al., 2021). Several studies have compared the effectiveness of these scales and their impact on the sensory data collected thereby (Lawless et al., 2010b; Kalva et al., 2014; Kershaw & Running, 2019; Yeung et al., 2021). However, it is still necessary to delve deeper to understand the performance of these scales and their relationship to consumer behavior.

Specifically, the present study .the quality of strawberries. The quality of a strawberry is directly correlated with its sensory attributes such as appearance, aroma, flavor, and texture (Ribeiro et al., 2021). The sensory quality of fruits, such as strawberries, is one of the main drivers of consumers' tastes and purchase decisions (Colquhoun et al., 2012). However, there is currently no standardized scale for assessing consumer preference for red fruits. In fact, there are even fewer reports on preference or hedonic studies concerning unprocessed fruits, possibly due to their perishability and fragility (Yeung et al., 2021). Some scales have been used to evaluate the sensory responses of strawberry consumers, such as the 9-point scale (de Jesus Filho et al., 2018) and global hedonic intensity scales (Oliver et al., 2018; Schwieterman et al., 2014). Nevertheless, further investigation into affective scales is needed to better understand the market potential of strawberries and the key factors that influence consumer acceptance.

This study thus aims to understand the relationship and interaction of different scales and measures by evaluating the sensory and attitudinal responses of strawberry consumers. In this context, the experimental design was built to evaluate the focal effects of these scales and their relationship with consumer responses. The latter were obtained with five different affective scales concerning the sensory attributes of juiciness, sweetness, and acidity, as well as the perspectives of acceptance and expectation, i.e., the taste and quality characteristics that influence consumer interest in purchasing strawberries.

Methodology

Materials

The strawberries (*Fragaria* × *ananassa* Duch) used in this study were purchased at a local market in the city of Lavras, state of Minas Gerais, Brazil. Strawberries were selected for this study due to their widespread global consumption. A total of 30 strawberry samples of the same variety were obtained, each originating from a different region or farmer. Thus, these different samples ensured the variability of the quality of the focal strawberries. Each sample contained approximately 4 kg of strawberries.

Fruit handling

The preparation and preprocessing of the samples followed the methodology proposed by Correa et al. (2014) and Ribeiro et al. (2021). The samples went through a selection process where any strawberries with flaws were removed. Hence, the selected samples were of a similar size, shape, and color, respecting the characteristics of the samples obtained from the different producers. Before the analysis, the strawberries were washed in running water and sanitized by immersion in a sodium hypochlorite solution (100 ppm) for 15 minutes. Next, the strawberries were sliced perpendicularly to their central axis into four equal parts, and their tips were removed to standardize the sizes of the samples. Finally, sensory analysis was conducted immediately after sample preparation.

Sensory analysis

The experiments were performed in ideal conditions, under a white light at a controlled temperature of 25°C and in individual cabins. This study was reviewed and approved by the Human Research Ethics Committee of the Federal University of Lavras, under code CAAE 12112113.8.0000.5148.

Sensory analysis followed the methodology proposed by Ribeiro et al. (2021). As shown in (Table 1), the sensory analysis was carried out over six sessions, held on separate days, involving a total of 715 consumers. Among the participants, 98.9% were aged between 18 and 45 years old, 60.6% were female, and 39.4% were male. All participants in this study were frequent strawberry consumers, reported a strong liking for the fruit, and expressed interest in participating in the study.

Five 9 cm unstructured scales were used to assess consumer responses to the strawberry samples and to quantify their perceptions. Figure 1 illustrates the scales used in this study. The focal consumers rated how much they liked or disliked the strawberry samples (Figure 1a), as well as their expectation of fruit quality (Figure 1b). In addition, the consumers rated their ideal levels of sweetness, juiciness, and acidity using 9 cm unstructured scales (Figure 1c); (Figure 1d); (Figure 1e). Finally, participants indicated whether they were satisfied with the sample and whether they were willing to pay more for it.

Table 1. Number of consumers and samples in each sensory session.

	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Total
Samples	5	5	5	5	5	5	30
Consumers	115	120	120	120	120	120	715

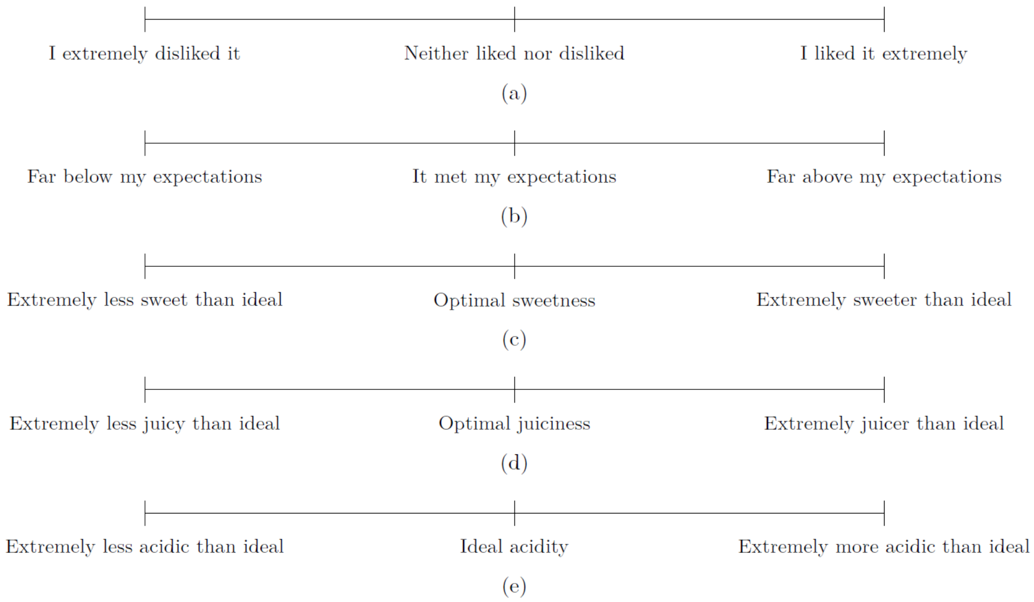

Figure 1. Model of the 9 cm unstructured scales. (a): Liked or disliked strawberry samples; (b): Expectation of the quality of the strawberry samples; (c): Ideal sweetness of the strawberries; (d): Ideal juiciness of the strawberries; (e): Ideal acidity of the strawberries.

Each test session was performed with a complete balanced block design, in which each consumer evaluated five different strawberry samples. Approximately 20 g of each sample was served, along with a glass of water. The samples were coded with three-digit random numbers and presented in a monadic and balanced order, following the sensory methodology proposed by Wakeling & Macfie (1995).

Statistical analyses

Analysis of consumer perceptions, given the relationship between binary and continuous scales for acceptance and expectation

The analysis of consumer perception was performed based on the data obtained from the 9-point hedonic scales and a binary scale assigned to the questions regarding satisfaction (yes = 1/no = 0) and willingness to pay more for the product (yes = 1/no = 0).

The perceptions related to consumer behavior were represented as constructs, which are defined by Arsendorpf (2004) as unobservable theoretical concepts. However, in the scientific field, a construct should be specified on an empirical basis. In line with this definition, while maintaining the binary coding assigned to the variables (Table 2), the constructs were interpreted as representations of consumer perceptions and classified as positive or negative.

Table 2. Coding of binary variables to define the constructs related to consumer behavior.

Coding (S, P)†	Status	Combination for construct definition (S, P) and naming
1	Satisfied	(S = 1, P = 1) – Positive perceptions
1	Willingness to pay more	
0	Dissatisfied	(S = 0, P = 0) – Negative perceptions
0	Unwillingness to pay more	

†S = satisfied and dissatisfied; P = willingness or unwillingness to pay more.

The discrimination between the presence and absence of consumer perception was specified by considering the additive effect (S = 1, P = 1) + (S = 0, P = 0) and the difference (S = 1, P = 1) - (S = 0, P = 0), respectively, favoring the construction of biplots that contemplate these effects independently. This was achieved using the singular value decomposition technique, as proposed by Greenacre (2003).

To perform this technique, it was necessary to organize the data in a hierarchical structure, a frequency table with three entries. The first entry consisted of sensory attributes, originally measured on the continuous scale, and subsequently categorized into two classes: scores greater than or equal to 4.5 and scores lower than 4.5. These were arranged in 'columns'. This cutoff score was chosen because it is the average value of the continuous scales, characterized by the terms 'Neither liked nor disliked it', 'It met my expectations', 'Optimal sweetness', 'Optimal juiciness', and 'Ideal acidity'.

After defining these constructs, we obtained the frequencies for the variables expectation and acceptance, which comprise the second input and are distributed in the 'line' direction. Finally, the third input was defined by the repetition of these variables for each construct. With this arrangement, a hierarchical structure became perceptible, observed by crossing the variables distinguished by the sensory attributes with the variables acceptance and expectation within each defined construct.

In matrix terms, this structure adopted the singular value decomposition proposed by Greenacre (2003), contextualized in this study by the block of variables composing the third input, that is, the constructs represented by the positive (S = 1, P = 1) and negative perceptions (S = 0, P = 0). This decomposition was initially applied to the specification of block matrix M, as defined in (Equation 1).

$$M = \begin{bmatrix} (\text{S=1,P=1}) & (\text{S=0,P=0}) \\ (\text{S=0,P=0}) & (\text{S=1,P=1}) \end{bmatrix} \quad (1)$$

The biplots obtained are thus the result of the combined influence of the variables (S = 1, P = 1) + (S = 0, P = 0) and their differences (S = 1, P = 1) - (S = 0, P = 0), following the resulting decomposition given in (Equation 2),

$$\begin{aligned} (\text{S=1,P=1}) + (\text{S=0,P=0}) &= \text{UD}_{\alpha}V^T \\ (\text{S=1,P=1}) - (\text{S=0,P=0}) &= \text{XD}_{\beta}Y^T \end{aligned} \quad (2)$$

where U and X are matrices of left singular vectors, V and Y are matrices of right singular vectors, each with k orthonormal columns, and D_α and D_β represent the diagonal matrices of positive singular values γ, in descending order of magnitude. In summary, the partitioned matrix M resulting from the decomposition is described by:

$$\begin{bmatrix} (\text{S=1,P=1}) & (\text{S=0,P=0}) \\ (\text{S=0,P=0}) & (\text{S=1,P=1}) \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} U & X \\ U & -X \end{bmatrix}\begin{bmatrix} D_\alpha & 0 \\ 0 & D_\beta \end{bmatrix}\frac{1}{\sqrt{2}}\begin{bmatrix} V & Y \\ V & -Y \end{bmatrix}^T \quad (3)$$

The presence of the factor $1/\sqrt{2}$ multiplying the left and right singular vectors ensures correct normalization, i.e., $\frac{1}{\sqrt{2}}\begin{bmatrix} U \\ U \end{bmatrix}^T \frac{1}{\sqrt{2}}\begin{bmatrix} U \\ U \end{bmatrix} = \frac{1}{2}U^TU + \frac{1}{2}U^TU = I$. Thus, the singular vectors to the left and right of (Equation 3) are orthonormal, that is, $U^TU = V^TV = I$ and $X^TX = Y^TY = I$.

After obtaining the singular values and their respective eigenvectors, the components were determined to generate biplots illustrating the relationship between sensory attributes and the variables acceptance and expectation, specifically in relation to the presence or absence of perception. The necessary matrix operations, the acquisition of the components, and the construction of the biplots were performed using a script in the R language (R Core Team, 2020).

Simultaneous response optimization using response surface models for maximizing acceptance and expectation as a function of sensory attributes

Response surface models were applied to determine the best combination of scores for the sensory attributes sweetness (A), juiciness (B), and acidity (C) that would maximize consumer acceptance (Ac) and expectation (Ex). Initially, separate models were fitted for each specific response variable (Ac and Ex), according to (Equations 4) and (Equations 5). Thus, the fits of the quadratic models were considered with the parameters corresponding to the linear and quadratic effects, given by:

$$\text{Ac}_i = \beta_0 + \beta_1 A_i + \beta_2 B_i + \beta_3 C_i + \beta_{11} A_i^2 + \beta_{22} B_i^2 + \beta_{33} C_i^2 + \xi_i, \quad (4)$$

$$\text{Ex}_i = \beta_0 + \beta_1 A_i + \beta_2 B_i + \beta_3 C_i + \beta_{11} A_i^2 + \beta_{22} B_i^2 + \beta_{33} C_i^2 + \xi_i, \tag{5}$$

where i = 1...; n = 715 consumers; the responses related to the evaluations of the attributes (A) sweetness, (B) juiciness, and (C) acidity; and ξ_i the experimental error distributed by the normal distribution with mean zero and constant variance σ^2, that is, $\xi_i \sim N(0, \sigma^2)$.

After the models were adjusted and validated by the coefficient of determination R^2, the contour curves were generated, considering the values predicted by models (4) and (5) as a function of the combination of sensory attributes. This exploratory approach enabled interpretations based on note ranges, which were discussed and subsequently validated through simultaneous response optimization (Derringer & Suich, 1980).

In this optimization procedure, the goal was to determine the combination of sweetness, juiciness, and acidity that would simultaneously maximize both acceptance (Ac) and expectation (Ex). This was achieved by applying a global desirability function *D*, which combines individual desirability functions d_j for each response, as described in (Equations 6):

$$D = \left(\prod_{j=1}^{p} d_j\right)^{1/p} \tag{6}$$

where dj (j = 1..., p) refers to the desirability function for each response variable (Equation 7), and p = 2 is the number of dependent variables, particularly for a maximization problem.

$$d_j = \begin{cases} 0 & if\, \hat{y}_j < y_{j_L} \\ \left(\frac{\hat{y}_j - y_{j_L}}{y_{j_T} - y_{j_L}}\right)^s & if\, y_{j_L} < \hat{y}_j < y_{j_U} \\ 1 & \hat{y}_j > y_{jU}. \end{cases} \tag{7}$$

where ŷ corresponded to the predicted value of the Ac and Ex responses; and y_{jL} and y_{jU}, respectively, referred to the lower and upper limits assigned to ensure that the response of the maximum combination of sweetness, juiciness, and acidity could be determined.

Results and discussion

Biplots obtained using singular value decomposition to explore the absence or presence of consumption perception

Table 3 shows the results of the statistical methodology proposed in section 2.5.1 for evaluating the behavioral attitudes of the panelists. The results in (Table 3), therefore, refer to the crossing of the variables acceptance and expectation in the continuous scales, in different classes of the sensory attributes sweetness (A), juiciness (B), and acidity (C).

Table 3. Breakdown of the acceptance and expectation ratings in the continuous scales with the sensory attributes classified by the definitions of the constructs (S = 0, P = 0) and (S = 1, P = 1), named negative and positive perceptions, respectively.

		Grade categories for sensory attributes					
Constructs	Acceptance / expectation	A < 4.5	B < 4.5	C < 4.5	A ⩾ 4.5	B ⩾ 4.5	C ⩾ 4.5
S = 0, P = 0	Ac < 4.5	262	202	93	34	94	203
	Ac ⩾ 4.5	438	247	249	457	648	646
	Ex < 4.5	432	306	164	59	185	327
	Ex ⩾ 4.5	268	143	178	432	557	522
S = 1, P = 1	Ac < 4.5	443	312	200	64	195	307
	Ac ⩾ 4.5	564	330	318	579	813	825
	Ex < 4.5	671	444	287	102	329	486
	Ex ⩾ 4.5	336	198	231	541	679	646

The first column displays the two constructs analyzed for the description of consumer perception, with negative perception denoted as S = 0, P = 0, and positive perception represented as S = 1, P = 1. The second column shows the ranges of the acceptance (Ac) and expectation (Ex) values evaluated, whose results are displayed separately for the low (< 4.5) and high (⩾ 4.5) ends of these two attributes. The remaining columns show the number of times the sensory attributes sweetness, juiciness, and acidity were cited, whereas the third, fourth and fifth columns show the number of times each sensory attribute was cited with a low score (< 4.5), and the last three columns display the number of times these attributes were cited with a high score (⩾ 4.5).

Two biplots were obtained to investigate consumer perception. In the first biplot (Figure 2a), the influence of consumption perception is evaluated with the sum of negative and positive perceptions. The second biplot (Figure 2b) shows the absence of consumption perception, which is represented by the difference between negative and positive perceptions.

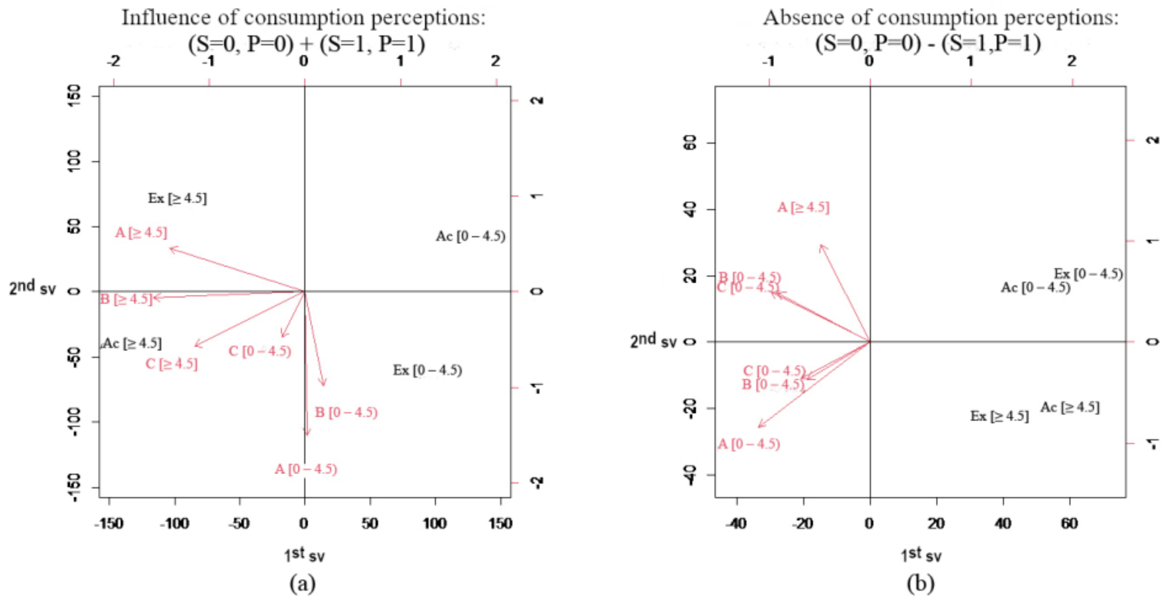

Figure 2. Results of the analysis of consumer perception (a) regarding the influence of perception and (b) in relation to its absence.

The biplots shown in Figure 2 were constructed using the first two singular values (sv) derived from the group of variables characterized by the combinations (S = 0, P = 0) + (S = 1, P = 1), which represents the constructs of negative and positive perception of consumption. These biplots highlight the influence of these perceptions on the acceptance and expectation of consumers. Moreover, values classified as ideal greater than or equal to 4.5 (ideal or more than ideal) drive the highest acceptance and expectation scores. Sweetness greater than or equal to 4.5 has a stronger relationship with higher scores for expectations. Acidity and juiciness greater than or equal to 4.5 are more closely related to acceptance. Low juiciness and sweetness (< 4.5) are associated with low consumer expectations (< 4.5). Regarding the absence of consumption perception ((S = 0, P = 0) - (S = 1, P = 1)), the biplot shows the nonexistence of a relationship between the evaluation of the attributes and the grade classes limited by the 4.5 cutoff point. Hence, no attribute evaluated by the ideal scale was related to acceptance or expectation.

The question of perception analysis was characterized by the validation of continuous responses given on the 9 cm scales, attributed to acceptance and expectation, together with the binary scale, defined as 'Yes' and 'No', referring to questions on satisfaction and willingness to pay more. Accordingly, the constructs that represent the behavioral attitudes of consumption for comparison with the variables measured in the continuous scales are clarified. (Figure 2a) demonstrates that the ideal sweetness, juiciness, and acidity scores have a strong relationship with consumer acceptance and expectation. However, because biplots are exploratory in nature, they only offer an overview, rather than an individual analysis of the associations among the variables. That is, it is not possible to ascertain the ideal scores of sweetness, juiciness, and acidity required to reach values greater than or equal to 4.5 for acceptance and expectation. Therefore, we used response surface methodology in a complementary analysis to understand the interaction of these variables with acceptance and expectation.

Simultaneous response optimization for maximizing acceptance and expectation

Two quadratic models were generated to estimate consumer acceptance and expectation based on the sensory responses on ideal sweetness, juiciness, and acidity. The estimates of the parameters of the quadratic response surface models, described in (Equations 1) and (Equations 2), are thus presented in (Table 4), as well as the significance levels and the coefficients of determination (R^2).

Table 4. Estimates of the parameters based on acceptance (Ac) and expectation (Ex).

Parameters	Ac (R^2 = 79.02%)		Ex (R^2 = 81.51%)	
	Coef	p-value	Coef	p-value
β_0	-0.4633	0.980	-3.93379	0.780
β_1	3.0887	0.186	1.25379	0.474
β_2	-3.0915	0.308	-1.66919	0.467
β_3	1.7182	0.811	2.96385	0.589
β_{11}	-0.2468	0.379	-0.05077	0.811
β_{22}	0.3334	0.294	0.19536	0.417
β_{33}	-0.1468	0.841	-0.26935	0.629

Table 4, therefore, shows that the model corresponding to acceptance obtained an R^2 of 79.02%. An R^2 of 81.51% was determined for expectation. These R^2 values indicate the quality and total fit of the focal models. Both models present coefficients of determination with values greater than 0.7, indicating that they are suitable for prediction purposes (Henika, 1982). Nonsignificant values ($p > 0.05$) for the independent variables were also observed in both models. That is, no variable was more important than the other, i.e., no variable had a greater effect on the predictive power of the models.

Via the predicted models and the estimates for acceptance and expectation, contour curves were obtained to visualize the regions associated with the highest acceptance and expectation scores, based on combinations of ideal sweetness, ideal juiciness, and ideal acidity (Figure 3). These contour curves were generated using pairs of independent variables (B x H), (C x H), and (B x C), a function of the sensory responses for consumer acceptance and expectation.

Figure 3, therefore, illustrates the influence and interaction of ideal juiciness, sweetness, and acidity levels on acceptance and expectation. Via the contour curves for the independent variables juiciness and sweetness (B x A), the higher the ideal juiciness and sweetness scores of the strawberries, the greater the acceptance (Figure 3a) and expectation (Figure 3d) of consumers. Moreover, ideal sweetness scores higher than 4.3 and juiciness scores higher than 4.7 generate the highest acceptance scores for strawberries, ranging from 6.0 to 6.5. Ideal sweetness scores higher than 4.5 and juiciness scores higher than 4.9 generate the highest expectation scores for strawberries, ranging from 5.25 to 5.5.

Notably, to achieve higher levels of consumer acceptance and expectation, sweetness and juiciness should be close to and/or greater than the ideal (values of 4.5 according to the scale used). Higher acceptance and expectation scores were also observed for ideal values of sweetness and juiciness above the ideal determined by the consumers according to their experiences with strawberries. In addition, considering 'sweeter and juicier than ideal' did not reduce acceptance and expectation—in fact, it enhanced acceptance and expectation scores.

On the other hand, sweetness scores lower than 3.5 and juiciness scores lower than 4.4, suboptimal values (scores below 4.5 according to the scale evaluated), were associated with lower acceptance. Sweetness scores lower than 3.3 and juiciness scores lower than 4.1, also suboptimal values (< 4.5), did not meet the expectations of consumers. These results validate the relationship of ideal perception to acceptance and expectation, showing that scores close to the ideal or higher for juiciness and sweetness drive higher scores for acceptance and expectation. However, scores below the ideal result in diminished consumer responses.

Evaluating the interaction of sweetness and acidity (A x C) on the acceptance responses (Figure 3b) showed that acceptance scores between 6.0 and 6.5 (value close to the term 'like extremely' on the scale used) can be achieved when the ideal sweetness scores are greater than 4.3 and acidity grades are below 5.0. Ideal sweetness scores higher than 4.6 and acidity scores lower than 4.8 generated expectation scores of 5.25 to 5.5 (Figure 3e). Based on these ranges, acidity scores lower than or equal to 5.0, i.e., close to ideal (4.5 according to the scale), or 'less acid than ideal' (< 4.5), favored consumer acceptance and expectation. A 'less acidic than ideal' score did not, however, decrease such acceptance and expectation.

Nevertheless, an acidity score greater than ideal, unlike sweetness and juiciness, did not favor the highest acceptance and expectation scores. Thus, for strawberries to be well accepted and meet consumer expectations, their acidity must be close to or below the ideal acidity, while their sweetness and juiciness must be equal to or greater than these ideal scores. Another interesting factor is that a low ideal sweetness value (< 3.5 and < 3.6) negatively affects acceptance and expectation, respectively. In this case, sweetness is thus more related to expectation, regardless of the acidity range. If the ideal sweetness is low, the expectation will not be met.

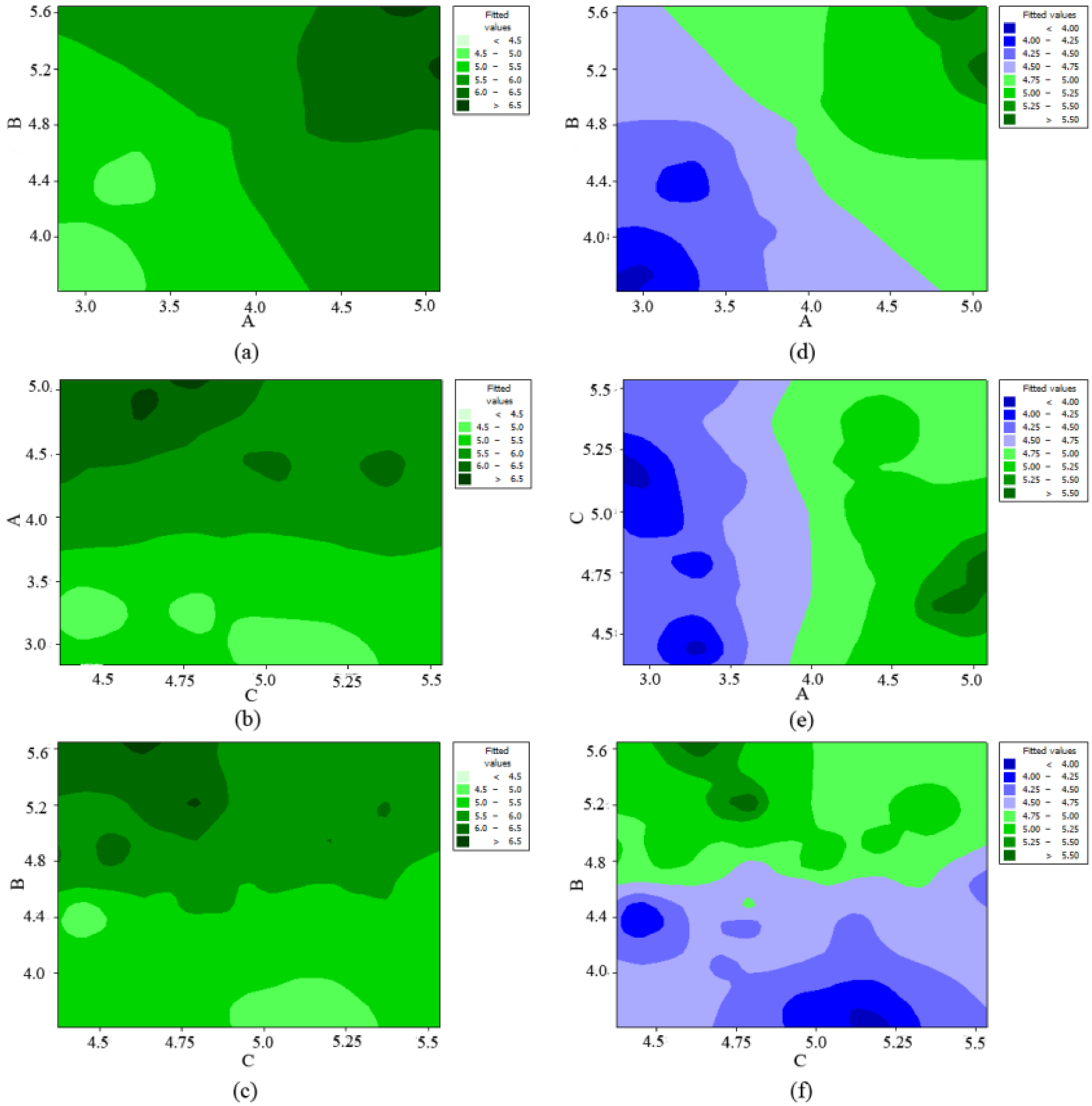

Figure 3. Contour plots of the surfaces of the quadratic model, a function of two factors and predicted values for acceptance and expectation: sweetness (A), juiciness (B), and acidity (C).

The same behavior concerning acidity is evident in the graph on the interaction of juiciness and acidity (B x C). An ideal acidity score below 4.9 and a juiciness score above 4.8 result in a sensory acceptance score between 6.0 and 6.5 (Figure 3c). In the evaluation of expectation (Figure 3f), when the ideal acidity score is less than 4.9 and juiciness is greater than 5.1, these provide expectation values of 5.25 to 5.5. Similar to the interaction between sweetness and acidity, acidity equal to or less than the ideal, and juiciness greater than the ideal, therefore, generate higher acceptance and expectation. In this case, juiciness is also more related to expectation because, regardless of the acidity range, if juiciness is lower than 4.5, consumer expectation will not be met.

Another important factor is the observed difference between the maximum acceptance score (6.0–6.5) and the maximum expectation score (5.25–5.5). This shows that there is a difference between fondness and expectation, that is, what consumers expect when consuming fruit. Regarding the behavior of the variables ideal sweetness, juiciness, and acidity, these variables behave similarly for acceptance and expectation, representing the same perception difference between acceptance and expectation. That is, the perceptions expressed by the focal consumers of strawberries did not lead to the same expressions when considering acceptance synonymous with expectation.

As shown in Figure 3, values close to or greater than ideal for sweetness and juiciness, and values close to or less than ideal for acidity have a positive effect on consumer acceptance and expectation. However, the evaluations of the contour curves related to acceptance and expectation were performed individually for these dependent variables. To better understand the behavior of the independent variables and confirm the maximum responses, a simultaneous response optimization was performed. This optimization of the models aimed at obtaining the maximum responses for acceptance and expectation. Thus, the objective was to estimate, in the contour curves, the best combination of sweetness, juiciness, and acidity that simultaneously maximizes acceptance and expectation, a function of the specification of restrictions for both variables. (Table 5) shows the values that validate this optimization. Thus, the aim was to maximize acceptance and expectation according to the restrictions on both variables, considering scores between 4.5 and 7.0. Notably, the closer the D statistic is to 1, the better the recommendation for the combination of sweetness, juiciness, and acidity for maximizing both acceptance and expectation (Cirillo, 2015).

According to the optimization results, the optimal values for sweetness, juiciness, and acidity were identified, ensuring the best combination thereof. Specifically, the optimal values of 5.08 for sweetness, 5.58 for juiciness, and 4.9 for acidity were determined. With this combination of scores, obtained by the ideal scale, we were able to simultaneously maximize consumer acceptance and expectation. That is, via the coefficients obtained and the optimized values of sweetness, juiciness, and acidity, we obtained a maximum acceptance of 6.88 and a maximum expectation of 5.95. These results therefore support the aggregated use of continuous scales and binary scales.

Table 5. Statistics associated with the ideal sweetness, juiciness, and acidity values that maximize acceptance and expectation based on the restrictions on both variables, i.e., the specification limits used in the simultaneous optimization of the variables.

	Limits		Statistics that validate optimization	
Dependent variable	Minimum (y_{1L})	Maximum (y_{1U})	d (Individual)	D (Global)
Acceptance (Ac)	4.5	7.0	0.99836	0.786
Expectation (Ex)	4.5	7.0	0.61882	
	Combination that simultaneously maximizes acceptance and expectation			
Sweetness	5.08			
Juiciness	5.58			
Acidity	4.9			

This study applies different affective scales not only to estimate consumers' sensory acceptance and expectation but also to understand the influences of these scales on sensory perception by assessing consumer satisfaction and intention to pay more for strawberries. The importance of fully understanding consumers' desires and needs, as well as their perceptions of food, in ensuring the success of products is undeniable. Indeed, a better understanding of consumer needs will likely result in more successful products (Varela et al., 2010).

In this context, the sensory science of foods is essential for understanding consumers, bridging the gap between food characteristics and consumer perception and acceptance (Yu et al., 2018). Thus, several methodologies have been recently developed to determine the affective reactions of consumers and investigate their perceptions of sensory characteristics. Among these, the 9-point hedonic scale is one of the most widely used for quantifying the affective responses of consumers (Kim et al., 2018). The hedonic scale may, however, be insufficient for understanding the whole picture of affective reactions and what interferes with consumer perception.

The literature has shown that, when evaluating the performance of differently constructed affective scales, there is no clear advantage favoring one scale over another (da Silva et al., 2013; Lawless et al., 2010a; Yeung et al., 2021). However, using different affective scales can yield valuable insights into the factors that influence consumer preference, which maydirectly affect consumer expectation, satisfaction, and even purchase intention. Understanding these parameters and their influence on consumer behavior is a key criterion for evaluating product quality and ensuring consumer satisfaction.

Moreover, fruit quality is directly linked to intrinsic factors—chemical, physical, and physicochemical factors—and sensory characteristics of food, such as appearance, aroma, texture, and flavor (Ribeiro et al., 2021). The sensory quality of fruits such as strawberries is thus a key factor in understanding the aspects that lead consumers to like and buy them (Colquhoun et al., 2012). As Yeung et al. (2021) have highlighted, there is no preferred scale for assessing consumers' fondness for red fruits. However, this study has shown that using different affective scales to quantify the intrinsic characteristics of strawberries may be effective for understanding what drives consumer acceptance and for defining fruit quality.

In this study, we have also observed that using the hedonic scale alone may not be enough to understand consumers' behavior or what truly induces them to buy an evaluated product. As highlighted by Ares et al. (2009), one of the main challenges in establishing the limits of consumer acceptance and perception is determining which criteria should be used to define whether, for example, a strawberry is acceptable. These authors note that such acceptance limits are often selected arbitrarily and that there is a lack of information regarding the implications of these limits for understanding consumer responses.

In the present case, we evaluated limits in understanding consumer perception and establishing the quality of strawberries. We found a clear influence of sweetness, juiciness, and acidity on consumer acceptance and expectation. We have also determined the values close to or greater than ideal (⩾ 4.5) for sweetness and juiciness. Values close to ideal or less than ideal for acidity are also related to good acceptance and ensure that a strawberry meets consumers' expectations. Expectations can be considered preconceived beliefs concerning products, affecting people's conscious and subconscious reactions to everyday decisions. Sensory expectations related to consumers' beliefs regarding the product's sensory characteristics, while their hedonic expectations refer to how much the focal product will be liked or rejected (Varela et al., 2010).

When strawberries are juicier and sweeter with ideal acidity, they may exceed the expectations of consumers, generating greater product acceptance and thus positively influencing satisfaction and purchase intention. The higher or lower these consumers' expectations are, the higher or lower their satisfaction rating will be (Farias & Santos, 2000). Hence, upon meeting such expectations, strawberries will likely be appreciated by consumers; if these expectations are not met, these strawberries will be rejected.

Therefore, to sell strawberries and ensure that consumer expectations are met, this fruit must have an ideal sweetness score above 4.3, a juiciness score above 4.7, and an acidity score below 5.0. Scores for these desirable attributes can be used to determine whether strawberries will be accepted or rejected. In this study, we have observed that juiciness and sweetness are important attributes for the acceptance of strawberries. Several studies have also determined sensory characteristics that lead to better quality strawberries (Ares et al., 2009; Lado et al., 2010; Vicente et al., 2014; Wendin et al., 2019). Some of these emphasize sweetness as a major driver of preference and acceptance of strawberries by consumers (Lado et al., 2010; Wendin et al., 2019). This fact supports the results obtained in this study.

Since these limits account for consumer perceptions, they improve the rather arbitrary criteria used by other authors to estimate the quality of strawberries thus far (Ares et al., 2009). In addition, these thresholds can be used to estimate consumer acceptance and expectation of strawberries, in addition to the factors that lead to satisfaction and purchase intention. Accordingly, it is possible to guarantee the quality of strawberries through criteria grounded in the perceptions of consumers.

Regarding the results obtained in the biplots generated in the absence of perceptions, the emotions perceived by consumers represent a set of hedonic responses elicited during the experiment (Makarem & Jae, 2016). Because no facial expressions or opinions directly expressing feelings were assessed, these responses can help explain results where sensory attributes were not associated with acceptance and expectation.

Another interpretation is provided by equity theory (Gashgari, 2016), which suggests that individual acceptance can be influenced proportionally by the acceptance of a group of consumers—meaning that, in this experiment's design, no distinct consumer segments or preference clusters emerged for one sample over another.

Conclusion

In the present study, the use of different scales was essential for understanding consumer behavior and determining strawberry quality parameters. These scales allowed a deeper understanding of what makes consumers accept strawberries and what their expectations are. Using only the acceptance scale would not provide a complete picture of what drives consumer liking. This study has therefore presented relevant data for researchers in the sensory sciences, who typically conduct many affective studies on different products.

In the case of strawberries, sweetness, juiciness, and acidity significantly affect acceptance and expectations of consumers and, consequently, their satisfaction. The values determined for these attributes can thus be used to estimate the sensory quality of strawberries and have implications for studies on fruit quality control aiming to minimize consumer rejection. The methodology applied in this study can also be adapted to other products where consumer perceptions are evaluated and the factors that lead to consumer acceptance and expectations are identified.

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