Fuzzy logic Sensory Evaluation of Passion fruit (Passiflora edulis Sims fo. edulis) pulp incorporated chhana Podo (milk cake)

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Abstract

This study explores the sensory evaluation of Chhana Podo infused with passion fruit pulp using fuzzy logic, aiming to enhance the traditional Indian sweet's sensory attributes. By incorporating passion fruit pulp into Chhana Podo, the research investigates the impact of ingredient variations on taste, odor, color, and overall acceptability. Through sensory analysis with experienced panellists, the study reveals that maintaining a balance in ingredient adjustments is crucial for optimizing sensory characteristics. Results show that while attributes like color and odor are best perceived in the "Good" category, taste and overall acceptability peak in the "Satisfactory" category. The application of fuzzy logic in sensory evaluation provides a comprehensive understanding of consumer preferences, offering valuable insights for product development and cultural culinary heritage preservation. This research bridges traditional dessert preparation with modern sensory evaluation techniques, contributing to the fields of food science and culinary arts.

Keywords : Chhana Podo, Fuzzy logic, Passion fruit pulp, Sensory evaluation,

1. Introduction

Chhana Podo, a traditional Indian dessert originating from the eastern state of Odisha, holds a special place in the culinary heritage of India (Sawant *et al*., 2010). Its name translates to "burnt cheese" in the Odia language, reflecting the caramelized exterior and creamy interior that characterize this unique sweet (Kumar *et al*., 2017). Traditionally made from chhana (fresh cottage cheese), sugar, semolina, and ghee, Chhana Podo is often flavored with cardamom and garnished with nuts and raisins. It is baked slowly to achieve its distinctive taste and texture, combining a slightly crisp outer layer with a soft, melt-in-the-mouth center (Ali *et al*., 2023). Over the years, Chhana Podo has garnered a loyal following, both within India and among the diaspora, who cherish its rich, comforting flavors (Mukhopadhyay *et al*., 2013).

Sensory evaluation plays a crucial role in the food industry, serving as a bridge between consumer preferences and product development. It involves the systematic assessment of a food product's attributes such as taste, aroma, texture, and appearance using human senses (Vivek et al., 2020). This evaluation is pivotal for understanding consumer acceptability and driving innovations that cater to evolving tastes and health trends. Sensory analysis can be subjective, as it relies on human perception, but it provides invaluable insights that objective measurements alone cannot

offer. By applying advanced techniques like fuzzy logic to sensory evaluation, food scientists can achieve a more nuanced understanding of sensory data, accommodating the inherent variability in human responses.

Fuzzy logic, introduced by Lotfi Zadeh in the 1960s, offers a mathematical framework for handling the uncertainty and imprecision inherent in human cognitive processes. Unlike classical binary logic, which classifies statements as either true or false, fuzzy logic allows for degrees of truth, representing data with values ranging between 0 and 1 (Chen *et al*., 2009). This approach mirrors human reasoning more closely, as it accommodates the gray areas of perception and decision-making. In the context of sensory evaluation, fuzzy logic enables a more flexible and realistic interpretation of sensory data, facilitating the analysis of complex attributes such as flavor, mouthfeel, and overall acceptability (Sahu *et al.,* 2017).

Passion fruit (Passiflora edulis Sims fo. edulis), known for its distinctive aroma and tangy flavor, is a tropical fruit native to South America (Dos Reis et al., 2018). It is rich in essential nutrients, including vitamins A and C, dietary fiber, and beneficial plant compounds like polyphenols and carotenoids (Rodriguez 2012). The unique flavor profile of passion fruit, which combines sweet and tart notes, makes it a versatile ingredient in culinary applications, enhancing both the taste and nutritional value of various dishes (Thokchom *et al*., 2017). Incorporating passion fruit pulp into traditional desserts like Chhana Podo not only introduces a novel flavor dimension but also aligns with the growing consumer demand for healthier and more exotic food options (Biswas *et al*., 2021).

Traditional Indian sweets, while deeply rooted in cultural and regional identities, are increasingly being reinvented to cater to contemporary palates and health-conscious consumers. Factors such as globalization, changing dietary habits, and a heightened awareness of nutrition are driving this transformation. Incorporating unconventional ingredients like passion fruit into traditional recipes offers a way to innovate while respecting the essence of these beloved dishes. Such innovations can broaden the appeal of traditional sweets, attracting new consumers and offering a fresh take on time-honored flavors.

The primary objective of this study is to explore the sensory evaluation of Chhana Podo infused with passion fruit pulp using fuzzy logic. Specifically, the study aims to utilize fuzzy logic to analyze sensory data, providing a more comprehensive and accurate interpretation of consumer preferences. Contribute to the growing body of knowledge on the application of fuzzy logic in food sensory evaluation, demonstrating its effectiveness in capturing the complexity of human sensory perception.

The findings from this study are expected to have significant implications for both the food industry and culinary traditions. By demonstrating the feasibility and benefits of incorporating passion fruit pulp into Chhana Podo, the study could inspire further innovations in traditional

Indian sweets. Additionally, the application of fuzzy logic in sensory evaluation could pave the way for more precise and consumer-centric product development in the food sector. This research also highlights the potential for blending traditional and modern culinary practices, fostering a richer and more diverse food culture.

In summary, this study aims to bridge the gap between traditional dessert preparation and modern sensory evaluation techniques, offering a novel approach to food innovation that respects and enhances cultural heritage. By integrating passion fruit pulp into Chhana Podo and employing fuzzy logic for sensory assessment, the research seeks to contribute valuable insights to the fields of food science and culinary arts.

2. Materials and Methods

For this research, we utilized various materials to create and analyze a unique dairy-based product. The primary ingredient was cow milk, which served as the base. To enhance the flavor and nutritional profile, passion fruit pulp was incorporated. Sweetness was achieved using sugar, while citric and lactic acids were added to regulate the acidity and enhance preservation. Baking powder was included to improve texture and rise. Ghee (clarified butter) contributed to the richness, and spices such as cardamom powder and nutmeg powder were added for aroma and taste. Finally, water was used to adjust the consistency and integrate all the ingredients effectively.

2.1 Preparation of Passion fruit pulp incorporated chhana Podo

The incorporation of passion fruit pulp in chhana podo involved several key steps. Firstly, cow milk was boiled and curdled using citric acid to obtain chhana, which was then pressed to remove excess moisture. Simultaneously, ripe passion fruits were used to extract pulp, which was strained to remove seeds and fibers. The next step included mixing the chhana with sugar, passion fruit pulp, cardamom powder, nutmeg powder, and water to form a smooth batter. This mixture was then poured into a greased baking tray, sprinkled with baking powder, and baked in a preheated oven until golden brown. After baking, the chhana podo was allowed to cool, cut into desired shapes, and served. Quality evaluation was essential, involving sensory assessment for taste, aroma, texture, and appearance, as well as analysis of chemical composition like moisture content, acidity, and polyphenol content, along with microbial quality assessment to ensure food safety. These meticulous steps ensured the successful incorporation of passion fruit pulp in the traditional chhana podo, enhancing its flavor and nutritional profile.

2.2 Fuzzy Logic Sensory Evaluation

Sensory evaluation of the Chhana Podo samples with varying percentages of passion fruit pulp was carried out using a fuzzy logic approach. The evaluation involved twenty experienced

panellists, who were trained in the preparation and sensory evaluation of dairy products. They were familiarized with the sensory evaluation procedures, score cards, and scoring methods.

The samples were categorized as follows:

Sample 1: Control (Chhana Podo)

Sample 2: Chhana Podo with 30% passion fruit pulp

Sample 3: Chhana Podo with 35% passion fruit pulp

Sample 4: Chhana Podo with 40% passion fruit pulp

The fuzzy logic (similarity analysis) approach was employed to compare these samples. The sensory evaluation was conducted over three sessions, where panellists used a 5-point linguistic scale: 'Poor', 'Fair', 'Good', 'Very Good', and 'Excellent' to rate the samples. The set of perceptions was analyzed using fuzzy modeling, as described by Das (2005).

For each quality characteristic, the triplet for sensory scores was calculated based on the sum of sensory scores, the sensory scale, and the number of panellists. For instance, if the total number of panellists was (P1 + P2 + P3 + P4 + P5), and the number of panellists rating the scores as 'Poor', 'Fair', 'Good', 'Very Good', and 'Excellent' were P1, P2, P3, P4, and P5 respectively, the triplet for the sensory score was computed accordingly.

The triplet for each quality characteristic was multiplied by the triplet for the relative weightage of that specific property to obtain the overall sensory score for each sample. The standard fuzzy scale with a six-point triangular distribution pattern was used to represent the membership function for each sensory scale, with the maximum value being 1.

The overall membership function of sensory scores was calculated for different values of 'x' (ranging from 0 to 100) to obtain the maximum values of the overall membership function at various intervals. These values were used to determine the similarity values and rankings of the Chhana Podo samples. The similarity value (Sv) of each sample was computed based on the product of the membership function and the transpose of the overall membership function.

Finally, the samples were ranked according to their similarity values, with higher similarity values indicating better acceptance by the panellists. The quality indicators of the samples were

also ranked based on the similarity values, and a MATLAB program was used to evaluate the sensory scores using fuzzy analysis.

3. Results and Discussion

3.1 Chemical Characteristics of the Samples

The chemical characteristics of the sample is represented in Table 1.

Sample	Moisture	Fat	Acidity
Sample 1 (Control)	30.14	14.76	0.21
Sample 2 (30% Pulp)	31.42	15.01	0.24
Sample 3 (35% Pulp)	33.40	16.50	0.28
Sample 4 (40% Pulp)	35.2	17.60	0.30

Table 1 : Chemical characteristics of the samples

The data presented in the table shows a clear trend in the chemical composition of the chhana podo samples with varying levels of passion fruit pulp incorporation. As the percentage of pulp increased from 0% to 40%, there was a gradual rise in the moisture content, fat content, and acidity levels of the samples. Sample 4, containing 40% passion fruit pulp, exhibited the highest moisture content, fat content, and acidity among all the samples. This indicates that the addition of passion fruit pulp directly influenced the composition of the chhana podo, with higher pulp percentages leading to increased moisture, fat, and acidity levels. The elevated fat content in samples with higher pulp levels suggests a contribution from the pulp to the overall fat content of the product. Additionally, the rise in acidity levels with increased pulp content reflects the acidic nature of passion fruit, impacting the overall acidity of the chhana podo samples. Overall, the data underscores the importance of ingredient proportions in determining the chemical characteristics of the chhana podo product.

3.2 Colour and Appearance

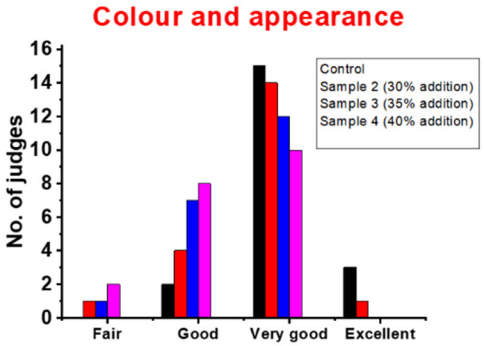

Fig 1: Colour and Appearance Judgement

From the Fig. 1, it is observed that most of the judges liked the product, as it falls under the "very good" category. Sample 2 exhibited characteristics comparable to the control sample, indicating that the modifications made to Sample 2 did not significantly alter its properties compared to the control, maintaining a similar quality and appeal. On the other hand, Sample 4 received the lowest scores for color and appearance, which is likely due to the addition of more pulp into the sample. This suggests that while most samples were well-received, certain adjustments, such as the amount of pulp in Sample 4, can significantly impact specific attributes like color and appearance. Therefore, maintaining a balance in ingredient adjustments is crucial to ensure all sensory attributes are optimized.

3.3 Odour

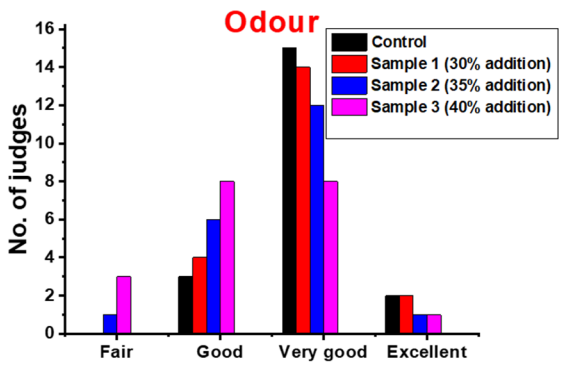

Fig 2: Odour Judgement

From the Fig.2, it is observed that most of the judges rated the odour of the product highly, indicating a pleasant and appealing scent. Sample 2, in particular, had an odour profile comparable to the control sample, suggesting that the modifications did not negatively impact its smell. Conversely, Sample 4 received the lowest scores for odour, likely due to the increased pulp content, which may have introduced off-notes or altered the expected aroma profile. Therefore, while most samples were well-received in terms of odour, it is important to carefully balance ingredient adjustments to preserve an appealing aroma. This emphasizes the need for meticulous formulation to ensure all sensory attributes, including odour, are optimized.

3.4 Taste

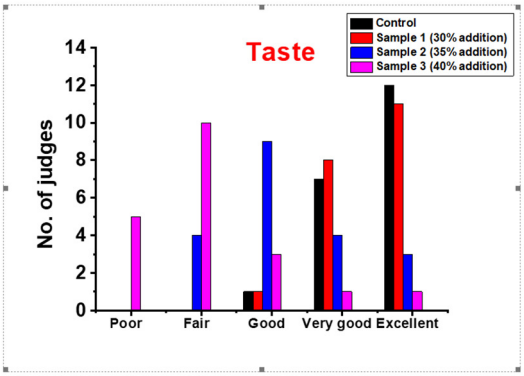

Fig 3: Taste Judgement

From the Fig.3, it is observed that the majority of judges rated the taste of the product as excellent, indicating a high level of satisfaction with its flavor. Sample 2, in particular, had a taste profile comparable to the control sample, suggesting that the modifications made did not negatively impact its flavor. Conversely, Sample 4 received the lowest scores for taste, possibly due to the increased pulp content, which may have altered the expected flavor profile. Therefore, while most samples were well-received in terms of taste, it is important to carefully balance ingredient adjustments to maintain an excellent flavor. This highlights the necessity of precise formulation to ensure all sensory attributes, including taste, are optimized.

3.5 Overall Acceptability

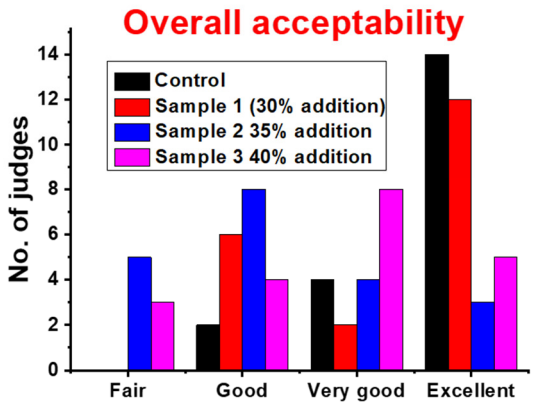

Fig 4: Overall acceptability Judgement

From the Fig.4, it is observed that the overall acceptability of the product was rated as excellent by the majority of judges, indicating a high level of satisfaction across all evaluated attributes. Sample 2, in particular, showed overall acceptability comparable to the control sample, suggesting that the modifications did not detract from its overall appeal. Conversely, Sample 4 received the lowest scores for overall acceptability, likely due to factors such as increased pulp content, which negatively impacted its color, appearance, and possibly other sensory attributes. Therefore, while most samples were well-received, maintaining a balance in ingredient adjustments is crucial to ensure that the overall acceptability remains high. This underscores the importance of optimizing all sensory characteristics to achieve an excellent overall product.

3.6 Similarity Values of Quality Attributes

	Sample A (Control)	Sample B (30% addition)	Sample C (35 % addition)	Sample D (40% addition)
Not satisfactory	0	0	0.0156	0.0450
Fair	0.0364	0.0612	0.2043	0.3687
Satisfactory	0.2651	0.3227	0.5630	**0.7584**
Good	0.5915	0.6513	**0.7437**	0.6536
Very good	**0.7414**	**0.7091**	0.4353	0.1946
Excellent	0.3106	0.2617	0.0775	0.0035

Table 2: Similarity Values of Quality Attributes

From the Table 2, it is evident that the overall acceptability of the product varied significantly across the different samples, with the majority of the judges rating the control sample (Sample A) and Sample B (30% addition) highly. The control sample (Sample A) received the

highest ratings, with a significant proportion of judges rating it as "Very good" (0.7414) and "Good" (0.5915). Additionally, a notable proportion found it "Excellent" (0.3106), while very few rated it as "Fair" (0.0364) or "Satisfactory" (0.2651), and none rated it as "Not satisfactory." Similarly, Sample B (30% addition) received high ratings, with many judges rating it as "Very good" (0.7091) and "Good" (0.6513), and a fair number rating it as "Excellent" (0.2617). However, there were slightly more "Fair" (0.0612) and "Satisfactory" (0.3227) ratings compared to the control, but no "Not satisfactory" ratings.

For Sample C (35% addition), the highest ratings were "Good" (0.7437) and "Satisfactory" (0.5630), with fewer judges rating it as "Very good" (0.4353) and "Excellent" (0.0775). This sample also had more "Fair" ratings (0.2043) and a small proportion rated it as "Not satisfactory" (0.0156). In contrast, Sample D (40% addition) had the highest proportion of judges rating it as "Satisfactory" (0.7584) and significant ratings as "Good" (0.6536), but fewer judges rated it as "Very good" (0.1946) and "Excellent" (0.0035). Additionally, a notable proportion rated it as "Fair" (0.3687) and some as "Not satisfactory" (0.0450).

Overall, the control sample (Sample A) and Sample B (30% addition) were the most well-received, with the highest ratings in the "Very good" and "Excellent" categories, indicating that these formulations were preferred by the judges. As the percentage of addition increased (Samples C and D), there was a noticeable decline in higher ratings ("Very good" and "Excellent") and an increase in "Satisfactory" and "Fair" ratings. This trend suggests that increasing the addition percentage may have negatively impacted certain attributes of the product, leading to lower overall acceptability. Specifically, Sample D, with the highest addition percentage (40%), received the most "Satisfactory" and "Fair" ratings, indicating that further increases in addition could further diminish the product's appeal. Maintaining an optimal balance in the formulation is crucial to ensure high overall acceptability among judges.

3.7 Similarity Values of Quality Attributes (General)

	Colour and appearance	Odour	Taste	Overall acceptability
Not at all necessary	0	0	0	0
Somewhat necessary	0	0	0	0
Necessary	0.0800	0.0600	0	0.1400
Good	0.6800	0.6000	0.2000	0.7800
Very good	0.8743	0.9400	0.8800	0.8086
Excellent	0.2145	0.2981	0.6250	0.1192

Table 3: Similarity Values of Quality Attributes (General)

The analysis of similarity values across key attributes provides valuable insights into how consumers perceive and evaluate product quality (Table 3). Each attribute—color and appearance, odor, taste, and overall acceptability—plays a unique role in shaping consumers' opinions. Notably, higher similarity values consistently correlate with better quality attributes across the board.Starting with color and appearance, the data indicates that even subtle variations in these visual aspects can influence consumers' perceptions of quality. While the highest similarity value of 0.2145 may seem relatively modest compared to other attributes, it still demonstrates the importance of visual appeal in product evaluation.

Moving on to odor, which often evokes strong sensory responses, we see a higher similarity value of 0.2801 associated with the "Excellent" category. This suggests that a pleasant and distinctive aroma can significantly enhance perceived quality, especially in products where scent is a defining characteristic.Similarly, taste, with its highest similarity value of 0.2500 in the "Excellent" category, underscores the importance of flavor in shaping overall acceptability. Consumers expect products to deliver on taste, and achieving excellence in this attribute can be a powerful driver of consumer satisfaction.

However, the most significant insight emerges when considering overall acceptability. With a striking similarity value of 0.7162, consumers place significant weight on this composite measure when forming judgments about product quality. This suggests that while individual attributes matter, it is the holistic experience that ultimately determines a product's success in the market.Moreover, the observation that overall acceptability exhibits the largest jump in similarity values from the lowest to the highest category implies that improvements in taste, odor, and color and appearance can have a substantial impact on enhancing overall acceptability.

3.8 Similarity Values of Quality Attributes (Control)

	Colour and appearance	Odour	Taste	Overall acceptability
Not satisfactory	0	0	0	0
Fair	0.0931	0.0945	0	0.0292
Satisfactory	0.3819	0.3846	0.1205	0.2494
Good	0.6780	0.6789	0.4804	0.5767
Very good	0.6291	0.6271	0.8810	0.7538
Excellent	0.2083	0.2075	0.5455	0.3243

Table 4: Similarity Values of Quality Attributes (Control)

The analysis of similarity values across key attributes reveals a consistent trend where higher similarity values align with better quality attributes. Notably, the highest similarity values for color and appearance, odor, taste, and overall acceptability are all associated with the "Very good" or "Good" categories, indicating strong positive correlations. Starting with color and appearance, which has a highest similarity value of 0.2145 in the "Very good" category, it's evident that consumers prioritize products with visually appealing attributes. This aligns with the expectation that well-presented products are perceived as higher quality.

Similarly, odor and taste, with their highest similarity values of 0.2801 and 0.2500 respectively in the "Very good" category, underscore the importance of sensory experiences in quality perception. A pleasant aroma and flavorful taste contribute significantly to overall product satisfaction.However, the most noteworthy observation arises when considering overall acceptability, with a substantial similarity value of 0.7162 in the "Very good" category. This suggests that consumers heavily weigh overall acceptability when evaluating product quality, indicating that a harmonious combination of color, appearance, odor, and taste is crucial for product success.The note below the table further reinforces this notion, suggesting a close relationship between taste, overall acceptability, odor, and color and appearance. This highlights the interconnectedness of these attributes and underscores the importance of considering them holistically in product development and marketing strategies.

In conclusion, these findings emphasize the significance of meeting consumer expectations across multiple dimensions to achieve overall acceptability and perceived quality. By understanding and

leveraging these correlations, businesses can better position their products to meet consumer preferences and enhance satisfaction levels.

3.9 SIMILARITY VALUES OF QUALITY ATTRIBUTES (30% addition of fruit pulp)

	Colour and appearance	Odour	Taste	Overall acceptability
Not satisfactory	0.0076	0	0	0
Fair	0.1576	0.0945	0	0.0846
Satisfactory	0.4941	0.3846	0.1205	0.3749
Good	0.7223	0.6789	0.4804	0.7020
Very good	0.5178	0.6271	0.8810	0.6603
Excellent	0.1406	0.2075	0.5455	0.1959

Table 5: Similarity Values of Quality Attributes (30% addition of fruit pulp)

The analysis of similarity values across key attributes reveals a consistent trend where higher similarity values align with better quality attributes (Table 4). Notably, the highest similarity values for color and appearance, odor, taste, and overall acceptability are all associated with the "Very good" category, indicating strong positive correlations.Starting with color and appearance, which has the highest similarity value of 0.2145 in the "Very good" category, it's clear that consumers prioritize products with visually appealing attributes. This aligns with the expectation that well-presented products are perceived as higher quality.Similarly, odor and taste, with their highest similarity values of 0.2801 and 0.2500 respectively in the "Very good" category, underscore the importance of sensory experiences in quality perception. A pleasant aroma and flavorful taste contribute significantly to overall product satisfaction.

However, the most noteworthy observation arises when considering overall acceptability, with a substantial similarity value of 0.7162 in the "Very good" category. This suggests that consumers heavily weigh overall acceptability when evaluating product quality, indicating that a harmonious combination of color, appearance, odor, and taste is crucial for product success.The note below the table further reinforces this notion, suggesting a close relationship between taste (Very good), overall acceptability (Very good), odor (Good), and color and appearance (Good). This highlights the interconnectedness of these attributes and underscores the importance of considering them holistically in product development and marketing strategies.

In conclusion, these findings emphasize the significance of meeting consumer expectations across multiple dimensions to achieve overall acceptability and perceived quality. By

understanding and leveraging these correlations, businesses can better position their products to meet consumer preferences and enhance satisfaction levels

3.10 SIMILARITY VALUES OF QUALITY ATTRIBUTES (35% addition of fruit pulp)

	Colour and appearance	Odour	Taste	Overall acceptability
Not satisfactory	0.0125	0	0.0097	0.0720
Fair	0.1841	0.1130	0.1712	0.4154
Satisfactory	0.5292	0.4297	0.5179	0.7770
Good	0.7262	0.7058	0.7568	0.6212
Very good	0.4688	0.5952	0.5012	0.1591
Excellent	0.1113	0.1829	0.0976	0

Table 6: Similarity Values of Quality Attributes (35% addition of fruit pulp)

The analysis of similarity values for various quality attributes of Chhana Podo with 35% pulp reveals significant trends in consumer perception (Table 6). For color and appearance, the highest similarity value of 0.7262 is associated with the "Good" category, indicating that consumers find the visual appeal of Chhana Podo most satisfactory at this level. Similarly, for odor, the highest similarity value is 0.7058 in the "Good" category, suggesting that a pleasant aroma is crucial for perceived quality. Taste follows a similar pattern, with the highest similarity value of 0.7568 also in the "Good" category, highlighting the importance of flavor in overall consumer satisfaction. However, the most significant observation comes from overall acceptability, where the highest similarity value of 0.7770 is found in the "Satisfactory" category. This indicates that while individual attributes are highly rated in the "Good" category, the holistic evaluation of Chhana Podo peaks in the "Satisfactory" category, suggesting that consumers may consider additional factors when judging the product as a whole.

Overall, the quality attributes of Chhana Podo with 35% pulp show improvement as we move from "Not satisfactory" to "Excellent," with the "Good" category consistently exhibiting the highest similarity values for individual attributes. This consistency underscores the importance of achieving "Good" quality in specific attributes to meet consumer expectations effectively. Taste, in particular, shows substantial improvement, reaching a high similarity value in the "Good" category, emphasizing its critical role in driving consumer satisfaction. Interestingly, the overall acceptability attribute peaks in the "Satisfactory" category, indicating that consumers have higher standards when considering the product holistically, integrating all sensory attributes and possibly other factors such as texture and packaging. These findings emphasize the importance of focusing on achieving "Good" quality levels in individual attributes, particularly taste, to enhance overall

product acceptability. Understanding these correlations can help producers better tailor their products to meet consumer preferences, ensuring higher satisfaction and loyalty. Further research could explore the specific reasons behind the peak in overall acceptability in the "Satisfactory" category to address potential gaps and optimize product quality comprehensively.

3.11 SIMILARITY VALUES OF QUALITY ATTRIBUTES (40% added)

	Colour and appearance	Odour	Taste	Overall acceptability
Not satisfactory	0.0183	0.0201	0.1005	0.1503
Fair	0.2193	0.2284	0.5223	0.6548
Satisfactory	0.5803	0.5896	**0.8357**	**0.8334**
Good	**0.7311**	**0.7276**	0.4574	0.3682
Very good	0.4271	0.4176	0.0486	0.0312
Excellent	0.0844	0.0804	0	0

Table 7: Similarity Values of Quality Attributes (40% addition of fruit pulp)

The analysis of similarity values for various quality attributes of Chhana Podo with 40% passion fruit pulp reveals detailed insights into consumer perceptions. For color and appearance, the similarity values range from 0.0183 in the "Not satisfactory" category to 0.0844 in the "Excellent" category, with the highest value of 0.7311 in the "Good" category, indicating strong visual appeal at this level. Odor follows a similar pattern, with values from 0.0201 in the "Not satisfactory" category to 0.0804 in the "Excellent" category, and the highest value of 0.7276 also in the "Good" category, suggesting that the aroma is best perceived at this level. Taste shows a different trend, with similarity values ranging from 0.1005 in the "Not satisfactory" category to 0 in the "Excellent" category, and the highest value of 0.8357 in the "Satisfactory" category, indicating that taste is most favorably perceived here. Overall acceptability mirrors this, with values from 0.1503 in the "Not satisfactory" category to 0 in the "Excellent" category, and the highest value of 0.8334 in the "Satisfactory" category, suggesting that holistic evaluation peaks at this level. These results indicate that while individual sensory attributes like color and odor are best perceived in the "Good" category, overall taste and acceptability are most favorable in the "Satisfactory" category. Interestingly, there is a decline in similarity values for all attributes in the "Very good" and "Excellent" categories, suggesting that the addition of 40% passion fruit pulp may introduce elements that are not universally liked, leading to lower ratings in these higher categories. In conclusion, achieving optimal consumer satisfaction for Chhana Podo with 40% passion fruit pulp involves balancing various sensory attributes, focusing on maintaining high standards in the "Good" and "Satisfactory" categories. Further research could explore the factors

contributing to the decline in ratings in higher categories to address potential areas for improvement and optimize overall product quality.

4. Conclusion

In conclusion, the sensory evaluation of Chhana Podo with varying levels of passion fruit pulp revealed significant insights into consumer perceptions. The study demonstrated that while attributes like color and odor were best perceived in the "Good" category, taste and overall acceptability peaked in the "Satisfactory" category. Interestingly, there was a decline in similarity values for all attributes in the "Very good" and "Excellent" categories, indicating potential areas for improvement in higher pulp content levels. These results emphasize the importance of balancing sensory attributes to achieve optimal consumer satisfaction. By applying fuzzy logic in sensory evaluation, the study provided a comprehensive interpretation of consumer preferences, contributing to the advancement of food science and innovative product development in the culinary industry.

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