SHORT COMMUNICATION

Sensory evaluation and nutritive value estimation of food products developed from the edible blossoms of *Allium cepa*, *Carica papaya* and *Cucurbita maxima*

Shreyasi Halder[1]*, Suchandra Dutta[2] and Kazi Layla Khaled[3]

[1]*Department of Applied Nutrition and Dietetics, Sister Nivedita University, New Town, West Bengal, India*
[2]*Department of Dietetics and Applied Nutrition, Amity University Kolkata, New Town, West Bengal, India*
[3]*Nutrition Research Laboratory, Department of Home Science, University of Calcutta, Kolkata, West Bengal, India*
**Email: shreyasi.st.pauls@gmail.com ORCID: 0000-0003-1199-009X*
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ABSTRACT

Flowers are conceived of as a sort of "new vegetable" in the food chain and one of the most promising novelties for satisfying the growing need for food innovation both in terms of organoleptic and nutraceutical profiles. Keeping this in mind, this study involved the attempt to convert the edible flowers of Allium cepa, Carica papaya and Cucurbita maxima into ten different ethnic food products, namely, onion flower mustard pickle, onion flower chili vinegar pickle, onion flower chaat masala, pumpkin flower jam, pumpkin flower sweet and sour pickle, pumpkin flower powder phuluri, pumpkin flower powder laddoo, papaya flower sweet and sour pickle, papaya flower mustard pickle (sour) and papaya flower powder soup. An organoleptic study of the developed food products showed that papaya flower powder soup had the highest mean hedonic score for all the attributes with the highest overall acceptability. In contrast, the papaya flower mustard pickle had the lowest acceptability. According to the Hedonic R analysis, the sweet and sour pickle pumpkin flower and papaya flower powder soup had overall higher preference values than the other tested pickles and powders. The flower-based food products recorded low in fat and moderate in protein, carbohydrate and soluble fibre. The food products were found rich in β-carotene and ascorbic acid, and are good sources of calcium, potassium, phosphorous, manganese and copper. Overall, the prepared flower-based food products, ethnic to Indian cuisine, are nutrient-dense and are likely to be acceptable, affordable and sustainable potential nutritional sources.

Keywords: Edible flowers, food composition, food products, Hedonic R analysis, sensory evaluation, sustainable nutrition.

The growing scientific evidence of the human health benefits of using flowers as food has rapidly evolved in the last couple of years. Brightly coloured flowers have been used for hundreds of years to make teas and wines; they are also dried and used as medicines or herbs; others are crystallized and used as desserts and supplements to butters, jams, marinades and sauces (Raquel *et al.,* 2017). It was reported that the active components of the flowers, like the phytochemicals, can be extracted by different methods, including maceration, reflux extraction, percolation, Soxlet extraction,

and boiling, which can then be utilized for preparing herbal medicines (Kazakova *et al.*, 2024). The available literature encourages the consumption of edible flower-based food products; for example, the Mahua (*Madhuca longfolia*) laddoo is prepared locally by tribal women. Butterfly pea (*Clitoria ternatea*) and *Dahlia coccinea* are reportedly converted into Indian deserts. Pansy (*Viola* × *wittrockiana*) is also used in soups and desserts. *Bauhinia variegata* is used to make pickles, and *Rhododendron arboretum* is used to make chutney or a sweet and sour pickle (Kumari *et al.,* 2021).

Allium cepa umbel reportedly contains approximately 89% water, 9% carbohydrates, and 1% protein and has an energy value of 166 KJ. *Allium cepa* flowers, which are usually discarded after the stalk is removed, are also good sources of phenols and flavonoids (Halder *et al*.,2022). A study in the Philippines confirmed that the male papaya flower as a functional ingredient for herbal tea production, primarily owing to its appealing aroma. In Indonesia, buds of male papaya flowers, locally called 'Bunga pepaya' are consumed in local dishes (Halder *et al*.,2022). *Cucurbita maxima* flowers have been consumed locally as vegetables in Mexico and India since ancient times as salads, dressings, soups and main dishes. *Cucurbita maxima* flower extracts with a high quantity of flavonoids (17.2 mg QE/100 g) have previously shown significant free radicle scavenging activity (Carboni *et al*., 2025). This study formulated and evaluated the sensory attributes of ten newly formulated food products from the edible flowers of *Allium cepa*, *Carica papaya* and *Cucurbita maxima* that can act as supplementary foods by increasing the nutrient content of our regular diet if incorporated judiciously. The nutritive value per 100 g of the prepared ethnic dishes was also calculated. The flowers were chosen for their high nutritional content and easy accessibility.

Whole-flower samples of *Allium cepa*, *Carica papaya* and *Cucurbita maxima* were collected from local markets in West Bengal, India. The flowers were graded based on their cleanliness, firmness, maturity, colour, size, and shape and were free from insect infestation and mechanical injury. Only the selected flowers were soaked in water at room temperature for 2 minutes to reduce the surface microbial load. After this, the flowers were converted into pulp, powder, vinegar soaked and finely chopped for further processing.

For onion flower mustard pickle: ingredients used were Vinegar-soaked flowers-100g, amchur powder-10g, mustard powder-5g, salt- 3g, mustard oil-20g, five spices cumin, brown mustard, fenugreek, nigella and fennel) -3g, dry red chilli powder-2g. The vinegar-soaked flowers were taken in a bowl. The spices were all added one by one with the flowers and mixed thoroughly. The mixture was carefully poured into a sterilized, airtight glass jar, capped and kept untouched for 10 days. It was further used for sensory evaluation.

For onion flower chilli vinegar pickle: ingredients were used **as** vinegar soaked flowers -100g, ginger-5g medium whole, garlic cloves-5g, green chilli-5g, vinegar-50 ml, salt- to taste.
The vinegar-soaked flowers were taken in a bowl. The rest of the ingredients were added one by one into the flower and mixed thoroughly. The mixture was carefully transferred into a sterilized, airtight glass jar, capped and kept untouched for 10 days. It was further used for sensory evaluation.

For onion flower chaat masala (with powder): Onion flower powder-5g, amchur powder-3g, black pepper-2g, rock salt-5g w2ere used. To the onion flower powder, the spices were added and mixed thoroughly to obtain the chaat masala, kept in an airtight container.

For pumpkin flower jam: Fresh pumpkin flower pulp-200g, powdered sugar-

150g, pectin- 1.5g, lime- 5g whole, orange peel powder- 10g, sodium benzoate- 0.5g were taken. Pumpkin flower pulp was boiled on low flame by continuously stirring, powdered sugar was added to the mixture, pectin was added next, lime juice and orange peel powder went next and stirred continuously. At this point, it was checked for doneness. Upon reaching the desired consistency, the mixture was removed from flame and sodium benzoate was added. The jam was cooled, capped and stored for sensory evaluation in a sterilized glass jar.

For pumpkin flower sweet and sour pickle/chutney: Pumpkin flower chopped finely- 35g, ginger-finely chopped- 5g, garlic-finely chopped- 5g, dried chilli finely chopped whole-5g, vinegar- 15 ml, sugar- 35g were used. Finely chopped flowers were taken in a pan and sugar was added and set on low flame. It was continuously stirred. After the sugar melted, rest of the ingredients were added to the mix and stirred well on heat. The pickle was cooled, capped and stored for sensory evaluation in a sterilized airtight glass jar.

For pumpkin flower phuluri (with powder): Pumpkin flower powder-5g, besan-20g, green chilli-chopped-5g, ajwain-0.5g, salt-to taste, split Bengal gram dal-25g, pea lentils-25g, baking powder-0.25g, refined soya bean oil- for frying-50ml were taken. To the pumpkin powder, besan, green chilli chopped, ajwain, lentil pastes, salt, and baking powder were added. The mixture was made into small balls by hand and deep-fried. The phuluries were served hot immediately for the sensory evaluation. To the pumpkin powder, besan, green chilli chopped, ajwain, lentil pastes, salt, and baking powder were added. The mixture was made into small balls by hand and deep-fried. The phuluries were served hot immediately for the sensory evaluation.

For Pumpkin flower laddoo (with powder): Pumpkin flower powder-20g, besan-80g, Soyabean oil-50 ml, sugar powdered-100g, cardamon black- whole-2g, ghee- 1tbsp were taken. In a pan, the oil was warmed on low flame, elaichi was added to it, and when the aroma started coming out, besan was added and stirred well, next the pumpkin powder was added and continuously stirred. The pan was taken off the flame and the sugar were added. Ghee was added next and mixed well. The mixture was given the shape of small balls. The laddoos were allowed to cool and then used for sensory evaluation immediately.

For papaya flower sweet and sour pickle/chutney: raw mango-100g finely chopped, papaya flower-100g, sugar-60g, garlic chopped-16g, ginger chopped-7g were taken. To a pan, freshly chopped papaya flowers soaked in vinegar and the sugar was added first and put on low flame. As the sugar started melting rest of the ingredients were added to it and stirred continuously. On attaining the perfect consistency of a pickle, it was cooled, capped and stored for sensory evaluation in a sterilized airtight glass jar.

For papaya flower mustard pickle: Papaya flower- 100g, raw mango finely chopped-100g, mustard oil-25 ml, mustard powder-20g, red chilli powder- 10g, salt- 5g, turmeric powder-3g were taken. The flower petals soaked in vinegar were used for this pickle. The petals were mixed well with all the ingredients and left untouched for a week. The pickle was stored for sensory evaluation in a sterilized airtight glass jar.

For papaya flower soup (with powder): Papaya flower powder- 5g (Flower paste is microwaved in convection mode to obtain the powder), ready-to-cook vegetable soup powder sachet-10g, water-150 ml were taken. With the soup powder contents, the papaya flower powder was added and hot water was poured and stirred continuously to avoid any lump formation. Served hot in small cups for sensory evaluation.

Sensory analysis was carried out for the following attributes: a) Appearance b) Colour c) Aroma d) Taste e) Overall acceptability.

Total carbohydrate content was estimated spectrophotometrically by using glucose as a standard (Szklarek *et al*., 2022)**.** The protein content was determined by using the Lowry *et al.* (1951) method. Fat content was

determined using the Soxhlet extraction method according AOAC (2005). Total Dietary Fibre Assay Kit (FOSS-Tecator, Fibretec™ E1023, Hoganas, Sweden) according to AOAC (2005) was used to determine the soluble fibre content. Thiamine and riboflavin were estimated according to Okwu and Josiah (2016). Niacin content was calculated as per Sadasivam and Manickam (1996). 100mg of pure ascorbic acid dissolved in 100 ml of 6% HPO3 was used as the Ascorbic acid standard (1mg/ml) in the method given by Sadasivam and Manickam (1992), for ascorbic acid estimation. Total β-carotene was presented as mg/100g on a fresh weight (FW) basis by using the method by Kishore *et al.* (2025). Atomic absorption Spectrometer (ICP-OES; Model No: VDV-5110; Manufactured by: Agilent Technologies) was used for carrying out the mineral estimations by applying the official methods of the Association of Official Analytical Chemists (AOAC, 1990 and 2016).

The data gathered from the sensory evaluation were statistically analysed by using SPSS 17 software. The standard deviation of the overall acceptability and sensory attributes of the food products among the panellists were determined. R-Index analysis is a nonparametric analysis that calculates the size of the difference or similarity between products (Lee and Houtj 2009). R-Index analysis was used here as a detection and sensory difference test, along with hedonic scaling and for the measurement of consumer concepts.

The data presented in Table 1 shows that the flower-based food products prepared in this study are low in fat and can be consumed without increasing blood cholesterol levels. Food products such as pumpkin flower phuluri plants are deep fried in soya bean oil, whereas onion flower mustard pickle and Papaya flower mustard pickle contain added mustard oil. However, since the quantity of these items to be served will be much less than 100 g, the fat content will be reduced to a negligible amount.

As shown in Table 2, flower food products are rich in β-carotene. The ICMR's Recommended Dietary Allowances (RDA) for adult men and women for vitamin A are 1000 µg/d and 840 µg/d, respectively (Anon, 2023). The total ascorbic acid concentration of food products ranges from 2 mg to 116 mg/100 g, which is sufficient for meeting the RDA standards of 80 mg/d and 65 mg/d for adult men and women, respectively (Anon., 2023).

The food products are particularly rich in calcium, potassium and phosphorous, as shown in Table 3. Calcium is needed for growth and bone development, and calcium deficiency can lead to osteoporosis. Phosphorus is an essential element of the human body and is required for a wide range of processes, such as ATP synthesis, signal transduction and bone mineralization (Serna and Bergwitz 2020). The prepared food products are also good sources of manganese and copper, which may be sufficient for fulfilling the recommended dietary allowances. Although copper deficiency is less common in humans, low intakes may adversely affect cholesterol and glucose metabolism, blood pressure control, cardiovascular function and the immune system (Burkhead and Collins, 2022).

From Table 4 and Figure 1, based on five different hedonic attributes, we can derive that amongst all the products, papaya flower soup had the highest hedonic mean score for all the attributes and overall acceptability (8.43±0.72), while papaya flower mustard pickle had the lowest acceptability, with a mean hedonic score of 6.73±1.28.

R-index values were computed from the data when they were ranked in order of preference, as described in the matrix of Figure 2, indicating the degree of preference for one pickle over its adjacent pickle in the hedonic ranking. According to Table 5, equal overall preferences or 100% preferences for the five different pickles have not been reported. It can be concluded that, overall, product B (pumpkin flower sweet and sour

pickle) has the highest preference value compared to the other tested pickles.

As shown in Table 6, no similar overall preferences or 100% preferences were reported for the four different edible flower powder products. Thus, from the above analysis, it can be concluded that, compared with the other powder products, product B (pumpkin flower powder phuluri) has a relatively high preference for product D (papaya flower powder soup), which has the overall highest preference value.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have 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: Approximate values of the macronutrient content of food products (per 100 g serving) prepared from *Allium cepa, Carica papaya* and *Cucurbita maxima* blossoms.

Food products (100 g)	Carbohydrate (g)	Protein	Fat	Soluble fibre	Energy (kcal)
Onion flower mustard pickle	2.18	2.05	22.22	1.21	216.9
Onion flower chilli vinegar pickle	5.12	1.34	0.25	1.40	28.00
Onion flower chaat masala	1.29	0.20	0.05	0.87	1.94
Pumpkin flower jam	5.00	0.27	0.15	1.71	26.43
Pumpkin flower sweet and sour pickle	8.19	2.47	0.25	1.64	44.89
Pumpkin flower phuluri (4 pieces)	35.6	15.6	38.16	4.04	548.00
Pumpkin flower laddoo (4 pieces)	10.34	3.65	11.17	1.83	114.53
Papaya flower sweet and sour pickle	15.11	1.92	0.15	5.34	18.35
Papaya flower mustard pickle	17.3	5.85	18.76	2.68	188.44

Table 2: Approximate micronutrient contents (vitamins) of food products (per 100 g of serving) prepared from *Allium cepa*, *Carica papaya* and *Cucurbita maxima* blossoms.

Serial No.	Food Products	Thiamine (B_1)	Riboflavin (B_2)	Niacin (B_3)	Total ascorbic acid	β-carotene
	(100 g)	(mg)				(µg)
1.	Onion flower mustard pickle	0.807	0.116	1.028	4	34.45
2.	Onion flower chilli vinegar pickle	0.250	0.121	0.608	16.17	30.6
3.	Onion flower chaat masala	0.230	0.090	0.430	4.34	15.74
4.	Pumpkin flower jam	0.163	0.015	0.162	50.96	2.81
5.	Pumpkin flower sweet and sour pickle	0.810	0.094	0.408	27.86	40.35
6.	Pumpkin flower phuluri	0.387	0.133	1.232	69.61	306.67
7.	Pumpkin flower laddoo	1.020	0.015	0.142	2.17	23.37
8.	Papaya flower sweet and sour pickle	0.203	0.071	0.479	116.05	83.46
9.	Papaya flower mustard pickle	0.327	0.184	1.846	113.5	234.54

Table 3: Approximate micronutrient contents (minerals and trace elements) of food products (per 100 g of serving) prepared from *Allium cepa, Carica papaya* and *Cucurbita maxima*.

Serial No.	Food Products	Calcium (Ca)	Potassium (K)	Iron (Fe)	Phosphorous (P)	Copper (Cu)	Manganese (Mn)
	(100 g)	(mg)					
1.	Onion flower mustard pickle	88.85	238.47	2.61	45.70	0.491	0.72
2.	Onion flower chili vinegar pickle	61.29	275.59	2.26	25.76	0.726	1.29
3.	Onion flower chaat masala	62.02	144.53	1.91	3.07	0.47	0.61
4.	Pumpkin flower jam	59.23	149.80	1.68	24.76	3.32	0.34
5.	Pumpkin flower sweet and sour pickle	60.54	250.03	2.14	63.81	3.48	0.83
6.	Pumpkin flower phuluri	77.25	625.13	6.59	230.45	3.76	0.98
7.	Pumpkin flower laddoo	58.99	734.09	8.09	276.87	3.32	0.49
8.	Papaya flower sweet and sour pickle	75.60	284.17	2.43	63.05	2.61	0.61
9.	Papaya flower mustard pickle	161.50	546.50	5.47	212.4	2.81	1.54

Table 4: Mean hedonic values of the food products as evaluated by panel members

Food Product Name		Sensory Properties				
		Colour	Aroma	Consistency	Taste	Overall Acceptability
Onion Flower	Mustard pickle	6.83±1.59	7.5±1.13	7.06±1.43	6.86±1.4	7.00±1.33
	Chilli vinegar pickle	6.73±1.22	7.66±1.58	6.46±1.97	7.53±1.77	7.6±1.37
	Chaat masala (with powder)	7.96±0.55	7.96±0.88	8.06±0.78	8.23±0.85	8.4±0.67
Pumpkin flower	Jam	7.16±1.46	6.5±1.3	7.4±1.27	7.96±0.88	7.6±0.95
	Sweet and sour pickle	6.73±1.43	6.83±1.34	6.6±1.54	6.9±1.53	7.03±1.09
	Phuluri (with powder)	7.8±0.69	7.53±0.93	7.83±0.69	8.03±0.98	8.26±0.69
	Laddoo (with powder)	7.03±0.8	7.46±1.13	7.7±0.87	7.6±1.03	7.73±0.94
Papaya flower	Sweet and sour pickle	7.5±1.3	6.76±1.38	7.3±1.11	7.06±1.38	7.16±1.23
	Mustard Pickle (sour)	7.8±0.8	7.73±0.9	7.16±0.94	7.13±0.89	6.73±1.28
	Soup (with powder)	8.26±0.78	8.03±0.76	8.3±0.7	8.3±0.66	8.43±0.72

The data are expressed as the mean ± SD (n = 30).

Table 5: Percentage of preference for one product over another for the different pickles as calculated from the hedonic R-Index response matrix for pickles

Preference	Percentage
Prefer A to B	35.3%
Prefer A to C	48.1%
Prefer A to D	48.6%
Prefer A to E	56.6%
Prefer B to A	64.6%
Prefer C to A	51.8%
Prefer D to A	51.3%
Prefer E to A	43.3%
Prefer B to C	64.0%
Prefer B to D	66.3%
Prefer B to E	71.4%
Prefer C to B	36.0%
Prefer D to B	33.6%
Prefer E to B	28.5%
Prefer C to E	59.0%
Prefer C to D	49.2%
Prefer E to C	41.0%
Prefer D to C	50.7%
Prefer D to E	60.0%
Prefer E to D	39.9%

Table 6: Percentage of preference of one product over another for the different powder products as calculated from the hedonic R-Index response matrix for powders

Preference	Percentage
Prefer A to B	34.5%
Prefer A to C	68.2%
Prefer A to D	47.8%
Prefer B to A	42.3%
Prefer C to A	31.7%
Prefer D to A	48.4%
Prefer B to D	41.1%
Prefer B to C	62.1%
Prefer D to B	55.5%
Prefer C to B	37.8%
Prefer C to D	31.2%
Prefer D to C	65.3%

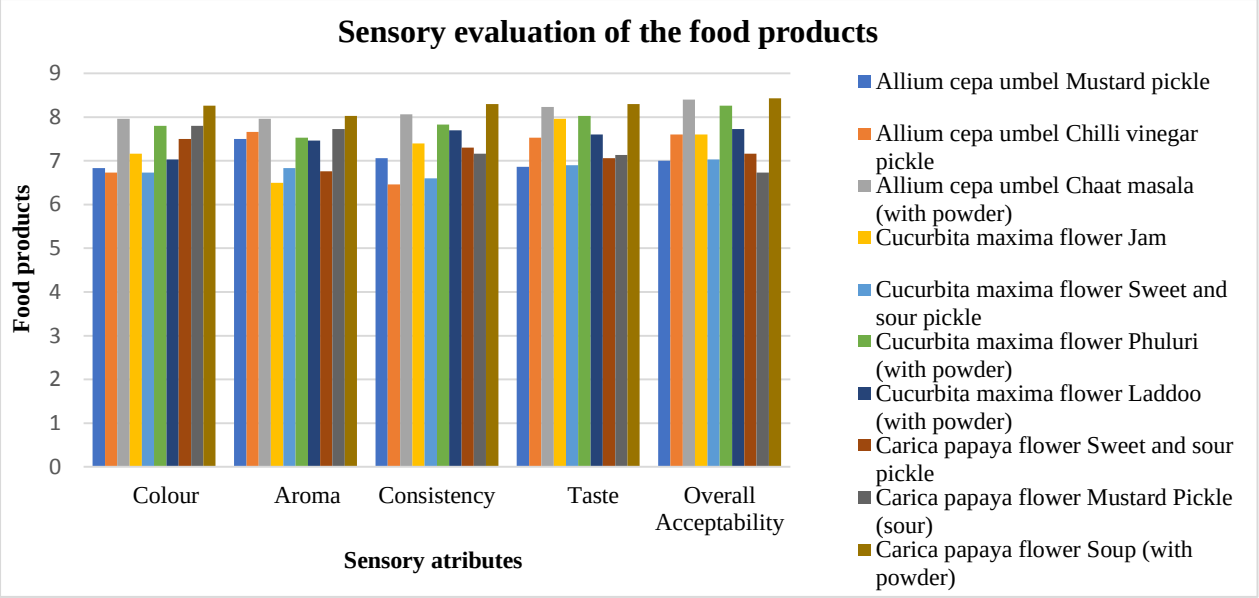

Figure 1: Graphical representation of the sensorial evaluation of food products prepared from *Allium cepa* umbel, *Carica papaya* flowers and *Cucurbita maxima* flowers.

	1st	2nd	3rd	4th	5th
Onion flower mustard pickle [A]	9	9	6	6	0
Onion flower chilli vinegar pickle [B]	16	8	4	2	0
Pumpkin flower sweet and sour pickle [C]	9	8	11	2	0
Papaya flower sweet and sour pickle [D]	5	17	5	3	0
Papaya flower mustard pickle [E]	6	8	10	5	1

Like more ← → Like less

Figure 2: Hedonic R-Index response matrix for pickles

	1st	2nd	3rd	4th
Onion flower powder chaat masala [A]	17	11	2	0
Pumpkin flower powder phuluri [B]	13	13	4	0
Pumpkin flower powder laddoo [C]	10	8	11	1
Papaya flower powder soup [D]	17	9	3	0

Like more ← → Like less

Figure 3: Hedonic R-Index response matrix for powder

Figure 4: Prepared Food products: 1. Onion flower mustard pickle 2. Onion flower chilli vinegar pickle 3. Onion flower chaat masala (with powder) 4. Pumpkin flower jam 5. Pumpkin flower sweet and sour pickle/chutney 6. Pumpkin flower laddoo (with powder) 7. Papaya flower sweet and sour pickle/chutney 8. Papaya flower mustard pickle 9. Papaya flower powder 10. Pumpkin flower phuluri (with powder)