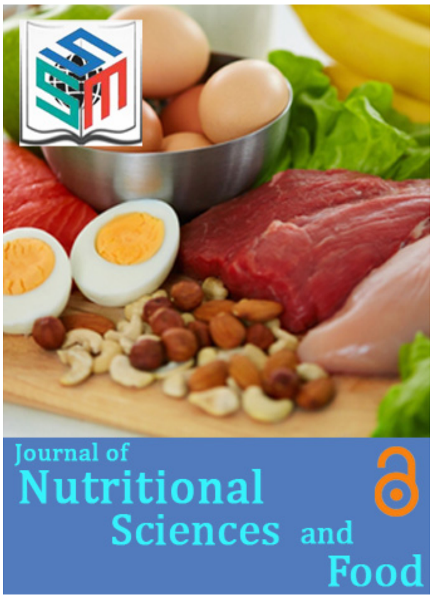

Research Article

Efficacy of Monosodium Glutamate in Sodium Reduction and Impact on Sensory Profile of Traditional Indian Dishes

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Citation: Prabhavathi SN, Prakash J (2021) Efficacy of Monosodium Glutamate in Sodium Reduction and Impact on Sensory Profile of Traditional Indian Dishes. J Nutri Sci Food 1: 001.

Received: May 29, 2021

Accepted: June 22, 2021

Published: June 30, 2021

Abstract

Sodium chloride is one of the most commonly used food additive, because it is low cost and has the ability to increase one likes of foods via bringing about modification in flavor and other functional parameters in a food. It is indispensable in food processing and is normally added to achieve technological properties. The present study aimed to formulate and evaluate sensory profile of low sodium traditional Indian dishes incorporating Monosodium Glutamate (MSG). A total of 12 dishes categorized as flat breads, split legumes based dishes (*Sambar* and *Dhals*), sauteed vegetables and gravies were prepared and evaluated for sensory acceptability with 10 trained panel members. All the dishes were also analyzed for sodium content in both control (without MSG and only with salt) and experimental products (salt partially substituted with MSG). The sensory data of rice based flat bread showed that substitution of MSG resulted in a superior taste in contrast to the control sample. The compiled scores for mixed vegetable sambar for the quality of taste indicated low initial scores for product without MSG (7.6±2.36), whereas after substituting MSG, a sharp increase in the score was noticed (11.3±2.54). The amount of sodium contributed by MSG was in the range of 6.15-14.7 mg/100g of the product which is proportionately lower than the amount contributed by table salt. The overall sodium reduction for the developed products was in the range of 30.6% - 43.3%. The results clearly demonstrated that MSG could be considered as a better choice of salt substitute for replacing certain amount of sodium content in the products and a better sensory profile.

Keyword: Flavor enhancer; Low sodium; MSG, Salt substitute; Traditional dishes

Introduction

Sodium chloride is considered as an indispensable ingredient in most of the processed savoury products. The salty taste contributed by sodium chloride is a prototypical stimulus [1]. Sodium is known to improve various sensory properties of food; mainly by increasing saltiness, decreasing bitterness and increasing sweetness in addition to bringing about other congruent flavor effects [2]. However, excessive use of salt has been recognized as a risk factor and associated with adverse health profiles. World Health Organization recommends an overall reduction in sodium intake to less than 2000 mg/day of sodium [3]. It was reported that a modest 15% reduction in sodium intake could prevent cardiovascular disease related deaths all over the world over 10 years [4]. Despite its negative health consequences, humans are still continuing to consume sodium in the form of salt in amounts well above the recommended levels in most of the developed countries. Hence, salt reduction should become the prime priority for public health and wellbeing.

Due to the adverse effect of high sodium consumption on health it has become imperative to use a suitable alternative that can compensate for the salty taste along with maintaining normal sensory attributes. The food processing industries have resorted to use salt substitutes to maintain normal sensory attributes of savoury foods. One of the most important flavor potentiating agents is Monosodium Glutamate (MSG) which is responsible for contributing umami flavor and has been proven to be a good flavor enhancer especially in low sodium chloride products. MSG is known to contain only 12% of sodium which is comparatively much lower than common table salt. Thus MSG incorporation would help to achieve normal salty taste perception along with maintaining normal sensory attributes without leading to substantial increase in total sodium content of the product [5,6]. It may be noted that MSG is not used in traditional Indian cooking and the taste perception of MSG is a new experience for Indians, though they may have experienced it while consuming oriental cuisine outside their homes, which is common now. Ethnic cuisine from other countries is available in Indian cities on account of globalization. Earlier studies from our laboratory have demonstrated the efficacy of MSG in reducing sodium levels of dishes and enhancing the taste quality for deep fried rice crackers [7], vegetable based soups [8], tomato soup [9,10] and spiced Poories [11]. Hence, the present study was carried out with an objective of assessing the sensory profile of low sodium traditional Indian dishes prepared by incorporating MSG as a flavor enhancer. The study also evaluated the efficacy of MSG in sodium reduction by analyzing sodium content of prepared dishes.

Materials and Methods

Materials

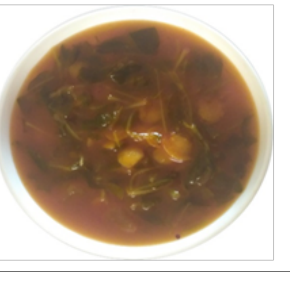
The ingredients needed for preparation of various dishes such as food grains, vegetables, curry powders, spice mixtures were procured from local market. All the ingredients were thoroughly cleaned and processed according to the standard procedure. MSG was obtained from Ajinomoto company, Japan. The chemicals used for the analysis were all of analytical grade and were procured from SD fine chemicals, India. Glass distilled water was used for all the analysis. All the estimations were carried out in duplicates. This particular study was designed to explore the flavor potentiating effect of MSG in Indian cuisine. About 12 commonly eaten day-to-day dishes [classified into 4 different categories] were selected, standardized and prepared. They were subjected to sensory evaluation and estimation of sodium content. A brief description of various categories of products is as follows:

1. **Flat breads** (***Roti***)- These are mainly cereal based preparations. Bland in taste and are often eaten with spicy preparations.
2. **Split legume based curry** (***Sambar and Dhal***) - Made with a combination of split legumes, spices, vegetable and/or acidulant (tomato/ tamarind) and are accompaniment to cereal based preparations such as flatbreads or rice.
3. **Gravies** - prepared using whole legume and spice combination and eaten with flat breads.
4. **Sautéed vegetables** - eaten as a side dish in a meal. These could also be half boiled and seasoned to enhance the flavor profile.

The spice combination employed in these preparations were unique to each dish which helped to impart a rich taste to these products.

Methodology

A total of 12 products were standardized and prepared under the categories such as breakfast items, sauteed vegetables, vegetable stews and gravies. Basic dishes and sodium reduced dishes were prepared and evaluated for sensory profile and sodium content. Basic dish was treated as control to estimate the amount of reduction in sodium. The detailed methodology pertaining to the preparation of dishes is appended in Appendix A.

1.Wheat based flat bread	
	**Ingredients:** Whole wheat flour- 100g, Oil – 20ml, (5 ml for the dough and 12.5 ml for shallow frying), Water – 65ml. **Experimental: MSG- 100 mg.** **Method:** To the mixing bowl, wheat flour, salt and required amount of water was added. The mixture was kneaded into soft dough. The dough was kept aside for half an hour, divided into balls of equal size. The balls were rolled out into medium size chapathis of 2mm thickness and were cooked on hot tava for 1 minute on both the sides till they were done.
2. Rice based flat bread	
	**Ingredients:** Rice flour – 100g, Salt – 1g, Water – 60ml, oil – 1 teaspoon. **Experimental: MSG- 120 mg, Salt- 0.6 g.** **Method:** In a vessel, water and salt were added and boiled. Rice flour was gradually added to the boiling water and stirred continuously to prevent lump formation. The dough was cooled, and kneaded well with a tea spoon of oil. It was divided into balls and patted into circular sheets and shallow fried.
3. Millet based flat bread	
	**Ingredients:** Finger millet flour 100– g, Salt – 1.1g, Onion – 25g, Coriander leaves – 5g, Oil – ½ tsp, (for shallow frying), Water- 70ml. **Experimental: MSG- 120 mg, Salt-0.65 g.** **Method:** To the mixing bowl, finger millet flour, salt, onion and chopped coriander leaves were added. The ingredients were dry mixed thoroughly. Water was added and soft dough was prepared. The dough was divided into equal sized balls which were then flattened into circular sheets and shallow fried.
4.Mixed vegetable sambar	
	**Ingredients:** Red gram dhal – 100g, Beans – 50g, Carrot – 50g, Tomato – 50g, Potato – 50g, Sambar powder – 4 tsp, Mustard – ¼ tsp, Red chillies – 4 in no, Oil – 2 tsp, Curry leaves – 15 in no, Tamarind extract – 2 tsp, Water-400ml, Salt – 1.1g **Experimental: MSG- 50 mg, Salt – 0.7g.** **Method:** Beans, carrot, tomato and potato were chopped and pressured cooked with red gram dhal and salt. To the above cooked vegetables, sambar powder and tamarind extract was added and boiled for 5 minutes. In a pan, oil was heated. Mustard seeds, curry leaves and red chillies were added and fried for a minute. The seasonings were added to the cooked dhal and vegetables, boiled for 2 minutes and removed from flame.
5. Fenugreek leaves sambar	
	**Ingredients:** Fenugreek leaves – 50g, Red gram dhal – 50g, Garlic – 2g, Oil – 1 tsp, Tomato – 100g, Sambar powder – 2 tsp, Tamarind extract – 2 tsp, Water-300ml, Salt – 1g **Experimental: MSG- 80 mg, Salt-0.55 g.** **Method:** Fenugreek leaves were cleaned, washed, chopped and cooked along with tomato, salt and red gram dhal till they became soft. Sambar powder and tamarind extract was added and boiled for 10 min. Crushed garlic was seasoned with a tsp of oil and added to the sambar.

6.Mixed leafy vegetable sambar

Ingredients: Amaranth leaves – 80g, Amaranthus tricolour leaves- 50g, Red gram dhal – 50g, Garlic – 2g, Sambar powder- 3 tsp, Oil – 1 tsp, Mustard – ¼ tsp, Curry leaves – 12 in no, Tomato – 100g, Tamarind extract – 2 tsp, Water-400ml, Salt – 1.1g

Experimental: MSG- 75 mg, Salt-0.6 g.

Method: The leafy vegetables were cleaned, washed, chopped and kept aside. Red gram dhal, tomato, leafy vegetables and salt were cooked in an open vessel till they became soft. Once the leaves were cooked to its doneness, Sambar powder and tamarind extract was added and boiled for 5 minutes. In a pan oil was heated, mustard seeds, curry leaves and crushed garlic were added and fried for 2 minutes on medium flame. The seasoned mixture was added to the sambar, boiled for 2 minutes and removed from flame.

7. Sautéed cabbage

Ingredients: Cabbage – ½ kg, Coconut gratings – 25g, Green chillies – 2 in no, Black gram dhal – 2 tsp, Oil- 15ml, Water-100ml, Turmeric – a pinch, Salt – 1g

Experimental: MSG- 60 mg, Salt- 0.55 g.

Method: Cabbage was cleaned and shredded. In a pan, oil was kept for heating. To the heated oil, black gram dhal, turmeric and slit green chillies were added and fried for 2 minutes. The shredded cabbage and salt was also added and fried for about 5 min. Small quantity of water was added and the cabbage was cooked on medium flame with constant stirring until it was done.

8. Sauteed beans

Ingredients: Beans – ½ kg, Split chickpea – 1 tbsp, Split Black gram – 2 tsp, Oil – 2tbsp, Mustard – ¼ tsp, Onion – 100g, Curry leaves – 20 in no, Asafoetida – a pinch, Coconut gratings – 30g, Water- 400ml, Salt – 1g

Experimental: MSG-50 mg, Salt-0.55g.

Method: The beans were cleaned, chopped, and pressure cooked with salt. In a pan, oil was heated and mustard seeds were added. To the above seasoning split Black gram and chickpea were added and fried on low flame till they became golden brown. Finally, onions and curry leaves were added and fried for 3-4 min. To the seasoned mixture pressure cooked beans and coconut gratings were added and mixed well.

9.Plain dhal fry

Ingredients: Split Red gram – 100g, Mustard – ¼ tsp, Cumin seeds – ½ tsp, Slit green chillies – 2 in no, Turmeric – a pinch, Oil – 1 tsp, Water- 300ml, Salt – 1g

Experimental: MSG-50 mg, Salt-0.55 g.

Method: Red gram was pressure cooked with salt.

A pan was heated, oil and cumin seeds were added. When they started to crackle, a pinch of turmeric, asafoetida and green chillies were added and fried for few seconds. The pressure cooked red gram was added to the pan, mixed well and cooked for 4-5 minutes.

10.Spinach dhal

Ingredients: Split green gram – 100g, Spinach – 50g, Mustard – ¼ tsp, Cumin seeds – ½ tsp, Slit green chillies – 2 in no, Turmeric – a pinch, Water- 300ml, Salt – 0.85g

Experimental: MSG- 75 mg, Salt- 0.5 g.

Method: Spinach was cleaned, washed and finely chopped. Green gram and spinach were pressure cooked with salt till they became soft. A pan was heated, and seasoning prepared with oil, slit green chillies, cumin seeds and pinch of turmeric. To the above seasoned mixture, pressure cooked dhal and spinach were added, stirred well and was cooked for 5 min on low flame.

11.White chickpea gravy

Ingredients: White chickpea – 150g, Tomato – 100g, Onion – 60g, Aniseed – 1 tsp, Coriander seeds – 1 tsp, Chilli powder – 1 tsp, Spice mix – 2 tsp, Ginger garlic paste – 1 tsp, Turmeric – a pinch, Green chillies – 2 in no, Potato – 100, Fresh coconut gratings – 2 tbsp, Poppy seeds – ½ tsp, Water- 400ml, Salt – 1g, Oil – 1 tbsp

Experimental : MSG- 80 mg, Salt- 0.65 g.

Method: Chickpea and de skinned potatoes were pressure cooked with salt. Aniseed and coriander seeds were roasted and powdered. Coconut gratings and poppy seeds were ground to a fine paste. Oil was heated in a pan, cut onions were added and fried, followed by ginger garlic paste and tomatoes and cooked for 2-3 min. To this mixture, coriander powder, chilli powder, spice mix, turmeric and slit green chillies were added and cooked for 3 minutes. Towards the end coconut and poppy seed paste was added and cooked for another 2 minutes. Boiled chickpea and potatoes were added to the above mixture and boiled for 10 min.

12.Green gram gravy

Ingredients: Green gram–125g, Onion –50g, Tomato-50g, Green chillies-10g, Cinnamon–1” piece, Turmeric– a pinch, Coriander leaves-5g, Ginger garlic paste–1 tsp

Pepper – 3 in no, Poppy seeds- ½ tsp, Oil – 1 tbsp, Mustard – ¼ tsp, Water-300ml, Salt – 1g

Experimental: MSG-100 mg, Salt- 0.6g.

Method: For the gravy: Cut onions, tomato, cinnamon, turmeric, green chillies, coriander leaves, pepper corns, poppy seed and green chillies were ground to a fine paste in a grinder. Green gram was pressure cooked with salt. In a pan, oil was heated and mustard seeds were added. To this ground paste was added and fried for about 2 min. Pressure cooked green gram was added, mixed and allowed to boil for 10 min.

Appendix A: Recipes of Indian traditional dishes.

MSG was added to the experimental product along with salt as indicated.

Training of the panel members

Volunteers familiar with sensory techniques and prior exposure to oriental cuisine were selected. For the purpose of accustoming the sensory assessors to the unique taste of MSG, all panellists who were a part of the study were trained adequately to obtain objective responses. Each selected panel member underwent a total of 18 training sessions. The panel members were selected based on their ability to correctly identify the various basic taste solutions presented. Initial screening comprised of 9 sessions. Here, due care was taken while selecting the panel members. Based on the responses obtained in this step, few members who were unable to respond properly or did not attend all training sessions were excluded. Subjects who were habitual alcoholics/smokers/beetle leaf chewers were excluded as these factors are known to impair the perception of the given taste quality [12].

Sensory evaluation of the products

All the prepared dishes (basic and sodium reduced) were subjected to sensory evaluation with 10 trained panel members for the major quality attributes such as appearance, taste, flavor, blend of flavor and overall quality. In addition to this, products such as amaranth sambar, sautéed beans and cabbage and fenugreek leaves sambar were also tested for the level of perception of MSG. Since the panelists were able to perceive the taste of MSG only in these products they were evaluated for the level of perceptibility. While, in other dishes it was unrecognizable. It blended well and could not be differentiated with the basic dish. Each dish comprised 2 set of products, i.e. basic dish (without MSG) and salt reduced dish. The samples were coded with three-digit random numbers and served in a sequential order. Only one particular set of products was presented to the panelists in a day for the evaluation purpose in order to prevent the fatigue. Water was served as palate cleansers in-between samples to minimize the carry over effect of MSG. Re-tasting of the samples was also allowed wherever panelists had difficulty in judging the taste quality.

Description of the score card

All samples were presented to panel members with a score card. Descriptive quality analysis was carried out using a 15 point scale comprising positive and negative quality assessors on a 15.0 cm line. Markings on the extreme right hand side of score card were indicative of higher degree of product acceptability, while, those on the extreme left hand side were considered to have poor quality. The assessors were instructed to mark over the scale indicating the random digit which was assigned for each product. Later the data was converted into numerical value of scores by measuring the mark on the line in cm with a scale to know the exact score given for any particular product [13,14].

Selection of carrier item

The developed products such as vegetable stews, gravies and split legume based preparations are referred as meal 'adjuncts' which are always served with an accompanying food item. The carrier items were selected in such a way that they would not mask the basic flavour characteristics of the adjunct which was served. The food items selected were bland in taste and did not have strong flavour characteristics. The food carrier and adjunct combinations that were chosen in this study are as follows:

1. Stews- plain white rice (rice grains boiled in plain water)
2. Gravies and split legume based preparations- wheat based flat bread (wheat dough sheeted and shallow fried)
3. Wheat, rice and millet based flat breads- mildly spiced coconut chutney (coconut, green chilli, tamarind and salt ground to a fine paste).

Analysis of sodium content in formulated dishes by flame photometer

About 5.0 g of sample was weighed into silica crucibles and heated over flame at low heat until all the organic matter volatilized or till no smoke was observed. The dish was transferred to muffle furnace for ashing. The prepared ash solution was filtered using Whatman No. 41 paper into 100 ml volumetric flask. A standard solution of 10 ppm, 20 ppm, 40 ppm, 60 ppm, and 100 ppm was measured for calibration curve. The aliquot of the ash solution was diluted and was automized into a calibrated flame photometer with the wave length dial set at 589nm [15].

Calculation

$$\text{Element (Na) ppm} = \frac{\text{ppm from calibration graph X Sample volume made to (100ml) X Dilution Factor}}{\text{Sample weight in grams}}$$

Statistical Analysis

All data were analyzed to obtain mean values and Standard Deviation (SD). These sensory analysis data were subjected to statistical analysis (mean±SD and ANOVA) to determine significant differences in samples using computer software SPSS version 18.0.

Results and Discussion

Impact of salt reduction on sensory attributes of prepared dishes

The results of sensory analysis of all dishes are compiled in table 1 and figure 1. While appearance is a common attribute for all dishes, texture was applicable to flatbreads and sauteed vegetables. For all curry type products such as sambar, dhal and gravies, consistency was evaluated. Aroma was applicable to all, and blend of flavour was specifically judged for products with added spices such as sambar and gravies.

Flatbreads

The mean sensory scores of low sodium wheat, rice and millet based flat breads is presented in table 1. Appearance and texture were not affected by lowering of salt and addition of MSG in any product with similar scores for control and experimental. The attributes of taste, aroma and overall acceptability showed an improvement on incorporation of MSG with significant differences for all products. The mean sensory scores ranged between 8.8 to 10.5 for control and 11.2 to 13.0 for experimental indicating statistically significant differences (p=0.02) between products. From the compiled mean sensory scores of rice based flat bread, it was very clear that substitution of MSG resulted in a superior taste in contrast to the control sample. Considerable improvement in the sensory score for taste was noticed when MSG was added. For instance, while the control product was given a total mean score of 8.4, a further increase of 12.3 was noted for MSG added product.

	Products		Appearance	Texture/Consistency	Taste	Aroma/Blend of flavour	Overall acceptability
Flatbreads (Roti)	Wheat	C	11.7±1.58	12.3±1.49	8.8±2.52	8.7±2.05	9.2±2.05
		E	11.7±1.58ns	12.3±1.49ns	12.0±1.86*	12.4±1.25**	12.7±1.57**
	Rice	C	12.1±1.22	12.3±1.12	8.4±1.99	9.8±2.00	10.5±1.76
		E	12.1±1.22ns	12.3±1.12ns	12.3±1.40***	12.5±1.52**	13.0±1.53*
	Finger millet	C	9.3±1.58	9.9±1.71	9.0±2.16	9.3±1.61	10.0±1.62
		E	9.3±1.58ns	9.9±1.71ns	12.0±1.74**	11.2±1.40*	12.0±1.41*
Sambar (Split legume based curry)	Mixed greens	C	8.6±0.91	8.7±1.00	8.7±2.49	8.5±2.03	9.5±2.52
		E	8.6±0.91ns	8.7±1.00ns	11.2±2.09*	12.2±1.18**	12.5±2.06*
	Fenugreek leaves	C	8.3±1.00	8.7±0.68	9.1±2.75	10.1±1.85	10.7±1.78
		E	8.3±1.00ns	8.7±0.68ns	12.6±1.84**	13.0±0.97**	13.2±.71*
	Mixed vegetables	C	12.6±1.52	12.2±1.15	7.6±2.36	8.8±2.55	8.0±2.31
		E	12.6±1.52ns	12.2±1.15ns	11.3±2.54*	11.8±1.61*	10.9±2.27*
Sauteed vegetables	Beans	C	9.1±0.94	10.8±1.53	6.9±2.55	9.7±2.57	8.0±2.20
		E	9.1±0.94ns	10.8±1.53ns	11.7±1.78***	12.6±1.93*	11.4±1.80**
	Cabbage	C	8.9±1.22	10.9±1.51	9.1±2.41	7.8±2.65	8.9±2.21
		E	8.9±1.22ns	10.9±1.51ns	11.8±2.19*	11.4±2.32*	12.4±1.41**
Dhal (Split legume based curry)	Spinach dhal	C	10.0±1.04	10.5±1.14	8.5±2.45	9.3±2.12	8.7±2.11
		E	10.0±1.04ns	10.5±1.14ns	11.5±1.67*	12.1±1.93*	11.8±1.74**
	Plain dhal fry	C	11.6±1.17	11.2±1.02	9.0±2.65	8.1±2.71	9.5±1.84
		E	11.6±1.17ns	11.2±1.02ns	12.0±1.78**	10.8±2.31*	11.8±1.57*
Gravy	White chickpea	C	12.8±1.44	12.5±1.14	10.4±1.95	8.9±2.36	8.0±2.16
		E	12.8±1.44ns	12.5±1.14ns	13.1±1.45*	12.1±1.38*	11.5±1.71**
	Whole green gram	C	10.8±1.41	10.9±0.85	9.4±1.77	8.2±2.33	8.1±2.35
		E	10.8±1.41ns	10.9±0.85ns	11.8±1.65**	10.9±2.19*	11.1±2.09*

Table 1: Effect of salt reduction on the sensory attributes of MSG incorporated dishes.

Foot note: Mean scores±standard deviation of 10 trained panel members. C: Control, E: Experimental.

*p≤0.05, ** P≤0.01, ***p≤0.001, NS: Not Significant

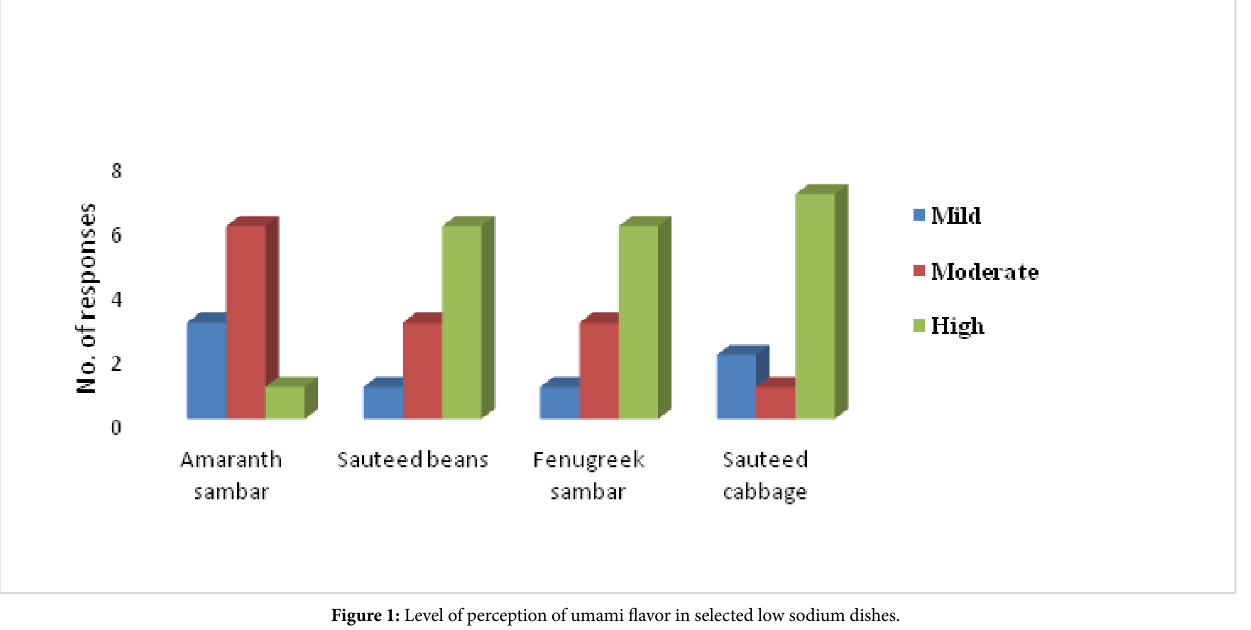


Figure 1: Level of perception of umami flavor in selected low sodium dishes.

Sambar: Split legume based curry

Sambar is a ubiquitous dish in a South Indian meal platter which is a common accompaniment to rice. It is generally prepared with split red gram, vegetables, spices and an acidulant. The sensory attributes of 3 types of Sambar given in table 1 shows that appearance and consistency were similar in both categories of products though other attributes differed significantly. Taste is the most essential attribute of any food product, and here the observations indicated that the sensory scores for taste improved with the incorporation of MSG. Lower scores were given for the control product, 7.6-9.1, which increased to 11.2-12.6 for experimental products. Aroma and overall acceptability followed similar pattern. The data pertaining to the mean sensory scores of fenugreek leaves sambar implied that the addition of MSG resulted in a greater level of enhancement in the perception of attributes of taste, blend of flavour and overall acceptability. Flavour of food along with its palatability are major determinants of food selection, and eventually of food intake also [16].

Many studies have established the role of flavour enhancers in improving the taste quality of foods and different types of flavour enhancers, both natural and synthetic have been used for the purpose. An experimental investigation on the formulation of flavour enhancer using locally available natural raw materials (mushroom, tomato, potato, garlic and salt) was conducted by Silva and Wansapala [17]. About eight different formulations were developed and tested by 30 untrained sensory panellists in order to obtain the best formula, which was subsequently compared with a commercial flavour enhancer like MSG in a rice preparation. The sensory results of the developed flavour enhancer, which was nutritionally rich, demonstrated a significantly higher preferences for the taste quality. Therefore, the investigators concluded that the product could be considered as a flavour enhancer with nutritional properties since it comprised of essential nutrients at an optimum concentration. In another study by Maheshwari et al. [11], MSG was demonstrated to have a synergistic effect with spices too. MSG added to a spiced fried product could reduce the level of salt as well as enhance flavour exhibiting synergism with the spices.

Sauteed/stir fried vegetable based preparations

As evident from table 1, the appearance and texture of control and experimental sauteed vegetables was similar. The scores given for taste quality showed an enormous improvement on incorporation of MSG with reduced salt, while control counterparts received lesser scores. The differences were shown to be statistically extremely significant ($p \leq 0.000$). Beans are generally reported to have a slight sweetish taste along with mild characteristic flavour. When the product was prepared only with the addition of salt, the responses were not encouraging, being lower for all the attributes related to taste. But, when MSG was added along with standardized level of salt, a considerable improvement was seen in the assigned sensory qualities. According to the panellists, addition of MSG resulted in an entirely different product which had much better sensory attributes in comparison to the control product. This could be attributed to the MSGs potentiality of enhancing the natural aroma and imparting a savoury taste to the dishes. This was the probable reason for the dishes to acquire a highly appetizing flavour. A study by Kumari et al. [8] demonstrated that MSG could be used very well for partially reducing salt in vegetable based soup with enhanced flavour profile and acceptability. It has been shown that glutamate given with a vegetable with savoury odour contribute towards a high degree of taste satisfaction than when given in isolation [18]. This proves the flavour potentiating effect of MSG in vegetable based dishes.

Dhal: Split legume based preparations

The basic difference between '*Dhal*' and '*Sambar*' is use of vegetables, spices and acidulants for the latter. Dhal is comparatively bland with or without vegetables, very little spices and no acidulants, whereas for sambar, use of a characteristic spice mixture is a must. Dhals are prepared using varieties of split or whole legumes, while sambar is principally based on split red gram. The sensory scores of dhal presented in table 1 showed similar scores for appearance and consistency, as was seen for other dishes. With respect to the taste attribute, scores got better after adding MSG as it potentiates and helps to bring out the hidden taste qualities. Thus, product with partial addition of MSG obtained higher score (11.51±1.67) in comparison to the product made without MSG (8.51±2.45). These differences in the score yielded marginally significant statistical differences ($p=0.01$). As opined by panellists MSG added product had a mildly sweetish and sour taste. This was found to have imparted a relatively higher degree of appetizing taste to the product and thus scores were observed to have improved with the incorporation of MSG.

Gravies

Gravies or curries are highly aromatic spiced dishes which are used as accompaniment to flatbreads or rice preparations. There are many types of gravies which are prepared with vegetables, legumes or meat and are indispensable to authentic Indian cuisine. The spice combinations used in these vary depending upon the region and ethnic groups. The sensory profile of gravies presented in table 1 followed the trend seen for other dishes. While addition of MSG did not affect appearance or consistency, other qualities were influenced significantly. Taste being the major parameter in deciding the products acceptability, partial substitution of salt with MSG enhanced scores (13.1 and 11.8) in comparison to the control product (10.4 and 9.4). This relative increase in the scores of taste quality might be attributed to the MSGs synergistic interaction with sour ingredients and essential flavour that might be present in spices which were used in the preparation. Significant differences were also observed for aroma, blend of flavour and overall acceptability. These gravy types of curries generally comprise of salty and sour taste imparted from the base ingredients. Here, it could be said that addition of tomato might have resulted in a very delicious taste profile. Tomato is known to contain umami flavour enhancing compounds, which impart savoury taste to the product. Therefore both the products were awarded considerably higher scores.

Perception of Umami flavour is selected dishes

Umami flavour is very characteristic of glutamate compounds and is recognized as one of the basic tastes. The term umami is basically a Japanese concept which means savoury or delicious which is a prototypical stimulus imparted mainly by monosodium glutamate. First discovered in seaweeds and recognized for its flavour potentiating effect, glutamate compounds are recognized as part of oriental cuisine, and used in a wide variety of dishes to make food tastier, palatable and have greater acceptability [19,20].

The panel members were asked to identify the presence of umami flavour in selected dishes with the help of a descriptive quality profile and their responses for mixed vegetable sambar, fenugreek leaves sambar, sautéed beans and cabbage are compiled in figure 1. With respect to the perception of umami taste in mixed vegetable sambar, it was evident that a proportionately higher number (6) opined that they could perceive the umami flavour at a moderate level. While the responses for mild level of perception was also comparatively higher. For sautéed beans category, a majority of the panel members were able to very clearly perceive the umami flavour at a higher level (6) in comparison to other two responses such as mild (1) and moderate level (3). Though cabbage is known to possess strong characteristic flavour, it did not interfere with the perception of umami flavour quality, which was detected as high. The overall responses for the perception of umami flavour in fenugreek leaves sambar was similar to beans.

Various scientific investigators through their experimentation have provided substantial evidence regarding the role of MSG in achieving considerable level of sodium reduction in the formulated dishes. The sensory acceptability of a garlic seasoning salt formulation was evaluated by a group of Brazilian investigators. They employed both MSG as well as KCL to replace 25% and 50% of salt respectively. The results clearly demonstrated that the product was highly acceptable since it had all the desirable sensory attributes especially when used with cooked rice [21]. In another study, local spicy soup dishes such as curry chicken and chili chicken which had varying amount of NaCl and MSG were evaluated. The amount of NaCl needed to achieve optimal level of acceptance was 0.8%. With partial replacement of NaCl in a ratio of 0.3% NaCl: 0.7% MSG, the dishes had the same level of palatability [22]. Leong et al. [23] investigated the effect of sodium reduction and flavour enhancer such as MSG on the sensory acceptability of two different types of hawker foods namely; chicken rice and mee soto broth that are known to be commonly consumed in Singapore. In sodium reduced recipes two levels of sodium chloride i.e. 0.48 and 0.55% for chicken rice and 0.76 and 0.86% for mee soto were used. The selected levels were reported to be equivalent to 31 and 22% reduction in sodium. MSG was added at the level of 0.2 and 0.4% to the prepared dishes. The study revealed that an amount of addition of 0.4% MSG lead to a total reduction in sodium by 22%. Quadros et al. [24] evaluated the sensory quality of a fish hamburger formulated with reduced sodium. The concentrations such as 1.5g/100g and 0.75g/100g of NaCl associated with 0.3g/100g of MSG were employed in formulations. The results showed that MSG incorporation contributed for an overall increase in the acceptability scores in products containing 0.75g NaCl/100g, i.e. it resulted in a total reduction of salt by about 50%.

The quality profile of cream cheese was evaluated by Silva et al. [25]. The cheese was formulated using various types of salt substitutes namely; potassium chloride, magnesium and calcium chloride, calcium and potassium lactate, potassium phosphate and MSG. The investigators reported that, potassium chloride contributed the highest salting equivalence in comparison to sodium chloride. While, MSG had the lower salting equivalence. Therefore MSG could be considered to have the maximum flavour potentiating property which could be regarded as beneficial for bringing down the sodium content in any product.

Analysis of Sodium Content of Prepared Dishes

The prepared dishes were analysed for sodium content to assess the level of reduction in sodium. Table 2 represents the sodium content of the various dishes. The data indicated that all the control samples had comparatively higher sodium levels than those of experimental products that were prepared with a combination of salt and partially substituted MSG. The data demonstrated a huge difference in the amount of sodium content of wheat based flat bread. Control product was shown to contain 407.3 mg sodium/100g of the product. While that of experimental product had only about 29.5 mg/100g.

The sodium content of control chickpea gravy was 416.2 mg/100g, and that of experimental product was only 289.2 mg/100g. Since the basic recipe involves the addition of various types of spice powders, in order to balance the taste, salt needs to be added at slightly higher concentrations. As MSG is known to impart savoury taste due to its synergistic interaction with various spices, it generally boosts up the taste along with bringing out other higher flavour qualities effectively reducing the need of salt.

A perusal of table 2 provides information about the total amount of sodium contributed by table salt, MSG and food ingredients and percent reduction in sodium content of MSG substituted products. The sodium content in all the control products was considerably higher which was in the range of 390-429mg/100g of the product. Whereas for experimental products, the amount of sodium from table salt was comparatively less. The amount of sodium contributed by MSG was in the range of 6.15-14.7 mg/100g of the product which is proportionately lower than the amount contributed by table salt. Therefore, it could be said that, by reducing the amount of table salt it is possible to achieve considerable reduction in the total sodium content. In general, the overall sodium reduction was in the range of 30.6% - 43.3%. Among the developed products, wheat based flat bread indicated highest amount of reduction (92.7%) since no salt was added during the preparation, and only 100mg MSG was added. Thus it resulted in a greater level of sodium reduction. MSG not only brings down the sodium content, but also acts as an appetite stimulating agent by enhancing the rate of salivary secretion. This particular property has been reported to be beneficial among certain segments of population like elderly people, where they may have difficulty in swallowing due to lack of salivary secretion. This problem could be overcome by incorporating MSG in the dishes. Similarly for other breakfast items like rice flatbread and finger millet flatbread, the percent reduction in sodium content was computed as 36.5 and 34.7% respectively.

Dos Santos et al. [26] demonstrated that the reformulated sausages containing MSG combined with lysine, taurine, disodium inosinate and disodium guanylate were beneficial in masking the undesirable sensory attributes associated with the replacement of 50% and 75% NaCl with KCl. This enabled the production of fermented cooked sausages with good sensory acceptance and approximately

Product	Sodium content (mg/100g)		Percent reduction in sodium in Experimental product
	Control	Experimental	
Wheat based flat bread	407.3±1.3	29.05±0.25	92.7
Rice based flat bread	390.5±0.5	248.5±0.5	36.6
Millet based flat bread	465.5±0.5	304.5±0.5	34.7
Mixed vegetable sambar	486.5±0.5	336.5±0.5	31
Mixed leafy vegetable sambar	658.0±0.8	472.1±0.35	28.8
Fenugreek leaves sambar	454.8±0.3	288.7±0.15	36.6
Sautéed beans	467.5±0.3	297.7±0.4	36.4
Sautéed cabbage	390.5±0.55	221.4±0.1	43.3
Plain dhal fry	422.8±0.15	252.7±0.05	40.2
Palak dhal fry	450.0±0.4	264.3±0.3	41.3
White chickpea gravy	416.2±0.05	289.2±0.15	30.6
Green gram gravy	436.6±0.2	288.2±0.1	34.1

Table 2: The analysed sodium content of the prepared dishes.

Foot note: Mean scores±standard deviation.

68% sodium reduction. Reduction of sodium in foods especially in fermented foods has been studied mostly since last three decades. Also, the effect of different mineral salts on the fermentation profile, microbial flora, physicochemical, textural, and flavour characteristics of product was investigated in this context. For instance, substitution of NaCl was carried out with KCl, CaCl2, and MgCl2 in sauerkraut, with monosodium glutamate, KCl, and CaCl2 in olives and with KCl in cheese fermentations, which has indicated that they could be used as an alternative choices for sodium reduction in formulated or reformulated preparations [27-30].

Conclusion

The study brought out important inferences that it is possible to produce traditional Indian dishes with 30-40% reduced sodium content with the substitution of monosodium glutamate. The products had lower intensities of saltiness and appetizing umami taste with good blend of sensory parameters. Further, substitution of MSG also resulted in enhanced perception of different flavor characteristics, which had a greater impact on the overall palatability of products.

Author’s Contribution

Dr. Prabhavathi S.N.: She was responsible for all the bench work, as well as analysis and compilation of data and writing the manuscript. This was a part of her doctoral research work.

Dr. Jamuna Prakash: Senior Professor and research supervisor, responsible for guiding and supervising the entire research work and correction of manuscript.

Funding

This study did not receive any funding.

Conflict of Interest

Authors declare no conflict of interest with the research reported in this study.

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